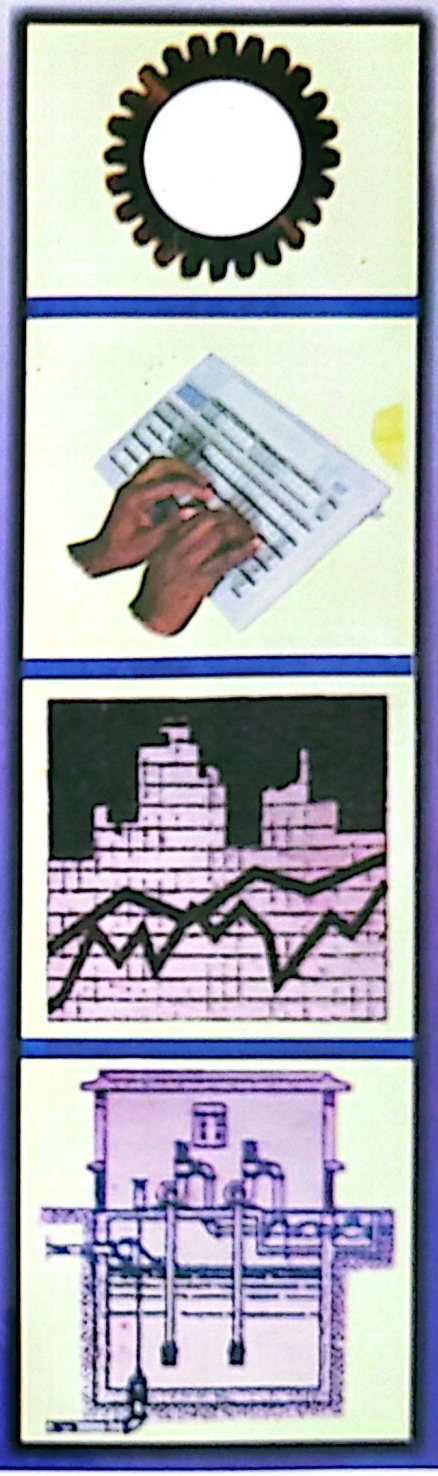
FUTA JEET

Vol. 6 No 2 December, 2010

ISSN: 1598-0271

INTERNATIONAL Journal

OF ENGINEERING AND ENGINEERING TECHNOLOGY



FUTA JEET

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY
The Federal University of Technology, Akure, Nigeria.

CamScanner

Investigation of Some Physical and Strength Properties of Clay and Weathered Bedrock for Production of Hydra Form Bricks

S. O. Abdulrahaman, B.M. Olaleye and M. A. Saliu
Department of Mining Engineering, Federal University of Technology, Akure, Nigeria.

Abstract: *Clay and weathered bedrock samples at Ilorin, Kwara State, Nigeria have been investigated; as alternative earth materials for the production of hydraform bricks. Varying mixes of clay and weathered bedrock samples were evaluated and their physical and chemical properties determined. The compressive strength of the bricks made from different mixes were determined using Hydraform Block Tester. The result of the investigation showed that a 50:50 mix ratio of clay and weathered bedrock samples gave hydraform bricks of highest strength averaging 4.4 MPa which makes it better and stronger hydraform blocks than the ones produced from laterite which is 2.90 MPa. The mix ratio also has a medium absorption rate of 6.25% which falls within ASTM standard and which is quite adequate for construction works applications.*

Keywords: Clay, bedrock, physical strength, properties, bricks

1.0 Introduction

In many countries, it has become imperative to source for locally manufactured building materials because there is an imbalance between the demands for housing and expensive conventional building materials. To address this situation, attention has been focused on low-cost alternative building materials. In Ilorin, Nigeria, conventional sandcrete blocks and fired clay bricks have being the most common building materials. Their high cost coupled with their low strength properties necessitated the search for an alternative, which is hydraform bricks made from lateritic materials. The hydraform brick industry is an extractive industry relying on natural resources for its raw materials. The location of hydraform brick factories has allowed the industry to provide long-term, stable employment to small neighbourhoods and communities; as well as diverse range of natural resources for the enhancement of latest innovations in building systems.

It has been discovered that bricks made from laterite materials have defects and fall short of strength parameters thereby losing its credence in the construction industry, (Adeleye and Ottan. 2007). Hence, the need to explore for other earth materials suitable for the production of hydraform bricks. According to Van-Amsterdam (2008), the development of new manufacturing techniques maintains clay brick and tile as competitive building materials that have good quality, long live and minimal maintenance requirements. Therefore, in this work, the physical properties and mineralogical composition of the Ilorin clay and weathered bedrock samples were evaluated and appropriate mix was formulated for the production of hydraform bricks. The strength parameters of the various hydraform bricks were determined for engineering application.

