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Research Paper

Geophysical Investigation of Causes of Road Failure along Abadina Community Road, University Of Ibadan, Nigeria.

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ABSTRACT
Geophysical method has been used to investigate the causes of road failure along Abadina community road with a view to characterize the subsurface lithology and to delineate the geological structure responsible for the road failure using Schlumberger electrode configuration. Five VES were carried out on the stable segments of the road while four VES were along the failed segments of the road. Three geo-electric layers were identified in the failed segments which include: topsoil, clay, weathered basement/fresh basement while four geo-electric layers which are topsoil, lateritic pan, sandy clay and weathered basement/fresh basement were identified in the stable segments. The clayey formation is not good as subgrade because of its high porosity and very low permeability hence it tends to absorbs water and swells this result in high conductivity or low resistivity and differential settlement of the layer which subsequently lead to road failure. The failures in the road arise from the differential settlement of the subgrade clay. It is recommended that for any road construction purpose, the clayey materials should be excavated because of their unstable characteristics and re-filled with more stable materials.
KEYWORDS: *Failed Segment, Stable Segment, Subgrade, Electrical Resistivity y, Clay*

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I. INTRODUCTION

Roads serves as interlink between two places, it provide traffic mobility and give access to adjoining land. Road transportation is the preferred mode of transportation because it suitable for short transportation, it is economical and it provides better accessibility. A road network is supposed to be a continuous stretch of asphalt layer for a smooth ride hence presence of visible cracks, potholes and depressions are generally regarded as road failure because they hinder a smooth ride [1]. Road pavement failure can be describe as a lack of continuity in a road network due to the presence of cracks, potholes, bulges and depression on the road. Road failures can occur after few years of construction before attaining the design age and the failures can either be functional such as surface pavement failure or structural which is deep-seated road failure [2]. Factors responsible for road failure include usage problems such as excessive traffic load or underestimation of traffic volume; design problems such as poor structural design, use of substandard construction materials and unethical construction practices[3][4]. Other factors are inadequate information on underlying soil layers and the local subsurface geology[5], existence of geological structures like fractures and faults, stream channels, and shear zones [6][7][8][9][10] and lack of proper drainage at the road embankment[4][10]. Several researchers [4][9] have used geophysical methods to investigate causes of road failure. [6] used vertical electric sounding method to examine the geological factors responsible for highway failure in basement complex terrain of southwestern Nigeria. The result identified suspected geological features and the clayey sub-grade soil below the highway pavement as the major geologic factors responsible for the highway failure. Relevant information on the actual causes of failure will greatly assist in preventing this recurring problem of road failure. The aim of this research is to characterize the subsurface lithology and to delineate the geological structure responsible for the road failure using electrical resistivity method.

II. GEOLOGY OF THE STUDY AREA

The surface area of Nigeria (923,768 Km2) is underlain in nearly equal proportions by crystalline and sedimentary rocks. The basement complex of Ibadan comprises Quartzites, banded and augen gneisses, granite gneiss and migmatite. The minor rocks include pegmatite, aplite, quartz veins and doleritic dykes. The

University of Ibadan campus is underlain by quartzite, banded gneiss and augen gneiss. The quartzites occupy the western part of the campus, while the eastern part is occupied by augen gneiss. Banded gneiss forms a strip between the quartzite and augen gneiss in a NW-SE direction. Quartzites and augen gneiss outcrop in various parts of the campus with the former being highly weathered as evident from surface expression, foliation planes, which are well developed and strike in the NW-SE direction.[1], [11] and [12]. The study area of about 1000m lies between longitude 3°53'93.50"E and 3°53'29.21"E and latitude from 7°27'06.40"N and 7°27'09.30"N. it houses the junior and non-academic staff of the University of Ibadan and connects major areas and locations such as the International Conference Centre and UI Second Gate, the Botanical Garden, Ajibode gate and the University bookshop. Despite been an interlink to the school gates and other major locations, the condition of the road does not allow for easy navigation of the road.

