Geophysical Investigation for Pre-Foundation Studies at RCCG, Calvary Love Parish 2, Ukpenu, Ekpoma, Edo State, Nigeria

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Abstract: - **The research was carried out within the Sedimentary terrain of RCCG, Calvary Love Parish 2, Ukpenu, Ekpoma, Edo State, Nigeria. The geophysical investigation involved the Vertical Electrical Sounding (VES) technique using the Schlumberger configuration and Dipole-Dipole Horizontal Profiling. The traverses were established E – W direction cutting across geologic strike. A total of two traverses were established with total length of 90 m and of varying inter-traverse spacing. A total of four (4) VES stations were occupied covering the entire study area. The acquired data were processed and interpreted integrally to elucidate the shallow subsurface geology of the study area. The results were qualitatively and quantitatively interpreted and are presented as sounding curves and geo-electric sections. The results obtained from the VES delineated three geoelectric units which comprise of topsoil, clayey sand and sandstone formation. The 2 D imaging (Dipole-Dipole) gave information on the subsurface characteristic in the area with low apparent resistivity which indicates low competence material. The geophysical data collected using these techniques were processed and interpreted to image the subsurface lithologies of the investigated area. However, various weak zones were delineated by the two techniques and from the comprehensive interpretation it is deduced that the building can fail, if it is constructed within incompetent clay materials and lateral inhomogeneity. The choice of foundation materials, clay content and topography elevation should be put into consideration.**

Key Word: **Geoelectric Section, Dipole Dipole, incompetent materials, foundation integrity**

I. INTRODUCTION

The statistics of failure of structure such as buildings, roads, dams and bridges throughout the nation has increased geometrically (Akintorinwa and Adelusi, 2009). Therefore the usefulness of geophysical investigation in engineering sector of our economy cannot be overemphasized. (Ilugbo *et al.,* 2018b). In recent years, many engineering professions such as civil, geotechnical and electrical engineers have come to realize that geophysical investigation is very important, as the information it furnishes assist these professional in the design process of structures and utilities. (Ozegin *et al.,* 2019). The applications of geophysical methods have been increasing in site characterization throughout state and federation (Ilugbo *et al.,* 2018a). The success in the applicability of geophysical techniques depends on so many factors. The most important is the existence of a significant and detectable contrast between the physical properties of the different units in the subsurface, such as velocity, electrical resistivity, conductivity, density, acoustic properties, subsurface geology and the environmental conditions (Akintorinwa and Adesoji, 2009). Despite this rapid growth and development, the impact of subsurface geologic structures in the area on the durability and easy maintenance of the erected structures have been seldom discussed. Vertical and near vertical cracks or discontinuities have been noticed in the walls of both old and recent buildings (Bayode *et al.,* 2012). This assertion can be attributed to the minimal attention paid towards the use of geophysics in foundation studies. In Engineering Geophysics and site investigation, structural information and physical properties of a site are sought (Sharma, 1997). This is so because the durability and safety of the engineering structural setting depend on the competence of the material, nature of the subsurface lithology and the mechanical properties of the overburden materials (Adelusi *et al.,* 2014). Foundations are affected not only by design errors but also by foundation inadequacies such as siting them on incompetent earth layers (Ilugbo *et al.,* 2018a). This research is therefore targeted at revealing the use of electrical resistivity approaches as protective and repair measures to limit the detrimental effects of these natural or imposed processes, and prolong the useful life of the buildings. Since every engineering structure is seated on geological earth materials, it is imperative to conduct pre-construction investigations of the subsurface of a proposed site in order to ascertain the strength and fitness of the host materials as well as post-construction monitoring of such structure to ensure its integrity.

II. SITE DESCRIPTION AND GEOLOGY OF THE STUDY AREA

The studied area is located within Ekpoma, Edo State along Ukpenu at RCCG, Calvary Love Parish 2 (Figure 1). It is situated between the UTM coordinates of Eastings 745100 - 745220 m and Northings 182600 - 182720 m. The elevation ranges from 241.5 to 425.7 m above the sea level. The accessibility of the study area is mainly by road and footpaths.

