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Original Research Article

Deterioration and Failure Rates of Maintained Roads in Nigeria

Ezeagu CA[1*] and Ezema NM[2]

[1,2]Department of Civil Engineering, Nnamdi Azikiwe University, Awka

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***Corresponding author:** Ezeagu CA
Department of Civil Engineering, Nnamdi Azikiwe University, Awka

Abstract

This study evaluated failure rates of roads maintained by FERMA in Delta state and its effects. The three roads investigated are: Benin-Asaba dual carriage way (266km), Warri-Sapele-Benin dual carriage way and Asaba -Allah-Ebu Edo state border road(47km). Road condition survey was carried out on the three roads to ascertain the extent of deterioration. Sieve analysis, liquid limit, compaction and CBR tests were conducted on the material used for the maintenance works for quality control purpose. Liquid limit, optimum moisture content, unsoaked CBR values were 21%, 8.5% and 117% respectively. These were observed to be within the FMW highway manual guidelines. It was observed that beyond 12months, Benin-Asaba and Warri-Benin roads experienced 2% and 5% failure rates while Asaba-Illah recorded 30% failure rate within a 12month period. These failures were attributed to heavy traffic with heavy duty wheel. Challenges of road maintenance in the field and remedial measures for highway maintenance is also discussed. The authors recommend that FERMA should seek redress and go back to the establishing blue print for operations and funding and also refers to Federal Roads Authority bill (2015) for backups. These tools have been provided to equip the agency to carry out her mandate effectively keeping the road infrastructures in good condition.

Keywords: Failure, maintenance, Rate, Road, and Traffic.

1.0 INTRODUCTION

Roads are one of the important assets of any country. Asides serving as means of transport for people, vehicles and goods, roads also provide avenues for such service apparatuses as water, electricity, sewerages, etc. (Emeasoba, 2013), hence making it an important necessity for any nation. According to Amos (2013), the process of road deterioration commences after a newly constructed road is open to traffic. Therefore, the process can be reduced considerably depending on adequacy and efficiency of measures put in place by the Road Agency.

FERMA, enacted through Act No 7 of 2002 was the first national policy centred on roads maintenance and management employing best practices and quality control. Its objective is to competently administer road maintenance with the objective of ensuring all federal roads in good, safe and comfortable condition for the best value in road transport (Oni, 2010).

Federal Ministry of Works and Housing (2003) estimate on the annual loss due to bad roads is valued at 80 billion naira, albeit additional vehicle operating cost arising from bad roads is valued at 53.8 billion. These values do not take into account the man-hour losses in traffic due to bad roads and other emotional and physical trauma people plying the roads are subjected to and there is also loss in productivity (Adebayo, 2015). Emeasoba (2013) in his study on sustainable socio-economic development in Nigeria with focus on road infrastructure maintenance concluded that there is virtually no noticeable road maintenance culture in the country. The problems of bad roads in the country have become an embarrassing stigma. In many parts of this country, normal interaction has been frustrated by bad roads. In this country, the main faults on most of our urban and rural roads are almost the same as the ones on the federal and state roads; they are; depressions on the road surfaces, presence of pot holes and cracks, development of gulley due to erosion, washing away of the road shoulders, faulty street lights, faulty drainage systems, faulty traffic signals and wiping off of pavement markings. These problems must be look into because our country cannot develop with rickety infrastructure and will not succeed in attracting direct foreign investment or tourism where things are this bad.

Effective road maintenance programme reduces vehicle operating costs, extends the life of pavements and results in significant savings on rehabilitation and re-construction. Road maintenance also contributes to national development in the areas of employment generation; improved agricultural production, enhanced industrial growth and stimulates technological growth. According to GIZ (2004), good road maintenance shows that a state actively promotes its economy and makes efforts towards good governance. Sutherland (2012) is of the view that a solid well-maintained road network is one of the factors that foreign investors look at when deciding to invest in any country.

