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# Geophysical Investigation of Foundation Condition of The Vice-Chancellor’s Quarter, Ugbowo Main Campus University of Benin, Using Schlumberger Methods.

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**Abstract**

A geophysical investigation was performed using Vertical Electrical Sounding (VES) at a site behind Vice-Chancellors’ Quarter Ugbowo, University of Benin main campus, Benin City to examine the geophysical parameters that can be used to evaluate the structural competence of the shallow section of the subsurface for construction purposes and building development. The Vertical Electrical Sounding was done using the schlumberger electrode array configuration and the schlumberger automatic analysis method of interpretation was adopted. The interpretation of the data plotted with IP2WIN software showed a significant Topsoil that is up to 1.5m. The major subsurface layers are the topsoil, lateritic layer, Sandy clay, and sand. The overall subsurface shows a reoccurring layer of laterites with the thickness ranging from 0.5m to 86.5m, resistivity value ranging from 220 Ωm – 410502 Ωm The study area shows relatively high resistivity values that suggest high laterite content which have impact on the competence and integrity of the soil construction and building development. Therefore, for building development in the study area, the topsoil must be excavated to a reasonable depth (within 0.5m-1.56m) at which the soil is adequately competent and choice of foundation material must take into account the characteristics of the Lateritic material.

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## Introduction

Foundation investigation is an important program in building and engineering structures. Several approaches have been used for the success of foundation investigations. Geophysical methods, particularly electrical resistivity technique, had been extensively used for a wide variety of engineering and environmental problems (Zohdy, 1975).The application of electrical resistivity survey has become a prime choice, as a result of the cheap cost that is involve and the fact that it saves time and easy to carry out, and can also be used to determine geological structures (Al-Sayed and El-Qady 2007).Engineering applications of electrical resistivity include investigation the bridge, dam and building structure foundations using electrical resistivity survey (Omoyoloye *et al*., 2008; Adeoti *et al*., 2008; Mahmoud; *et al*., 2009). Soil mixtures have been used extensively in developed countries to construct great lengths of road when other materials like cement and lime were not either available, developed or widely used. Developing countries with low per capita income, low cement and lime production, can use the same technique today. Laterite being readily available in many places can be mixed with sand to improve its strength, stability and other properties for this purpose. The electrical properties of laterites were useful tool for electrical resistivity investigations to evaluate depth and area extent of laterite soil in Vice-Chancellor’s Quarter University of Benin main campus, South-South, Nigeria to determine its foundation condition.

## Brief Geology of The Study Area

The study area which is Vice-Chancellor’s lodge area University of Benin Ugbowo Edo State of Nigeria is underlined by Benin formation (Information Centre, 2010). Details of the geology and hydrogeology of the Benin formations have been documented (Kogbe, 1976). The area lies between longitude E5º37’32.83’’ and E 5º37’36.9’’ between latitude N 6º 23’ 56.69’’N and N 6º 24’ 00.8’’ approximately 350km SW of Abuja. The topography of the area is plane surface

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which has the following rock types, top soil, laterite, clay, sandy clay and clean sand which is in close agreement with the Benin formation that ranges from miocene to recent. The inhabitant of these survey area earns their sources of livelihood from farming and petit business activities such as trading.

