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SURVEY AND ASSESSMENT OF FLEXIBLE PAVEMENT ON IDAH TO ANYIGBA ROAD, NORTH CENTRAL, NIGERIA.

by

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ABSTRACT

Pavement distresses are those defects visible on the pavement surface. They are symptoms, indicating some problem of pavement deterioration such as cracks, patches, potholes, ruts among others. The distresses increase journey times, operating costs, transport fares. A well maintained road increases safety and ride quality.

The methodology used was the visual condition survey whereby a pilot survey, was first carried out on foot in order to confirm the level or severity of damage, after which a digital camera was used to take the photographs of the defects, and then classifying them into types. Soil analysis of the subgrade was carried out in accordance to B.S. 1377. All the portions of road studied are in very poor condition. They are beyond rehabilitation.

The study found that the Compaction test falls between 191.64kg/m^3 and 1302.4kg/m^3, Optimum moisture content falls between 7.8% and 28.9%, California bearing ratio (soaked) falls between 11% and 45%, unconfined compressive strength falls between 32.4KN/m^2 and 486.7KN/m^2. The study also found that the main defects on the road are potholes, edge cracks, transverse cracks, longitudinal cracks and fatigue cracks.

The study concluded that the probable causes of the defects may be due to inadequate or lack of drainage, poor design and poor workmanship, lack of corrective and preventive maintenance, increased and repeated loading which is greater than what the pavement was initially designed to carry. The study recommended that based on the fact that the pavement's deterioration is beyond rehabilitation, it should be redesigned and reconstructed.

Key Words: Visual condition survey, Geotechnical investigation, Defects, Subgrade.

1.0 Introduction

Highway engineers and the construction industry have traditionally designed and constructed two types of pavement, flexible and rigid. Pavement engineers choose the most cost-effective pavement type that is capable of supporting anticipated traffic under existing environmental conditions and providing safety and driving comfort to the travelling public (VDOT, 2001).

Most surface roads in Nigeria are constructed of asphalt, a flexible material that can flex and stretch a bit in its new state, but when it becomes older, the bitumen binder becomes brittle and cracks can open in the surface at this stage.

Flexible pavements are so named because the total pavement structure deflects, or flexes, under loading. A flexible pavement structure is typically composed of several layers of different materials. The layers are usually arranged in order descending load bearing capacity with the highest load bearing capacity material (and most expensive) on the top and the lowest load bearing capacity material (and least expensive) at the bottom.

Pavement deterioration starts as soon as road is opened to traffic and the deterioration begins slowly but progresses over time at a very fast rate until it becomes visible. To minimise early deterioration, it is necessary to plan, design, construct and maintain the roads to standards.

Pavement distresses are those defects visible on the pavement surface. They are symptoms, indicating some problem of pavement deterioration such as cracks, patches, potholes and ruts. The type and severity of distress a pavement has can provide great insight into what its future maintenance and/or rehabilitation needs will be. The distress is generally described in terms of severity, extent and distress type. (Luo and Prozzi, 2005).

Pavement deterioration is due to complex distress as pavements crack through fatigue under repeated loading, environmental factors, shearing and disintegration of pavement materials when mechanical or chemical bonds are broken through weathering, infiltration, or loading, these affect ride quality, safety and comfort of all road users (Gary, et al, 2009).

This can be achieved by assessing the pavement that has failed in its early life with a view to finding the probable causes and preventing such from happening in the future.

The costs associated with pavement failure can be reduced if detailed investigation is conducted in order to understand the causes of pavement failure (Madanat and Ben-Akiva, 1994).

1.1 The structural arrangement of flexible pavement

The structural arrangement of flexible pavement is made up of wearing course, road base, sub-base, capping (where necessary), and subgrade.

Capping is usually introduced where the subgrade is weak. Capping is laid between the subbase and subgrade. So it is optional. Stabilisation is another method of improving the strength of subgrade (Apeh, 2016).