2.0 Clay and weathered bedrock

Clays are distinguished from other fine-grained soils by various differences in composition. Geologists and Soil Scientists usually consider the separation to occur at a particle size of 2μm

CamScanner

(clays being finer than silts), while sedimentologists often use 4–5μm, and colloid chemists use 1μm (Guggenheim and Martin, 1995). Geotechnical Engineers distinguish between silts and clays based on the plasticity properties of the soil, as measured by the soils' Atterberg Limits, (Guggenheim and Martin, 1995). ISO 14688 grades clay particles as being smaller than 0.063mm, and silts larger. Clay is one of the oldest building materials known to man and its extraction has been tailored to suit the prevailing demands, (Patterson and Murray, 1983). Today, it is possible to produce both conventional and innovative products that will keep demand levels high. The development of new manufacturing techniques maintains clay brick and tile as competitive building materials that have good quality, long life and minimal maintenance requirements, (Van-Amsterdam, 2008).

The quality of the end product of brick works and its characteristics are determined by the raw materials, (Jones and Berard, 1972). The extraction of clay is in most cases directly connected to the production process. Little waste occurs because extraction is only economical where the stripping ratio is low. In some locations, extraction of clay may not be a continuous process, so the immediate impact and rate of change may not be pronounced. Compared to other industrial minerals, volumes and rates of extraction of clay are very low, (Virta, 1992). Clay brick and tile manufacturing plants are frequently situated close to clay deposits and sand quarries thereby minimizing the energy expended in transporting material to the factory. Also, the volume of raw materials required can be accurately assessed so that, there is little risk of waste and prudent use of resources is ensured.

Bricks are probably the oldest industrialized building material. The earliest bricks were made from clay, taken from sources close to the surface of the ground or from river banks and moulded into shape by hand and dried in the sun. People from the Bronze Age realized that by firing (to set fire to the clay or to burn the 12mm size. The Weathered Bedrock under Ilorin Clays generally occur directly below the clays and their associated coarse detrital grains. brick - shaped clay) of the brick results in greater permanence and hardness.

Clay bricks were traditionally made locally and not transported very far so that they had widely differing characteristics depending on the material available and the way the bricks were treated by the maker. In the 19th century, a process was developed for making bricks from sand and lime by subjecting them to high pressure steam to bind the materials together by the formation of calcium silicate, (Jones and Berard, 1972). Today, bricks are also made from concrete. Concrete bricks are made using the normal materials associated with mortar i.e sand, fine aggregate and cement to which colouring agents may be added.

Lithologic characters of the Ilorin clays show dominant clay colours of various shades of grey and brown with mottled appearance very common. The colours include yellowish grey, dark yellowish-brown, pale yellowish brown and moderate brown along with dark grey and black. There is often colour 'Layering' in the field: a top greyish clay with various percentages of reddish brown stains followed by a more homogenous gray, yellowish grey. This sub-unit is often the most plastic, but it is sometimes absent in some sections, (Adeleye, 1992). It is more prominent in a large part of the Sobi area than the Oloje area in Ilorin, Nigeria, (Fig. 1). The basal part which is dominant, is darker coloured and displays various shades of brown and yellow including dark brown, moderate brown, dark yellowish brown, pale yellowish brown. It is only in a few localized sections that light grey clays occur below the darker clays, in the Oloje area, (Adeleye and Ottan, 2007).

The clays are characteristically massive to the naked eyes. There are isolated cases of 'Pseudo-bedding' which are products of localized concentrations of dead rootlets. The false beddings often have up to 30° dip. Coarse clastic elements are common feature of the entire clays. The elements include various sizes of fresh, and ferruginied weathered rock fragments of sand to pebble sizes rarely up to They are often gradational into the overlying clays in terms of clay contents (materials less than 2 microns in size). Texturally, however, the

CamScanner

top clayed parts of the weathered bedrock often contain ghost appearances of medium to porphyritic granites from which they were derived. This feature is accentuated by various subtle shades of grey, yellow and brown colours of this sub-unit, (Adeleye,1992).

3.0 Materials and methods

A bulldozer (CAT D6) and wheel loader were employed to excavate part of the clay and weathered bedrock deposit from two different locations in Ilorin, Nigeria (Sobi and Oloje) as shown in Figure 1, for the collection of bulk samples. Representative samples were drawn from the bulk samples using coning and quartering method, and are subjected to physical and chemical analyses.

3.1 Consistency test

Fourteen samples of clay and corresponding weathered bedrock were analysed in accordance with American Standard Test Methods (ASTM D4318-10) to determine the consistency limits of the samples. The results of the tests are presented in Table 1. J3A, J5A, J6A, J9A, F2A, F3A and F5A are the clay samples from different boreholes in the locations while J3B, J5B, J6B, J9B, F2B, F3B and F5B are the corresponding weathered bedrock samples from the boreholes.