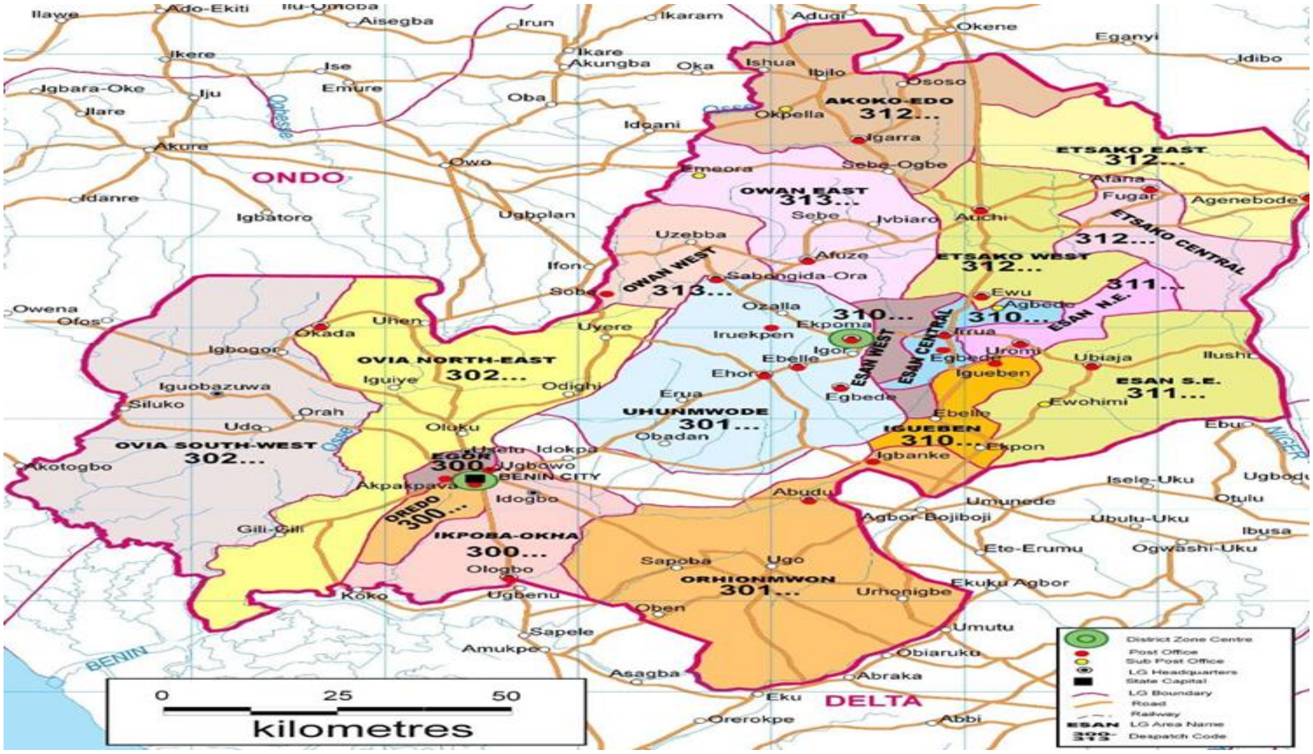


Fig 1. Map of Edo state, showing location of the study area

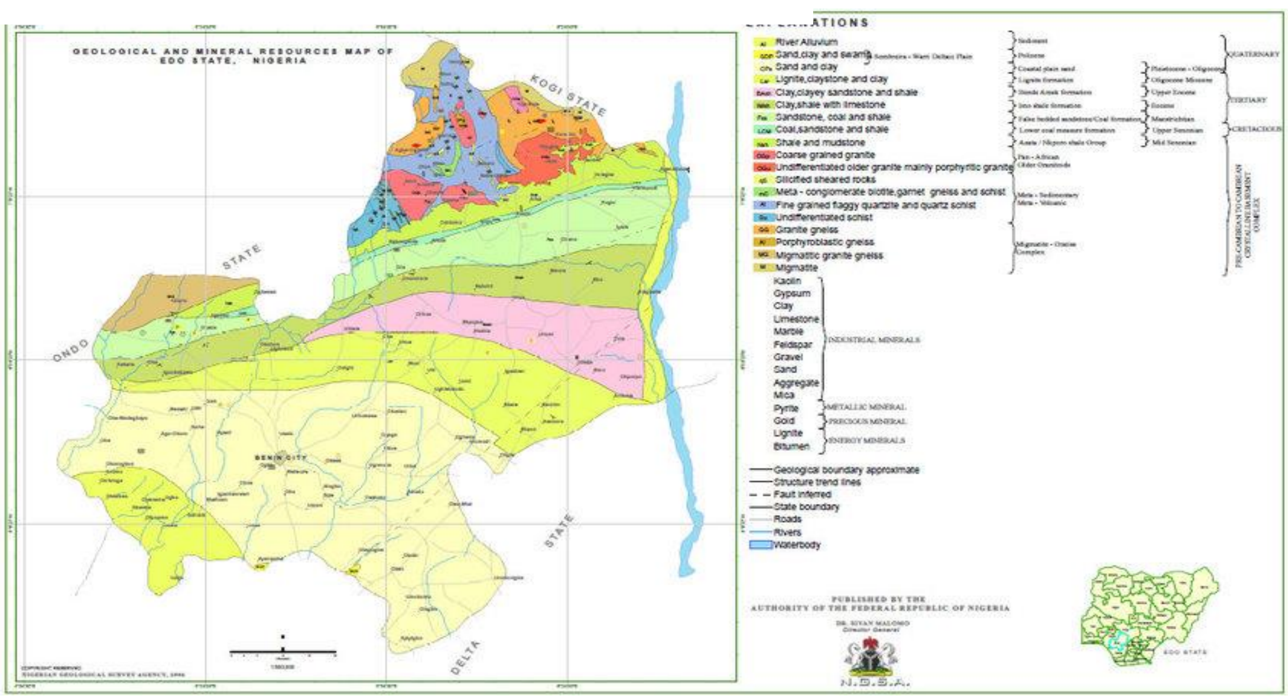


Fig. 2. Fig 2 Geological Map of Edo State Showing Benin City and other Locations (Nigerian Geological Survey Agency, 2006)

