JOURNAL of CIVIL ENGINEERING
A PUBLICATION OF THE NIGERIAN INSTITUTION OF CIVIL ENGINEERS
...Sustaining the world's infrastructure
(A Division of the Nigerian Society of Engineers)
VOL. 12 NO. 2 ISSN 01897691 JUNE, 2020

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VARIATION OF COMPRESSIBILITY CHARACTERISTICS WITH DEPTH OF RESIDUAL SOILS ON BASEMENT COMPLEX OF CENTRAL NIGERIA

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Abstract:

Disturbed and undisturbed soil samples, collected from six bore holes within the study area were used to evaluate variation of compressibility characteristics with depth of overburden over Basement Complex of central Nigeria. Tests conducted included index properties, mineralogical, shear strength and one dimensional consolidation. Results of the study showed similarity in lithology of the overburden, to residual soils of area underlain by Migmatite–Gneiss Complex in southwestern Nigeria. Mineralogy of the soils generally revealed dominance of kaolinite mineral, with ocassional traces of illite within the profile. The observed trend in variation of shear strength parameters was attributed to the variation in composition of the soils along the depth of the profile. The observed variability in settlement characteristic was generally attributed to variation in characteristics of the tropical residual soils with depth, which must have resulted from the varied extents of decomposition and laterization process, resulting to mechanical heterogeneity of the sequences. Variation of compressive index (c_c) with depth, showed a deviation from the usual assumption that, due to lithostatic load, c_c decreases with depth. It was therefore concluded that the definition of preconsolidation pressure, as in the literature, do not perfectly hold for tropical residual soils.

Keywords: Basement complex, compressibility characteristics, residual soil, shear strength parameters.

1.0 Introduction

Residual soils have been described by Pitts and Kannan [1] as soils that resulted from *in-situ* weathering of rocks and subsequent modifications by pedological processes. Wesley [2] described residual soils as the final products of *in-situ* physical and chemical decomposition of bed rocks, whose original fabrics have been lost. Thick layers of overburden are common in tropical regions because of its warm climate [3]. In most part of Nigeria, residual soils overlie the parent rocks, which could either be from crystalline rocks (from Basement Complex) or from sedimentary origin

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(from Sedimentary Basins). In most parts of Nigeria, these soils are widely employed as construction and foundation materials. According to Adebisi and Adeyemi [4], sub-surface soil investigation of foundation for houses in Nigeria usually receives less attention, because foundation failures rarely occur, as majority of the houses are light structures. In Nigeria, sub-surface conditions at building sites in some cases (especially within Sedimentary Basins) are such that bedrock is far beneath the ground surface, while at other sites (especially within Basement Complex Terrain), it can be close to the ground surface. In either case, residual soils still constitute material on which most of the foundations are sited.

In Nigeria and throughout tropical Africa, residual soils occur in different forms [5]. Although, the commonest residual soil profile in the tropics (Nigeria inclusive) is the lateritic weathering profile, they could also be laterite or non-lateritic soils, consisting of clay-sized particles. Depending on their mineralogical compositions, clay-sized particles are known to pose challenges to civil engineers during and after construction [4]. This is because they exhibit plasticity and compressibility characteristics. Compressibility is the ability of a clay soil to reduce in volume on application of structural load over a period, resulting in settlement. According to Alhaji and Alhassan [6], in geotechnical design of foundation, safety of the structure is ensured based on satisfaction of two conditions: 1. the supporting soil is safe against shear failure due to the imposed loads by the superstructure; 2. the settlement of the foundation is within permissible limit. Evaluation of the magnitude of settlement and rate of settlement of foundations due to structural loads is essential for safety and stability of the structures. In evaluating settlement of foundations on fine grained soils, compressibility characteristics are used. Compressibility characteristics are often described using two indices: compression index (c_c) and coefficient of consolidation (c_v). While c_v is used to predict the time required for a given settlement to take place, the c_c is used for direct computation of magnitude of the settlement. Compression index is described as the slope of the straight-line part of the pressure-void curve on a semi logarithmic plot (virgin curve), which is normally obtained from test results of one-dimensional consolidation [7]. A third and equally important settlement parameter, also usually obtained from one-dimensional consolidation test result, is preconsolidation stress, which is described as the maximum vertical overburden stress that a soil deposit has sustained in the past [8]. Determination of compressibility characteristics of soil deposits is considered as one of the most important requirements in any soil investigation work [9].

Adebisi and Adeyemi [4] stated that the sequence of geological formation and mineralogical composition of parent rocks, to an extent control the compressibility behavior of residually derived soils. Obermeier and Langer [10] established relationship between geological formation and engineering properties of soils and weathered rocks. Pitts and Kannan [1] stated that residual soils are not homogeneous masses but are layered with profound changes in character and properties with depth. Satyanaga and Rahardjo [3] opined that due to the different degrees of weathering within a profile depth, the characteristics of residually derived soils tend to vary with depths. Gustavo *et al.* [11] stated that in-situ soils are usually formed by the varied chemical, physical and biological means which changes the structure and parent minerals of intact or parent rock, and that their characteristics depend majorly on the level of alteration of the bed rock. Vargas [12] and Vaz [13] proposed weathering profile for tropical residual soils, by defining the top-most soil stratum as 'in-situ soil that is more mature' (and call it lateritic soils) and the base stratum as 'in-situ soils that are younger'. According to Vaz [13], the matured residual soil (eluvia soil) usually possesses homogeneity in terms of colour, particle size and mineralogy, with complete lack of texture and structure of the bed rock matrix. The recently formed residual soil, which is also regarded as saprolite, on the other hand, means that section of the decomposed soil profile, where the soil significantly keep its microfabric and the size of the bed rock [14, 15]. Wesley [16] presented criteria adopted in describing soil as saprolite, to include (i) being soils from the geotechnical view point, (ii) exhibiting vivid inherited structural characteristics that allowed for identification of the bedrock material and (iii) being authentically residual (being obtained directly from decomposition of the rock at the base). Most residual soils in Nigeria are lateritic in nature.

