



VOL. 2, NO. 1 JUNE 2018

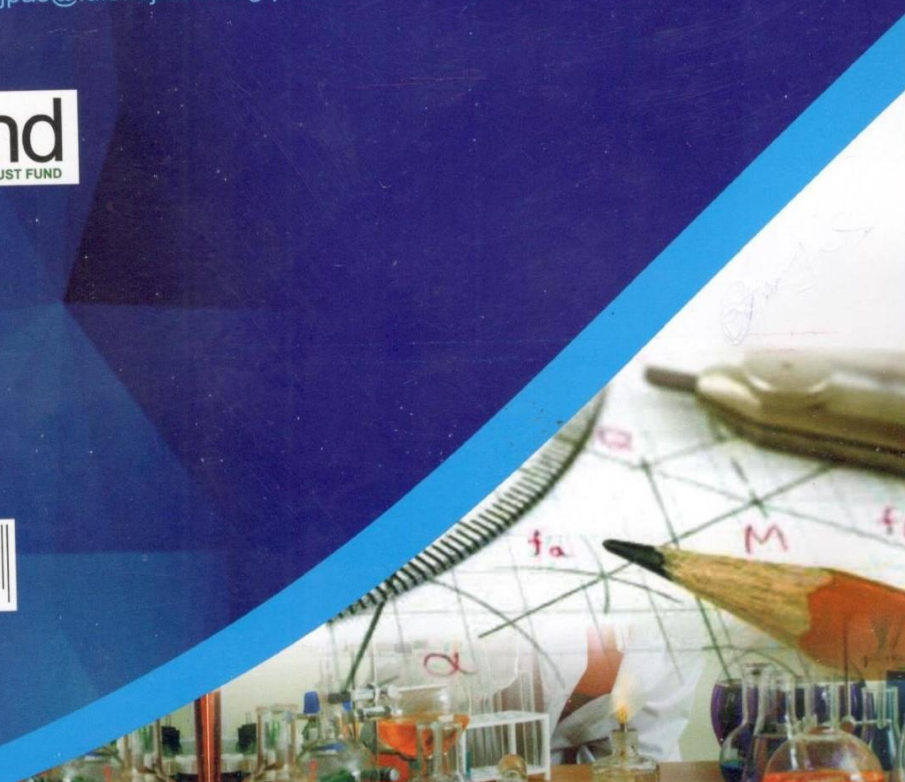
# Confluence Journal

of Pure and Applied Science.

Faculty of Science  
Federal University Lokoja, Kogi State Nigeria  
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ISSN: 2616-1303



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## STABILITY ASSESSMENT OF SOME EXISTING BUILDINGS IN UNILORIN PREMISES USING SCHLUMBERGER SOUNDING TECHNIQUE

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### ABSTRACT

Geophysical electrical resistivity method of Schlumberger Vertical Electrical Sounding (VES) was carried out within the premises of University of Ilorin, along each traverse near some selected high rise buildings on the University campus. The study was aimed at mapping the subsurface geologic features such as rock layering, lithological types and sequence in the subsurface that may pose danger to the existing structures. A total of fourteen (14) VES stations were established with maximum current electrode separation of 200 m and inter VES spacing of 20 m. VES geo-electric equivalent layers ranges from three (3) to five (5) layers within the area. Geoelectric 2D sections further confirmed that the area is characterized by layering series of topsoil, laterites, sandy clay, weathered/fractured basement and fresh basement. The resistivity distribution confirmed that the vicinities of profiles 2-5 to be moderately competent and highly competent with resistivity range of about 100-2000  $\Omega m$ . However, there is an isolated low resistivity distribution (60-300  $\Omega m$ ) around profile 1 in the vicinity of Faculty of Arts that terminates at about 20 m depth. This is attributable to incompetent footing. The subsurface features and overburden materials delineated in profile 5 close to postgraduate students' hostel is most favourable to civil engineering constructions as the range of resistivity distributions (200-2000  $\Omega m$ ) is attributable to competent footing for the super structures.

