



Causes and effect of rural roads failure on agricultural produce of Olorunda local government area, Osun State, Nigeria

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General Note



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ABSTRACT

This study examines the causes and effects of rural roads failure on agricultural produce from Olorunda local government area of Osun State, Nigeria. Data for the research was derived using questionnaire of 120 respondent searches from farmers and drivers

using 12 rural roads of the local government area. Also, geotechnical investigations of the soil of the failed portion of the road were carried out. The data collected through structure questionnaire were analysed using descriptive analysis. The result of the questionnaire analysis gave 0.34% as the sampling error in the investigation with 56% male, 44% female, 41.67% of government officials and age range of 18 – 60 years old using the road. Questionnaire investigation revealed correlation between the road failure and agricultural produce as the road failure exacerbate the negative agricultural produce. Geotechnical investigation revealed California bearing ratio (CBR) value of (50% to 70%) for BP1 and BP2. It can be inferred that the soil sample is not effective for sub grade and BP10 of CBR 8% is specified to be used as fill material. The specific gravity of the soil ranged between 2.58-2.70 which indicates generally low level of lateritic soil properties. The subsoil of the study location classifies as well graded silty sandy soil. The percentages of the fines range from 35% to 40%. The natural moisture content of the sampling sites ranged between 18.1% and 70.1% for samples BP1 and BP12 respectively which indicates an increasing trend down the soil profile. These revealed that the soils around these areas are wet, with most of them having natural moisture content of above 15%. The consistency limit showed that the liquid limit, plastic limit and plasticity index of the soil samples ranging from 14 to 46, 7 to 46 and 5 to 19 respectively. The soils can be classified as CL-CH, and SP-SW. Geotechnical investigation revealed the properties of the soil materials used in construction of the road were generally below the specifications of the Federal Ministry of Works and Housing. This could largely be responsible for failures of some portion of rural roads of Olorunda local government area of Osun State. The government (i.e. state and local) should see to effective maintenance of the farm roads within the local government in order to enhance transportation of agricultural produce with less damage to perishable crops and increase in farmers' income.

Keywords: Road failure, questionnaire, soil physical properties, geotechnical investigation, Olorunda, Osun State, Nigeria

1. INTRODUCTION

Rural transport is important for the evacuation and marketing of farm products and the delivery of farm inputs and extension services (Usman et al., 2013). It also aids innovation diffusion, expand production and raise incomes (Afolabi et al., 2016). Improved transportation reduces travel time thereby, increasing the time available for economic and social activities while also promoting access to basic facilities (Kassali et al., 2012). Households in remote areas have been associated with lower levels of consumption expenditure while the value of farm outputs is found to increase with road quality, frequency of transport services and proximity to commercial centres (Barwell, 2015). It is disheartening in Nigeria to note that most of the roads in the country are in various states of disrepair and many of them have become hazardous and sources of economic drain in terms of high road users cost, spoiling of farm produce, loss of lives and property and loss of rural and highway road investment (This Day Newspaper, 7th November, 2018). Major Nigerian rural roads are known to fail shortly after construction and well before their design life. Road failure has been a major concern to the Federal and State Governments and its rehabilitation has constituted some financial burden to the various tiers of government. The causes of roads failure in Nigeria have been traced to several factors among which are poor construction materials, poor design and specification, road usage, poor drainage, geological and geotechnical factors. It is therefore vital for engineers to carry out pre design investigations of the roads so as to ensure that sufficient safeguards are incorporated in its design and construction. Rural roads are one of the infrastructures facilities that is in total collapse, road failure has not only caused setback to the economy of the case study area and the country at large but also has caused loss of lives and properties, human injuries through accidents, environmental pollution and degradation, wastage of agricultural produce, impedance of human movement and the flow of economic activities and encourage armed robbery activities along affected areas when vehicles carrying agricultural produce breaks down or there is a long queue on the roads. Abdulkareem and Adeoti (2004) examined the method of road maintenance in Nigeria and defined and analysed the causes of structural failure of rural road pavement and suggest some factors; action of weather, rain and heat, unstable ground conditions and poor drainage, poor construction material and methods, post construction activities like digging of trenches along the road etc., poor workmanship and inadequate maintenance. Okigbo (2012) study on Nigeria rural roads identified poor design and construction, poor maintenance of already built rural roads, use of low quality materials in construction, poor workmanship and poor supervision of construction work and the applying of heavy traffic that were not meant for the road as some of the factors causing rural road failure. Furthermore, he also suggest that the following will lead to rural road failure such as; poor rural road facilities, no knowledge base, inadequate sanction for rural road failure, no local standard of practice, poor laboratory in situ tests on soil and weak local professional bodies in rural road design, construction and management. Various natural factors were observed to be responsible for failure on the case study roads. These factors will includes: The topography of the land, land use pattern, soil nature, rainfall and poor maintenance practice of road infrastructure as well as

