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# Sub-Soil Investigation Of A Proposed Construction Site At Ado - Ekti, South Western, Nigeria

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***Abstract*—Ado-Ekiti metropolis is a fast growing State Capita with new buildings springing up daily. There has been no documented research on the geophysical and geotechnical properties of the soils in this area. This research aim at the Sub-soil investigation of a proposed construction site located at Similoluwa area of Ado- Ekti, Nigeria to determine the suitability of the soil to host civil engineering structures. The investigation involved excavation of trial pits and obtaining both disturbed and undisturbed samples for laboratory analysis. The field and laboratory data were established using ABEM SAS 1000 Terrameter and Laboratory geotechnical equipment's in compliance with relevant specifications. Classification tests carried out showed that soils were classified as clay of medium compressibility and clay of high compressibility respectively a properties of fine grain soils. This implies that the potential for swelling and shrinking when wet and dry that could have negative impact on the stability of structures placed on them is low The data collected revealed that the third layer (Fresh Basement) to be the most competent for founding medium to large engineering structures due to the presence of crystalline rocks of varying depths (3.3m in VES 1, 8.6m in VES 1, 12.5m in VES 4 and 17m in VES 3) and resistivity values that range between (1053 – 2526 Ohm-m) to mitigate this situation, a sligthly lower bearing capacity of 200kN/m$^2$ may be adopted and the entire area should be excavated upto Fresh Basement Rock of about 13 m depth depending on the height of the proposed structure. This research will provide information for Engineers, Planners, Contractors and designers within this metropolis**

***Keywords*— Geophysical, Geotechnical, Laboratory, Basement, VES Stations**

## I. INTRODUCTION

The goal of the subsurface investigation is to obtain a detailed understanding of the engineering and geologic properties of the soil and rock strata and groundwater conditions that could impact the foundation (Day, 2006).A site investigation should attempt to foresee and provide against difficulties that may arise during construction because of ground and/or other local conditions (Anon, 1999). Cases of buildings collapse in Nigeria has been on the rise on daily basis. This calls for detailed geotechnical sub soil investigation of sub structures so as to guard against re-occurrence of such failures (Owoyemi e t al 2016). Material study of foundation soils to a large extent, serves as preventive measure for foundation failures. Nwankwoala and Warmate (2014), studied the foundation geotechnical properties of a site in Port Harcourt, Aduoye and Agbede (2014) used Terzaghi's equations to determine the bearing capacity of soil samples from Obafemi Awolowo University Campus. He found correlations between angle of internal friction and bearing capacity of the studied soils. Other researchers such as Ola (1988), Ogunsanwo (2002), Ige and Ogunsanwo (2009), Oyedele et al.,.(2011), Avwenagha et al. (2014) have worked on the geotechnical properties of foundation soils in Nigeria. However, there is presently few researches on the geophysical survey and geotechnical properties and foundation bearing capacity of the soil in the study area. Similoluwa area is a fastest growing quarter in the Ado-Ekiti metropolis.

This sub surface investigations are designed to Identify the outcrop (if any) and structural characteristics and delineate the near surface geologic structures like faults/fractured zones, shear zones with thick overburden. It also attempts to delineate the geo-electric/geologic sequence beneath

the depth sounding station sand due to geo-electric parameters

Thereby Identify the competent horizon/units, their depth and lateral extent. This will lead to recommend the possible excavation and reinforcement depths to the competent horizons to make them suitable for founding the proposed reservoir structure

## II. MATERIAL AND METHODS

The data were collected within the premises of the Ekiti State Water Corporation located behind Fajuyi Park, Ado Ekiti, Southwestern Nigeria. Its coordinates are between N 07° 37.913' and N 07° 37.931, and between E 005° 12.898'' and E 005° 12.918' respectively. The highest elevation recorded in the area is 446.3m above sea level Figure 2 is the flow chart which describes the approaches of site investigation exercise performed on the site in question

