# Two dimensional (2-D) resistivity imaging survey for the suitability of the proposed administrative building: A case study of 0.0.U (Main Campus, Ago- Iwoye, Southwestern Nigeria

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## Abstract

A comprehensive investigation was carried out involving Geophysical Survey using 2-D Resistivity imaging supported by 1-D vertical electrical sounding with Schlumberger Array on each profiles were carried out. Four traverses with Wenner and Dipole-Dipole Electrode configuration were established around the Proposed Administrative Building, Olabisi Onabanjo University, Main Campus, and Ago-Iwoye, Southwestern Nigeria. The work was carried out using the ABEM 1000SAS Terrameter. Four vertical electrical sounding (V.E.S) points were probed using the Schlumberger Configuration. The results of the interpretation of the VES data was able to delineate 3- 4 Geo-electric layers with resistivity of the top soil ranging from 308.4 to 539.9Ω/m. Three out of the four profiles of the 2-D resistivity imaging will be able to sustain the proposed structure with foundation of Profile 1, 3 and 4 dug to 2m, 2.3m and 3m respectively while that of Profile 2 needs lying of Concrete bases to be able to sustain the proposed structure. From these result, it could be concluded that 2-D imaging gives better information of the sub-surface than 1-D Geophysical Survey.

***Keywords***: Applied geophysics; Earth science; Geo-physical survey; Metamorphic rocks.

***Abbreviations***: O.O.U - Olabisi Onabanjo University; VES - Vertical Electrical Sounding.

## Introduction

Applied geophysics is expanding technically in many directions. Applied geophysics have an opportunity and a responsibility to serve society's needs not only in energy and minerals, but also in vital applications related to water, natural hazards, environmental and geotechnical problems.

The incidence of failed buildings and other superstructures is common. These failures result from lack of consideration for the geological materials that make up the subsurface on which the structures rest. Poor foundation designs and the use of inferior building materials are some important reasons for building and foundation failures (Olatunji *et al*., 2010). Some earth materials, due, to their nature, cannot firmly support solid and rigid structures; among these materials are clays and clay-bearing earth. On the other hand, however, earth materials such as sands and basement rocks could provide firm support for solid foundations (Sutrisna *et al*., 2005).

The study which is conducted for aimed at the characterization and establishes the suitability of the subsurface materials that underlie the site of the proposed administrative building at main campus of Olabisi Onabanjo University, Ago-Iwoye, Nigeria.

### Location of the Study area

Olabisi Onabanjo University (O.O.U) main campus is located within the crystalline basement complex terrain of the south western Nigeria. The study area is perfectly located between longitude $3^{0}52^{I}$E and $3^{0}53^{I}$E and latitude $6^{0}54.5^{I}$N and $6^{0}56^{I}$N (Fig.1). The entire campus covers an area extent of approximately 43.5km$^{2.}$

### Geology of the study area

Rocks found in the study area are mainly metamorphic rocks of the gneiss family and they are of 4 types which includes;

*Table 1.* Qualitative and Quantitative Interpretation of VES curves

| VES no | No of layers | Resistivity (Ωm) | Thickness (M) | Depth (M) | Inferred lithology |
|---|---|---|---|---|---|
| 1 | 1 | `308.4 | 0.7 | 0.7 | Topsoil |
| | 2 | 112.2 | 2.8 | 3.6 | Sandy clay |
| | 3 | 1098.0 | 15.0 | 18.6 | Fresh bedrock |
| | 4 | 414.7 | - | - | Fractured basement |
| 2 | 1 | 385.5 | 1.0 | 1.0 | Topsoil |
| | 2 | 379.8 | 1.2 | 2.2 | Sandy clay |
| | 3 | 84.9 | 38.0 | 41.2 | Clayey |
| | 4 | 1925.0 | -- | -- | Fresh basement |
| 3 | 1 | 539.9 | 1.9 | 1.9 | Topsoil |
| | 2 | 136.1 | 16,3 | 18.2 | Sandy clay |
| | 3 | 96.1 | 7.8 | 26.0 | Clayey |
| | 4 | 1048.9 | -- | -- | Fresh basement |
| 4 | 1 | 369.9 | 1.7 | 1.7 | Topsoil |
| | 2 | 104.3 | 0.8 | 2,5 | Sandy |
| | 3 | 51,6 | 3.2 | 5,7 | Clay |
| | 4 | 353.6 | -- | -- | Fractured basement |

