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VERTICAL ELECTRICAL RESISTIVITY INVESTIGATION OF FOUNDATION CONDITIONS NEAR A BURIED STREAM CHANNEL IN PART OF PORT HARCOURT, RIVER STATE, NIGERIA

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ABSTRACT

Four Vertical Electrical Soundings have been carried out for building sites using Schlumberger array within a buried River channel near Okilton close, Port Harcourt. The objective was to delineate the different geoelectric and geologic parameters of the subsurface as a means of determining its effect on foundation. Five geoelectric layers were obtained from the interpretation of the field curves by computer modelling.This includes the topmost layer which consists of silt, sand and organic materials (humus). The topmost layer is followed in succession by clayey layer, clay/silt, fine sand and coarse sand. The topsoil and clay layers resistivities range between 28.8 to 168 ohm's meters and 115.3 to 120.5 ohm's meters respectively. The maximum resistivity obtained for the fine sand layer ranges between 421 to 885 ohm's meters. The low resistivities of the subsurface layers may be attributed to the high moisture content, presence of clay and the soft subsurface materials of the buried river channel. The clay is susceptible to expansion on moisture influx and contraction when it gives out the water. The clay and soft materials that filled the buried channel release the moisture and consolidate gradually when a building is on it. The subsurface materials therefore have great effect on the long term stability of the building foundations in the area due to gradual subsidence of the buildings. The low apparent resistivities of the subsurface layers are also an indication that the corrosion of the area is high to moderate. The results show that the durability and lifespan of civil engineering structures and underground utilities in the area will be reduced. It is advisable to replace the topsoil and the clay layer with more competent materials before the foundation of any building in the area and there should be a drainage system in the area.

Keywords: *Okilton, Buried channel, Building, Foundation and subsidence*

INTRODUCTION

Large-scale urban sprawl and urbanization are common phenomenon in most developing countries. Urbanization has been accelerating at a tremendous rate. According to data collected by the United Nations (1990), 50 years ago less than 30 percent of the world population lived in cities. Now, more than 50 percent are living in urban settings which occupy only about 1 percent of the Earth's surface. During the period from 1950 to 1995, the number of cities with population higher than one million increased from 85 to 325. By 2025, it is estimated that more than 60 percent of 8.3 billion people will be city dwellers.

Port Harcourt, the capital of Rivers State has a mass influx of people in the past two decades. This is as a result of the numbers of oil companies, oil allied industries and commercial activities in the region. In order to accommodate this population expansion there has been a lot of indiscriminate building of houses without taking into consideration the nature and feasibility of the subsurface for the foundation of civil engineering structures. As a result of the indiscriminate building of houses especially during dry seasons most stream channels have blocked and buried. These buried stream channels are been filled with unconsolidated organic, peat and alluvia materials. Most landlords have cited the foundation of their buildings on these hazard environments without considering the implication.

The study area, Okilton Drive is one of the newly developing residential areas in Port Harcourt. The area is located near a buried stream channel. It is usually associated with high flooding during the wet season every year. The basement of most of the buildings within the region is cover with water for months as a result of the flood. This has made most of the residents to pack out of their houses or from the down floor of storey building to the upper floors and only to return when the water has dried up or subsided.

The major problem of engineers from the time past is the disregard of the fact that the design of any structure should be preceded by a careful study of the foundation material on which a structure would be placed. Site investigation in one form or the other is always required for long term stability of structures. Foundation of structures is generally recognized as an important part of building design.

Adequate determination of geological conditions at building sites is an essential component of foundation design. Foundation failures are rarely due to facility structural design; they are usually related to failure of the load-bearing foundation beds (Adebisi and Oloruntola, 2006).

In the last decade, the involvement of geophysics in civil and environmental engineering has become a promising approach. Geophysical methods are implemented in a wide range of applications ranging from building ground investigations to the inspection of dams and dikes (Soupious et al., 2007; Adebisi and Oluruntola, 2006; Schoor, 2002; ASCE, 1996; Sharma, 1997; Olorunfemi et. al., 2004), aiming towards the exploration of geological structures and the determination of the physical parameters of the rock formations. In the case of building construction, geophysics can be applied for exploration purposes to provide useful information regarding the early detection of potentially dangerous subsurface conditions (Oyinloye and Ademilua, 2006; Fatoba and Salami, 2004). The sources of hazards in civil engineering disciplines result essentially from undetected near-surface structures such as cavities and/or inhomogeneities in the foundation geo-materials (Salami and Meshida, 2006). Information related to local soil condition is vital for risk assessment and mitigation.

