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Geophysical Investigation of Road Failure Using Electromagnetic Profiles along Opoji, Uwenlenbo and Illeh in Ekpoma -Nigeria

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Abstract: A shallow electromagnetic evaluation of Ekpoma main road base integrity has been undertaken in this study with the aim of identifying probable zones of untimely failure.Abem Wadi equipment (conductivity meter) was used for the study. This technique is presumed useful in fast and cheap roadwork performance evaluation.

Key words: Resistivity · Road Failure · Geologic · Rocks · Cracks

INTRODUCTION

The electromagnetic (EM) technique has historically been one of the most common geophysical methods used to investigate road failure. EM surveys are cost effectives and the data can be interpreted quickly in the field.Unlike other techniques it is unusual for the more labor intensive then EM survey,but provide depth information. Data from resisitvity surveys require inversion, and are usually presented as a contoured cross section of apparent resisitvity or conductivity [1, 2].

Road failures could be defined as a discontinuity in a road network resulting in cracks, potholes, bulges and depressions [3, 4]. A road network is supposed to be a continuous stretch of asphalt lay for a smooth ride or drive. Visible cracks, potholes, bulges and depressions may punctuate such smooth ride. The punctuation in smooth ride is generally regarded as road failure.

In 1985 for example, a total of N185 million was spent on rehabilitation maintenance of 1,600 Km Federal roads throughout the country [5]. Further, a sum of N82 million was invested on the maintenance of 680 Km of roads which were overlaid with asphaltic concrete in order to increase their strength. Such sums could have been reduced if adequate geological advice were sought prior to the construction of these roads [6]. In 2006, a total of 2 billion naira was spent on the rehabilitation maintenance of 2500 Km roads along Akwa Ibom / calabar road in Nigeria.

Road failure then, is a problem that every right thinking Nigerian should be concerned about with a view to finding lasting solution. In the light of our present economy, certainly, the adage – " Prevention is better than Cure " is relevant so that the large sums of money spent on road repairs could be injected into other vital sectors of the economy or even used in improving upon the existing road network in the country. If this must be achieved, sufficient technological data on the causes of road failures must not only be provided but also be utilized in the maintenance of such roads or the construction of other roads on similar soils. We must therefore learn from previous mistakes if we desire to develop meaningfully.

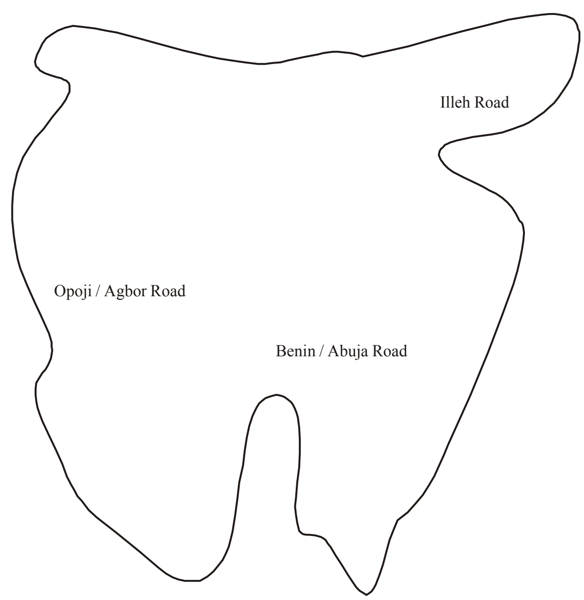

Fig. 1: Map of the Study Area

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Study area description: The road investigated in this study is the flexible pavement roadway existing along Opoji,Uwenlenbo and Illeh village. Fig. 1). The road serves as a link between the University town of Ekpoma and the Eastern part of Nigeria and Abuja.At the time of study, the road has not undergone any major failure. However, some micro cracks have started to come into sight on some portions of the roadway. The Opoji road is situated within latitude 06º 44'N and longitude 006º 08'E, while the Uwenlebo road is situated at latitude 06° 44'N and longitude 006° 08'E and Illeh road is situated at latitude 06 44 and longitude 006° 08'E respectively.

