

Geoelectric Imaging for Foundation Failure Investigation AT Olabisi Onabanjo University (O.O.U) Minicampus, Ago Iwoye, southwestern Nigeria.

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Abstract: An investigation of the cause (s) of the foundation failure of the PDS building in the Mini-Campus of Olabisi Onabanjo University, Ago Iwoye Nigeria was carried out using the electrical resistivity method. The aim was to delineate the subsurface as a means of determining the cause (s) of the foundation failure. Measurement involving Dipole-Dipole configuration and vertical electrical sounding (VES) were taken along four (4) traverses, using the Pasi Earth (16GL) Resistivity meter. The results were presented as a pseudosection, 2-D resistivity map and geoelectric sections. Three geoelectric layers were delineated from the results; these are the top soil (sandy clay), weathered layer (clayey sand) and fresh basement. The pseudosection and resistivity map suggest that clayey material constitute some part of the subsoil materials. It is concluded from these that the building failed due to incompetent clay layer and improper foundation design on some side of the building on which the building was founded.

Key words: Electrical Resistivity, Foundation failure, Incompetent clay, Geoelectric layer, Vertical electrical sounding.

INTRODUCTION

The incessant incidence of foundation failure of structure is becoming alarming in Nigeria. This failure has been attributed to a number of factors such as inadequate information about the soil and the subsurface geological material, poor foundation design and poor building materials. This has led to the loss of life and loss of goods and properties worth millions of naira. The structural failure ranges from settlement, differential settlement, upthrust and total collapse^[3].

Some earth materials, due to their nature, cannot support solid and rigid structure among these materials are clays and clay-bearing earth. Similarly, earth materials such as sands and fresh basement rock provide firm support for solid foundation.

To this end, geophysical methods besides geotechnical approaches are routinely used for foundation investigation. The geophysical methods that suit such investigation are the electrical resistivity, gravity and seismic refraction methods^[7,4,5].

The electrical resistivity method usually furnishes the engineers information about the depth to the bedrock, the composition of the geologic layers and the trend/nature of geological fissures that can jeopardize or threaten the life span of the structure.

In this study, the electrical resistivity survey of geophysical technique is used to investigate the

foundation bedrock, and the sub soil condition of the studied area in order to determine the cause(s) of the failure of the PDS building which manifest in form of tilting and cracks.

Location of the Study Area: The study area is the PDS building which falls within the Mini Campus of Olabisi Onabanjo University Ago Iwoye. The area is located within the Southwestern Nigeria and is between longitude 3°53' 300" - 3°56' 340" East of the Greenwich meridian and Latitude 6°55' 232" - 6°57' 300" North of the equator. The area is accessible by major roads such as Ilisan expressway, Oru-Ijebu road, Ishara express and a whole lot of minor roads.

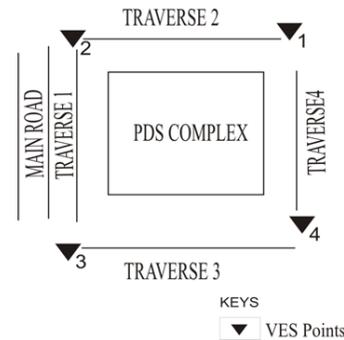


Fig. 1: Map Showing the Traverses of the Study Area

Geology of the Area: The study area which is an Ago-Iwoye area falls within the basement complex of Southwestern Nigeria^[6]. The area is underlain by gneiss of various grades and suites occupying most part of the area, the rocks are porphyroblast gneisses, Biotite gneisses granite and banded gneisses^[7,1]. A small portion of the area is covered by the massive quartzite schist, mica schist. There are foliation observed on rocks like banded gneiss and granite gneiss and the foliation in gneiss is referred to as gneissosity which is the alteration of light and dark colored minerals.

Methodology: For the purpose of this research ,the electrical resistivity method involved Dipole Dipole and shlumberger array were employed. Four main traverses were occupied around the building(T1-T4). The Pasi Earth Terrameter(16GL model), direct current (D.C) sources and four electrodes were used for the survey. The current electrode spacing were varied from 1-50m(i.e AB/2 =50M,AB=100M) for shlumberger array and our n=1-5,and a=5 for the Dipole - Dipole configuration .The shlumberger data were presented in form of curves by plotting the apparent resistivity against electrode spacing(AB/2) on a bi-log graph. The curves were interpreted by partial curve matching and computer iteration by using RESIST software.

