INVESTIGATION OF GROUNDWATER SEEPAGES IN A BASEMENT COMPLEX TERRAIN USING GROUND PENETRATING RADAR AND VERTICAL ELECTRICAL SOUNDING TECHNIQUES

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CERTIFICATION

This is to certify that this research work carried out by Mr. Salako Adebayo Olayinka (SCP11/12/H/0165) has been read and approved as meeting part of the requirements for the award of Master of Science (M.Sc.) degree in Applied Geophysics in the Department of Geology, ObafemiAwolowo University, Ile – Ife, Nigeria.

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DEDICATION

This research work is dedicated to God Almighty and to my wonderful loving Parents; Dr and Mrs. Salako.

ACKNOWLEDGEMENTS

Firstly, I will like to thank the Omnipotent and Sufficient God, the one who knows the beginning from the end, for his marvelous grace over me.

My profound thanks and gratitude goes to my Supervisor; Dr. A. AAdepelumi, the M.Sc. Applied Geophysics Coordinator; Prof. M.OOlorunfemi for this fatherly admonishment, counsel and technical support.

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I will like to appreciate the attitudinal response of my course mates during the field work and in the processing of my data in areas where I experience hitches. Thank you all for you moral support.

Lastly I would like to say a big thank you to my Parents Dr. & Mrs. Salako; my Uncle and his wife; Dr. and Mrs. Salako and my siblings; Dr. FolukeIrabor, Pharm. DeolaOgunsanya, Pharm. RonkeAbeyo, Mrs. Ife Jaiyesimi and ToyinSalako for their encouragement and financial support. Thank you all.

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ABSTRACT

Ground Penetrating Radar (GPR) and Electrical Resistivity (ER) surveys were carried out in the Basement Complex environment at Erinle area within the Ede metropolis, Osun State. This was with a view to investigating groundwater seepage and its effects on buildings in the study area.

Ground Penetrating Radar (GPR) profiles with lengths of between 80 m and 100 m each were acquired along eight (8) traverses; seven of which ran West-East, while the remaining one ran North-South to the general strike of the geology. The data were acquired at a station interval of 10 m along the 100 m spread. The data were subjected to processing by the RADprowin (GPR Software) to produce radargrams. Thirty two Vertical Electrical Sounding (VES) stations were acquired using the ABEM SAS300C Resistivity Meter along eight (8) traverses with the Schlumberger array and a maximum spread of 100 m. The data obtained from the electrical resistivity survey were interpreted using the partial curve matching and computer assisted 1-D forward modelling. The VES interpretation results were used to generate geoelectric sections.

The Ground Penetrating Radar (GPR) and Electrical Resistivity delineated three subsurface layers. These include the topsoil, the weathered layer and the basement bedrock. On the geoelectric sections, the topsoil had resistivity range of 69 Ωm to 426 Ωm and thickness range of 1.2 m to 7.2 m. The weathered layer had resistivity range of 19 Ωm to 281 Ωm and thickness range of 7.0 m to 17.4 m. The basement bedrock had resistivity range of 459 – 5289 Ωm and thickness range of 4.9 m to 8.6 m. On the radargrams, the topsoil was characterized by planar to smooth reflections. The weathered layer was characterized by nearly smooth reflections while the basement bedrock was characterized by chaotic reflections with micro-diffractions. The

weathered layer revealed anomalously low resistivity values (< 65 Ωm). These anomalously low resistivity values were probably due to increase in clay and water content. This thus made Traverses 1, 2, 3 and 5 more susceptible to groundwater seepages as compared to the other traverses, as these traverses revealed anomalously low resistivity values (< 65 Ωm). Linear and near – vertical structures (subsurface structures) were delineated at a depth range of 2 m to 6 m along GPR profiles represented by Traverses 1, 2, 3 and 5. These subsurface structures which included micro – fractures, joints and mud cracks could serve as conduits for groundwater seepages.

The Study concluded that low resistivity/high water moisture content was due to increase in clay and water content in the weathered layer and some sections of the topsoil. This made such zone susceptible to groundwater seepages through micro-fractures, joints and mud cracks.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study Area

Cases of collapses or distressedbuildingshave become a common occurrence in Nigeria in the last two decades. The Nigerian Institute of StructuralEngineershave raised several alarms in the past on perpetual issues of collapsed buildings in the country. There are many causes of this problem, but the most fundamental cause identified is foundation and structural failures. Foundation problems in buildingsmay occur as a result of buildings erected on weak soil strata that do not have the strength to carry the load on it (low load bearing capacity).Roberts (1996) posited that, foundations built with good materials and first class workmanship will fail if poor soil conditions are encountered.