Challenges of road maintenance

Different challenges are often encountered in the field in the course of road maintenance. Some these challenges are host community interference, encroachments, destruction or defacing of roads furniture**,** inadequate availability of both heavy and or light construction equipment such as hand roller, Bitumen Spraying machine, Dumper tippers etc., has been making execution of maintenance work very difficult. Also, lack of adequate material testing laboratories for quality control purposes, insufficient training programs for staff that will furnish them with the most recent international best practice, security challenges in the country and lastly insufficient funding which has been observed as the major problem of the agency which has made her unable to operate within her established blue print.

Adebayo (2015) explored the potentials of Geographic Information System (GIS) in data capture, processing and analysis to produce a GIS-based Road Maintenance Model using Ikeja Road Network in Lagos, Nigeria as a case study. The model was recommended to the Nigerian Federal Road Maintenance Agency (FERMA) and State's own Road Maintenance Agencies.

1.1 Deterioration and failure of roads

Different factors can be attributed to influencing the menace of road failures on our highway. Some of which are poor design and construction, heavy traffic, poor maintenance culture, poor highway facilities, inadequate facilities and trained laboratory manpower, use of low-quality materials, use of untrained workers, insufficient supervision, sanctioning of appropriate body significantly contributing to road failures, non-involvement of professional bodies in highway design, construction and maintenance.

Burningham and Stankevich (2005) noted that if road defects are neglected, the repair costs rise to six times maintenance costs after 3 years and eighteen times after 5 years. With respect to public transport infrastructure, it seems that the government does not have an effective framework yet for preventive (planned) maintenance. Nwankwo *et al*. (2008) investigated the probable cause of pavement distress on the Walter Odeli Crescent road in Delta state. They employed soil borings in the examination and condition survey of the pavement structure and subgrade. Results revealed that the edge cracks were due to excessive traffic and the scalling failure on the pavement was attributed to poor quality construction and mix design. In Ebuzoeme (2010), premature pavement failure in the northern part of Nigeria is mainly as a result of washout on identifiable sections while in the southern part of Nigeria, it is usually extensive sometimes covering the entire highway pavement due to the geography and geological formation of the area. The road deterioration on Port Harcourt-Patani-Warri road Southeast was attributed to subsurface flow, poor quality aggregates, changes in pavement condition due to interaction of local road aggregates with water caused swelling, stripping and potholing (Abam *et al*., 2000). In Ezeagu, Ibeabuchi and Mezie (2020), the causes of road failure on three major roads in Awka, Onitsha and Nnewi were investigated. Results of study revealed aggregates used were outside grading envelope, asphalt properties were outside specification limits, concrete elements from compressive strength test were below specification limits and bitumen content was inadequate. Okigbo (2012) stated that one of the main problems of road construction in Nigeria is delays and a display of incompetence by the contactors. He suggested appropriate sanctions be applied as a deterrent to future occurrence of such show of incompetence.

1.2 Review of institutional arrangements in other countries

A review of other countries experiences regarding institutional arrangements for road maintenance will provide valuable insights from which useful lessons can be learned in the effort to provide an efficient and sustainable road maintenance system in Nigeria. This revealed three valuable insights: (i) Public financing does not hold the key for the reform of the road sector; the need to involve the road users and business community is vital;(ii) The real causes of problems associated with poor road maintenance policies were weak or unsuitable institutional arrangements for managing and financing roads; and (iii) Poor road maintenance policies are a subset of the underlying issues of managing and financing the road network as a whole. These mentioned insights point to the fact that a distinct body, which is relatively independent of Government and affiliated to the private sector, is indeed a vital tool in the efficient and sustainable management of road networks. Countries considered in this review as regards institutional arrangement for road maintenance are Ghana, Honduras, Costa Rica, and Lesotho.

In Ghana, under the trunk road network

stabilization program (TRNSP), it will use both National and International competitive bidding to execute 90% of periodic maintenance works by private road contractors, with the Mobile Maintenance Unit (MMU) and Bridge. Maintenance Unit (BMU) of the GHA executing the remaining 10%. The MMU carries out periodic and emergency maintenance of trunk roads while the BMU maintains bridges across the country. GHA's funding comes chiefly from the consolidated fund and foreign donor agencies (Bahl, 1991; CBN, 2003).

