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PERFORMANCE ASSESSMENT OF MAKURDI BURNT BRICKS

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ABSTRACT

This work presented in the paper involved onsite observation of the production process, determination of physical properties and chemical composition of the soil sample used for production of Makurdi burnt bricks (MBB). A total of 22 brick specimens, of the MBB was examined in the laboratory for compressive strength, water absorption and abrasion resistance. The results reveal the soil sample as a true laterite having a Silica-Sesquioxide ratio of 1.01, Silica content of 42.95 and clay content of 27.38 and total clay + silt content of 30.78. The Atterberg's limit test gave the liquid limit as 36.79; plastic limit, 26.11and plastic index, 10.68. Compressive strength was 3.46 N/mm^2 and 11.75 N/mm^2 for Samples A and B respectively; Average water absorption for Sample B (16.49%) was double that of Sample A (8.58%) while the Abrasion resistance ability of Sample B (33.67%) was four times better than Sample A (9.32%).

KEYWORDS: *Burnt Bricks, Performance Assessment, Compressive Strength, Abrasion Resistance, Water Absorption.*

INTRODUCTION

A visit to Makurdi, the Benue State Capital of Nigeria in 2009 for generated a research interest on the Makurdi locally made burnt bricks (MBB). Something of interest is the rampant use and acceptability of the MBB; it is really a display of the residents attempt at meeting the need for shelter using materials that the environment can afford in line with the postulations of Fitch and Branch (1960). Adegoke and Ajayi (2003) posited that a good material for shelter provision must allow participation from the community and thereby improving the economy of that community. This is what they called appropriate technology. Such materials must be readily available, appropriate (economically and physically) to the environmental demands, thermally efficient and socially acceptable (Olusola, 2005).

MBB can be said to fall specifically into the category of materials described by the researchers quoted above. The bricks are not only being adopted for modern building structures as shown in Plates 1 & 2, but are also used for incinerators, drainage works, waterlogged sites and free standing walls of fence with little or no treatment as shown in Plates 3 & 4. The use of the MBB was not limited to private residential houses but public and corporate building structures too. A good example is the wall of fence of J. S. Tarka Foundation Civic Centre in Makurdi.

