EFFECTS OF DELAYED MAINTENANCE ON PAVEMENT CONDITION ON SOME SELECTED ROADS (LOKOJA METROPOLIS AS CASE STUDY)

BY

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REG. NO.PGD/CE/08/026

A PROJECT PRESENTED TO THE DEPARTMENT OF CIVIL ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF POST GRADUATE DIPLOMA IN CIVIL ENGINEERING

FEBRUARY 2011

APPROVAL PAGE

This project has been read and approved as meeting the requirements for the award of the Post Graduate Diploma (PGD in Civil Engineering) Federal University of Technology, Minna, Niger State.

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DEDICATION

To my beloved father, Usman Ocheja and dear wife Mrs Victoria Ojoma Usman for all their encouragement and above all to the almighty God that had made it possible for me to undergo this course.

ACKNOWLEGEMENT

I wish to express my sincere gratitude to my supervisor Engr. Dr. P. N. Ndoke for his patience, advice, guidance and cordial supervision of this project.

I also wish to extend thanks to my Head of Department Engr. Prof. S. Sadiku, Engr. Dr.T. Y. Tsado, Engr. Prof. O. D. Jimoh, Engr. A. M. Mustapha, Engr. Dr. A. Amadi, Engr. Dr. J. I. Aguwa, Engr. S. Oritola, Engr. R. Adesuji, Engr. I. Jimoh, Engr. J. Olayemi, Engr. I Abdulkadir, Engr. Dr. Ugwueleka, Engr. Mrs. O. Gbadebo, Engr. M. Alhassan, Engr. Kolo S. S. and other members of staff for their untiring efforts at shaping my career.

Special thanks goes to my family members for their care, concern, love especially my father Mr Usman Ocheja and my Brother and Sisters, Prof. S. S. Usman of Kogi State University, Anyigba, Hon. Friday Usman of Kogi State Judiciary, Mrs Naomi Adama and Mrs Hannah J. Ahiaba for all their assistance and prayers .

I am greatly indebted to staff of the Federal Roads Maintenance Agency, Lokoja for their assistance during the course of this project.

Sincere thanks goes to my course mates, especially Mr. Ochigbo r.c, Mr. Gbadebo Lawrence and Mr. Efe Omoruyi.

Finally, to the Almighty God for everything.

ABSTRACT

The project is aimed at addressing and evolving positive measure of timely and prompt maintenance programmes for Lokoja roads. Due to untimely maintenance by the concerned road maintenance authority these roads have developed into a very bad state hereby posing death traps to motorists. To address the problem, reconnaissance survey, condition surveys and site inspections were carried out. The present maintenance cost for Adankolo Ring Road was calculated as N2,587,414.08, Ganaja Lokoja Road N2,496,129.00. Present maintenance cost for Nataco - Kaduna Junction road was calculated as N8,013,945.60 and the present maintenance cost for Aliyu Obaje Road was calculated as N529,813.44 and that of Government House Road was given as N2,272,448.40. The sum total maintenance cost was calculated as N15,899,750.52. Postponed or delayed maintenance will result not only in economic loss of hard earned resources expended in the road infrastructure but would also increase the number of accidents and to the need for expensive reconstruction to restore the asset to original standard or shape.

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CHAPTER ONE

INTRODUCTION

1.0 Background of the Study

One of the most frequent complaints by Road maintenance Engineers and Agencies is the lack of adequate funds for maintenance. This may not be unconnected with the fact that maintenance works are only carried out when the infrastructure has gone too bad. A major operation like rehabilitation will require more funds than crack sealing.

A cursory observation of most roads in Lokoja reveals that there are already tell-tale signs of failure. Most failure modes would begin with minor cracks and as water enters with a combination of wheel load effects, the cracks develop to potholes which may later develop to major deformations leading to a total failure, structurally of the road.

