Influence of Bentonite Content on Termite Reworked Soil: an Ado-Ekiti, South Western Nigeria Experience

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***Abstract* - This paper examines effect of curing time and bentonite content on termite reworked soil. Samples of termite reworked soil and natural bentonite soil were obtained from different location in Ado-Ekiti. Tests were conducted on the mixture of the samples to evaluate the effects of specific gravity (grain size analysis), consistency limit (shrinkage, liquid, plastic tests), compaction, direct shear box test, unconfined compressive strength and CBR (i.e. California bearing ratio). The samples were termite reworked soil and bentonite. The tests were carried out at 0%, 10%, 20%, and 30% respectively. The results showed that the bentonite does not have positive effect on the strength characteristic of the laterite sample. However, the sample treated with bentonite should be stabilized with cement or lime for better curing result.**

Keywords: Ado-Ekiti; Bentonite;Curing time; Grain size analysis; Soil strength characteristics; Termite reworked soil;

1.0 INTRODUCTION

Termite re-worked soil is found to be suitable for many engineering applications. And the quality of this soil could be improved byadditives. Commonly used additives are usually imported. Meanwhile there are several clay minerals that are underutilized which could be used as additives to improve soil properties. Bentonite is such a clay(Kabasaetal, 2001).

Reworked soils of termite are stable than surrounding ground mass because of the saliva added when building the structures by worker termites. A termitarium, which may be up to 7.0 meters may weigh up to two and half tones (Atkins, 1980).Termites play integral roles in soil development, as they are one of the primary soil producers in arid and semi-arid systems.

According to Jones (1990), a cemented surface on a termitarium may serve to reduce erosion. Animal activities such as that of termitemay lower soil PH and rejuvenate soil as they concentrate calcium and other nutrients in soils, in part of East Africa, termitaria are used by farmers as soil amendments (Watson, 1977).In Nigeria, with recent rapid development in building and construction industries, civil engineers have found termitaria tool for locating borrow pit because their occurrences indicate that the surrounding soil is rich clay materials or laterites. This study centers on ascertaining if there is significant effect of bentonite on the engineering properties of termite re-worked soil.

Bentonite is an absorbent aluminum phyllosilicate, essentially impure clay consisting mostly of montmorilorite. The peculiar characteristics of bentonite clays, thioxotropic, swelling and absorption properties, have counted for their demand for various industrial uses. These properties have been attributed to the type of clay material, the nature of exchangeable anion(s) present in the bentonite and its cationexchange capacity.Bentonites continues to be the most widely used material for thickening fresh water base drilling fluid. Wyoming bentonite is the most commonly available commercial bentonite for drilling fluid applications it is principally composed of sodium mentmorillonite. This accounts for its high degree of hydration of its particles by the dispersed water medium.Conversely, most bentonite deposits are non-swelling bentonite (Principally made up of calcium montmorillonite). Attempts has been made to convert calcium bentonite to sodium salts in order to exchange the calcium ions for sodium and obtain a bentonite with improved swelling capacity and viscosity. There is also increasing demand for bentonite in other area such as cosmetics, pharmaceuticals etc. Generally, bentonite that are required for these applications are pure white bentonite with a high montmorillonite content and whose exchangeable cations are at least 60% univalent (Odom, 1984).

1.2 LOCATION OF THE STUDY AREA

The location of the study area is within Ado-Ekiti, South-Western Nigeria Fig. 1.0 shows the topographical map of the study area. Ado-Ekiti lies within latitude $7^{0}35'$ N and $7^{0}38'$S and longitude $5^{0}11'$E and $5^{0}16'$W. Ado-Ekiti falls within the basement complex rock of south western Nigeria in several parts of Africa under lain by crystalline basement complex rocks, the major rock types include migmatites, gneisses, quartzes and schist.Ado-Ekiti enjoys a tropical climate and vegetation with two distinct seasons, viz: the dry season and rain season. The dry season starts in November and ends in February while the rain season begins in march and end in October on the average sporadic rainfall may occur during the dry season while temperature range between 25^{0}c and 30^{0}c.The study area has a mean annual rainfall of 1,500mm and has a high relative humidity of about 80% (DMS, 1999). Ado-Ekiti has a wet low land forest vegetation with the vegetation getting greener during rainy season.

