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APPLICATION OF 2-D IMAGING SURVEY FOR ASCERTAINING THE CAUSE(S) OF ROAD FAILURES ALONG SAPELE/AGBOR ROAD IN DELTA STATE, NIGERIA

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ABSTRACT

Surveying involving 2-D imaging dipole–dipole geophysical technique was carried out along Sapele-Agbor Highway situated in Southern, Nigeria to determine the primary causes for Highway pavement failure. Twelve profiles spreading over 100 meters were in each cases conducted on road surface sections along the stable (control) and unstable portions of the road. Data were gathered together along the various profile employing ABEM Terra meter SAS 1000. The field data were processed and inverted utilizing Dipro software. This was done by specifying and locating the geoelectric arrangement within the surface, sub-base and sub grade soil to obtain the confirming cause(s) of the road associated with pavement failure. Geoelectric sections identified four geologic layers embracing the topsoil, clayey, laterite and sand. The sections failure is due to disparity of the material used for road model (construction) as some comprises of clay materials. The results show the presence of low resistivity values at several subdivisions of the 12 profiles. Resistivity values varying from 21.60 Ωm – 1026.0 Ωm to a depth of 14.92 m from the surface was observed along Okpara Water side, Aghalokpe and Otumara. In Igun, Eku and Obiaruku resistivity values ranges from 10.5 Ωm – 500.0 Ωm to a depth of 5.5 m from the topsoil, 22 m from sub grade and 9.8 m - 50 m were observed along the four profiles. Urhomehe, Urhonigbe, Abavo and Agbor indicate resistivity ranging from 59.25 Ωm – 1467.50 Ωm for stable and unstable sections of the road with depth up to 15.0 m for some profiles. Low resistivity values, not greater than 199 Ωm observed in some distinctive regions of 12 profiles comprises of expansive, compressible, collapsible and sandy clay materials which have the capacity of absorbing water. These make the roads swell and collapse leading to road failure under stress and strain. Many stable portions of the road are characterized with high resistivity value greater than 199 Ωm, mostly laterite materials. Competent fill soil should replace low resistivity soil to a depth of 5 m – 7m from the surface of the road. Good drainage system is also recommended within the unstable road sections.

Keywords: Road Failure, Imaging, Electrical Resistivity, Geological formations, Application

INTRODUCTION

Road failure is describe as the inability of an average or normal road to necessitate its usable services by neglecting to provide a smooth surface for vehicles movement (Akintorinwa et al., 2010). Problems associated with Road failure include cracking, potholes, depressions, rutting, and upheavals, shoving and raveling (Ozegin et al., 2016; Akinola et al., 2020; Emmanuel et al., 2021; Ademila 2022). Road pavement is simply referred to as a formational materials placed upon sub-soil layers (Woods, 2002). Flexible highways allow easy, fast and uninterrupted movement of vehicles. They have become very useful for conveying individuals, goods and services from one place to another mainly in Nigeria and other developing countries where other means of transport such as rail, air, and water transport systems are widely underdeveloped. However, numerous bad portions of the road do more destruction than good due to inadequate planning of surface, sub-grade and sub-base materials. They cause several deadly crashes at period of traffic delays, increase in cost of transportations, breaking down vehicles and losing valuable time (Osinowo et al., 2011; Peter et al., 2018; Young et al., 2021).

Road failure without desired age has become widespread in Nigeria and other developing countries which has resulted to loss of multi millions dollars over some decades due to inferior construction and roads maintenance. These failed portions have resulted to loss of love ones (human lives) and valuable properties. Thus, the failed parts of the road are mainly caused by low resistive sub materials below the vehicular pavement and the mapped out features are the main geological factors liable for road failure.

Several factors responsible for road failures include geological factors, geotechnical factors, poor construction materials, road usage factor, bad design, maintenance practices and geomorphologic factors (Adegoke 1980; Ajayi 1987; Momoh et al., 2008; Odunfa et al., 2018; Ademila 2022). The geological factors include the soil's condition, failures caused by human activities, near-surface geological series, the occurrence of geological strata such as faults and fractures, presence of shear and cavities zones (Momoh 2008; Adiat et al., 2009 ; Emmanuel et al., 2021). Surface drainage system and Topography are the geomorphological observations. Other factors considered by some civil engineers and researchers include: flawed foundation or facilities and poor road arrangement, inadequate maintenance (John 1976; Abynayaka 1977; Oglesby and Garry, 1978; Jain and Kumar, 1998:) traffic actions, human influence, geological breakdown (ANSMWH, 1998; Ibrahim 2011; Adeyemo and Omosuyi, 2012); the existence of cracks and ground borders and construction of roads on a weathered base (Ibitomi et al., 2014;Shehu*et al*.,2020; Ogungbe et al., 2021).

Road transportation is a crucial factor for the growth and progress towards achieving national growth resulting to overall success and social well being. The disrepair and poor state of most Nigeria roads has become an alarming challenge on federal, state, and local governments to repair the roadways (Festus and Obaloluwa, 2021). Despite several efforts at reconstruction, majority of our highways failed indefinitely after commissioning. Rehabilitation has been a reoccurring and a huge financial strain on all tiers of government and even on non-government bodies. This abortive reconstruction and rehabilitation or rebuilding and corrective maintenance of roads in Nigeria, designed with asphalt concrete to improve their resilience, would have been overcome if adequate geophysical and geological suggestions had been gotten before building major and minor roads (Rafiu et al.,2020). Geophysical inquiry provide unique information on the geotechnical needed on design construction to better the strength and consistent of the highways.

Oladapo et al. (2008) studied on road failures in the basement complicated area of southern Nigeria applying Dipole-diploe, Wenner and Vertical Electrical Sounding (VES) technique (Oladapo, 2008). In his study, it was observed that the failed segment (portions) of the road way are distinguished with relatively low resistivity not greater than 200 Ωm with stable zones having resistivity very well greater than 402 Ωm (Oladapo, 2008;Peter et al.,2018).

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The application of two-dimensional (2D) imaging geophysical survey is employed for the investigation of bedrock depth, structural depiction and assessment of subsoil competency (Burland and Burbidge, 1981; Adelekan et al., 2017; Akinola et al., 2020). The 2D electrical resistivity pictorial representation is also applied to discover cracks and cavities, geotechnical testing on highways, buildings and bridges. The survey has proven to be a productive tool for discovering irregularities and detecting subsurface geology complexness (Griffiths and Barker, 1993; Andrews et al., 2013; Young et al., 2021). Sapele-Agbor roads networks and roads in numerous state areas are truly in worse conditions, leading to vehicles damage, causing lethal traffic conditions, travel time delays and accidents.

The failure of Sapele-Agbor roads network at intervals portions has resulted to breakdown of vehicles, lost of lives and properties, passengers' injury and trouble conveying goods on the route.

The study roads have prolonged failure characterized with potholes, water percolated channels, cracks and depressions. These failures are never stopping despite past rehabilitation endeavor.