The seepage of groundwater from the subsurface to the surface through conduits such as faults, fractures and cavities reduces the bearing capacity of the soil strata and may also lead to differential settlement, cracks on walls and flooding especially during the rainy season (Idornigie*et. al.,* 2006). Omorinbola (1986) suggested that groundwater recharge in Ede area is through influent seepage and infiltration of rain water into the aquifer and regoliths. Groundwater seepage has been identified as one of the factors responsible for the high number of distressed buildings found at Erinle area within the Ede metropolis. Plates 1.1, 1.2 and 1.3(see Appendix E) are the pictures taken within the study area showing the effects of groundwater seepages in some locations. There is therefore the need to integrate Ground Penetrating Radar

(GPR) and Electrical Resistivity geophysical techniques to investigate the extent of the seepage and to forestall future loss of lives and property.

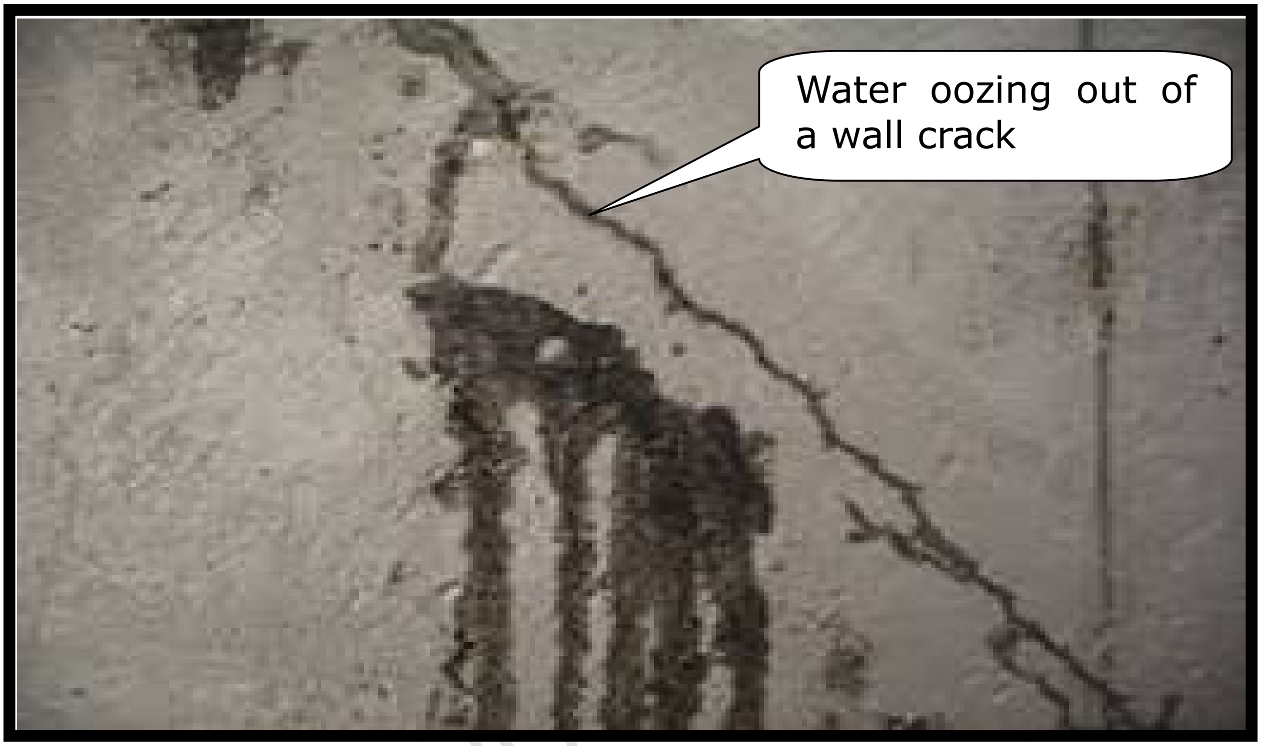

Plate 1.1: Water Oozing from Cracks on theWall of a Building in the Study Area(Erinle)

