ASSESSMENT OF IMPACT OF ACTIVITIES OF LOCAL ROAD MAINTENANCE ON THE MINNA-KATAEREGI HIGHWAY, NORTH CENTRAL NIGERIA

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Abstract

It is important to ensure that water is prevented from getting in contact with the subgrade in order to maintain its stability and a stable road pavement. The activities of the local road maintenance as well as the groundwater fluctuation along Minna-Kataeregi road were investigated. This was in order to ascertain the impact of the local road maintenance on the performance of this road. The result shows that there is considerable seasonal moisture change along the studied road. The activities of the Local road maintenance expose the subgrade to water as well as raising the water table. This resulted in instability of the subgrade that has translated to poor performance of the road instead of improving the road.

Keywords: Groundwater, Minna, Performance, Local Road Maintenance,

1. Introduction

A road is a path established over land for the passage of people, vehicles and animals. Roads provide dependable pathways for moving people and goods from one place to another. They differ in quality from dirt roads to concrete paved multi lane highways. There are many types of roads ranging from multi-lane freeways and expressways to two way country roads. They can be classified into three major categories: highways, urban or city streets and rural roads. The road considered in this study may be categorized as a highway.

Road is usually built up in several layers as shown in Figure 1 below. To be able to support heavy vehicular movement at high speeds, each layer has a specific function and helps the one above it in supporting the weight and pressure of moving traffic. The number of layers in a road depends on the inferred use of the road, but generally roads are made up of three layers consisting of the sub-grade, base and sub-base below the wearing surface. The sub-grade refers to the soil immediately beneath the sub-base followed by the base and sub-base which is below the wearing surface.

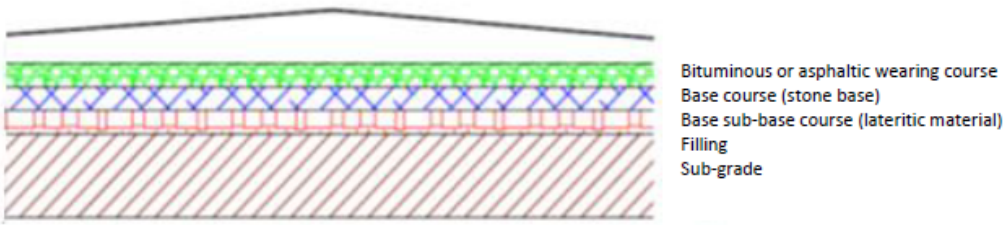

Figure 1. Typical Layers Of A Road Pavement

The road pavement is the hard crust placed on the soil formation after the completion of the earthworks. Its main functions are to provide a smooth riding surface, to distribute the traffic loads over the soil

formation sufficiently to prevent the soil from being overstretched and to protect the soil formation from the adverse effect of weather.

The characteristics of the pavement are therefore dependent on the nature of the traffic and on the property of the soil on which the pavement is constructed. The soil foundation which receives the traffic loads directly from the pavement is referred to as the subgrade as earlier mentioned. The base may be surfaced with either a concrete (rigid) or bituminous (flexible) surfacing.

A successful subgrade should be able to resist the effects of both traffic and weather. A reduction in the supporting power of the subgrade as a result of either of these causes is sometimes referred to as regression.

In this paper, the impact of activities of local road maintenance along the Minna-Kataeregi Road, Central Nigeria is analyzed. The study area is located along the Minna-Kataeregi Road. It lies along longitude (06°31'32.4"E) to (06°22'53.8"E) and latitude ($09^0$35′44.4″ N) to (09^0 05' 38.3"N).

This road has continued to experience failure after construction and frequent maintenance almost on a yearly basis by the locally untrained road maintenance. Thus, this research was carried out to determine the possible impact of this unprofessional road maintenance on the performance of the road.