The Dipole- Dipole data were presented in form of pседosection and interpreted by DIPRO software to provide both lateral and vertical information of the study area. The interpretation was qualitative .Dipole-Dipole was set-up to have a clear view of the 2-dimensionanl view of the subsurface, where the construction building is failing. Since the apparent resistivity value collected in field are affected by the thickness and fluids content of each of the subsurface layers, the interpreted result should provide a minor accurate picture of resistivity as a function of depth.

The DIPRO software gives a 2-D inverted resistivity value as a function of depth. The pseudosection and cross-section was also plotted to have a different view of lateral and vertical variations within the subsurface. The pseudosection shows an interpretation of unilateral data and its contour maps, while the cross-section shows a lateral view of the iterated curve with respect to the elevation differences

RESULT AND DISCUSSION

We have noticed that the foundation of the PDS building is tilting toward N-S. The building failure is manifested in form of cracks. The cracks and tilting observed on the building may have been caused by subsidence of the foundation soils. Inversion process of the data for four (4) different profiles, which were run at each side of the building was carried out. The profile were arranged to have 2-dimensional view of the subsurface in order to determine the competency of the subsoil within the premises of the failed structure.

All the results are in form of pseudosection and 2D resistivity structure map and they were interpreted qualitatively. The 2D inversion of the Dipole-Dipole was carried out using DIPRO SOFTWARE (see traverse 1-4).

The result of the VES reveals the vertical information of the geologic layers to the depth of about 10m.Three main geoelectric layers were identified: top soil (sand/sandy clay), weathered basement and fresh basement (see fig:5 I- IV) .The weathered basement (clay), which constitutes the second layer has thickness of about 2.7m at VES1 location and overlain by thin sand layer of resistivity value of 318 ohms-m and thickness of 0.7m.This layer is sandy clay/sand in other VES locations. The manifested failure is pronounced at the VES1 location, which we presume that is due to this thick incompetent layer.

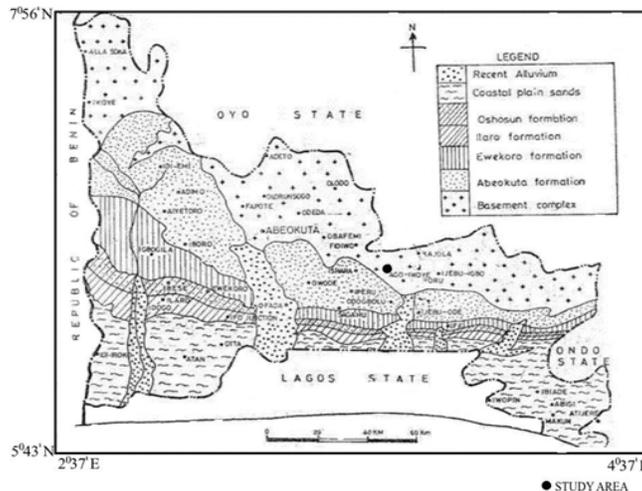


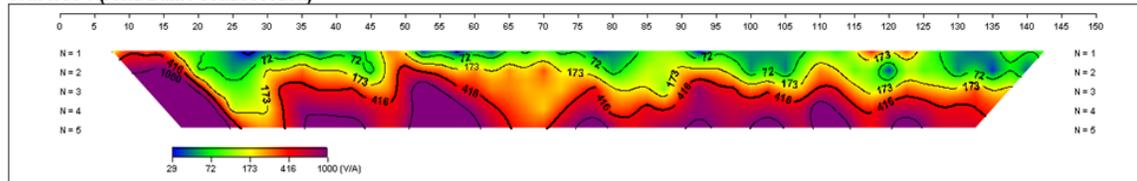
Fig. 2: Geological Map of Ogun State^[2].

Traverse 1: The direction of the traverse goes from E-W, the lateral extent of the traverse is 150m.

