GEOPHYSICAL INVESTIGATION OF PRE-BUILDING FOUNDATION OF KWARA STATE UNIVERSITY QUARTER USING ELECTRICAL RESISTIVITY METHOD.

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ABSTRACT

Incessant increase of collapsed buildings has raised alarm in our society. Many buildings collapsed due to many factors, in which the foundation is major. If the foundation is weak, the structure placed is in danger. In this research, the foundation of Kwara State University Staff Quarters was investigated before laying the structure on the site location. The electrical resistivity method was used to investigate the subsurface geologic layer with a view to determining the depth to the bedrock and thickness of the geologic layers. Vertical Electrical Sounding (VES) using Schlumberger array was carried out. ABEM terrameter (SAS 300) was used for the data acquisition. The field data obtained was analyzed using computer iterative modeling using the WinResist software. The VES results revealed the heterogeneous nature of the subsurface geological sequence: hardpan topsoil (clayey and sandy-lateritic), weathered layer, partly weathered or fractured basement, and fresh basement. The resistivity value for the topsoil layer varies from 40 Ωm to 450 Ωm with thickness ranging from 1.25 m to 7.5 m. The weathered basement has resistivity values ranging from 50 Ωm to 593 Ωm and thickness of between 1.37 to 20.1 m. The fractured basement has resistivity values ranging from 218Ωm to 520Ωm and thickness of between 12.9 to 26.3 m. The fresh basement (bedrock) has resistivity values ranging from 1215 Ωm to 2150 Ωm with infinite depth. However, the depth from the earth's surface to the bedrock surface varies between 2.63 to 34.99 m. The study stressed the importance of the findings in civil engineering structures.

Keyword: Building foundation, Bedrock, Resistivity, site location.VES.

INTRODUCTION

A building is a walled structure built for use as living, working or storage facility known to provide shelter, comfort or used as a public utility. Buildings among other things can provide socio-economic benefits to the country. The increase in failures of buildings nowadays is so enormous that it has become a serious concern to the professionals in the building industry, clients, governments, and the general public. Most often the geophysicist's input as regards adequate geotechnical report of the project site before, during, and after the construction exercises are neglected. Many lives and properties have been lost and wasted due to incessant collapse of buildings as a result of foundation problems, poor construction practice, and the use of substandard building materials among other things. Building cracks commonly occur due to resultant differential settlement in the subsurface. In order to obtain the desired satisfaction, comfort and safety, every building whether temporary, permanent or monumental structures needs to be properly designed, well planned, constructed and maintained. According to Tim (2002) and Horny (2001), certain clay soils can swell if they get saturated and when there is loss of water in them, they shrink drastically. These expansions and shrinkages of clayey soils can result to cracks on buildings even shortly after they are constructed. The closeness of static water level to the foundation beds could also precipitates foundation instability (Egwuogwu, and Sule, 2012). It is necessary to note that foundation of any structure bears the load. Moreover, building failures can be considered to have occurred in a component when that component can no longer be relied upon to fulfill its principal functions (Horny, 2001). Building failure, according to

Ofomola et al. (2009), is an unacceptable difference between the expected and observed performance of building components. They identified two types of failure in building, which are cosmetic and structural types. Cosmetic failure occurs when something has been added to or subtracted from the building, thus affecting the structures' outlooks. On the other hand, structural failure affects both the outlook and structural stability of the building distinguished between defect and failure in buildings (Akintorinwa and Abiola, 2011).

Kwara State University, as a growing university, has allocated some sites for staff quarters. In the light of this, this paper studies, analyzes and characterizes the subsurface settings for buildings proposed to serve as staff quarters in Kwara State university, Malete using electrical resistivity technique.

LOCATION AND GEOLOGY OF STUDY AREA

The study area lies within the latitude 080 43′ 53"N - 080 42′47′′N and longitude 004028′55"E - 004030′00′′E (Figure 1). The study area is in the northeastern part of Malete; bounded by Yeregi and Alapo to the northwest. The study area and its environs fall within the Precambrian Basement Complex of Nigeria which consists of older and younger metasediments, older and younger Granites, and volcanic intrusive which are overlain unconformably by younger sedimentary basins of Lullumeden, Niger-Delta, Bida, Benue, and Dahomey (Bayode et al., 2012; Ayininuola and Olalusi, 2004; Roddis, 1993; Grant, 1970). The study area is mainly of biotite gneisses in the southeast, porphyritic and microgranite to the northeast, migmatite and grey gneiss to the southwest. The geological structures seen in the study area are brittle and ductile deformational structures (Mc-curry Wright, 1977; Oyawoye, 1972).