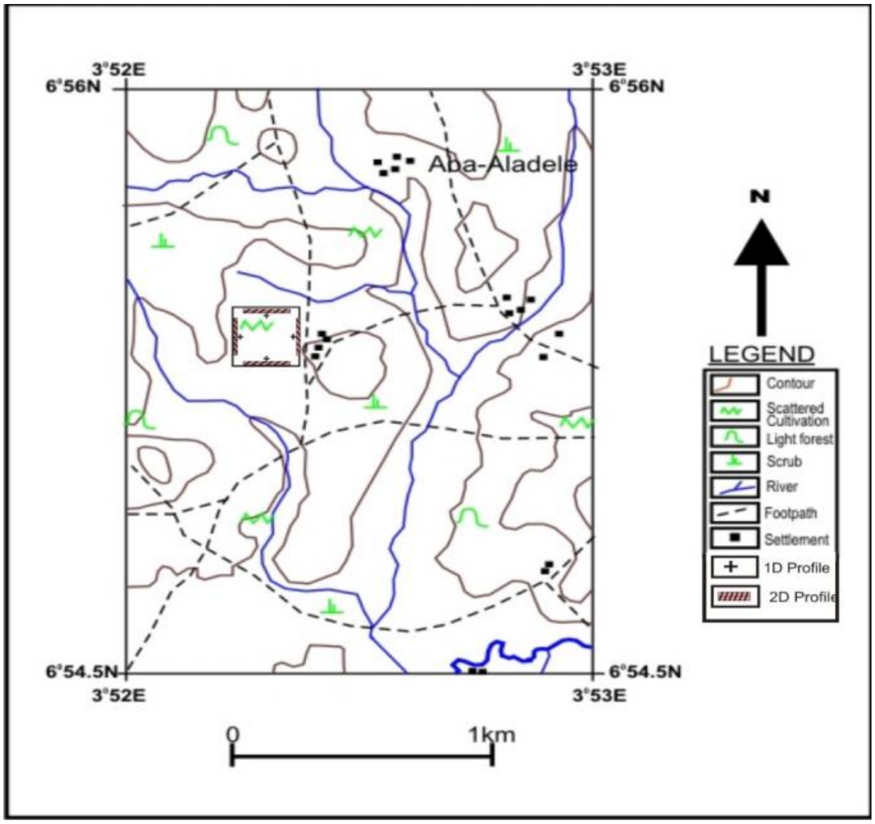


*Fig.1.* Location of study area Olabisi Onabanjo University (O.O.U) main campus

i. Porphyroblastic gneiss
ii. Quartzite schist
iii. Banded gneiss
iv. Biotite-hornblende granite

## Material and methods

The methods adopted for this study include:

i. Vertical Electrical Sounding method, using Schlumberger Array

ii. 2-D resistivity imaging using the Dipole-Dipole

iii. 2-D resistivity imaging using the Wenner Array

Electrical resistivity method involves the measurement of the apparent resistivity of rocks and soil as a function of depth or position. The common techniques used in hydro-geologic and environmental investigations are Vertical Electrical Sounding and Resistivity Profiling.

The major advantage of the 2-D resistivity survey is that it takes care of the limitation of the 1-D resistivity survey by taking into consideration horizontal changes as well as the vertical changes in the layer resistivity as the resistivity changes in both directions along the survey line. It is therefore a more accurate model of the subsurface. Two-dimensional electrical imaging/topography surveys are usually carried out using a large number of electrodes, 25 or more, connected to a multi-core cable (Tse *et al*., 2005).

