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Assessment of Flexible Pavement on Some Selected Roads in Ola Oluwa Local Government, South Western Nigeria

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Abstract
The most used mode of transportation in Nigeria is road while flexible pavement is the most constructed on the roads. This project work is all about carefully assessing the condition of the flexible pavement on some selected roads, determine some causes of the failure on the selected roads in Ola Oluwa Local Government area of Osun State, South-western Nigeria. The visual assessments of the pavement were carried out through Pavement Condition Survey and the drainage condition of the selected roads. Disturbed soil samples were taken from the failed and unfailed portion of the roads and their geotechnical properties determined. After the thorough assessment of the pavements on selected roads it can be concluded that the failures on the roads are due to non-functioning drainage facilities, poor design, non-standard construction materials and poor maintenance culture.
Keywords: Flexible pavement, Pavement Condition Survey, disturbed soil samples, geotechnical properties.

1. Introduction
Road, path established over land for the passage of vehicles, people, and animals. Roads provide dependable pathways for moving people and goods from one place to another. They range in quality from dirt paths to concrete-paved multilane highways.

Road transport is the most widely used of all modes of transport in Nigeria. The most common pavement usually found on Nigeria roads is the flexible pavement.

According to (Bello, 2007; Raju *et al*., 2012; Bello, *et al*., 2015) the number of layers in a road often depends on the intended use of the road, but generally roads have three distinct layers. From bottom to top, the layers are the roadbed or sub-grade, the base course or the sub-base, and the wearing course. The objectives of the study are:

- To identify the type and set out of pavement distress in Ola oluwa local government.
- To determine the index properties of the failed and unfailed portions of the selected roads
- To examine the strength properties of the failed and unfailed part of the roads.

Failure of pavement roads is a common occurrence in Nigeria (see Fig. 1). Various reasons are known to induce highway pavement failure (Chukweze, 1988). However, the pertinent factors influencing failure of highway pavements cannot be controlled without evaluating the geotechnical properties of the soil materials used in construction of the roads. Jegede (1995) and Bello and Adegoke (2010) observed that the soil material properties at the failed sections of the road have usually not been thoroughly investigated.

In addition, according to Yoder and Witczak (1975) there are two types of pavement distress, or failure. The first is a structural failure, in which a collapse of the entire structure or a breakdown of one or more of the pavement components renders the pavement incapable of sustaining the loads imposed on its surface. The second type of failure is a functional failure; it occurs when the pavement, due to its roughness, is unable to carry out its intended function without causing discomfort to drivers or passengers or imposing high stresses on vehicles. The cause of these failure conditions may be due to inadequate maintenance, excessive loads, climatic and environmental conditions, poor drainage leading to poor subgrade conditions, and disintegration of the component materials. Excessive loads, excessive repetition of loads, and high tire pressures can cause either structural or functional failures.

2. Materials and methods
2.1 Site visit and materials collection
During the site visitation (see Figs 2 and 3), the conditions of the pavement on the selected roads were visually assessed and pictures of the pavement were taken, also the condition of the drainages of the selected roads were also assessed.

Twelve disturbed samples were collected from six selected roads, two samples from each road; one from the failed portion and one from the unfailed portion. The samples were collected at depth ranging from 0.5-0.8m and the coordinates where the samples were collected are taken. The selected roads were designated A1-A6 and the soil samples designated J1-J12.

2.2 Methods
2.2.1 Location and Geology of the Study Area
The area of research is Ola Oluwa, it is a Local Government Area in Osun State, Nigeria. Its headquarters are in

the town of Bode Osi. It has an area of 328 km² and a population of 76,593 according to the 2006 census. It is located between 7.783ºN and 4.217ºE. Geologically, they are part of the African crystalline shield which consists predominantly of migmatised and undifferentiated gneisses and migmatites, occupying about 30-50% of the surface of Nigeria. Ola (1978) believe that the migmatite-gneiss complex originated from ancient sediments and minor igneous rocks that have gone through polycyclic alterations during the various episodes of metamorphism, migmatisation and granitisation processes.

2.2.2 Pavement Condition Survey

The method was based mainly on visual inspection of pavement in which the pavement distresses, likely causes and the severity of the failures were checked, also the drainage condition of the selected road are checked too.

2.2.3 Sample Collection and Laboratory Testing

Twelve pits were dug from six selected pavements at depth ranging from 0.5m – 0.8m, with each pavement having two pits, one from the failed portion of the pavement and the other from the unfailed portion of the pavement. The images of the selected pavements are shown in the appendix.

2.2.4 Geotechnical properties

The index properties of the soil samples were carried in accordance to BS 1377 of 1990 on the obtained soil samples. The strength properties carried out are compaction test in accordance to West African Standard, soaked California Bearing Ratio (CBR) was carried out on the soil samples and the Unconfined Compressive Strength (UCS) of the soil samples was also carried out (Bello *et al*., 2015).