Plate 1: A modern structure built from MBB

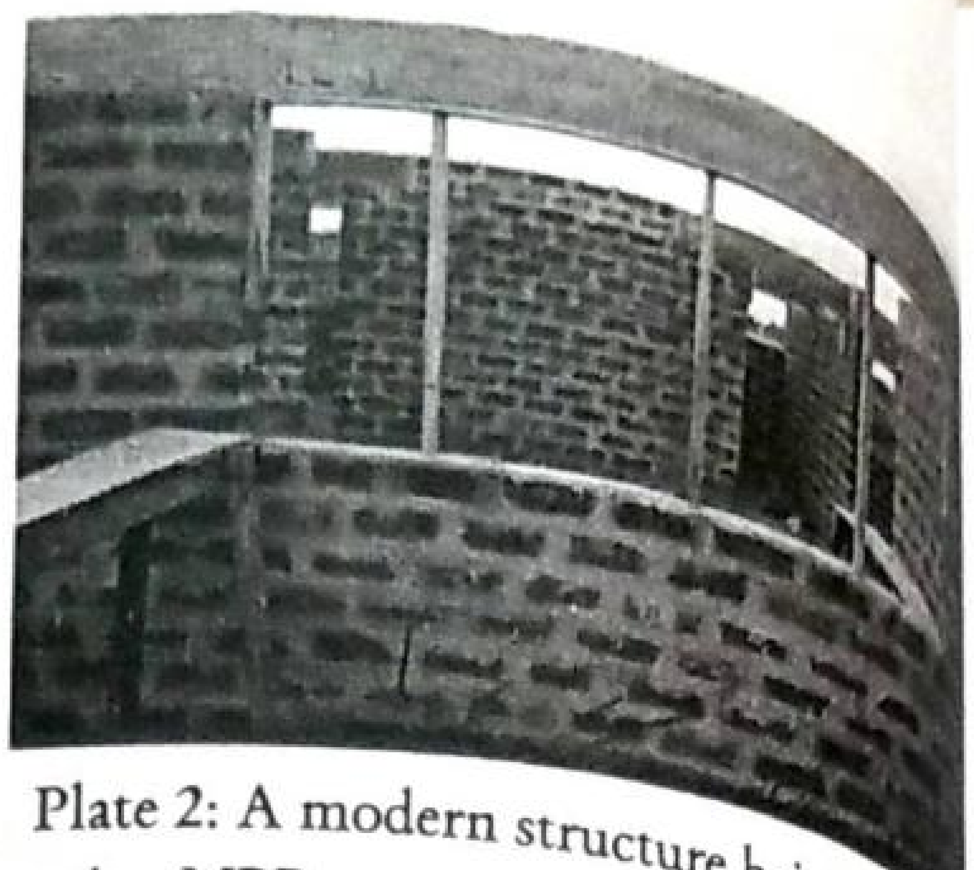

Plate 2: A modern structure being constru using MBB

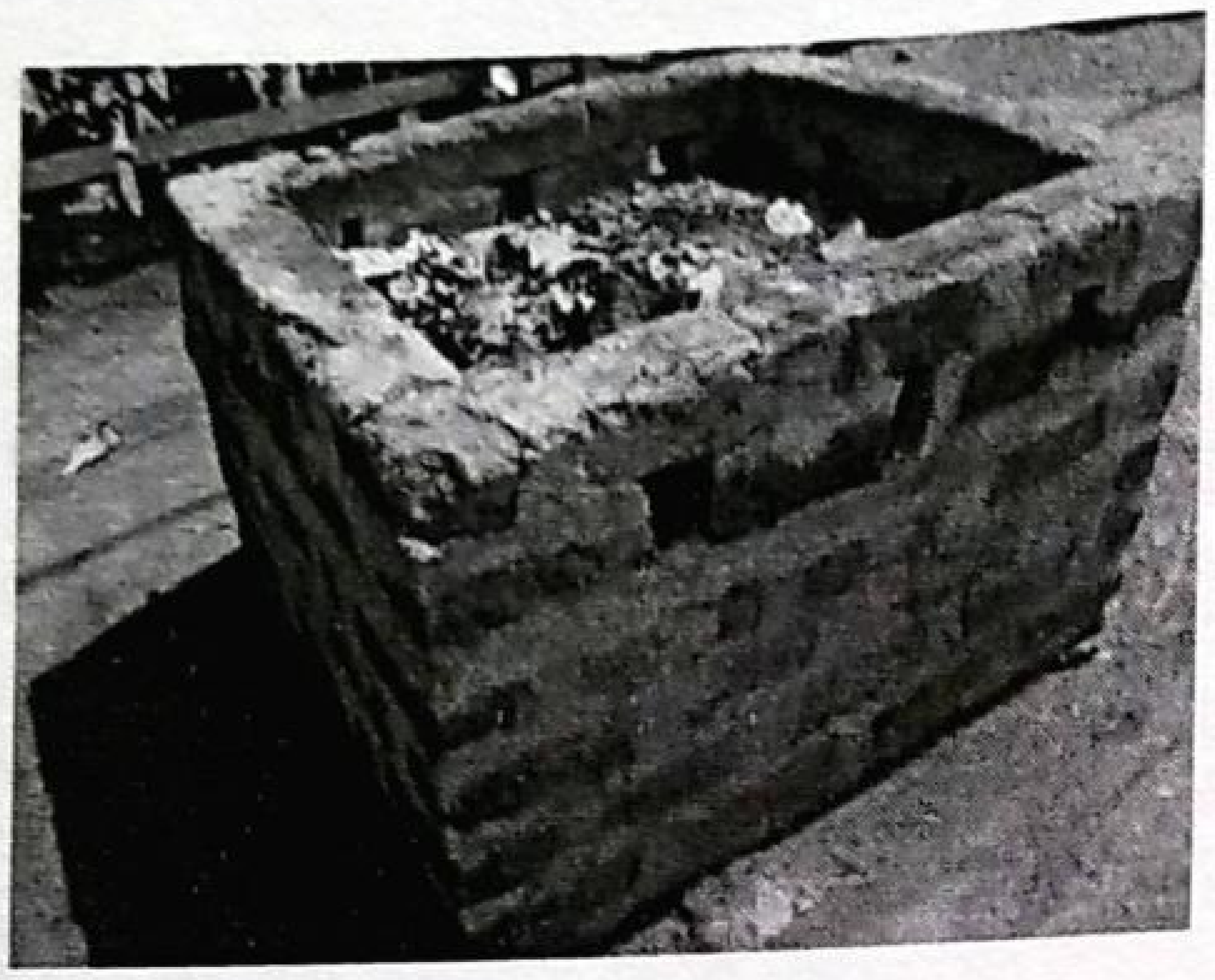

Plate 3: MBB used to construct an open Incinerator

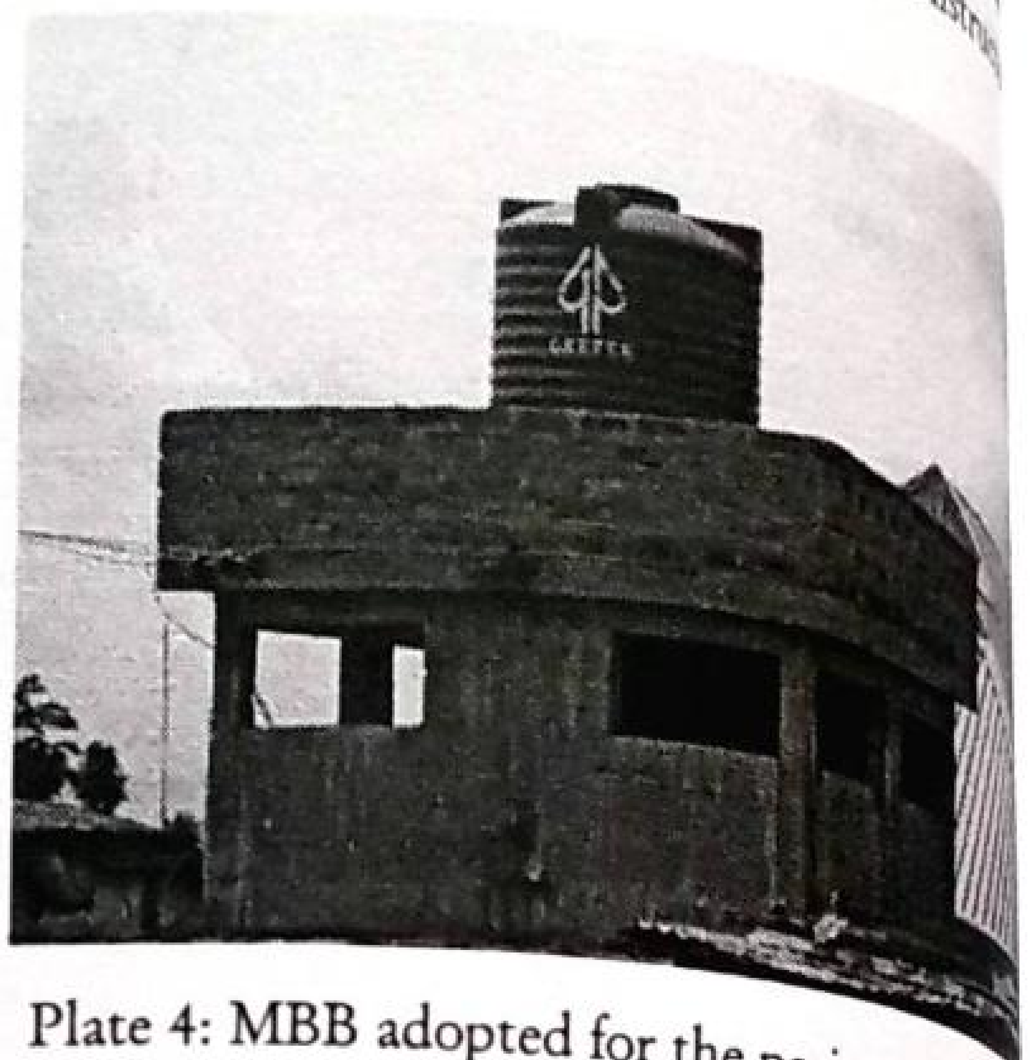

Plate 4: MBB adopted for the perimeter wall of a Water Tank Tower

The MBB were said to be cheap, sold as low as ₦5/brick at normal period, while the highest price stands at ₦8/brick during the peak period as against the unit price of ₦100 and ₦120 for 150 mm and 225 mm sandcrete blocks respectively, implying masonry unit material cost of ₦235/m^2 to ₦376/m^2 using MBB as against ₦1000/m^2 to ₦1200/m^2 for sandcrete blocks, hence giving a saving in masonry material cost of about 70%. This is coupled with the fact that brickwall surfaces are often finished without additional cement/sand rendering. Despite the numerous advantages of the MBB and its high level of public acceptance and use in Makurdi and its environments, there are no empirical data on the engineering properties of this important masonry unit nor is there a research report on the classification and suitability of the soil being used for its production. This paper thereby presents a report of the study of the production process and performance assessment of the MBB with a view to determine the suitability of the soil type used, adequacy of technology adopted for its production, the performance assessment of the MBB at meeting requisite standards and its durability in the prevailing environment.

Brick is defined in the Encarta English Dictionary (2009) as a rectangular block of clay or similar material (i.e. laterite) that is baked until it is hard and is used for building houses, walls or other permanent structures.

Usage of burnt bricks dates back to the stone age. They had brick for stone, and they had asphalt for mortar (The Maxwell Leadership Bible, 2007 NKJV).

In pre-modern China, brick-making was the job of a lowly and unskilled artisan, but a kiln master was respected as a step above the latter. The Romans made use of fired bricks and the Roman legions which operated mobile kilns introduced bricks to many parts of the empire. Roman bricks are often stamped with the mark of the legion that supervised its production. The use of bricks in Southern and Western Germany for example, could be traced back to traditions already described by the Roman Architect Vitruvius (Wikipedia, 2011). Brick or earth for wall construction in Nigeria is of long proven use; earth bricks are still mostly used for dwellings, which are built without formal authorization such as obtained in the rural housing or uncontrolled low income housing in the urban areas.

The soil used for brick making is often called different names such as earth, clay or laterite but the term "laterite" according to Encarta English Dictionary (2009) originates from the Latin word *later* meaning brick. Laterite is defined as red tropical soil: a reddish mixture of clayey iron and aluminium oxides and hydroxides formed by the weathering of basalt under humid, tropical conditions (Encarta, 2009).

Numerous definitions have been given to Laterite depending on the professional inclination of the authors. While some are purely morphological, some are purely physical and some others are purely chemical.

The term "laterite", according to Hamilton (1995), was first used by Buchanan in 1807 to describe a ferruginous (high iron content), vesicular (contain small cavities), unstratified and porous material with yellow archers caused by its high iron content, and occurring abundantly in Malabar, India. It was used for weathering materials from which blocks were cut, that after drying were used as building bricks. Hence the word "laterite" was derived from the Latin word "*later*" which means brick or tile. Laterite has also been recognized as the alteration or in-situ weathering products of various materials including crystalline igneous rocks, sediments detrital deposit and volcanic ash. The degree of weathering to which the parent materials have been subjected influences greatly the physical and chemical composition of Laterite soils (Olusola, 2005).