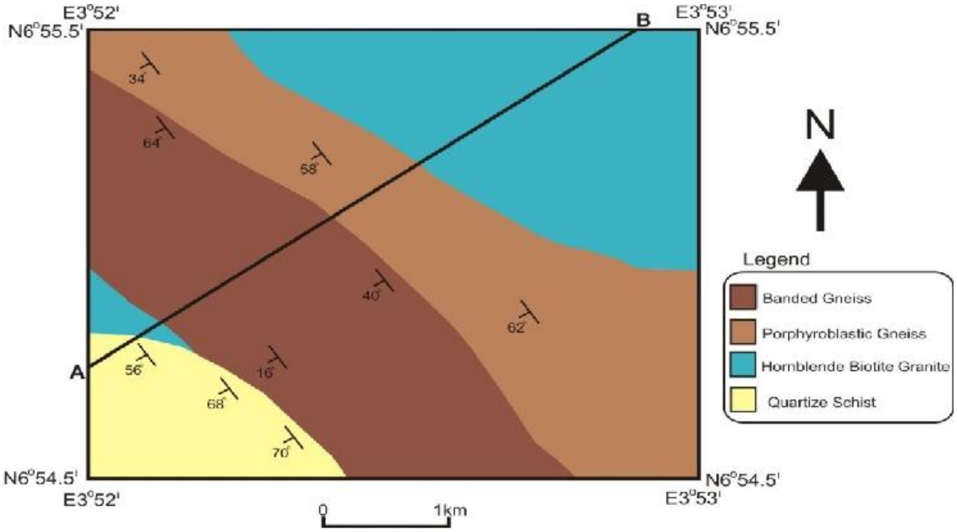


*Fig.2a.* For a system with 20 electrodes as shown in the Figure above, firstly 19 of measurements with a spacing of “la” is made, followed by 18 measurements with “2a” spacing then by 17 measurements with “3a” spacing and so on