1.3MEANING OF TERMITE REWORKED SOIL

A termite reworked soil is a more stable soil made up of chewed up, partially digested wood, saliva, and feaces to produce a more durable building material (longair, 2004). A reworked soil are more stable than surrounding ground mass because of the saliva added when building the soil by worker termite. Termites which could dig up to 10meters below the surface bring up mineral grains which had been used to confirm the deposits of minerals in some countries e.g. Gold deposit in Mali (Afro News, 2008). The process of soil transportation for mound building had been reported to cause modification of soil characteristics which had been observed to promote pedobioperturbation and nutrient cycling. Termite as a major bioturbators created biogenic structure (galleries, nests, mounds, fungus unit chambers) that strongly influenced the physical and chemical properties of soil (Kaschuk et al, 2006).

1.4MEANING OF BENTONITE

Bentonite is aclay mineral which is largely composed of montmorillonite which is mainly a hydrous aluminum silicate. It is highly colloidal and plastic clay with the unique characteristic of swelling of several time its original volume when placed in water. Bentonote was formed from volcanic ash deposited in an ancient sea, and modified by geological process into the present sodium Bentonite. Bentonite were calculated between 74.5 and 70 million years ago. At that time, the million area was the center of a shallow inland sea which stretched from the Arctic Ocean to present day Mexico and was at least 1600 kilometers wide.Bentonite has been called the clay of thousand uses. Bentonite clay is composed of microscopic platelets consisting of layers of aluminum hydroxide held between layers of silicate atoms. This platelets is stacked one on top of the other.

2.0 RESEARCH METHODOLOGY

The soil sample of termite re-worked soil was collected from a termitarium at Aba Erinfun, Ado-Ekiti. Also, Bentomite was collected from NTAarea (New Iyin Road) at Ado-Ekiti.

2.1SPECIFIC GRAVITY

2.1.1 Procedures: Ensure that the soil sample is sun dried before it is used for the test. Weight the two density bottles on the weighing balance and record as M_1. After weighing, put soil sample into the density bottles at one-third height of the bottle, weigh the samples and the bottle i.e sample + bottle (M_2) and record.add water into the two samples, then weigh the samples i.e sample + bottle + water (M_3) and record. Pour the two samples away from the density bottles and rinse the bottle with clean water. Fill the two density bottles with distilled water and weigh i.e. bottle + filled water (M_4) and record.

2.1.2PARTICLES SIZE ANALYSIS

Procedures: about 600g of soil sample is obtained and soaked in water for 24hours. The soaked sample was thoroughly washed and manually sieve with 75mm. the finer sand size was allowed to settle while the coarser material were separately oven dried at 105^0c and 110^0c.The dried finer sand was kept for hydrometer method while the dry coarser material was allowed to pass through a mechanical sieve shaker and was leave for 15 minutes, then, the particles in each sieve was weighed and recorded.

2.1.3LIQUID LIMIT

To determine the liquid of a soil, a sample of either oven or air dried soil passing through a 0.425mm sieve is mixed with percentage of bentonite provided at 0%, 10%, 20% and 30% and later mixed with distilled water to a stiff consistency. A portion of the soil sample is placed in the cup of the liquid limit device and leveled off parallel to the base.This was carried out in the laboratory by using cone penetrometer machine and the already filled cup is placed under the penetrometer and the penetrometer is allowed to drop on the soil sample in past form to know the penetration and the soil sample was put into the weighing can of know weight and the sample is weighed and recorded to know the weight of the wet soil.After that, the sample was later transferred into an even and leaved if for 24hours and reweigh again to know the weight of the dried soil. The whole procedure is repeated with the moisture content slightly varies in each case. This is done until after four or five trials.

