



ASSESSMENT OF THE GEOTECHNICAL PROPERTIES OF TERMITE REWORKED SOILS

Olowofoyeku, Adeoye¹, Ofuyatan Olatokunbo², Bamgboye Gideon² and Busari Ayobami²

¹Department of Civil Engineering, Yaba College of Technology, Lagos, Nigeria

²Department of Civil Engineering, Covenant University, Ota, Nigeria

E-Mail: toksofuya@yahoo.com

ABSTRACT

The determination of the geotechnical properties of inhabited termitaria (termite mounds) from three different locations in Lagos, Nigeria was carried out. Soil samples were taken at the cores of termitaria and also at 3m of either side of termitaria. Nine bulk representative soil samples depicting three termitaria soils and six adjacent soil samples were collected. Some geotechnical properties such as specific gravity, grain size distribution, consistency limits, linear shrinkage, CBR, and consolidation of the soils were determined. The chemical properties of the termitaria soil as compared to the adjacent surrounding soil was also analysed. The result showed that the geotechnical properties of termitaria are far better than the adjacent or surrounding soils. The activity of termites was identified as the primary cause of these improvements.

Keywords: geotechnical properties, physical properties, chemical properties, termitaria termites.

1. INTRODUCTION

Termites are an important soil forming factor in many areas, helping in soil turnover and creating small zones of better aerated and more fertile soils by bringing soil material up from underneath to the surface.

Nest construction by termites ranges from inconspicuous belowground chambers to large aboveground mounds, called termitaria. The termitaria are built of soil and earth particles which are cemented together to form hard bricklike material which are very resistant to weathering and erosion as well as very difficult to chip with a sharp pick. (Adeyemi and Salami, 2004).

Termites are of the genus *Macro-termes*, through activity of mound and subterranean gallery construction and soil particle redistribution; alter mineral and organic soil composition, topography, hydrology and drainage, and nutrient flow rates which can ultimately influence vegetation and regional biodiversity (Dangerfield et al. 1998). These modifications of soil properties associated with termitaria, further affects tree establishment and plant species composition and richness which ultimately alter the distribution of other vertebrate and invertebrate animal species (Longair, 2004.)

Kosemani (2010) studied the use of termitaria material as partial replacement for fine aggregate of the concrete mix used in the production of interlocking concrete paver. Results from this research showed that compressive strength of the interlocking concrete pavers increased with age and decreased with increasing replacement of fine aggregate with termitaria material. (Olusola et al, 2006) also carried out studies on termite hill and lime as partial replacement for cement in plastering. Test results showed that the compressive strength of the mortar cubes increases with age and decreases with increasing percentage replacement of cement with lime and termite hill.

The soil associated with termitaria typically has lower soil bulk density and elevated mineral carbon, nitrogen, phosphorus, magnesium, calcium, and clay

content compared to the surrounding adjacent soils to the termitaria (Sileshi et al, 2010). Ayininuola, 2009, (Abe and Oladapo, 2014) recorded a higher organic carbon content, C/N ratio, Ca, Mg, K and P in termitaria of *Macrotermes* and *Odontotermes* species than the surrounding soils in Nigeria.

Furthermore, due to the fact that termites are bioturbators, they are responsible for the higher levels of the metals in termitaria soil since termites are known to feed on organic matter which could result in elevated levels of elements in termitaria. Konate, et al (1998) discovered that there were elevated levels of the iron and titanium in termitaria soils compared to the surrounding soils in their quest in finding various means of prospecting for these two metals. They therefore concluded that termitaria sampling can be used as preliminary step in mineral prospecting since they provide an indication of the potential of the positive anomaly, and enables a judgment on the scale of the ore metal accumulation.

Generally, soils are been reworked by the activities of termites. The determination of the effect of reworking by termites on the geotechnical properties of the soil and the use of these termitaria as an engineering material is a major objective of this research.

2. MATERIALS AND METHOD

Three termitaria were selected randomly from Ayobo, Festac and Yaba areas of Lagos, Nigeria. Soil samples were collected from the crust of the termitaria at 3 metres on either side of the termitaria as shown in Figure-1 and three soil samples collected at each location. At each termitarium location five sample collection points were established. Each site represented as A, B and C with position 1 referring to the termitaria core while positions 2 and 3 refers to 3 meters left and right of the termitaria respectively. The samples collected from each site were then transported to the soil laboratory for testing. The geotechnical properties tested for were the Sieve analysis, Atterberg Limits (Liquid, Plastic and Shrinkage limits),



shear strength, California bearing ratio, and Specific gravity. A bulk representative chunk of the samples were also taken to the soils chemistry laboratory for testing of

some chemical properties such as: the metallic content, pH, organic carbon (OC), organic matter (OM) etc.



Figure-1. One of the termitaria prior to sampling.