**Keywords:** Schlumberger, Sounding, Resistivity, Competent, Traverse and Pseudo-section

### 1.0 INTRODUCTION

Buildings, being primarily shelters for people, need to be taken care of in order to save life. During an on-the-spot assessment of collapsed buildings in Abuja one of the overall assertions by the civil engineers on site was that the incessant increase in the failure of buildings has been attributed partly to subsurface problems

which have not been accorded adequate attention by the owners and building experts prior to foundation design and construction. Lives have been lost and lots of properties have been wasted due to building collapses resulting from foundation problem, poor construction practice and the use of substandard building materials among other causes.

In the last decades, the involvement of geophysics in civil and environmental engineering has become an auspicious approach. Geophysical methods are employed in a wide range of applications ranging from subsurface investigations for

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How to cite this paper: Olatunji, S. & Folorunso, I. O. (2018). Stability Assessment Of Some Existing Buildings In Unilorin Premises Using Schlumberger Sounding Technique  
Confluence Journal of Pure and Applied Sciences (CJPAS), 2(1), 189 - 197.

rise buildings using the VES technique by mapping out the resistivity distribution, identifying the layers and their rock component within the subsurface and determine the geologic features such as faults, fractures, voids and clay that may pose danger to the existing structures within the campus of University of Ilorin.

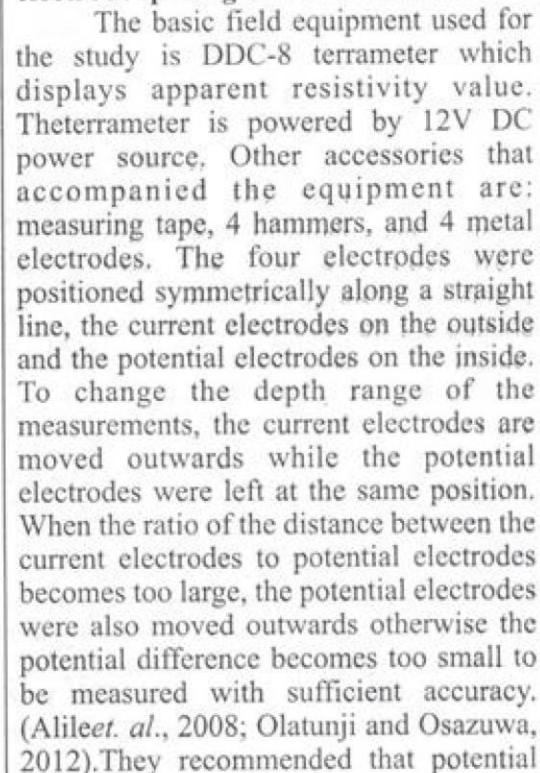
The locations of the targeted buildings are shown in Fig. 1 and their coordinates are presented in Table I. Ilorin metropolis, within which the study area lies, falls within the basement complex in the north central region of Nigeria (Fig. 2).

The area lies entirely on the Nigerian Basement Complex comprising the crystalline basement rocks of high-grade metamorphic rock faces. The common rock types include migmatite gneiss, augen gneiss, quartzite, older granite (extensively weathered) and superficial deposit. Thus, the structures considered are located on Migmatite-gneiss rocks of Ilorin (Oluyide *et al.*, 1998). Oluyide (1998) furthered that these rocks generally belong to those classified as lit-par-lit magmatite which are conventional migmatite with their components disposed in parallel order encompassing banded gneiss.

The frequent cases of building collapse pose the need for investigation into the cause and the means to proffer a lasting solution to the menace. This work therefore aimed at assessing the post foundation integrity of some selected high

electrode pairs. The depth of penetration is proportional to the separation between the current electrodes, in homogeneous ground. Varying apparent resistivities obtained when current electrodes position are changed provide information about the stratification of the ground (Dahlin, 2000).

Schlumberger array for vertical electrical sounding (VES) was used to collect resistivity data. This concerns symmetric arrangement about the centre of potential and current electrodes. Current sink is expands symmetrically about a common centre. This results in a semispherical current loop into the subsurface. So, the electric potential established by the flowing current is therefore monitored with the potential electrodes. A profile of multiple VES points was surveyed at closest range to each building understudied for data collection. A maximum current electrode spacing of 200 m was used.



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electrode separation expansion should be within the limit of not more than one-tenth of current electrode separation at any time.

