RIPPABILITY SURVEY USING GEOPHYSICAL METHODS WITHIN AN AREA OF ILESA, OSUN STATE, NIGERIA.

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Abstract

In developing countries where relatively recent roads are soon riddled with gashes, potholes, and sinkholes, the rippability survey is a useful tool of reconnaissance. Seismic Refraction and Electrical Resistivity were used to delineate the 'habitat' suitable for road construction along four untarred interconnected lanes within the study area. The objectives of the survey were to estimate the elastic properties of the sub-surface materials, determine their distribution, and thickness in order to provide information relevant for determining the cost of cutting the selected roadbeds down to consolidated soil. Four profiling traverses were covered in the area of study. A 12-channel geophone was inserted into the earth at intervals of 3m, and a metal plate used as the energy source. Readings were taken across the length of the traverses and seismograms generated. Also, the Vertical Electrical Sounding method was used to profile the subsurface using a few points along these traverses. Geo-electric sections were generated. The seismic 'geo-refraction' sections show two layers with the first layer reflecting the rippable layer while the second layer shows the non-rippable layer. The average depth to the rippable layer is about 10m while from the vertical electrical sounding, four geo-electric sections with clay as the topsoil, underlain by lateritic soil, followed by a consolidated region which precedes the crystalline basement rock were deduced. The depth to the consolidated surface across the surveyed areas is an average of about 12m. This depth information and revealed lithological characteristics are useful in the estimation of the cost of excavation.

INDEX TERMS: Rippability, 'Geo-refraction' sections, Geo-electric sections, excavation.

1 Introduction

Understanding the nature of rock types including their competency and strength properties is pertinent when considering the design of any construction project. This makes it important to assess the surface and subsurface sequence as well as the structural settings of an area prior to construction to determine its suitability and prevent structural damage.

Rippability of an earth material is the measure of its ability to be excavated. It describes the relative ease with which the material can be removed using excavation equipment. Accurate evaluation of rock rippability will enable the preparation of both construction schedule and cost estimation, facilitate the selection of proper ripping equipment and maximize operation.

Rippability is a qualitative property of rock. It has three classifications namely rippable (easily removed), marginal, and non-rippable (difficult to remove). The rippability of any area may be evaluated using appropriate geophysical methods carried out on the site to reveal subsurface conditions such as lithology and depth of strata.

The study area is within Latitude 7˚38''5.274'N to 7˚37''57.234'N and Longitude 4˚46''39.126E to 4˚46''31.572'E, located in Ilesa, South Western Nigeria. The area is extensively covered by clay making it unsuitable for construction due to the plastic nature of clay. Due to the contraction and expansion of the clay mineral which leads to fracture and cracks of the surface as a result of temperature changes, construction projects laid on clay material are prone to structural deformation. Hence, the need for a rippability survey to determine the extent of unsuitable material which would be excavated prior to construction.

For the purposes of this study, the seismic refraction and electrical resistivity methods were employed. Historically, the seismic refraction method has been employed in the indirect determination of the degree of rippability. The seismic refraction method has been used by several authors over the years in the investigation of the near surface ([2], [5], [6]. Some others have used the method together with the electrical method (Tasker [7], Ayolabi [1], Egbai [4]).

The physical principle in operation in the determination of rippability is based on the fact that seismic waves travel faster through rocks that have a higher bulk density than through rocks less consolidated. The seismic velocity measured in seismic refraction surveys provides a qualitative measure of the rock strength and the presence of major fractures.

The electrical resistivity method used as a complementary method with the seismic refraction method involves mapping resistivity changes in the earth in order to identify overburden properties, lithologies, and variations within the subsurface. Resistivity is a fundamental parameter of the material that describes how easily the material can transmit electric current. It is useful in distinguishing competent from 'unsuitable' rocks, as the actual current is highly influenced by conductive layers. High values of resistivity imply the material is very resistant to the flow of electricity and low values of resistivity imply the material transmits electrical current very easily.