absence of proper drainage. Water is the main contributor to the failure and damage of roads. Water can be in the form of ground water, surface water (streams and rivers) or rain, as runoff from the surrounding areas. It is well known that the rate of road deterioration increases if the water content of the granular material increases. In rigid pavements (i.e. concrete), temperature gradients across the concrete slab can cause structural defects (Gergis, 2016). The deterioration of the pavements show slow progress during the initial years after construction, but it becomes very fast progress during later years probably because of increase in rate of heavy vehicles and some natural factors. Performance evaluation involves a thorough study of various factors such as: sub grade support, pavement composition & its thickness, traffic loading and environmental conditions. Agriculture remains the chief occupation of rural communities, and for the poor, subsistence agriculture is often combined with laboring on other farms to stave off food insecurity (Obare et al., 2002). Accessibility to land, agricultural inputs, credit, equipment, information and markets are all depended on rural road network and transportation which is clearly crucial in rural income generation (Arethun and Bhatta, 2012). Rural transport is an important factor in reducing global poverty (thought to affect 1.3 billion people). It has a role in improving food security and agricultural productivity over the medium and long term, as population growth, environmental stress, and climate change converge to challenge food security, both globally and within the African continent (Adedeji et al., 2014). According to Banjo et al., (2012), rural transport has a central role in agriculture, whereby transport systems affect farm growth through their influence on the physical access that farmers have to markets, as well as price fluctuations. Poor rural transport systems increase the costs of marketing to and from farm areas, inhibit product flows, limit the spread of information, and increase risk to farmers. They also state that agriculture has a reciprocal effect on the viability of transport investments, with the structure and performance of the farm sector and the volatility of agricultural production and weather having a significant influence on the rate of return from rural transport investments (Banjo et al., 2012). According to Salami et al. (2010), the road system, which is the most important for market development in terms of distribution of inputs and output to and from farms, is the most serious infrastructural bottleneck facing agricultural development. A recent systematic review of over 50 world-wide studies has shown that rural road investment has had a wide range of positive effects on the welfare of rural populations. Strong positive effects have been shown in traffic volumes, reduced transport costs, increased agricultural production, increased agricultural marketing, increased employment, and better health and education outcomes. The negative effects were found to be minimal (Hine et al., 2016). There are often considerable trade-offs made in rural marketing. The cost of transporting produce to market can be prohibitive both in terms of the transport service fare and the time cost, a factor that is exacerbated by the poor road condition and inflated transport costs that are inherent in low density farming regions. For this reason, farmers often trade at the farm-gate to avoid the high costs of taking small loads to market, which can be a high-risk exercise, particularly for perishable goods. This study will provide vital information on the problems caused by the ignorance on how to use rural road and the problems caused by individual's contributions on the rural roads and necessary solutions to the problems. This study will go further by carrying out laboratory test on the geotechnical properties of the soil samples that will be collected from the selected sampling areas; it could also provide crucial information to curtail natural disaster causing rural road failure in the case study area. The research work aimed to analyse the effect of rural roads failure on agricultural produce of Olorunda local government area of Osun State with specific objectives to investigate the method of drainage constructed on the roads, determine the physical and mechanical properties of soil samples of the failed portion and the effect of the failure of the roads on agricultural produce and consequently on the farmer's income and economy of the country.