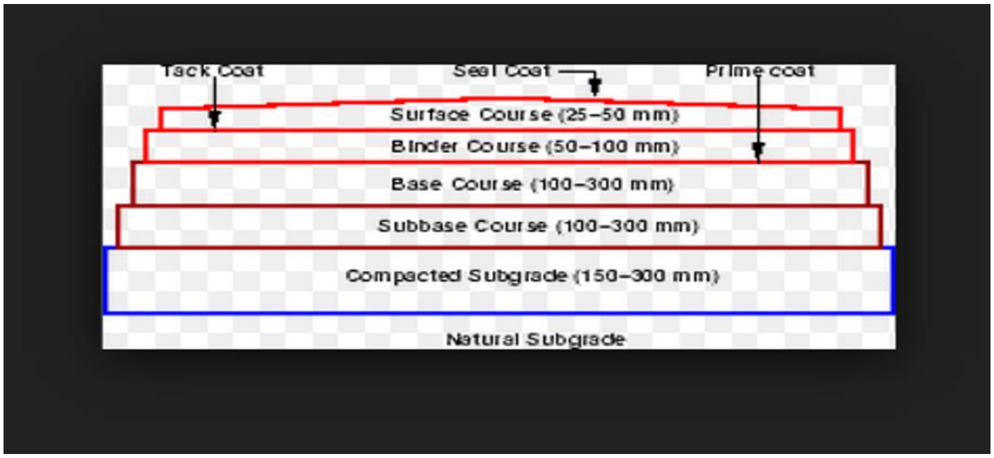

Figure 1.0: Structure of Flexible pavement

It is constructed to be flexible. It is neither too thick nor too thin. It will be too costly if it is too thick, and it will not be able to protect the underlying unbound layer which could cause rutting at formation level if it is too thin.

The intensity of a load reduces as the load is transmitted downwards from the surface by spreading over an increasingly large area, carrying it deep enough into the ground through successive layers of granular material. The least flexible which is the strongest material is at the top of layer while the most flexible, the weakest material is found in the lowest layer. This is so because at the surface, the wheel load is applied to a small area, resulting in high stress levels, but deep down in the pavement, the wheel load is applied to a larger area, resulting in low stress levels thereby making it possible to use weaker materials there. The design life is typically 20 years (Ali, 2016).

2.0 Literature review

Excess moisture is the main cause of pavement failures. Queensland transport found that excess moisture reduces the strength and stiffness of pavement materials, being worse for sub grade material than for the sub base or base (Queensland transport, 2012). Almost all pavement failures are associated with excess moisture. Moisture entry into lower courses may be due to inadequate pavement surface drainage in the process of construction, exposing pavement surface to rain in the process of construction, porous or open graded asphalt (Zumrawi, 2014)).

When water enters into cracks and freeze, the cracks widen. When the weather is poor, this "freeze-thaw" effect leads to a quick defect in the asphalt surface forming potholes. This is the reason there are much potholes in cold, wet weather.

For road to serve its design life, the surface of the pavement should be kept sealed (Apeh, 2016).

The level to which a flexible pavement deflects when subjected to loading shows, partly its adequacy as far as structural capacity is concerned. Repeated deflection may cause the pavement to crack and distort due to fatigue, excessive bending stresses, accumulated plastic deformation and other factors.

When a flexible pavement deflects, it is partly elastic in character, but it also contains plastic strains. When an applied load is removed, elastic strain is regained while plastic strains are not regained. Therefore, the accumulation of non-recoverable plastic strains associated with repeated application of load results in distortion of pavement surface (AASHO, 2007).

Over the lifespan of a road it would deteriorate due to repeated traffic loading and environmental factors. Maintenance is what is required to keep it in its original condition. This has several benefits, including stretching the period over which the benefits of the investment made are available and therefore provides a higher rate of return on the initial investment. The construction of roads is of limited importance if there is no effective maintenance system in place (Rogers, 2003).

Early maintenance work is required for highways to be operational and safe for motorists and other road users.

Preventive maintenance is necessary to extend the life of a pavement. When applied early in the life of a pavement, it corrects small defects before they become big issues. It saves money, reduces delays, and improves safety and ride quality (Bashir, 2006).