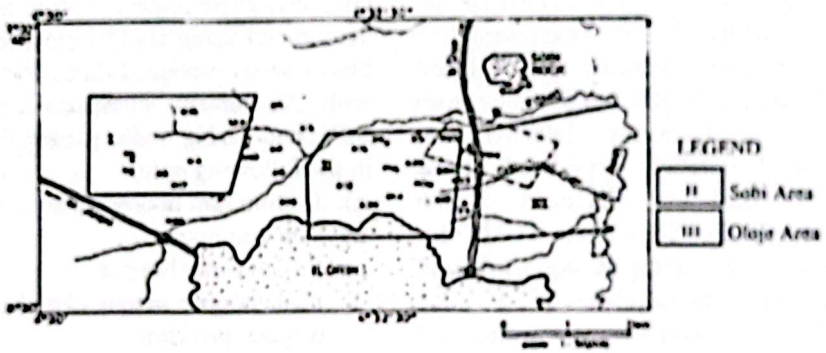


Fig. 1: Map of the main clay deposit areas of Ilorin, Nigeria

Table 1: Physical analysis of clays and weathered bedrock from the study areas

Sample No	% P.L	% L.L	% P.I	Natural colour
J3A	14.79	37.20	22.41	Yellowish Gray
J3B	24.2	118.00	93.74	Dark Yellowish Brown
J5A	21.51	93.60	72.09	Moderate Brown
J5B	22.9	60.00	37.06	Yellowish Gray
J6A	16.97	60.00	43.03	Dark Yellowish Brown
J6B	22.1	72.40	50.28	Pale Yellowish Brown
J9A	14.43	43.20	28.77	Dark Yellowish Brown
J9B	16.96	50.00	33.04	Yellowish Gray
F2A	22.0	106.80	84.78	Pale yellowish Brown
F2B	17.74	82.60	63.86	Pale yellowish Brown
F3A	27.31	141.60	114.29	Pale yellowish Brown
F3B	20.83	72.00	51.17	Yellowish Gray
F5A	20.2	88.00	67.79	Pale yellowish Brown
F5B	20.71	85.20	64.49	Yellowish Gray

P. L. = Plastic limit, L. L. = Liquid limit, P. I. = Plastic index

It is significant to note that mixing of clays and weathered bedrock units often produce different colours in the natural states. Irrespective of mix ratios, similar raw materials produce more related colours. The appearance of reddish/brownish colour is most probably related to the iron contents of the raw materials.

3.2 Grain size analysis

Grain size analysis was carried out on representative samples of the clays and weathered bedrocks in accordance with the specifications of DIN (1996), BS 1377-10 (1990) and American Association of State Highway and Transportation Officials (AASHTO, 2007). The coarse fractions were wet sieved and the fines were analysed by the hydrometer method. Eleven representative samples were randomly selected and analyzed from the Sobi area, and also ten samples from Oloje area were randomly selected and analyzed. In each borehole considered in the two areas, the real clay fractions in the boreholes (F1-F11 for Sobi Clay; J1-J10 for Oloje Clay) and the corresponding weathered bedrock fractions in the boreholes (F1-F11 for Sobi Clay; J1-J10 for Oloje Clay) were analyzed separately. The results are presented in cumulative curves on semi-log scale as depicted in Figures 2 - 5.

3.3 Mineralogical composition

Silica was gravimetrically determined after digestion with Na_2CO_3, dehydration and filtration at 1000°C. The R_2O_3 group (Al_2O_3, Fe_2O_3, and TiO_2) were determined by colorimetric and titrimetric methods. Calcium and magnesium were determined by Ethylene Diamine Tetra Acetate (EDTA) titrimetic method. Manganese, sodium and potassium values were determined by atomic absorption spectrophotometric method, using standards after digesting in perchloric and hydrochloric acid mixture. Seven samples of clays (A1-A7) and their corresponding weathered bedrocks samples (B1-B7) were respectively analysed from the Sobi area, while eight each were treated from the Oloje area as C1-C8 and D1-D8 respectively, (Tables 2-5).

3.4 Determination of compressive strength

Three basic varying mixes were considered from several locations within the study areas for comparative analysis. They are: 25% clay with 75% weathered bedrock; 50% clay with 50% weathered bedrock; and 75% clay with 25% weathered bedrock. Each pair of corresponding clay and weathered bedrock samples was milled in a roll crusher and the varying mixes obtained by volume using graduated buckets.

For preparation of the bricks, each composite mixes was moulded into hydraform bricks of 230mm x 220mm x 115mm size. The compressive strength of the various bricks was determined using Hydraform Block Tester. The bricks were produced from the varying mixes with 5% cement; compaction pressure of 10 MPa; and curing under plastic sheet for 7 days, in the following order.

a) Bottom ram in down position
b) Top ram open
c) Fill mix into hopper
d) Push hopper across chamber and return to original position
e) Close top ram
f) Move bottom ram upwards to compact the soil-cement mixture
g) Open top ram
h) Move bottom ram upwards until the produced brick is completely out of the chamber
i) Take brick away for curing
j) Move main cylinder downward until the end, (Hydraform Group, 2009).

