Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol. 3, No.7, 2013

Geotechnical Investigation of Road Failure along Ilorin-Ajase – Ipo Road Kwara State, Nigeria.

Dr. I.P. Ifabiyi
tokunifabiyi@yahoo.com
Department of Geography and Environmental Management Faculty of Business and Social Science P.M.B 1515, University Of Ilorin, Ilorin. Kwara State, Nigeria.
Mr. Kekere, A.A
Kedams005@yahoo.com
Department of Art and Social Science, Unilorin Secondary School, University Of Ilorin, Ilorin, Nigeria.

Abstract
The incessant failure of road network in Nigeria has generated a lot of concern by road users and government. Apart from lives and properties that are lost annually to road crashes, road rehabilitation across the country has become a financial burden to the federal government. Several factors have been identified to be responsible to road failure in Nigeria; they include geological, geomorphological, road usage, bad construction and wrong approach to maintenance. Hence, this paper examines some of the factors responsible for road failure along Ilorin-Ajase Ipo road, Kwara State Nigeria. Soil samples were collected from Five (5) portions of the road that are badly affected by road failure. These portions include: Agricultural and Rural Management Training Institute (ARMTI) 17+800km, Kabba Owode 18+00Km, Idofian 23+700Km, Koko 29+700Km and Omupo 35+700Km axis. The soil samples collected were analyzed four engineering properties: particle size distribution (PSD),atterberg limit, compaction test California Bearing Ratio (CBR). The result of Principal components indicated that, in the study area sandy soil contribute 50%,Coefficient of curvature account for 28.1% and coefficient of Uniformity 14.1%.T he overall results showed that poor foundation materials and poor Engineering construction have affected the rate of failure of the road along Ilori –Ajase Ipo road.

Introduction

Studies on road failure have been widely carried out using geophysical and geotechnical methods. Geophysical method involves the use electrical resistivity and electromagnetic (EM) approaches (see Aigbedion 2007; Adiat et'al 2009) which tries to evaluate the subsurface condition of road to establish integrity of road and likely fault zones which could results to road failure while geotechnical method employs the use of laboratory equipments to investigate foundation materials of road with a view to testing various engineering properties such as, particle size distribution (PSD), plastic Limit (PL), liquid limit (LL), compaction test, California Bearing Ratio (CBR) test among others. This study therefore, tries to analyze the impact of foundation materials on road failure.

Road failure could be in the forms of cracks, potholes, bulges, and depression, which makes road network unsafe and not motorable to road users. Road failure in Nigeria is a major problem after the problem of power supply, it has not only cause a setback to Nigerian economy but it has led caused loss of lives and properties in millions of Naira annually. Rehabilitation of this road network has become a financial burden t o the Federal, State and Local government. Federal Road Safety Corps (FRSC 2011) reported that, Nigeria ranks 191 of 192 countries of the world with unsafe roads, and as a result 162 deaths per 10,000 populations occur from road crashes. Most accidents recorded occurred within the bad portions which are largely due to failure. Vehicles in the bid to avoid potholes, cracks, depressions take the wrong directions sometimes in the dark, jump into these bad spot and results in head – on collision. Ilorin – Ajase-Ipo road also has been affected, vehicles spend longer hours before getting to their destinations due to road failure this has negatively affected the socio-economic activities of people leaving along the road network.

The study area

Ilorin-Ajase-Ipo Road is one of the four transect route linking the Kwara State capital Ilorin, Nigeria (see Oyegun 1986). It lies between latitude $4^{o}20_{2}^{'}$ and $5^{o}303'$ worth of the equator and between longitude $4^{o}303'$ and $5^{o}404'$ east of the Greenwich meridian. The road network follows several towns and villages which attract socio economic activities such as village market, cattle market and the presence of some federal government agencies, which include Agricultural management training Institute (ARMTI) and National Centre for Agricultural Mechanization (NCAM). It remains the only exit to Kogi State, Federal capital Territory (Abuja), West, Eastern and Southern parts of Nigeria. It has very high vehicular flow throughout the year.Fig.1 below shows Ilorin-Ajase-Ipo road Kwara State,Nigeria.

Fig. 1 Ilorin Ajase-Ipo Road, Kwara State, Nigeria.
(Source: Office of surveyor General Kwara State).