Fig. 1: Road bed covered with clay, Ifedapo Quarters, Imo, Ilesa

2 STUDY AREA

The area investigated, covers the untarred roads designated Asaolu, Bugbe-ayo, PCC (Preferred Comprehensive College) and Bakery lanes, Imo area, Ilesa. At the time of investigation, features observed on the roads include major mud-cracks, potholes, oscillation ripple marks and depressions which make movement of automobiles difficult.

Fig. 2: Google Map of the study Area

3 METHODOLOGY

3.1 SEISMIC REFRACTION

A total of twenty-nine (29) seismic refraction profiles were run along four (4) troaverses. Both forward and reverse shooting were carried out along each profile.

The following steps were followed in the execution of the survey:

- A tape was run along a straight line to measure and mark distances at every 3 meters
- The 12-channel geophone was inserted into the earth at every 3m, starting with trigger geophone at 0m.
- The metal plate (energy source) was placed before the trigger geophone for both forward shot and the reverse shot.
- The geophones were connected to the geophone cable followed in sequence of the label on the cable (1-12). And the geophone cable was connected to the seismograph.
- The trigger geophone was connected to seismograph by the trigger cable
- The power source (battery) was connected to the seismograph by the power cable.
- The seismograph was switched on and readied to take readings.
- The metal plate was hit with a sledge hammer about 10 times to produce the seismic waves, sending signal to the trigger geophone before dispatching to other geophones.
  (Note: All forms of disturbance - for instance movement, was restricted during the course of hammering.)
- The seismograph was allowed to read the data and display the result.
- The result was observed and printed.
- The GPS reading of each source point (forward and reverse) was recorded.
- The above procedure was undertaken for each survey line.

- The seismic refraction data were processed and interpreted. The general processing and interpretation flow consisted of the initial selection, or 'picking' of the seismic first breaks (the first wave arrival).

3.2 ELECTRICAL RESISTIVITY

A total of eight (8) vertical electrical soundings using the Schlumberger array were carried out at the study site. The maximum current electrode separation AB/2 of 140m was used, while the maximum potential electrode separation MN/2 of 15m was used for the VES.

AEMC® Ground Tester Model 6472 terrameter was used to obtain the apparent resistivity at each VESpoint.

Fig.4: (i & ii): Setting up of the Seismic Traverse Line and inserting geophones into the earth

4 RESULTS AND DISCUSSIONS

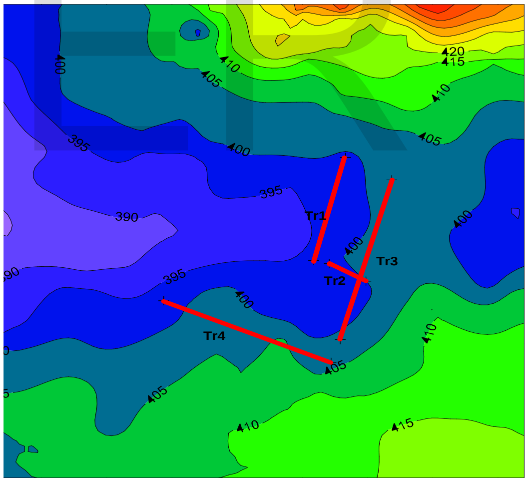


Fig. 5: **CONTOUR MAP SHOWING SURVEY TRAVERSES.**

The area of investigation covered four traverses within the Ifedapo community, which is off the L.A. Primary school junction in Imo, Ilesa, Osun State.

The traverses were given particular names for easy identification based on prominent features within the area.

Traverse 1 is designated the Asaolu lane, traverse 2 designated Bugbe-ayo lane, traverse 3 named PCC(Preferred Comprehensive college) lane, and the fourth lane named Bakery lane.