Mitchell and Soga [17] and Gidigasu [18] define laterite as those soils having the ratio of silica to alumina to be lower than 1.33, while lateritic soils as those with this ratio falling between 1.33 and 2.00, and when the ratio is more than 2.00, the soils are known as non-lateritic tropically weathered soils. According to Gidigasu and Kuma [19], Adekoya [20], chemical, physico-chemical and geotechnical characteristics (properties) of lateritic (residual) weathering products varies both vertically and horizontally. Alhaji and Alhassan [21] also observed variability of these properties with depth of granitic basement derived lateritic weathering profile. Taking into consideration, the mineralogical composition and geological mode of formation, Adebisi [22] investigated influence of parent rock factor and various probable foundation depths on soil properties, used for design and analysis of foundation, and revealed that parent rock factor has stronger influence on the plasticity and compressibility characteristics of the soils than sampling depth. Sohail *et al.* [23]

studied geotechnical and consolidation characteristics of soils in part of Lahore, Pakistan and found that compressibility characteristics decrease with depth. Study by Carreón-Freyre *et al*. [24] showed that compression index of fine grain lacustrine soil deposit can be vertically variable. Ganesalingam *et al*. [25] observed anisotropy and variation of consolidation characteristics with depth in dredged mud. Adebisi and Adeyemi [4] assessed compressibility characteristics of laterized residual soils in southwestern Nigeria and concluded that mode of geological formation and mineralogical composition of the parent rocks, to an extent control the compressibility behaviour of the soils. Adepoju *et al.* [26] studied compressibility characteristics of remoulded residual soils derived from different crystalline basement rocks underlying Ado-Ekiti metropolis in south-western Nigeria, using one-dimensional loading, and reported spatial variation in compressibility parameters.

Oyediran and Durojaiye [27] studied variability of geotechnical characteristics of some residual soils from southwestern Nigeria, using disturbed samples obtained from two test pits, spaced 30m apart. Subjecting the samples to grain-size distribution, specific gravity, consistency limits, linear shrinkage, compaction and Unconfined Compressive Strength (UCS) tests, they concluded that the soils were generally of high fines contents (between 59.50 and 64.50%), indicating poor engineering properties.

Idehai *et al.* [28] worked on relationship between geotechnical properties of residual soils in Akwa Ibom and Abuja areas of Nigeria, by conducting natural moisture content, consistency limits, free swell, linear shrinkage, particle size analysis, specific gravity, compaction, California Bearing Ratio (CBR), UCS and direct shear tests. Results of their study indicated consistency of natural moisture content with fine contents of the soils, correlation between specific gravity and silica/iron content of the soils, supporting the claims that clay minerals are coated by iron oxide which results in to its cementation and consequently leads to reduction of plasticity characteristics by suppressing the surface activity of clay fraction in soil. The results also indicated that the tested soils were admixtures of fine and granular materials, with their geotechnical properties reflecting combined effects of these fractions and moisture. They therefore, concluded (from shear strength results) that the stress-strain relationship of the studied soils was affected by several factors ranging from soil compositions like mineralogy, grain size and grain size distribution, shape of particles, pore fluid type and content, ions on grain as well as those in the pore fluid. The initial undisturbed state like the initial void ratio, effective normal stress and shear stress/stress history and structure such as arrangement of particles within the soil mass and cementation.

Disturbed and undisturbed weathered residual soil samples used for the study were collected at various depths from six boreholes (BH01 at 8˚49′34.0′′N, 6˚56′52.3′′E, BH02 at 9˚24′14.1′′N, 7˚02′01.1′′E, BH03 at 9˚27′46.2′′N, 7˚02′45.2′′E, BH04 at 9˚34′30.0′′N, 7˚03′38.8′′E, BH05 at 9˚36′44.7′′N, 7˚04′07.4′′E and BH06 at 10˚14′39.6′′N, 7˚6′57.3′′E) (Figure 1). These bore holes were selected from a series of bore holes, based on thickness of the weathered material. Bore holes with approximately the same thickness (10.0m) of overburden soil were selected for used in this study.