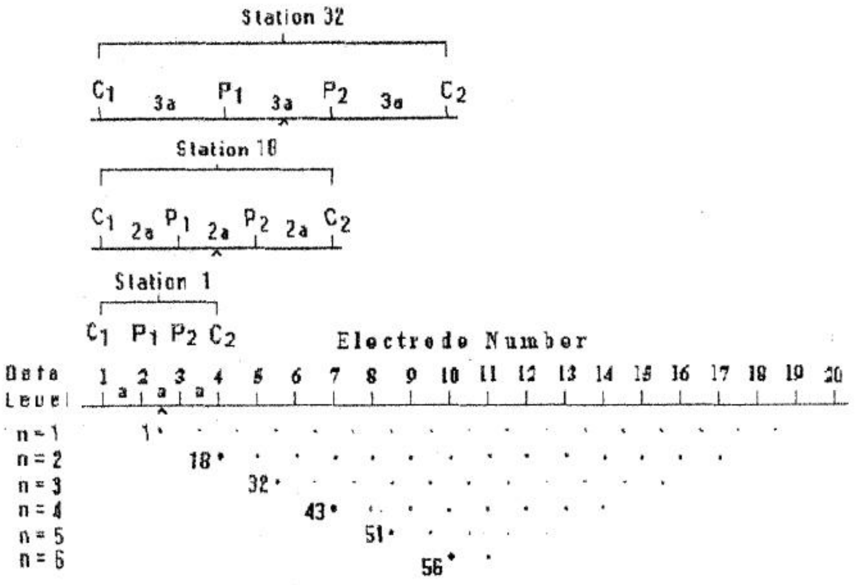


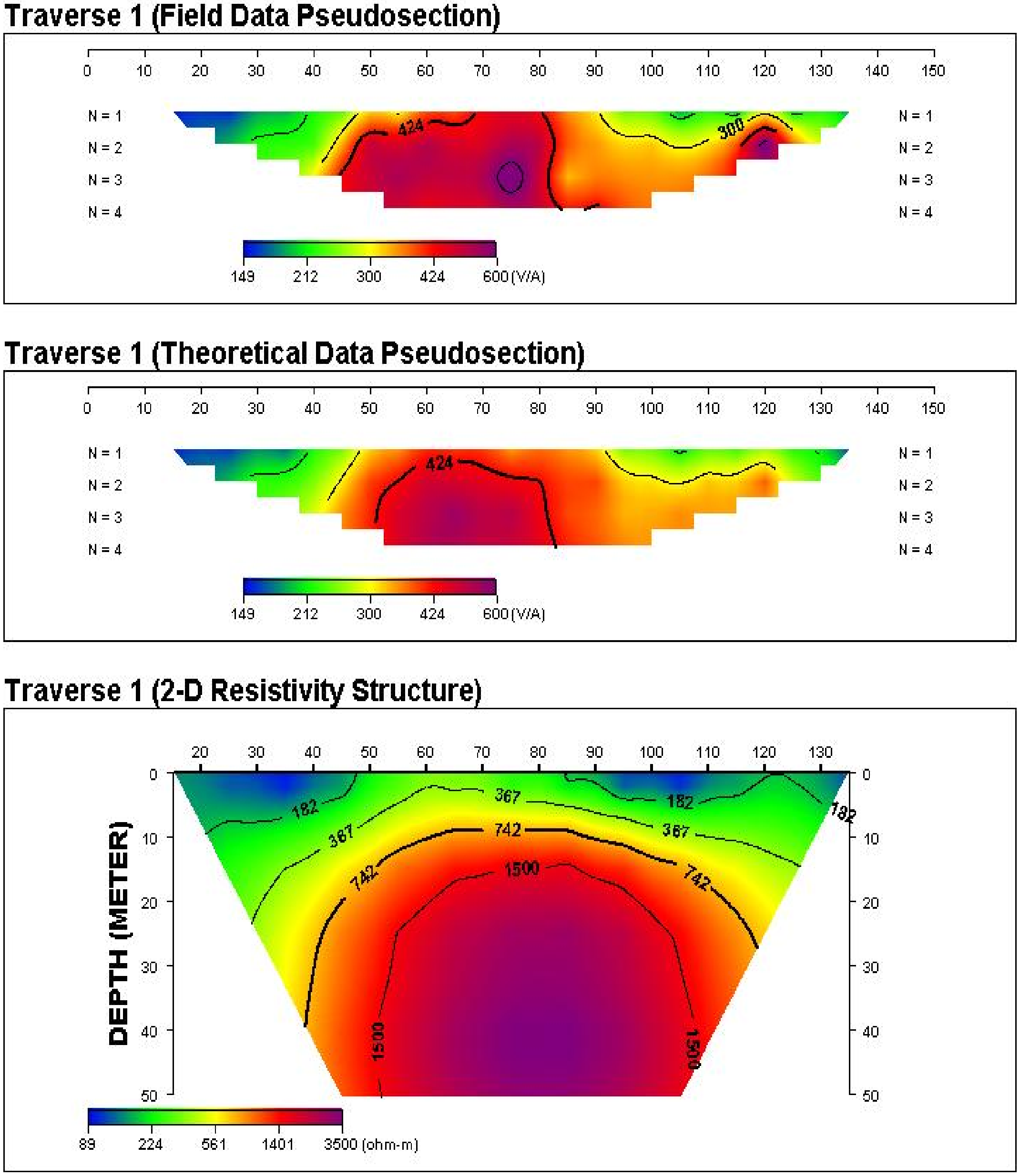
*Fig. 2b.* A typical arrangement of electrodes for a 2-D electrical survey and the sequence of measurements used to build up a pseudosection (Loke, 2004)

For the present work, the Wenner Array and Dipole-Dipole array was used for acquiring the resistivity data. Other arrays being used for acquiring data for 2-D imaging includes the Pole-Pole array, which is similar in operation to the Wenner Array, the Dipole-Dipole, Wenner Schlumberger and the Pole-Dipole array, which has a slightly different survey procedure to that of the Wenner and Pole- Pole array. A possible sequence of measurements for the Wenner electrode array for a system with 20 electrodes is shown in Fig.2a & 2b. Normally a constant spacing between adjacent electrodes is used.

## Results and Discussion

The results and discussions of the geophysical studies conducted on this site are hereby presented. Specifically, these include the geophysical measurements Vertical Electrical Sounding (VES) and the 2-dimensional imaging survey. The results of the geophysical studies showed that four distinct geoelectric layers underlies the site. After applying the curve matching techniques and computer iteration program for the ID (VES), the results obtained as shown in Table 1 revealed the geo-electric parameters of the various layers. From Table 1, the four layers for the VES are Top Soil, Sandy Clay, clay, Fractured and Fresh Bedrock.

The Depth to Bedrock at the site ranges from 3.6m at location 1 (VES1) to 41.22m at location 2 (VES2) with a Mean of 23.61m. This depth to Bedrock corresponds to the depth of weathering i.e. the thickness of the overburden. The Topsoil layer at the site has a thickness ranging from 0.7m to 1.9m and a Mean of 1.33m. The Sandy Clay is the largest layer at the site which has a thickness ranging from 2.8m to 38.0m and a Mean of 15.1m. Although the Fresh Basement (Bedrock) thickness cannot be estimated, it was encountered around 7.8m to 38.0m in VES3 and VES2.