MATERIALS AND METHOD OF STUDY

Location and Geology of Survey Area

The study area is situated along Sapele-Agbor road across two senatorial districts in Delta State. It links Bayelsa, Edo and Anambra states. It is about 110.63m in length and the study area is located at latitude 05044' 27.4" N, longitude 005^0 54' 43.7" E to latitude 6^0 7' 8" N, longitude 6^0 11' 3" E (Fig.1). The areas constitute residential buildings, Bridges, trees on both road sides. The investigated area elevation is within 7–155 m above the average sea level. The dry and wet seasons are the two seasons in cognizant in the study area with annual rainfall varying between 2300 and 3001 mm (Remison, 2004).

The locations are described with both raining and the dry seasons. The wet or raining season occur between April and October while the sunny or dry season is from the 11th month (November) to the third month (March). The abundance rainfall in the survey areas are the fundamental source of recharge of groundwater (Okiongbo and Akpofure, 2012; Anomohanran and Iserhien-Emekeme, 2014). The Orogodo River is a narrow distance river which flow through towns of Agbor, Abavo and terminates in River Ethiope. River Ethiope whose source is from Umuaja runs through Urhonigbe, Urhomehe, Umutu,, Obiaruku, Abraka, Eku, Igun, Okpara Waterside, Aghalokpe, and Amukpe of the study areas which is further linked to the Atlantic Ocean. The various communities in the study areas also get water for domestic purpose. Subsistence farming is also practiced in the various communities of the studied areas.

The study area shows distinguishable features sloping toward the sea, comparatively flat, undulating and featureless Sombreiro - Warri Deltaic level (Short and Stauble, 1967). Fresh water wetlands occupy the low-level lying areas compared to surrounding topography and the riverbanks. The rain forest vegetation is predominant in the study areas and is beneath three principal stratigraphic units (Short and Stauble, 1967; Asseez, 1989). They are the Akata formation with pronounce indications of marine shale to considered as the rock wellspring for hydrocarbon. The Agbada formation which consist of arrangement of various shales and sands. Prolific aquifer is in the early Benin Formation and many water supply boreholes are accessible almost everywhere in this formation in the current Niger Delta. Notwithstanding, the strata is covered in the Sombreiro – Deltaic plain by a series of silts, sandy clay, fine to coarse granular sands, and clay identifying bands. The non uniformity of the clay formations thickness is one of the major reasons for road failure in the study areas.

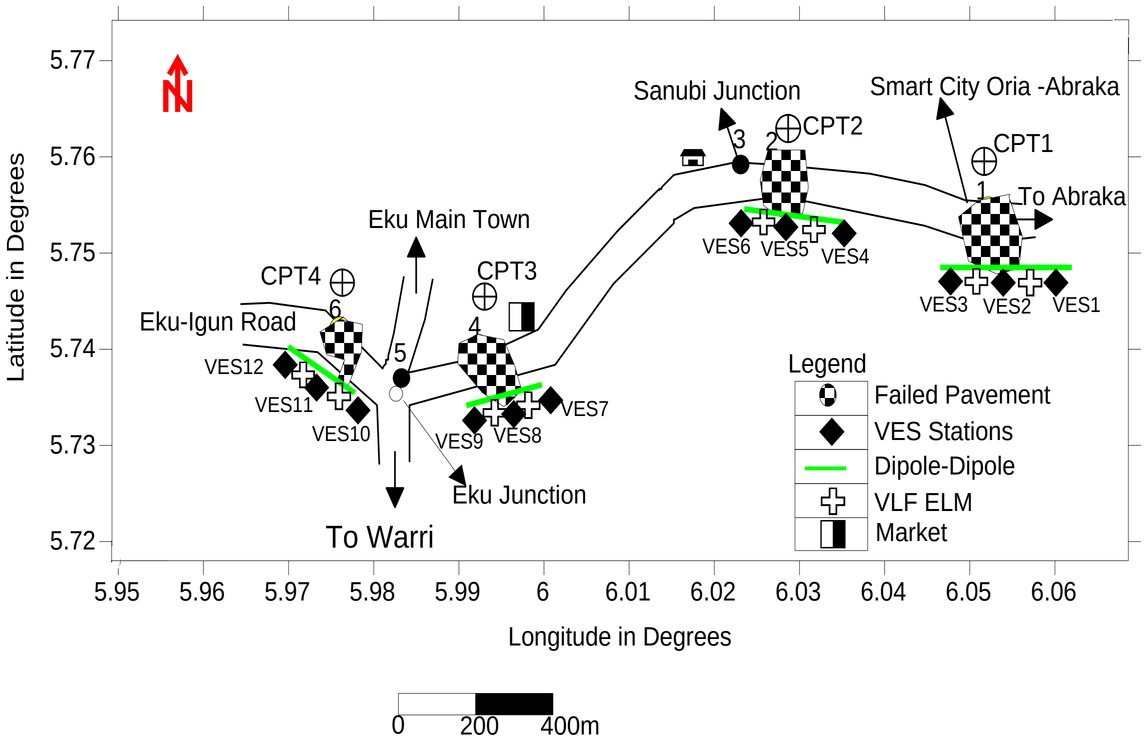

Figure 1: Data acquisition map of some study areas

Data Collection Method

The materials applied include ABEM SAS 1000 Terra meter, distance measuring device (tape), hammers, electric cables, electrodes, Dipro software, Battery, laptop, Global Positioning System (GPS) etc.

2-D electrical resistivity method was employed for this study. Twelve profiles with length lying within 120 and 210 m was established for both the stable and failed portions of the road pavement within the area.

The 2-Dipole profiling was carried out along the investigated areas with respect to both failed and stable portions of the Sapele-Agbor road (fig. 2). A total of twelve (12) dipole dipole lateral lines coverage with length lying within 120 and 210 m were established in the study areas with expansion factor (n) which varied from 1 to 4, 1 to 5 and dipole length ‘a’ of both 5 m and 10 m electrode spacing (interval) were taken. The dipole –dipole resistivity data were obtained by employing the ABEM Terrameter SAS 1000. The gotten apparent resistivity data further undergo inversion and converted to 2-D resistivity structures using the Dipro software package for Window (2000) as shown in fig 3-14. The tape as a measuring instrument was used for all length measurements during the investigation. The location (latitude and longitude) of Dipole-dipole points and boreholes log were also obtained with the aid of the GPS.

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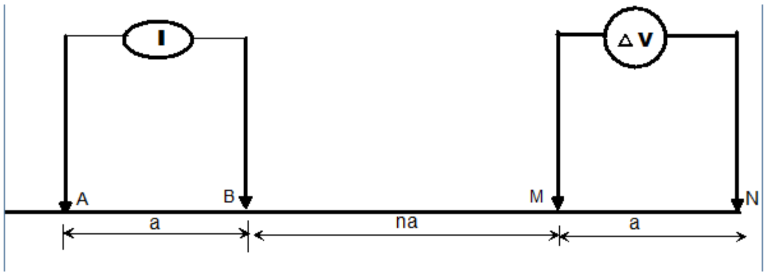

Fig.2 Dipole-Dipole Electrode Arrangement (Telford et al., 1990).

From Fig.2 AB denote current electrode spacing, MN is the potential electrode separation.

The dipole–dipole method (Fig. 2) which also combined horizontal profiling and vertical electrical sounding; its apparent resistivity is represented by the Eq. (1):

$$\rho a = -\pi Rna(n + 1)(n + 2) \quad (1)$$

where *n* is the expansion factor, R is electrical resistance and π is a constant equivalent to 3.142.