2. Literature Review

According to the (U.S. Army Corps of Engineers, 1984), the soil in the subgrade exists above the water table and beneath a sealed surface; this does not stop the ingress of water. As a consequence, partially saturated or saturated conditions can exist in the soil. Also, road pavements are constructed at a level where the subgrade is affected by wetting and drying, which may lead to swelling and shrinkage, respectively, if the subgrade consists of expansive clay. Such volume changes are non-uniform, and the associated movements may damage the pavement.

Workers like (Gidigasu, 1972), (Gidigasu, 1978), (Ajayi, 1982), (Ayangade, 1992), (Adeyemi, 1992), (Okagbue and Ifedigbo, 1995), (Adeyemi and Oyeyemi, 1998), (Jegede and Oguniyi, 2004) have attributed the causes of road instability to factors ranging from minerallogic, geotechnical and soil conditions. (Gidigasu, 1972) attributed the majority of road pavement failures in the tropics to mineralogical and geotechnical factors. (Ajayi, 1982) noted that the road failure he studied occurred where the pavement was founded on saprolite rather than the strong lateritic horizons. (Adeyemi, 1992) noted that the degree of stability of the road he studied increased with the amount of kaolinite present in the subgrade soil and with increase in the California Bearing Ratio (CBR) and unconfined compressive strength (UCS) of the sub-grade soils. (Ayangade, 1992) observed that there was a positive correlation between the strength characteristics of the foundation soils and the stability of the pavement along the Oshogbo – Gbongan road, south western Nigeria. (Jegede and Oguniyi, 2004) attributed the incidence of highway pavement failures for Nigerian highways to improperly compacted edges of the pavements to non- provision of drainage facility along the roads, and low California Bearing values among others.

The rock types mapped include fine to medium grained biotite granite, granite gneiss, schist and sandstone. The granite was affected by the Pan African Orogeny with late tectonic emplacement of granites and granodiorites. The end of the orogeny was marked by faulting and fracturing (Abaa 1983, Gandu *et al*.,1986, and Waziri, 2015). The granites are thus fractured, jointed and deeply weathered in some places.

The area has an average annual rainfall of about 1,000 mm. Rainy season usually starts during the month of April, and reaches the peak by August/September and ends in October. Low average temperature of 24°C is recorded between the months of July and September while high temperature is usually recorded during the months of February to April, at an average of 35^0C. The harmattan wind is experienced between December and January.

3. Methodology

Groundwater fluctuation that may affect moisture content of subgrade was monitored. Static water levels were measured from hand-dug wells located very close to or along the road (Figure 2) during the peak of the dry (April) and rainy (September) seasons. A water level meter was used in taking the measurements while a GPS was used in taking the ground elevation as well as the co-ordinates of the wells. The total depths of the wells were also measured. The following parameters were determined;

i. Total depth of well D (m)

ii. Dry season static water level A (m)

iii. Wet season static water level B (m)