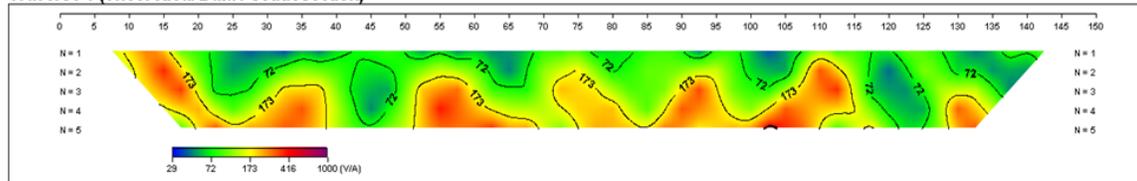
The pseudosection and 2-D resistivity map were qualitatively interpreted revealed three geoelectric layers, which are top soil, (which contain pocket of clay), weathered bedrock and the fresh basement respectively.

From the field data pseudosection, theoretical data pseudosection and 2D resistivity structure along TR1 shows that it is relatively stable for foundation structure, because the weathered basement has moderate resistivity and the basement is close to the surface. The only structure observed along this traverse is at distance position 60-75m, which is a highly weathered structure that is outside the building area.

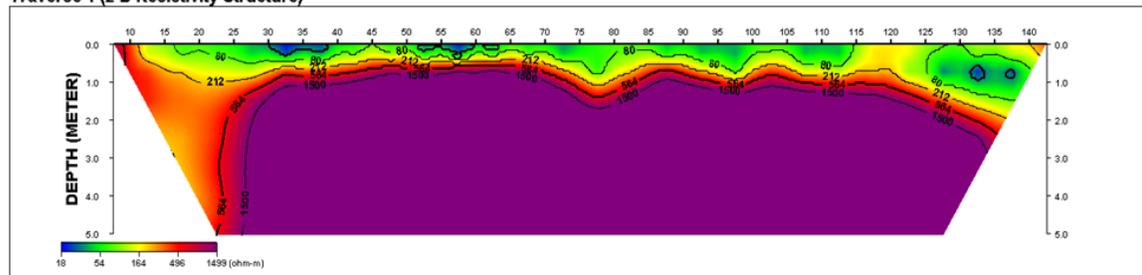
Traverse 1 (Field Data Pseudosection)



Traverse 1 (Theoretical Data Pseudosection)



Traverse 1 (2-D Resistivity Structure)

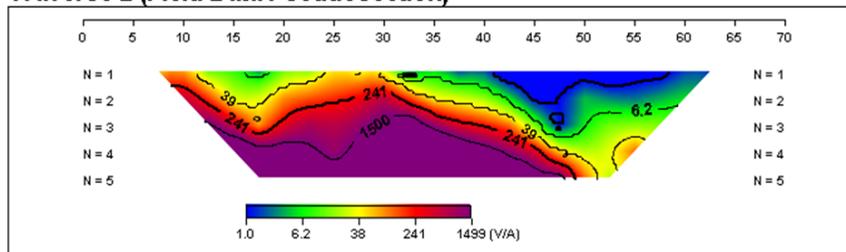


Traverse 2: This traverse goes in the N-S direction with a lateral extent of 65m, the pseudosection and 2-D resistivity map delineate three geoelectric layers which are the top soil (clay/sand), weathered basement and fresh bedrock.

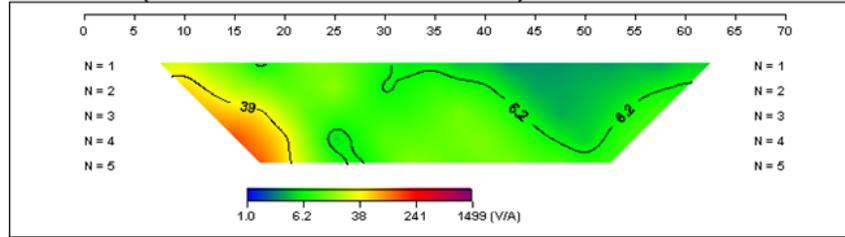
At the beginning of this traverse, from distance position 0-35m, the overburden is competent which is a weathered basement due to its high resistivity. Toward the ending of this traverse, it has a very low resistivity which is diagnostic of clayey weathered material which is not a good foundation materials, it has a resistivity value less than 50Ωm. This may have been the cause of the foundation subsidence, which has been observed in this part of the building due to cracks on the walls. The weathered clayey material is up to the depth of 4m.

The 2.D resistivity structure has also confirm this by showing a low resistivity material to a depth of about 4m toward the back of this building, whereas at the front, this incompetent weathered clayey material is very close to the surface.