In Honduras, the Road Maintenance Fund was created in 1993. The fund is supervised by a Board, which consists of 4 representatives from the central government, one representative from the municipalities and 3 representatives from the direct road users. The principal financial source of the fund is a levy on fuel in the form of a dedicated tax (Ziettow and Bull, 2002; CBN, 2003).

Costa Rica created its Road Fund, which is funded mainly by a levy on fuel in1998. The fund takes care of the maintenance, rehabilitation and improvement of the national road network but with priority given to routine and periodic maintenance. In Lesotho, the Road Fund was set up in 1995 under the name Roads Relief Fund with the basic objective of routine and periodic maintenance of all roads in Lesotho, including those under jurisdiction of the Ministries of Works and Local Government; financing on a cost share basis, urban council roads and the unclassified roads under the jurisdiction of Development councils; and financing road upgrading, maintenance, rehabilitation, new works and road safety projects (CBN, 2003).

The aim of the work is to evaluate the deterioration of roads maintained by Federal Roads Maintenance Agency (FERMA) in Delta state. This study provides the knowledge gap by investigating the role of knowledge management initiatives in reducing the rate of failed roads in the country. It educates both students and the public on the dangers of poorly maintained road. Knowledge of remedial measures of the different road failures through this research has been made available to the public.

2.0 MATERIALS AND METHODS

2.1 Study area

The area of study for this investigation is Delta state. Three major roads were utilized as case study; they are: Benin-Asaba dual carriageway, Warri- Sapele Benin dual carriageway and Asaba- Allah Ebu Edo state border. A map of the study area is presented in Figure 1.