The cured bricks were tested using Hydraform Block Tester which works with the same principle as the Vega Universal Testing machine (model UTM-3) for compressive strength, with the shortest axis of the bricks aligned parallel to the vertical in the following order:

a) lowering the jack by turning nut anticlockwise and pushing down,
b) turn nut clockwise
c) reset gauge to zero
d) each brick was placed in the tester and

CamScanner

making sure that the brick is properly levelled, touching the top and bottom pad

e) evenly, and then jacked slowly until the brick failed.

f) the maximum gauge reading was recorded and resultant compressive strength was evaluated using formula below, (ISRM, 1989):

$$Compressive\ strength = \frac{F}{A} \ldots\ldots(1)$$

3.5 Water absorption test

The water absorption test was carried out by soaking the various bricks in bath of water for 24hours. The resultant increase in weight of those bricks was taken. Their rates of absorption were then determined using the formula below, (BS 1924-2, 1990 and ASTM, 2010):

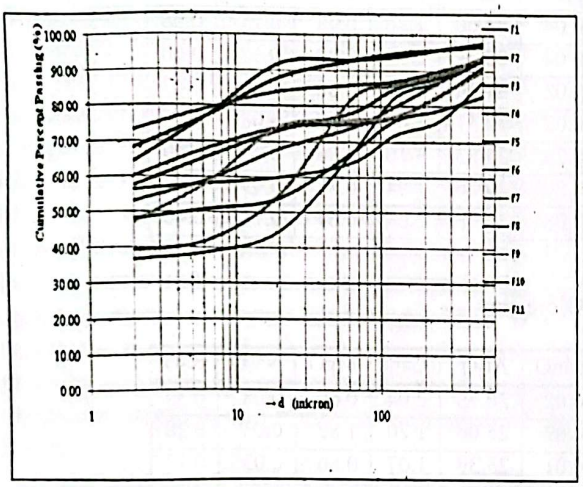


Fig. 2: Cumulative grain size curves of Sobi clay on semi-log

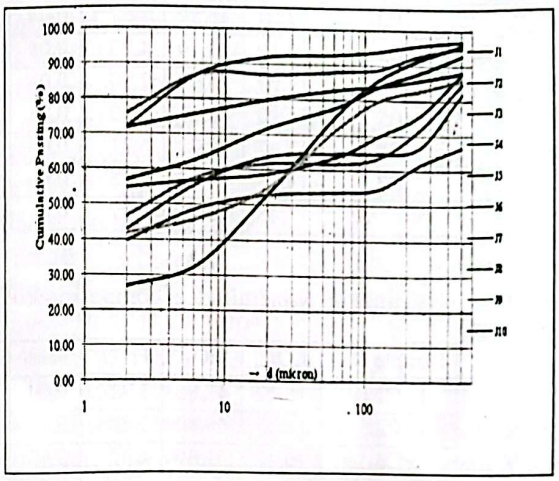


Fig. 4: Cumulative grain size curves of Oloje clay on semi-log

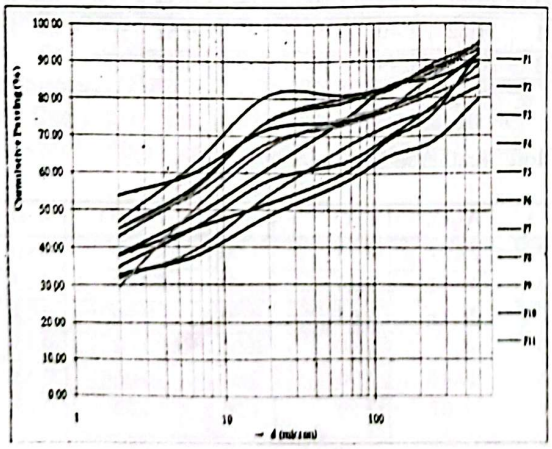


Fig. 3: Cumulative grain size curves of Sobi weathered bedrock on semi-log

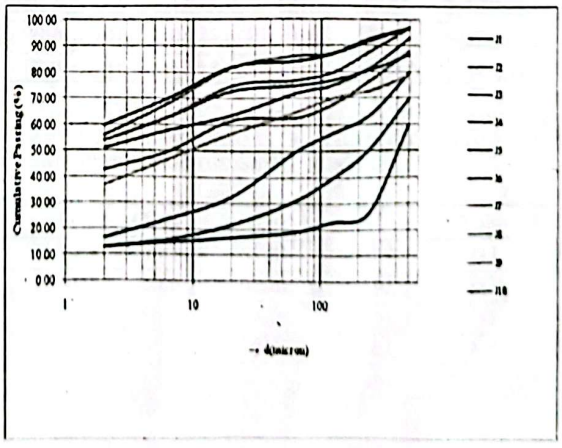


Fig. 5: Cummulative grain size curves of Oloje weathered bedrock on semi-log

CamScanner

Table 2: Mineralogical composition of Sobi clay

Sample No.	LOI	SiO_2	Fe_2O_3	TiO_2	MnO	Al_2O_3	CaO	MgO	Na_2O	K_2O
A1	14.92	48.30	4.42	0.07	0.07	28.98	1.60	1.20	0.09	0.49
A2	15.34	47.50	3.27	0.03	0.03	30.57	1.40	1.40	0.06	0.40
A3	15.83	43.90	5.86	0.04	0.01	32.55	1.10	0.40	0.04	0.30
A4	14.09	49.10	3.80	0.06	0.03	31.84	1.12	0.04	0.07	0.35
A5	14.32	45.96	4.11	0.06	0.02	31.89	1.12	2.20	0.04	0.28
A6	14.92	50.13	5.10	0.03	0.13	26.05	1.96	1.00	0.11	0.56
A7	15.01	50.85	3.50	0.06	0.02	28.56	1.40	0.20	0.08	0.32
Average	14.92	47.96	4.29	0.05	0.04	30.06	1.39	0.92	0.07	0.39

Table 3: Mineralogy composition of Sobi weathered bedrock

Sample No.	LOI	SiO_2	Fe_2O_3	TiO_2	MnO	Al_2O_3	CaO	MgO	Na_2O	K_2O