The objective of the present work is to apply the Schlumberger Vertical Electrical Soundings (VES) to investigate the subsurface settings of a buried stream channel and its environment and to ascertain its fitness for building foundations. The study area is located within a residential area in Okilton Close, Port Harcourt, Rivers State (Fig. 1).

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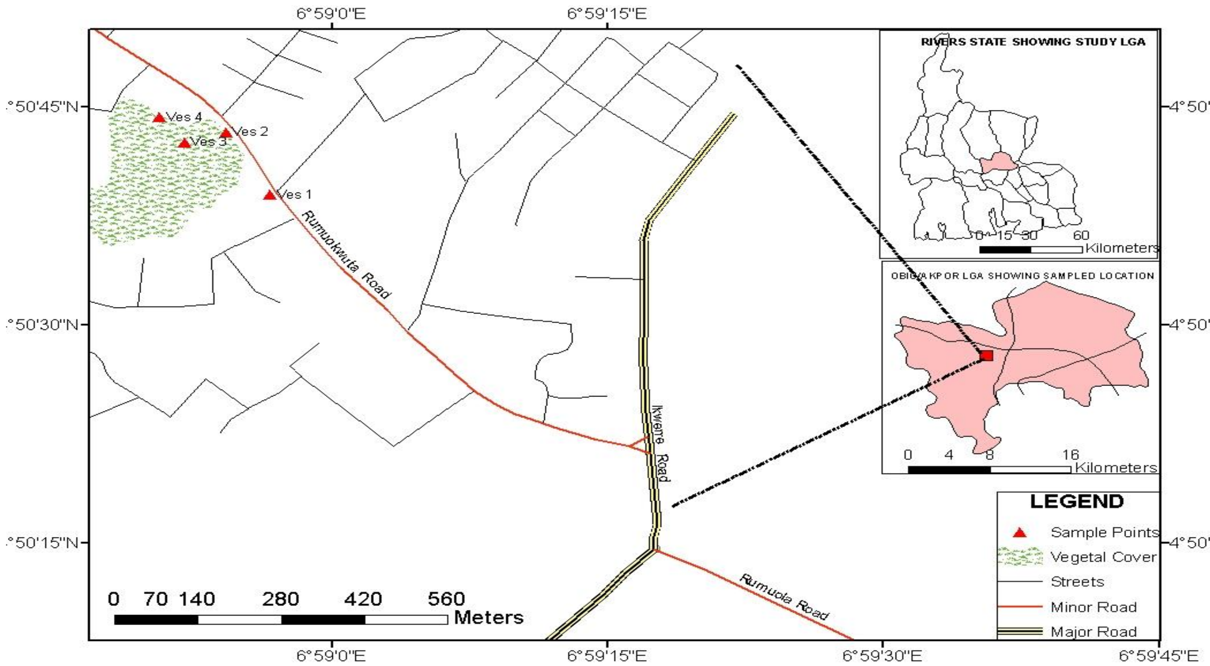

Fig1: Map of Okilton Drive, Rumuokwuta showing the sounding points. Insert is a map of Rivers State and Obio/Akpor L.G.A.

Summary of the Geology of the Study Area

The study area is located within the Niger Delta Sedimentary Basin. The Niger Delta is the youngest sedimentary basin within the Benue Trough system. The Niger delta development began after the Eocene tectonic phase. Up to 12.0 km of deltaic and shallow marine sediments have been accumulated in the basin. The Niger and Benue Rivers are the main supplies of sediments.

Three lithostratigraphic units are distinguished in the Tertiary Niger Delta. The basal Akata Formation which is predominantly marine prodelta shale is overlain by the paralic sand/shale sequence of the Agbada Formation. The topmost section is the continental upper deltaic plain sands – the Benin Formation (Ekweozor and Daukoru, 1994; Michele et al., 1999).

The Niger delta has a tropical rain forest climate with distinct wet (April-October) and dry (November-March) seasons. The daily relative humidity values ranged from 55.5 percent in the dry season to 96 percent in the rainy season. The mean annual rainfall ranges from 2000mm (in land) to over 4000mm at the coastal areas. Temperature varies uniformly and ranges from 21^0C at night to 30^0C during the day. The high humidity and long wet season (about 7-9 months) ensures adequate supply of water and the presence of moisture in the air promote the growth of perennial trees and shrubs. This high humidity can be attributed to a large scale of mist and fogs generated by the reaction between the equatorial high temperature and the Atlantic Ocean (Gobo, 1998).

MATERIALS AND METHODS

This study was carried out in two phases; walkover and geophysical surveys. The walkover survey involves site visitation and assessment of the study area and the present conditions of the existing buildings and other civil engineering structures in the area.