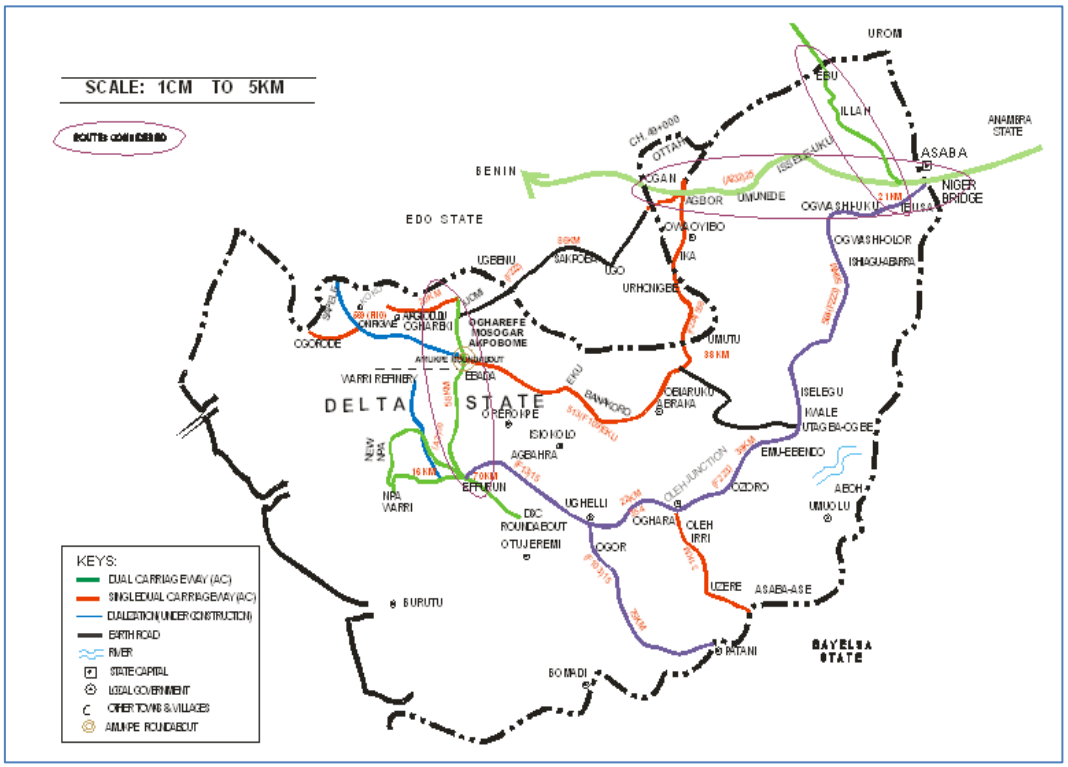

Fig-1: Map showing the study area

2.2 Roads condition survey

Benin-Asaba dual carriageway

Benin-Asaba dual carriageway is 266km long. This length comprises of Edo section Ch. 0+000 - Ch. 49+200, while Delta section starts from Ch. 49+200 - Ch. 133+000. Benin - Asaba dual carriageway is one of the most important Federal Roads in Delta State because it links the East to the Western part of the country. The road is inundated with isolated deep potholes and failed sections which have resulted in traffic gridlock at different sections of the road, and this has led to huge public outcry.

Warri - Sapele - Benin dual carriageway

This is one of the most important federal roads in Delta State because of its strategic location. It is heavily trafficked and there are so many defects on this road because of the frequent heavy axial load that ply it resulting in fatigue of the pavement. This has manifested in alligator cracks, isolated potholes, failed sections and undulations on the pavement.

Asaba – Illah – Ebu Edo State Border

Asaba – Illah – Ebu Edo state border road in Delta state is a 47km long federal road. The road width is 7.3m, while the shoulders are 2.75m. The road structures consist of laterite sub base and base courses, asphaltic concrete wearing course and surface dressed shoulders. The road is the shortest link between Delta and Edo state. It is also the shortest route from Asaba and its environs to Abuja, Federal capital territory through Illushi, Uromi and Ewu in Edo state. This road also serves for easy evacuation of farm produce from the communities along the road corridor to Asaba and other cities. This road is characterized by critically failed sections, potholes, eroded shoulders, silted concrete lined drains, carriageway and shoulders, and dense vegetation at the verges of the shoulders. Since the commissioning of Utor Bridge at the border of Edo state and Delta State in 2014, there has been tremendous increase in traffic on this route, and this resulted in the sudden collapse of the carriageway.

The pavement consists of 7.3m wide Asphaltic concrete wearing and binder courses, with quarry crushed stone base course and laterite sub-base. The road is constructed with facilities like extra lanes in some sections and surfaced dress (hard) shoulders on either of both bounds.

Present condition of the roads

The Benin -Asaba road as shown in Fig. 2 has deteriorated to be point where the subgrade soil is now visible owing to the heavy traffic that ply this route. On the Warri - Sapele - Benin dual carriageway, there are so many defects on this road because of the frequent heavy axial load passes that have resulted in fatigue of the pavement. This has manifested in alligator cracks, isolated potholes, failed sections and undulations on the pavement. The intense raining season has led to the development of potholes and some sections of the carriageway have collapsed resulting in serious traffic gridlock on both bounds of the road. The Asaba-Allah road serves for easy evacuation of farm produce from the communities along the road corridor to Asaba and other cities.Since the commissioning of Utor Bridge at the border of Edo state and Delta State in 2014, there has been tremendous increase in traffic on this route, and this resulted in the sudden collapse of the carriageway.

Fig-2: Condition of Benin Asaba road

Fig-3: Condition of Warri-Sapele road

Fig-4: Condition of Asaba – Illah – Ebu Edo

2.3 Materials and Testing

Materials used in this investigation include stone base, laterite soil, bitumen. Sieve analysis, consistency limit, compaction and California bearing ratio tests were conducted on the subgrade and stone base material in order to ascertain its quality. These

tests, were done in accordance with BS1377:1990: part 2, AASHTO (proctor) compaction test T-99.