RESULTS AND DISCUSSIONS

The results of the electrical 2D resistivity maps (inversion) of the sub formation collected from the earth sample sections are shown in Figure 3-14 with profile from 100-190 m at different depths up to 50 m. Low and high resistivity values were delineated in the various sections of the roads in the 2D structure, which are indications of instability and stability respectively of the road sections.

Figure 3 denotes the 2-D resistivity image from the known resistivity magnitude (measurement). It reveals topsoil resistivity ranged from 480 Ωm to 2230 Ωm and surface thickness of 2.5 m, the second layer contains clay and sand formation with resistivity from 226 Ωm to 4071 Ωm and thickness from depth 2.5-5.0 m, the third layer comprises sand settlement with resistivity ranged from 484 Ωm to 2304 Ωm with depth of 5 m, and the last (fourth) layer resistivity ranged within 245 Ωm to 3571 Ωm with thickness up to 15 m. Low resistivity can be depicted at both second and third layer as blue color zone with clayey sand settlement, and the area can fail in the process of time without rehabilitation due to the presence of clay. It shows a low resistivity set of values from 125 Ωm – 375 Ωm, between two major regions at lateral distances ranging from 10 m – 55 m and 85 m – 115 m from a depth of 2.84 m – 14.90 m and 2.54 m – 9.20 m respectively bounded with blue and green colors.

Figure 4 represents the 2-D resistivity map from the obtained apparent resistivity size (magnitude). It shows topsoil resistivity ranged from 194 Ωm to 1033Ωm and surface thickness of 2.5 m, the second layer contains sand and clay composition with resistivity ranged from 189 Ωm to 2381 Ωm and thickness 5m depth from 2.5 m, the third layer contains sand formation with resistivity ranged from 606 Ωm to 5427 Ωm with depth of 10m from 5m and the fourth layer resistivity ranged within 723 Ωm to 6472 Ωm with thickness up to 15 m with lateral distance from 22.5 m to 97.5 m. The clayey sand present at a lateral distance of 75 m to 95 m to depth of 7 m from the surface which was observed with resistivity values of 189 Ωm and 194 Ωm account for the reason why the road segments failed since low resistivity support road failure as detected with portions shaded with blue color in the first and second layers.

Figure 5 unveils Aghalokpe 2-D resistivity structure obtained from certain resistivity metric (measurement). It exhibits topsoil resistivity ranging from 445 Ωm to 3577Ωm to a depth of 2.5 m from the surface, the second layer contain sand(fine and medium sand) and sandy clay compacted with resistivity varying from 253 Ωm to 1547Ωm and at depth 2.5m to 5.0m. The third layer contains both clay and sand mixture with resistivity numerical quantity ranging from 227 Ωm to 1813 Ωm at depth of 5.0 m to 10.0 m and the fourth layer resistivity ranging within 342 Ωm to 1866 Ωm with thickness up to 15 m from 10.0 m. The failed portions at lateral distance of 25 m to 45m for second, third and fourth layers underneath the topsoil is characterized by low resistivity in the 2D structure varying from 227 Ωm to 307 Ωm with the confinement of sandy clay which can fail without reaching the designed age. The stable regions have moderate resistivity obtained to be within 459 Ωm and 1866 Ωm.

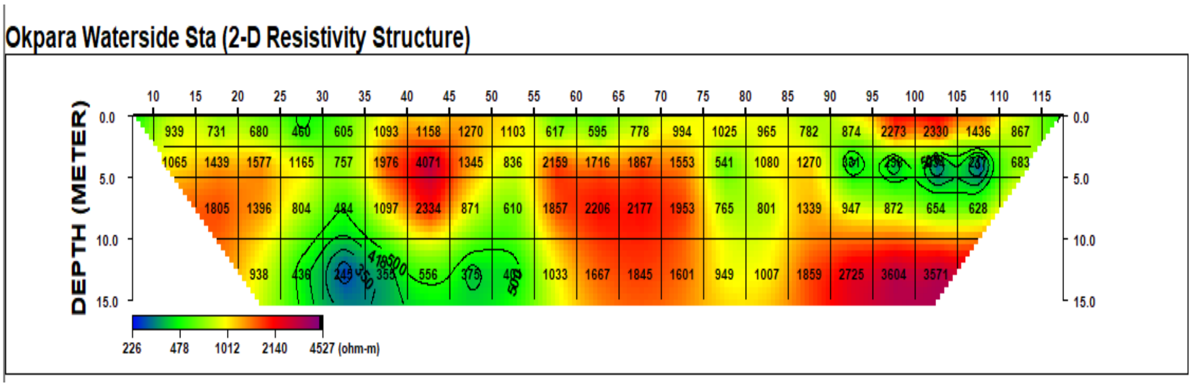

Fig. 3: 2-D resistivity structure along Okpara Waterside 1.

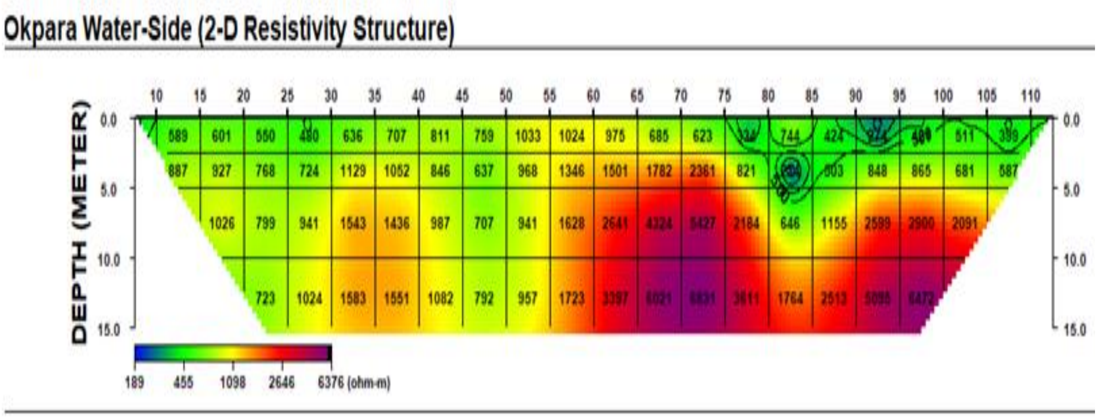

Fig. 4: 2-D resistivity structure along Okpara Waterside 2.