The second stage involves the application of vertical electrical resistivity method of Geophysical survey. The geophysical investigations consist of four Vertical Electrical Soundings using the Schlumberger array. The few numbers of soundings was due to lack of accessibility and space.

The Electrical resistivity survey was carried out with ABEM Terrameter SAS 1000. The electric current was introduced into the subsurface by means of two current electrodes, arranged on a straight line with the potential electrodes placed between them and symmetrically moved with respect to the centre of the configuration. The maximum current electrodes separation for the four Schlumberger techniques ranges between 40 and 100metres respectively.

The apparent resistivity measurements at each station were plotted against electrode spacing (AB/2) on bi-logarithmic graph sheets. The curves were examined to obtain the number and nature of the layering. Partial curve matching was carried out for the quantitative interpretation of the curves. The results of the curve matching (layer resistivities and thickness) were fed into the computer as a starting model in an iterative forward modeling techniques using RESIST Version 1.0 (Vander Velper, 1988). The final layer resistivity and thicknesses were obtained from the modeling.

RESULTS

The vertical electrical sounding data are presented as depth sounding curves, table and geoelectric section. Typical computer model curves obtained from the acquired data from the study area are shown in Figure 2 (a and b). The curve types identified in the study area are AAA and HA. The values of the resistivity and thickness of each subsurface layer for the four sounding points are shown in Table 1. The study revealed four to five subsurface layers and that the resistivity of the area increases with depth.

The result of the VES interpretation were correlated with available nearby borehole lithologic logs (Fig. 3) to produced the geoelectric section of the study area shown in Figure 4. The succession of the geoelectric layers from the ground surface can be established as follows:

*Loose surface sediments (Top soil): It consists of silt, clay and debris materials with resistivity values ranging from 28.8 to 164.5 Ohm's metres. The thickness varies between 1.75 to 2.42metres.

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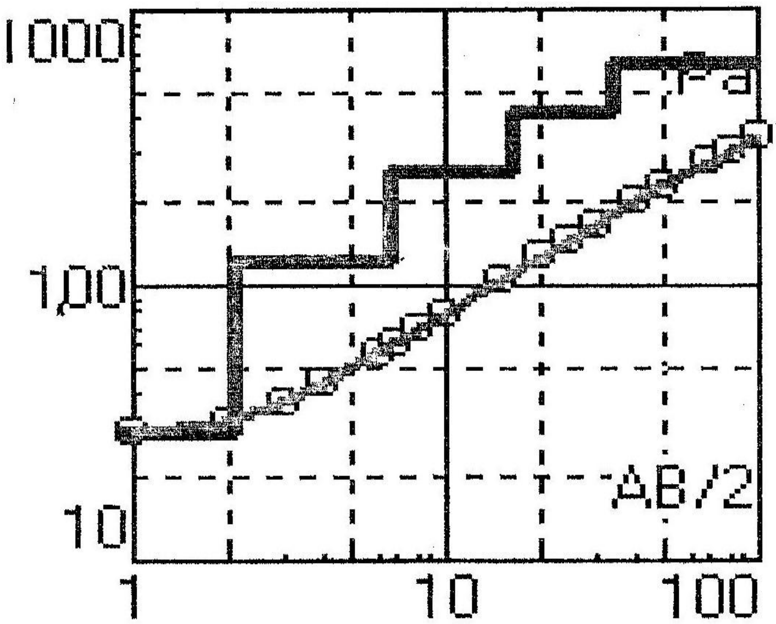

Fig. 2a: Interpreted resistivity curve for VES 1

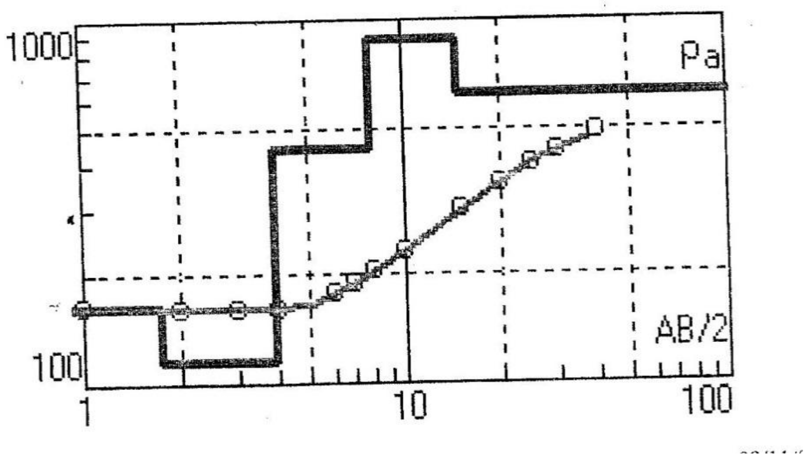

Fig. 2b: Interpreted resistivity curve for VES 2

Table.1: Results of the interpretation of 1-D resistivity sounding points.