In the VES configuration used, Geometric factor  $G$  is given by:

$$G = \pi \frac{\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2}{2\left(\frac{MN}{2}\right)}$$

Thus, Apparent Resistivity  $\rho_a = \frac{\Delta V}{I} \cdot G$

### 3.0 RESULT AND DISCUSSION

The VES data were processed using a third party software package, *IP2Win* developed by Bobachev, (2003) of Moscow State University. The output of the VES data is a log-log plot of apparent resistivity versus electrode separation. Some typical sounding curves obtained from the computer iteration of resistivity data are presented in figure III for VES 1 to VES 3. Additional information obtained includes the number of layers, resistivity of the different lithological layers and corresponding thickness of layers (Fig. III). The summary of the interpretation as obtained from *IP2Win* is as shown in Table IIa and IIb.

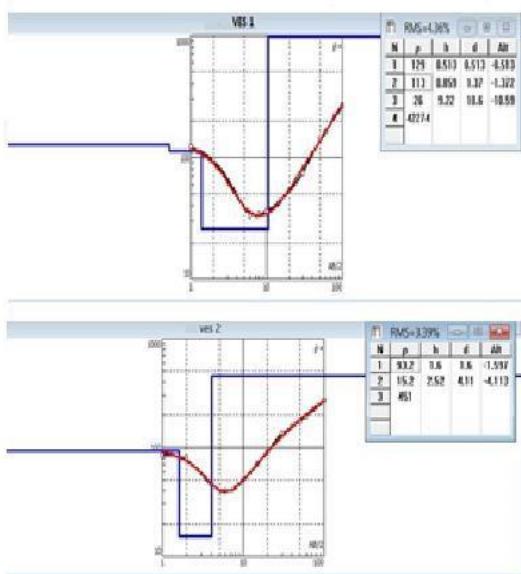


Fig.III: Sample Field Curves

Table IIa: Summary Interpretation of VES 1-7

| VES STATION | Curve Type | No. of Layers | Resistivity ( $\Omega m$ ) | Thickness | Depth to Bedrock | Remark             |
|-------------|------------|---------------|----------------------------|-----------|------------------|--------------------|
| VES1        | QH         | 4             | 129                        | 0.513     | 10.6             | Topsoil            |
|             |            |               | 113                        | 0.859     |                  | Laterites          |
|             |            |               | 26                         | 9.22      |                  | Weathered Basement |
|             |            |               | 42274                      |           |                  | Fresh Basement     |
| VES2        | H          | 3             | 93.2                       | 1.6       | 4.11             | Topsoil            |
|             |            |               | 15.2                       | 2.52      |                  | Laterites,         |
|             |            |               | 451                        |           |                  | Weathered Basement |
| VES3        | KH         | 4             | 169                        | 0.504     | 3.71             | Topsoil            |
|             |            |               | 1000                       | 0.769     |                  | Laterites,         |
|             |            |               | 10.2                       | 2.43      |                  | Weathered Basement |
|             |            |               | 29802                      |           |                  | Fresh Basement     |
| VES4        | HA         | 4             | 1018                       | 4.7       | 10.1             | Topsoil            |
|             |            |               | 15.9                       | 3.52      |                  | Laterites          |
|             |            |               | 54.2                       | 1.91      |                  | Weathered Basement |
|             |            |               | 10766                      |           |                  | Fresh Basement     |
| VES5        | KH         | 4             | 340                        | 0.5       | 2.5              | Topsoil            |
|             |            |               | 2373                       | 0.677     |                  | Laterites,         |
|             |            |               | 12                         | 1.32      |                  | Weathered Basement |
|             |            |               | 121                        |           |                  | Fresh Basement     |
| VES6        | KH         | 4             | 103                        | 0.419     | 23               | Topsoil            |
|             |            |               | 3275                       | 1.002     |                  | Laterites,         |
|             |            |               | 243                        | 21.6      |                  | Weathered Basement |
|             |            |               | 4264                       |           |                  | Fresh basement     |
| VES7        | KH         | 4             | 187                        | 0.637     | 4.26             | Topsoil            |
|             |            |               | 1871                       | 1.5       |                  | Laterites,         |
|             |            |               | 100                        | 2.13      |                  | Weathered Basement |
|             |            |               | 695                        |           |                  | Fresh Basement     |