However, road maintenance in most developing countries including Nigeria is often viewed as an activity that is carried out only when the road is damaged. But no one would apply this approach to his house, or even his health.

Lack of maintenance is the main reason Nigeria's road infrastructure is always in poor state. It pains me to see the pavement surface of virtually all roads in Nigeria covered with defects but nobody thinks of correcting it at its early stage until the whole structure collapses.

Background of study

The Idah to Anyigba road is a major road in Igala landwhich cuts across Four Local Government Areas (Idah, Igalamela, Ofu and Dekina). It was constructed in 1976 by Oni and Sons Nigeria Limited. In those days, roads in Nigeria were well designed and constructed.

Since that time no major form of maintenance activities were carried out on the road, except sometimes in the mid – nineties where it was patched and surface dressing was applied on some portions of the road, precisely from Ogidibeje junction to Akpagidigbo.

Corrective maintenance was no longer necessary because having suffered a long time neglect, the pavement have deteriorated so badly to the extent that the base courses down to the subgrade do not possess enough bearing capacity to carry the load that is being imposed on it as a result of increased, repeated or cyclic loading, environmental factors and lack or inadequate provision of drainage facilities. The road needed total reconstruction and not patching or surface dressing.

Failure to keep the road in a serviceable condition have increased journey time, operating cost andtransport fares have increased, thereby increasing the cost of doing business generally in Igala land. It has also affected safety and ride quality.

3.0 Methodology

Pilot survey

Apilot survey was conducted on Idah – Anyigbaroad to confirm whether the defects are visible on the pavement surface. The road whichcuts across Four Local Government Areas, Idah, Igalamela, Ofu and Dekina in North Central, Nigeria was divided into four portions for the sake of convenience. The division is as follows; Ajaka to Ofe-udu, Ofe-uduto Ugwolawo, Ugwolawo to Akpagidigbo, and Akpagidigbo to Umomi.

Visual condition survey

Visual condition survey was conducted on the pavement surface of the road in order to provide a more accurate and detailed assessment of the pavement deterioration to assist in determining appropriate repair techniques. The visual condition survey that was carried out entailed walking along the road to identify the defects, classify the defects into types, assigning severity levels and density rating for the types of defects that was identified using photographs. In addition to the visual condition survey carried out, the soil and geology of the study area was analyzed to determine the causes of the pavement failure, the amount, type and condition or severity level of defect. An assessment of the effectiveness of drainage facilities provided was also done.

Drainage Condition Assessment

The drainage structures provided for the road was assessed, because theoverall performance of the pavement structure is a function of the drainage facilities on ground, Surface drainage is only said to be satisfactory if it can drain water from the pavement surface and does not allow water to pond either on the bituminous surfacing or on the shoulders of the road**.**

Sample Collection.

Sixteen trail pits were dug at a depth of 0.6 to 0.8 inches on the failed and unfailed portions of the four roads within the study area, and the average was taken. This was done in order to carry out series of laboratory test on the subgrade layer of the pavement. The following laboratory test were carried out; particle size distribution (sieve analysis), Atterberg limit (Liquid and Plastic limits), specific gravity, compaction and California bearing ratio (CBR) in accordance to British Standard Institute (BS 1377, 1990). These testswere carried out in Soil laboratory of the Department of Civil Engineering, Federal Polytechnic Idah, Kogi state, Nigeria.

4.0 Result and Discussions

Pavement Condition Survey: The visual condition survey method was carried out on four roads in order to determine the extent of failure of the road. The main defects found on the roads are Pothole and Longitudinal and transverse cracks and edge cracks.

All the roads inspected are in very poor state. They have all failed.

Table 1: The Condition of the pavement on Idah to Anyigba Road

	Route	Length of the road (KM)	Width of the road (M)	Main Defect on the pavement surface	Extent of damage		
	Ajaka – Ofe-udu	10.70	8.60	Potholes, Longitudinal and transverse cracks, Fatigue crack, Edge cracks.	High Severity, visible throughout the length and width of the road.		
	Ofe-udu - Ugwolawo	11.85	8.60	Potholes, Longitudinal and transverse cracks, Edge cracks, Fatigue cracks,	High Severity, throughout the length and width of the road.		
	Ugwolawo - Akpagidigbo	14.42	8.60	Potholes, transverse and longitudinal cracks, Edge cracks.	High Severity, throughout the length and width of the road.		