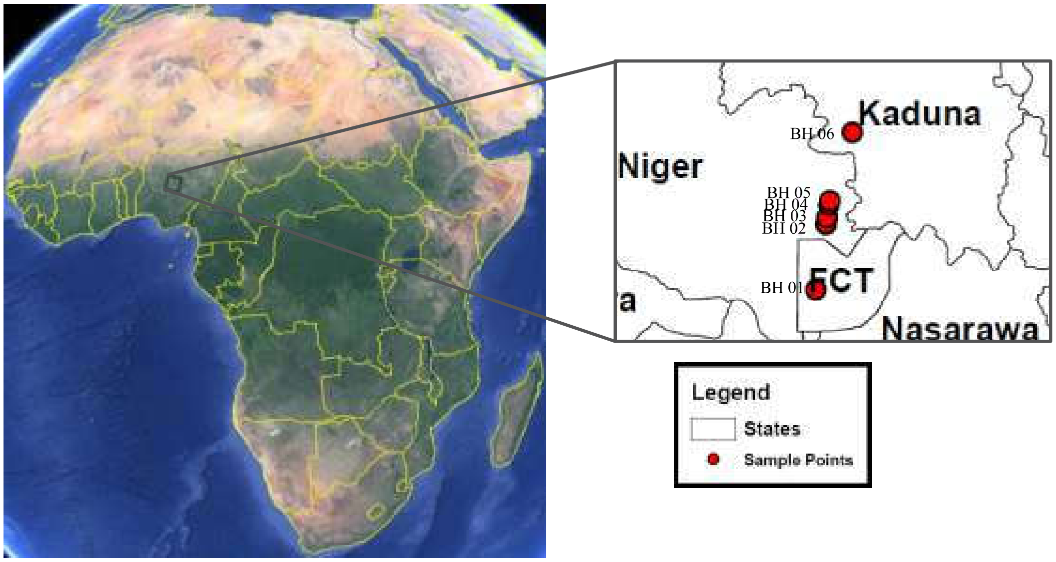


Figure 1: Location of the study area showing samples collection points

3.0 Methodology

Tests carried out on the disturbed soil samples are Natural Moisture Content (NMC) test, particle size distribution test, consistency (Atterberg limits: Liquid Limit-LL and Plastic Linit-PL) test and X-Ray Diffraction (XRD) test, while shear strength parameters (undrained triaxial) and one dimensional consolidation tests were carried using the collected undisturbed soil samples. Samples for shear strength parameters (undrained triaxial) and one-dimensional consolidation tests were selected at depths, where changes in strata were observed. Moisture content, particle size distribution, Atterberg limits, shear strength parameters (undrained triaxial) and one dimensional consolidation tests were carried out in accordance with procedures in the relevant parts of BS 1377 [44]. Moisture content, particle size distribution and consistency tests were carried out in accordance with procedures outlined in BS 1377-2 [45]. Shear strength parameters (undrained triaxial) test was carried out in accordance with procedure outlined in BS 1377-7 [46] using cylindrical soil samples of 38mm diameter and 76mm height, while the one dimensional

Imoukhuede *et al.* [29] evaluated geotechnical properties of residual soils on two different Basement Complex Areas of Nigeria and concluded that the geotechnical properties of the studied soil are dictated by combine effect of their index properties. Mohammed *et al*. [30], using disturbed soil samples collected from a trial pit, dug to a depth of 3 m, at intervals of 0.5m, carried out investigation of index properties of a residual soil profile on Basement Complex of Minna, Niger state, Nigeria. Employing visual inspection, the authors observed that the soil profile consisted of three layers: light reddish at the top, reddish soil at the middle and whitish soil at the bottom respectively, with the soils classifying, using Unified Soil Classification System (USCS), as silty (SM) and clayey sand (SC). They also observed that compaction characteristics of the soil also varied with depth, and therefore concluded that index and other studied properties of the residual soil vary with depth.

Although, lateritic (residual) weathering profile has been categorized into three major horizons [21], this and other residual weathering products in Nigeria are still being consider as uniform with depth. This is because majority of the studies carried out in the past, on geotechnical study of weathering profiles in Nigeria were essentially on their distribution, classification, depth of profiles, nature and formation [31, 32, 33, 34, 35, 36, 37, 38, 39]. Only little has been done concerning the various weathering horizons and variation of their characteristics with depth in Nigeria. More so, study of variation of compressibility characteristics with depth of residual soils within Basement Complex of central Nigeria has not been given much attention in the literature.

2.0 The Study Area and Sampling

The area where this study was carried out is shown on (Figure 1) is located within the Basement Complex of central Nigeria, belonging precisely to Migmatite–Gneiss Complex (also known as Migmatite-Gneiss-Quartzite Complex), having ages ranging from Pan-African to Eburnean [40]. The area consists of crystalline base rocks, which are typical of the Basement Complex of Nigeria. According to Olanrewaju [41] and Rahaman [42], the rock units within the area consist of Migmatized Granite-Gneiss, foliated quartzite, medium-grained biotite-granite, charnockite, porphyritic plagioclase-granite and porphyritic orthoclase-granite. Study by Wright [43] have shown that overburden soil in the study area is precisely underlain by Granite Basement, which is bounded to the north and south by older basement rocks of the Precambrian to upper Cambrian age, and to the north-west by the rocks of Illo-group formation. Several rivers that are tributaries of river Niger drained the area. Rainfall in the area varies considerably from station to station, with maximum per year varying from 1000 to 1500 mm.

consolidation test was carried out in accordance with procedure outlined in BS 1377-5 [47] using soil samples of 50mm diameter and 20mm height. Moisture content, particle size distribution, consistency, shear strength parameters (undrained triaxial) and one dimensional consolidation tests were conducted in the Geotechnical Laboratory of Civil Engineering Department, Federal University of Technology Minna, Nigeria. Vaughan *et al.* [48] stated that although, Atterberg limits are used for classification of residual soils, in the case of tropical (residual) soils, the results may depend on the temperature and drying method. In this work, the drying method adopted by Gustavo *et al.* [10], which was based on recommendations by Fookes [49], was used. For shear strength parameters, the soil specimens were tested at loadings of 50, 100 and 150 kPa and at natural moisture content condition.