The study area falls within the Anambra Basin covering Eguare Ekpoma town and Ukpenu extension in Esan West Local Government area of Edo State, Nigeria (Figure 2). Three major formations underlain the study area vis-à-vis Imo shale, Bende-Ameki formation and Ogwashi-Asaba (Okeke, 2011, Aigbedion, 2007, Kogbe, 1978 and Salufu, 2014). The area of study is underlain by Bende – Ameki formation while the nearby area is underlain with 3% of Imo shale and Ogwashi – Asaba. The area is underlain by clay, shale, sandstone, limestone and sand. The Niger Delta sediment include Benin, Agbada and Akata formations and they range in age from Eocene to recent (Aigbedion , 2007).

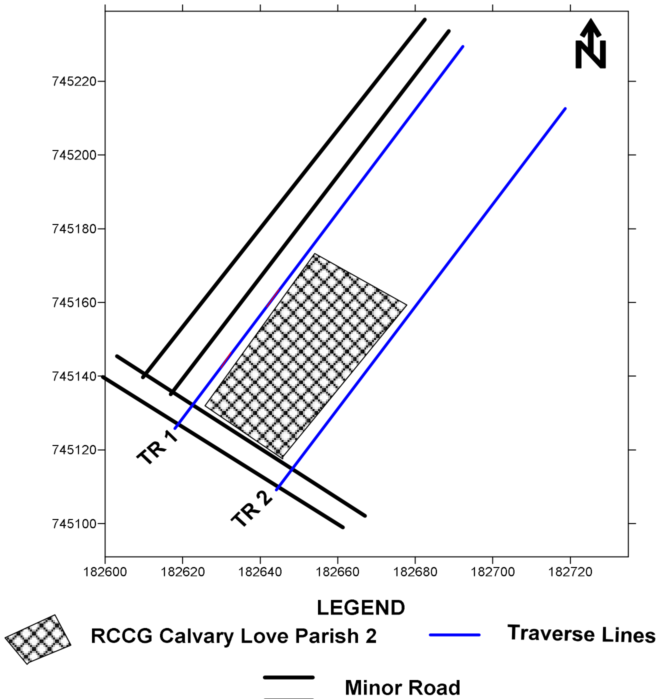

Figure 1. Base Map of the Study Area

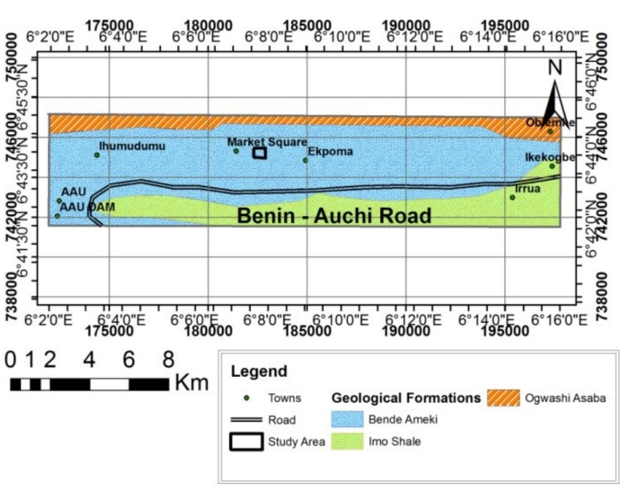

Figure 2. Geological Map of Ekpoma Showing the Study Area (modified after Salufu and Ujuanbi, 2015)

III. METHODOLOGY

The method that was used in this study is Electrical Resistivity method using two techniques viz; Vertical Electrical Sounding (VES) and 2-D Electrical Resistivity Tomography (ERT) with the corresponding configurations, Schlumberger and Dipole-Dipole respectively (Figure 3). Resistivity values were obtained by taking readings using the R50 resistivity meter. Four (4) sounding stations were occupied along the traverses, and the current electrode spacing (AB/2) was varied from 1 to 40 m. To process the electrical resistivity data, the apparent resistivity values were plotted against the electrode spread (AB/2). This was subsequently interpreted quantitatively using the partial curve matching method and computer-assisted 1-D forward modeling with WinResist 1.0 version software. The dipole-dipole data were inverted using 2-D subsurface images using the DIPPRO™ 4.0 inversion software. The inter-electrode spacing of 5 m was adopted while inter-dipole expansion factor (n) was varied from 1 to 5. The results from the two techniques were integrated in order to determine detailed pre-foundation studies before any building construction work is embarked upon for safety, sustainability and economic survival.

