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PROPERTIES OF CEMENT STABILIZED TERMITE MOUND BUILDING BLOCKS

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ABSTRACT

This study examines the *strength, erosion and water absorption properties of cement stabilized compressed termite mound building blocks. Fifty-four 240mmX110mmX100mm blocks were produced. The blocks were moulded and stabilized with varying percentage of Ordinary Portland cement (OPC), ratio of 0, 2, 4, 6, 8 and 10% respectively. All the blocks were cured for a total of 21days in which the bricks in the first seven days after production were covered with polyethylene bags to allow complete hydration process of the binders and afterwards were uncovered and allowed to dry for another 14 days. The compressive strength of the stabilized termite hill soil blocks ranged from 2.01 to 3.86N/mm^2 and the corresponding densities ranged between 1970kg/m^3 to 1826kg/m^3. The washability of the bocks ranged from high (grade 5) to slightly weak (grade 2) resistance to erosion. The result of this research indicates that the use of OPC below 4% does not satisfy the NIS standard for building blocks. However, encouraging results were obtained from stabilization mix proportion from 4% onwards, having compressive strength of 2.67N/mm^2 at 4% cement and 96% termite mound soil, which conforms to the recommended value of the Nigerian Industrial Standard and it possess a high washability, (grade 4).*

Keywords: building blocks, cement stabilization, compressive strength, termite mounds, water absorption.

1.0 INTRODUCTION

Termite modified soil is a material got from termite mounds, which are widely spread in the tropics including Nigeria. The small mounds are only 30cm or 50cm in height and are built by the *cubitermean species* that feed under the cover of recent leaf falls while the large mounds (less frequent) are built by wood feeders and foreign termites such as *macrotermean specie*. The interior of these mounds presents a maze of irregular chambers and passages and its walls are so resistant that it is difficult to make any impressions on them even with a sharp pick (Davies and Richard, 1987).

The soil from the mound is modified through biological process. The soil particles are cemented together by the termite saliva and excrement resulting in a strong waterproof structure capable of keeping out most of the termites' enemies (see Plate 1). The sand to clay ratio of mound material is that of the subsoil and does not reflect any selection by the termite (Olaoye and Anigbogu, 2000). The ratio of sand to clay content of tall mounds fell between 1:1 and 3:1 (Hesse, 1955). Due to the improved properties termite mound soil possess, its usage in the production of earth bricks was studied to examine its engineering properties in combination with or without a cement stabilizer.

Termite mounds abound in the forest and derived savanna zones of south eastern Nigeria, (Maduakor, 1995) also it is predominantly found in Jebba, Mokwa, Gombe, Bauchi, New bussa. There are two common types of termite mound. The cathedral type (MM) built by termites of *Macrotermes* species, and the umbrella type (CM) built by *Cubitermes* species (Wood 1988; Watson 1976). Mounds formed by *Macrotermes* and *Cubitermes* species of termites are common in the agroecological zones of southeastern Nigeria (see Plate 2 and 3). The densities of these mounds in some locations are high (Kang 1978), occupying a not inconsiderable 'percentage of farmers' fields, and are thus bound to have a significant influence on the surrounding soils. Published results show that MM are built mainly from the subsoil materials of the surrounding soil (Hess 1955; Pomeroy 1983; Watson 1976; Wood 1988; Kang 1978). They are higher in extractable bases, % organic carbon, total phosphorus, and nitrogen than the surrounding top and subsoil (Arshad 1981; Hess 1955; Wood 1988; Pomeroy 1983; Watson 1976, 1979). They contain finer soil particles since finer materials are preferentially selected for their construction (Arshad 1981; Wood 1988). They are less weathered and leached than the surrounding soils but this obtains in inhabited mounds only. Uninhabited mounds weather like any other heap of soil material (Hess 1955).

The erosion of both the inhabited and uninhabited mounds leads to mound materials being deposited on the surrounding soil. These materials modify the soil profile and may lead to changes in the soil physical and chemical properties. Mounds have extensive underground galleries which have significant effects on the porosity and hydrological properties of the soil (Wood 1988; Hess 1955; Watson 1976; Arshad 1981).

This study is very paramount because inspite of the long proven use of earth wall construction in Nigeria, 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 (Easton, 1987). Various materials have been used to stabilize laterite for the sole purpose of making building blocks. The prominent materials are cement, lime, bitumen, burnt brick, corn-corb ash and clay (Olateju, 1991; Adesanya, 2001). The progresses made with each of these materials are well documented in journals and conference papers (Okoli and Zubairu, 2002). But in-spite of the elaborate work done on lateritic soil blocks little has been done or documented record on termite mound soil blocks, which record shows, has cementitious particle and water proof structure which makes it have a better advantage for the production of blocks (Olaoye and Anigbogu, 2000).