X-Ray Diffraction test (XRD) was conducted at Ithemba laboratory, Somerset West 712, South Africa. Phase characterization of the minerals and estimate of the average crystallite size of the various synthesised materials were conducted on a Bruker AXS D8 X-ray Diffractometer system, coupled with Cu-Kα radiation of 40 kV and a current of 40 mA. The λ for Kα was 0.1541 nm, while the scanning rate was 1.5º/min, and was operated at a stepping width of 0.05° over the 2θ range. The powder samples were placed and clipped on the rectangular aluminium sample holder. The diffractograms were recorded in the 2θ range of 20 - 90º and the phase identification was done. The system used a time constant of 0.5s, a scanning step of 0.2º, a scanning angle range of between 20 and 90º and a scanning speed of 60sec/step. The Scherer equation (equation 1) was used to determine the crystal size from half height peak width.

$$d = \frac{k\lambda}{\beta \cos\theta} \qquad (1)$$

4.0 Results and Discussion

4.1 Lithology of the soils

Adopting the method of Carreón-Freyre *et al*. [24], changes in the soil type with depth of the weathering profiles (lithology) are presented in Figure 2. Points marked with yellow circles (●) are depths, where the collected samples were subjected to consolidation and shear strength parameters tests. From the figure, for BH01 (Figure 2-a), brownish clayey sand capped the weathering profile to depth of 2.0m, which is followed by brownish clay soil of low plasticity that spans to 3.0m depth. 2.2m thick greyish clayey sand followed the brownish clay soil of low plasticity. Below the greyish clayey sand was 1.0m thick greyish silty sand, 0.75m thick greyish silty soil of low plasticity and 2.25m thick greyish silty sand that extends to the bedrock.

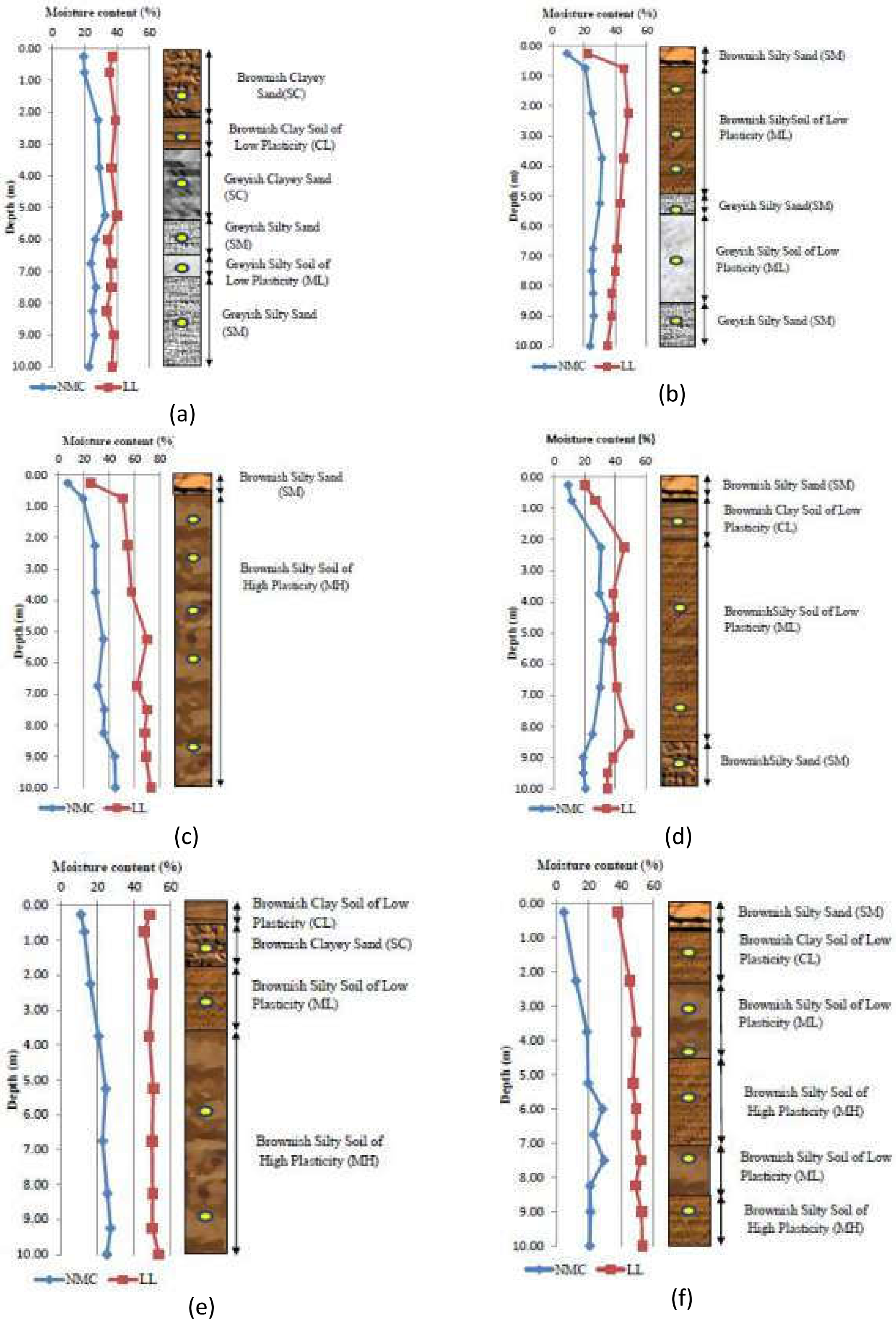
BH02 (Figure 2-b), has 0.5m thick brownish silty sand capping the weathering profile, followed by brownish silty soil of low plasticity, that spans to 5.0m depth. 0.5 m thick greyish silty sand followed the brownish silty soil of low plasticity. Below the greyish silty sand is 3.0m thick grayish silty soil of low plasticity, overlying grayish silty sand that extends to the bedrock.Figure 2-c, which shows variation of the soil type with depth at BH03, has the weathering profile capped with 0.5m thick brownish silty sand, which is underlain by brownish silty soil of high plasticity that extends to the bedrock. Figure 2-d shows variation of the soil type with depth at BH04, with brownish silty sand capping the weathering profile to 0.75m depth, which is followed by 1.25m thick brownish clay soil of low plasticity, which is further underlain by brownish silty soil of low plasticity that spans to 8.5m depth, and the profile terminating with 1.25m thick brownish silty sand to the bedrock.