iv. Level of fluctuation of ground water C (m) = A-B

v. Percentage of variation E (%) = B/A X 100

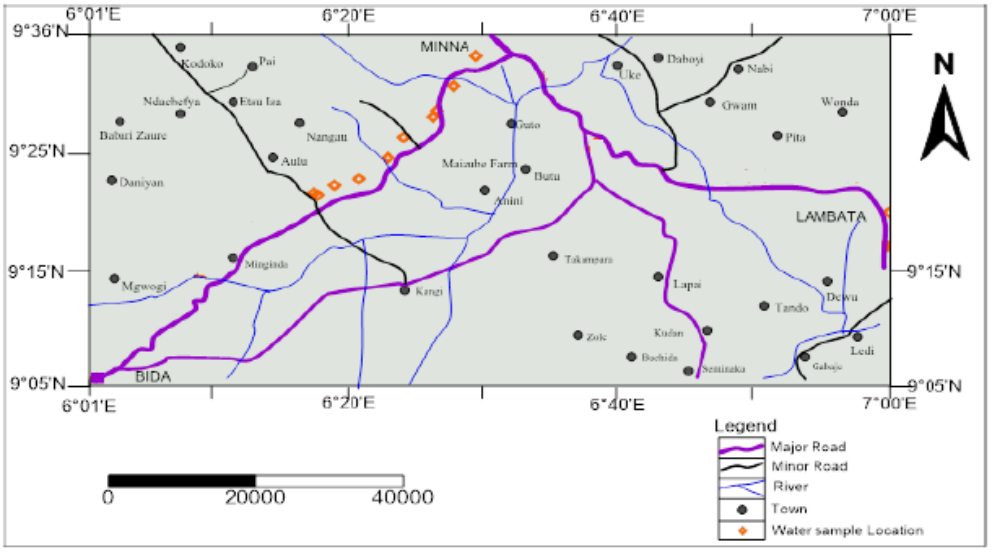

Figure 2. Map Showing The Location Of Water Inventory Along Minna-Kataeregi Road, North Central Nigeria.

4. Results and Discussion

The result of the groundwater inventory is shown in table 1. The result shows that the groundwater fluctuation is high with very low water table especially during the rainy season.

It was observed that pits that range from few centimeters to five meters were dug either on the failed shoulders of the road pavement or very close to the shoulders (Figure 3). Geologic/soil materials recovered from these pits were used in filling the pot-holes (failed portions on the road pavement). Rain

water is normally collected in the dug holes during the rainy season. A closer observation further reveals that some of the dug geologic materials are part of the subgrade especially where the pits are as deep as five meters (Figure 3).

Studies by (Waziri *et al.,* 2012) and (Waziri, 2015) showed that the portion of the road pavement under study is underlain by granites, gneisses and ampobilite schist. The minerals that make up the rocks include nacaphite, vallerite, ferriwinchite, birnessite, caicium titanium oxide, hornblende, albite, quartz, actinolite, plagioclase (Labrodorite), and silicate minerals (Waziri, 2015).

These rocks have undergone fracturing and weathering resulting in formation of clayey secondary minerals. Thus the subgrade materials along this road consist of clayey materials that can swell and shrink when exposed to wet and dry conditions. Groundwater inventory from hand-dug wells located close to the studied road show a high percentage of variation which suggests that the groundwater table variation along the road is high.

The activities of the untrained local road maintenance along this road expose the subgrade to water. Water in pavement subgrade has long been recognized as a primary cause of premature pavement distress, deterioration and failure. When present in subgrade or base course for any length of time, water has been shown to weaken both concrete and asphalt pavements. In addition to its purely physical properties, the water in soil is of interest to engineer due to its action as a solvent. The chemical action of water during leaching further breakdown the subgrade and bring the soluble salts in to solution.

The dissolution of these salts gives rise to positively charged ions such as calcium, magnesium and sodium which can be adsorbed unto the surfaces of the soil particles. These exchangeable bases and the type of exchangeable bases in the soil can affect its physical properties to a considerable extend. The soluble salts can affect the soil and engineering properties by attacking concrete and other materials containing cement and corroding metals such as iron pipes. Montmorillinitic clay and illites are among the secondary minerals identified from the weathered products of the rocks underlying this road (Waziri *et al,* 2012).

Table 1: Groundwater fluctuation along Minna-Kataeregi Road, North Central Nigeria

Location	Well Depth (m)	SWL * Dry Season A (m)	SWL * Wet Season B (m)	Variation (A-B)	% of Variation	Rock Type	Lat. (N)	Long. (E)	Elev. Amsl(m)
Kataeregi	10.1	9.3	8.0	1.3	116.3	Granite gneiss	9^0 21' 45.1"	6^0 17' 44.0	155
SabonYeregi	8.5	8.2	6.8	1.4	103.7	Migmatite	9^0 22'36.5"	6^0 18'56.5"	136
Gadda	4.0	3.8	2.8	1.0	135.7	Schist	9^0 23'11.4"	6^0 20'50.1"	131
Sabon Dagga	7.9	6.7	6.0	0.7	111.7	Granite	9^0 25'02.2"	6^0 22'57.3"	180