The first to establish the chemical concept of the definitions of Laterite was probably Mallet (1883) as quoted in Osunade (1984), Owoshagba (1991) and Olusola (2005). He established the ferruginous and aluminium nature of lateritic soils. Fermor (1981) defined various forms of laterite soils on the basis of the relative contents of the so-called laterite constituents (Fe, Al, Ti, Mn) in relation to silica. A chemical definition based on the (S-S) Silica Sesquioxides ratio ($SiO_2/Al_2O_3+Fe_2O_3$) had been proposed, the conclusion being an S-S ratio <1.33 implies a true laterite; an s-s ratio between 1.33 and 2.0 refers to a lateritic soil; and an S-S ration <2.0 indicates a non-lateritic, typically weathered soil.

Gidigasu (1976) gave a broad-based definition of Laterite which may be more appropriate for engineering applications. He states that the word laterite should be used to describe "all the reddish residual and non-residual tropically weathered soils, which genetically form a chain of materials ranging from decomposed rock through clays to sesquioxides (Al_2O_3 + Fe_2O_3) rich crust, generally known as cuirass or carapace". Cuirass stands for the upper layer of laterite accumulation zone and is particularly enriched in iron oxide minerals. Carapace on the other hand stands for the lower part of laterite accumulation zone. Miller (1999) also describes laterite as heavily leached tropical subsoil which is not fertile and comprises mainly iron and aluminium oxides and kaolinite-clays.

Rajput (2006) stated that brick earth is derived by the disintegration of igneous rocks and that a good brick earth should be easily moulded and dried without cracking and warping. Discussing on the chemical composition, he further stated that it should have the following:

1. Alumina (Al_2O_3) or Clay = 20-30 percent by weight
2. Silica (SiO_2) or sand = 35-50 percent by weight
3. Silt = 20-25 percent by weight.

Total content of clay and silt is recommended to preferably be less than 50 percent by weight. Rajput (2006) further stated that brick earth must have proper proportions of sand, silt and clay; be homogeneous; have sufficient plasticity and be free from lumps of lime and nodules of kankar. This conforms to the postulations that the material used for brick production falls under other previous authors and researchers' classification of the soil called laterite.

Burning of bricks is one of the popular methods of stabilization; others are introduction of cement and other pozzolanic material such as Rice husk ash, volcanic ash, sugarcane bagasse ash and many others. Burning of bricks being possibly the first means of stabilization has to be thorough and uniform for the essence of imparting hardness and strength to the bricks and increasing the bricks' density so as to enhance their water resistance tendencies. This study thereby examines MBB with a view to determining the physical properties and chemical composition of the soil used in making the bricks, investigate the production process, specifically the method of burning and assess their compressive strength and durability properties.

MATERIALS AND METHODS

Materials Collection

This study involved observation of the production process of the MBB at the local site in Km. 4, Gboko road, Makurdi. Keen attention was paid to the burning process of the bricks while some quantities of the soil sample were collected for laboratory analysis for physical and chemical properties, with some samples of the finished bricks also collected for determination of compressive strength, abrasion and water absorption.