Figure 2-e presents variation of the soil type with depth at BH05. Brownish clay soil of low plasticity capped the weathering profile to 0.5m depth, which is followed by 1.0m thick brownish clayey sand. The brownish clayey sand is underlain by 1.5m thick brownish silty soil of low plasticity, below, which is 6.5m thick brownish silty soil of high plasticity that terminates to the bedrock. Figure 2-f has variation of soil type with depth at BH06, with brownish silty sand capping the weathering profile to 0.75m depth, and followed by 1.5m thick brownish clay soil of low plasticity, that preceded 2.0m thick brownish silty soil of low plasticity, below which is 2.5m thick brownish silty soil of high plasticity, underlain by another 1.5m thick of brownish silty soil of low plasticity. Below the brownish silty soil of low plasticity is brownish silty soil of high plasticity that terminates to the bedrock.

The studied lithologies (profiles) can generally be considered to consist of fresh bed rock, at the base of the stratum, to highly weathered saprolite or residual soil at the top of the profile [50]. The observed lithology is generally similar to that presented by Adebisi and Adeyemi [4] for area underlain by Migmatite–Gneiss Complex of southwestern Nigeria.

4.2 Mineralogy of the soils

Some selected results of mineralogy of the studied residual soils are presented in Figure 3. At BH 01, soil minerals, found throughout the profile include quartz, kaolinite and muscovite, while at BH 02, quartz, kaolinite, illite and albite where found within the profile. Soil from BH 03 showed presence of quartz and kaolinite, while that from BH 04 indicated quartz, kaolinite, palygorskite, phlogopite, palygorskite and albite as mineral present within the profile. At BH 05, quartz, kaolinite, microcline and Phlogopite were observed as minerals, while soil from BH 06 showed presence of quartz, kaolinite, muscovite, microcline and phlogopite as minerals.



(a) (b)

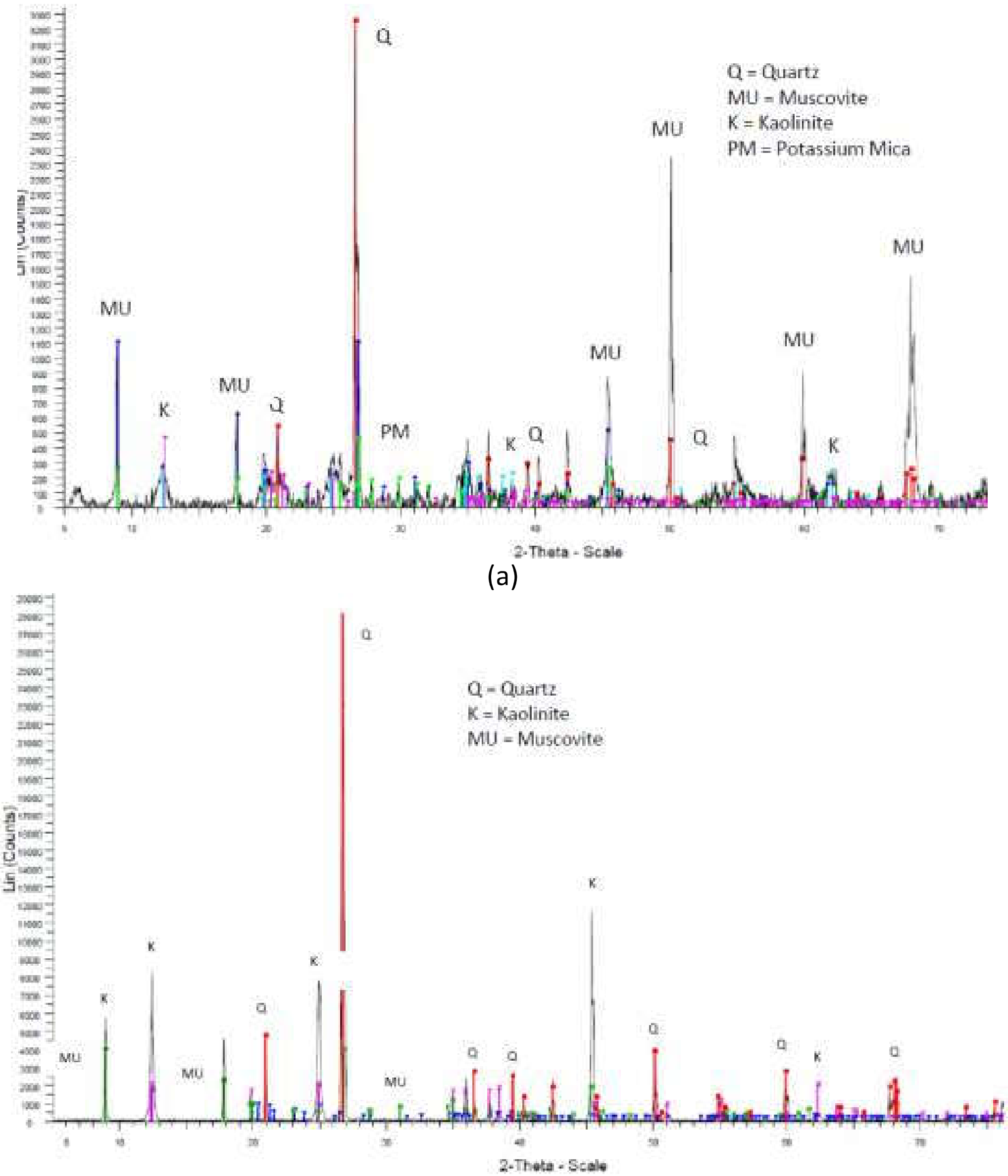
(c) (d)