Table IIb: Summary Interpretation of VES S-14

| VES STATION | Curve Type | No. of Layers | Resistivity ( $\Omega m$ ) | Thickness | Depth to Bedrock | Remark             |
|-------------|------------|---------------|----------------------------|-----------|------------------|--------------------|
| VES8        | KH         | 4             | 165                        | 1.52      | 9.08             | Topsoil            |
|             |            |               | 1475                       | 1.42      |                  | Laterites          |
|             |            |               | 102                        | 6.14      |                  | Weathered Basement |
|             |            |               | 1338                       |           |                  | Fresh basement     |
| VES9        | HKH        | 5             | 416                        | 1.02      | 17.1             | Topsoil            |
|             |            |               | 2064                       | 1.49      |                  | Laterites          |
|             |            |               | 27.3                       | 4.04      |                  | Weathered Basement |
|             |            |               | 736                        | 10.5      |                  | Fracture basement  |
| VES10       | HA         | 4             | 10.5                       |           | 54.6             | Fresh Basement.    |
|             |            |               | 398                        | 3.04      |                  | Topsoil            |
|             |            |               | 109                        | 1.2       |                  | Laterites,         |
|             |            |               | 190                        | 50.4      |                  | Weathered Basement |
| VES11       | KH         | 4             | 35227                      |           | 3.16             | Fresh basement     |
|             |            |               | 219                        | 0.5       |                  | Topsoil            |
|             |            |               | 818                        | 0.643     |                  | Laterites          |
|             |            |               | 16.1                       | 2.02      |                  | Weathered basement |
| VES12       | HKH        | 5             | 25083                      |           | 25.5             | Fresh basement     |
|             |            |               | 298                        | 0.5       |                  | Topsoil            |
|             |            |               | 1030                       | 0.836     |                  | Laterites          |
|             |            |               | 136                        | 8.22      |                  | Weathered Basement |
| VES13       | HKH        | 5             | 8220                       | 15.9      | 29.6             | Fracture basement  |
|             |            |               | 113                        |           |                  | Fresh Basement.    |
|             |            |               | 484                        | 0.5       |                  | Topsoil            |
|             |            |               | 4580                       | 0.836     |                  | Laterites          |
| VES14       | A          | 3             | 213                        | 2.23      | 7.11             | Weathered Basement |
|             |            |               | 11576                      | 26        |                  | Fractured basement |
|             |            |               | 98.2                       |           |                  | Fresh basement     |
|             |            |               | 53.3                       | 0.544     |                  | Topsoil            |
|             |            |               | 650                        | 6.57      |                  | Laterites          |
|             |            |               | 156910                     |           |                  | Weathered basement |

The competence of soil with respect to the resistivity value, according to Idornigie and Olorunfemi 2006, for engineering construction purposes is rated as follow:

- Incompetent ( $\leq 100 \Omega m$ ); this could be clay or water-bearing zone.
- Moderate ( $100-350 \Omega m$ ); this may be sandy clay environment.
- Competent ( $350-750 \Omega m$ );

iv. Highly competent ( $\geq 750 \Omega m$ ); this could be fresh basement area depending on the state of freshness.

Based on the benchmark above, 2D pseudo-sections from all the profiles along the high-rise buildings were produced (Fig. IV-VIII) for the purpose of competence rating. The result is summarized in table III. The area falls between moderate and highly competent ratings.

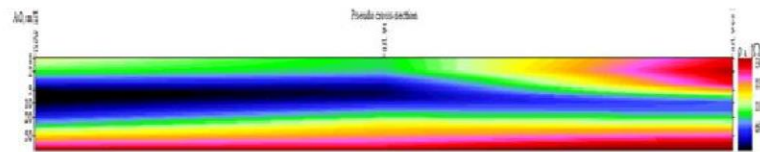


Fig. IV: 2D pseudo-section for Profile 2, (VES 1, VES 2 and VES 3)

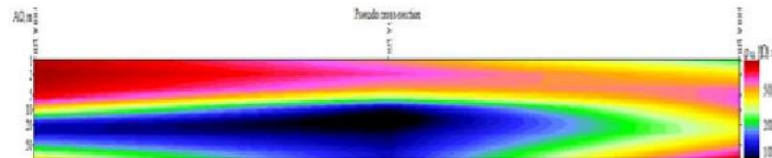


Fig. V: 2D pseudo-section for Profile 2, (VES 4, VES 5 and VES 6)