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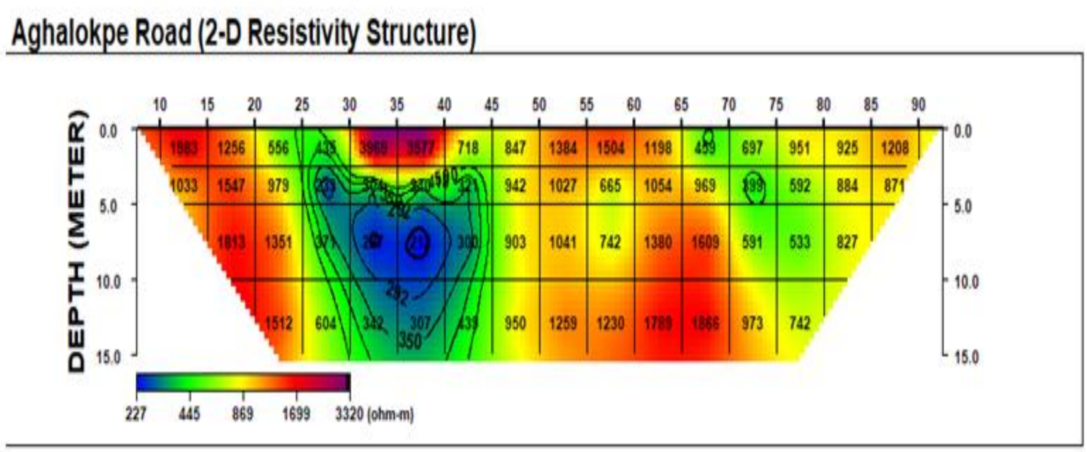

Fig. 5: 2-D resistivity structure along Aghalokpe.

Figure 6 also discloses the 2-D resistivity structure divulging resistivity section at Otumara. It unveils topsoil resistivity range of from 56 Ωm to 745Ωm and thickness of 2.5 m near the surface, the second layer contains lateritic clay, sand and clay depositions with resistivity changing within 87 Ωm to 1534 Ωm and at 2.5 m thickness. The third stratum contains both sandy clay and sand formation with resistivity numerical quantity ranging from 158 Ωm to 6530 Ωm at depth of 20 m from 10.0 m and the fourth layer resistivity intervals from 160 Ωm to 4090 Ωm with thickness of 35 m from 20.0 m. The fifth stratum vary with resistivity from 128 Ωm to 2247 Ωm with formation of clayey sand and medium to coarse sand. Some domains outlined with blue shades have slightly low resistivity values with most area having resistivity greater than 140 Ωm. Three distinctive zones marked with blue colour with very low resistivity values were viewed at various distances within 20.0 m – 79.50 m, 80.5 m – 100.50 m and 150.50 m – 170.50 m at a depth of 2.54 m - 15.0 m, 3.00 m-50 m and 12.25 m- 25.0 m respectively. The lateral road distance of 80.5 m-100.5 m will fail intermittently due to huge underlying clay formation mixture present from the surface to depth of 50 m compared to other lateral distances. Thus, the stable portions are characterized with low conductivity (high resistivity values). The unstable or failed sections of the road are due to clay sub grade formation at significant depths than the stable sections with shallower or no depth of formative clay.

Figure 7 gives 2-D resistivity form lengthwise along Igun road. It exhibits lateritic/clay topsoil resistivity values spreading between 98 Ωm to 1034 Ωm with 2.5 m thickness from the surface, the second layer enclosed clay and sand composition with resistivity varying from 102 Ωm to 150 4Ωm at thickness of 2.5m . The third layer contains both clayey sand and sand formation with resistivity numerical point values ranging from 222 Ωm to 5872 Ωm at depth of 5.0 m from the second layer depth and the fourth layer with only sand formation with resistivity interval from 546 Ωm to 9750 Ωm at thickness of 15 m from 10.0 m. The unstable sections of the Igun road point out a low resistivity (< 140) values from 102.0 Ωm – 139.00 Ωm, distinguished with two major regions at lateral distances of 35 m to 45 m and 85 m to 105 m to a depth of 2.5 m – 7.20 m and 2.0 m – 2.52 m respectively. These low resistivities of the clay materials threaten the integrity of the road causing road failure as a result of distress place on the road.

Figure 8 is the 2-D inverted model at Eku shows four subsurface layers. The resistive topmost layer constitutes of laterite/clayey sand in addition to resistivity and thickness values varying between 168 – 674 Ωm and 2.5 m thickness respectively. The topsoil layer accounts also for highway road integrity (uprightness) due to soil types present. The second layer show both stable and failed sections of the road with clayey sand and sand formation with resistivity varying from 206 Ωm to 1517 Ωm at depth of 2.5 m. The succeeding third layer which is a stable zone account for sand formation with resistivity values between 577 Ωm and 6619 Ωm with depth 2.5 m - 5.0 m. The fourth stable layer contain medium to coarse sand formation with resistivity ranging from 999 Ωm to 11017 Ωm to a depth of 5.0 m from the preceding layer. An indication of resistivity value from 105.0 Ωm – 500.0 Ωm, between lateral distances of 19.50 m – 55.50 m along Eku road to a particular depth of 5.50 m through the profile surface show a signal that the road segments would definitely fail in future due to the existence of clay and clay formation in the road subsoil formation to a particular depth of 6 m.

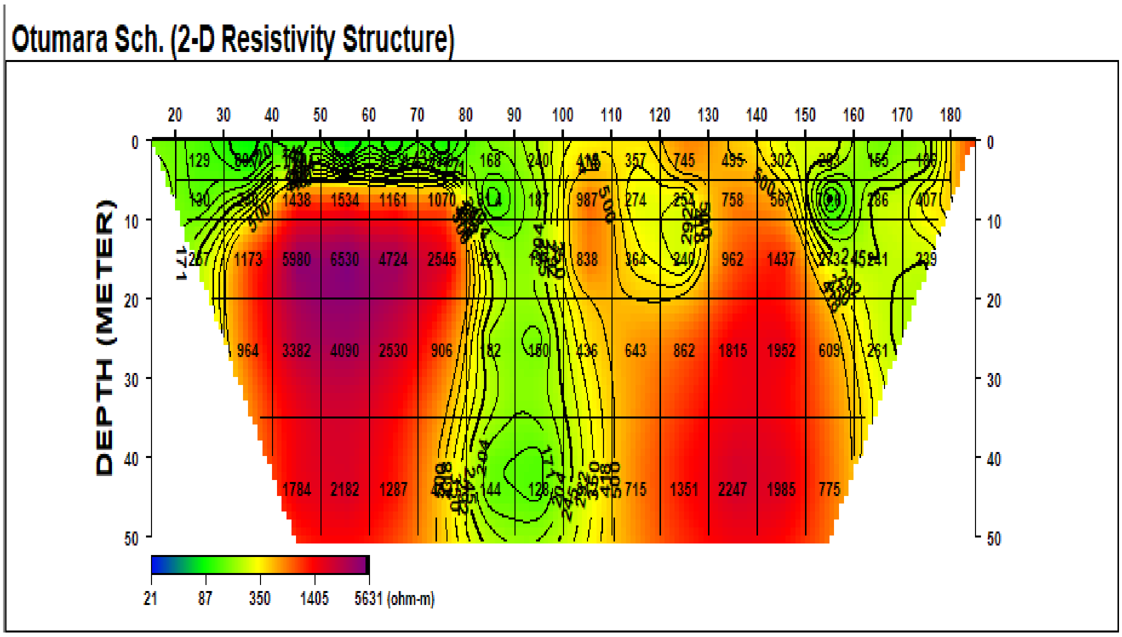

Fig. 6: 2-D resistivity structure along Otumara Primary School.