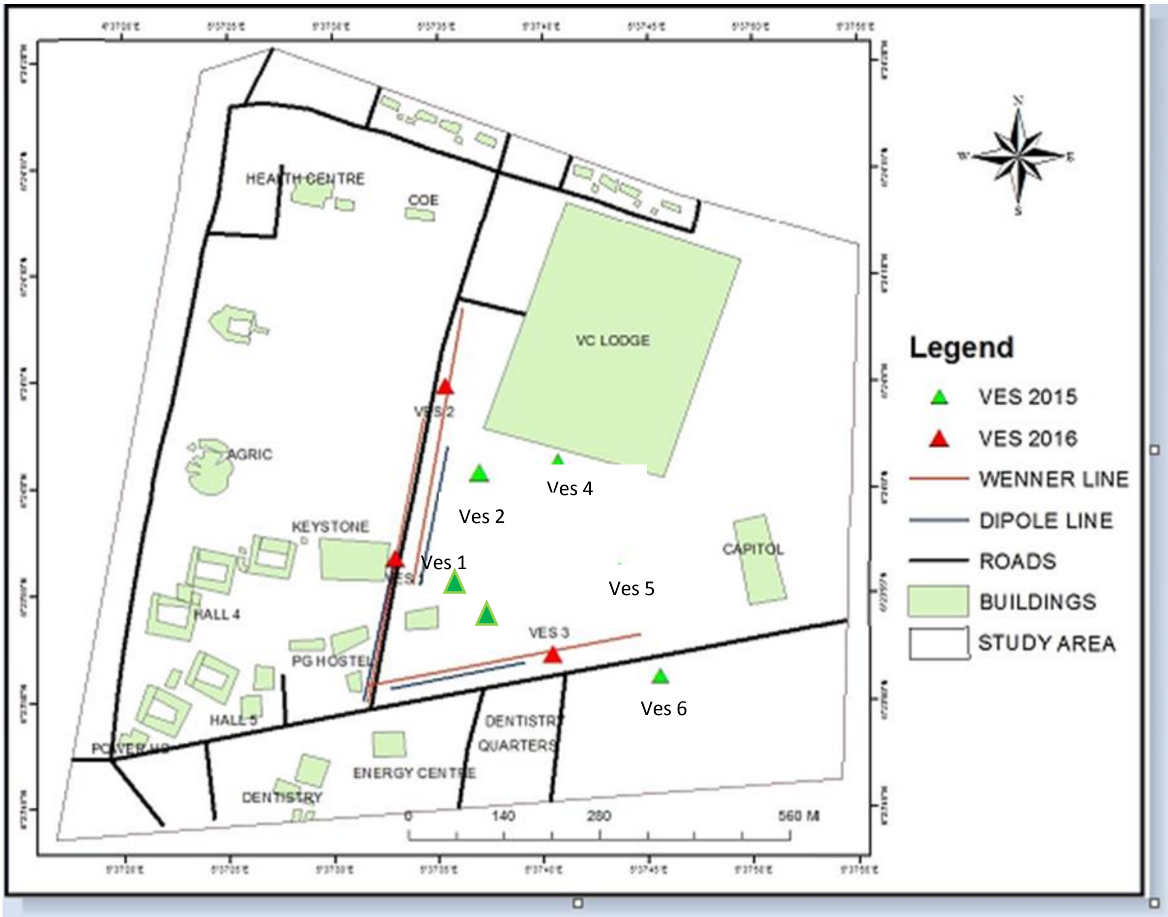


Fig.3 Fig 3 Map of the study showing Spatial distribution of the VES point

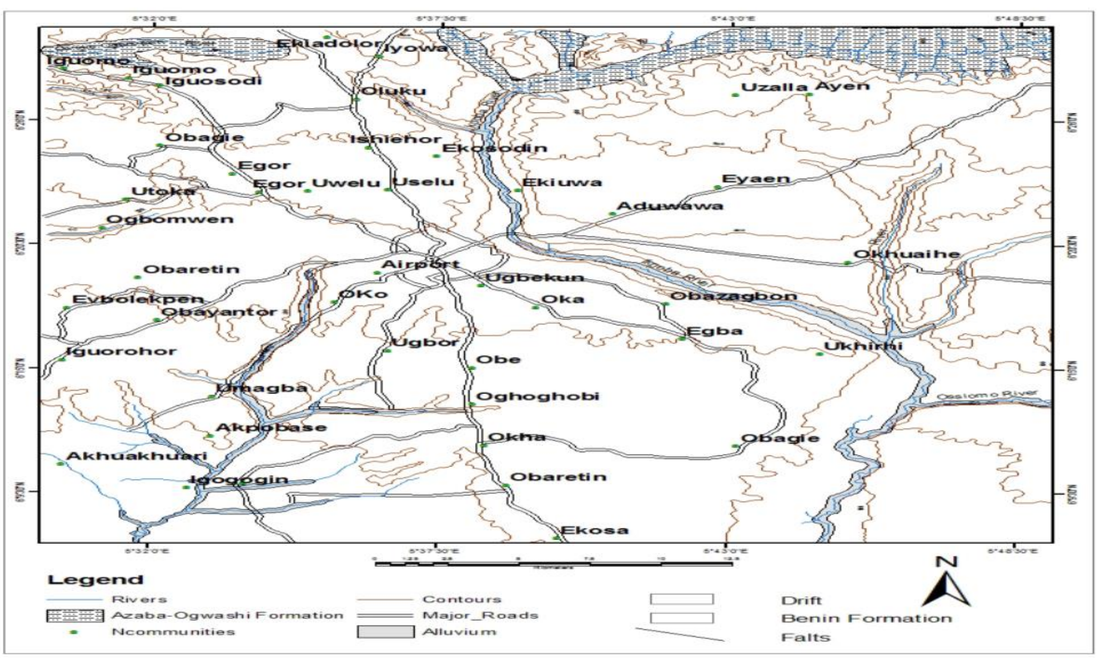


Fig 4. Benin region geological formation (source: Akujieze, 2004).

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**Materials and Methods**

Measurement of resistivity were made using ABEM Terrameter SAS 1000 T, while Global positioning system (GPS) was used to measure or get the elevation above the sea level; longitude and latitude of the Vertical Electrical Sounding (VES) position. The first step undertaken on the field was the reconnaissance study of the area to know the places to be sounded. Having established these points, they were marked on the base map and were expanded symmetrically about the center of the spread. When the distance between the current electrodes get too large, it becomes necessary to increase the distance between the potential electrodes in order to have a measurable potential difference.

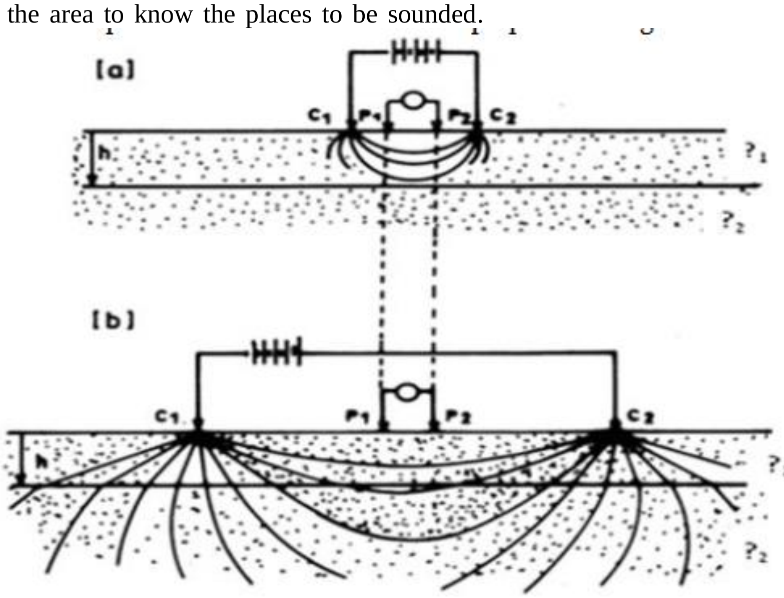


Fig 5 Principle of electric sounding (a) For small current electrode separation (b) For larger current electrode separation

The Vertical Electrical Sounding data are plotted and inverted using IPI2win software which creates a 1-D model from the sounding data. The geological interpretation was done using the representative values or resistivity reported by Suryakanta (2015). Strater 3 software was used to draw the 1D subsurface model for visualization.

The interpretation of vertical electrical sounding data for the survey is quantitative. The method employed is partial curve matching method, each curve generated from the sounding curve was matched segment by segment, while this is in progress, the axes of both the field curves and the model resistivity curve must be in parallel. Generally, the layer resistivity and thickness are given as:

$\rho_2 = \rho_1 K_1$

$\rho_3 = \rho_{2r} K_2$

$\rho_4 = \rho k_3$

$\rho_n = \rho_{(n-1)r} K_{n-1}$

Where,

$K_1, K_2, K_3$ ............. $K_{n-1}$ are reflection coefficient of each layer

$\rho_1, \rho_2, \rho_3,$ ................ $\rho_n$ are resistivities of 1st, 2nd, 3rd ....... nth layer respectively

$\rho_{2r}, \rho_{3r},$ ............ $\rho_{(n-1)r}$ are reflection apparent resistivity of 2nd, 3rd, ...................... n-1 layers respectively.