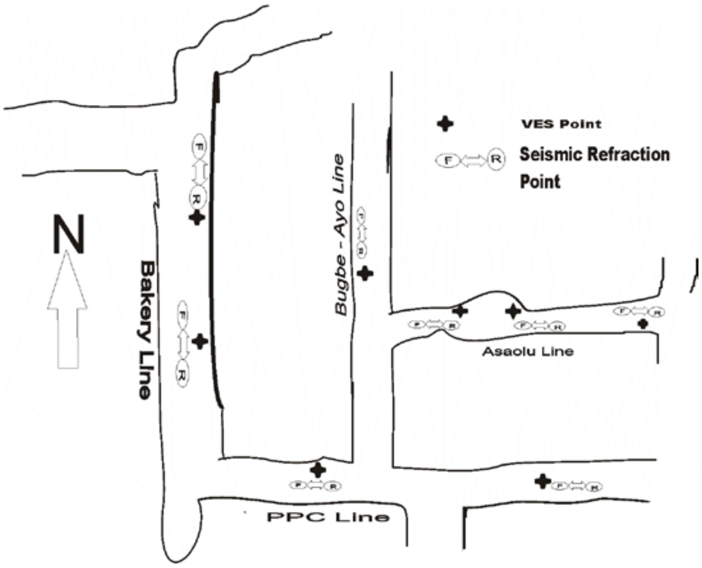
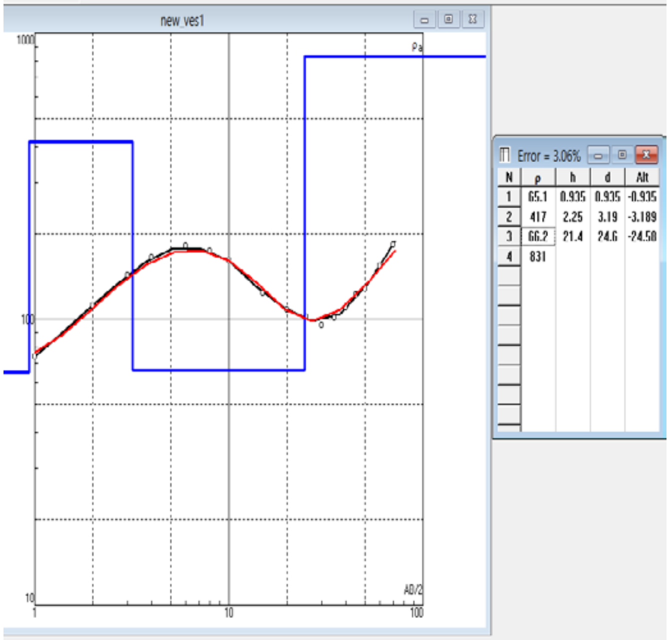


Fig. 6: Data Acquisition Map

The interpretation software, **IPI2WIN** – A 2D Interpretation software was used to model and interpret the Vertical Electrical Sounding data. From the curves generated from the data, four geo-electric layers lithologies were identified in each traverse based on the resistivity values.

The first layer unarguably identified as clay soil form the top soil; next to it is the soil is lateritic. Underlying the Laterite is the consolidated rock layer which rests on the crystalline basement bedrock.



Error = 3.06%

N	ρ	h	d	Alt
1	65.1	0.935	0.935	-0.935
2	417	2.25	3.19	-3.189
3	66.2	21.4	24.6	-24.50
4	831			

Fig. 7: Sample of resistivity bi-log curve

The software **REFRACTSOLN** was used for the interpretation of the Seismic Refraction Data. Time-distance (T-X) graphs (Fig.8) for each profile were generated.

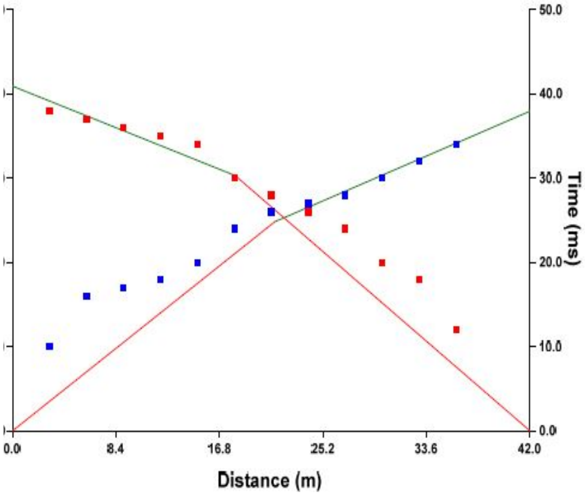


Fig. 8: Time distance graph for traverse 1A.