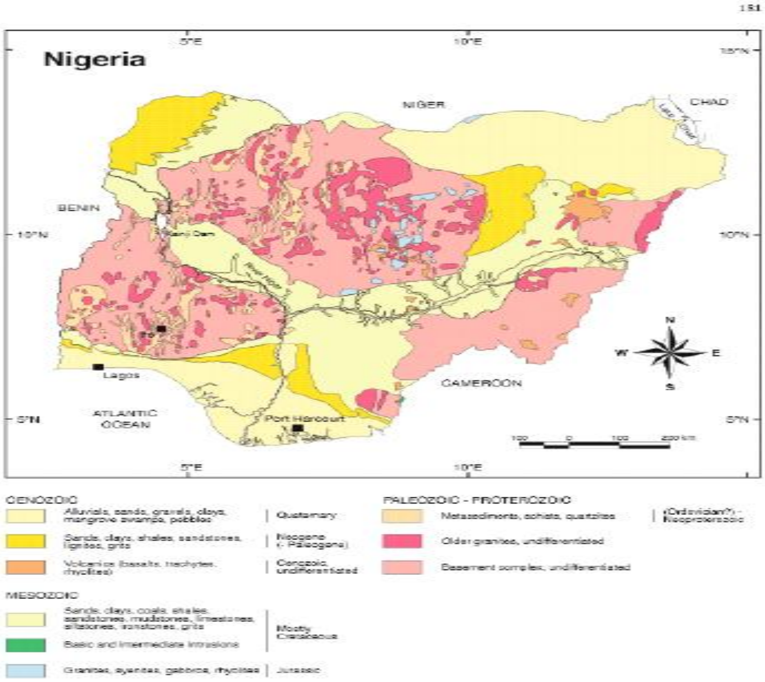

Figure 1: Geological map of Nigeria

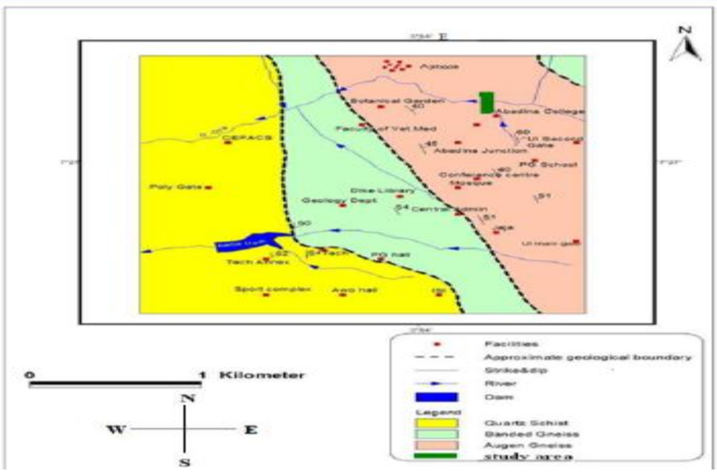

Figure 2; The Geological map of University of Ibadan campus

III. MATERIAL AND METHOD

The Schlumberger electrode configuration was employed because it provides more accurate apparent resistivity values with respect to depth, better than other electrode configuration type. It is also not labor intensive when compared with other configurations. The materials used include Campus Tiger Terrameter, measuring tape, masking tape, hammers, steel electrodes, and Global Positioning Satellite (GPS). The Campus Tiger Terrameter was used for acquisition of resistivity. The field measurements were recorded with maximum current electrode separation (AB) of 110 m and a total of nine Vertical Electrical Sounding (VES) were conducted. Five VES were carried out on the stable segments of the road while four VES were along the failed segments of the road. The longitude and latitude of each sounding station was recorded with the aid of Global Positioning System (GPS) and the soundings were performed parallel to the road pavement. The apparent resistivity measurements at each station were plotted against the electrode spacing (AB/2) on a log-log paper, partial curve matching were carried out for quantitative interpretation of the curves which give the number of layers, layer resistivity and thickness of each layer. A qualitative interpretation was later performed using forward iterating modeled with the aid of WINRESIST VERSION 1.0 which has very low RMS error.

IV. RESULT AND DISCUSSION

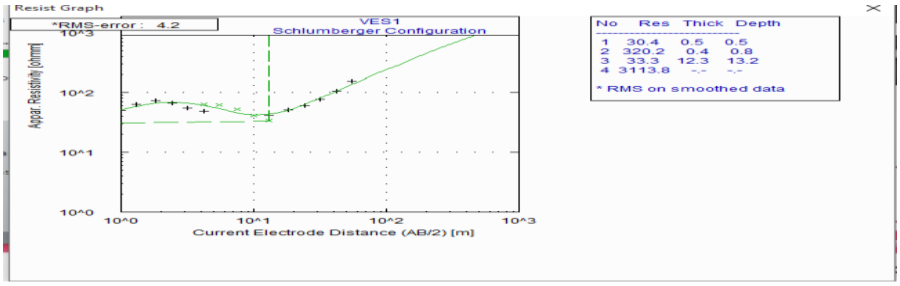

Figure 3: Interpreted Schlumberger depth sounding curve for VES 1.