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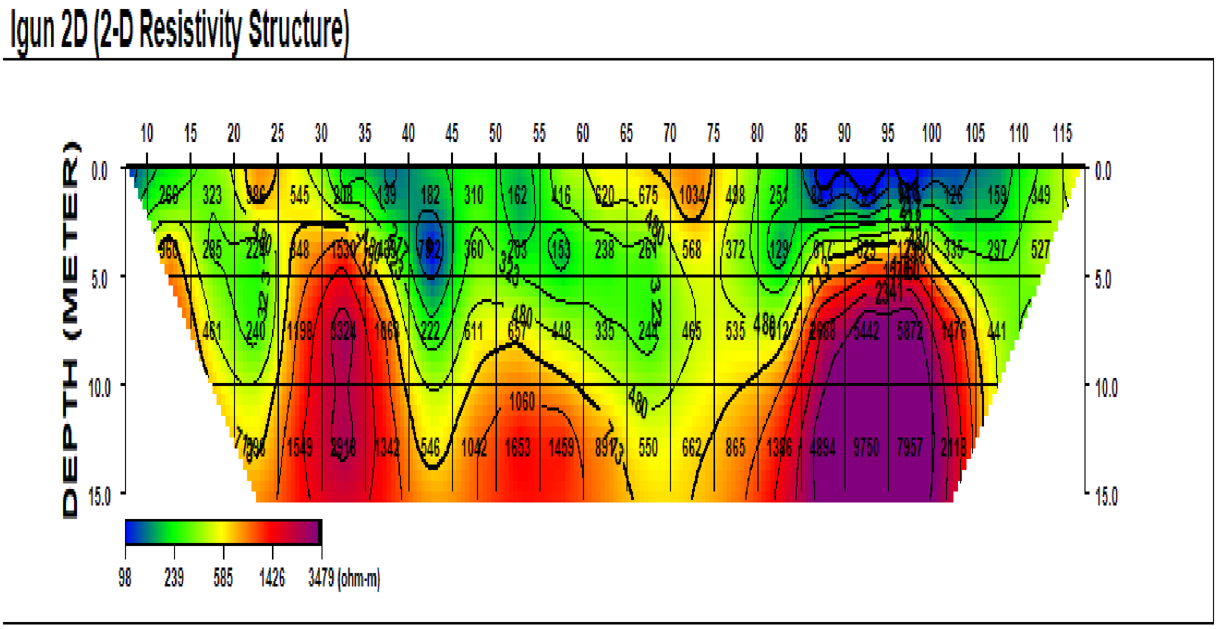

Fig. 7: 2-D resistivity structure along Igun

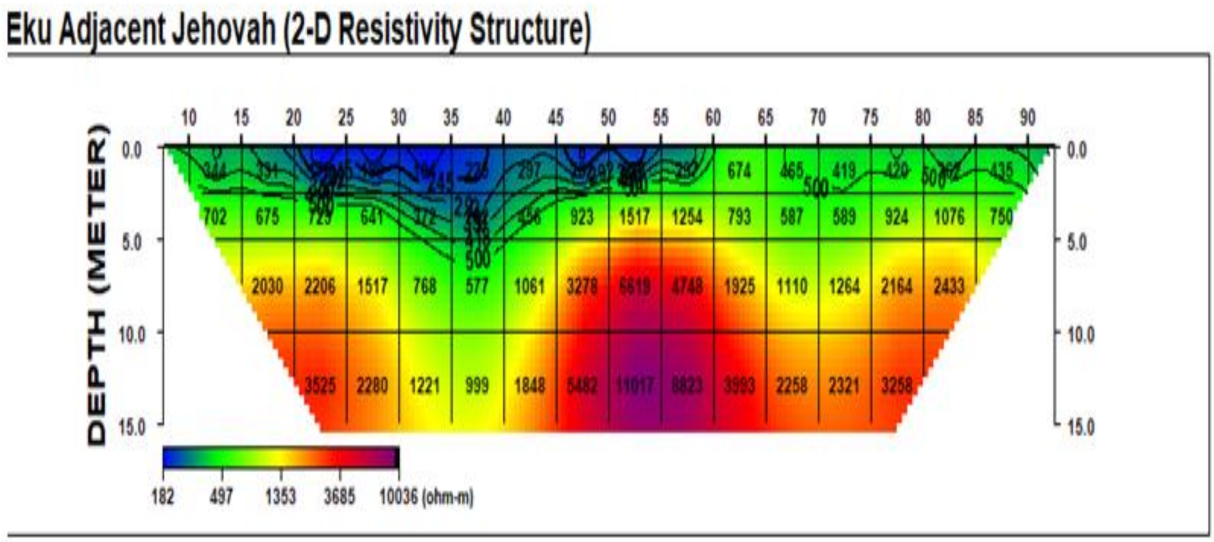

Fig. 8: 2-D resistivity structure along Eku.

Figure 9 is a 2-D Resistivity Image of the resistivity plot identified along Obiaruku road sections in a stable road. The result consists of four formative layers. The foremost (first) layer has a resistivity value of 372-2720 Ωm with a thickness of 2.5 m is a topsoil lateritic layer. The next (second) layer has a resistivity value of 270-3830 Ωm with lateritic and sand lithology with a thickness of 2.5 m. The third layer is distinguished with a resistivity value of 537-5056 Ωm with a layer depth of 10 m and is suspected to be a layer of sand formation. The fourth layer which is both clay and sand formation has resistivity value of 185-7183 Ωm at a thickness of 15 m and is allegedly comprising of sandy clay and fine to coarse sand. The fifth layer which is also an embodiment of clay and sand deposit is group with resistivity of 133-3823 Ωm to a thickness of 50 m from 35 m depth.

It only displays a low resistivity beginning from 106.0 Ωm – 500.0 Ωm and at 68.50 m – 102.0 m distances to a unique depth of 49.60 m from 22.0 m depth of the sub grade. This is the only distinct zone mapped in this stable road that may fail after long usage of the road since the clay formation occur at a deep depth of 50 m from 22 m sub grade depth.

Figure 10 represents the 2-D Resistivity formation (structure) along Obiaruku road on a failed section. The first three consecutive layers generally contain moderate resistive subsoil materials and beneath are low resistive clay settlements layers which give a signal of failure in the future. The reoccurring rehabilitation of the road in this Obiaruku failed portions are due to poor drainage system, clayey filling materials and the occurrence of compacted clay structure underneath the earth surface. It depict high resistive topsoil range of 320 Ωm to 2844 Ωm and 5 m thickness near the surface, the second layer contain mainly laterite and sandy clay with resistivity varying within 126 Ωm to 1764 Ωm and at another 5 m thickness. The third substratum contains clay, clayey sand, sandy clay and fine to coarse sand with resistivity assigned value ranging from 60.6 Ωm to 1737 Ωm at a depth of 20 m from depth 10.0 m and the fourth layer (stratum) resistivity ranged from 22.8 Ωm to 273 Ωm with 35 m thickness from 20.0 m. The fifth substratum varied with resistivity between 10.5 Ωm to 169 Ωm with clay formation (clay, clayey sand and sandy clay). It shows a very low resistivity features with first steps from 10.50 Ωm to 125.0 Ωm, beneath the topsoil at lateral length of 20 m to 160.8 m within a depth range of 9.80 m – 50.00 m of the failed (unstable) portions of the road shaded with blue and green color band. At lateral length of 50-80m contain clay formation with very low resistivity of 10.5 Ωm to 39.1 Ωm at the fourth and fifth strata and these are proves of subsurface structures that precipitate to incessant failure due to inability of sufficient sub grade strength to support heavy vehicle.