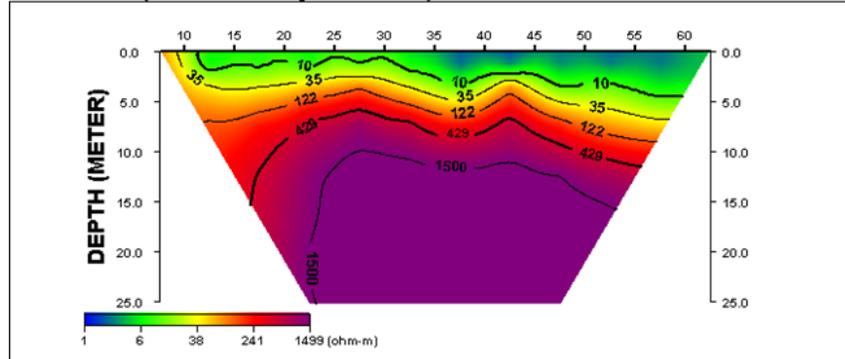
Traverse 2 (Field Data Pseudosection)



Traverse 2 (Theoretical Data Pseudosection)



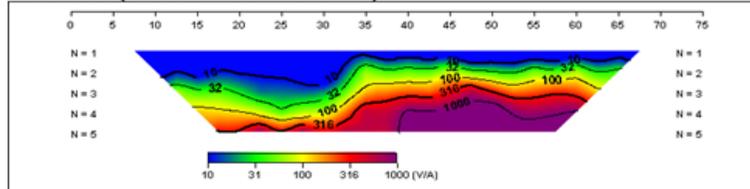
Traverse 2 (2-D Resistivity Structure)



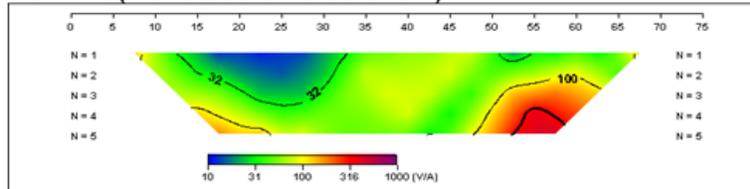
Traverse 3: The direction of the traverse is to the N-S, and the lateral extent is 65m, the pseudosection and 2-D resistivity map delineate three geoelectric layers which are the top soil (sandy clayey), weathered basement and the fresh bedrock.

Much failure are not observed in this side of the building. It has a low resistivity at distance position 10-35m, with resistivity value less than 20Ωm and it is incompetent for a foundation structure, but much failure are not observed because foundation design has taken care of this. The loose clayey material is up to the depth of 3m

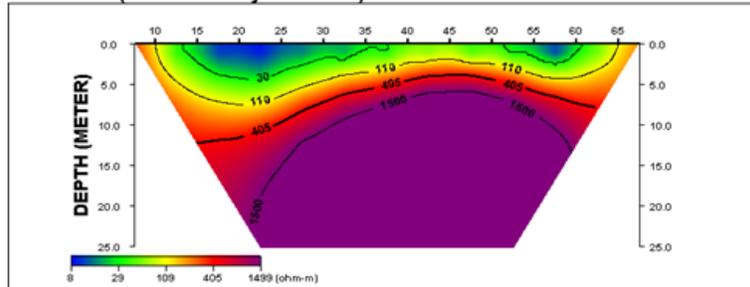
Traverse 3 (Field Data Pseudosection)



Traverse 3 (Theoretical Data Pseudosection)



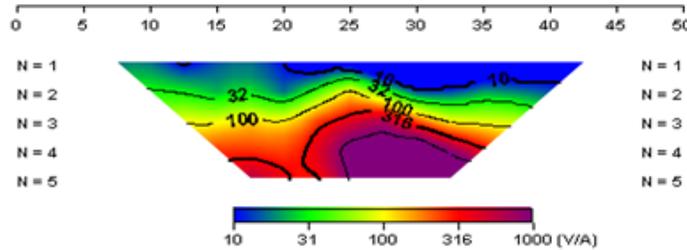
Traverse 3 (2-D Resistivity Structure)



Traverse 4: The direction of this traverse is E-W and the lateral extent of 45m. the pseudosection and 2-D resistivity map delineate three geoelectric layers which consist of the top soil (sandy clay), weathered basement and fresh basement.