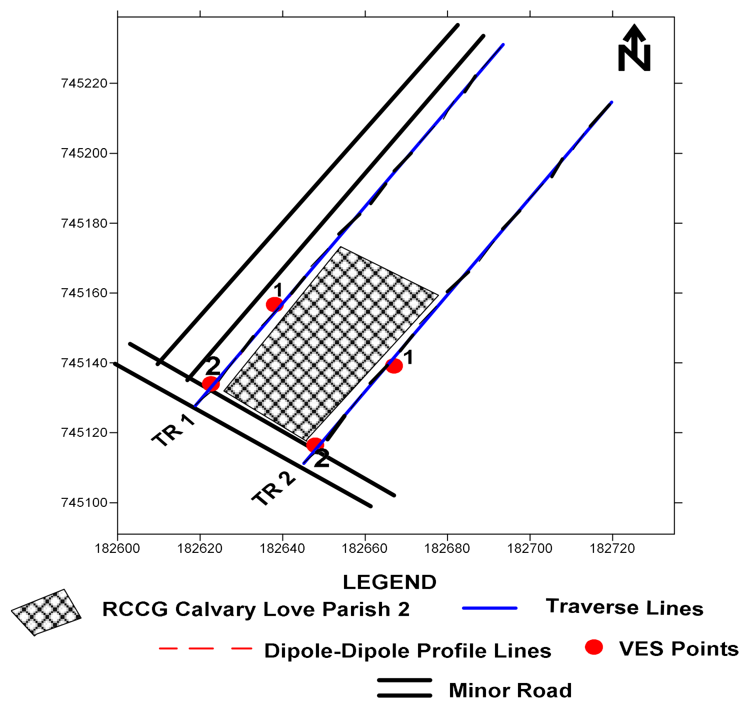

Figure 3. Data Acquisition Map of the Study Area

IV. RESULTS AND DISCUSSION

The results of the study were presented as Sounding curves geo-electric sections and pseudo sections.

Characteristic of the VES Curves

Curves types identified ranges from H and HK varying between three to four geo-electric layers. Typical curve types in the area are as shown in Figure 4(a-b).