Local Production of Burnt Bricks in Makurdi

The stages involved in processing the local burnt bricks as observed in Makurdi are as follows:

The soil was excavated from a boring pit and stacked in heaps in the open for rain to wash out the soluble salts which might later cause white scum on the product. After the soil had been thoroughly washed, it was stored in an open storage area until when ready for use. Before putting it to use, water was then added to the soil to form a paste.

The laterite paste was then poured into a mould of 270 mm x 110 mm x 80 mm and the bricks moulded. The freshly produced bricks were stored in the open air in rows, covered temporarily with dried grass to ensure protection against adverse weather conditions. This ensures that there is constant drying. This depends completely on the weather conditions and can take from 4 to 6 weeks of proper or desired drying before burning.

The bricks were only ready for burning at the completion of proper drying. The properly dried bricks were stacked with a provision for firing or heating to develop hardness at the bottom. The staked bricks were covered with a thick layer of soil paste to reduce the loss of heat during firing as shown in Plate 5. The fire was started, heat developed and then after few days of firing the fuel was cut off entirely and the burnt bricks were allowed to cool naturally. The fuel mostly used in firing is wood.

When the bricks are well burnt, a cherry-red hue develops and this condition is held for about 6 hours. Sufficient fuel must be available when the burning starts as the entire batch of bricks might be lost if the fires were allowed to die down during the operation. Firing with wood took two to five days. The bricks were adjudged to have been thoroughly burnt when a part of the heap starts falling without the bricks breaking as seen in Plate 6. Burnt brick samples were examined by breaking off a part of the brick to see how the inner surface is; bricks not well burnt gave an inner colour of ash as in Plate 7 while well burnt brick gave a uniform yellowish brown colour same as the external surface.