Similarly

$h_2 = h_1 D_n/D_{r1}$

$h_3 = h_{2r} D_n/D_{r2}$

$h_4 = h_{3r} D_n/D_{r3}$

$h_n = h(n-1)r\ D_n/D_{r(n-1)}$

Where,

$h_1, h_2, h_3, h_4,$ ... $h_n$ are the thickness of 1st, 2nd, 3rd, 4th, ............. nth layer respectively

$h_{2r}, h_{3r}$ ............. $h_{(n-1)r}$ are the reflected thickness of the 2nd, 3rd, ... n-1 layer respectively

$\frac{D_n}{D_{rn}}$ = depth ratio

Fig 6 Formula for layer resistivity and thickness

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The partial curve matching can be regarded as the preliminary interpretation of the field curves which produce the layer resistivity and thickness values for computer iteration.

**Results and Discussion**

The result of the geophysical survey is presented in Sounding Curves, Geo-electric sections and Maps. The layer model interpretations of all the VES points are presented in the fig (7-12). The results of the interpretation show a system of three geo-electric layers for VES3-6 while VES1 shows a system of four geo-electric layers and VES 2 a total of five geo-electric layers with curve patterns A for VES 1,3,4,6, HK for VES 2 and K for VES 5.A summary of the VES interpretation is presented on Table 1.0. From the Table, it is quite evident that significant Topsoil is up to 1.5m. The major subsurface layers are the topsoil, lateritic layer, Sandy clay, and sand. The overall subsurface shows a reoccurring layer of laterites with the thickness ranging from 0.5m to 86.5m, resistivity value ranging from 220 Ωm – 410502 Ωm, the study area shows relatively high resistivity values that suggest high laterite content.