Figure 11 is a 2-D resistivity picture denoted along Urhomehe road. It figure out topsoil resistivity values starting from 348 Ωm to 772 Ωm from the surface to a particular depth of 2.5 m, the second sand formation layer resistivity varying within 774 Ωm to 1467Ωm at 2.5m deep is a stable portion. The third layer also embrace sand formation with resistivity beginning from 1930 Ωm to 4146 Ωm at vertical distance of 5.0 m from preceding layer depth and the next fourth layer with sand (coarse) formation with resistivity beginning point of 2778 Ωm to 6829 Ωm with deepness of 5 m when viewed from 10.0 m. Generally, a moderately and high resistivity with initial value of 348.0 Ωm and a final value of 1467.80 Ωm, in position of 10.50 m – 90.0 m shown in figure 11 with a depth space of 5.00 m from near surface of the side. This is an apparently stable zone with increasing resistivity as depth increases. However, Failure could occur when the road constructed has elapse designed age, due to insufficient construction materials and inadequate routine maintenance.

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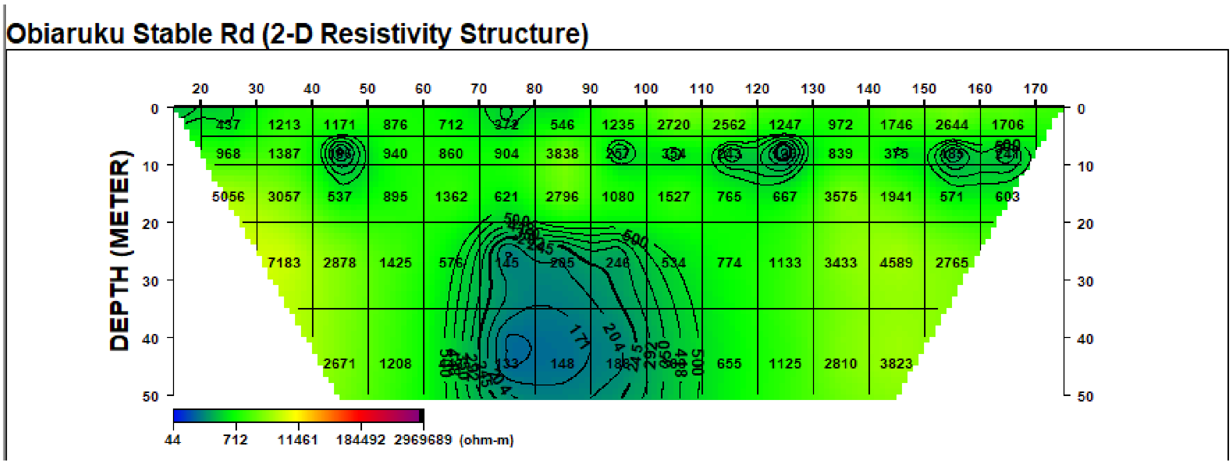

Fig. 9: 2-D resistivity structure along Obiaruku road 1.

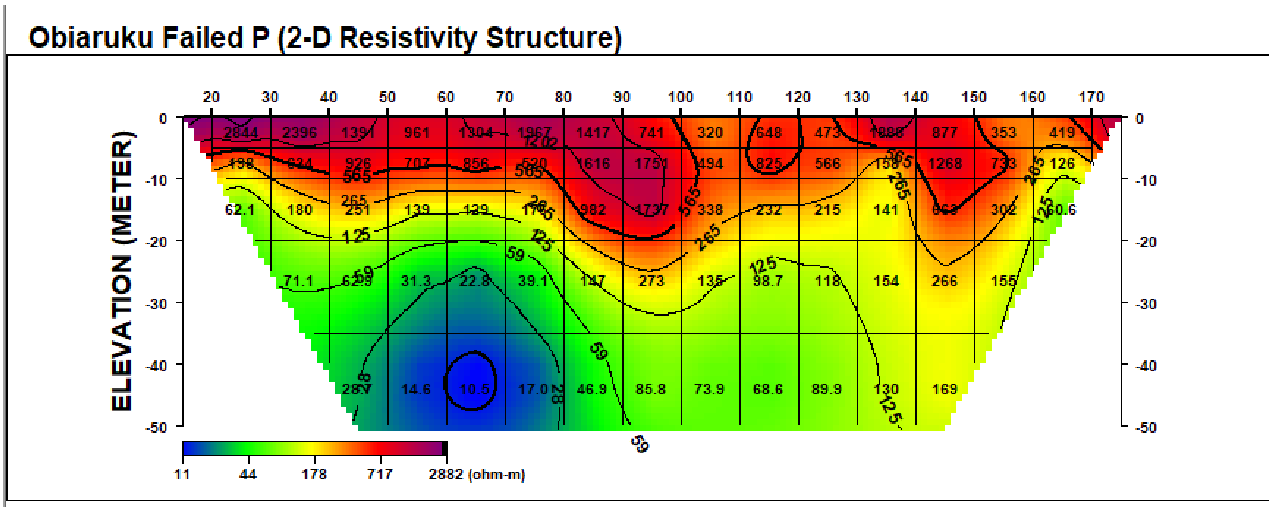

Fig. 10: 2-D resistivity structure along Obiaruku road 2.

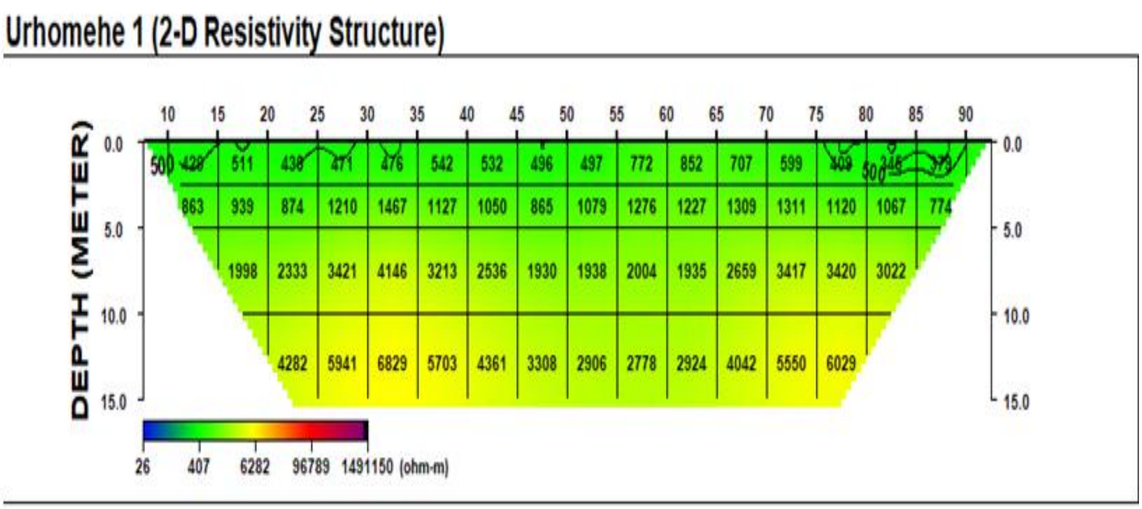

Fig. 11: 2-D resistivity structure along Urhomehe road.