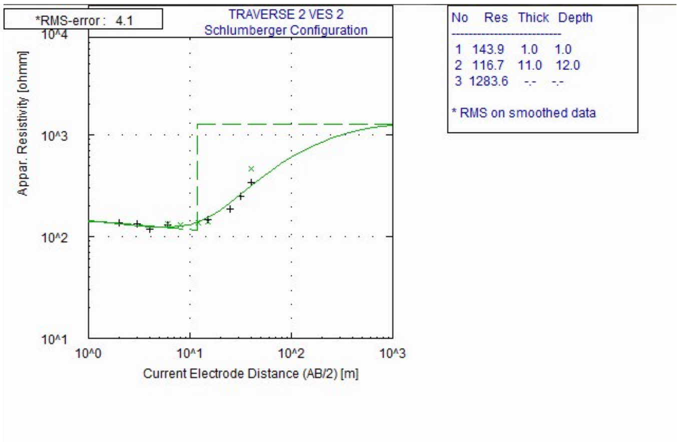

Figure 4a. Typical 'H' sounding curve

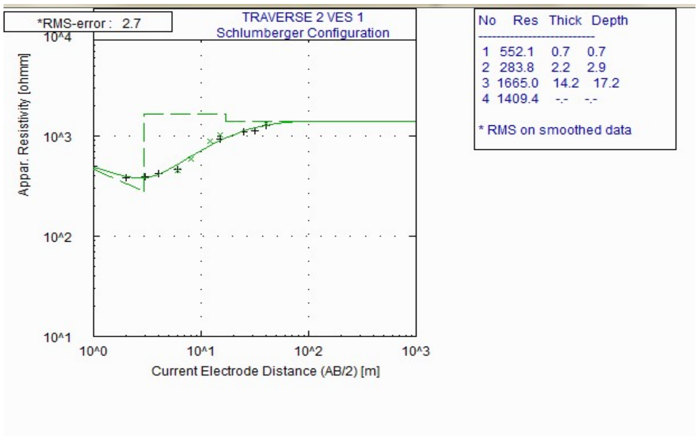

Figure 4b. Typical 'HK' sounding curve

Geoelectric and Lithological Characteristic along the Three Traverses

In order to have better understanding of the nature of the lithologies underlying the study area, and to have a detailed description of the lateral and vertical variation in resistivity, thickness and topography of the subsurface lithologies, the VES interpretation results were used to prepare two (2) geoelectric sections across the study area, that align approximately along E-W direction as shown in the Figure 5a to 5b. The geoelectric sections of the study area show a total of three subsurface layers namely: the topsoil, clayey sand and sandstone. The topsoil comprising of clay, clayey sand, sandy clay and sand with the resistivity values ranges from 142 to 552 Ω-m with its thickness varies from 0.7 to 1.2 m, the clayey coarse sand comprises of clay, clayey sand and sand with resistivity values range from 115 to 291 Ω-m and thickness ranges from 2.2 to 11 m while the sandstone layer resistivity varies from 1187 to1797 Ω-m. The resistivity values of the topsoil are indicative of clay, sandy clay, and clayey sand. This layer may not be of any particular interest since topsoil is usually excavated. Hence, foundation of the proposed structures cannot be found on this layer.