2. MATERIALS AND METHODS

Study Area

The study was carried out in Osun State, located in south-western Nigeria on latitudes 7.0° and 9.0°N, and longitudes 2.8° and 6.8°E. The state has rolling hills topography and lies between 300 m and 600 m above sea level. Average rainfall decreases from 1475 mm in the forest belt in the southern sections of the state to 1125 mm in the savannah section to the north. Mean annual temperature ranges from 27.2°C in June to 39.0°C in December. Soil types are varied but most contain a high proportion of clay and sand and are mainly dominated by the lateritic series. The State is mainly agrarian. Food crops grown in the area include maize, yam, cassava, cocoyam, rice and vegetables. The permanent crops cultivated include cocoa, kolanut and oil palm. These crops are usually mixed or intercropped (Adisa and Sofoluwe, 2013). Figure 1- 3 show the Map of Nigeria, Osun State and Olorunda local Governments area of the study area, its headquarter at Igbona on the outskirts of the state capital, Osogbo. It has an area of 97 km² (37 sq. mi) with total population of 131,761 as at 2006 population census (Abodunrin *et al.*, 2014). This study was based on twelve (12) selected rural roads of the local government.

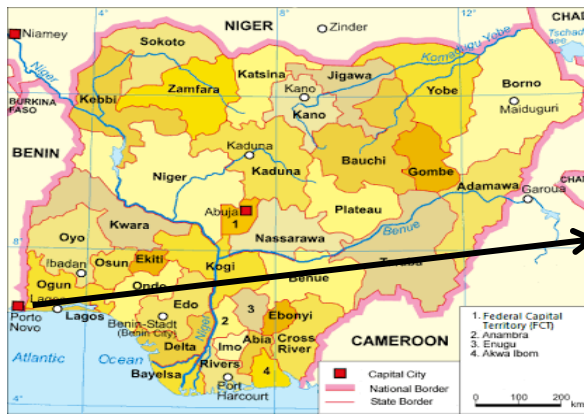


Figure 1 Map of Nigeria



Figure 2 Map of Osun State



Figure 3 Map of Olorunda Local Government Area

Data Collection

The simple road selection method was used in administering the questionnaire to bodies utilizing the road. Three sets of questionnaires were designed for this study, first questionnaire to the drivers, the second questionnaire to the farmers and the third to the questionnaire to the pedestrians. Each questionnaire consisting of three sections, section A, B and C of each location selected for the research, and minimum of twenty drivers, twenty farmers and also twenty to the pedestrians using the roads were chosen and questioned. The distribution of questionnaires and the response of people showed in a tabular form, the questionnaires used to gather information such as hindrances encountered on the roads, damages caused by failure on the roads, ergonomic factor of the drivers and the type of vehicles used on the road, level of maintenance, type of drainage systems available, names of roads selected and the bio data of each bodies used in the questionnaires. One hundred and twenty (120) of questionnaires were given to drivers, ten each to twelve locations selected. One hundred and twenty (120) of questionnaires were given to farmers, ten each to twelve locations selected and same also to pedestrians. The collections of the questionnaires were done immediately and the data collected was analysed using descriptive analysis such as frequency counts, mean and percentage to analyse the socio-economic characteristics of the respondents such as gender, age, profession, educational level, transportation mode, farm access roads. In addition to the research, soil samples were collected from each twelve locations for geotechnical investigations such as: moisture contents, California bearing ratio, liquid limit, plastic limit and plasticity index, specific gravity, particle size distribution and

compaction test. Generally, the procedures used in carrying out these aforementioned soil tests were in accordance to British standard methods (BS 1377) specifications.

3. RESULTS AND DISCUSSION

Road Users' Socio-economic Characteristics

The respondents consist of 67 males and 53 females which represent 56% and 44% of the respondents respectively as shown in Table 1. The road users were in their middle age between 18 and 60 years where no or primary education level has the highest percentage. This indicates a low level of education of the road users.

Table 1 Frequency and percentage of farmers socio-economic characteristics, n=120

Road users socio-economic characteristic	Frequency	Percentage
Gender of Respondents		
Male	67	56%
Female	53	44%
Age Range (in years) of Respondent		
18 – 30	10	8.33%
31 – 40	29	24.17%
41 – 50	42	35%
51 – 60	28	23.33%
Over 60	11	9.17%
Profession of the Respondents		
Contractors/Business	9	8%
Government workers	31	26%
Farmers	80	66%
Education level of respondents		
None	64	53.33%
No or Primary	22	19.17%
Secondary	23	18.33%
Tertiary	11	9.17%
Transportation mode		
Foot	71	59%
Bicycles	13	11%
Motorcycles	25	21%
Car	11	9%
Farm access road		
Tarred road	26	22%
Un-tarred road	79	66%
Footpath	15	12%