CALCULATIONS

Moisture in the soil by oven drying method (standard method) was calculated using

$$\text{Moisture content, } M_c = \frac{W_2 - W_3}{W_3 - W_1} \times 100 \quad (1)$$

Where:

W1 = Weight of tin (g)

W2 = Weight of moist soil + tin (g)

W3 = Weight of dried soil + tin (g)

The spray rate for the prime coat was calculated thus:

Weight of bitumen in tray, W = (Weight of tray +bitumen - (Weight of tray) g

Area of tray, A = length x breadth (in mm or m)

b – density of bitumen at room temperature

$$\text{Spray rate} = \frac{W}{1000Ab} \text{ (in liters/sq. meter)} \quad (5)$$

3.0 RESULTS AND DISCUSSION

With reference to the standard liquid limit device, the liquid limit value is defined as the minimum water content at which a part of soil cut by a groove of standard dimensions, will flow together for a distance of 12 mm under an impact of 25 blows in the device. The value of 21% was evaluated for the subgrade soil. This is in accordance with FMWH highway design manual (2013). The in situ density tests were done by sand replacement method and a dry density value of 2.236g/cm^3 was obtained. Graphical illustrations of the sieve analysis and compaction quality control results on the soil sample are shown in Figure 5and 6.

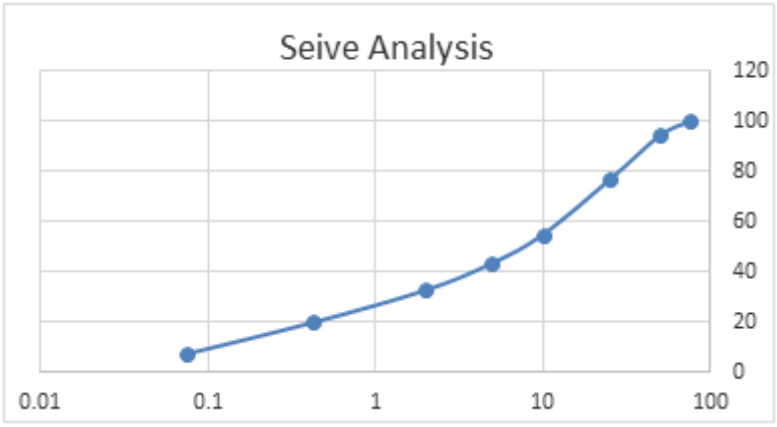

Fig-5: Sieve analysis for subgrade soil

Compaction Results for subgrade soil

An optimum moisture content value of 6.2% was reported for the soil material. Also, having a maximum dry density value of 1.682g/cm^3.

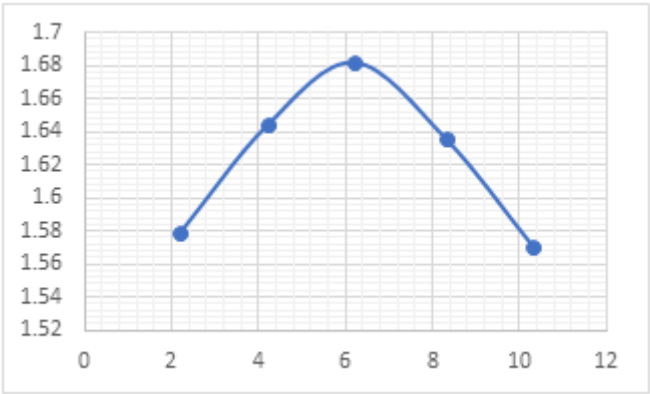

Fig-6: Compaction result for subgrade soil

On the work progress on the roads**,** Figures 7-9 below gives details on the Benin -Asaba, Warri-Sapele-Benin and Asaba – Illah – Ebu Edo State border roads. The Prime coat was applied at an average spray rate of 1.083litres/m^2. The insitu-density of the soil and stone base was determined by sand replacement method.