Table 1 : Summary of the VES Results of the study area

VES station	Resistivity(Ω)	Thickness (m)	Depth (m)	Curve Type
1	30.4 320.2 33.3 3113.8	0.5 0.4 12.3	0.5 0.9 13.2	KH
2	276.8 103.5 19.8 815.0	0.6 2.9 6.2	0.6 3.5 9.6	KH
3	146.1 15.1 651.1	1.9 6.3	1.9 8.1	H
4	206.8 55.9 8.3 2320.2	0.5 4.5 6.8	0.5 5.0 11.8	QH
5	72.3 46.9 392.0	0.7 18.1	0.7 18.8	H
6	64.5 35.3 3123.8	1.1 16.2	1.1 17.2	H
7	63.8 55.2 33.1 1348.7	0.5 4.2 12.5	0.5 4.8 17.2	QH
8	120.3 36.1 1377.4	2.0 16.3	2.0 18.3	H
9	166.7 67.6 30.9 67.7	0.8 2.3 10.7	0.8 3.2 13.9	QA

VES 1 of KH curve type is located at latitude 7°27'06.40''N and longitude 3°53'93.50"E with four geo-electric layers. The first geo-electric layer is composed of topsoil with resistivity values of 30.4Ωm and thickness of 0.5m. The second geo-electric layer is composed of sandy clay with resistivity values of 320.2Ωm and thickness 0.4m and depth of 0.9m. The third geo-electric layer is composed of saturated sandy clay with resistivity of 33.3Ωm and thickness of 12.3m and depth of 13.2m. The fourth geo-electric layer is composed of the weathered fractured basement layer with resistivity value 3113.8Ωm.The curve type of VES 2 is KH and it is located at latitude 7°27'04.30''N and longitude 3°53'93.80"E with four geo-electric layers. The first geo-electric layer is composed of topsoil with resistivity values of 276.8Ωm and thickness of 0.6m. The second geo-electric layer is composed of sandy clay with resistivity values of 103.5Ωm and thickness 2.9m and depth of 3.5m. The third geo-electric layer is composed of saturated sandy clay with resistivity of 19.8Ωm and thickness of 6.2m and depth of 9.6m. The fourth geo-electric layer is composed of the weathered fractured basement layer with resistivity value 815Ωm. The curve type of VES 3 is H located at latitude 7°27'04.10''N and longitude