Traverse 1 (Field Data Pseudosection)

Traverse 1 (Theoretical Data Pseudosection)

Traverse 1 (2-D Resistivity Structure)

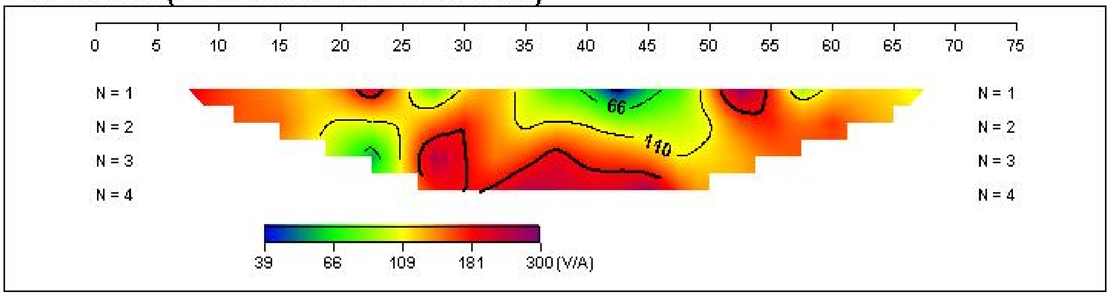
*Fig. 3a.* Resistivity data along profile 1

The presence of clays in the subsurface configuration is particularly critical to the stability of the proposed structure. This is because clays absorb water and retain soil in their complex chain structures and only release the water slowly under pressure. It is a known fact that clays swell after absorbing water and shrink when the absorbed water is released. Therefore, structures that rest on this type of materials are raised on swelling and drops when shrinking takes place. This process of raising and dropping contributes significantly to the failure of structures and will manifest in wall cracks and in severe cases leading to outright superstructure failure. The Sandy and Fresh Bedrock layer can both sustain the structures effectively.

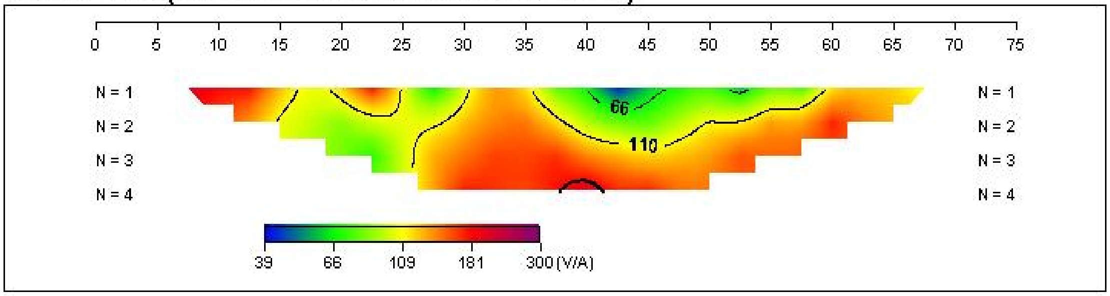
### For the 2-D

#### *Traverse one*

Traverse 2 (Field Data Pseudosection)



Traverse 2 (Theoretical Data Pseudosection)



Traverse 2 (2-D Resistivity Structure)