Ilorin-Ajasse Ipo Road is found on an undulating plain on a height of about 300m above sea level, underlain by pre Cambrian basement complex rock which has undergone processes of metamorphism and magnetic intrusion (Oyegun 1995). Generally, the foundation materials of the road network are dominated by sandy soil, clayey soil and some fragmented igneous rock shattered along side of the road. The climate of the area belongs to the humid tropical climate characterized by wet and dry seasons. The two seasons are largely produced by two important air masses. The tropical maritime air which originates from the southwesterly direction and the tropical dry continental air masses flow from North easterly direction. Ilorin-Ajasse-Ipo Road also falls between Zones D and E of the ITD movement (see Ojo 1977; Olaniran 2002) where vast producing cloud forming rainfall is enhanced. The annual rainfall is between 1000- 1150mm the rainfall exhibit double maximum pattern with a little dry spell around August. This implies that there is adequate soil water to allow geomorphic processes. The temperature ranges between 25^{oc} to 28.9^{oc} reaching 29^{oc} (NIMET Ilorin). The soil belongs to the ferruginous tropical soils which is reddish-brownish in color. It has high clay content. The dominant clay type is the kaolinite clay type and illite group. Lateritic iron stone are quite feasible in some segments of the study area.

Materials and Methods

Soil samples were obtained from foundation materials dug by manual effort. These samples were collected from 5 different locations of the foundation materials. The samples were collected from the sites of worst failures. These samples were first air dried under the sun to allow moisture to escape before basic test were performed. The tests were conducted in accordance with the British Standard in the Civil Engineering Department of the University of Ilorin, Ilorin Nigeria. 5 soil engineering properties were tested. These are atterberg limit comprising of liquid limit and plastic limit test, particle size analysis comprising determination of percentage clay, silt and sand. It also entails determination of coefficient of uniformity and curvature. Other test include, compaction test and the California Bearing Ratio (CBR) test, which were conducted to test the stability of the road foundation along Ilorin-Ajase –Ipo road. The result obtained in this study were subjected to Principal Component Analysis (PCA) on the whole, about 10 variables were generated. The Principal Components Analysis was used to reduced the variables to a few original variables.

Results and Discussion

According to Table 1.1, gravel composition is in the range of 5-43% and sand between 34 and 95%, they were classified as based on Universal Soil Classification System (USCS) as gravely soils, sandy as well as poorly graded soils. This implies that foundation materials were poorly graded with high percentage of sandy soil composition which affects the rate of compaction of the road.

Table 1. Soil Geotechnical Properties

Soil Properties	A	B	C	D	E
Particle size Distribution [PSD](%)					
Gravel	64	66	58	5	43
Sand	36	34	42	95	57
Plasticity Index (PI)	23	18	25	26	20
Optimum moisture content (OMC)	14	13	10	14	13
Maximum Dry Density (MDD) kg/m^3	1830	1820	1880	1800	1900
Coefficient of uniformity (CU)	8	7	11	4	16
Coefficient of curvature (Ccvr)	1	1	2	2	1
Soil Classification (USCS)	GP	GP	GW	SW	SP

Source: Authors field work 2010. GP = poorly graded gravel GW= Well graded gravel SW= well graded sand SP =poorly graded sand

Table 2. Component loading value and Cumulative loading variance of road failure explained by Engineering properties.

Variable	Components		
	1	2	3
Gravel	-.866	-.288	-.402
Sand	.866	.266	.402
Coefficient of uniformity(cu)	-.725	.124	.070
Coefficient of curvature (ccvr)	.047	.946	-.186
Liquid limit (LL)	.972	.179	.078
Plastic Limit (PL)	.726	-.442	.260
Plasticity Index (IP)	.439	.778	-.209
Optimum Moisture content (OMC)	.554	-.711	.100
Maximum Dry Density (MDD)	-.741	.340	.580
Total Eigen value	**4.550**	**2.529**	**1.273**
% of variance	**50.557**	**28.095**	**14.145**
% Cumulative variance	**50.557**	**78.6552**	**92.798**