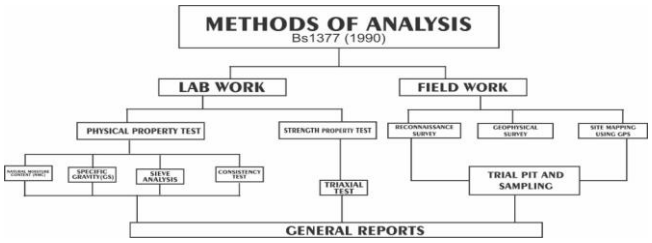



***Figure 2: Sub soil investigation flow chart methodology***

Geological reconnaissance studies and Geophysical investigation was conducted at the precinct of the site with five trial pits established for sampling of undisturbed and disturbed soil samples taken at a depths 2 m each. Thereafter, a hand auger was used to drill below this depth until refusal was attained to achieve a firm stratum. ABEM SAS1000 Terrameter was used for Vertical electrical sounding (VES) field data collection. This was followed by laboratory analysis to test the samples using Control Milano Triaxial compression machine to determine the shear strength. The tests were performed in compliance with BS 1377(1990) and FMW, 1997 Vol.II

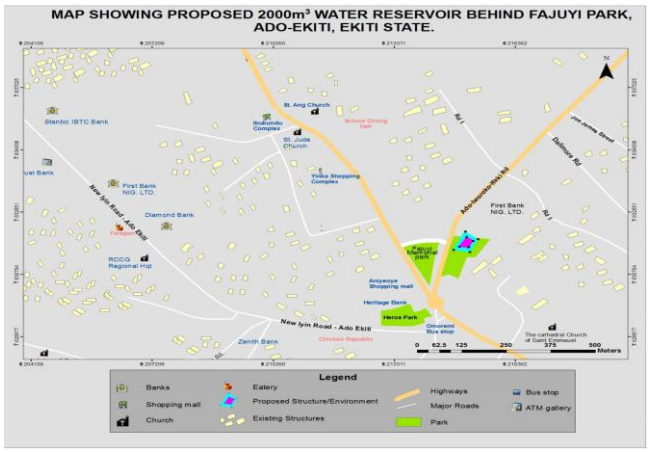



**Figure 1 Proposed site topo map of the 2000m$^3$ water reservoir**

## III. RESULTS AND DISCURSION

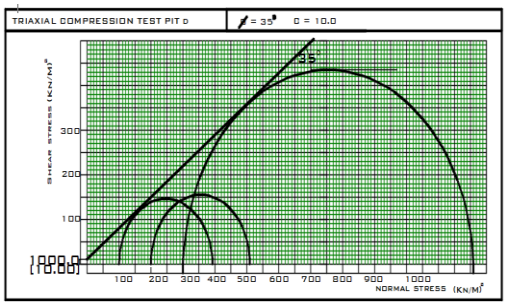
This data presented were used to characterise different subsurface geological units and to provide the engineering, environmental and geophysical properties of the area. Table 1: revealed the summary of all laboratory geotechnical properties tests results.

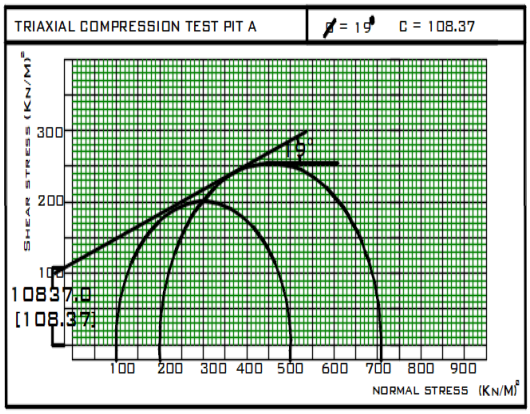
**Table 1: Summary of the tables of all laboratory tests Results.**