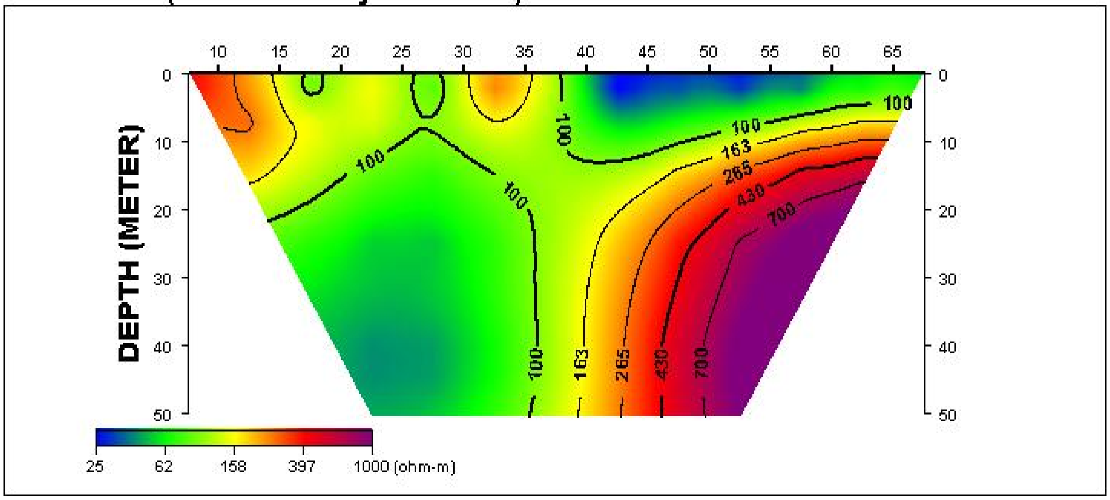


*Fig. 3b.* Resistivity data along profile 2

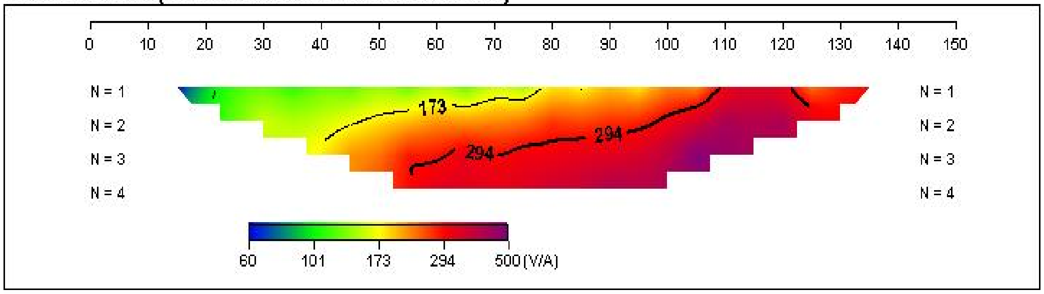
The 2-D inverted resistivity shows four layers as reviewed in the Fig.3(a). The resistivity of the first layer (Top soil) ranging from 0 to 182Ωm; terminating around station50, extending through station85 to 135 at about 2m above the subsurface. The second layer is a weathered basement (sandy), which has resistivity values ranging from 182Ωm to 367Ωm and to depth of 25m. The third layer is partially weathered (sandy), which has resistivity values ranging from 367Ωm to 742Ωm and with depth of 35m. The fourth layer is fresh bedrock, which has resistivity values ranging from 742Ωm to 3500Ωm and with depth of 28m to the bedrock. The fresh bedrock signifies that this place is devoid of geologic features therefore suitable for foundation structure. At station 50-85, this is the second layer (good for foundation structure).

The lateral and vertical movement of these materials shows relative difference in geologic materials, from station 0 to 48 and 90 to 135 along profile 1. The foundation should be dug to 2.5m and from station 50-85, the foundation can be dug to just 1.1m (because the competent layer is showing at the surface) to sustain a good building.

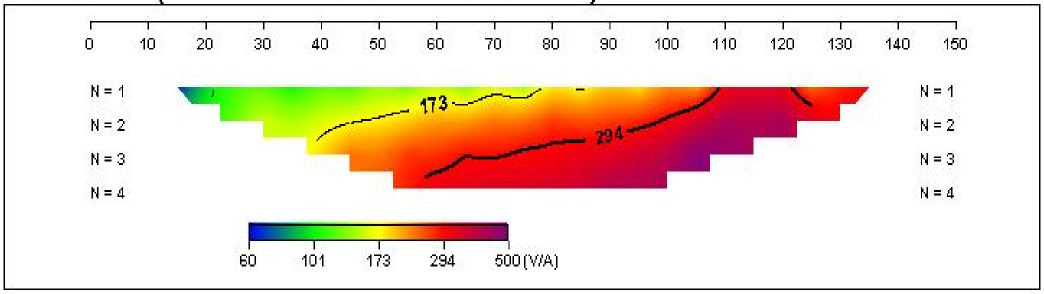
### *Traverse two*

This transverse shows different features which make it less useful for geotechnical studies; a major fracture extends from station 15 to 65 laterally Fig.3(b). There are four layers observed in this

Traverse 3 (Field Data Pseudosection)



Traverse 3 (Theoretical Data Pseudosection)



Traverse 3 (2-D Resistivity Structure)