Geomorphology and geology: The Opoji, Uwenlebo and Illeh road in Ekpoma,Nigeria is situated on a gently undulating terrain with elevation between 351 m above mean sea level on the southeastern flank and 355 m at the north central area of the town. The area lies in the tropical rain forest with mean annual rainfall of about 1300mm. Annual mean temperature is between 18°C and 35°C. Rocks of the Precambrian basement complex of southwestern Nigeria [7] underlie the study area. The lithological units include sands and clays. The area of study falls within the sedimentary complex rocks of Nigeria. The type of granite mostly found in the area of study are gneiss consisting of Feldspar, mica and quartz as dominant minerals.

Field procedures: An Abem Wadi electromagnetic equipment was used to acquire the data.In order to measure the horizontal magnetic field component, the receiver coil is turned to the frequency of the selected VLF field with the phase control set at zero. The direction of minimum horizontal component is then determined using the volume control. This also gives the bearing of the transmitter unless there is significant secondary field. To take reading, the operator held the instrument with both coils horizontal and the shorter coil at right angle to the main coil and parallel to the short coil. The quadrature control may be re-adjusted during this process.

The control is re-set before taking the vertical readings. The instrument also measures the quadrature component (horizontal component).

A set signal is picked up around any geologic body found from the primary signal of the transmitter, also gives signal strength of the transmitter which should be in the range of 10-30 frequency range (15-30KHZ).The analog scale of the receiver displays the measurement in percentages.

The ratio of the real component (Re) to the imaginary component (lm) determines the degree of conductivity. A high value of RE/Im indicates a good conductor while a medium conductor is represented by Re/Im equals 1.0.High conductivity zone is a weak zone associated with fractures, joints and fault.

RESULTS AND DISCUSSION

From profile 1ie Opoji Road, Ekpoma. It is obvious that intervals 0-70m is fairly stable. While intervals 80-110m is unstable that is weak and conductive. Between 200-250m the zone is observed to be incompetent (unstable), while intervals 260-460m is observed to be fairly stable (Table 1).

Table 1: Profile1: Opoji road, Ekpoma

Station(m)	Raw Real	Filtered real	Raw Imaginary
0	0.0	12.1	71.1
10	23.9	-19.7	21.8
20	-47.3	-6.1	-94.4
30	32.3	36.6	1.9
40	4.5	10.8	-23.9
50	9.4	13.2	99.9
60	19.3	-45.3	99.9
70	-60.2	-45.7	99.9
80	-11.6	38.1	99.9
90	54.4	4.2	99.9
100	-50.2	6.1	99.9
110	60.3	13.0	99.9
120	-32.8	-0.9	99.9
130	32.3	24.4	99.9
140	7.5	42.6	99.9
150	-58.4	-8.3	99.9
160	51.1	-14.4	99.9
170	-60.4	-28.8	-15.0
180	36.4	-4.3	99.9
190	-41.9	27.4	99.9
200	-2.8	57.9	99.9
210	58.1	44.3	99.9
220	-3.5	14.4	99.9
230	24.0	24.0	99.9
240	1.1	1.1	-54.5
250	2.8	1.0	5.1
260	0.0	-6.3	99.9
270	-8.1	-4.4	99.9
280	6.2	-15.7	99.9
290	-27.8	0.5	99.9
300	23.2	14.3	99.9
310	1.8	-43.6	-23.2
320	-35.4	-60.2	-99.9
330	-33.8	-33.8	-99.9

Table 1: Continued

340	-11.9	-11.9	-99.9
350	-4.0	10.5	-99.9
360	0.0	62.5	-23.3
370	64.6	55.9	99.9
380	5.0	-4.3	5.8
390	11.4	-7.5	35.2
400	-18.8	-30.8	42.5
410	-7.3	-42.4	99.3
420	-40.5	-27.8	8.6
430	-1.0	20.0	-84.6
440	17.5	13.3	-62.8
450	3.5	3.5	-10.9
460	-4.2	4.2	-64.9