Fig-7: Priming of Benin-Asaba road road

Fig-8: Priming of Warri /Sapele/ Benin

Fig-9: Asaba – Illah – Ebu Edo State Borders

Table-1: Test Summary for Stone base

MATERIAL	TP Nº	DEPH (mm)	LL (%)	% Passing sieve No			DENSITIES (g/cm³)			OMC	CBR	
				10	40	200	MOD AASHO	WAS COMP	BS COMP		24HRS SOAKED	UN-SOAKED
STONE BASE STOCK PILE	1	/	21	54.9	19.9	7.4	2.236			8.5		117
AVERAGE			**21**	**54.9**	**19.9**	**7.4**	**2.236**			**8.5**		**117**

Failure Rates of roads maintained

After carrying out road maintenance, the road pavement still experiences new failure or failure occurs at same point/location that was maintained. The table below shows the failure of roads maintained in Delta state within one year and above.

Table-2: Failure Rates of Roads Maintained

S/N	Road	Months of failure		Remarks
		>12	<12	
1	Benin-Asaba		2%	New failure occurs within 12months due to heavy traffic
2	Warri-Benin	5%		New failure occurs within 12months due to heavy traffic
3	Asaba-Illah-Ebu	30%		New failure within 12 months due to majorly heavy traffic wheel,

4.0 CONCLUSION

One of the greatest assets of a nation is its road network and can only be preserved through adequate maintenance. The deterioration of roads under maintenance by FERMA within Delta state was evaluated in this study. The road pavement suffers rapid deterioration coming from heavy goods vehicles, poor drainage, post construction activities, inadequate maintenance etc. The road condition survey revealed the poor state of the three roads investigated - Benin-Asaba dual carriage way, Warri-Sapele-Benin dual carriage way and Asaba -Allah-Ebu Edo state border road. Also, the Liquid limit, optimum moisture content, unsoaked CBR values for stone base material used in the maintenance works were 21%, 8.5% and 117% respectively. This was observed to be within the FMW highway manual guidelines. The study also revealed that beyond 12months, Benin-Asaba and Warri-Benin roads experienced 2% and 5% failure rates while Asaba-Illah recorded 30% failure rate within a 12month period. These failures were all attributed to heavy traffic with heavy duty wheel.

The following remedies to highway failure are suggested

1. Provision of adequate and appropriate designs. The construction of a road starts from conception, planning and design. Without a good design of the road the functionality of the road may not be achieved.
2. Provision of highway facilities. High way facilities like drainages, shoulders, highway signs and markings are needed for the good functionality of the roads in Nigeria. Such facilities that will provide adequate functionality for the highway.
3. Adequate soil tests in road construction. Knowledge of the soil situation helps both at the design and construction stage of the road. The subgrade should be tested and found to be adequate before usage.
4. Appropriate road construction materials. The materials for road construction and maintenance must be tested and confirm adequate by competent examiners before being used for road construction. Those materials that are of standard quality are what are needed for good road construction.
5. Use of well-trained road engineers. Engineering professional bodies like COREN should be involved in both the training and the supervision of highway engineers both in the school stage and in the direct construction work on our roads.
6. Enhanced use of other modes of transportation. Other modes of transportation like the rail lines and waterways should be developed to reduce the pressure on the road transportation mode in the country.

5.0 RECOMMENDATION

Having looked at the causes of road failure, rate of deterioration on roads maintained by FERMA and remedies of improper road construction practices, recommendations have been outlined on how to avoid such occurrences in the future:

1. A local standard of practice for the country should be provided. Its use should be maintained and strict compliance monitored.
2. An acceptable annual levy could be charged for various categories of vehicles. Stakeholders meetings at community levels of all local governments could be organized to explain the advantages of the levy on improved road conditions. Annual levy of N1000 - N5000 depending on vehicle type and axle load could be charged.
3. The Imposition of fuel levy could generate quick fund. This should be done tactically in the light of the presently unstable high cost of petrol and other petroleum products.
4. Private sector initiative and community participation on road infrastructure maintenance should be encouraged and done to mutually acceptable specifications and standard.
5. Efforts should be made by stake holders in road construction to ensure accurate design of any road way before its construction proper while taking into consideration all the features of the area to be affected by the roadway, the service burden to be carried by the road way and the expected life span.

If the Nigerian authorities will carefully carryout the recommendations given in this paper it will go a long way alleviating the country's road transportation problems.

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