Geotechnical Analysis of the Soil Sample of the Failed Road Portion

Specific gravity

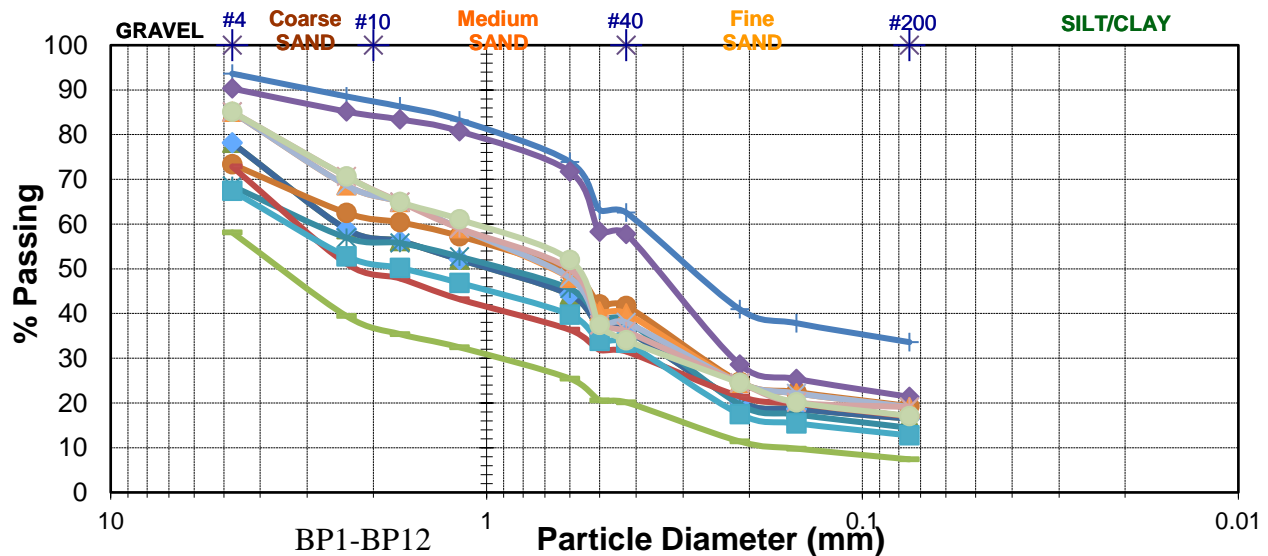
The summary of result of the specific gravity for the twelve samples collected from the study location is as summarized in Table 2. The specific gravity for the study soil samples ranged from 2.58 to 2.70. The greater is the specific gravity; the higher the degree of laterization provided the soils are from the same parent materials. According to standard specification, an acceptable lateritic soil material should have specific gravity ranging from 2.5 to 2.75. Based on this fact, samples from the study area are considered to be acceptably high which may be attributed to high mineral composition of the samples.

Table 2 Result of specific gravity of the soil samples

Sample	1	2	3	4	5	6	7	8	9	10	11	12
Specific Gravity, Gs	2.58	2.69	2.64	2.58	2.59	2.59	2.68	2.70	2.56	2.69	2.56	2.67

Particle size distribution

Particle size distribution for the twelve soil samples from the study location shows that the soil has clay content for most samples ranged from 35.6% to 84.8% except for samples BP 3 with clay content of 21.3%. The twelve soil samples when plotted on the same graphs shows a correlation between the particle gradation and which simply means that the soil is well graded. CU is a parameter that indicates the range of distribution of grain sizes in a given soil specimen (Braja, 2002), and since it is greater than 4, it shows that the soil is well graded (GW) (Hamaj and Younis, 2014) (Figure 4).