Source: Author's field work 2010

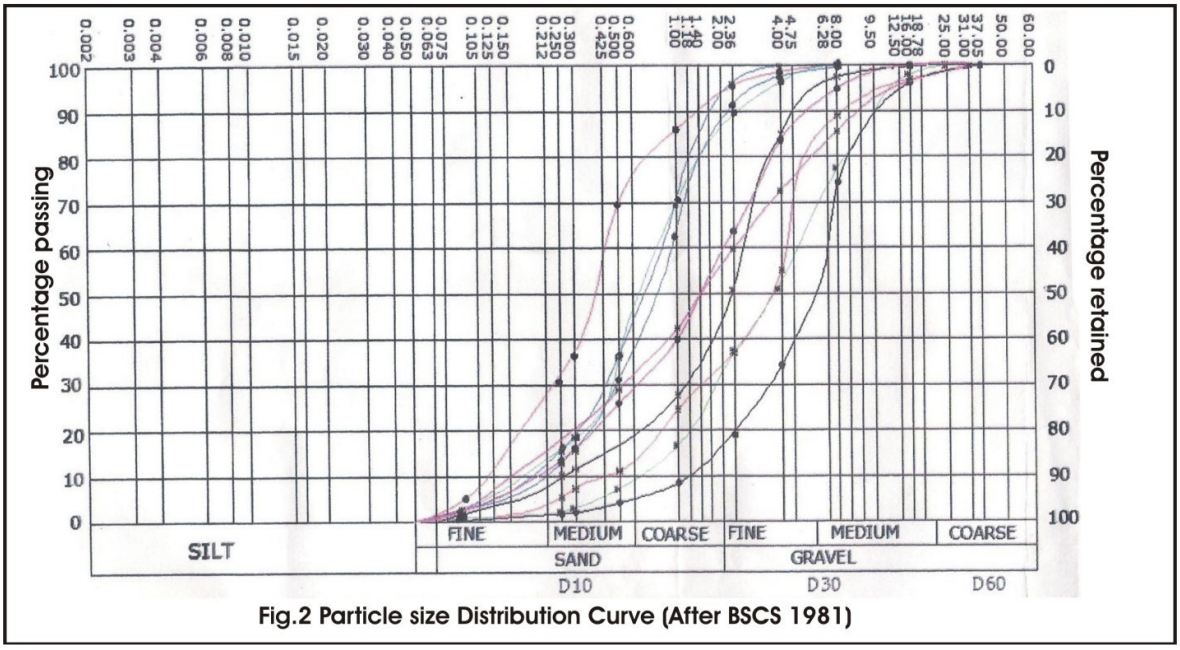

Fig.2 Particle size Distribution Curve (After BSCS 1981)