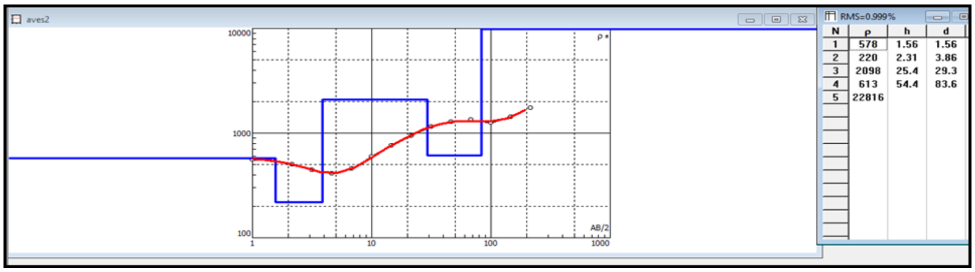


Fig 7 Computed iterated graph for VES 1

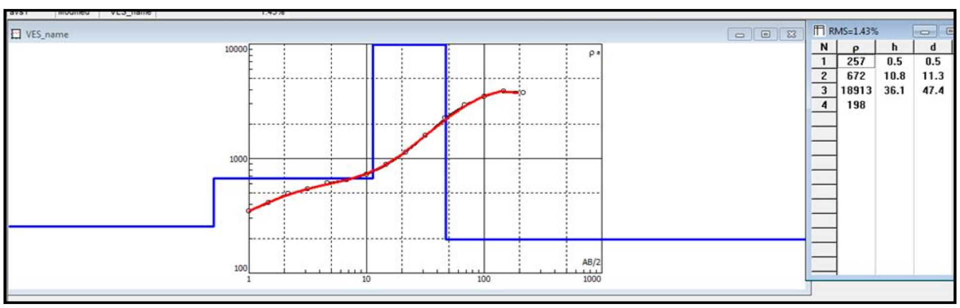


Fig 8 Computed iterated graph for VES 2

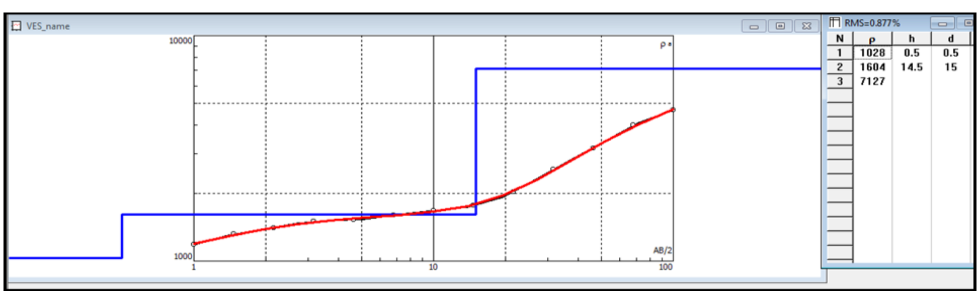


Fig 9 Computed iterated graph for VES 3

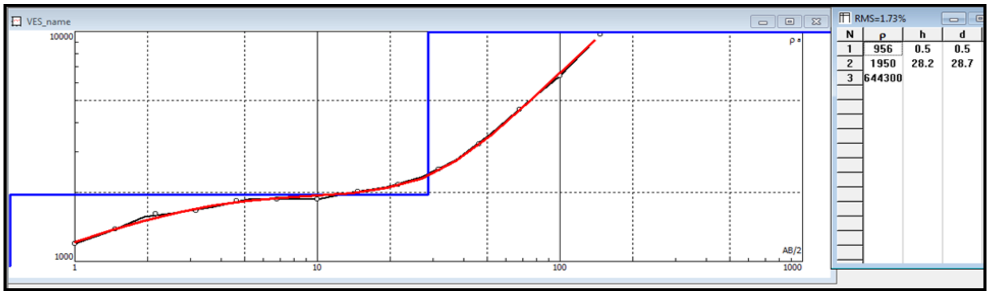



Fig 10 Computed iterated graph for VES 4

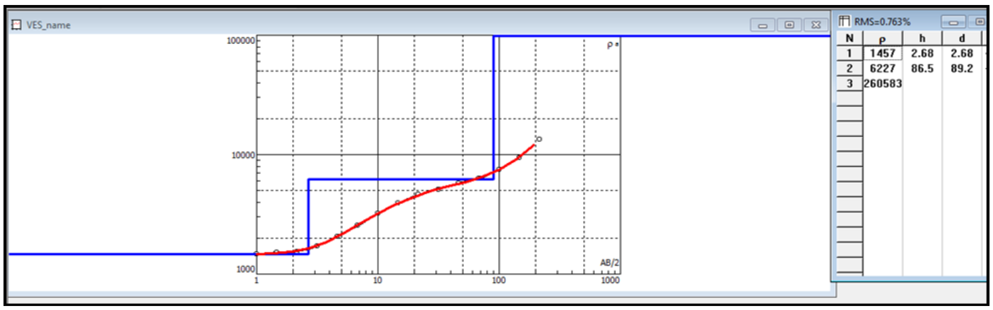



Fig 11 Computed iterated graph for VES 5

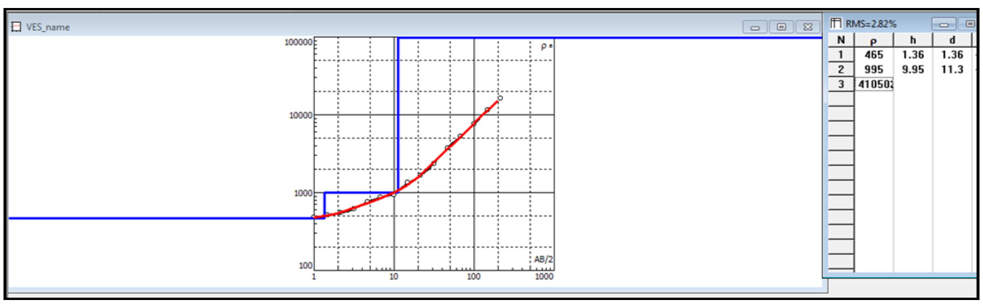



Fig 12 Computed iterated graph for VES 6

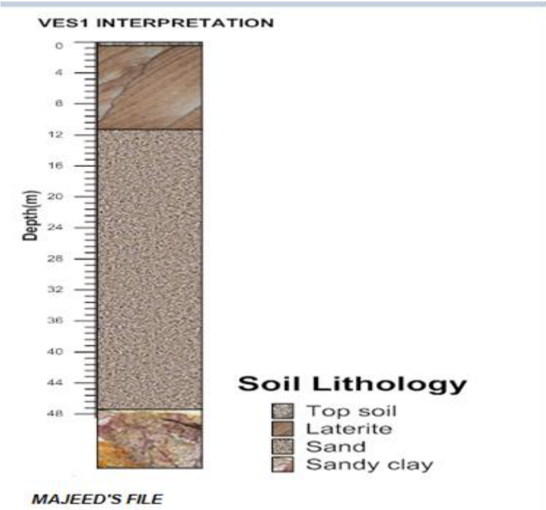
Table 1.0: Summary of VES data interpretation