Plate 5: Staked bricks set for firing

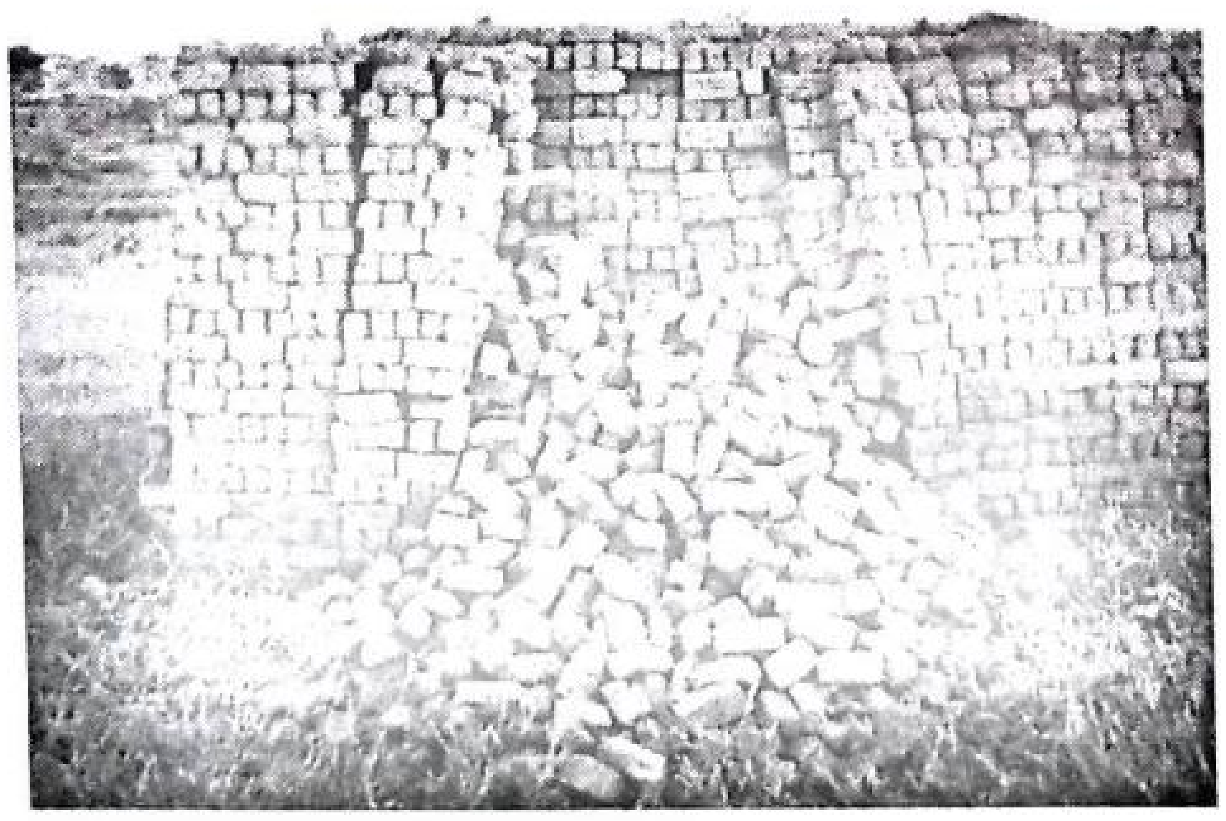

Plate 6: Staked bricks after firing

Plate 7: Inner ash colour of brick no well burnt

Plate 8: Stacked burnt bricks around firing channel

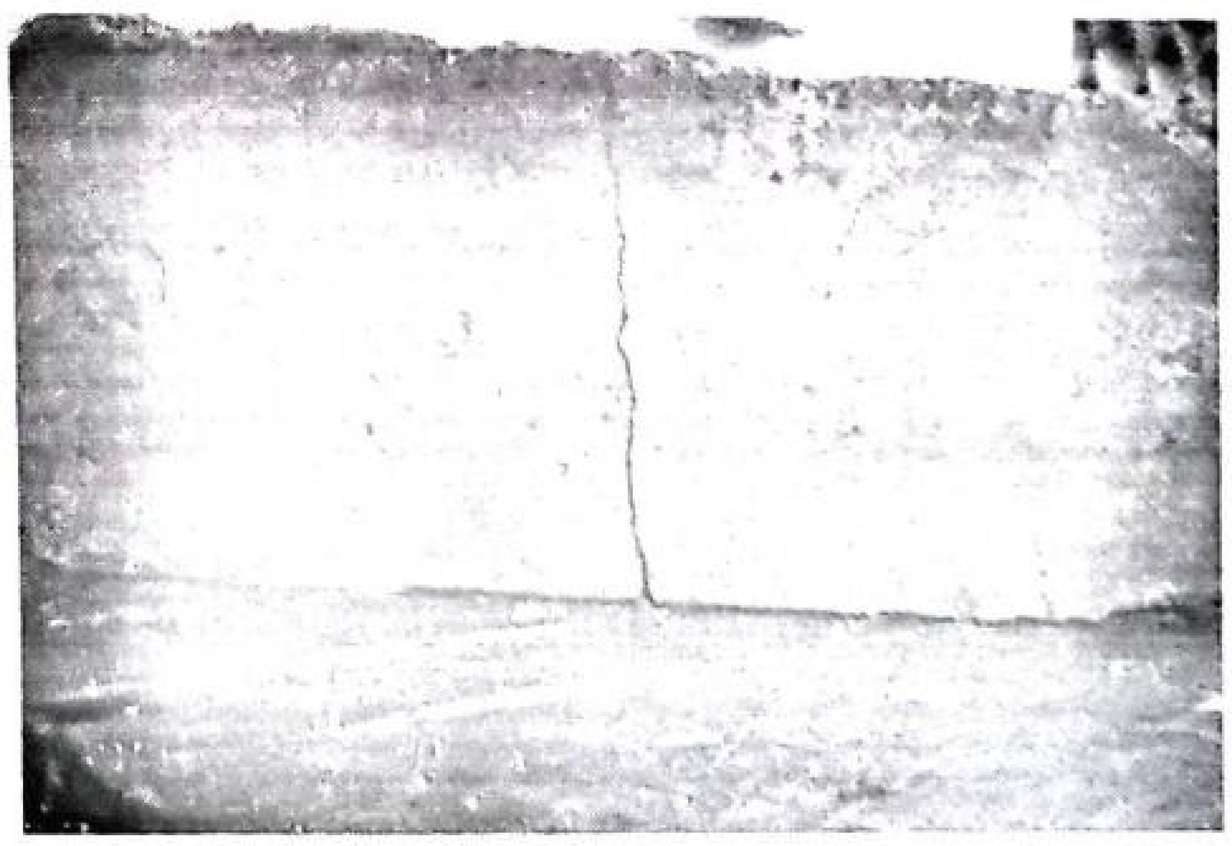

Plate 9: Crushed burnt brick (Sample A)

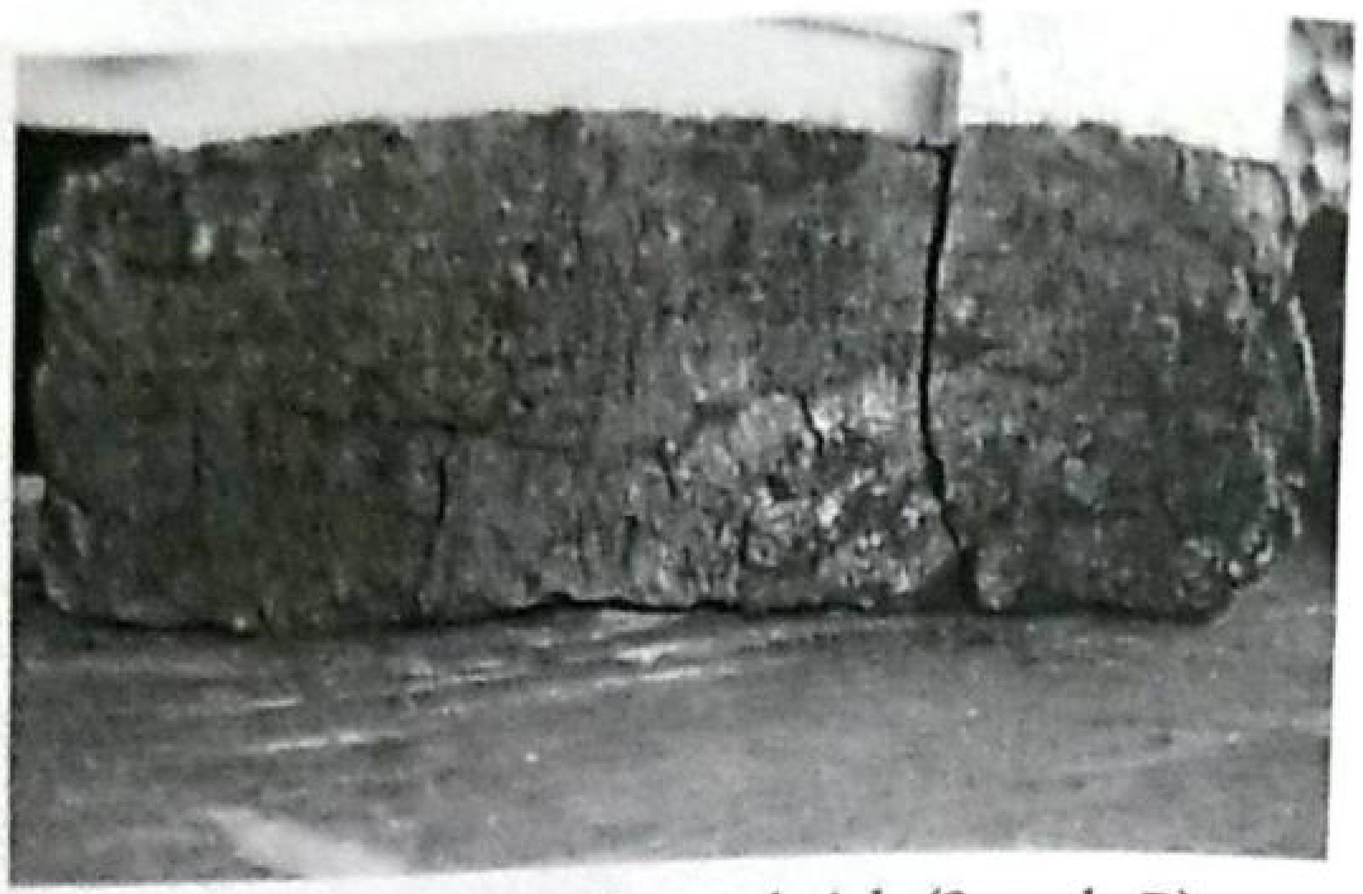

Plate 10: Crushed burnt brick (Sample B)

During the firing, the bricks shrink as much as 10%. As they were taken out of the staked batch after firing, they were sorted to different grades with the main criteria being strength, irregular dimensions and sometimes cracks. Two classifications of good bricks always result from this process; well burnt bricks usually adopted for normal building construction (Sample A - those bricks not in direct contact with fire source) and the over burnt referred to as iron-bricks - commonly used for drainages and waterlogged areas (Sample B - those brick in direct contact with fire source). Plates 9 and 10 present Sample A having uniform yellowish brown colour and Sample B in dark grey/black shining charcoal-like colour.