2.2 PLASTIC LIMIT

Procedures: About 20g of soil passing 0.425mm sieve is mixed with water and moulded into a ball. The ball is rolled by hand on a glass plate with sufficient pressure to form a thread when the diameter of thread becomes about 3mm, the soil is kneaded together and then rolled out again.The process is continued until the thread crumbles when it is 3mm diameter; and at this stage the moisture to obtain about two or three times and the average moisture content taken as the plastic limit.

Plasticity index = *liquid limit – plastic limit*

2.3 COMPACTION TEST

Procedure: Obtain some quantity of the dry sample and pulverized it. Weigh 300g of the soil and pour this into the large tray. Mix the weighed soil sample with the percentage of bentonite provided i.e 0%, 105, 20%, and 30% respectively. Hand mix the sample thoroughly and add amount of water varying between 4% and 6% of the weight of the soil.After mixing the soil with water divide the soil into 3 appropriate equal parts prepare the mold very well, fix the base plate to the mould and weigh it. Attach the extension collar and lightly oil the mould. Fill in the first part of the divided soil into the mould and using the 2.5kg rammer given it 25mm below the rammer. Treat the second and third part in exactly the same way ensuring that the last layer did not extend more than 6mm above the top of the mold in to the extension collar after compaction of the last layer.Remove the extention collar gently and use straight edge to trim–off the excess soil until it is perfectly flush with top of the mould. If the collar removed part of the soil in the mould, take some of the soil in the collar and tamp it into the mould by means of the straight, edge weigh the mould with the compacted soil and record. Extrude the soil from the mould and take samples from the top, middle and bottom for moisture content determination.Break all the lumps and mixed the soil with 25 water and repeat the procedure until there is failure in the soil sample.Conduct the same procedures for other percentages of bentonite.

2.4 CALIFORNIA BEARING RATIO

Procedure:obtain 6000g of the dry soil sample mixed it with the percentage of bentonite provided i.e. 0%, 10%, 20% and 30% respectively. Hand mix the the sample thoroughly and add amount of water derive from the moisture content of compaction test. After mixing the sample with water, divide the soil into 3 appropriately equal parts.Prepare the CBR mould with its base plate and weigh. The extension collar shall then be filled and a filter paper placed on the bottom fill the first part of divided soil into mould and using the 4.5kg rammer given it 62 blows of the rammer. Treat the second and third part exactly the same way.After the blows of rammer has been eventually distribution over the surface of the soil, remove the extension collar and strike off the excess soil using straight edge.Conduct the penetration test by placing the mould on the lower palate of the CBR machine and adjust the machine until the plate makes contact with the top of the mould. Adjust the dial gauge to zero, and select a suitable gear so that rate of penetration of about 1.27mm and the ring reading (load readings) at penetration reading of 0.25mm, 0.5mm,0.75mm,1.0mm,1.25mm, 1.50mm,1.75mm,2.0mm, 2.25mm, 2.50mm, 3.0mm, 3.5mm, 4.0mm, 5.55mm, 6.0mm, 6.50mm, 7.0mm, and 7.5mm was provided at start.Graph of lead reading against the penetration was plotted and the values of the load corresponding to the 2.5mm and 5.0mm penetration was pulled finally the C.B.R value for 2.5mm and 5.0mm penetration was calculated using2.5mm -13.24 KN and 5.0mm – 19.96 KN standard loads.

3.0 RESULT AND ANALYSIS

3.1 PARTICLE SIZE DISTRIBUTION

The result of the sieve analysis of the samples are shown in table 1.1 below. The sieve analysis for the 0%, 10%, 20% and 30% sample show that it is a fine grained soil according to unified soil classification system (USCS 1960) shows that “50% or more is passing through sieve number 200um

3.2 ATTERBERG LIMIT

The liquid limit (LL) and plasticity index (PL) values ranges between 32.9% to 45.2%, 13% to 21% for (LL) and (PL) respectively.These values do not meet the requirement for that, the LL and PL of sub- base not be more than 35 and 12% respectively (FGN 1997). However, for the bentonite treated laterite of 0%, 10% and 20% are quite suitable for sub- grade material according to Nigeria specification (1997) .The below analysis in the table 1.2 below revealed that, the higher the percentages of bentonite content, the higher the (LL) and (PI) values.