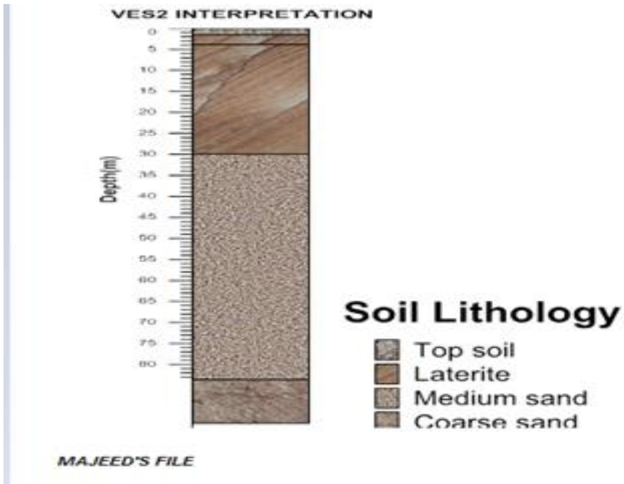
| S/N | Layers | Resistivity (Ωm) | Thickness (m) | Depth (m) | Curve Type | Probable Lithology | Coordinates LatN/LongE |
|---|---|---|---|---|---|---|---|
| VES 1 | I | 257 | 0.5 | 8.5 | A-Type σ1<σ2<σ3 | Lateritic (weathered) | $6^{O}$ 23' 56.69''/ $5^{O}$37'32.83'' |
| | II | 672 | 10.8 | 10.8 | | Lateritic (weathered) | |
| | III | 18913 | 36.1 | 36.1 | | Laterite | |
| | IV | 198 | | | | Sandy Clay | |
| VES 2 | I | 578 | 1.56 | 1.56 | HK-Type σ1>σ2<σ3>σ4 | Top soil | $6^{o}$ 24' 4.87''/ $5^{o}$37'35.21'' |
| | II | 220 | 2.31 | 3.86 | | Laterite | |
| | III | 2098 | 25.4 | 29.3 | | Laterite | |
| | IV | 613 | 54.4 | 83.6 | | Sand | |
| | V | 22816 | | | | Laterite | |
| VES 3 | I | 1028 | 0.5 | 0.5 | A-Type σ1<σ2<σ3 | Topsoil (Sandy) | $6^{O}$ 23' 4.87''/ $5^{O}$37'35.21'' |
| | II | 1604 | 14.5 | 15 | | Laterite | |
| | III | 7127 | | | | Laterite | |
| VES 4 | I | 956 | 0.5 | 0.5 | A-Type σ1<σ2<σ3 | Top soil | $6^{O}$ 23' 51.2''/ $5^{O}$ |
| | II | 1950 | 28.2 | 28.7 | | Laterite | |

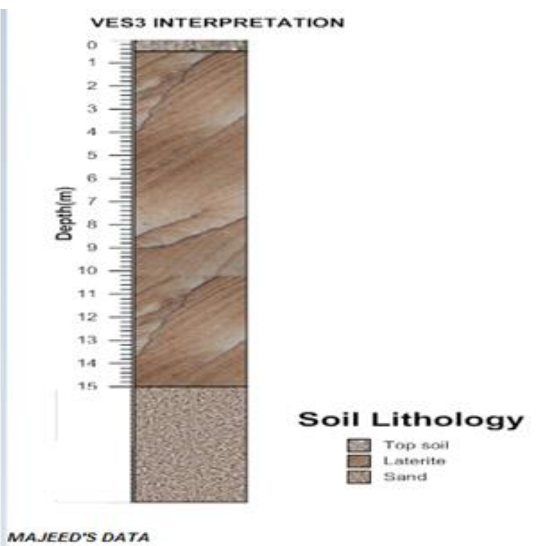
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | III | 644380 | | | | Laterite | 37'.45.3'' |
| VES 5 | I | 1457 | 2.68 | 2.68 | K-Type σ1<σ2>σ3 | Laterite | 6 $^{O}$23' 52.9''/ 5 $^{O}$37'44.5'' |
| | II | 6227 | 86.5 | 89.2 | | Laterite | |
| | III | 260583 | | | | Laterite | |
| VES 6 | I | 465 | 1.36 | 1.36 | A-Type σ1<σ2<σ3 | Laterite | 6$^{O}$ 24' 00.8''/ 5$^{O}$37'36.9'' |
| | II | 995 | 9.95 | 11.3 | | Sand | |
| | III | 410502 | | | | Laterite | |