	Akpagidigbo - Umomi	5.65	8.60	Potholes, transverse and longitudinal crack, Edge cracks.	High Severity, throughout the length and width of the road.		

Assessment condition of the drainage: It was observed that drainage was provided for portions of Ajaka to Ofe-udu, Ugwolawo to Akpagidigbo and Akpagidigbo to Umomi only, and the drainage provided is already blocked because of the presence of debris dumped by people living along the road.

Soil analysis/Laboratory test

Table 2: Geotechnical properties of soil samples taken from the road

Sample	Ajaka to Ofudu Road	Ajaka to Ofudu Road (Failed).	Ofudu to Ugwolawo Road.	Ofudu to Ugwo lawoRoad (Failed).	Ugwolawoto AkpagidigboRoad.	Ugwolawoto AkpagidigboRoad (Failed).	Akpagidigboto UmomiRoad.	Akpagidigbo to Umomi Road (Failed).
% passing sieve 0.075µm	51.2	43.8	33.7	20.9	35.8	41.9	34.3	18.98
Plastic limit (%)	30.3	26.8	6.9	19.75	18.2	32.9	18.6	16.8
Liquid limit (%)	35.7	28.4	19.5	26.8	21.3	34.1	21.2	20.4
Optimum moisture content (%)	19.6	19.1	14.2	28.9	11.7	7.8	9.2	21.3
Maximum dry density (kg/m³	1302.4	191.6	1131.4	551.2	1201.6	321.7	1151.6	401.6

Unconfined compressive strength (UCS)	72.4	150.2	32.4	92.2	40.2	83.84	105.9	486.7
cohesion	32.6	73	135	75.7	20.3	40.9	54.9	44.9
Specific gravity (Gs)	2.6	2.2	2.8	1.99	2.9	2.2	2.6	2.3
California Bearing Ratio (soaked) (%)	11	43	45	32	11.2	18.8	40.2	17.9
Plastic index (%)	5.4	1.6	12.6	7.05	3.1	1.2	2.6	3.6

Specific Gravity, Gs:The specific gravity of the soil sample ranges from (1.99 to2.9). The highest specific gravity value is onUgwolawoto Akpagidigbo roadwhile the lowest is on Ofe-uduto Ugwolaworoad (failed).

According to specification, a good lateritic material should have specific gravity ranging from 2.5 to 2.75.Ajaka to Ofudu road, Ofudu to Ugwolaworoad andAkpagidigbo to Umomisamples met this requirement.

Grain size distribution:According to Federal Ministry of Works and Housings specification (1972) only soil samples obtained on Ofudu to Ugwolaworoad (unfailed), Ofe-udu to Ugwolawo road (failed), Akpagidigbo to Umomi road and Akpagidgbo to Umomi road (failed)are suitable for use as subbase and subgrade material because the soil particle passing through sieve No.200 is less than *35%*.

Atterberg limits:The liquid limit of the soil samples falls within the range of 19.5% to 35.7%, while the plastic limit of the soils falls within the range of 6.9% to 32.9% and the plasticity index ranges between of 1.20% to 12.64%. Soils whose liquid limits is less than 30% are considered to be of low plasticity, those whose liquid limits range between 30% and 50% are considered to be of medium plasticity, while those whose liquid limit are higher than *50%* are said to have high plasticity. That means that samples from Ajaka to Ofudu road (failed), Ofudu to Ugwolawo, Ofudu to Ugwolawo road (failed), Ugwolawo to Akpagidigbo, Akpagidigbo to Umomi, Akpagidigbo to Umomi (failed), are classified as low plasticity, while Ajaka to Ofudu road is classified as medium plasticity.