It has a low resistivity weathered material to the depth of 3m along this traverse, but with little failure observed. This resistivity value ranges from 10Ωm-15Ωm. The foundation design has taken care of the possible failure in this side. The clay distress of the foundation here might appear less severe most likely because the thick clay layer is uniform along the traverse and causing uniform settlement

Traverse 4 (Field Data Pseudosection)



Traverse 4 (2-D Resistivity Structure)

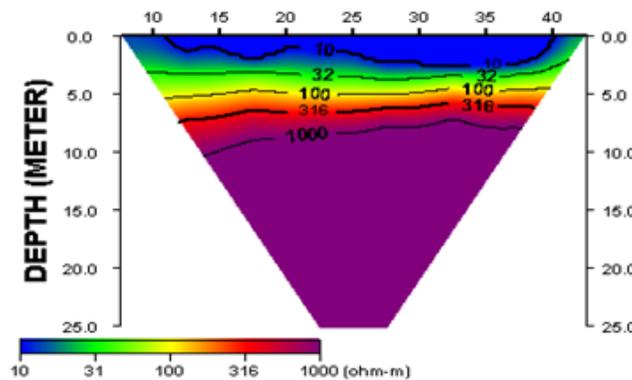


Fig. 4: Field Data plot for Traverse 4

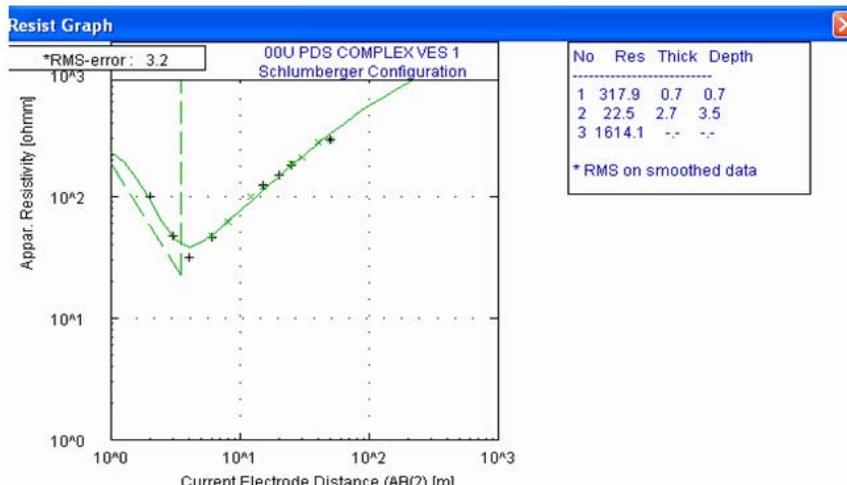


Fig. 5(I): the Schlumberger Depth Sounding Curve Beneath Ves 1 at Oou, Pds Complex

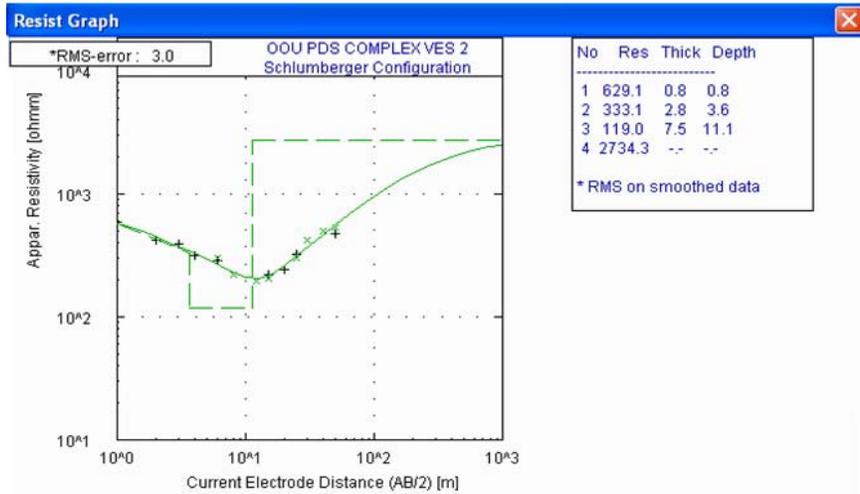


Fig. 5(II): the Schlumberger Depth Sounding Curve Beneath Ves 2 at Oou,pds Complex