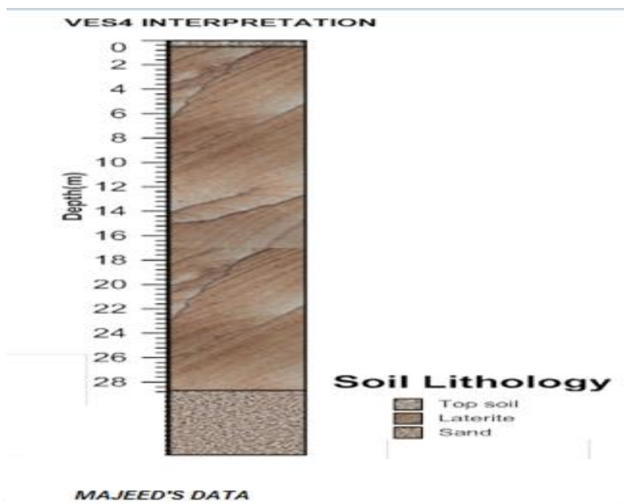
**Strata 3 plots of VES Layers**

Strater 3 software was used to draw the 1D subsurface model for visualization. It shows the soil lithology of the area.



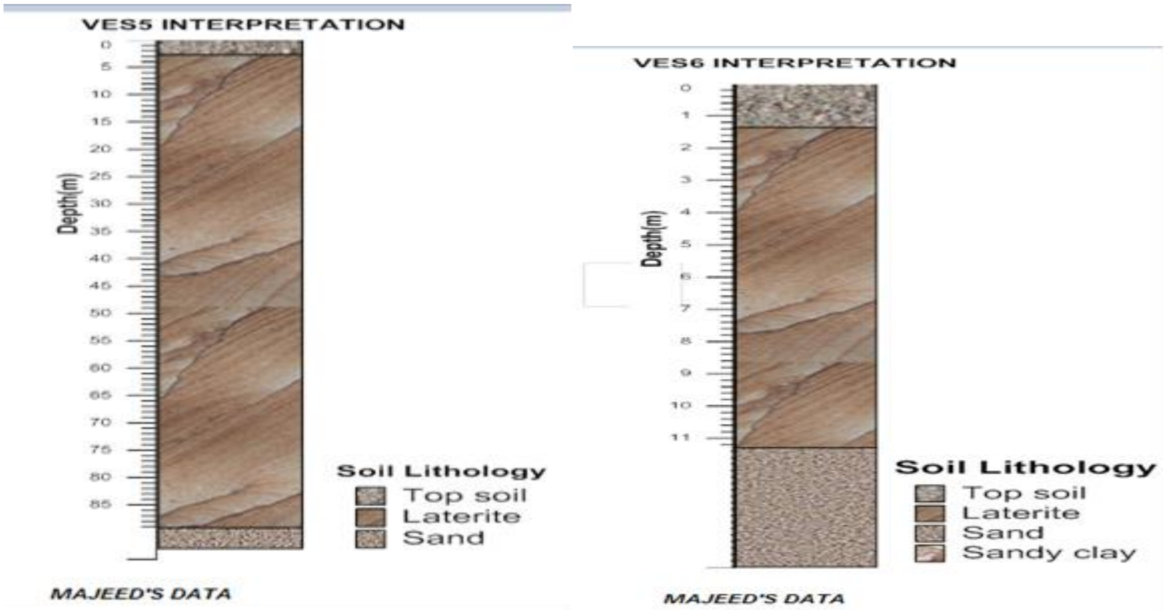



Fig 13a-f Strater 3 Plot of VES

**Conclusion**

The interpretation of Six Vertical Electrical Sounding in the study area shows that four major layers were delineated from the study area which comprise mainly Topsoil, Laterite, sand and sandy clay. From the study area, the prevailing soil is mainly laterite, as evidence from the geoelectric layers and Strata 3 plot of VES, which means that the topsoil must be excavated to a reasonable depth (within 0.5m-1.56m) at which the soil is adequately competent and choice of foundation material must take into account the characteristics of the Lateritic material for the choice of shallow foundation in the study area. It is observed that the lateritic layers are between the depth of 1.36m to 89.2m below the earth surface which means that, for building development in the study area, the topsoil must be excavated to a reasonable depth in between the lateritic layer at which the soil is adequately competent to bear the load because lateritic soil has a greater load bearing capacity. The choice of foundation materials must take into account the characteristic of the wet lateritic material and the sandy clay of the soil.

**Recommendations**

Based on the interpretation of the data and field results obtained, I will like to make the following recommendation

1.Excavation of soil to a depth at which the soil is lateritic in nature (adequately competent and highly consolidated) to sustain the structure of any kind is advised.

2. As it is well known, geophysical method cannot be used as substitute for geotechnical method due to the fact that it does not provide any information about the strength parameter of the soil but its application is useful in reducing the time and cost in drilling several boreholes and carrying out laboratory tests. A geotechnical test should be carried out on the laterite in other to determine the kind of additive needed for stability for its intending load. Hence, integrated geophysical methods would enhance accurate delineation of the stratigraphic layers of the subsurface in the study area.

**Acknowledgement**

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