S/N	Resistivity, ohm's- m					Thickness, m.			
	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	h_1	h_2	h_3	h_4
1	28.8	120.5	275.6	421.7	636.2	2.11	6.62	16.38	34.72
2	164.5	115.3	442.6	625.8		1.75	3.93	7.79	
3	29.3	105	339.4	404.3	640.4	1.85	3.27	6.8	25.3
4	40.6	127.4	260.3	450.3	712.2	2.42	5.86	14.78	28.43

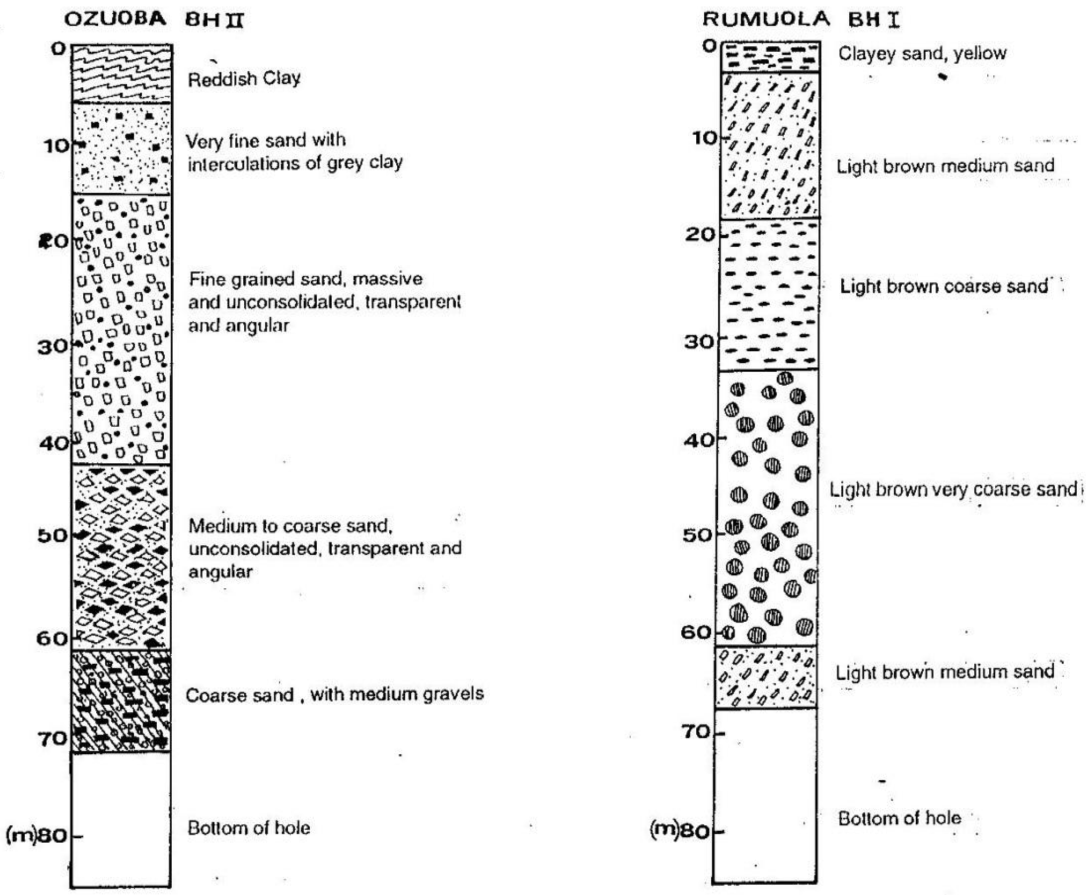

Fig. 3: Lithologic logs of some boreholes within the study Area

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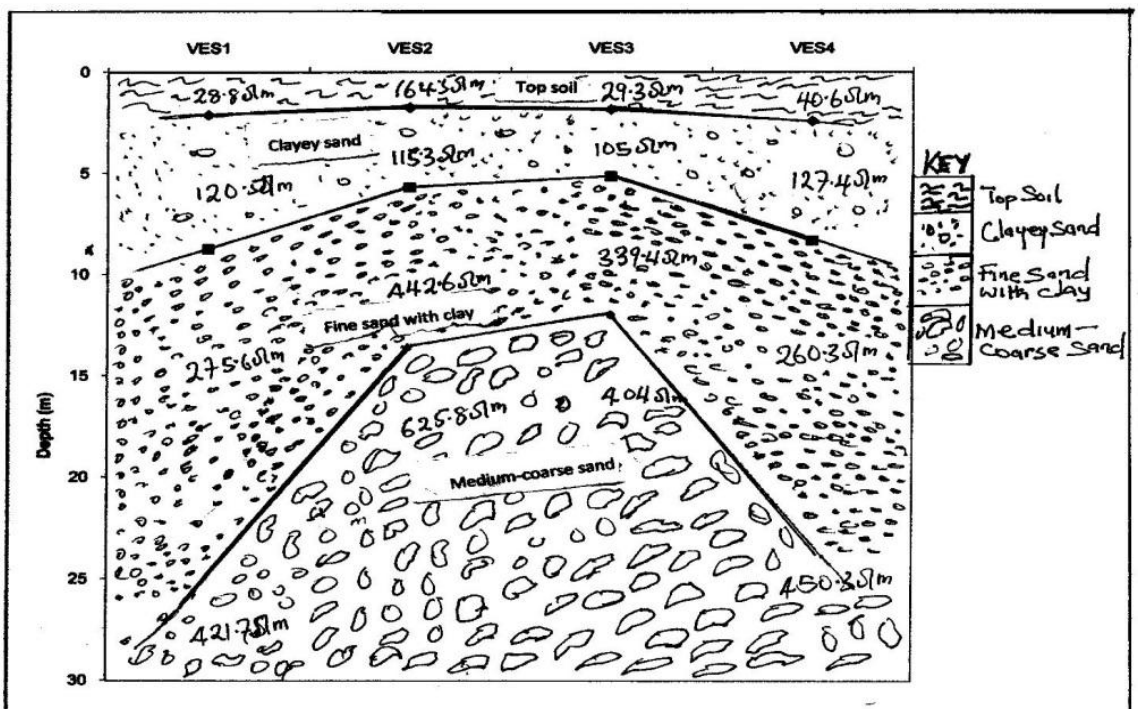

Fig. 4: Geoelectric Section of the Surveyed Area.

* The second layer is made up of clayey sand with grey clay having thickness ranging from 3.93 to 6.62metres. The apparent resistivity ranges from115.3 to 120.5 Ohm's meter.

* The third layer consists of fine sand with intercalation of clay. The thickness varies between 7.79 to 16.38metres. The apparent resistivity ranges from 257.5 to 442.6 Ohm's meter.

* The fourth layer which is made up of medium to coarse sand has resistivity and thickness ranging between 421 to 625.8 Ohm's meter and 14.73 to 34.72metres respectively.

*The fifth layer with a resistivity of 636.2 Ohm's meter is interpreted as coarse sand.

DISCUSSIONS

The result of the boreholes and VES correlation and interpretation show that the buried channel and environ are associated with low resistivities values that increases with depth. The low resistivity value is an indication of weak and soft materials saturated with moisture. The 4- 6 m column of incompetent clay in the second layer is an indication of hazard zone. The clayey material is a hazard to any engineering structures because of its swelling and shrinkage properties.The clay materials undergo gradual differential settlement when structures are placed on it thereby causing cracks and lose of durability in buildings.

The low apparent resistivities of the subsurface layers are also an indication that the corrosion of the area is high to moderate. The implication of this is that the foundation of buildings and buried utilities will suffer quick corrosion and thus reducing their life span. This is also confirmed with the result of the walkover survey which shows that most buildings in the area are undergoing gradual subsidence due to the compaction of the subsurface clay and the high moisture soft materials of the channel fills. The absent of drainage system to channel the flood water away is another major challenge in the Okilton Drive and it is having a great effect on the foundation of the buildings.

A total of four vertical electrical soundings were established. Five geoelectric units were obtained from the interpretation. The results of the interpretation shows that the buried channel is associated with low resistivities layers which is an indication of weak and soft materials saturated with moisture. The presence of clay and unconsolidated layers of high to mild corrosion are indications that the area is not feasible for building foundations. It is advisable that the top soil and clay materials should be removed and replaced with a more competent and less corrosive materials before any structure is built in the area. Recent and present damage, such as terrain subsidence, cracks and collapse of civil engineering structures such as buildings, call for attention and for soil investigation using geophysical methods to guide additional exploratory trenching and drilling. These methods are quick, inexpensive and use non invasive means to provide information about the subsurface properties.

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