A total of 30 bricks, 15 for each sample specimens were collected for assessment in the laboratory.

Instrumentation

The chemical analysis of Laterite sample was carried out at the Sagamu Works Department of Lafarge Cement (West African Portland Cement Company - WAPCO) via an X-ray Fluorescent Analysis using a Total Cement Analyser model ARL 9900 XP. The physical properties test on the soil sample, compressive strength and water absorption on the MBB were carried out in the Department of Building laboratory, FUT, Minna and Abrasion test on the MBB was carried out at the Civil Engineering Laboratory of Federal Polytechnic, Bida using the Los Angeles Abrasion Testing Machine. Furthermore all mass measurements were taken on weighing balances available in the various Laboratories of the Federal University of Technology (FUT), Minna and Federal Polytechnic, Bida.

Experimental Procedure

Determination of Chemical Composition of Laterite Sample

The Laterite sample was prepared in F.U.T, Minna and then taken to WAPCO, Sagamu Works for analysis. About 150 g of the Laterite sample was packaged in a small nylon bag and sent to the Chemical Laboratory of WAPCO.

The determination of the chemical composition at WAPCO in accordance with ASTM C311 2008 involved drying, grinding, pressing and analysing. The materials were dried in an oven at 100 $\pm$10°C for about two hours until a constant weight ($\pm$0.01 g) was obtained after which the sample was placed in a desiccator to cool for about 30 minutes before grinding commences. In order to aid grinding and to prevent sticking of the sample to dish, 0.8 g of stearic acid was weighed into sample dish before adding 20.0 g of the material (VA sample) into it. Grinding was done on a gyro-mill grinding machine (Model HSM 100H, Serial Number MA 11566-5-1, 2004), which stops automatically after grinding for a pre-set time of 3 minutes. The sample was then ready for pressing.

The ground sample plus 1.0 g of stearic acid to ensure adequate binding, was used to fill the pellet cup to the brim. The pellet cup was then centrally placed in an automatic hydraulic operated press (Model TP 40/2D), pressed at 20 tons load and 30 seconds hold time. On completion of pressing, the pressed pellet was carefully removed from the cylindrical pressing die and transferred into the X-ray analyser sample holder ready for analysis.

The analysis was carried out using X-Ray Fluorescent Analyser called Total Cement Analyser (Model ARL 9900 XP), connected directly to a computer system. The pressed pellet was loaded in the sample port of the analyser and the assembly left for about three minutes after which the values of elements concentration were displayed on the monitor. This was saved directly on the system and printed out as the result of the analysis.

Physical Properties of Laterite Sample

The physical properties tests carried out on the Laterite soil sample included sieve analysis to determine the particle size distribution; Atterberg limits tests (i.e. liquid and plastic limits) to determine the plastic index of the soil sample. Also determined were the specific gravity and the moisture content of the soil sample. The tests were carried out in accordance with the requisite current British standards (i.e. BS EN 933 1:1997 and BS EN 12620 1:2002 for sample grading; BS EN 1377 2:1990 for Atterberg limits; BS EN 1097 6:2000 and BS EN 1097 5:1999 for moisture contents).

Performance Assessment of the MBB

The major tests carried out on the MBB are the compressive strength, abrasion and the water absorption. A total of twenty two (22) numbers of the burnt bricks were used for these tests in accordance with the appropriate British Standards.

The compressive strength in accordance with BS EN 12390 3:2000 involved subjecting a total of ten bricks (five numbers for each brick specimen type) to crushing on an ELE compression machine (maximum capacity 2000KN, Model No JYS 2000A CLASS 1 Serial No. 16) while the crushing force was noted and average of the compressive strength calculated for five specimen giving the compressive strength value of the brick sample. Plates 9 and 10 presents the two sample types of brick crushed.

Abrasion test and water absorption are both durability measures to determine the ability of the brick to resist wearing away by erosion and other environmental conditions (i.e. abrasion) on one hand; while water absorption properties on the other hand is a measure of the suitability of a brick for construction works. Rajput (2006) specifies that the water absorption of a good brick should not exceed 20% weight of the dry brick.

The water absorption in accordance to BS 1881 - 122:1983 was carried out using a total of six brick samples (three each for each sample type). The specimen bricks were first weighed dry, and then immersed in water for a period of sixteen hours (16 hrs) and weighed again; the difference in weight indicated the water absorbed by the brick. The average of three replicates for each sample type gave the water absorption value of the brick.

The compressive strength and water absorption tests were carried out at the Building Laboratory of Federal University of Technology, Minna.

The abrasion test in following the concept spelt in BS 1881 122:1983 was carried for a total of six specimens of the MBB adopting three each for Samples A and B respectively in Civil Engineering Laboratory of Federal Polytechnic, Bida using the Los Angeles Abrasion Testing Machine available. The test involved weighing the brick sample

Before inserting the machine and subjected to 500 revolutions and weig again. The difference in weight calcula in percentage (%) gives an indication of % durability of the brick sample while average of three replicates was adopted this study as the % durability.