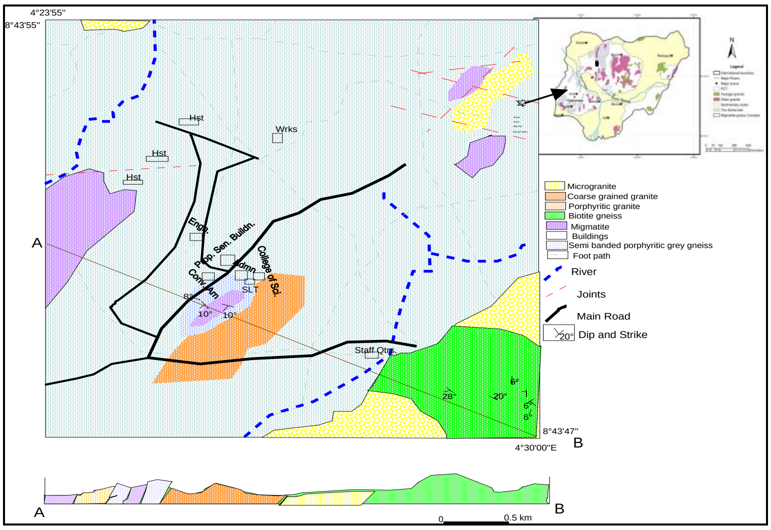


Figure 1: Road network and geological map of the Study Area

MATERIALS AND METHOD

Measurement of resistivity were made using ABEM WADI (SAS 300B) terrameter, while Global positioning system (GPS) was used to measure or get the elevation above the sea level, longitude and latitude of the VES position. Measuring tape was used to measure inter-electrode spacing separation. Other accessories to the terrameter include the booster, four metal electrodes, hammers and cables for current and potential electrodes. The first step undertaken on the field was the reconnaissance study of the area. Having established these points, they were marked and Vertical Electrical Sounding was carried out by using Schlumberger array as shown in Figure 2.

Let the separations of the current and potential electrodes be L and a respectively. Then

$$r_{DB} = r_{AC} \text{ and } r_{AD} = r_{CB} \quad (1)$$

$$\text{and} \quad r_{AD} = r_{CB} = \frac{(L+a)}{2}, \quad (2)$$

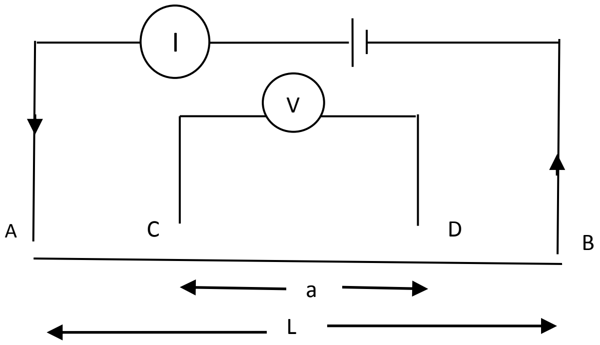


Figure 2: Schlumberger configuration for resistivity measurement, consisting of a pair of current electrodes (A, B) and a pair of potential electrodes (C, D).

Substituting in the general formula,

$$\rho_a = 2\pi \frac{V}{I}\left[\frac{1}{\left(\frac{1}{r_{AC}} - \frac{1}{r_{CB}}\right) - \left(\frac{1}{r_{AB}} - \frac{1}{r_{DB}}\right)}\right] \quad (3)$$

$$\rho_a = \frac{\pi v(L^2 - a^2)}{4Ia} \quad \text{(Tim (2002)} \quad (4)$$

where r_{DB} is the distance between electrode D and B,, r_{AC} is the distance between electrode A and C, r_{CB} is the distance between electrode C and B, r_{AD} is the distance between electrode A and D, *L* is the distance between current electrode A and C, a is the distance between potential electrodes C D, *v* is the potential difference and *I* is the current flow.