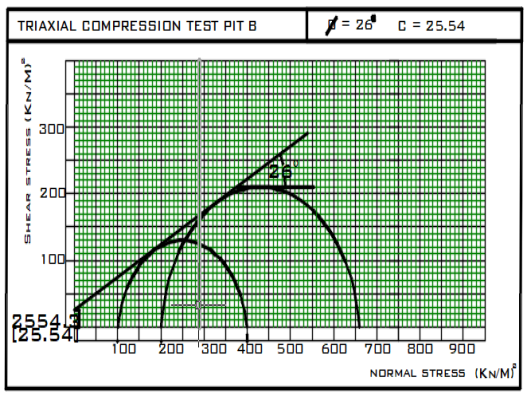
| Trial pits | A | B | C | D | E |
|---|---|---|---|---|---|
| Depth/Test | 2m | 2m | 2m | 2m | 2m |
| moisture content % | 19.55 | 23.25 | 24.30 | 14.05 | 23.1 |
| % passing 75mu | 64,14 | 63.34 | 62.82 | 35.20 | 63.92 |
| C ( kN/m$^2$) | 108.37 | 25.54 | 205.60 | 10.00 | 112.74 |
| ϕ Degree | 19 | 26 | 15 | 35 | 18 |
| Liquid limit % | 47.5 | 33.2 | 53.9 | 37.2 | 52.0 |
| Plastic limit % | 31.0 | 12.8 | 28.5 | 23.0 | 33.4 |
| Plasticity index % | 16.5 | 20.4 | 15.4 | 14.2 | 18.6 |
| Specific Gravity | 2.58 | 2.53 | 2.57 | 2.59 | 2,58 |
| Bearing capacity (kN/m$^2$) | 338 | 171.9 | 786 | 57.44 | 364.6 |

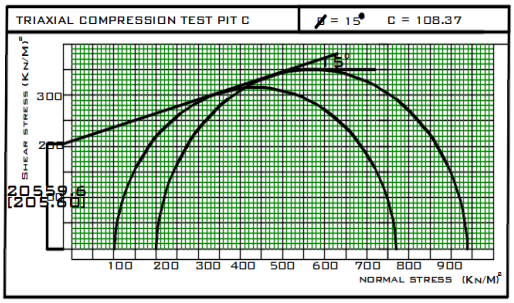
*A. *C: Cohesion*

The results showed that soils were classified as clay of medium compressibility and clay of high compressibility respectively according to unified soil classification system. The figure 3a - d shows the result for triaxial compression test conducted using Control Triaxial compression machine for shear strength parameters which ranges between 10-205 **kN/m$^2$** and 15 -35 for cohesion and frictional angles respectively while figure 4a - d were determined using mechanical sieve shaker for soil classification. The results showed that in almost all the trial pits the percentages passing through sieve 200 are greater than 35 % which group the soil as a fine grain soils material



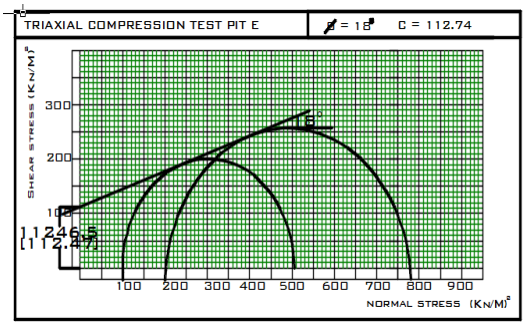
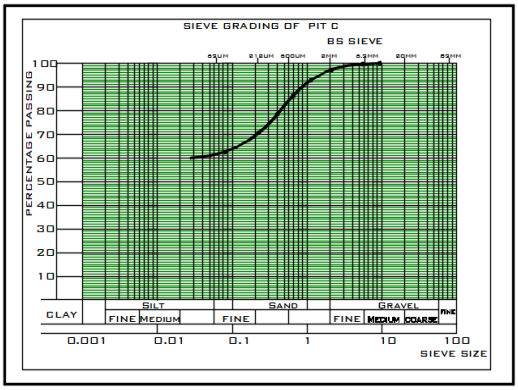
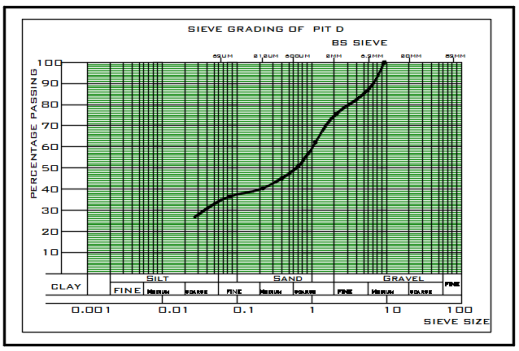




Figure 3a - e: Graph of Triaxial test



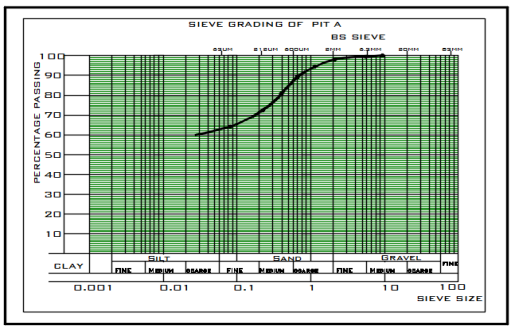




Figure 4a - d: graphical representation of sieve analysis for the trial pits

Table 2-5 shows the summary of VES station 1-4 which were analyzed using the ABEM SAS 1000Terrameter.