RESULTS AND DISCUSSION

Constituents of the Soil Sample

The result of the chemical analysis carrie out on the Laterite sample is shown Table 1. It reflects Silica Sesquioxide (S Ratio tagged SR in the Table, as 1.0 implying a **true laterite.**

Table 1: Chemical Analysis of Laterite Sample

Elements	% Composition by weight	Others	Values
SiO_2	42.95	Cl^-	0.00
Al_2O_3	27.38	L.O.I	
Fe_2O_3	14.95	SUM	83.76
CaO	-0.65	LSF	-0.34
MgO	-0.62	SR	1.01
K_2O	0.32	AR	1.83
Na_2O	0.23	C_3S	-487.34
P_2O_5	0.03	C_2S	-481.23
TiO_2	1.14	C_3A	16.92
Mn_2O_3	0.16	C_4AF	36.45
SO_3	-0.14	$Al_2O_3+Fe_2O_3$	42.33
Total $SiO_2+Al_2O_3+Fe_2O_3$	85.28		

The laterite sample was noted to be light brown in colour and have a high quantity of Silica (SiO_2 = 42.95 %), average Iron Oxide and Aluminium content (Fe_2O_3 = 14.95 % and Al_2O_3 = 27.38 %) and can be classified to be Aluminium Laterite but not bauxite in line with Tietz's (1997) classification since the Aluminium content is higher than the Iron content. The soil thereby conforms to Rajput's (200 requirement for a good brick making ear on basis of the Alumina (Al_2O_3) or clay a Silica (SiO_2) or sand content.

The result of Liquid and Plastic Limits a shown in Tables 2 and 3 while Fig.1 show the plot of the Liquid Limit obtained v the use of Microsoft Excel.

Table 2: Liquid Limit of Laterite Sample Used

	LIQUID LIMIT				
Penetration (mm)	15	17	19.5	22.5	24.5
Can Number	A	B	C	D	E
Weight of Can (g)	24.1	24.3	24.6	23.9	25.4
Weight of Can + wet Soil (g)	29.6	29.9	30.1	30.2	31.7
Weight of Can + dry soil (g)	28.5	28.6	28.8	28.4	29.5
Weight of wet soil (g)	5.5	5.6	5.5	6.3	6.3
Weight of dry soil (g)	4.4	4.3	4.2	4.5	4.1
Moisture Content (%)	25.0	30.2	31.0	40.0	53.7

Table 3: Plastic Limit of Laterite Sample Used

	Plastic Limit	
Can Number	20	10
Weight of Can (g)	24.9	24.3
Weight of Can + wet Soil (g)	26.2	25.4
Weight of Can + dry soil (g)	25.9	25.2
Weight of wet soil (g)	1.3	1.1
Weight of dry soil (g)	1.0	0.9
Moisture Content (%)	30.0	22.2
Average	26.11	

Using the equation of the line of best fit given as y = 2.725x 17.71 and R^2 = 0.882, the Liquid Limit (L.L .i.e. Moisture Content at 20 mm penetration) = 36.79. Table 3 presents the Plastic Limit = 26.11, while the Plastic Index = L. L P. L = **10.68**; all these show that the laterite sample has Atterberg limits conforming to the range as specified by the findings of Abidoye (1977).

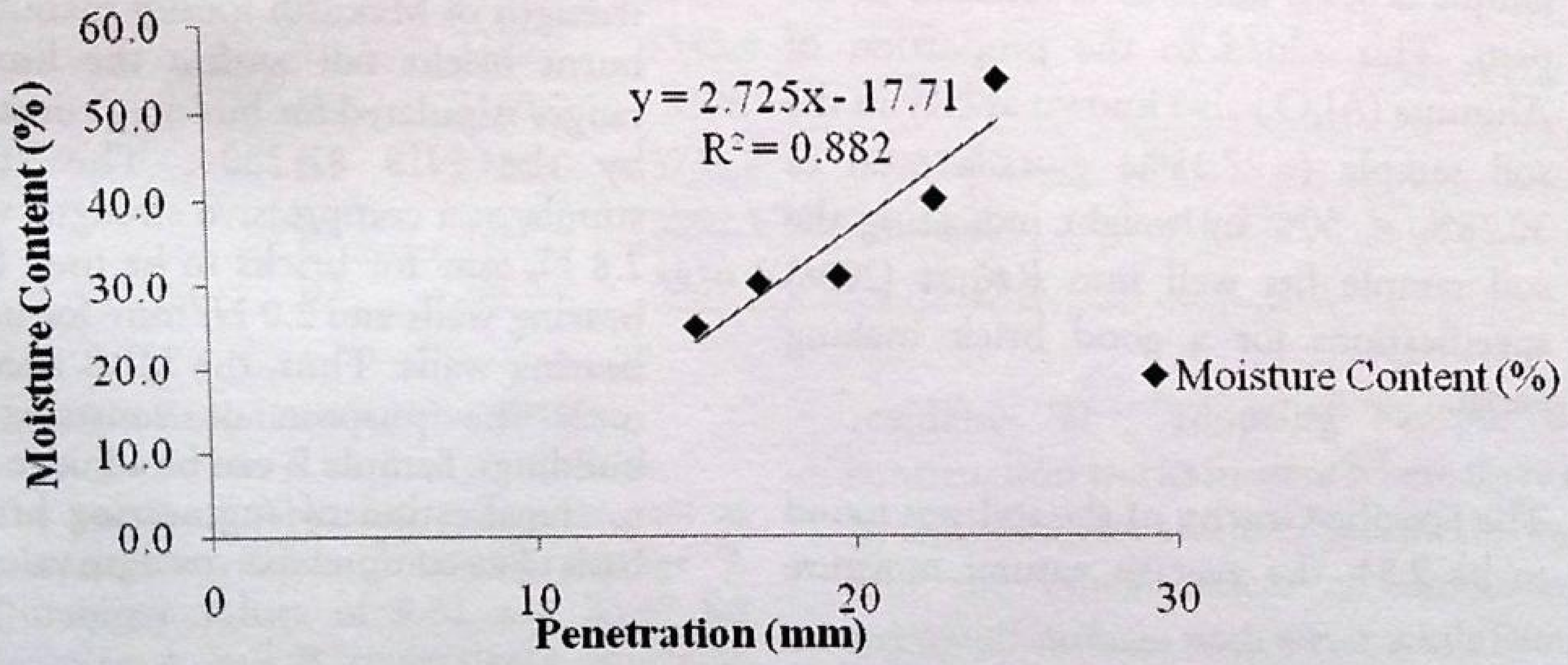

Fig. 1: Liquid Limit of Laterite Sample Used

Table 4 presents result of the sieve analysis of the Laterite sample.