Various organizations and individuals have achieved several minimum compressive strength requirements for soil cement blocks; the specified minimum strength for blocks tested at 28 days is $2.5N/mm^2$ (NIS, 1976). It was suggested that generally, most soils, which are well compacted will be strong enough for single storey houses and a minimum strength of $2.76N/mm^2$ would appear to be adequate. Most other recommendations for soil blocks vary from $2.10N/mm^2$ to $3.50N/mm^2$.

2.0 MATERIALS AND METHODS

The soil sample was sourced from Kutigi Village in Niger State, Nigeria. It was checked to ensure that it contains no substances that could impair its binder ability or make it unfit. The termite mount known also as *termitarium* was broken down and crushed manually into grain sizes. Burham Brand cement was used for this research work (BS EN 197: Part 1), Potable water from the municipal water supply was used for this study. The grading of the laterite was carried out using the British Standard sieves. The following sieve sizes 20mm, 9.5mm, 4.75mm, 2.36mm, 1.18mm were used, (BS 812: Part 103). Particles retained on 9.5mm sieve were considered too large and were not used in the study (see Plate 4). The graded samples were combined in given percentages to reduce the presence of excessive clay as shown in Table 1.

Table 1: *The percentage combination of Termite Mound Soil.*

Aggregate Size (mm)	***% Combination***
Less than 20	*10*
Less than 10	*40*
2.36-4.75	*30*
Less than 2.36	*20*

Moulding of the Block

Manual block moulding machine was used (see plate 5), which has the capacity to mould two blocks simultaneously. The dimension of the moulds is 240mmX110mmX100mm. The moulds were normally filled to the brim and again compacted before leveling off. A total of 54 blocks were produced (see Plate 6). A detail of the mix proportions of the blocks are shown in Table 2. Water was added until the mix became mouldable but it was observed that the higher the proportion of cement (OPC), the greater the volume of water needed to make the mix mouldable. The stabilization was done with OPC at 0%, 2%, 4%, 6%, 8% and 10%.

Table 2: *Details of the Termite Mound Blocks*

Sample Mix Proportion (%)	***Nos Of Samples***	***Dry Weight At 21 Days (Kg)***
T 100	*9*	*4.82*
T 98 C2	*9*	*4.84*
T 96 C4	*9*	*4.88*
T 94 C6	*9*	*4.96*
T 92 C8	*9*	*5.13*
T 90 C10	*9*	*5.20*
TOTAL SAMPLE	=	54 Samples

T = % Termite mound soil, C= % OPC

Curing and Testing of Blocks

All the samples were cured under waterproofing material for the first seven days; thereafter the bricks were sun dried for two weeks (14 days), so as to allow complete hydration process of the binders, as also explained by Ola (1976). The termite mound building blocks produced were subsequently tested to failure using the compressive strength crushing machine.

Washability Test

Water was poured on the samples from a height of about 3.0m for 5 minutes by means of a controlled shower tap. They were then rubbed with fingers; the quantity and the ease with which soil particles came off were used to judge the erosion resistance of the blocks (see Plate 7).

Water Absorption

Three (3) bricks, each for each mix ratio were tested. The bricks were allowed to dry in an oven at 110°C to 115°C till they attain a constant weight, which usually take place in 48 hours. They were then allowed to cool at room temperature, which took four (4) hours and weight W_1 was measured, they were then kept in clear water at 27 ± 2°C for 24 hours and then wiped dry with a damp cloth and weight W_2 was measured. The average percentage of water absorbed as percentage of dry weight is shown in Table 2. The values were not greater than the values specified by Varghese (2006).

$$\% \text{ Absorption} = \{(W_2 - W_1)/W_1\} \times 100$$

Three field tests were carried out on the termite mound soil, these are namely; the smell/washing/touch tests to determine the presence of organic matters. The sedimentation test to determine the gravel sand and clay proportions and the Cigar test to verify the consistency of the soil.

The moisture was determined in accordance with British Standard on Methods of Soil for Civil Engineering Purposes for conducting the Atterberg limit tests by the casagrande method to ascertain the Liquid Limit (LL) and the Plastic Limit (PL) and also in the test for the determination of the specific gravity was followed (BS 1377).

