Assessment of the Geotechnical Properties of Termite Reworked Soils

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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.

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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 below ground chambers to large above ground 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 Macrotermes, 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 spices 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

Figure 2: One of the termitaria prior to sampling

Three termitaria were selected randomly from Ayobo, Festac and Yaba areas of Lagos, Nigeria. Soil samples were collected from the crust of the termitaria as well as 3 metres on either side of the termitaria as shown in Figure 1. This implies that three soil samples were collected at each location. Therefore, at each termitarium location five sample collection points were established. Each site was represented as A, B and C with position 1 referring to the termitaria core while positions 2 and 3 refer to 3 meters left and right of the termitaria respectively. The samples collected from each site was then transported to the soils laboratory for testing. The geotechnical properties tested for include: 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 was 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.

3. Results and Discussion

The particle analysis results showed all the soil samples were well graded. The large concentration of particles was 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 is 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	Container (W1)	Wet + Container (W2)	Dry + Container (W3)	PLASTIC LIMIT (PL)	LIQUID LIMIT (LL)	PLASTICITY INDEX (PI)= LL-PL	SHRINKAGE LIMIT (SL)
A1	23.50	24.90	24.70	16.67	39.00	22.33	11.0
A2	27.20	32.00	31.30	17.07	30.00	12.93	15.2
A3	23.40	31.90	30.90	13.33	28.00	14.67	11.3
B1	16.20	23.20	23.00	2.94	17.00	14.06	5.6
B2	20.00	27.20	26.80	5.88	29.00	23.12	5.7
B3	22.50	31.70	30.40	16.46	44.00	27.54	14.5
C1	22.50	32.30	30.60	20.99	49.00	28.01	19.2
C2	21.80	27.90	27.20	12.96	34.00	21.04	11.5
C3	10.30	18.10	17.40	9.86	36.00	26.14	9.8

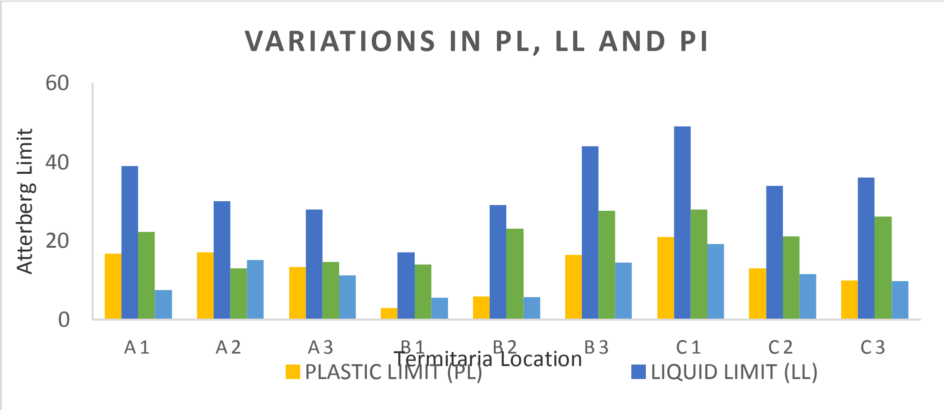

Figure 3: Variations in PL, LL, PI and SL

The liquid limit of termitaria A1 and C1 are 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 %**	**NO3 ***	**Mg ***	**Fe ***	**Ca ***	**K ***	**Si ***	**Al ***
				(cmol / g)						
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 show 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 X 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 is closely linked with mineralogy/chemical composition of the soil. It shows the extent of laterization of soil. The mean specific gravity values 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 for the evaluation of subgrade strength of roads and pavements. The results obtained by these tests are used with the empirical curves to determine the thickness of pavement and its component layers. This is the most widely used method for the design of flexible pavements.

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. Conclusion

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.

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