Figure 12 unveil the resistivity pattern of Urhonigbe profile along the road. It gives a topsoil resistivity, varying from 375 Ωm to 1668 Ωm at 2.5 m via the surface, the second layer explains fine, medium and coarse sand having resistivity values limit from 601 Ωm to 2008 Ωm with estimated thickness of 5.0 m from 2.5 m, the third layer contains the same formation with second layer with unique resistivity value pointing from 533 Ωm to 1761 Ωm with depth of 5m to 10 m and sand grain formation from borehole well log was noticed in the fourth sub-stratum with resistivity bounded within 483 Ωm and 1624 Ωm with 5 m thickness. Two fault zones were labeled out with appreciating resistivity (certain value) along Urhonigbe road. At a distance between 10.5 m – 20.0 m along the road, resistivity values (< 800 Ωm) from 375.25 Ωm – 771.0 Ωm from the top soil to a depth of 5.2 m were observed. Also at 38.50 m – 75.00 m spread, resistivity values varies from 375 Ωm – 455 Ωm from the surface to a noticeable depth of 2.5 m of the profile were among the vital observations. This could be traced to poor clay subsoil filling materials that used for the failed road segment construction.

Figure 13 also portray the 2-D Resistivity underground terrain from the changing resistivity extent categorized along Abavo road. It indicate topsoil resistivity range of from 157 Ωm to 1682 Ωm and thickness of 2.5 m via the earth surface, the second layer contain laterite and sand deposits with resistivity changing within 203 Ωm to 6331 Ωm with also 2.5m thickness. The third layer contains both clay cluster and segmented sand formation with resistivity from 27.6 Ωm to 3369 Ωm at depth of 10 m. The fourth layer contain section of relatively low and slightly moderate resistivity ranging from 1.91 Ωm to 3036 Ωm grouped at 15 m thick. The fifth layer entails extremely low and moderate resistivity from 1.55 Ωm to 2074 Ωm which is a clear indications of clay settlement, fine, medium and coarse sand. In this profile, is a section (zone) of unstable relatively low level resistivity visualizes points ranging from 1.55 Ωm to 27.5 Ωm, from lateral spread of 28 m to 84 m to a protracted depth of 32 m thickness. There is also a distance separation from 160 m – 170 m alongside the section to a depth range of 10.0 m – 20.10 m with low values of resistivity from 40.6 Ωm - 69.50 Ωm that also posed threat on road sustenance. This observed clay zone is inappropriate to sustain (maintain) road pavement.

Figure 14 typify the resistivity sections along Agbor road. It give a picture of resistivity topsoil variation of 129 Ωm to 583 Ωm from 0.0 m - 2.5 m layer thickness, the second observed layer contain mainly laterite and sand structures with resistivity that varies from 435 Ωm to 2240 Ωm and precisely at 2.5m thickness. The third to fifth layers are well established on stable zone on sand structure with reference to resistivity values between 504 Ωm to 5231 Ωm at significant depth of 20 m.

Two unique zones were detected with absolutely low resistivity values in this profile. At a sure distance between 14.5 m – 22.0 m of this profile, low computed resistivity values fall between 129 Ωm – 317 Ωm to a shallow depth of 3.0 m with respect from the top soil was noticed. Also at displacement between 60.50 m – 119.50 m, a slightly low (small) resistivity significant value from 159.25 Ωm – 382.00 Ωm to a depth of 8.0 m was observed from almost surface of profile and are both shaded with Blue and Green colors. The lithological formation of the study is in accordance with the well logging data in figure 15.

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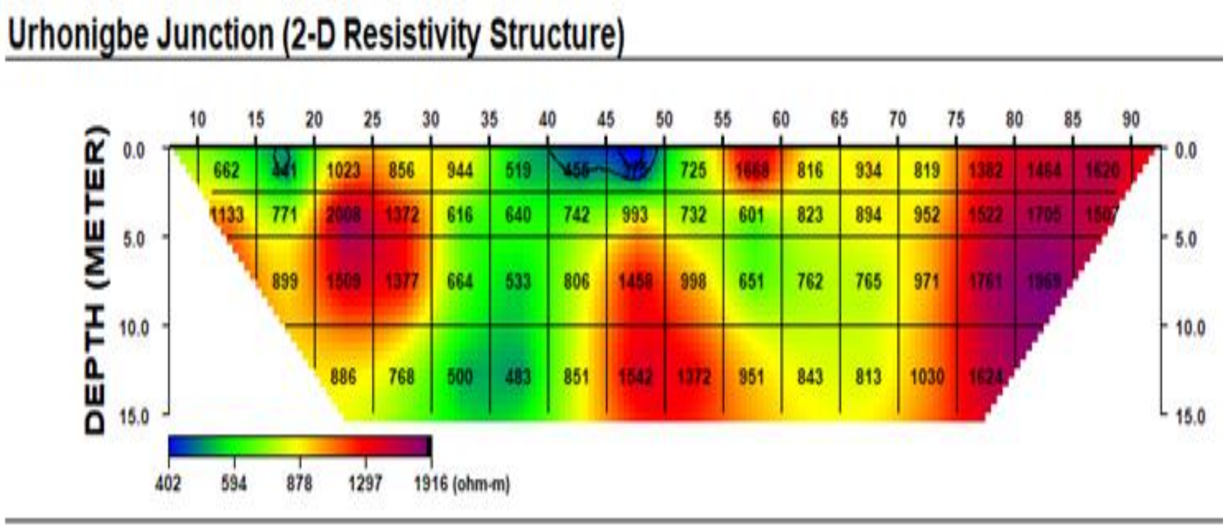

Fig. 12: 2-D resistivity structure along Urhonigbe Junction.

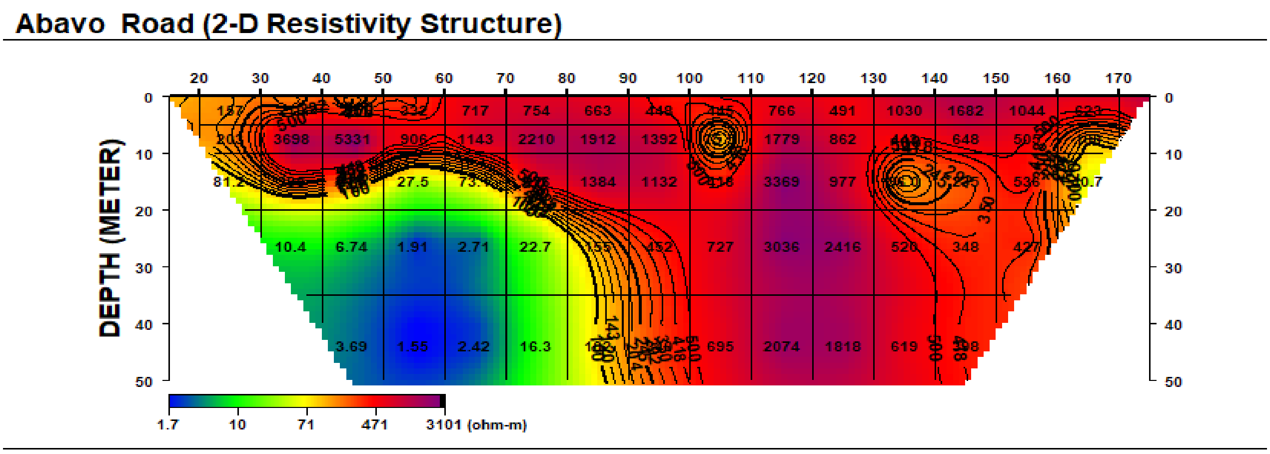

Fig. 13: 2-D resistivity structure along Abavo road.