3. RESULTS AND DISCUSSIONS

The particle analysis results showed that all the soil samples were well graded. The large concentration of particles were within the range of 0.075mm to 6.75mm with termitaria having higher concentration of particle size below 0.075mm than the surrounding. This revealed that termitaria have higher clay and silt content than the surrounding soils. Table-3 shows that the cohesion values

and angle of internal friction as well as the specific gravity of termitaria were higher than that of the adjacent surrounding soils. The termites' activity was responsible for higher values of cohesion obtained. This further attested to the fact that termites' activities in their colonies promoted forces of attraction and adhesion among the soil particles of termitaria.

Table-1. Summary of result of consistency test and shrinkage limit.

Site ID	Plastic limit (PL)	Liquid limit (LL)	Plasticity index (PI)= LL-PL	Shrinkage limit (SL)
A1	16.67	39.00	22.33	11.0
A2	17.07	30.00	12.93	15.2
A3	13.33	28.00	14.67	11.3
B1	2.94	17.00	14.06	5.6
B2	5.88	29.00	23.12	5.7
B3	16.46	44.00	27.54	14.5
C1	20.99	49.00	28.01	19.2
C2	12.96	34.00	21.04	11.5
C3	9.86	36.00	26.14	9.8

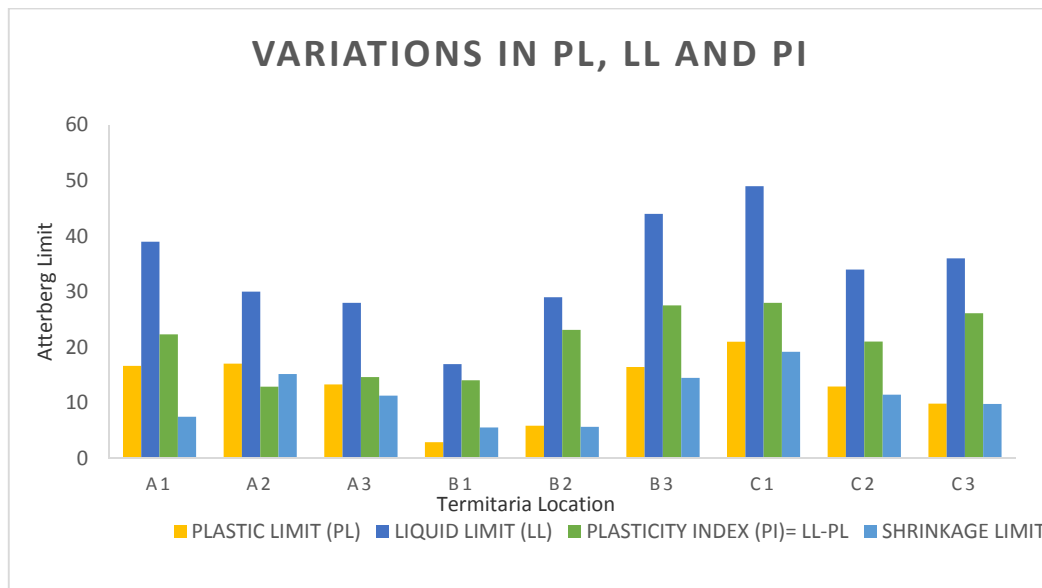


Figure-2. Variations in PL, LL, PI and SL.

As shown in Figure-3 the liquid limit of termitaria A1 and C1 were higher than that of the adjacent soil. The liquid limit of termitaria B1 is however lower than that of the adjacent surrounding soil. This phenomenon was also reflected in the plasticity index. The plasticity index is a measure of the plasticity of the soil. A soil with a high PI tend to be clay, those with a lower PI

tend to be silt, and those with a PI of 0 (non-plastic) tend to have little or no silt or clay. Termitaria A and C are therefore classified as having Medium plasticity while termitaria B has Low Plasticity. The low plasticity of termitaria B can be attributed to the high presence of straws used in the construction of the mound by the termites.

Table-2. Chemical properties of samples.

Termitaria location	pH	OC %	OM %	NO ₃ *	Mg *	Fe *	Ca *	K *	Si *	Al *
A1	7.2	0.26	0.35	0.012	1.38	1.40	0.41	0.45	0.13	0.52
A2	7.3	0.25	0.31	0.017	1.27	1.38	0.42	0.46	0.12	0.58
A3	7.5	0.23	0.38	0.019	1.32	1.40	0.40	0.44	0.13	0.57
B1	7.4	0.58	0.62	0.020	1.24	1.41	0.41	0.48	0.14	0.60
B2	7.2	0.50	0.46	0.032	1.30	1.42	0.36	0.50	0.13	0.62
B3	7.4	0.52	0.55	0.040	1.26	1.44	0.38	0.54	0.12	0.60
C1	6.8	0.50	0.50	0.042	1.28	1.46	0.44	0.58	0.13	0.62
C2	6.5	0.43	0.52	0.041	1.24	1.43	0.42	0.62	0.13	0.61
C3	6.4	0.48	0.54	0.046	1.28	1.44	0.38	0.60	0.14	0.58

The chemical test results shown in Table 2 indicate that the pH of the sites A and B are acidic though tending towards neutral. The pH of site C is however alkaline. There is variation in the value of organic carbon and organic matter in all locations. Site B

has the highest content of both organic carbon and organic matter with site A having the least value. The presence of metals also varied. The value of iron was highest in all locations closely followed by Magnesium with Si having the lowest content.