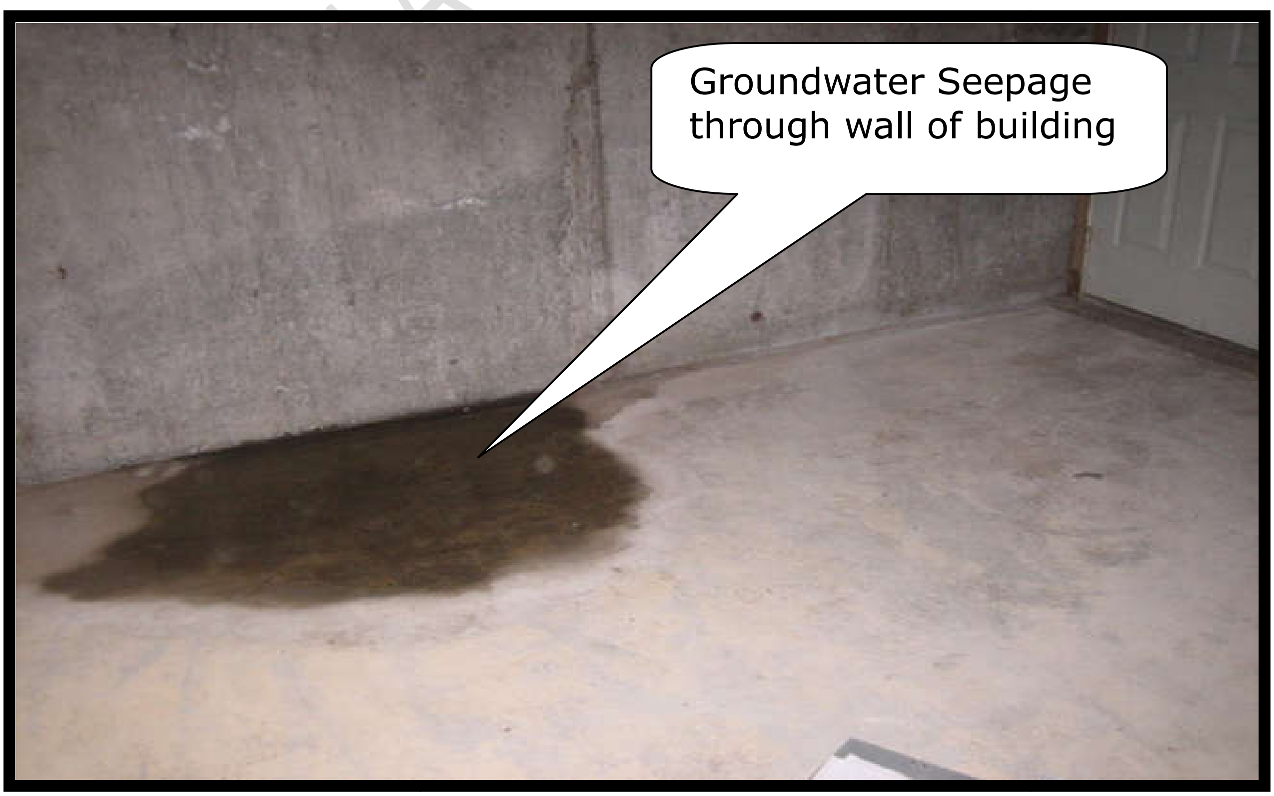

Plate 1.2: Water Seepingthrough the Floor of a Building in the Study Area (Erinle)

Groundwater movement or seepage through geological formation or engineering structures is amenable to geophysical detection (Bogoslovsky and Ogilvy, 1970; Butler *et. al.,* 1988). The electrical resistivity of a formation is directly related to the nature, distribution of the formation water and the occurrence of geological structures such as micro-fractures and cavities within the subsurface. This could be mapped using Vertical Electrical Sounding (VES) and Ground Penetrating Radar techniques (Olorunfemi*et al.,* 1986; Osama and Peter, 1998).

Considering that Erinle found within the Ede metropolis is a commercial area with a fairly large population,cases of collapse or distresses in buildings within the area would pose a serious threat to human life, the economy of the nation and could further increase accommodation problems in the state. In view of this, the present study was carried out with a view to understanding the architecture of the subsurface; detect groundwater seepage zones and structural features (such as micro-fractures, joints, mud-cracks) that could facilitate groundwater movement into the foundations of a set of houses located within the Erinle area of Ede town, Osun State.

1.2 Description of the Study Area

1.2.1 Location of the Study Area

The study areaErinleis located within the Ede metropolis, Osun State, Nigeria (Figs. 1.1 and 1.2). Osun State is bounded in the north by Kwara State, in the east partly by Ekiti State and Ondo State. It is situated between latitudes 7^{o}45'1"N and 7^{o} 45' 3 "N, and longitudes4^{o} 25' 49" E and 4^{o}25'52" N (Figure 1.2). The Study area is accessible by Ede – Oshogbo Road and footpaths