**Table 2: Summary of VES 1 Interpretation**

| Layer | Resistivity (Ohm-m) | Thickness (m) | Depth (m) | Probable Lithology | Geological Competency Significance |
|---|---|---|---|---|---|
| 1 | 233 | 1.8 | 1.8 | Lateritic top soil | Poorly Competent |
| 2 | 136 | 6.8 | 8.6 | Sandy Clay Weathered Basement | Fairly Competent |
| 3 | 1500 | ∞ | **>9m** | Fresh BC. | Highly Competent |

**Table 3: Summary of VES 2 Interpretation**

| Layer | Resistivity (Ohm-m) | Thickness (m) | Depth (m) | Probable Lithology | Geological Competency Significance |
|---|---|---|---|---|---|
| 1 | 318 | 0.7 | 0.7 | Lateritic top soil. | Poorly Competent |
| 2 | 127 | 2.6 | 3.3 | Sandy clay | Fairly Competent |
| 3 | 1053 | 8.6 | **11.9** | Shallow Basement | Provisionally Competent |
| 4 | 416 | ∞ | **>12m** | Fractured BC. | Not competent deeper depth necessary |

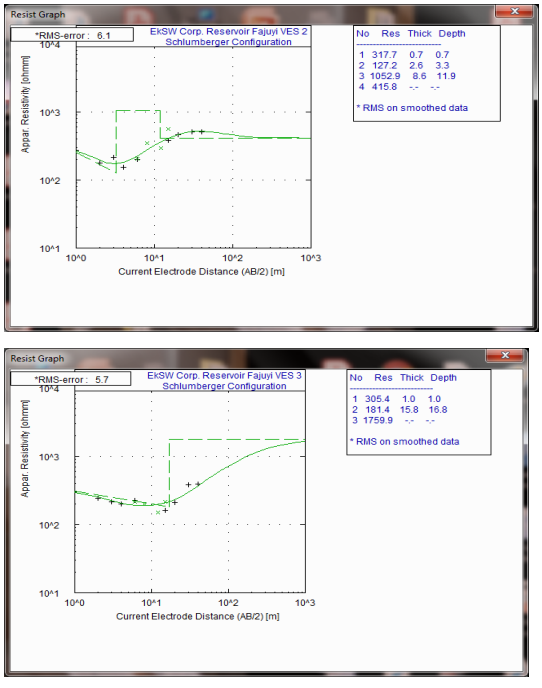
**Table 4: Summary of VES 3 Interpretation**

| Layer | Resistivity (Ohm-m) | Thickness (m) | Depth (m) | Probable Lithology | Geological Competency Significance |
|---|---|---|---|---|---|
| 1 | 305.4 | 1.0 | 1.0 | Lateritic top soil | Poorly Competent |
| 2 | 181.4 | 15.8 | 16.8 | Sandy Clay Weathered Basement | Fairly Competent |
| 3 | 1760 | ∞ | **>17m** | Fresh Basement. | Highly Competent |

**Table 5: Summary of VES 4 Interpretation**

| Layer | Resistivity (Ohm-m) | Thickness (m) | Depth (m) | Probable Lithology | Geological Competency Significance |
|---|---|---|---|---|---|
| 1 | 98.4 | 1.0 | 1.0 | Lateritic top soil. | Poorly Competent |
| 2 | 119 | 11.5 | 12.5 | Sandy Clay Weathered Basement | Fairly Competent |
| 3 | 2526 | ∞ | **>13m** | Fresh Basement | Highly Competent |

Geophysical survey results showed that the geo-electrical succession consists of three to four layers namely as shown in figure 4, Lateritic topsoil, Sandy clay, Weathered Basement and Fresh/fractured Basement. The implication of the above analysis is that the third layer (fresh basement) will be the most competent for founding medium to high engineering structures. The depths of penetration of the layer are 9m (VES 1), 3m (VES 2), 17m (VES 3) and 13m beneath VES 4. Fracture incidence occurs only beneath VES 2 below the fresh rock depth of 12m. VES 3 has the highest overburden thickness of 17m and VES 4 has the highest resistivity (2526 Ohm-m) in the rock. Figure 2- 5 shows the iterated for VES station 1-4.