**Figure 4** Summary of PSD for 12 samples

Consistency limit test

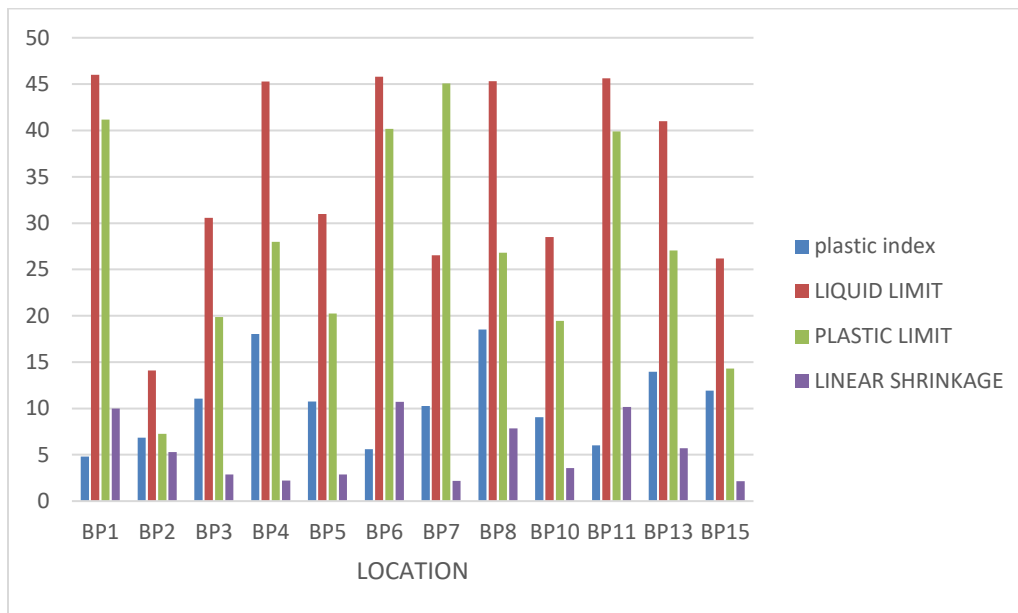
Table 3 is the result obtained for the liquid limit (LL) and plastic limit (PL) for the soil samples. According to Nik-Daudet al. (2016), the liquid limit and plasticity index of a soil should be at least 20% and $\geq 7\%$ respectively because a low hydraulic conductivity is attributed to higher liquid limits and plasticity indices. Table 4 presents the results of the coefficient of variance, standard variation and mean for the consistency limits of the soil samples. Consistency indices are used for classifications of cohesive (fine-grained) soils in relation with compaction and tillage practices. They also provide information for interpreting several soil mechanical and physical properties such as shear strength, compressibility, shrinkage and swelling potentials. Although, several studies have been conducted regarding the land use effects on various soil mechanical properties, little is known about the effects of land use and slope positions on Atterberg limits and consistency indices. From the graphical representation in Figure 5, it can be inferred that location 1 has the highest plastic limit (Haigh et al., 2013) and sample 15 has the lowest liquid limit which indicates that sample location one is more of clay silt and it decreases down the progression to coarse grained soil with very little plasticity (Haigh et al., 2013). The consistency limit values are based on the average triplicate determination of the physical parameters. From the data presented in table 3, the soils can be classified as CL-CH and SP-SW. The CL-CH groups are organic soils of low to high plasticity while the SP-SW group classifies as Coarse grained of low plasticity.

Table 3 Summary of the consistency limit of the 12 soil sample locations

Sample	BP1	BP2	BP3	BP4	BP5	BP6	BP7	BP8	BP10	BP11	BP13	BP15
LL	46.00	14.10	30.58	45.28	31.00	45.80	26.54	45.30	28.50	45.62	41.00	26.20
PL	41.18	7.26	19.88	27.98	20.24	40.18	45.07	26.79	19.44	39.89	27.05	14.29
PI	4.82	6.84	11.06	18.05	10.76	5.62	10.25	18.51	9.06	6.02	13.95	11.91
LS	10.00	5.28	2.89	2.22	2.86	10.71	2.19	7.86	3.57	10.15	5.71	2.14

Table 4 Summary of statistics of the consistency limit values

Consistency limit	Mean	Max	Min	SD	CV (%)
Liquid limit	34.738	46.000	14.100	11.660	33.566
Plastic limit	24.554	41.180	7.260	11.838	48.214
Plastic index	10.184	18.510	4.820	4.612	45.283
Linear shrinkage	5.981	10.710	2.140	3.238	54.135

**Figure 5** Graphical relationship of the Consistency limits**Moisture Content**

The moisture content of the soil samples is as shown in table 5 ranges from 18.1 to 70.1%. These high ranges of moisture content are not suitable for road construction. This indicates a possible reaction between sub grade and sub base soils with water from the numerous fractures from the basement settlement which increases the water content of the soils. The result in weak shears strengths of the soil and therefore causes the frequent failure and bad portion of the overlying pavements. According to Edori and Iyama,

2017, high moisture content is due to de-aeration which displaced air in the soils and also the oxygen content of the soil and decreased microbial activity.