3. Results and discussion

3.1 Pavement Condition Survey

From the survey, all the selected roads are single carriage way, based on Pavement Condition Rating (PCR), pavement A3 and A4 are considered to very good while pavement A1, A2, A5, A6 are rated between good and fair. The result is presented in Table 1.

Drainage Condition Assessment: the drains assessed were by visual inspection and it was observed that most of the drains are blocked or not functioning well. Also there is no continuity of the drainage constructed i.e. some section of a road has drainage while some other section do not have, and this is applicable to all the roads accessed.

3.2 Geotechnical properties

The summary of the geotechnical properties results of the soil samples are summarized in Table 2.

Natural Moisture Content: the natural moisture contents of samples J1, J2, J3, J4, J5, J6, J7, J8, J9, J10, J11, and J12 are 3.21%, 2.94%, 2.97%, 1.63%, 3.03%, 2.49%, 2.08%, 1.67%, 2.04%, 3.77%, 2.56% and 1.17%. Moisture content values of soil samples usually depends on void ratio and specific gravity (Bello *et al.,* 2015). Other factor is the climatic conditions which include temperature, rainfall intensity and the duration of the rainfall.

Table 2 shows the summary of the index properties. According to AASHTO (Association of American States Highway and Transportation Officials) classification, samples J3, J4, J7, J9, J11, J12 belong to the group A-1-b, samples J2, J10 belong to group A-2-4, samples J5 and J9 belong to group A-2-6, while J6 and J8 belong to groups A-6 and A-1-a respectively and sample J1 could not be classified. In the Unified Soil Classification System, samples J3, J7, J11 have common a symbol of SC and a group name clayey sand, samples J2, J4, J6, J10, J12 also have a common symbol of SC-SM and a group name of Silty, clayey sand, sample J8 has a symbol SC and group symbol name Clayey sand with gravel while samples J1, J5, J9 could not be categorised.

The atterberg limits result show that the liquid limits value fall between 19.78% and 31.82%, while the plastic limits falls between 14.29% and 29.17% and the plasticity index ranges between 1.1% and 10.47%. Federal Ministry of Works and Housing (1972) recommends a liquid limit of 50% maximum and plasticity index of 15% maximum for subbbase and base materials. Based on this all of the samples cannot be used for subase and base materials and could be one of the factors that caused failure of the roads.

From the compaction test the maximum dry density ranges from between 1.36 Mg/m^3 and 1.74 Mg/m^3, while the optimum moisture content ranges between 3% and 14.1%. The CBR values the CBR values for the soaked samples ranges from 1.49% to 15.49% .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, this concludes that samples J10, J11 and J12 are only suitable as subgrade material, while the rest cannot be used as either subgrade, subbase or base materials, and could have contributed to the failure of some pavement sections in Ola Oluwa Local Government.

Unconfined Compressive Strength (UCS) carried out on the soil samples J1, J2, J3, J4, J5, J6, J7, J8, J9, J10, J11 and J12 and their compressive strengths are 51kN/m^2, 41.35kN/m^2, 57.40kN/m^2, 73.4kN/m^2, 54.56kN/m^2, 43.5kN/m^2, 84.54kN/m^2, 72.73kN/m^2, 57.73kN/m^2, 31.88kN/m^2, 42.4kN/m^2, and 49.1kN/m^2. The low compressive strengths can be due to the permeability of water when the samples were kept under humid air for seven days.

4. Conclusion

The results from the site visitation showed that there are different kind of distresses existing in Ola Oluwa Local Government area, South Western Nigeria, some of which are edge cracks, pot holes, ravelling and some random cracks and some of the selected roads are rated from very good to fair.

The results from the geotechnical properties of the soil samples showed that samples J2, J4, J6, J10, J12 are silty, clayey sand and are considered as fair or poor for subgrade use depending on the other properties of each soil, samples J3, J8, J11 are clayey sands are are good for subgrade materials. From the California Bearing Ratio (CBR) tests, only samples J10 (12.22%), J11 (14.90%) and J12 (15.49%) can be used as a subgrade material. It can then be concluded that the failures on the roads are associated with non-functioning drainage facilities, poor design, and sub-standard construction materials and poor maintenance culture.

It is recommended that all these factors associated with the failure be rectified for a long life pavement construction with little maintenance.