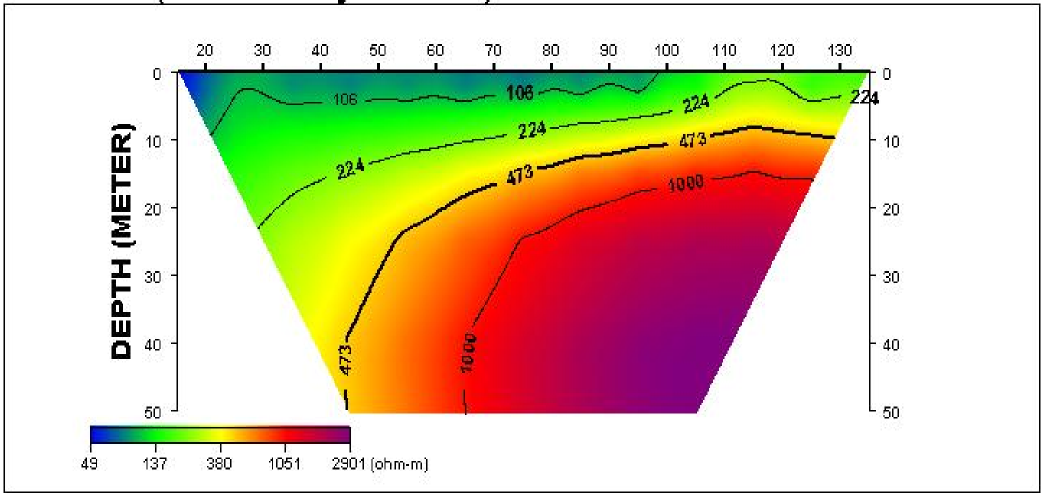


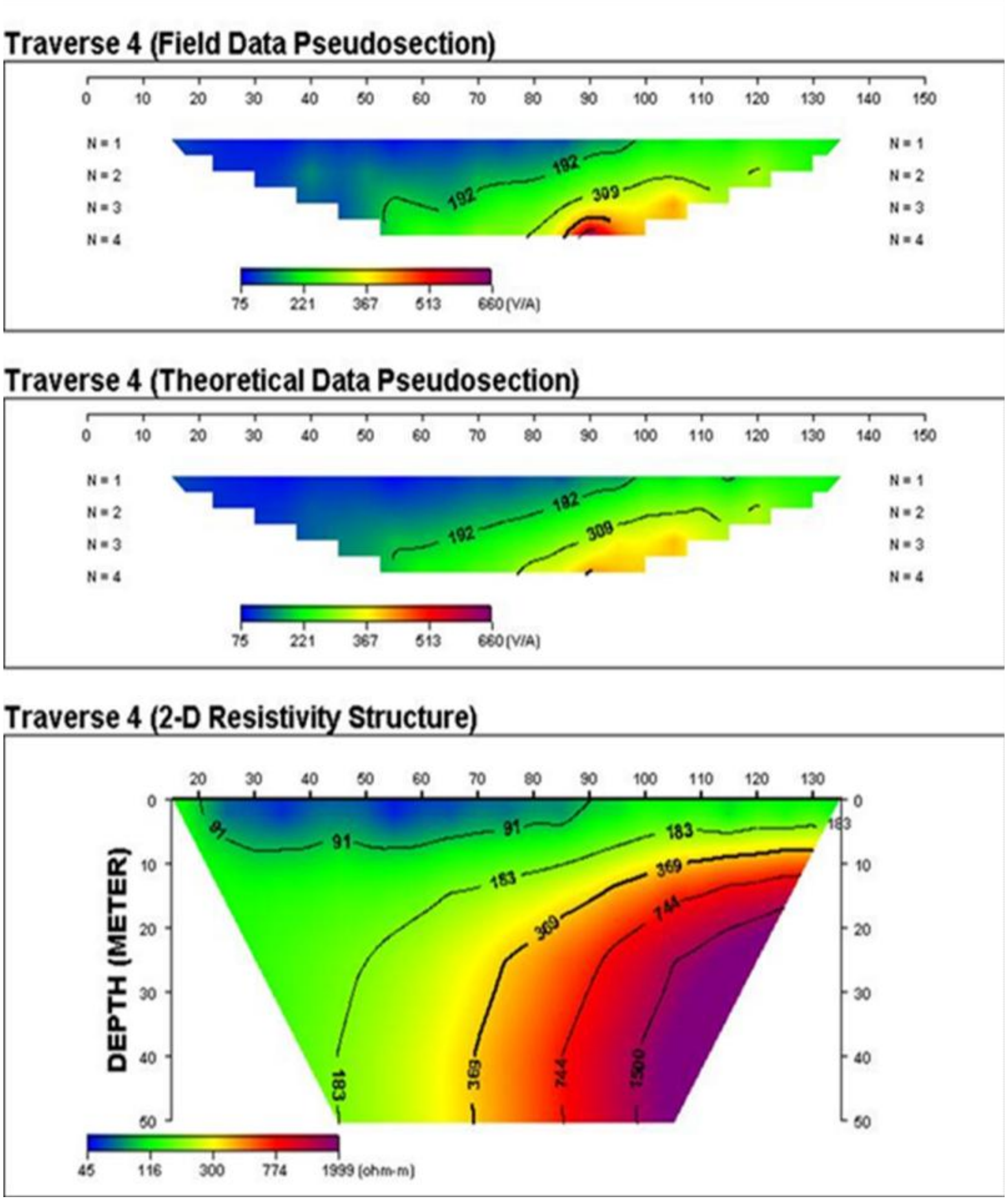
*Fig. 3c.* Resistivity data along profile