**Table-3.** Results for cohesion (C), angle of friction (Φ) and specific gravity of samples.

Shear strength			Specific gravity	Coeff. of permeability $\times 10^{-4}$ mm/s
Site ID	C	Φ		
A1	58	25	2.50	7.74
A2	50	22	2.50	6.73
A3	56	23	2.51	7.25
B1	38	23	2.48	6.27
B2	34	24	2.43	6.81
B3	31	24	2.41	6.52
C1	52	21	2.58	6.85
C2	39	22	2.44	7.36
C3	43	20	2.45	7.52

The specific gravity of soils was closely linked with the mineral/chemical composition of the soil. It shows that the extent of laterization of soil. The mean specific gravity value of the soils is shown in Table-3. From the table, it can be seen that the specific gravity value of site A, B and C is 2.50, 2.48 and 2.58

respectively. This is significantly higher than the values for the adjacent surrounding soils with the values ranging between 2.43 and 2.51. This result indicates that termite reworked soils from all three locations have higher specific gravity than the surrounding soils, thus the termite reworked soils have a higher degree of laterization.

Table-4. CBR values for all site locations.

Location	A1	A2	A3	B1	B2	B3	C1	C2	C3
CBR %	9.25	7.10	6.95	9.16	7.04	7.07	9.25	7.04	7.13

The California bearing ratio test is meant to evaluate the subgrade strength of roads and pavements. The results obtained as shown in Table-4 are used with the empirical curves to determine the thickness of pavement and its component layers.

CBR values ranging from 3 to 7% are considered as a poor to fair consistency. Table-4 shows that the CBR value of the termitaria at locations A1, B1 and C1 with values 9.25, 9.16, and 9.25% respectively are better than the adjacent surrounding soils. The values of the adjacent surrounding soils range from 7.04 to 7.13%.

4. CONCLUSIONS

The study has shown that the geotechnical properties of the termitaria soil is better than that of the adjacent surrounding soil. It is therefore advised that if termitaria are encountered on construction sites, they can be used as earthwork or backfill materials rather than discard them.

REFERENCES

Abe OE, Oladapo SA. 2014. Investigation of the Index Properties of Lateritic Soil Reworked By Termite for Road Construction. *International Journal of Engineering Research and Technology (IJERT)*. 3(4): 1032-1034.

Adeyemi GO, Salami RO. 2004. *Some Geotechnical Properties of Two Termite-reworked Lateritic Soils from Ago-Iwoye, South-Western Nigeria*. Geotechnology. ISBN 133: 35-41.

Ayininuola GM. 2009. *Variability in Geochemical Properties of Termitaria: University of Ibadan Case Study*. *Pacific Journal of Science and Technology*. ISBN: 10(1): 567-572.

BS 1377 *Methods of test for Soils for civil engineering purposes* (England: British Standards Institution, 1998).

Dangerfield JM, McCarthy TS, Flerry WN. 2008. The mound building termite *Macrotermes michaelseni* as an ecosystem engineer. *Jour. Tropic. Ecology*. 14: 507-520.

Konate S, Le Roux X, Tessier D, Leepage M. 1998. Influence of large termitaria on soil characteristics, soil water regime, and tree leaf shedding pattern in a West African savanna. *Plant and Soil*. 206(1): 47-60.

Kosemani KO. 2010. *The use of Termitaria Dunghill in the production of Interlocks*. Final Year Thesis, University of Agriculture, Abeokuta (Unpublished).

Longair RW. 2004. *Tusked Males, Male Dimorphism and Nesting Behaviour in a Sub-Social Afro Tropical Wasp*,



Synagriscornuta, and Weapons and Dimorphism in the Genus (Hymenoptera: vespidae: eumeniae). Journal of the Kansas Entomological Society. 77(4): 528-557. 9.

Olusola EA, Olanipekun O, Ata OT, Olateju. 2006. Studies on Termite Anthill and Lime as Partial Replacement for Cement in Plastering. Building and Environmental. 41(3): 302-306.

Sileshi GW, Arshad MA, Konate S, Nkunika POY. 2010. Termite induced heterogeneity in African savanna vegetation: mechanisms and patterns. Journal of Veg Sci. 21: 923-937.