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Table 1: PCR results of roads assessed

ROUTE NO	DESCRIPTION	WIDTH OF ROAD(m)	FUNCTIONAL CLASSIFICATION	PCR VALUE
A1	Market Road	6.11	Community collector	72
A2	Opposite Police Station Road	5.51	Local road	88.65
A3	Palace Road	7.25	Local road	95.25
A4	Ikire Ile Road	8.22	Community collector	93.75
A5	Asa Road	6.20	Residential collector	79.3
A6	Sectariat Road	7.80	Community collector	81.2

Table 3: Geotechnical properties of soil samples

Samples	**J1**	**J2**	**J3**	**J4**	**J5**	**J6**	**J7**	**J8**	**J9**	**J10**	**J11**	**J12**
% passing 0.075um	32	25.3	23.3	22.7	24	36	18.7	13.3	22.7	26.7	22.7	18.7
Liquid limit (%)	-	31.8	25.4	19.8	28.8	25.9	31.0	25.2	24.0	28.9	21.7	20.5
Plastic limit (%)	-	25	24.3	14.3	18.3	20.8	29.2	21.6	0	22.5	18.3	16.3
Plasticity Index (%)	-	6.8	1.1	5.5	10.5	5.0	1.9	3.6	24.0	6.4	3.4	4.2
Maximum dry density(Mg/m^3)	1.61	1.61	1.69	1.69	1.66	1.6	1.72	1.74	1.72	1.68	1.36	1.74
Optimum moisture content (%)	12.6	14.1	10.7	11	9.2	12.2	12	10	9.1	5	3	9.7
CBR Soaked (%)	2.68	4.47	6.55	1.85	1.56	2.90	3.00	1.49	2.98	12.22	14.90	15.49
AASHTO	A-1-b	A-2-4	A-1-b	A-1-b	A-2-6	A-6	A-1-b	A-1-a	A-2-6	A-2-4	A-1-b	A-1-b
USCS	-	SC-SM	SC	SC-SM	-	SC-SM	SC	SC	-	SC-SM	SC	SC-SM