The first three layers were determined to be the rippable and the marginal layers judging from their seismic velocity values and the fourth layer been the non – rippable following a standard rippability chart (Fig. 9).

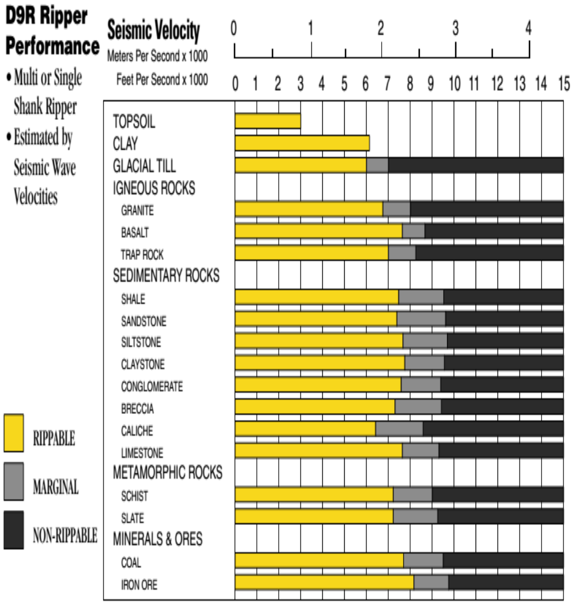
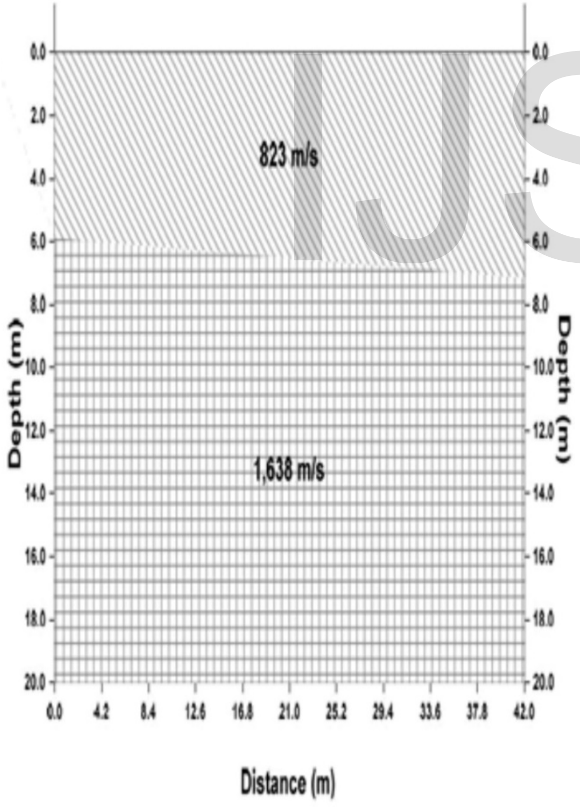


Fig. 9: Rippability Chart [3]