3.0 RESULTS AND DISCUSSIONS

The results in Table 3 shows that CU and CC are 8.50 and 1.18 respectively, which describe the soil to be well graded thus, meeting the design requirements since it possesses a balanced particle distribution. Table 3 shows the result of Atterberg limit test performed on the termite mound soil, the average plasticity index is 16.34% and specific gravity is 2.55 which meets the stipulated value by BS and indicates that the soil is good and cohesive (BS 1377).

Table 3: Summary of Physical Properties of Termite Mound Soil.

PARAMETER	*VALUES*
Moisture Content (%)	*12.60*
Coefficient Of Uniformity (CU)	*8.50*
Coefficient Of Curvature (CC)	*1.18*
Specific Gravity	*2.55*

Fineness Modulus (F.M.)	*2.91*
Liquid Limit (LL) %	*26.34*
Plastic Limit (PL) %	*10.10*
Plastic Index (%)	*16.34*
Linear shrinkage (%)	*8.00*
Bulk density (Kg/m^3)	*1375*

The details of mixes, densities, corresponding compressive strength, erosion resistance and the water absorption are presented in Table 4, the higher the cement content in the mix (Termite mound soil), the greater the density, compressive strength and the erosion resistance. While water absorption rate reduces due to the improved plasticity of the termite mound soil by the secretion from the termite as compared to the result of work done on laterite soil (Olaoye and Anigbogu, 2000; Olaoye and Izam, 2004), water absorption of the block after 24 hours immersion in water at room temperature did not exceed 10% by weight. Referring to Table 4, all the replacement in exception of T100%/C0% meets the recommended specification that must not exceed 8 percent (ASTM C 67). The cigar test gives an average broken length of 7.89cm, which falls within the range of 4cm and 8cm limit therefore showing that the termite mound soil is good for producing bricks, it is not organic, as it did not give out a misty smell (UNCSH, 1987). The result of the field test on the soil showed that it is not sticky to touch and therefore has low clay content.

Table 4: *Average Compressive Strength, Erosion Resistance and Water Absorption.*

Sample Mix Ratio (%)	***Density (Kg/m^3)***	***Compressive Strength (N/mm^2)***	***Erosion Resistance (Grade*)***	***Water Absorption (%)***
T 100	*1826*	*1.66*	2	9.7
T 98 C2	*1833*	*2.01*	3	6.0
T 96 C4	*1849*	*2.67*	4	5.8
T 94 C6	*1879*	*3.02*	4	6.6
T 92 C8	*1940*	*3.39*	5	4.6
T 90 C10	*1970*	*3.86*	5	3.0

** Grade 1 – Very weak washability resistance, Grade 2 – Weak washability resistance,*

Grade 3 – Medium washability resistance, Grade 4 – High washability resistance,

Grade 5 – Very high washability resistance. T - % Termite mound soil, C- % OPC

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Table 5 shows the test result on abrasion performed on the bricks. It can be concluded that the bricks are less susceptible to abrasion due to wind and water as compared to lateritic soil in Olaoye and Izam, (2004) study. The more the weight of the bricks the less prone they are to abrasion. However, if the surface is well treated with improved surface finish of cement plaster, it will resist abrasion better. For the water absorption test, it was observed that the bricks did not crumble in water and this may be as a result of cementations and water proofing nature of termite mound soil and cement.

***Table 5:** Abrasion test on the stabilized Termite Mound Brick.*

Sample Mix Ratio (%)	*Weight Before Brushing W_1(g)*	*Weight After Brushing W_2(g)*	*Loss In Weight (g)*	*% Loss In Weight*	*Depth Of Penetration (mm)*
T 100	5242	5237	5	0.10	0.7
T 98 C2	5248	5245	3	0.06	0.45
T 96 C4	5256	5253	3	0.06	0.12
T 94 C6	5373	5371	2	0.04	0.09
T 92 C8	5541	5539	2	0.04	0.05
T 90 C10	5667	5665	2	0.04	0.03

CONCLUSION

The results obtained from the various tests indicate that:

1.The compressive strength of the cement stabilized compressed termite mound building block were at maximum when the blocks were produced with a mix ratio of 90% termite mound soil and 10% ordinary Portland cement. The values obtained were within the limit recommended by the building regulation for the construction of bungalow and low rise building. However, if used in double course works to increase the wall thickness for load bearing walls, they might be suitable for the construction of upper floors of storey buildings.

2. The cement stabilized compressed termite mound building blocks have good resistance to water absorption except when the termite mound is not stabilized with Portland cement, then it should be protected from direct contact with water.

3. Other characteristics of cement stabilized compressed termite mound building blocks such as density, washability/erosion resistance, water absorption and compressive strength were found to be in compliance with standard recommendations and are similar to that of other masonry units. The block can withstand moderate weather conditions in service more so if the faces are plastered to avoid early deterioration.