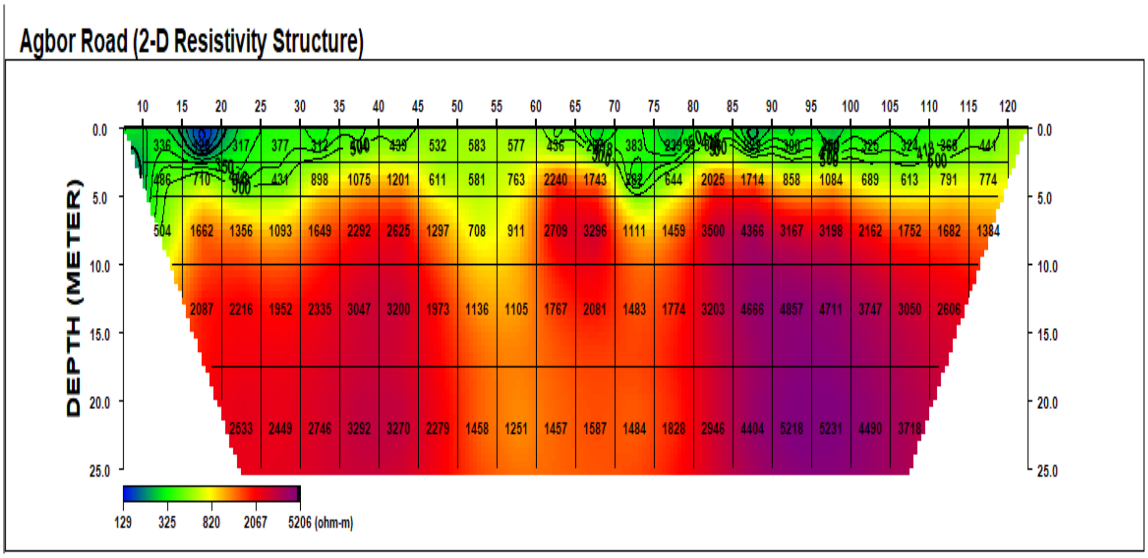

Fig. 14: 2-D resistivity structure along Agbor road.

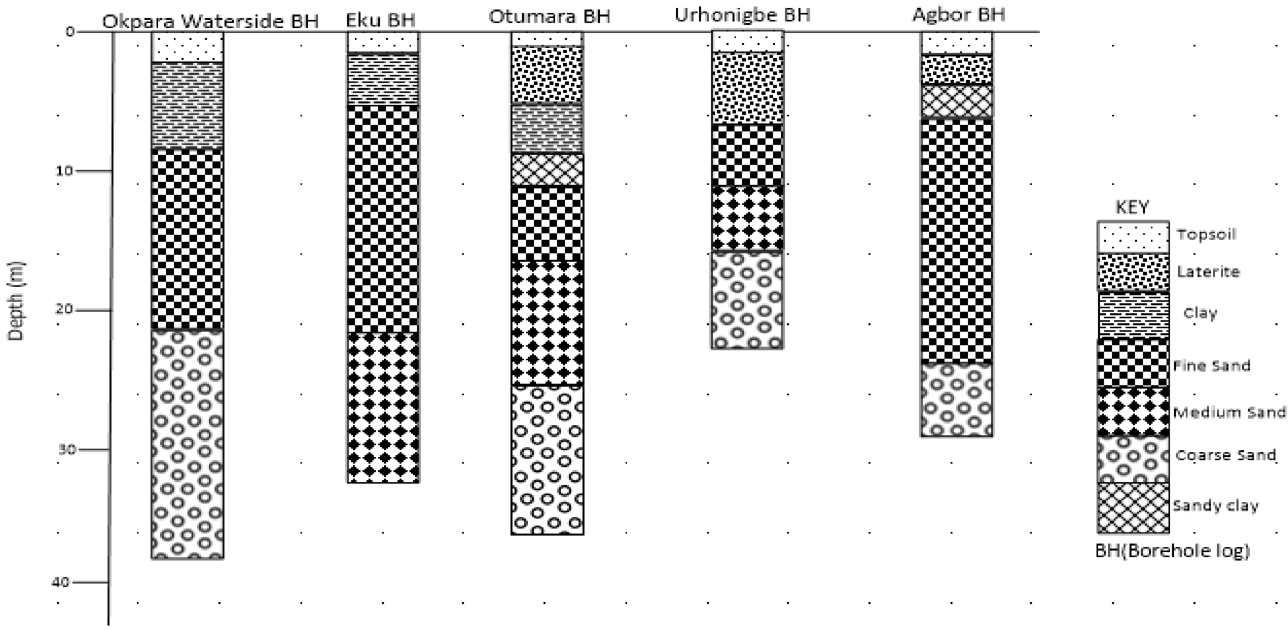

Fig. 15: Well log Data of some sections of the studied areas

It has been observed that low resistivity values observed in the study comprises of expansive, collapsible, compressible and sandy clay materials which correlate with borehole data (fig. 15) have the tendency of absorbing water. These make them to swell and eventually collapse resulting to road failure under imposed wheel load stress. The stable sections of the road are mainly characterized with high resistivity value greater than 199 Ωm, mostly laterite and sand materials. The low resistivity is attributable to bad (weak) zone resulting to road instability. Thus, the huge clay composition leading to water saturation of subgrade causes continuous pavement failure shortly after road repair and even reconstruction.

Additional works in these con areas could be observed from the work of Egbai, 2012; Egbai *et al.*, 2012; Atakpo, 2013; Anomohanran, 2014; Anomohanran and Iserhien-Emekeme,2014; Oseji, 2014 and Egbai *et al.*, 2019.

CONCLUSION

Geophysical study of Sapele - Agbor highway has been adopted to establish the factors that result to the incessant failure along the twelve dipole-dipole sections of highway. The results from the stable and unstable road sections indicate the presence of clayey composition (low resistivity values) and shallow water table are the causes of road failure from the study areas. Clayey soils are capable of retaining high water quantity making them swell and not meet up to demand due to motion of weighty vehicles. Poor and insufficient drainage pattern is also attributable for the never stopping road failure. Thus, these clayey formations with low resistivity (< 110 Ωm) as observed from the study beneath the earth surface present in the distinctive zones are the main causes of the pavement not resulting to intended objective (failing before desired age).

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