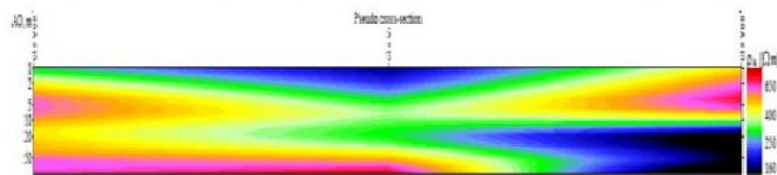


Fig. VI: 2D pseudo-section for Profile 3, (VES 7, VES 8 and VES 9)

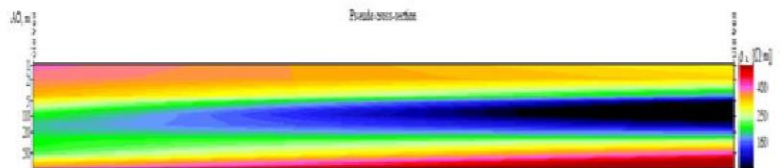


Fig. VII: 2D pseudo-section for Profile 4, (VES 10 and VES 12)

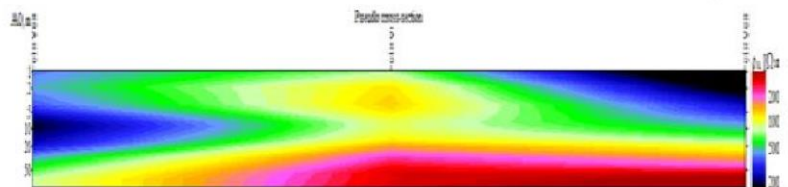


Fig. VIII: 2D pseudo-section for Profile 5, (VES 12, VES 13 and VES 14)

Table III: Subsurface Competence Rating Around the Structures

| SN | Building                                                             | Resistivity Range on the Associated Profiles ( $\Omega m$ ) | Competence Rating |
|----|----------------------------------------------------------------------|-------------------------------------------------------------|-------------------|
| 1  | Faculty of Arts Main Building                                        | Profile 1: 60 - 300                                         | Moderate          |
| 2  | New Faculty of Arts Lecture Theatre                                  | Profile 2: 100 - 500                                        | Moderate          |
| 3  | Faculty of Communication and Information Science Main Building       | Profile 3: 160 - 650                                        | Competent         |
| 4  | Faculty of Communication and Information Science New Lecture Theatre | Profile 4: 160 - 400                                        | Competent         |
| 5  | Post-Graduate Hostel                                                 | Profile 5: 200 - 2000                                       | Highly Competent  |

The resistivity pseudo-sections show continuous high resistivity zone close to the surface in all the profiles. Resistivity of the layer from depth 0-5m varies from 60 -300  $\Omega$ m along profile 1. Hence, this layer is rated to be moderately competent. Also, the lithological unit is made up of sandy clay and possibly the bedrock may be encountered very close to the surface. However, from profile 2 high resistivity layer runs from depth 0-5m and varies from 100 -500  $\Omega$ m. Hence, the layer is rated to be moderately competent. Also the lithology is made up of sandy clay. We now consider the highest resistivity zone on the surface. Resistivity of this layer from depth of about 50m increases downward and varies from 200 $\Omega$ m – 2000 $\Omega$ m along profile 5. Hence this layer is rated to be highly competent. The lithology is made up of sand/laterite/bedrock. Moreover, profiles 1 to 5 are suitable for construction because of their high resistivity and therefore the existing buildings on them could be stable and not suffer stability threat.

#### 4.0 CONCLUSION

*The number of geo-electric layers in the area ranges from 3 to 5. These layers are mostly identified to be the top soil, lateritic, sandy clay, weathered basement and fresh basement. The competence rating is from moderate to high. No area was found incompetent. That is there is no construction threat base on the results obtained. Though, fresh basement is at varying depths in all the profiles but it is shallow around postgraduate hostel. This could be responsible for the high competence obtained in the area. The knowledge of the depth to basement is very necessary when high-rise building is to be constructed. This will give a clue to the choice of foundation depth. Therefore in case of any plan to construct high-rise buildings in the area more geophysical study to reveal the basement topography is recommended.*

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