The highest compressive strength ($3.86 N/mm^2$) was obtained at 10% stabilization while the optimal compressive strength (2.67N/mm^2) was at 4% stabilization with OPC which conforms with the recommended value by the Nigeria Industrial Standard i.e. 2.5N/mm^2. Hence stabilization at 4% (T86%/C4%) is recommended.

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APPENDICES

Plate 1: A termite mound sample

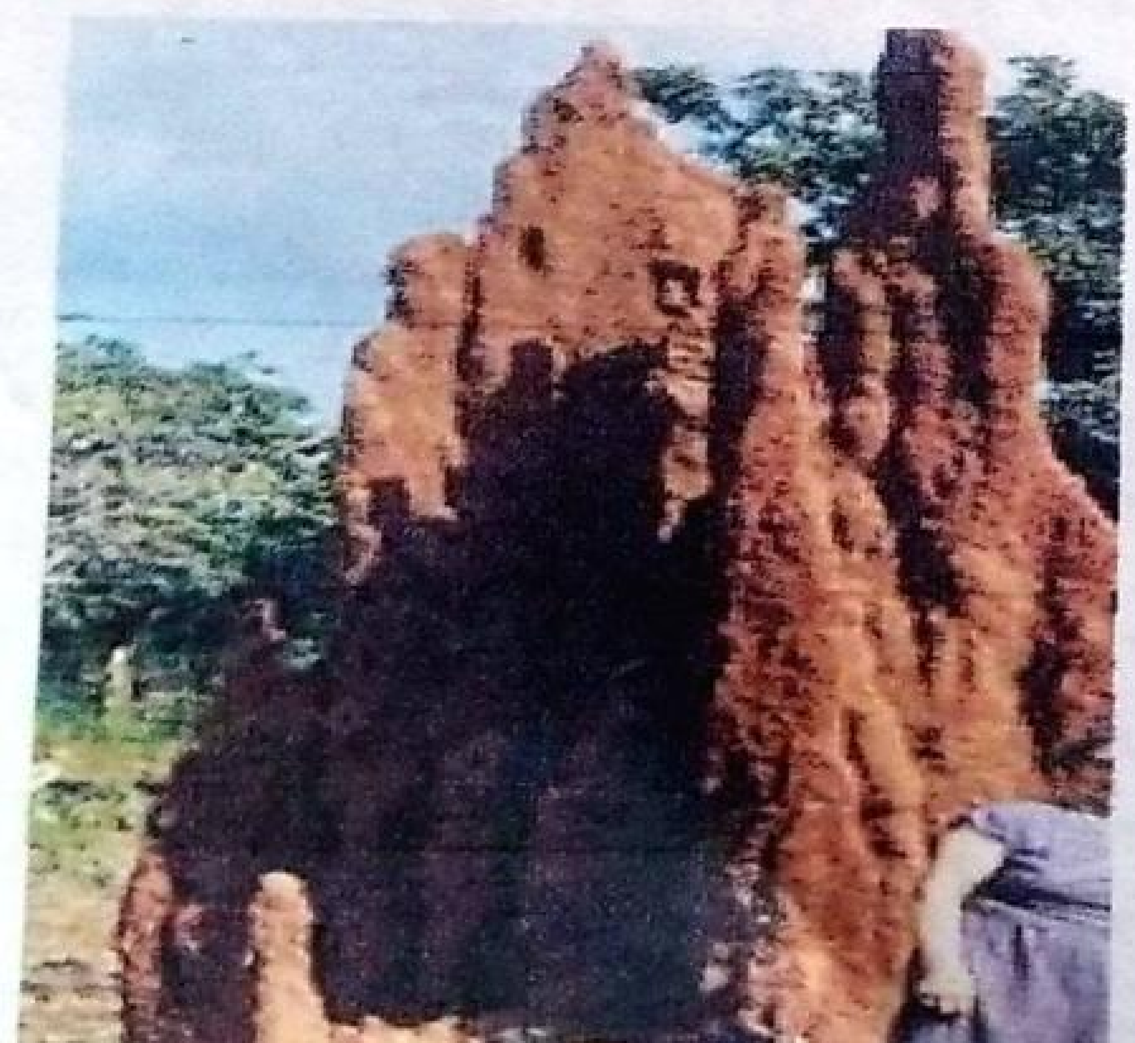

Plate 2: African termite mounds

Plate 3: African termite mounds

Plate 4: Termite mound soil

Plate 5: Manual Brick molding Machine

Plate6:Samples of Termite mound block

Plate 7: Product of Washability Test