Data acquisition

The observed field data was converted to apparent resistivity values by multiplying with the Schlumberger geometric factor, K. The sounding curve for each point was obtained by plotting the apparent resistivity on the ordinate against half current-electrode spacing on a bilogarithmic transparent paper.

RESULTS AND DISCUSSION

The results of the resistivity, depth and curve type are presented on table 1 and qualitatively presented as the Flow net and Maps while VES curves of the study area were shown in appendix

Flownet

The flownet of the study area is slightly undulating to plain terrain with a good number of exposed outcrops in most places. The exposed rocks form the high relief area within 280 m to 350 m above the sea level (asl). The low relief of 280 m asl occurs in the northwestern part and 350 m asl in the southeastern part (Figure 3). The study area drainage system is characterized by seasonal proliferation of smaller channels.

Table 1: Summary of the resistivity, depth and curve type

VES	$\rho_1(\Omega m)$	$\rho_2(\Omega m)$	$\rho_3(\Omega m)$	$h_1(m)$	$h_2(m)$	Curve Type
1	862.7	83.8	959.9	2.1	17.8	H-type
2	846.2	119.1	4528.2	2.3	9.7	H-type
3	1090.7	110.2	705.6	3.3	18.3	H-type
4	601.1	514.1	1586.4	2.8	14.0	H-type
5	1045.8	99.4	1171.3	2.9	11.5	H-type
6	1386.1	102.1	743.9	2.7	14.2	H-type
7	683.8	91.8	1015.5	4.8	18.5	H-type
8	622.3	80.2	890.2	4.6	18.0	H-type
9	629.0	80.1	384.9	3.1	12.3	H-type
10	684.4	81.9	930.3	4.4	14.2	H-type
11	398.8	84.5	1843.8	4.2	11.8	H-type
12	483.8	105.3	664.3	2.1	9.3	H-type

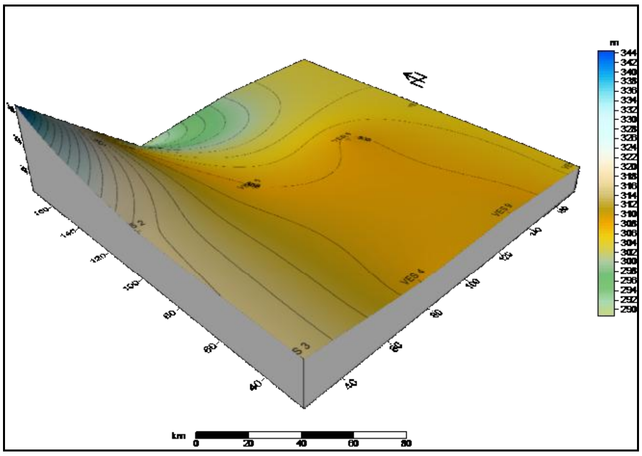


Figure 3: Flow Net of Kwara State University Staff Quarters (underdeveloped)

Maps

Some maps (Figures 4-7) were drawn from the layer interpretation of the sounding curves. These include: Overburden isopach map, weathered layer isothickness map, Weathered layer isoresistivity map, Bedrock relief map and Bedrock isoresistivity map

Overburden Isopach Map

The depth to basement (overburden thickness) map is presented in Figure 4 at 1m interval. This was done to enable a general view of the weathered geometry of the surveyed area. The overburden is assumed to include the topsoil, the lateritic horizon and the clay/weathered rock

(Rahaman,1976; Olorunfemi and Okhue, 1992). The values range from 8m to 18.5m.