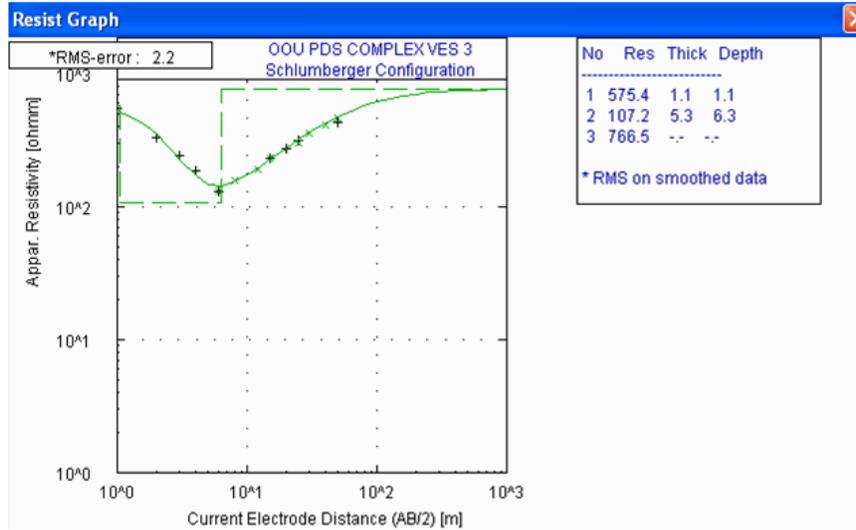


Fig. 5(III): The Schlumberger Depth Sounding Curve Beneath Ves 3 at Oou, Pds Complex

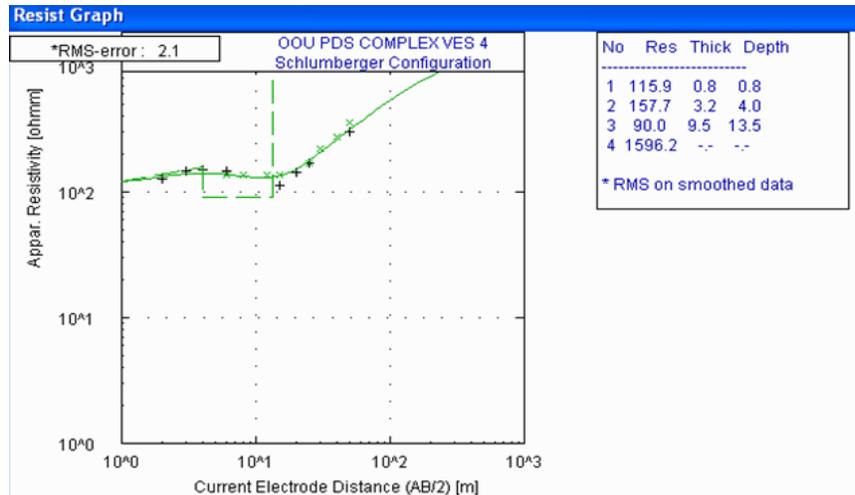


Fig. 5(IV): The Schlumberger Depth Sounding Curve Beneath Ves 4 at Oou, Pds Complex

Conclusion and Recommendation: The PDS building at the mini campus of Olabisi Onabanjo university was investigated using Dipole-Dipole Configuration and Schlumberger array involving vertical electrical sounding (VES) of electrical resistivity method. Measurements were taken along four traverses round the building. From the qualitative interpretation of the pseudosection and 2-D resistivity map, three geoelectric layer were delineated which corresponds to the top soil (sand/clayey sand), weathered basement and fresh basement respectively in all the traverses. The Dipole-Dipole data delineate highly incompetent clay layer along traverse 2, to the depth of about 4m toward the end of the traverse.

The VES interpretation reveals that the area is underlain by three major geoelectric layers, the top soil (sand/sandy clay), weathered basement and fresh basement. At VES 1 location (i.e. end of traverse 2), the weathered layer is made up of clay formation with resistivity value of 23ohm-m to the depth of about 4m. The building failure is more pronounced at this location. Although incompetent clay layer were seen along other traverses but foundation design has taken care of this.

In the light of this result, it is observed that the failure of the foundation is due to differential settlement toward the end of traverse 2 which is pronounced by the observed tilting and cracks. Due to the treat of the tilting and cracks observed on this building which result from differential settlement, it is advised that reinforcement and concrete packing should be done in areas with more pronounced subsidence so as to avert further damage and total collapse. Buttress pillar will also go a long way to rescue the building from further differential settlement and total collapse

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