(e) (f)

***Figure 2**: Lithology of soils at the bore holes: (a) BH01, (b) BH02, (c) BH03, (d) BH04, (e) BH05, (f) BH06*

Results of mineralogical test revealed relative homogeneity of the studied residual soil. Quartz, which is revealed by its normal 3.34 and 4.27 Å peaks usually regarded as one of the most resistant primary minerals (Barton and Karathanasis [50], is present throughout the study soil. According to Dolui *et al*. [51], quartz is stable in its dissolved condition because it is less susceptibile to weathering. Kaolinite, which is identified by 1.489 Å peak (Dolui *et al*. 2014) is observed to be the most noticeable clay mineral in the studied profiles. Kaolinite is the most common mineral in 1:1 clay mineral group, which because the Van der Waals bonds which are usually formed between the basal oxygens of the tetrahedral sheet and the hydroxyl ions of the octahedral sheet [50], makes it possesses low affinity to water. Illite, identified by 10 and 13.7 Å peaks [51] and muscovite, which belong to 2:1 clay minerals group, were also noticed in the profiles. While muscovite is a dioctahedral mica, containing Al^{3+} in the octahedral sheet and K^+ in the interlayer, Illite is mostly linked with the clay-sized micas [52].

As the decomposition of granite rocks goes deeper as typical of the studied area, primary rock forming minerals are significantly changed to secondary minerals, notably, clay minerals by varied modes of chemical weathering such as hydrolysis and hydration [51]. Islam *et al*. [53] have shown that during this process, several other secondary minerals such as illite, gibbsite and smectites are commonly produced to be followed by montmorillonite, kaolinite and halloysite. It has been reported by Banfield and Eggleton [54] that vermiculite minerals, kaolinite and goethite minerals are firstly formed by decomposition of biotite minerals usually associated with granite rocks, while Islam *et al*. [53] showed that in later stage of weathering, K-feldspar can alter into secondary clay minerals such as illite and kaolinite. Some researchers [55, 56, 57, 58, 59] were unanimous that formation of kaolinite mineral from biotite usually occurs under very high weathering condition, which are commonly obtainable in tropical to subtropical hot humid climates. Dolui *et al*. [51] opined that by using the method of precipitating a solution, feldspar was observed to alters into secondary clay minerals, whereas the biotite minerals was observed to be replaced gradually by kaolinite mineral. According to Harris and Adams [60], alteration of feldspar in to illite and later in to kaolinite was recorded during intense chemical decomposition of granitic rock, because at the higher stage of decomposition, silicate clay minerals are transformed to further secondary clay minerals. In tropical and subtropical environments, Wilson [61] observed that secondary clay minerals are generally produced from biotite. Due to some early weathering effects on feldspar and biotite minerals in granite rocks, there is possibility of kaolinite been formed from biotite via vermiculite [51]. The presence of kaolinite and illite as clay minerals in the studied profiles is responsible for the relative variation in both moisture contents and consistencies of the sequences.



(a)

(b)

Figure 3: X-ray diffraction tests results of soils from: (a) BH01 at 1.5m and (b) BH06 at 7.5m

4.3 Variation of shear strength parameters of the soil with depth

Figures 4 and 5 present variations of shear strength parameters with depth of the residual soils investigated. While Figure 4 presents variation of cohesion with profile depth, Figure 5 presents variation of angle of internal friction.

From the figure, increase in values of cohesion with depth was observed for BH01 and BH03 from the depth 1.5m to 3.0m, after which decrease was observed with further increase in depth. The initial increase observed between 1.5 to 3.0m depth can attributed to presence of clayey soils within this strata. For BH02, BH04 and BH 05, decrease in values of cohesion was generally observed with increase in depth, which is attributed to presence of relatively plastic/clayey materials at shallower depth that eventually gave way to relatively silty materials as the depth of weathering increases down to the bedrock. For BH06, cohesion of the soil initially decreased with depth to around 5.0m, after which increase was observed with further depth increase to bedrock. The initial decrease in cohesion of the soil is attributed to formation of lateritic gravel layer, resulting from breakdown of the clay minerals and leaching of oxides of iron and aluminum from the stratum.

From the Figure 5 decrease in value of angle of internal friction with increase in depth is generally observed with soils from BH01, BH02, BH03, BH05 and BH06. This trend is attributed to increase in fine content of the soils as the profile depth increases down. Soil from BH06 generally recorded the highest values of angle of internal friction, due to relatively high content of granular materials within the strata, especially at depth of between 0 to 6.0m. Soil from BH04 showed increase in values of angle of internal friction with increase in depth. This trend is attributed to increase in granular content of the soils as the profile depth increases down to the bedrocks [3]. This is confirmed by silty nature of the soils at lower strata.