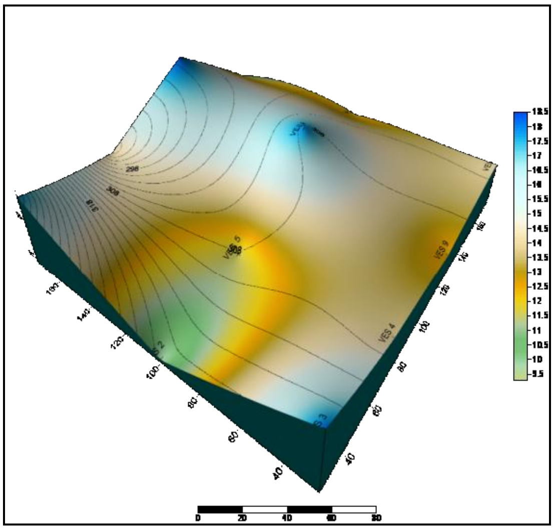


Figure 4: Overburden isopach map

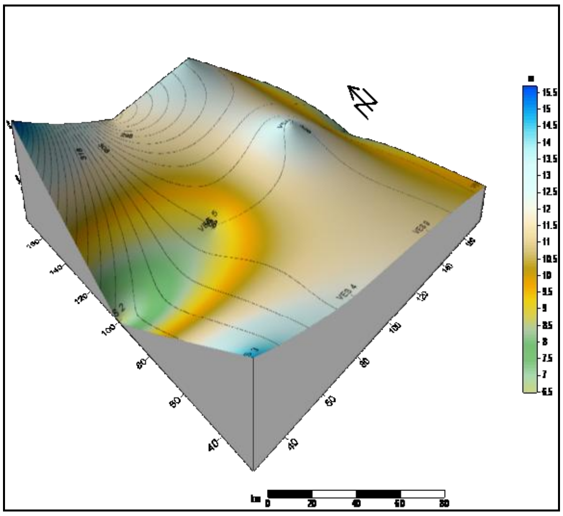


Figure 5: Weathered layer isothickness map

Weathered layer isothickness map

The thickness of these lithological materials varies between 6m and 17.7 m. This was determined from the layer interpretation of the sounding results. The weathered layer isopach map was produced using a contour interval of 1m (Figure 5). The map was produced with a view to observe how the weathered basement layer considered being the major component of the weathered in the study area varied from place to place.

Weathered layer isoresistivity map

In order to have an insight to the subsurface potentials of the study area, a weathered resistivity map (Figures 6 and 7) was produced from the interpreted VES data results of this work. The resistivity value of the weathered at each VES site location was plotted at 20 Ωm. The map was produced in order to distinguish high water-bearing weathered layer from low water-bearing ones, and to find out whether or not the degree of weathering /saturation varies from point to point in the study area.

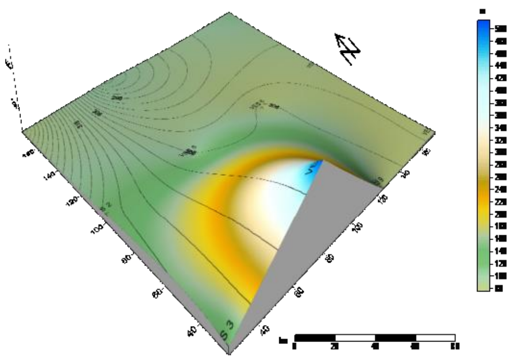


Figure 6: Weathered layer isoresistivity map

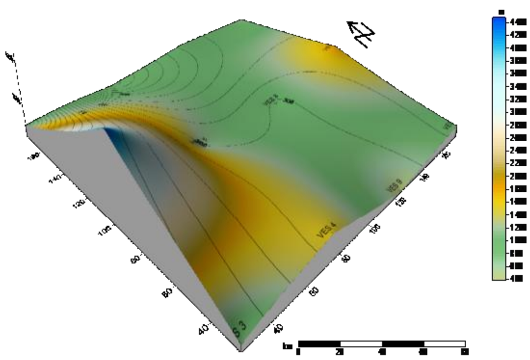


Figure 7: Bedrock isoresistivity map

Bedrock relief map

The bedrock relief map (Figure 8) is a contoured map of the bedrock elevations beneath all the VES stations. These elevations were obtained by subtracting the overburden thicknesses from the surface elevations at the VES stations. The bedrock relief map generated for the locations shows the subsurface topography of the bedrock across the surveyed area. The hydrogeologic significance of bedrock relief has been recognized by (Okhue and Olorunfemi, 1991).