transverse. The top soil with relative low resistivity value of blue coloration with values ranging from 25Ωm to 40Ωm; showing clayey materials can be seen moving from station 40 to 60 on the subsurface at a depth of 2.5m above the subsurface.

The most conspicuous layer shows weathered region with resistivity ranging from 62Ωm to 163Ωm which extends laterally from station 15 to 65 above and moving down to a depth of 50m above the sub surface. This place is good for hydrological zone which gives a good yield in borehole drilled in this area. The weathered basement is seen towards the south western part of this area, with increasing resistivity ranging from 163Ωm to 265Ωm with a thin layer of yellow coloration. The last layer is fresh bedrock, which can sustain the building with resistivity ranging from 265Ωm to1000Ωm. The 2-D inverted resistivity structure shows that this region is very good for underground water development but not for structural foundation.

### *Traverse Three*

The first layer (Top Soil) has resistivity values ranging from 0 to 106 Ωm terminating at station 100 at about 2.3m above the subsurface Fig.3c. The second layer is a weathered basement (Sandy), which has resistivity values ranging from 106Ωm to 224Ωm and with depth of 32m to the bedrock. The third layer (partially weathered), has resistivity values ranging from 224Ωm to 473Ωm and with depth of 7m to the bedrock. The fourth layer is fresh bedrock, which has resistivity values ranging from 473Ωm to 2901Ωm and with depth of 1.0m to the fresh basement. At station 0 to 100, the foundation should be dug to 2.4m and from station 100 to 135, the foundation can be dug to just 1.2m to give a good structure of the building.


Traverse 4 (Field Data Pseudosection)

Traverse 4 (Theoretical Data Pseudosection)

Traverse 4 (2-D Resistivity Structure)

*Fig. 3d.* Resistivity data along profile 4

### *Traverse four*

The 2-D inverted layer resistivity shows four layers as revealed in the Fig.3(d). The resistivity of the first layer (Top soil) is ranging from 0 to 9IΩm; terminating at station 90 and with depth of 3m above the sub-surface. The second layer is a weathered basement (Sandy), has resistivity values ranging from 91Ωm to 183Ωm and with depth ranging from 0m to the basement (Westside of the profile). The third layer is partially weathered (also Sandy) with resistivity value ranging from 183Ωm to369 Ωm and depth 6m to bed rock (also to the west side of the profile 4). The last layer is fresh bedrock which signifies that this particular place is devoid of geologic features; the resistivity values ranging from 369Ωm to 1999Ωm with depth ranging from 8m to fresh basement. At station 0 to 20, the foundation can be dug to 1.2m. At station 20 to 90, the foundation should be dug to 3.3m and at station 90 to 135, the foundation should be dug to 2.2m to sustain a good building.

## Conclusion

Four distinct layers exist in the subsurface and these are Top Soil, Weathered Layer, Fractured and Fresh Bedrock. The Clays lying within the top of each profile constitute the only source of concern with regards to the foundation and the stability of the super structures to be erected at the site. It is thus suggested that an admissible bearing pressure could be adopted if the footing is established below 2.0m.

## Recommendation

It is recommended that the foundation should be set below the Sandy Clay layer and this can be achieved by excavation of the foundation lines and lying of concrete bases. However, if for any reason the foundation is set above the sandy clay, a raft foundation mesh should be used and in addition to this mesh, weep pipe (PVC) holes should be put in place to drain storm water away from the clay into a drainage system.

## References

1. Olatunji OA, Sher W and Gu N (2010) Building information modeling and quantity surveying practice. *Emirates J Eng Res*, 15(1), 67-70.
2. Sutrisna M, Buckley K, Potts K and Proverbs D (2005) A decision support tool for the valuation of variations on civil engineering projects. *RICS Research Papers*, 5(7), 1-41.
3. Tse TK, Wong AK and Wong FK (2005) The Utilisation Of Building Information Models In nD Modelling: A Study of Data Interfacing and Adoption Barriers. *Info Technol Constr J*, 10, 85-110.