Table 2: Profile2 Uwenlenbo,Ekpoma

Station(m)	Raw real	Filtered real	Raw imaginary
0	0.0	18.6	3.4
4	21.9	7.0	93.3
8	-10.2	-15.1	59.1
12	0.4	-26.5	-51.9
16	-25.8	-38.2	-8.9
20	-20.6	-3.6	-99.9
24	6.2	16.8	-99.9
28	18	-12.9	-99.9
32	-24.9	-24.9	-99.9
36	-4.2	-4.2	-99.9
40	-4.9	9.6	-99.9
44	0.0	50.1	-99.9
48	64.6	14.4	-99.9
52	-50.2	9.1	-99.9
56	-60.3	37.0	58.0
60	19.5	-17.8	-99.9
64	6.5	6.2	-99.9
68	-3.6	-11.4	-15.0
72	0.7	-22.7	-54.1
76	31.0	7.6	-99.9
80	32.5	18.0	-99.9
84	-0.1	-46.4	-99.9
88	-14.1	-26.6	-98.8
92	-11.1	39.1	39.1
96	57.3	7.1	99.9
100	-50.2	14.4	99.9
104	60.3	66.9	99.9
108	4.2	-7.6	99.9
114	-5.1	10.1	99.9
116	11.8	5.8	99.9
120	1.0	-34.1	99.9
124	-24.2	-52.3	1.0
128	-44.1	-44.1	-41.6
132	-12.8	-12.8	-55.2
136	-6.1	-6.1	-38.4

Table 2: Continued

140	0.0	0.1	-99.9
144	0.0	0.4	-99.9
148	0.5	0.0	-90.9
152	0.5	-0.5	-83.2
156	-0.1	-0.1	-93.5
160	-0.1	-0.1	-76.5
164	0.0	0.0	-42.8
168	0.0	0.0	25.2
172	0.0	0.0	72.6
176	0.0	0.0	-10.9
180	0.0	0.0	-94.1
184	0.0	0.0	-53.9
188	0.0	0.0	-19.9
192	0.0	0.0	-29.5
196	0.0	0.0	-23.7
200	0.0	0.0	93.0

Table 3 Profile 3: Illeh road, Ekpoma

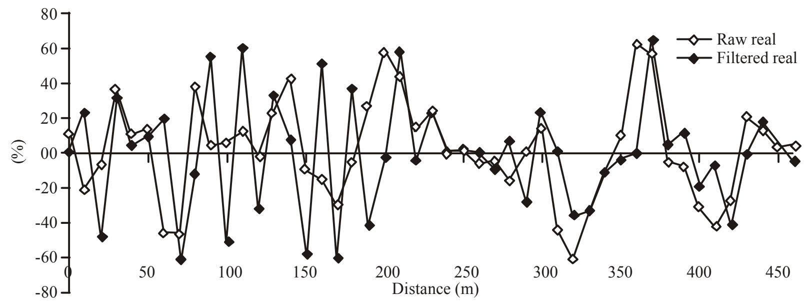
Station(m)	Raw real	Filtered real	Raw imaginary
0	0.0	0.8	15.3
10	1.0	2.4	18.3
20	-0.9	10.4	8.2
30	10.9	11.1	6.3
40	3.4	-2.7	13.9
50	-2.4	-9.4	0.0
60	-8.7	-5.6	3.8
70	1.2	-2.5	14.3
80	-4.2	-4.2	18.9
90	0.3	0.3	26.2
100	-0.6	-0.6	36.9
110	0.0	1.9	40.2
120	0.0	6.6	26.6
130	8.5	0.0	25.6
140	-6.7	-5.8	32.6
150	2.5	2.8	26.3
160	2.5	0.2	36.2
170	-1.0	-3.0	34.6
180	-1.9	-1.9	44.1
190	-0.8	-0.8	45.4
200	-0.4	-0.4	36.6
210	0.0	0.0	38.2
220	0.0	6.4	33.0
230	0.0	23.8	54.0
240	28.9	6.1	97.6
250	-16.2	-18.0	77.5
260	-1.0	-6.8	99.9
270	-9.5	-9.5	99.9
280	-1.4	-1.4	99.9
290	-1.0	0.6	99.9
300	0.0	11.5	99.9
310	7.0	27.5	99.9