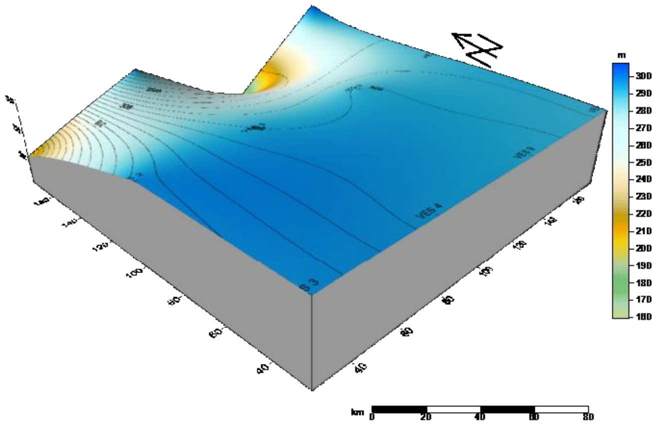
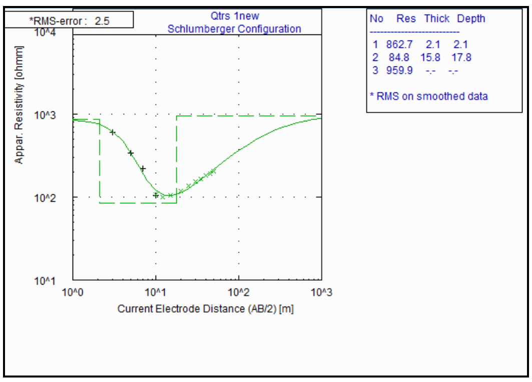
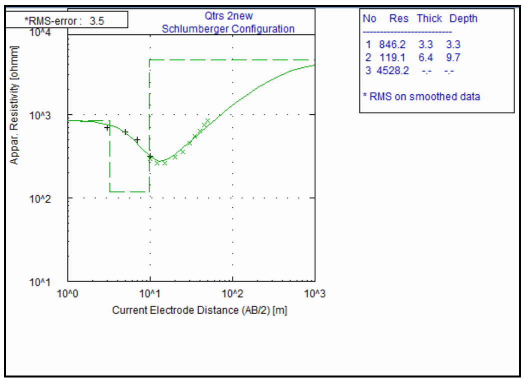


Figure 8: Bedrock Relief Map

The result of the geophysical survey is presented in sounding curves, The layer model interpretations of all the VES points are presented in the Figures 9a to 9j. The results of the interpretation show a system of three geo-electric layers for VES1-11. The VES results revealed the heterogeneous nature of the subsurface geological sequence: hardpan topsoil (clayey and sandy-lateritic), weathered layer, partly weathered or fractured basement, and fresh basement. The resistivity value for the topsoil layer varies from 40Ωm to 450Ωm with thickness ranging from 1.25 m to 7.5 m. The weathered basement has resistivity values ranging from 50Ωm to 593Ωm and thickness of between 1.37 to 20.1 m. The fractured basement has resistivity values ranging from 218Ωm to 520Ωm and thickness of between 12.9 to 26.3 m. The fresh basement (bedrock) has resistivity values ranging from 1215Ωm to 2150Ωm with infinite depth. However, the depth from the earth's surface to the bedrock surface varies between 2.63 to 34.99 m.



a.