B1	12.89	47.90	2.90	0.04	0.02	32.51	3.25	0.30	0.20	0.18
B2	13.04	46.30	3.67	0.04	0.04	34.60	1.76	0.03	0.15	0.36
B3	12.19	43.10	4.29	0.05	0.04	36.22	2.52	0.80	0.11	0.60
B4	14.07	45.90	2.90	0.04	0.02	34.50	1.40	0.60	0.04	0.47
B5	14.20	46.81	3.50	0.05	0.02	32.51	1.68	0.08	0.08	0.34
B6	13.42	48.70	6.21	0.09	0.24	25.83	3.16	1.80	0.10	0.49
B7	14.23	48.20	4.35	0.06	0.20	29.76	1.94	0.86	0.09	0.34
Average	13.43	46.70	3.97	0.05	0.08	32.28	2.24	0.64	0.11	0.40

Table 4: Mineralogical composition of Oloje clay

Sample No.	LOI	SiO_2	Fe_2O_3	TiO_2	MnO	Al_2O_3	CaO	MgO	Na_2O	K_2O
C1	15.12	47.80	3.31	0.04	0.02	30.78	2.04	0.60	0.08	0.32
C2	15.45	48.80	7.30	0.11	0.02	25.06	1.20	1.82	0.03	0.28
C3	16.12	51.80	4.43	0.05	0.01	25.39	1.07	0.86	0.03	0.18
C4	14.57	52.32	3.21	0.01	0.02	26.26	1.40	0.80	0.04	1.47
C5	13.62	53.20	4.24	0.09	0.04	25.26	1.40	1.60	0.10	0.49
C6	12.37	59.22	3.72	0.05	0.04	20.92	1.40	2.00	0.08	0.49
C7	13.54	53.41	4.37	0.08	0.05	25.21	1.97	1.20	0.04	0.34
C8	15.29	45.80	5.10	0.09	0.01	31.62	1.40	0.40	0.12	0.32
Average	14.51	51.54	4.46	0.07	0.03	26.31	1.49	1.16	0.07	0.49

Table 5: Mineralogical composition of Oloje weathered bedrock

Sample No.	LOI	SiO_2	Fe_2O_3	TiO_2	MnO	Al_2O_3	CaO	MgO	Na_2O	K_2O
D1	15.78	48.20	1.60	0.02	0.03	28.01	4.53	1.00	0.37	0.90
D2	14.03	45.56	4.61	0.05	0.03	31.52	3.16	0.60	0.18	0.25
D3	16.02	50.10	3.87	0.01	0.02	28.11	1.68	0.60	0.09	0.23
D4	13.90	50.02	3.50	0.02	0.03	30.37	1.40	0.08	0.03	0.13
D5	14.48	46.20	4.21	0.04	0.08	29.41	1.96	3.01	0.06	0.53
D6	10.23	52.70	5.80	0.04	0.06	26.62	2.80	1.20	0.09	0.48
D7	13.52	43.60	4.86	0.04	0.06	33.71	2.60	1.00	0.11	0.48
D8	15.22	44.26	4.55	0.03	0.03	32.77	1.68	1.20	0.04	0.32
Average	14.15	47.58	4.13	0.03	0.04	30.07	2.48	1.09	0.12	0.42

CamScanner

$$Absorp = \frac{\text{Weight of saturated brick} - \text{Weight of dry brick}}{\text{Weight of dry brick}} 100\% \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

3.6 Quality control test

The test procedures suggested by ISRM (1998), ASTM (2010) and DIN (1996) for the determination of compressive strength, absorption rate and particle size distribution of the samples were strictly followed respectively on the various test conducted.