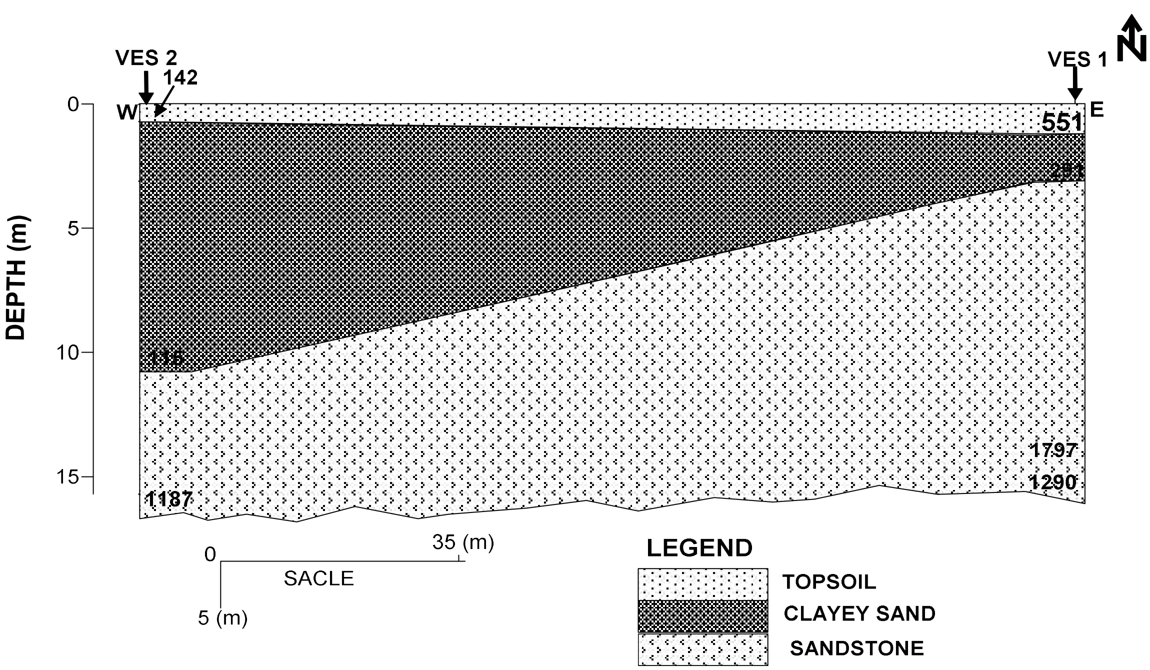

Figure 5a. Geoelectric Section along traverse one

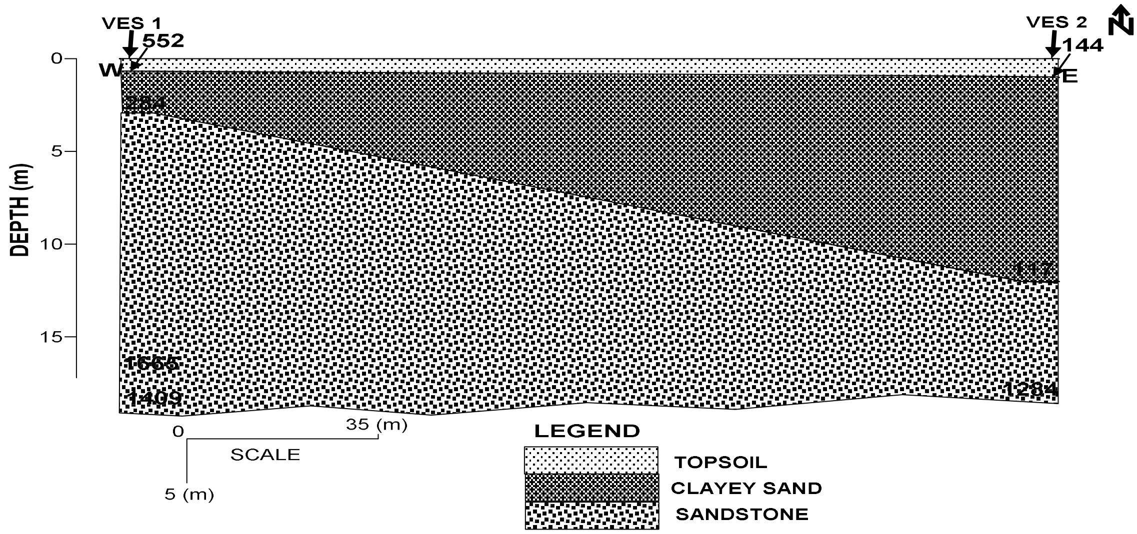

Figure 5b. Geoelectric Section along traverse Two

Dipole-dipole Pseudosection

The 2-D Pseudosection was produced from the dipole-dipole data taken along the two (2) traverses Figure 6 (a-b). The Dipole-Dipole traverses covered a distance of about 90 meter along East to West Orientation. It delineated three to four major subsurface material/layer components, identified with various colour for easy characterisation; The layer lithological materials varies from Topsoil comprises of clay, clayey sand and sandy clay material as indicated in green/blue colour with layer resistivity variation of 93 to 306 Ωm. Following this layer is another characterised by low resistivity variation from 600 to 4707 Ωm with the dominant resistivity being between 5000 Ωm and 246122 Ωm. These are as characterised by lithologic units that can be classified sandy shales, and shaly sands, with layer thickness varying from 1 to 10 m they are indicated with green, light green, and green/blue colour. These zones are characteristically weak and made up of attributes of low foundation integrity. The few zones with materials of high/moderate integrity can be found around the pegging of the traverse within 40 to 95 m to a depth of 5 m along traverse one and two.