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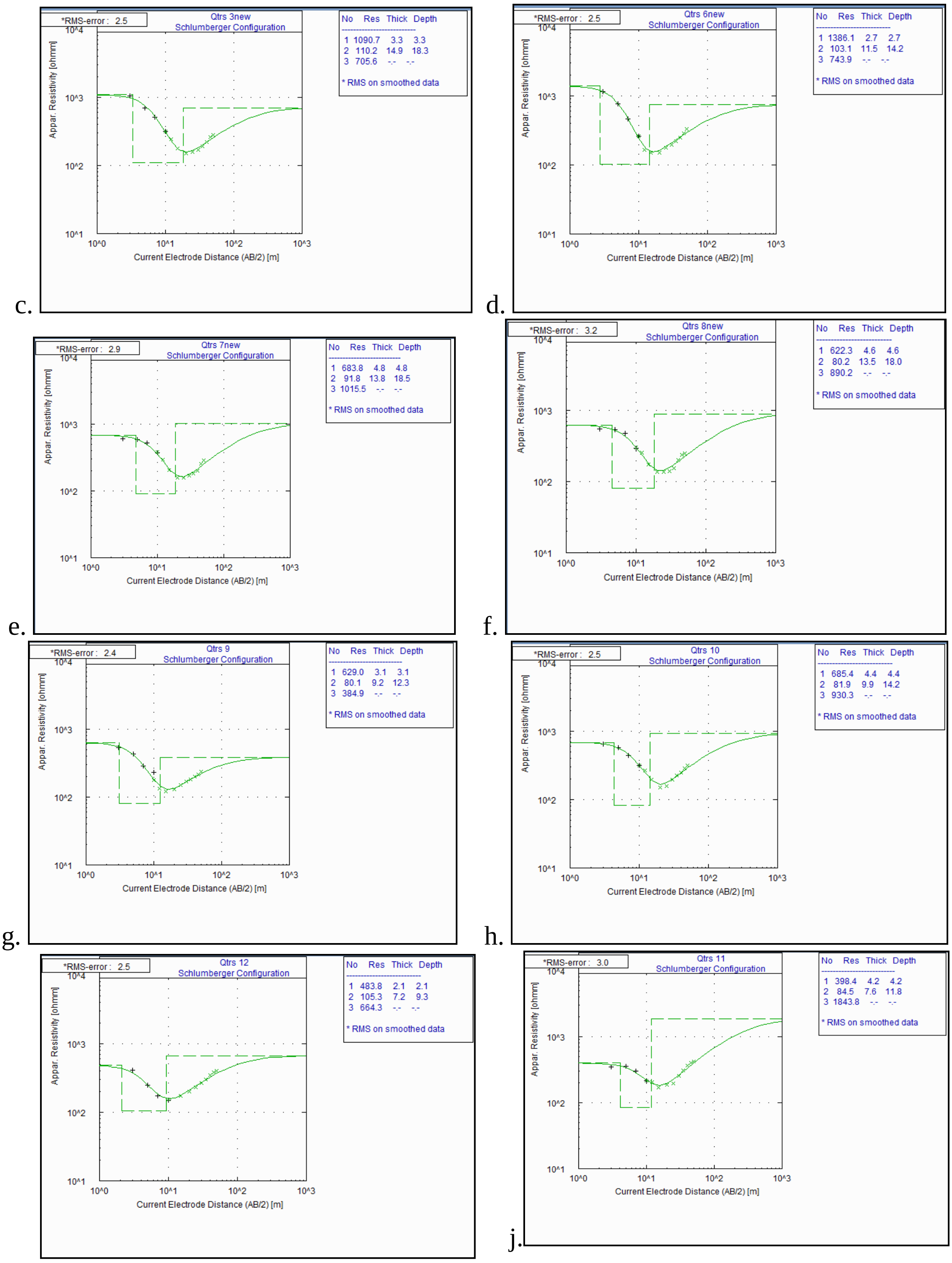

Figure 9 (a - j): VES curves identified within the Study Area.

CONCLUSION

The geophysical investigation for pre-building foundation of Kwara State university quarter, Malete was carried out using vertical electrical sounding survey. From data acquired and its interpretation, the VES results from the studied area revealed the heterogeneous nature of the subsurface geological sequence: hardpan topsoil (clayey and sandy-lateritic), weathered layer, partly weathered or fractured basement, and fresh basement. The resistivity value for the topsoil layer varies from 40 Ωm to 450 Ωm with thickness ranging from 1.25 m to 7.5 m. The weathered basement has resistivity values ranging from 50 Ωm to 593 Ωm and thickness of between 1.37 to 20.1 m. The fractured basement has resistivity values ranging from 218Ωm to 520Ωm and thickness of between 12.9 to 26.3 m. The fresh basement (bedrock) has resistivity values ranging from 1215 Ωm to 2150 Ωm with infinite depth. However, the depth from the earth's surface to the bedrock surface varies between 2.63 to 34.99 m. Based on the qualitative interpretation of the VES data, it is deduced that VES Stations 2, 3, 5 and 9 are viable positions for sitting buildings with appreciable thickness of weathered and fractured basement ranging from 12.71m to 33 m. The study stressed the importance of the findings in civil engineering structures.