4.0 Results and discussion

The comparative analysis of the mineralogical composition of the clay and the weathered bedrock in the study area are shown in Tables 6 and 7 while Table 8 shows that of 50:50 mix ratio. Figures 6-8 depict the graphical representation of the comparative analysis. From the Figures, it can be seen that silica content (SiO_2) is predominantly high in the samples while the percentage composition of iron content (Fe_2O_3) is minimal. The high and low values of silica and iron contents present in the samples can be used as advantage. This is because, the bricks made from the samples with high silica and low iron contents will yield high compressive strength and minimize corrosion of the bricks .

All the cumulative curves show kinks which are evidence of polymodality, (Velde, 1995). The clays have therefore, not travelled far from their source areas. Out of the eleven clay samples from Sobi Area, four are shown to be silts or siltstones which are sandy and argillaceous (Figure 2). Whereas in the Oloje area, five out of the ten samples are true clays; the other five are sandy to pebbly and argillaceous silts or siltstones (Figure 4). The differences may be as a result of the geological origin of the deposits. The sand fractions (+ 63μ) are more in the Oloje than Sobi area, confirming field observations. The Sobi weathered bedrock samples, apart from one exception which is clay, are best described as silts or siltstones, argillaceous and sandy silt - stones (Figure 3).

The Oloje materials show a much greater scatter in size and are 50% clays stones (50% of size and above are less than 2 microns), 20% siltstones and 30% sands or sandstone (Figure 5). All the samples show polymodality as well because of the kink nature of the curves. The much wider scatter of the sizes of the Oloje 'clay' and weathered bedrock samples, compared with Sobi, suggests that more care has to be taken in the striping of Oloje materials to ensure consistency in the mix for brick works. In general, the weathered bedrocks have higher alumina values than their 'clay' equivalents (Tables 2 - 8). Alumina is also averagely higher in Sobi than Oloje. The range in Sobi is 36.22% - 28.56% whereas; it is 33.71% -20.92% in Oloje. The silica values are also higher in the 'clays' (59.22% - 43.90%) than in the weathered bedrocks (52.78% - 43.10%).

The total Fe_2O_3 values do not help in discriminating between the rock sub-units, in the two areas. The values range mostly between 3% - 5%, with the entire range as 1.6% - 7.3%. Titanium is consistently low (0.01% - 0.11%). Manganese is also low and commonly under 0.1 % except for 3 out of 30 values (0.24 - 0.13%). The other elements are low and yield no patterns for discriminating between the sub-units of the rocks, (Table 8).

From the investigations and analyses carried

Table 6: Comparative analysis of mineralogical composition of clay in the study areas

Location	LOI	SiO_2	Fe_2O_3	TiO_2	MnO	Al_2O_3	CaO	MgO	Na_2O	K_2O
Sobi Clay	14.92	47.96	4.29	0.05	0.04	30.06	1.39	0.92	0.07	0.39
Oloje Clay	14.51	51.54	4.46	0.07	0.03	26.31	1.49	1.16	0.07	0.49

CamScanner

Table 7: Comparative analysis of mineralogical composition of weathered bedrock in the study areas

Location	LOI	SiO_2	Fe_2O_3	TiO_2	MnO	Al_2O_3	CaO	MgO	Na_2O	K_2O
Sobi Bedrock	13.43	46.70	3.97	0.05	0.08	32.28	2.24	0.64	0.11	0.40
Oloje Bedrock	14.15	47.58	4.13	0.03	0.04	30.07	2.48	1.09	0.12	0.42

Table 8: Mineralogical composition of the 50:50 mix ratio

Soil	LOI	SiO_2	Fe_2O_3	TiO_2	MnO	Al_2O_3	CaO	MgO	Na_2O	K_2O
Clay	14.71	49.75	4.38	0.06	0.04	28.19	1.44	1.04	0.07	0.44
Bedrock	13.79	47.14	4.05	0.04	0.06	31.17	2.36	0.86	0.12	0.41
Average	14.25	48.45	4.21	0.05	0.05	29.68	1.90	0.95	0.09	0.42

Table 9: Compressive strength of blocks from the various mixed samples

S/N	Sample No	Compressive Strength (MPa)		
		(A25%, 75%)	(A50%, B50%)	(A75%, B25%)
1.	J3	6.5	6.1	6.0
2.	J5	3.0	4.5	3.0
3.	J6	3.0	3.7	3.3
4.	J9	1.5	1.5	1.5
5.	F2	3.5	5.5	3.7
6.	F3	1.2	5.0	6.0
7.	F5	3.9	4.8	3.8
AVERAGE		3.2	4.4	3.9

Table 10: Absorption of brick materials

Type of Material	Dry weight (gm)	Wet weight (gm)	Absorption (%)	Absorption rate (%)
M1	4.74	5.09	0.35	7.38
M2	4.80	5.10	0.30	6.25
M3	4.84	5.13	0.29	6.03

MI = 25% clay, 75% weathered bedrock
M2 = 50% clay, 50% weathered bedrock
M3 = 75% clay, 25% weathered bedrock

out on the various mixes, the 50:50 mix was found to have highest average compressive strength of 4.4 MPa as against the other two mixes (25% clay with75% weathered bedrock and 75% clay with 25% weathered bedrock) which are 3.23 MPa and 3.90 MPa respectively as shown in Table 9 and Figure 8.