Figure 1 Flexible Pavement Section

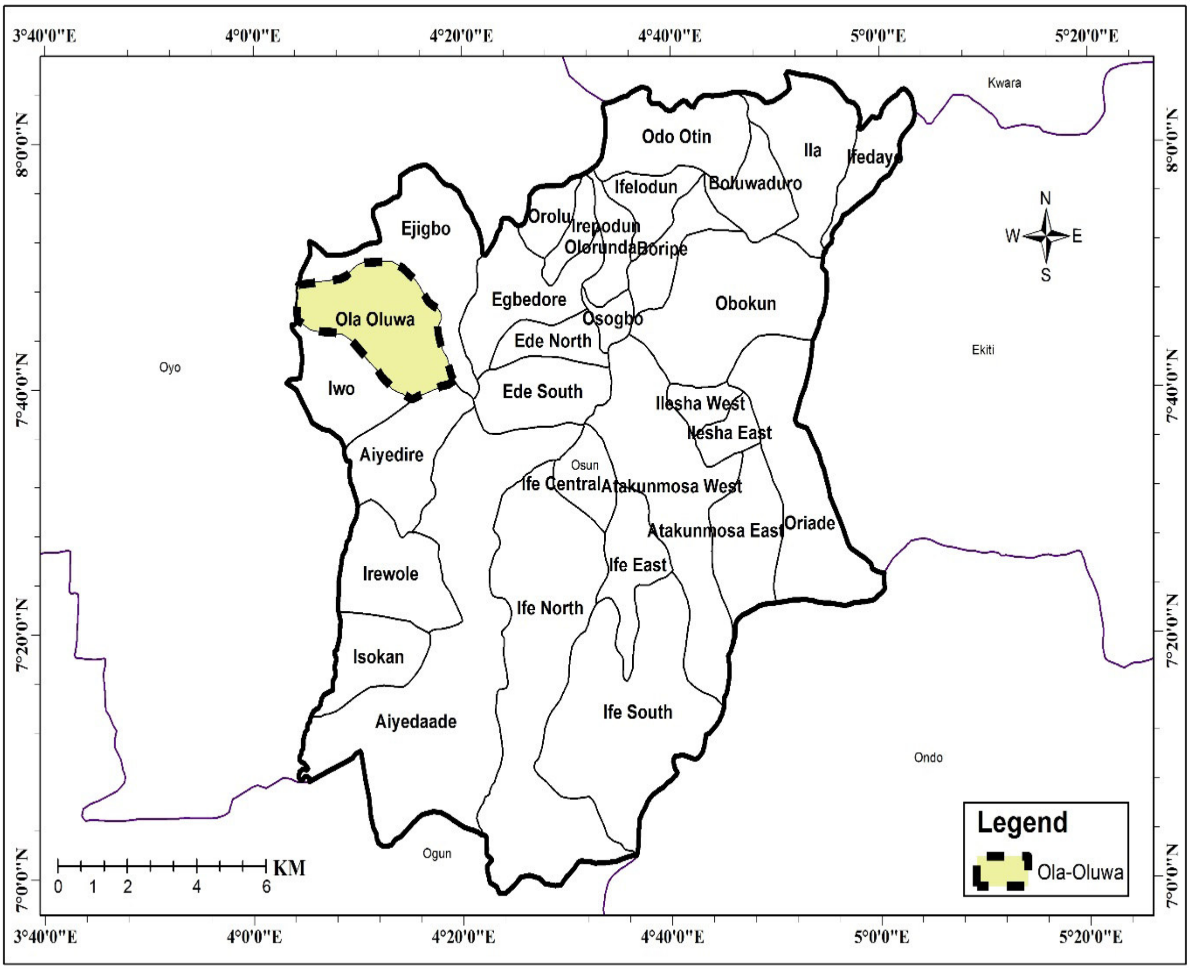

Figure 2 Map of Osun showing Ola Oluwa Local Government

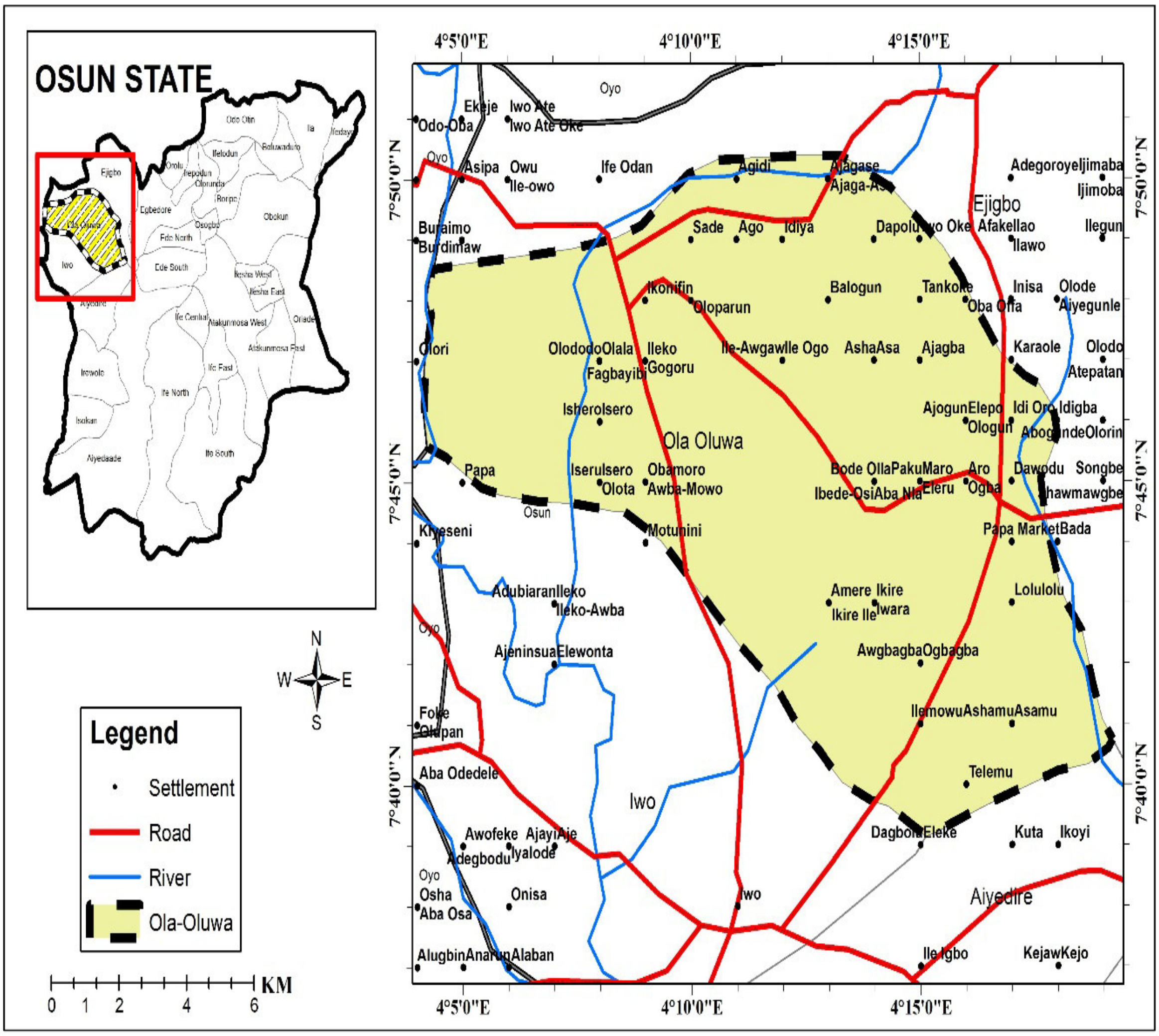

Figure 3 Map of Ola Oluwa Local Government