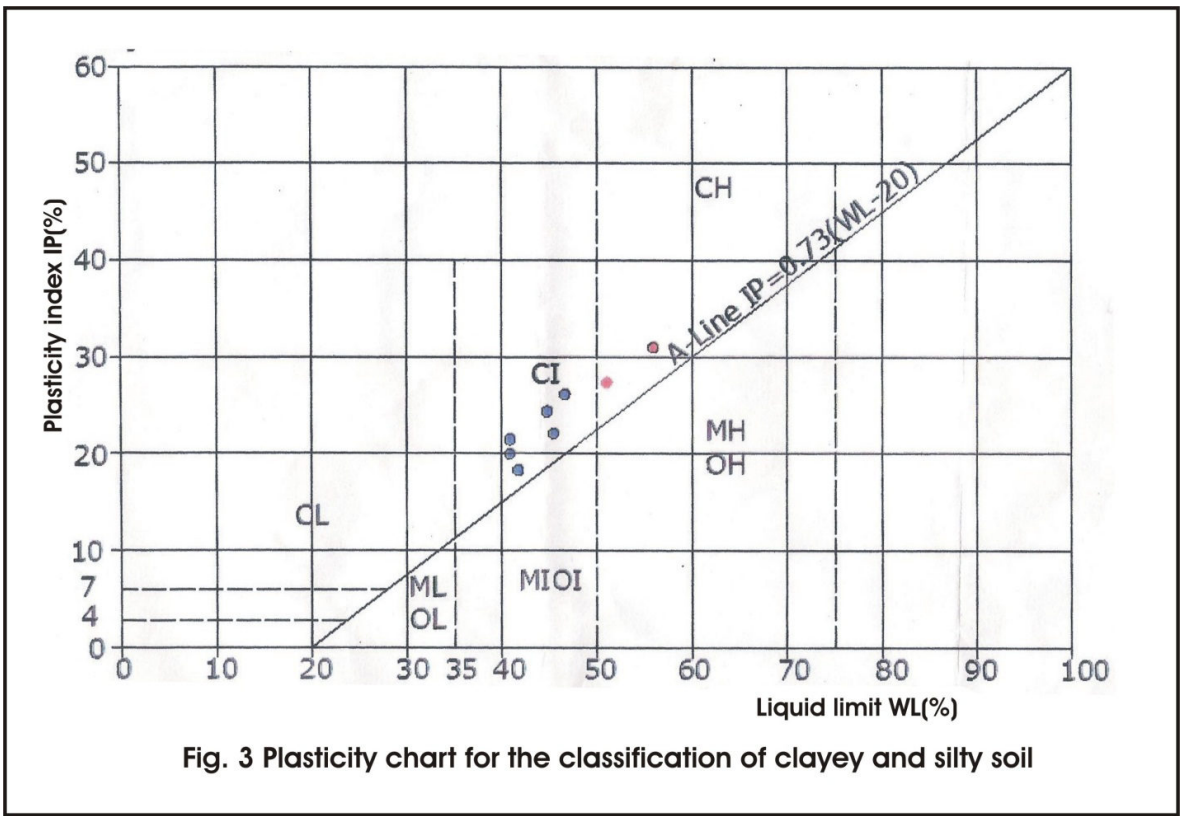

Fig. 3 Plasticity chart for the classification of clayey and silty soil

The result shows that moisture content ranges from 10-14%, Plastic Limit(PL) between 17-26% and Liquid Limit(LL)41 -51%.The results obtained shows that it is within acceptable limit. However, results of plasticity index (IP) which is plotted on plasticity chart in Fig.3 above shows that chainage 17+200Km, 18+600Km, 20+650Km contain soils of intermediate clay content (CI) while 29+250Km contained a very high clay content (CH).The presence of clay soil in foundation materials is capable of causing swelling and brokerage of road surfaces when in contact with moisture during wet season.

The value for maximum Dry Density (MDD) of the foundation soil ranges from 1800-l900kg/m^3

according to O'Flaherty (2001) this value meet the anticipated value of compaction level for flexible pavement condition for low volume vehicle but the increasing volume of heavy duty vehicles plying this road with several tones of materials have affected the level of compaction rate which was originally designed to meet low volume vehicle. This has further worsened the problem of road failure.

Components of Road failures

The result of PCA presented in Table 1, indicated that three major components explain the causes of road failure along Ajase –Ipo road. These are liquid limit (50%).The relevance of liquid limit implies that the foundation materials is subjected to continuous wetting especially during wet season as a result of this, the foundation materials increases in water content thereby change the soil behavior by making it plastic this makes failure imminent. Coefficient of Curvature (Ccvr) has contributed 28.1% to the explanation of road failure. Ccvr explains the gradation of this result in Table 1 suggest poor gradation which implies that the foundation materials of the road is poorly graded it therefore means that the road foundation is not stable. Maximum dry density (MDD) contributes 14.1% to the explanation of road failure in the study area. The relevance of the MDD to the explanation is expected in view of the high contribution of LL. The rate of LL affects rate of compaction and also MDD. The MDD value recorded in this study means that the material cannot be properly compacted. This is expected in view of the high concentration of gravel and sandy materials (Table 1) less than average rate of compaction will result in weak foundation and then failure problem.

Conclusion and implication of Study

Effort to maintain the road along Ilorin-Ajase Ipo road by government agency have not yield any result because the maintenance carried out was approached wrongly. It is evidently clear from the findings that poor foundation materials constitute the foundation of the road for instance, the presence of clayey soil and sandy soil have contributed to road failure witnessed on the road. This areas badly affected should be scooped out and replaced with stabilizing agent like lateritic soils to ensure stability of foundation. In addition surface drainage should be provided to enable discharge of runoff because concentration of runoff during precipitation affects compaction level of the foundation where drainage facility is provided debris and sediments should be cleared regularly to avoid blockage of culvert and drainage channels to enable free flow of water from the surface of foundation because concentration of run-off affects stability of foundation.

More so, attention should be given to quality control by appropriate government agencies to ensure road are constructed to meet desired standard because this study observed that, the thickness of bituminous overlay of the road under study is between 45-50mm which is far below recommended standard for flexible thickness of paved road as against 150-250mm as suggested by O'Flaherty(2001). However, there is need to extend this present study beyond this Ilorin-Ajase Ipo road with the view of checking road failure problem in Nigeria.

References

Aigbedion. I. (2007) Geophysical Investigation of road failure using Electromagnetic profile along Opoji, Uwenkenbo and ILleh in Ekpoma – Nigeria. *Middle – East Journal Of Scientific Research* 2(3-4): 111 – 115

Adiat. K.A.N., Adelusi; A.O. and Ayuk .M.A. (2009) Relevance of geophysics in road failure investigation in a typical basement complex of south western Nigeria. *Pacific Journal of Science and Technology*10 (1): 528 – 539 www.akamaiuniversity. US/PJST.

Federal Road Safety Corps (FRSC, 2011) *United Nation Decade of Action on Road Safety*, Benin City, Nigeria.

O'Flaherty C.A (1979) *Highway Engineering*, Edward Arnold – London

O'flaherty C.A (2001) Soils for road work: In O'flaherty, C.A. (ed). *Highways The Location, Design, Construction and Maintenance of Pavements,* 133

Ojo O. (1977) *Cimate of West Africa* Heinemann Press.

Olaniran O.J (2002**)** Rainfall anomalies in nigeria: the contemporary understanding 55th *Inaugural Lecture, University Of Ilorin, Nigeria*. Unilorin Press, University of Ilorin. 8-10.

Oyegun R. O. (1986) *Water Resources in Kwara State*. Matanmi and Sons printing and publishing Co.Ltd. Ilorin, Kwara State.