The absorption rate of brick materials made from the different mixes are presented in Table 10. It could be seen that the absorption rate of M1 is the highest while M3 is the lowest. M2 which is 50:50 mix ratio has a medium absorption rate of 6.25% which is quite adequate for construction work application.

CamScanner

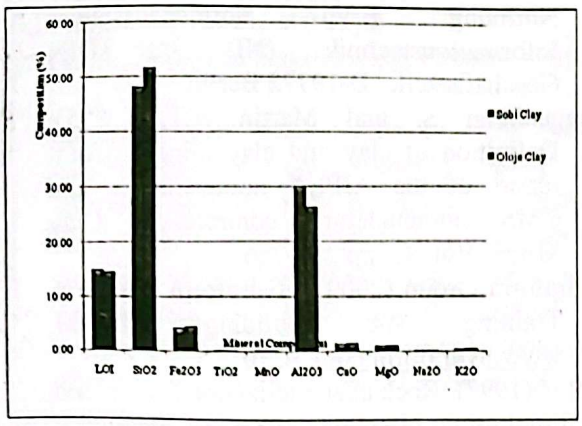


Fig. 6: Comparative analysis of mineralogical composition of clay in the study areas

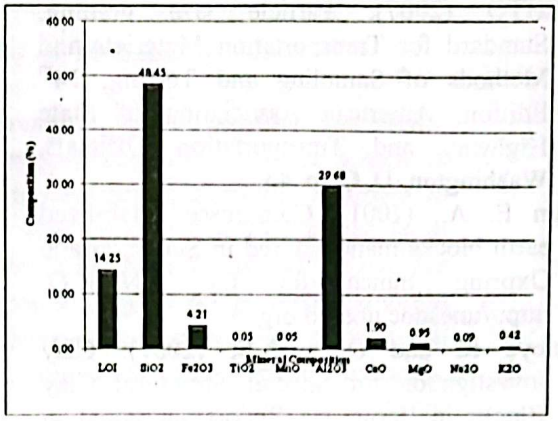


Fig. 8: Mineralogical composition of the chosen mix

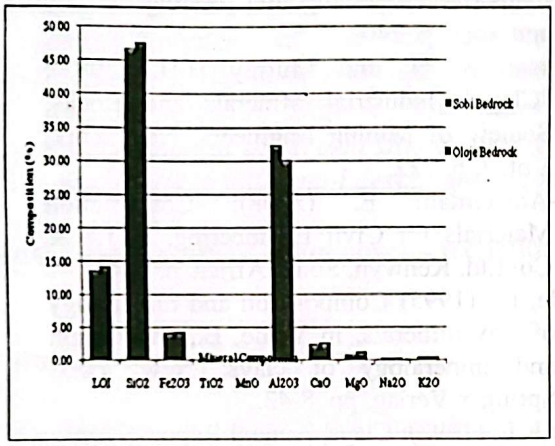


Fig. 7: Comparative analysis of mineralogical composition of weathered bedrock in the study areas

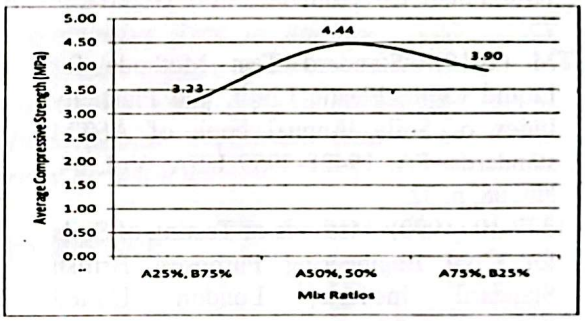


Fig. 9: Compressive strength of the various mixes

5.0 Conclusion

A 50:50 mix ratio of clay and weathered bedrock gave hydraform bricks of relatively high strength (4.4 MPa) and that of laterite, 2.90 MPa. Also, the absorption rate of the bricks made from the 50:50 mix was found to average 6.25% which is adequate for engineering work application as compared to 11.70% for bricks made from laterite, (Adam, 2001). The suitability of clay and weathered bedrock for the production of hydraform bricks further enhance the hydraform building system; which allows an on-site production of interlocking, dry stacking soil-cement bricks; and will favourably compete with conventional building systems because of its substantial cost savings; high speed of construction, excellent thermal properties and do not require skilled labour.

CamScanner

References

AASHTO (2007): Particle size grading, Standard for Transportation Materials and Methods of Sampling and Testing, 14th Edition, American Association of State Highway and Transportation Officials, Washington, D. C., p. 45.