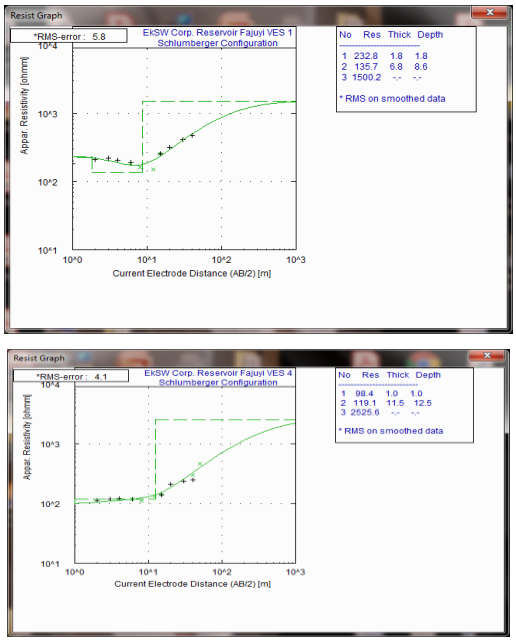
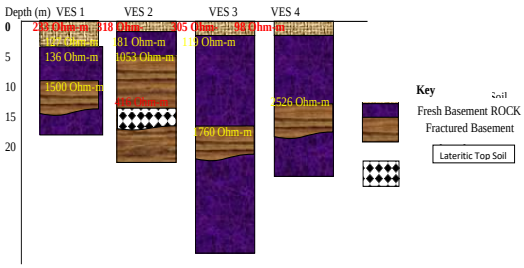



**Figure 5a-d: Iterated Curve for Ves 1 to Ves 4**




## IV. CONCLUSION

Site investigation (Geotechnical and Geophysical) investigation was carried out on site of the proposed site of the 2000m3 reservoir at the back of fajuyi memorial park Ado Ekiti, Ekit State

Five trial pit of 2 m deep each was excavated with five undisturbed and disturbed samples Obtained for laboratory tests. The results of the tests reveal that the soil has a percentage of fines greater than 0.075 fractions that is > 35% in almost all the depth investigated, this caused the soil to be classified into the group of clay of high compressibility (CH). The high cohesion value and a low angle of friction value were observed in each of the depth. Also groundwater was not encountered, but the soil samples were very wet hence its effect should be considered in the design

It is expected the settlement of the soil will be long since the soil in the area contains a considerable percentage of clay. The effect of settlement should therefore be considered during design

Geophysical Survey reveal the area under investigation to be generally of thin to moderate overburden as evident through all the VES stations occupied. Although there exist interesting resistivity contrasts. In VES 1 competent layer was encountered at 9m depth, while VES 2 presents a provisionally competent horizon at 3.3m depth but the underlying fracture bed beyond a depth of 12m presents apparent competent geo-electric layer.

In VES 3 competent layer was also encountered at 17m depth, whereas VES 4 competent layer is encountered at 13m depth

## V. RECONMENDATION

The Structural Engineer in charge may which to consider any of the following recommendations to mitigate against settlement and to enhance structural stability of the proposed reservoir**.**

A sligthly lower bearing capacity say 200 kN/m$^2$ may be adopted. Rigidity could be provided to the structure so that the whole structure settles uniformly (RAFT FOUNDATION). This will even out the settlement.

The foundation depth may need to vary in relation to the elevation of the site. The investigation of the study area has revealed the third layer (Fresh Basement) to be the most competent for founding medium to large engineering structures due to the presence of crystalline rocks of varying depths (3.3m in VES 1, 8.6m in VES 1, 12.5m in VES 4 and 17m in VES 3) and resistivity values that range between (1053 – 2526 Ohm-m). The entire area may be excavated up to sandy clay/weathered basement of about 10 m depth depending on the height of the proposed reservoir

Lateral confinement may be adopted such as sheet pile walls. Pre loading of the site to attain necessary pre-consolidation stage could be considered

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