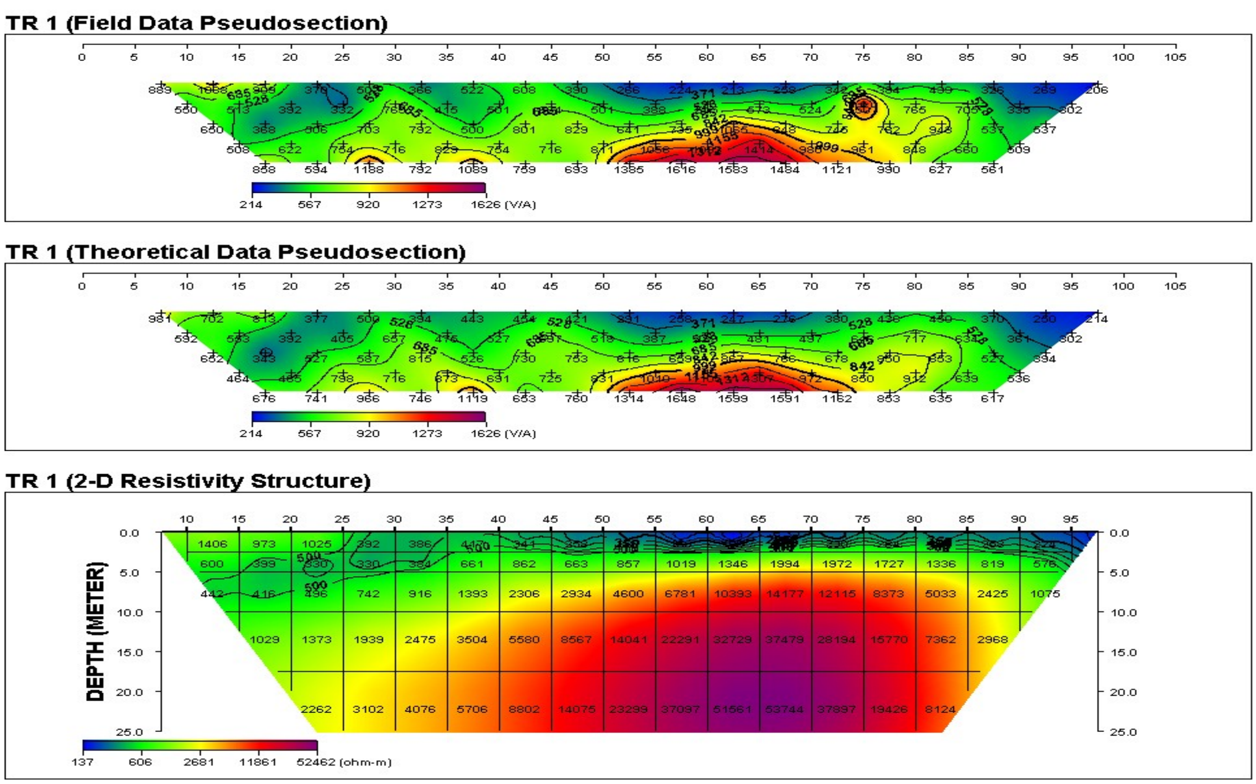

Figure 6a. Dipole – Dipole Pseudo-section along Traverse One

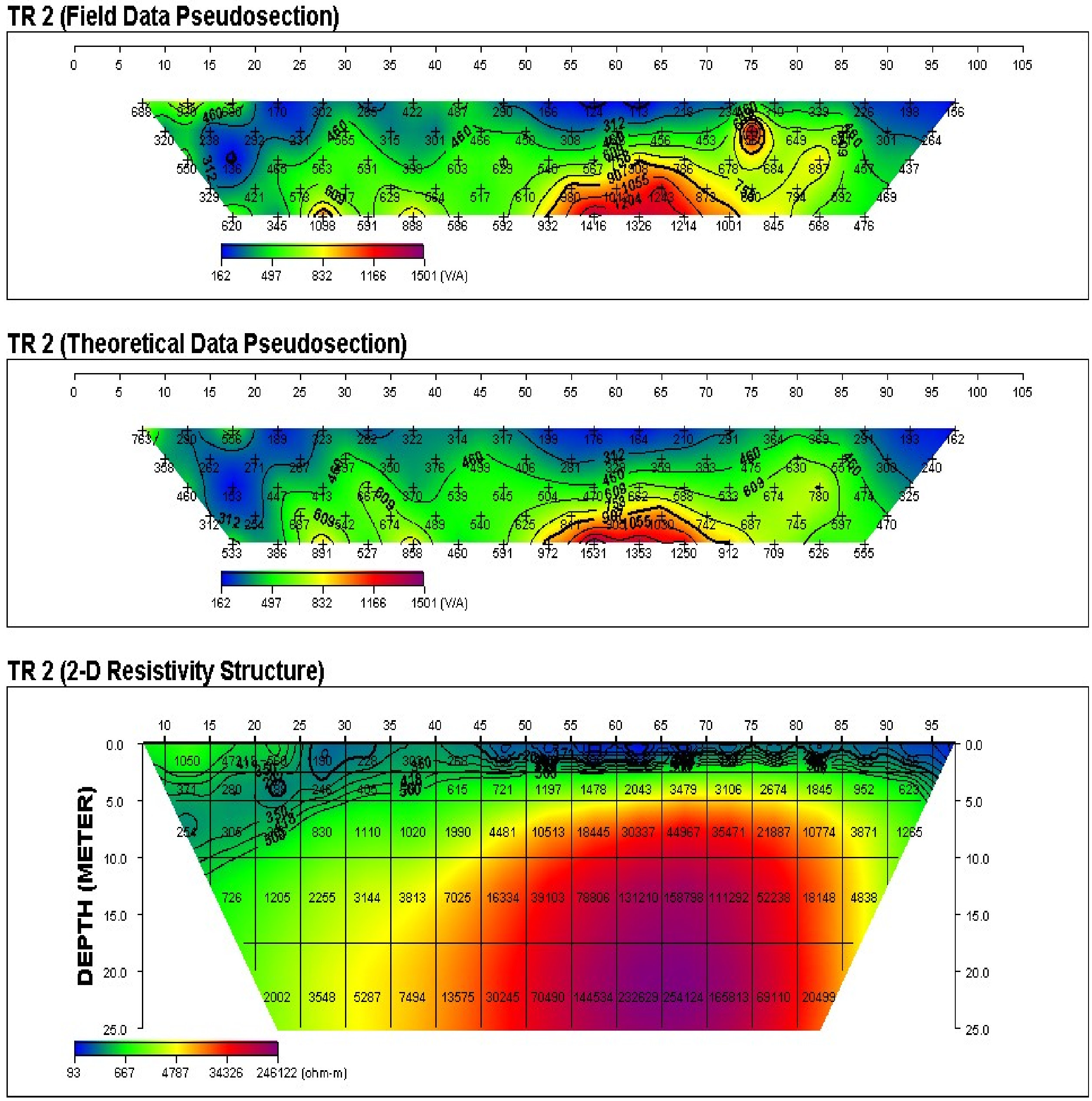

Figure 6b. Dipole – Dipole Pseudo-section along Traverse Two

Synthesis of results

Figure 7 and 8 displays the correlation of result obtained from the electrical resistivity techniques. The geoelectric section at a distance 25 to 35 m demonstrated weak zone which also coincides with Dipole – Dipole Pseudo-section (Figure 7). This also agrees with the low resistivity zone observed on the dipole-dipole pseudo-section at a distance 25 to 35 m and geo-electric section which indicate low integrity and high susceptibility to failure, if the structure is lay within this zone (Figure 8). Correlating the electrical resistivity methods employed along traverses one and two highly show a weak zone. These weak zones will contribute a great deal to any structure within this zone. The result shows that clay/shale and clayey sand is more predominant within the study location which is the major factor and a challenge responsible for 90% problem of construction. These results reveal that the techniques used for this study are complementary.