Adam E. A., (2001): Compressed stabilized earth blocks manufactured in Sudan, Graph Oxpring trance for the UNESCO. http://unesdoc.unesco.org.

Adeleye R. and Ottan A.S. (2007): Clay Investigation for Special Structural Clay Blocks in Ilorin, A Report submitted to Delrot Nigeria Ltd, Ilorin, Nigeria, p. 66.

Adeleye R. (1992): Clay Occurrences within 250km of Ilorin, A Report submitted to Kwara State Government, Ilorin, Nigeria, p. 75.

ASTM (2010): Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils, Annual book of ASTM standards, PA, 19428-2959 USA, Vol. 04, No. 08, p. 32.

BS 1377-10 (1990): Methods of Testing of Soils for Civil Engineering Purposes, British Standard Institute, London United Kingdom, p. 32.

BS 1924-2 (1990): Methods of test for stabilized soils. British Standards Institute, London. United Kingdom, p. 88.

DIN (1996): Determination of particle size distribution of soil, Deutsches Institut Fur ton, p. 13.

Normung E.V. Normenausschuss Informationstechnik (NI) im DIN Geschäftsstelle, D-10772 Berlin.

Guggenheim S. and Martin R.T. (1995): Definition of clay and clay mineral. Joint report of the AIPEA nomenclature and CMS nomenclature committees. Clay Miner, Vol. 43, pp 255-256.

Hydraform Group (2009): Hydraform Machine, Training and Building Manual. www.hydraform.com p. 70.

ISRM (1998): Rock characterization testing and monitoring: International Society for Rock Mechanics Commission. Ed. E. T. Brown. Pergamon press, p. 211.

Jones J. T. and Berard, M. F. (1972): Ceramics, Industrial Processing and Testing. Willey and Sons, p. 240.

Patterson S. H. and Murray H.H. (1983): "Clays", Industrial Minerals and Rocks, Society of Mining Engineers, New York, Vol. 3, p. 722.

Van-Amsterdam E. (2008): Construction Materials for Civil Engineering, JUTA & Co. Ltd, Kenwyn, South Africa, p. 184.

Velde, B., (1995) Composition and mineralogy of clay minerals, in Velde, B., ed., Origin and mineralogy of clays: New York, Springer-Verlag, pp. 8-42.

Virta R.L. (1992): Clays, Annual Report (Draft), Bureau of Mines, U. S. Department of the Interior,Washing.

FUTAJEET

An International Journal of Engineering and Engineering Technology

In this issue

Volume 6, Number 2, December 2010

CONTENTS

S.O. Abdulrahaman, B.M.Olaleye and M.A. Saliu.	Investigation of Some Physical and Strength Properties of Clay and Weathered Bedrock for Production of Hydra Form Bricks	1
M.O. Alatise and A.B. Rodiya	State of Water Delivery and Water Poverty Assessment in Nigeria, a Case Sstudy of Ekiti State	11
F.R. Falayi	Appraisal of the Structure and Facilities Available in Selected Pig Farm Houses in Ondo State	19
O.O. Rotowa,	Bed Material Variation Downstream of River Elemi, Ekiti State, Nigeria	24
E.O Ajaka	Analysis and Processing of (Akure) Black Sand for Recovery of Precious Metals	33
T. I. Ogedengbe, R. Heinemann, S. and Hinduja	Development and Performance Evaluation of a Micro Milling Machine	43
C.O. Ijagbemi,	Employing Cassava Waste as Adsorbent for the Removal of Toxic Heavy Metals from Industrial effluents	56
O.J. Olukunle O.C. Ademosun and A.S. Ogunlowo	Performance Evaluation of the Header Unit of an Electric Powered Combine Harvester	64
G. O Adegboyega, M.R.Adu, and A.O. Melodi	Power Losses in Distribution System at Akure, Ondo State.	75
M.A. Saliu, J.M. Akande and J.O. Haleem	Economic Viability of Small Scale Quarrying in Nigeria: a Case Study of Amurin quarry Supare Akoko, Nigeria.	81
O.O. Aluko and Y. M. D Adedeji	Building Collapse in Nigeria: Architects' Perspective.	90
K.K. Alaneme	Influence of Double Step Ageing Temperatures and Soaking Time on the Mechanical Properties of Al – 0.43mg – 0.446si Alloy	97
B. A. Olisa and M. T. Olowokere	Total Organic Carbon (TOC) Calculation Using Geophysical Method: Application to Organic-Rich rocks, Niger Delta Deposits	103
O. Akinola and T.I. Ogedengbe	Development of An Air-Agitated Kerosene Pressure Stove	110
A.O. Owolabi and O.O. Makinde	Traffic Delay Study at Unsignalised Intersections in Akure, Nigeria Using Tanner's Model and Kimber/Hollis Equations	116
C. S. Okoli and G. Fleming	Development of a Two-Dimensional Mathematical Model for the Prediction of Flow Characteristics in a Trapezoidal and Compound Prismatic Channel	124