Table 3: Continued

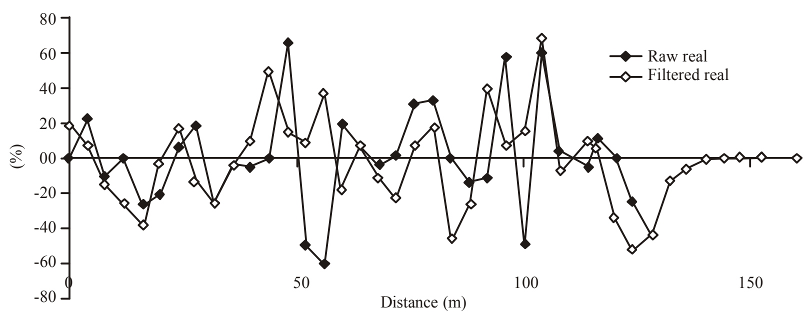
320	21.6	23.8	58.5
330	7.2	4.5	37.9
340	5.7	-16.5	17.8
350	21.3	-22.9	15.3
360	-5.3	-7.1	234.0
370	-7.5	1.2	11.8
380	8.1	4.0	15.6
390	-0.6	-8.2	6.5
400	-8.5	2.4	6.4
410	5.6	14.8	8.1
420	12.8	-0.2	9.8
430	-10.7	-4.11	-21.0
440	6.1	26	-15.6
450	-5.2	-1.0	-5.8
460	3.5	7.3	-4.8
470	2.8	10.7	-5.2
480	5.3	3.8	11.2
490	17.6	20.1	-14.2
500	14.3	-22.6	-14.8

Table 3: Continued

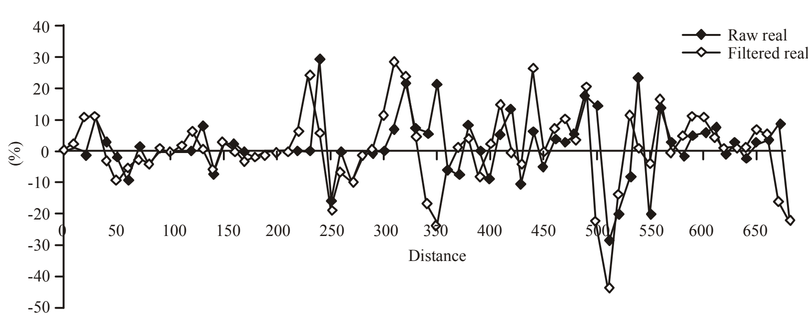
510	-29.0	-43.1	-36.5
520	-20.2	-14.4	-58.3
530	-8.5	11.5	-16.8
540	23.5	1.1	-52.0
550	-20.1	-4.1	-93.6
560	13.4	16.1	-40.7
570	3.0	-0.6	2.8
580	-1.6	4.8	74.7
590	4.6	11.4	-61.5
600	6.0	10.6	11.3
610	7.4	4.6	2.0
620	-1.4	0.9	9.7
630	2.7	1.2	-3.9
640	-2.0	1.1	-11.2
650	2.3	7.0	-1.3
660	3.1	5.5	-3.5
670	8.9	-15.9	7.0
680	-22.6	-22.6	-5.0



Profile 1: Opoji road , Ekpoma



Profile 2: Uwenlebo Road, Ekpoma



Profile 3: Illeh Road. Ekpoma

From profile 2 Uwenlebo Road, Ekpoma, it is observed that interval 0-36 m is stable and none-conductive. While between 40-116 m we have fairly stable zone, then between 120-136 m we have a stable or none-conductive zone. Between 140-160 m is a fairly stable zone, while, 164-200 m is neither weak nor competent, or there was no reasonable signal i.e. the earth subsurface material are near homogenous as seen in Table 1.2 and the profile 2 graph.

From profile 3 Illeh Road, Ekpoma intervals 0-30 m is weak and conductive and therefore unstable. While between 40-100 m is stable or competent and therefore none-conductive, between 110-610 m is fairly stable, while between 660-680m is stable (Table 3 and the profile 3 graph).

CONCLUSIONS

The physically obvious road failure witness along profile 1 and 2 are not as a result of the instability in the under ground geology alone but rather may be due to factor like drainage and quality of materials used for the construction of some of the Nigerians road. It was observed in this study that majority of the area failed because the road was constructed over clay. This implies that responses to the underlying materials to imposed stresses is a dominant factor responsible for failures. For durability of Nigeria roads, such factors which result to failure of road should be adequately checked and remedied.

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