3.2.1 Specific gravity: The value of the specific gravity of the samples are shown in table 1.3 below, they are suitable for sub-grade material only

3.3 COMPACTION TEST

As shown in the table 1.4 below, maximum dry density (MMD) and optimum moisture content (OMC) of the samples treated with bentonite ranges from 1215 to 1740kg/m^3 and 14 to 17.70 for MMD and OMC respectively. The below analysis according to Nigeria specification (1997). It does not meet the requirement for minimum density specify of 2000kg/ m^3

3.4 CALIFORNIA BEARING RATIO

The California bearing ratio test of the examples ranges from 6.23% to 25.70% respectively. These value are considered poor since they fell out of the minimum specified for sub- base and base course material. The results of the California bearing ratio for the sample are shown below

3.5 DIRECT SHEAR BOX TEST

The shear box test conducted for the samples range from 16 to 43 and 2^0 to 27^0 for cohesion © and fractional angle (Φ) of the bentonite treated sample. Table 1.6 revealed the results of the direct shear box test.

4.0 CONCLUSION AND RECOMMENDA

4.1 RECOMMENDATION

The samples treated with bentonite should be stabilized with cement or lime for better result, since bentonite does not have positive effect on the strength characteristic of the laterite soil sample, The bentonite sample would be more advantageous in ceramics industries, if further research work is done on the industrial application of bentonite material. Continued study will further verify the comparative analysis between bentonites and other laterite sample in Ekiti state, southern part of Nigeria.

4.2 CONCLUSION

The general analysis of this research work for 0%, 10%, 20%, and 30% bentonite treated laterite in the laboratory lead to the following deductionsThe sieve analysis was considered to fine grained soil for all the percentages (0%, to 30%) according to (USCS:1960)The atterberg limits was considered not suitable for base and sub-base course material. The value ranges between 32.9 to 45% and 13 to 21% for L.L and P.I. respectivelyThe compaction test evaluated for MDD and OMC and considered not suitable, since they fell out of minimum specified.The bearing ratio test were also considered not suitable for base and sub-base.

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APPENDIX: TABLES AND FIGURES

Table 1.1: Sieve percentage of the following

SAMPLE	GRAVEL	SAND	SILT	CLAY
BENTONITE				
0%	99.5	0.5	0	0
10%	99.0	1.0	0	0
20%	98.0	2.0	0	0
30%	95.0	5.0	0	0

Table 1.2: Results of atterberg limit tests for the studied soil

Sample + bentonite %	P.L (%)	L.L (%)	P.I (%)	S.L (%)
0	19.00	32.90	13.00	9.40
10	19.90	38.20	199.00	9.30
20	19.80	40.90	21.10	10.14
30	24.30	45.20	20.90	9.40

Table 1.3: Results of specific gravity tests for the studied soil

SAMPLE + BENTONITE (%)	SPECIFIC GRAVITY (KN/m^2)
0	2.69
10	2.37
20	2.19
30	2.28

Table 1.4: results of compacted tests for the studied soil

SAMPLE + BENTONITE (%)	MDD (kg/m^3)	OMC (%)
0	1230	14.00
10	1740	14.80
20	1215	15.50
30	1535	17.70

Table 1.5: result of California bearing ratio test for the studied soil

SAMPLE + BENTONITE (%)	C.B.R. VALUE @ 2.5	C.B.R. VALUE @ 5.0
0	6.23	7.26
10	8.20	11.15
20	7.93	11.15
30	21.15	25.70

Table 1.6 : result of the direct shear box tests for the studied soil

Sample + Bentonite (%)	Cohesion ©	Fractional angle (Φ)
0	16	18^0
10	43	26^0
20	30	27^0
30	16	2^0

City: Ado-Ekiti. Latitude and Longitude of the city Ado-Ekiti is 7.63333^0 N / 5.21667^0W

Here is the latest Map of Ado-Ekiti city:

Country: Nigeria

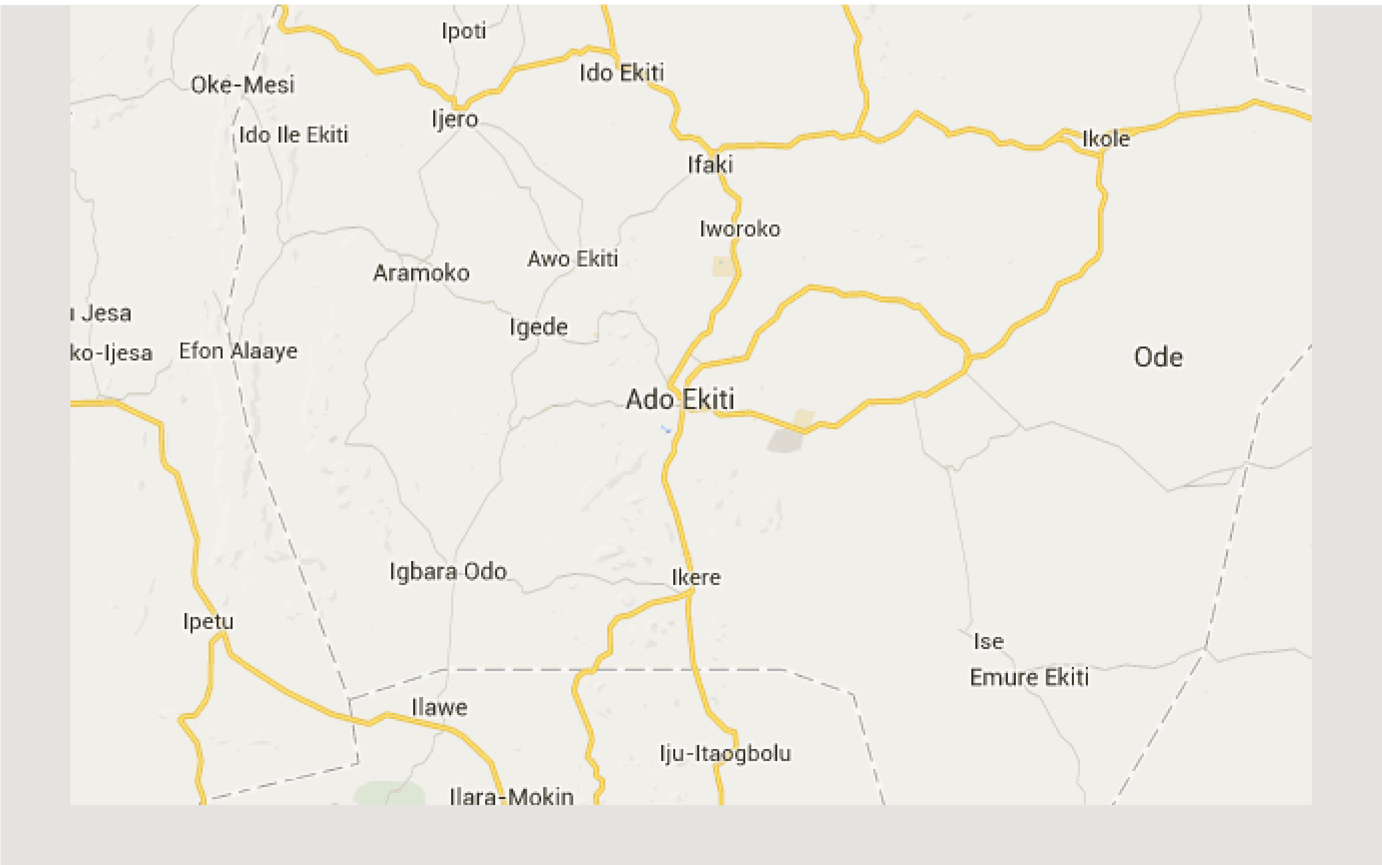

Fig 1.0: (a) Map showing the geographical location of Ado-Ekiti
Source:www.google.com.ng/maps/@7.6327305,5.2446843,14z (accessed in October 2014)