Bisisi	9.8	9	7.6	1.4	118.4	Granite	9^0 26'48.7"	6^0 24'04.3"	189
Garatu	9.6	9.4	2.1	7.3	447.6	Granite	9^0 28'36.6"	6^0 26'12.4"	219
Pompom	7.0	5.5	2.7	2.2	203.7	Granite	9^0 31'19.7"	6^0 27'41.6"	239
GidanMangoro	9.5	8.9	8.0	0.9	111.3	Granite	$9^0$33'56.9"	6^0 29'24.3"	237
Garatu	5.4	4.9	0.2	4.7	110	Granite	9^0 29'09.9"	6^0 26'28.8"	224

*SWL – Static Water Level

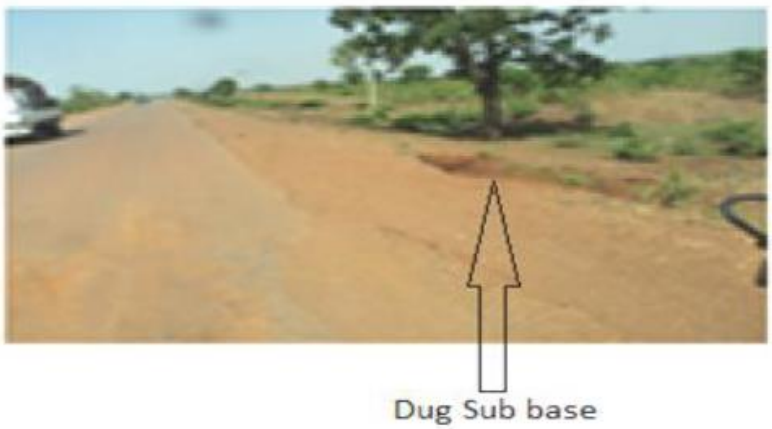

Figure 3. Water Collected In A Hole Dug In The Subgrade By Local Road Maintenance Along Minna-Kataeregi Road North Central Nigeria.

Works by Beaver and Winterkorn (1942) has shown that these clay minerals are flat, elongated or lamellar and have a large surface area per unit weight than would be the case if they were more spherical in shape. The plate –like shape is a major factor causing the plasticity exhibited by clay particles when in contact with water.

The activities of the untrained local road maintenance have led to further degrading the road pavement. This is because they expose the subgrade to water which results in weakening the subgrade since nearly all soils decrease in strength with increasing moisture content and this effect is marked in clayey soils. This has caused severe longitudinal cracks in pavement roads. The subgrade need to be adequately

protected from moisture. The water collected in the holes dug by the local road maintenance could infiltrate into the subgrade leading to a rise in the water table thereby increasing the moisture content of the subgrade material. The subgrade is close to the surface and can be affected by the seasonal weather changes that lead to fluctuations in the moisture content of the subgrade. This is mostly pronounced in the verges of the road.

The effect of these changes in moisture content in the verges is often found to extend for some distance under the edges of the road into the subgrade (Research Laboratory, 1974). According to (Transport and Road Research Laboratory, 1974), when the subgrade is composed of heavy clay, these seasonal fluctuations in moisture content are accompanied by corresponding changes in the volume of the soil. In such cases, the edges of the roads have been found to be subject to a seasonal rise and fall, with respect to the center of the road, of as much as 2 inches. During droughts, these movements are greater and may result in the serious cracking of bituminous surfaces as observed in the studied road.

5. Conclusion

This study reveals that the activities of local road maintenance along the Minna – Kataeregi highway in Niger State, Nigeria has led to poorer performance of the road instead of improving the performance of the road. This is due to introduction of water to the subgrade layer of the road through digging of pits near the road to collect geologic/soil material used in filling the potholes. Water in the subgrade layer weakens the road and leads to failure manifested by the presence of more potholes. This study therefore suggests that their activities be discouraged.

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