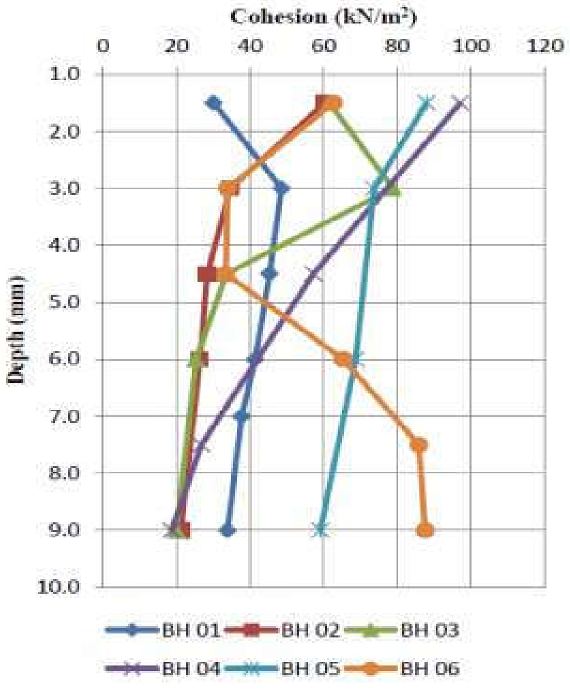


Figure 4: Variation of cohesion with profile depth

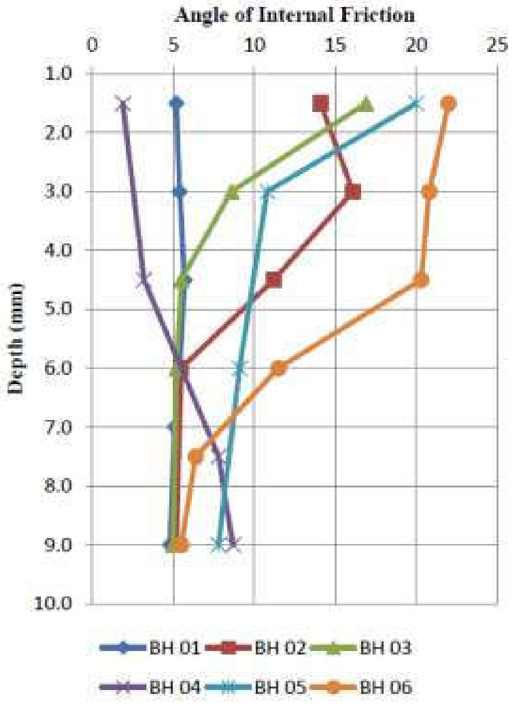


Figure 5: Variation of angle of internal friction with profile depth

4.4 Variation of settlement characteristics of the soil with depth

Variation of settlement characteristics with depth of the studied residual soils is presented in Figures 6 to 8. While Figure 6) presents variation of preconsolidation pressure with profile depth, Figures 7 and 8 present variation of compressive index and coefficient of consolidation respectively, of the residual soils with profile depth.

From the figure, although the preconsolidation pressure of residual soils from BH06 showed decrease with increase in depth, no define pattern was generally observed with soils from the other bore holes. From the definition of preconsolidation pressure, which is regarded as the maximum vertical overburden stress (pressure) that a particular soil deposit has sustained in the past, it is evident that for tropical residual soils, this definition does not hold. This is because, by its definition, preconsolidation pressure of a particular soil deposit (especially deposits formed by transportation/deposition in the distance past, whose outer surfaces have been eroded) is supposed to increase with depth [24], but this is not the case observed here. For the case of tropical residual soil, as evident in the variation of mineralogical composition, the soil along the profile of the deposit undergoes changes as a result of the process of laterization and lithostatic loads. But for transported/deposited soils, changes along the profile are mainly due to lithostatic loads.

From Figure 7, it was observed that the compressive index of the studied residual soils initially increased with depth to depth of between 4.5 to 6.0m, after which the Cc values decreased with further depth increase. This observed trend can be attributed to variation of the soil composition as the profile strata changes along the depth. It is generally observed that strata, where compressive index values were highest consist of soil with high plasticity and porosity. Carreón-Freyre *et al*. [24] reported a similar trend of Cc with depth of lacustrine deposit, which they said was a deviation from the common assumption that Cc decreases with depth due to lithostatic load. They therefore suggested a different mechanical behavior as being responsible for the observed variation of Cc with depth of the lacustrine sediments. They attributed this to mechanical heterogeneity of the sequences (mixtures, within the profile, of sand and silt lenses that are less compressible, and clay that has relatively higher compressibility).