Table 4: Sieve Analysis on Soil Sample

Sieve Sizes	Weight of sieve (g)	Weight of sieve + sample retained (g)	Weight of sample retained (g)	% retained	% Passing	Cumulative retained
5.00mm	478.6	507.2	28.60	5.72	5.72	94.28
3.35 mm	468.9	499.7	30.80	6.16	11.88	88.12
2.00mm	423.4	493.0	69.60	13.92	25.80	74.20
1.18mm	387.9	481.0	93.10	18.62	44.42	55.58
850 µm	356.3	415.6	59.30	11.86	56.28	43.72
600 µm	468.6	531.5	62.90	12.58	68.86	31.14
425 µm	436.2	476.0	39.80	7.96	76.82	23.18
300 µm	314.2	351.6	37.40	7.48	84.30	15.70
150 µm	421.1	459.6	38.50	7.70	92.00	8.00
75 µm	405.3	428.3	23.00	4.60	96.60	3.40
PAN	272.2	289.3	17.00	3.40	100.00	0.00
Total			500			

A summary of the grading curves gives $D_{60} = 1.22$, $D_{30} = 0.59$, $D_{10} = 0.20$ and hence Coefficient of Uniformity (Cu) = D_{60}/D_{10} = 1.22/0.20 = **6.16**; Coefficient of covalence (Cc) = $D_{30}^2/D_{60} \times D_{10}$ = $0.59^2/1.22 \times 0.20$ = **1.52**. These show that the laterite sample is well graded.

A close look at Table 4 reveals the proportion of the soil sample passing 75 μm sieve representing silt particles in the soil sample is 3.4% (same as % retained in the pan). This added to the proportion of Alumina (Al_2O_3) also known as clay in the soil sample (=27.38%) gives a total of 30.78% < 50% by weight indicating the soil sample fits well into Rajput (2006) specifications for a good brick making earth.

The Specific Gravity of the soil was found to be 2.54, the average natural moisture content was 16.54 and the Fineness Modulus value of 2.79, indicating medium fine grading.

Compressive Strength of MBB

The result of the compressive strength test carried out on the MBB is as presented in Table 5 revealing average compressive strength values of 3.46 N/mm² for Sample A and 11.74 N/mm² for Sample B. Sample B was noted to be very strong and harder than Sample A. Implying the compressive strength of Makurdi locally manufactured burnt bricks fall within the limits and ranges stipulated for building construction by the NIS 87:2004. The standard stipulates a compressive strength value of 2.8 N/mm² for bricks to be used for load bearing walls and 2.0 N/mm² for non-load bearing walls. Thus, the MBB adequately meet the purpose of construction of buildings. Sample B can be adjudged to fit to classification of engineering bricks on basis of its compressive strength value.

Table 5: Compressive Strength Test of MBB

Sample No	Weight (Kg)	Crushing load (N)	Area (mm)	Compressive Strength (N/mm²)	Average Compressive (N/mm2)
A1	3.81	10700	2970	3.60	
A2	3.83	10400	2970	3.50	
A3	3.75	10200	2970	3.43	3.46
A4	3.68	9500	2970	3.20	
A5	3.70	10600	2970	3.57	
B1	4.27	34155	2970	11.50	
B2	4.21	31200	2970	10.51	
B3	4.16	35640	2970	12.00	11.74
B4	3.97	37700	2970	12.69	
B5	4.23	35700	2970	12.02	

Water Absorption Characteristics of the MBB

Table 6 presents the result of the water absorption test carried out on MBB. It reveals an average value of 8.58% for Sample A and 16.49% for Sample B both falling within the limit of 20% by weight specified by Rajput (2006) for building bricks. It was however noted that Sample B absorbed twice the quantity of water absorbed by Sample A; this could be the result of the over-heating. The samples however do not dissolve nor melt in water.

Table 6: Water Absorption Test

Sample No	Initial Wt. of Specimen w_1 (g)	Final Weight of Specimen w_2 (g)	% Water Absorption $=\frac{(W_2 - W_1)100}{W_1}$	Av. %Water Absorption
A1	3480.0	3810.6	9.50	
A2	3275.2	3545.4	8.25	8.58
A3	3145.0	3396	7.98	
B1	3250.0	3753.8	15.50	
B2	3300.0	3852.1	16.73	16.49
B3	3275.0	3839.6	17.24	

Abrasion Resistance of the MBB

The result of Abrasion resistance test as presented in Table 7 reveals average % Durability values of **9.32** and **33.67** for Samples A and B respectively, implying Sample B is about four times as durable against wear effect and abrasive attack as Sample A. This confirms the choice of the residents of adopting Sample B for construction works in areas where there could be tendencies for erosion effect on the walls by rain and other sources of contact of the brickwall surfaces with water while Sample A is limited to only wall construction in buildings.

Table 7: Abrasion Resistance Test of MBB

Sample	Initial Wt. of Specimen w_1 (g)	Wt. after 500 Revolutions w_3 (g)	% Durability $D=100-\frac{(w_1-w_3)100}{w_1}$	Av. Dur...
A1	3250.0	334.5	10.29	
A2	3300.0	260.3	7.89	
A3	3275.0	320.5	9.79	9.3...
B1	3480.0	1369.8	39.36	
B2	3275.2	1123.2	34.29	
B3	3145.0	860.1	27.35	33.6...

CONCLUSION AND RECOMMENDATION

The results affirm that soil sample used for production of Makurdi local burnt brick is a true laterite having a Silica Sesquioxide ratio of 1.01, Silica content of 42.95 and clay content of 27.38 and total clay + silt content of 30.78 and is therefore suitable for the production of burnt bricks. The two brick samples has average compressive strength values (Sample A, 3.46 N/mm2 and Sample B, 11.75 N/mm2) meeting NIS 87:2004 stipulation of 2.8 N/mm^2 for bricks to be used for load bearing walls and 2.0 N/mm^2 for non-load bearing walls. Sample B could even be adopted for use as engineering brick on the basis of compressive strength. The two Sample types were found adequate for building construction on basis the of water absorption and abrasion resistance properties.

The general acceptability of the MBB in Makurdi can be linked to the observed usage of the bricks for public buildings by the State Government and other corporate organizations in the State. Government at the three tiers in Nigeria should emulate this practice as noticed in Makurdi, Benue State and encourage the patronage of alternative building materials emanating from various research works in our Universities and other Instit... learning in Nigeria. Further s... MBB targeted at developing impr... kiln for better and proper burni... bricks is highly necessary, while ... of lateritic soil for local brick... should be controlled by th... Authorities to avert eros... environmental degradation... indiscriminate excavations.

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