REFERENCES

Adeyemo I.. A. and Omosuyi G.O. (2012). Hydrogeologic, Electrical and Electromagnetic Measurements for Geotechnical Characterization of Foundation Beds at Afunbiowo, near Akure, Southwestern Nigeria. Indian Journal of Science and Technology, Vol. 5, No. 2, pp. 2017-2022.

Akintorinwa O.J and Adeusi F.A, (2009). Integration of Geophysical and Geotechnical Investigations for a Proposed Lecture Room Complex at the Federal University of Technology, Akure, SW, Nigeria, Ozean Journal of Applied Sciences 2(3), pp. 241- 254.

Akintorinwa O.J. and Abiola O. (2011).Subsoil Evaluation for Pre-foundation Study using Geophysical and Geotechnical Approach, Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS) 2 (5), pp. 858-863.

Ayininuola G.M. and Olalusi O.O. (2004): Assessment of Building Failures in Nigeria: Lagos and Ibadan case study. African Journal of Science and Technology Vol. 5 No. 1, 73 - 78.

Bayode .S, Omosuyi G.O and Abdullai H.I. (2012). Post-Foundation Engineering Geophysical Investigation in Part of the Federal University of Technology, Akure, Southwestern Nigeria, Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS), 3 (1), pp. 91-97.

Egwuonwu G.N. and Sule P.O. (2012). Geophysical Investigation of Foundation Failure of a Leaning Superstructure in Zaria Area, Northern Nigeria. Research Journal in Engineering and Applied Sciences, 1(2), 110-116

Godwin B. Egbeyale, Titus T. Ogunseye and Kess O. Ozegin (2019). Geophysical investigation of building foundation in part of Ilorin, north central Nigeria using electrical resistivity method. Journal of Physics; conference series.

Grant, N. K. (1970). Geochronology of Precambrian Basement Rocks from Ibadan, South Western Nigeria. Earth and Planetary Sci. Lett., 10: 29-38.

Hornby A. S. (2001). Oxford Advanced Learner's Dictionary of current English. Oxford: Oxford University Press.

McCurry, P. and Wright, J. B. (1977). Geochemistry of calcalkaline volcanics in Northwestern Nigeria and a possible Pan-African suture zone. Earth Planetary Science Letters, 37, pp. 90-96.

Ofomola M. O., Emekeme R.E., Okocha F. O, and Adeoye T. O. (2018). Evaluation of sub soil competence for foundation studies at site III of the Delta State University, Nigeria. Journal of Geophysics and engineering.

Ofomola M.O., Adiat K.A., Olayanju G.M and Ako B.D (2009). Integrated Geophysical Methods for Post Foundation Studies, Obanla Staff Quarters of the Federal University of Technology, Akure, Nigeria. Pacific Journal of Science and Technology. 10(2) pp. 93-111.

Okhue E. T, and Olorunfemi M.O. (1991). Electrical Resistivity Investigation of a Typical Basement Complex Area-The Obafemi Awolowo University Campus Case Study. J. Min. Geol. 27(2):63-69.

Olorunfemi and Okhue, (1992). Hydrogeologic and Geological Significance of a Geoelectric Survey at Ile-Ife, Nigeria Journal of Mining and Geology. 28(2):221-229

Olowofela J.A. (2005). Measuring the electrical resistivity of the earth using a fabricated resistivity meter. European journal of physics.

Omowumi, Falae Philips (2014). Application of electrical resistivity in building foundation investigation in Ibese Southwestern Nigeria. Asia Pacific of energy and environment.

Oyawoye, M.O. (1972). The Basement Complex of Nigeria. In: African Geology (T.F.J.)

Rahaman, M.A. (1976). Review of the Basement Geology of Southwestern Nigeria. In: Kogbe, C.A. (ed.) Geology of Nigeria. Elizabethan Pub. Co., Lagos. 41-58.

Roddis, W.M. (1993): Structural Failures and Engineering Ethics, American Society of Civil Engineerng (Structural Div.), Vol. 5, pp. 1539-1555.

Tim. C, (2002). House Foundation. Ask the Builder, Nationality Syndicated Newspaper Columnists. www.askthebuilder.com, Free Weekly News and Tips, Column and Special Offers on Tim Cater's eBooks and Checklists.