Compaction:British standard light was used. The maximum dry density ranges between 191.6kg/rn3 and 1302.4kg/m^3, while the optimum moisture content ranges between 7.8% and 28.90%.SoiI sample characterized by high value of maximum dry density and low optimum moisture content is best suitable as subbase and subgrade material.

Sample of soil obtained from Ajaka to Ofe-uduhas the highest maximum dry density and the lowest optimum moisture content isUgwolawoto Akpagidigbo(failed). The highest value of optimum moisture contentis Ofe-udu to Ugwolawo(failed) while the lowest maximum dry densityAjaka to Ofe-udu road (failed). The Nigerian Specification for Road and Bridge Materials (Nigeria Federal Ministry of Works and Housing, 1970) recommends that for a material to be used as generally as fills it should possess MDD greater 47 kg/m3, OMC less than 18%. Making Ofe-udu to Ugwolawo road, Ugwolawo to Akpagidigbo road, Ugwolawo to Akpagidigbo road (failed), and Akpagidigbo to Umomi road suitable for fills.

Unconfined Compressive Strength (UCS): The values of the unconfined compressive strength of the soil ranges from 32.4kN/m2 to 486.7kN/m2 strength while the cohesion ranges between 20.3kN/m2 and 135kN/m2.According to Das (2009), soils having an unconfined compressive strength of 50-100 kN/m^2 can be classified as medium, those having unconfined compressive strength of 200-400 kN/m^2 are classified has very stiff and those exceeding 400 kN/m^2 are classified as hard. Based on this assumption, Ofe-udu to Ugwolawo road, and Ugwolawoto Akpagidigbo road soil samples are classified as soft soil.Ajaka to Ofe-udu road, Ofe-udu to Ugwolawo road (failed), and Ugwolawo to Akpagidigbo road (failed) soil samples fall in category of medium, while Akpagidigbo to Umomi road (failed) sample is classified as hard, because it has the highest unconfined compressive strength**.**

California Bearing Ratio (CBR):The un-soaked California bearing ratio of the sample falls between 11% and 45%. Federal Ministry of Works and Housing (1972) recommends that for soaked samples the values of CBR for subgrade, subbase and road base should not be less than 10%, 30% and 80% respectively. All the soil samples satisfied the requirement to be used as subgrade. Soil samples obtained from Ajaka to Ofe-udu road (failed), Ofe-udu to Ugwolawo road, Ofe-udu to Ugwolawo road (failed) and Akpagidigbo to Umomi road are suitable for subbase. None of the soil sample is suitable for base.

5.0 Conclusions and Recommendations

Conclusions

The assessment of the flexible pavement on Idah – Anyigba road suggests that there is a high degree of distress on the pavement surface; the main defects are transverse cracks, potholes, longitudinal cracks, edge cracks and fatigue cracks.

These defects may a have occurred due to inadequate or lack of drainage facilities in some cases, Poor design and construction, moisture entry into the courses below the pavement, inadequate thickness of asphaltic cement and poor soil quality. All the roads studied have high severity defects. Both the longitudinal cracks, transverse cracks and potholes are the type patching and/or surface dressing can no longer correct, because the base courses are affected already. The roads need total reconstruction.

The un-soaked California bearing ratio of the sample ranges from 11% to *45%*. After careful assessment of the flexible pavement on Idah to Anyigba road, North Central, Nigeria,and the information gathered, it is enough to conclude that the failure of pavements could be due to the following factors:

Poor design and poor construction, inadequate provision of drainage, moisture entry into the courses below the pavement through cracks, potholes, failure of subgrade soil, lack of corrective and preventive maintenance and blockage of drains by the people living along the roads.

Recommendations

i. The road studied have visible defects that are beyond repairs, it should be redesigned and reconstructed to standards to conform to B.S. 1377.

ii. There is every need to provide drainage facilities on the road. It would prolong the lifespan of the road. The drainage should be constructed with reinforced concrete and not with blocks.

iii. Effective corrective and preventive maintenance should be used by all agencies of government responsible for road construction and rehabilitation in Nigeria.

iv. The standard of design and construction should be improved by engaging qualified and skilled manpower.

v. Soil test and/or soil investigation should be carried out before design commences.

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