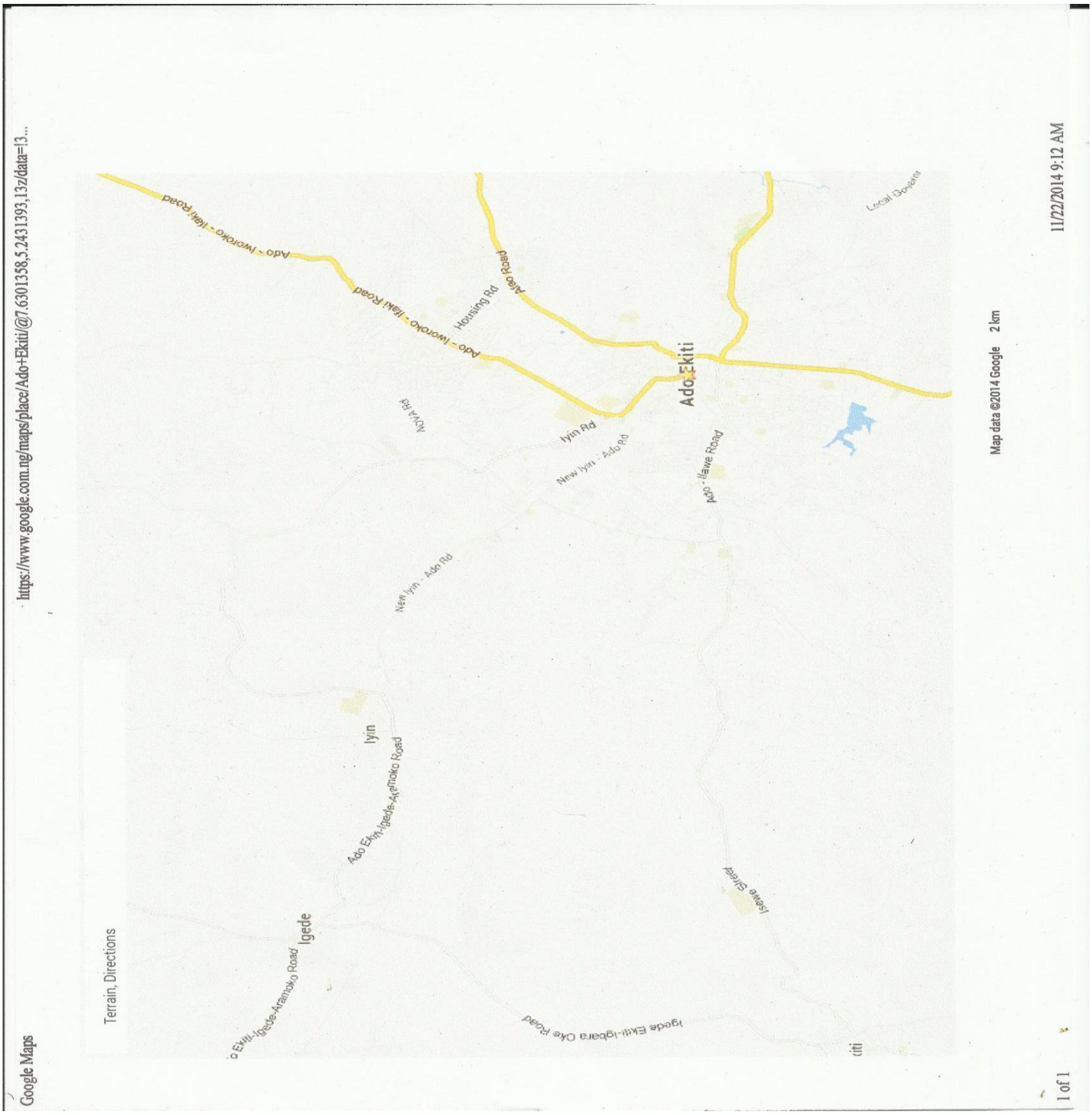

Fig.1.0: (b) Map showing Ado-Ekiti local environs

Source:www.google.com.ng/maps/@7.6327305,5.2446843,14z (accessed in October 2014)