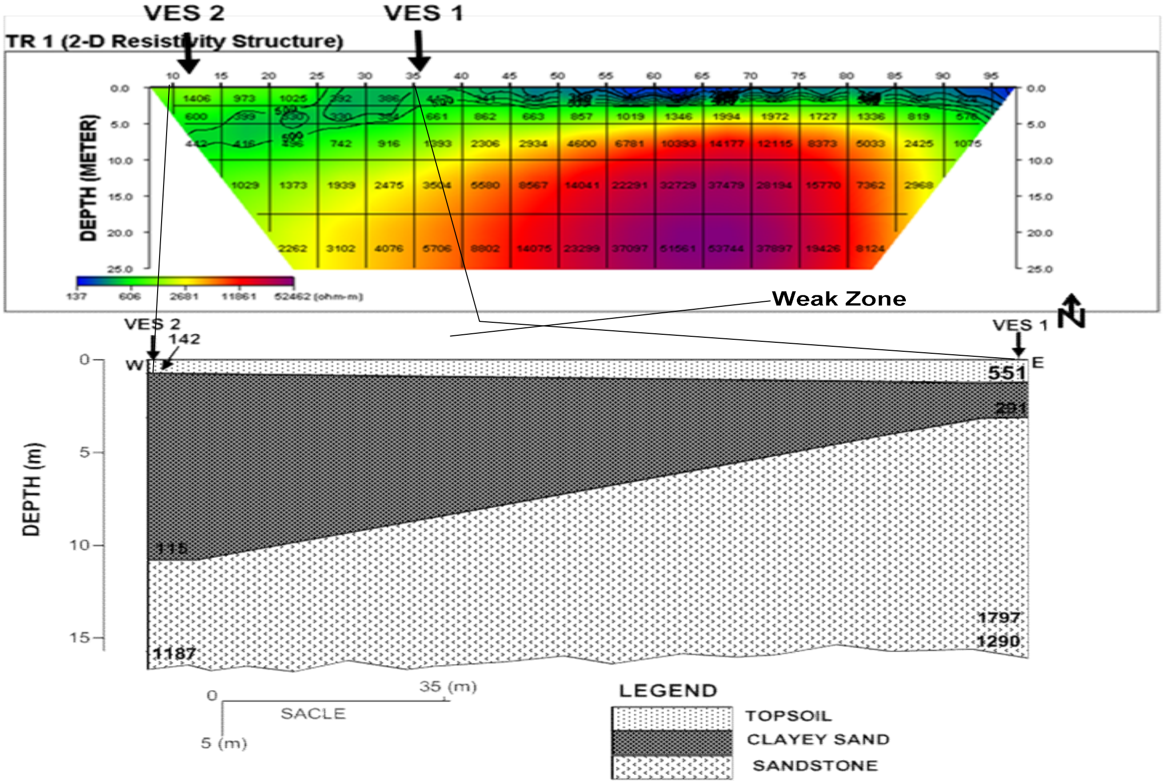

Figure 7. Correlation of Results along traverse one

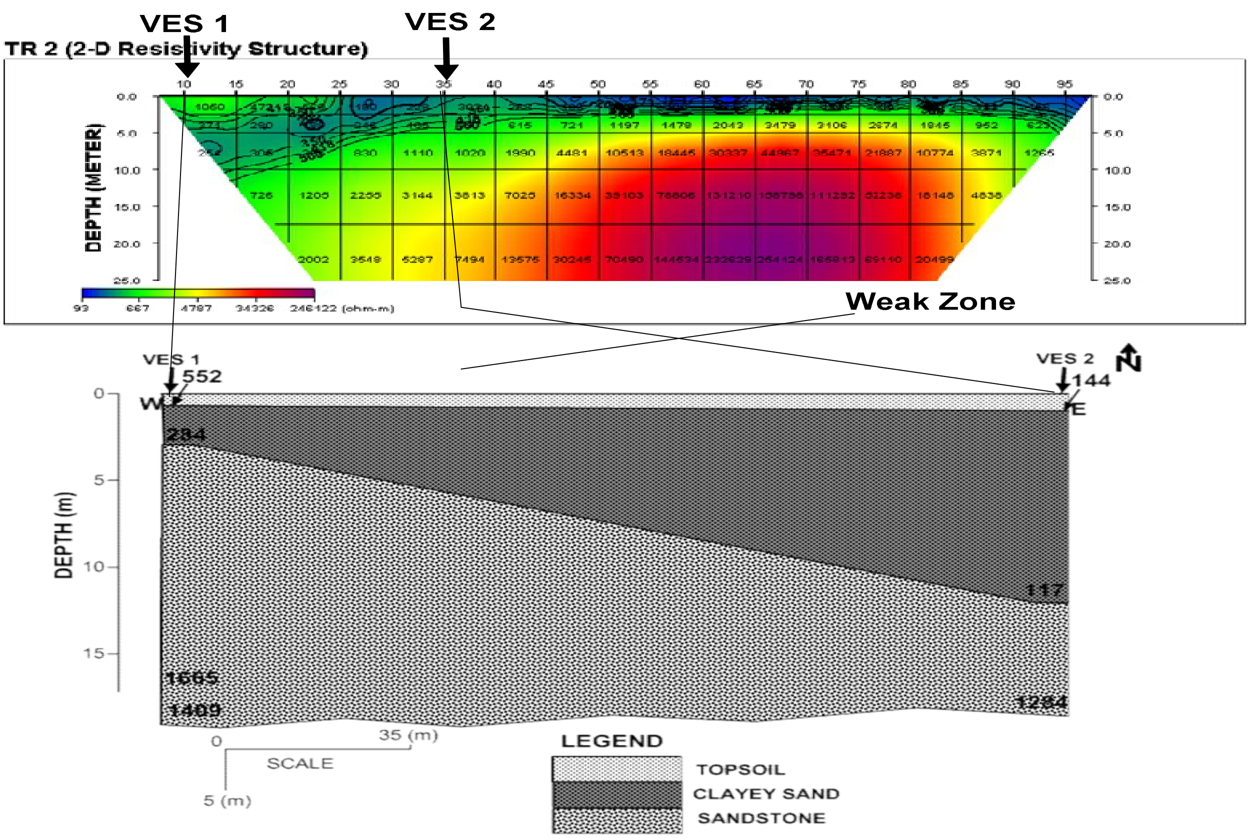

Figure 8. Correlation of Results along traverse two

V. CONCLUSION

The study has shown the relevance of geophysical site study for foundation design consideration. Geophysics, therefore, remains a very vital tool which can be applied in civil engineering work. The investigation delineated three significant layers which are topsoil, which will be excavated before any foundation can be laid. The second layer delimited was clayey sand, and the last was sandstone. Some of the sounding curves generated over the VES stations and Dipole-Dipole Horizontal Profiling were reasonably correlated with each other. The geophysical data collected using these methods were processed and interpreted to image the subsurface lithologies of the investigated area. However, various anomalous zones were delineated by the two techniques and from the comprehensive interpretation it is deduced that the building can fail if it is constructed within incompetent clay materials and lateral inhomogeneity. The choice of foundation materials, clay content and topography elevation should be put into consideration. The results also define geological linear features suspected to be fracture/ fault/ lithological contact. These are weak zone that are inimical to stability of any civil engineering structures.

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