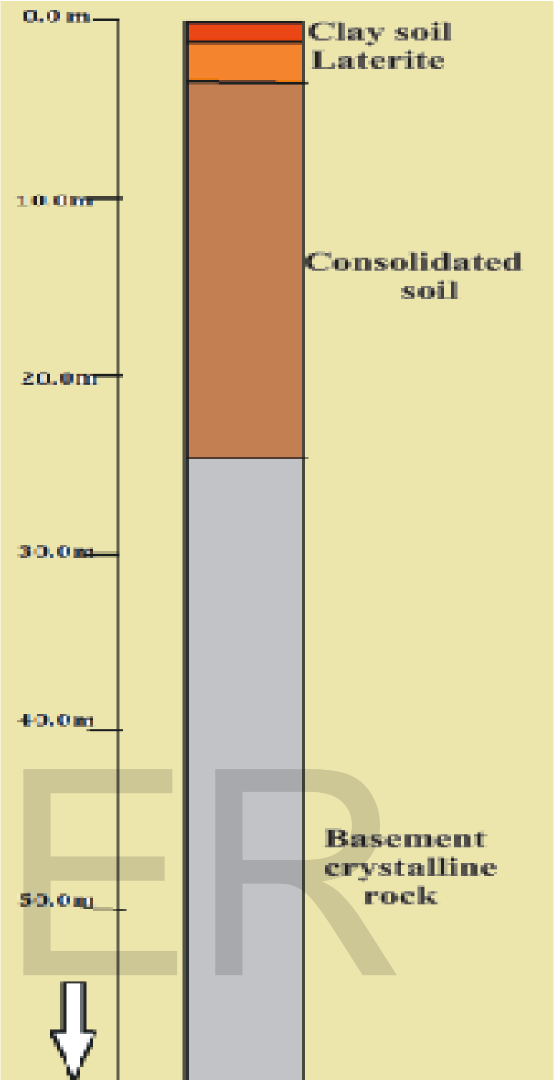


Fig.10:'GEO-REFRACTION' AND GEOELECTRIC SECTIONS FOR TRAVERSE 1A (Rippability Depth 7.1m)

The geo-refraction section for traverse 1A whose rippable depth is 7.1m from the two horizontal layer time – distance graph with the first layer velocity of 823m/s and second layer of 1638m/s. According to the geo-electric section the rippable depth falls within the consolidated layer.

TABLE 1.0: DEDUCTIONS FROM GEOFRACTION AND GEOELECTRIC SECTION

TRAVERSES	GEOREFRACTION SECTIONS		GEOELECTRIC SECTIONS.	RIPPABILITY DEPTH (m)
	Velocity1 (m/s)	Velocity2 (m/s)	RECOMMENDED ZONE	
1A	823	1638	CONSOLIDATED LAYER	7.1
1B	858	1487	CONSOLIDATED LAYER	5.1
1C	594	1901	CONSOLIDATED LAYER	7.5
1D	750	1907	CONSOLIDATED LAYER	9.3
1E	816	1487	CONSOLIDATED LAYER	7.7
2A	205	500	CONSOLIDATED LAYER	8.2
3A	211	403	LATERITIC	12.5
3B	352	673	CONSOLIDATED LAYER	12.2
3C	236	452	LATERITIC	5.6
3D	204	827	LATERITIC	5.5
4A	257	301	LATERITIC	6.8
4B	168	287	LATERITIC	10.7
4C	169	260	CONSOLIDATED LAYER	14.6
4D	177	207	LATERITIC	6.4

CONCLUSION

The results obtained from the seismic refraction revealed one refractor for most of the lines along which the investigation was done and in a few cases two. The geo-electric sections revealed the lithologies within the various lanes of investigation. It further showed that the lithologies are not uniform and depth to basement varies from place to place. Four distinct geo-electric layers namely the clay topsoil, Laterite, the consolidated layer and finally crystalline basement were identified. The 'geo-refraction' sections reveal elastic properties and depths and lithologies- the first layer showing the rippable and the marginal layer which correlates with the geo-electric layers of clay, Laterite and the consolidated layer while the second layer shows the non – rippable layer which aligns with the crystalline basement rock. The velocity increases with the depth.

The excavation depths recommended for the study before road construction work include, in the Asaolu lane, 5.1m – 9.3m; in the Bugbeayo lane, 8.2m should be removed; in the PCC lane within 5.5m – 12.5m and in the Bakery lane the range should be 6.4m – 14.6m. Other engineering solutions could however be proffered based on the observations made.

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