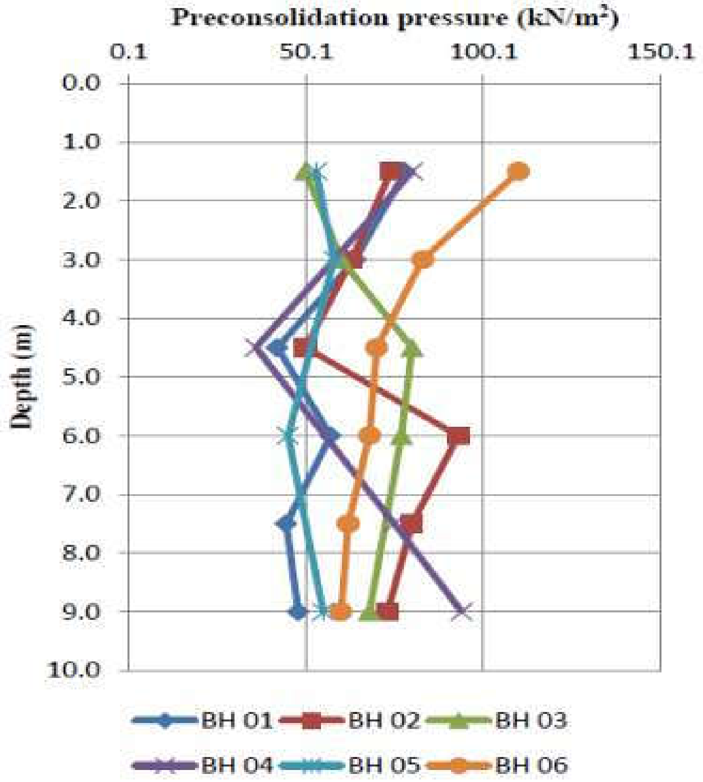


Figure 6: Variation of preconsolidation pressure with profile depth

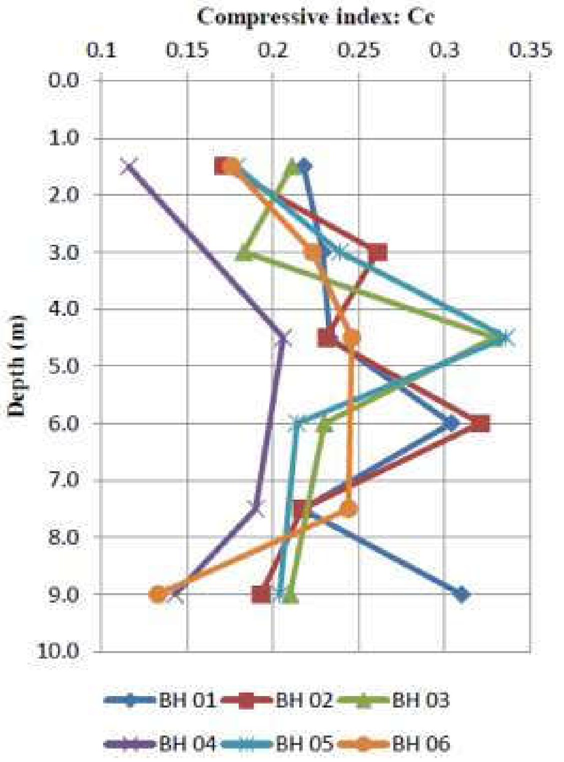


Figure 7: Variation of compressive index with depth with profile depth

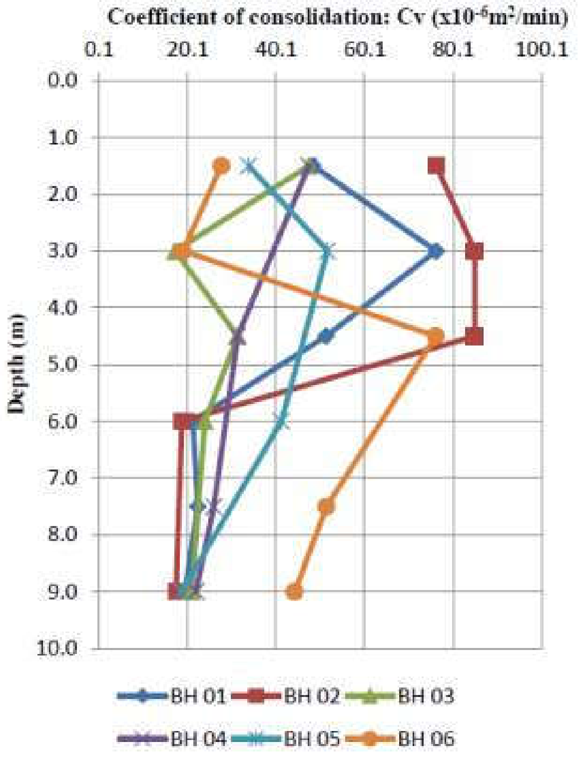


Figure 8: Variation of coefficient of consolidation with profile depth

From Figure 8, it was observed that the coefficient of consolidation of the residual soil showed general decrease with increase in depth, which is attributed to type and nature of the soils along the profile depths. Clayey soils were generally encountered at shallower depth, while at dipper depth, silty soils predominate. Since clayey soil is generally more reluctant in releasing it absorbed water than silty soil, it is natural that settlement of such soils will take a longer time than that of silty soils.

The observed variability in settlement characteristic is generally attributed to variation in characteristics of the residual soil with depths, which is due to the different degrees of weathering and laterization process along the profiles [3], resulting to mechanical heterogeneity of the sequences.

5.0 Conclusion

From the study, the following conclusion is drawn:

Lithology (profile) of the studied soil generally consists of fresh or unweathered parent rock, at the bottom of the profile, to highly weathered saprolite or residual soil at the top of the profile, which was generally similar to residual soil of area underlain by Migmatite–Gneiss Complex in southwestern Nigeria.

Mineralogy of the soil generally revealed dominance of kaolinite as clay mineral, with ocassional traces of illite, which were adjurged as responsible for the relative variation in both moisture contents and consistencies of the sequence.

The observed trend in variation of shear strength parameters (c and ϕ) was attributed to increase in granular content of the soils as the profile depth increases down to the bedrock, which was confirmed by the silty nature of the soil at lower strata.

Variation of compressive index with depth, showed a deviation from the common assumption that Cc decreases with depth due to lithostatic load, which was attributed to mechanical heterogeneity of the sequence (mixtures, within the profile, of sand and silt lenses that are less compressible, and clay that has relatively higher compressibility). The observed variability in settlement characteristic is attributed to variation in characteristics of the residual soil with depth, which is due to the different degrees of weathering and laterization along the profiles, resulting to mechanical heterogeneity along the profile. Therefore the definition of preconsolidation pressure, as in the literature, does not perfectly hold for tropical residual soils.

8.0 References

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