3°53'93.30"E with three geo-electric layers. It falls to a minimum, and then increases again due to an intermediate layer that is a better conductor than the upper and lower layers. The first geo-electric layer is composed of topsoil with resistivity values of 146.1Ωm and thickness of 1.9m. The second geo-electric layer is composed of clay with resistivity values of 15.1Ωm, thickness of 6.3m and depth of 8.1m. The third geo-electric layer is composed of basement rock with resistivity of 651.1Ωm. The curve type of VES 4 located at latitude 7°27'01.80"N and longitude 3°53'93.20"E is QH with four geo-electric layers. The first geo-electric layer is composed of topsoil with resistivity values of 206.8Ωm and thickness of 0.5m. The second geo-electric layer is composed of sandy clay with resistivity values of 55.9Ωm, thickness 4.5m and depth of 5.0m. The third geo-electric layer is composed of saturated sandy clay with resistivity of 8.3Ωm and thickness of 6.8m and depth of 11.8m. The fourth geo-electric layer is composed of the weathered fractured basement layer with resistivity value 2320.2Ωm. The curve type of VES 5 located at latitude 7°27'02.10"N and longitude 3°53'94.40"E is H with three geo-electric layers. The first geo-electric layer is composed of topsoil with resistivity values of 72.3Ωm and thickness of 0.7m. The second geo-electric layer is composed of clay with resistivity values of 46.9Ωm and thickness 18.1m and depth of 18.8m. The third geo-electric layer is composed of basement rock with resistivity of 392.0Ωm. The curve type of VES 6 located at latitude 7°26'99.80"N and longitude 3°53'93.70"E is H with three geo-electric layers. The first geo-electric layer is composed of topsoil with resistivity values of 64.5Ωm and thickness of 1.1m, the second geo-electric layer is composed of clay with resistivity values of 35.3Ωm and thickness 16.2m and depth of 17.2m. The third geo-electric layer is composed of basement rock with resistivity of 3123.8Ωm. The curve type of VES 7 located at latitude 7°26'99.00"N and longitude 3°53'95.30"E is QH with four geo-electric layers. The first geo-electric layer is composed of topsoil with resistivity values of 63.8Ωm and thickness of 0.5m. The second geo-electric layer is composed of sandy clay with resistivity values of 55.2Ωm and thickness 4.2m and depth of 4.8m. The third geo-electric layer is composed of saturated sandy clay with resistivity of 33.1Ωm and thickness of 12.5m and depth of 17.2m. The fourth geo-electric layer is composed of the weathered fractured basement layer with resistivity value 1348.7Ωm. The curve type of VES 8 located at latitude 7°27'10.00"N and longitude 3°53'91.90"E is H with three geo-electric layers. The first geo-electric layer is composed of topsoil with resistivity values of 120.3Ωm and thickness of 2.0m and of depth 2.0m respectively. The second geo-electric layer is composed of clay with resistivity values of 36.1Ωm and thickness 16.3m and depth of 18.3m. The third geo-electric layer is composed of basement rock with resistivity of 1377.4Ωm. The curve type of VES 9 located at latitude 7°27'09.30"N and longitude 3°53'29.21"E is QA with four geo-electric layers. The first geo-electric layer is composed of topsoil with resistivity values of 166.7Ωm and thickness of 0.8m. The second geo-electric layer is composed of sandy clay with resistivity values of 67.6Ωm and thickness 2.3m and depth of 3.2m. The third geo-electric layer is composed of saturated sandy clay with resistivity of 30.9Ωm and thickness of 10.7m and depth of 13.9m. The fourth geo-electric layer is composed of the weathered fractured basement layer with resistivity value 67.7Ωm. The failed segments are VES 3, 5, 6 and 8 which consist of three geoeletric layers each, the first layer is topsoil which has resistivity values ranging from 64.5Ωm to 146.1Ωm with thickness ranging from 0.7m to 2.0m. The wide range in the resistivity values of the topsoil can be due to different degree of compaction. The second layer has resistivity between 15.1Ωm and 46.9Ωm this is less than 100Ωm which is characteristic of clayey formation of [13] with thickness ranging from 6.3m to 18.1m. Stable sections are VES 1, 2, 4, 7 and 9 which consists of four geoelectric layers each. The first layer is topsoil which has resistivity values ranging from 30.4Ωm to 276.8Ωm with thickness ranging from 0.5m to 0.8m, the second layer is made up of lateritic pan and sandy clay with resistivity ranging from 55.2Ωm to 320.2Ωm and thickness ranging from 0.4m to 4.5m. The third layer resistivity ranges from 8.3Ωm to 33.3Ωm and thickness ranging from 6.2m to 12.5m. the subgrade in the stable segments have higher resistivity than subgrade within the failed segments of the road this show that the stable portions of the road are more resistive than the failed segments.

V. CONCLUSION

The geophysical investigation carried out in the study area has been effective in characterizing the sub-surface materials that underlies the study area as well as depth to bedrock. The results obtained from the Vertical Electrical Sounding (VES) carried out on the Abadina road, shows three geo-electric layers for failed segments VES 3, 5, 6 and 8 which includes: topsoil, highly weathered basement (clayey formation), and fresh basement while four geo-electric layers for stable segments VES 1, 2, 4, 7 and 9 were delineated which have a lateritic pan as their second layer. The low resistivity of the sub-grade in failed segments can be attributed to the presence of high moisture clay in the subsurface. The clayey formation is not good as subgrade because of its high porosity and very low permeability hence it tends to absorbs water and swells, this result in high conductivity or low resistivity and differential settlement of the layer which subsequently lead to road failure. The failures in the road arise from the differential settlement of the subgrade clay. It is recommended that for any road construction purpose, the clayey materials should be excavated away because of their unstable characteristics and re-filled with more stable materials.

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