Table 5 Moisture content for the soil samples

Sample	1	2	3	4	5	6	7	8	10	11	13	15
Wt of can, (g)	5.6	5.7	8.5	6.5	6.0	5.7	5.6	5.9	6.7	6.5	6.8	5.7
Wt of can + wet soil, (g)	45.2	55.2	65.7	76.1	46.3	56.4	45.2	51.2	84.2	77.2	79.0	45.0
Weight of can + dry soil, (g)	38.0	48.6	59.0	68.0	38.1	48.6	38.1	40.4	75.5	68.1	69.6	38.2
Weight of dry soil, (g)	32.4	32.3	40.5	41.5	32.1	42.9	32.3	34.5	48.8	41.6	42.8	32.5
Weight of moisture, (g)	7.2	17.2	16.7	28.1	8.5	7.8	7.3	10.8	28.7	29.1	29.4	6.8
Moisture content, (%)	22.2	53.1	41.2	67.7	26.1	18.1	22.6	31.3	55.8	70.1	68.7	20.9

California Bearing Ratio (CBR)

Table 6 gives the summary of results for the California bearing ratio (CBR) of the twelve soil samples. Braja (2002) said California bearing ratio of the soil samples is used in the classification of the soil. According to standard CBR values of materials by Layade and Ogunkoya, (2018); BP1, BP15, BP11, BP4, BP2 can be used as sub-base as it is greater than 30%. BP3, BP5, BP7 can be used as subgrade and BP13, BP8, BP6 has the highest CBR value can therefore be used as fill materials.

Table 6 Summary of CBR results for the twelve (12) soil sample locations

Soil Sample	CBR Values (%)
BP1	63
BP2	56
BP3	22
BP4	32
BP5	16
BP6	14
BP7	21
BP8	11
BP10	42
BP11	36
BP13	8
BP15	63

Compaction test

Table 7 is the results of the optimum moisture content (OMC) and the maximum dry density of the soil sample. The maximum dry density ranging from 1778kg/m³ to 2040kg/m³ while the optimum moisture content from 15.28% to 23.9%. According to Bello et al., (2007), samples characterized with high value of maximum dry density and low optimum moisture content is best suitable as sub base and sub grade materials. Also, the Federal Ministry of Works and Housing, (1997) and Oyelami and Alimi, (2015) and specified OMC less than 18% for both sub-base and sub grade materials. Based on these specifications, samples BP4 and BP6 are not suitable as sub base and sub grade material.

Table 7 Result of moisture and density of the soil sample

Samples	OMC (%)	MDD (KG/M ³)
BP1	22.50	1778
BP2	22.30	1876

BP3	22.45	1773
BP4	15.28	1874
BP5	21.58	1882
BP 6	16.26	1850
BP7	22.80	2038
BP8	23.90	1905
BP10	22.80	2040
BP13	22.00	1930
BP15	22.20	1871
BP11	23.00	1820

4. CONCLUSION

Having conducted the Questionnaire analysis on 120 respondents at the Olorunda Local Government, Osun State, Nigeria and laboratory tests for the index properties of the twelve soil sample and major/detailed test such as the California Bearing Ratio (CBR) and Compaction characteristics of the soil, it can be inferred that correlation was found between the road failure and agricultural produce as the road failure exacerbate the negative agricultural produce, The physical properties of the soil materials used in construction of the road shows bad paving properties. The specific gravity of the soil is high and portrays high minerals composition of the soil samples. The natural moisture content values are not tolerable. Plasticity index and liquid limit are the important factors that help an engineer to understand the consistency or plasticity of soil sample. The soils in the study area are wet, plastic and possess high linear shrinkage which indicates that the soils are susceptible to swelling which is evident on the waviness and potholes on the road. With the CBR value of (50% to 70%) for BP1 and BP2, it can be concluded that the soil sample is not effective for use as sub grade and sub base materials. The study concluded that the persistent road failure could be attributed to the clayey sub soils and water ingress into the sub grade soil due to lack of drainage channels at the shoulders of the road pavement. With the provision of drainage facilities at both shoulder area of the road, the road is expected to be durable for farmers and other users.

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Conflicts of Interest: The authors declare no conflict of interest.

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