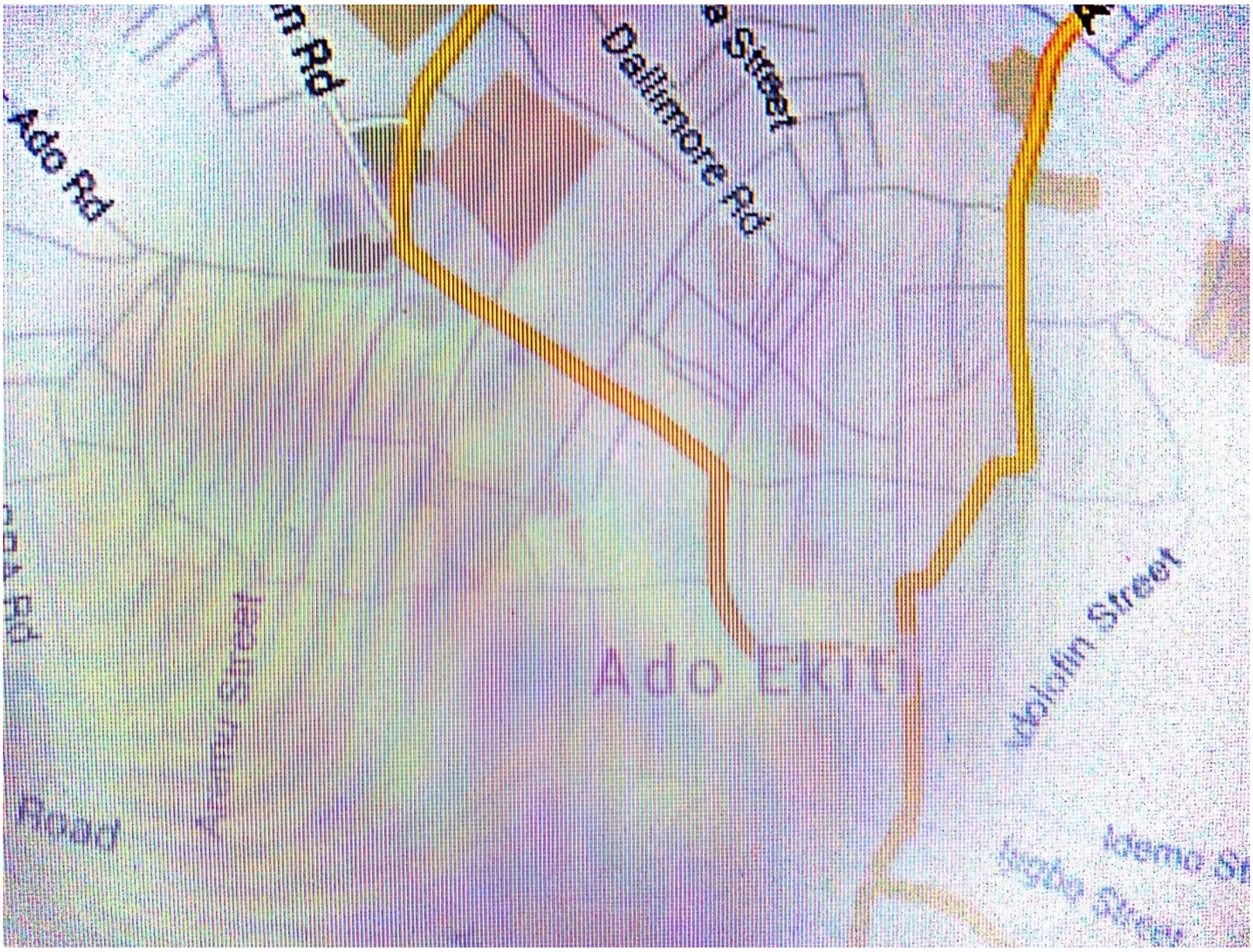

Fig3. Map showing Dallimore from Ijigbo Street and the major road to New Iyin Road left