Another closer observation reveals that the nation as a whole lacks a good maintenance culture. Authorities seem to think that the infrastructures have an "eternal life", so they leave them to rot to the extent that when they decide to carry out maintenance, they need to expend huge sums of money. As the distress on our road vary, so do the maintenance options as well as their costs.

As soon as a road is constructed and brought to use, a new responsibility is created to preserve the new investment and to serve and protect the interest of the traveling public who use and pay for the roads. Sudden failures, damages by storms, gradual deterioration and occasional obstruction are all road hazards that cause personal injury and/ or delays. In order to safe-guard the traveling public and to continue the economic and safety benefit of the public road system, it is necessary to maintain them in a proper manner.

1.1 Significance of the Study

A careful and appropriate maintenance of Nigeria roads will cut down costs incurred by passengers and drivers in the form of vehicle operating costs. It will also reduce extra cost on the part of Government as it is always said that "a stitch in time saves nine".

A smooth road providing a smooth ride function will definitely wipe out or limit delays experienced by drivers and commuters on poorly or non-maintained roads. This study will draw the attention of the maintenance engineers and authorities to the necessities of carrying out adequate and prompt maintenance on our roads.

Also, the study is expected to serve as a reference for students wishing to undertake similar topics for their future researches.

1.2 Aim/Objectives

The aim of this work is to find out the effects of the delayed maintenance and formation of distresses for urban roads.

The objectives of the project are:-

(i) Identification and measurement of distress type and sizes.

(ii) Calculation of various maintenance options and costs.

1.3 Scope of the Study

The project is limited to the maintenance of paved roads and significantly covers the identification of road maintenance practices, problems, financing, pavement characteristics and administrative policies of road maintenance activities with a particular reference to Kogi State.

CHAPTER TWO

REVIEW OF LITERATURE

A review of existing literature on research topic has been carried out and details are presented below.

2.1 Development of Highway in Nigeria

The economic development of Nigeria has reflected the development of her transport systems. This is particularly true of the road transport system which is by far most widely used mode of transport in the country (Onakomaiya, 1981). Of all commodity movement to and from the seaports at least two third are now handled by road transports while up to 90 percent of all other internal movements of goods and person takes place by roads.

Since the turn of this century, Nigeria has passed through various forms of colonial and post-colonial administrations, each with its own vested interest and bias for different modes of transport. Although various development programmes have been implemented on the basis of some official guidelines or principles of road transport development, it is doubtful whether one can yet speak of a definite comprehensive national policy on road transport development (Onakomaiya, 1981).

In the past, wheeled transport appears to have been unknown in Nigeria until the turn of the present century. Prior to the arrival of British administration, the dominant mode of overland transportation was by porters and draught animals over bush paths and trails which were, in essence, the easiest lines of communication between neighbouring settlements (onakomaiya, 1981). The earliest efforts at transport improvement in the North were directed towards the clearing of paths of 10 to 20 feet (3 to 6 meters) wide through the bush. In one case wheeled transport drawn by animals proved a little more expensive than porters, with the seat of the Northern government established at. Zungeru, a cart road for mule and ox-carts was begun in 1914, for two main reasons. Firstly, it was hoped that this would "reduce the strain through on the inland provinces in the provision of porters" for the British officials, secondly, that the earth works so created would be suitable for the eventual construction of a light railway. Lugard originally wanted to build the mule road to Zaira and then to Sokoto, Katsina and Maiduguri. However, with the authorization of the Bar- Kano railway in 1907, the efforts of the Northern government were concentrated on their railway, the cart-

road was abandoned at Tegina, 32 kilometers (20 miles) North of Zungeru (Onakomaiya, 1981).

In the south, where draught animals could not be used owing to the tsetsefly, the possibilities of motor transport served as an early stimulus to the building of roads (Onakomaiya, 1981). As early as 1903, a superintendent of roads was based in Calabar to begin the survey and construction of roads in the Eastern provinces (from Calabar-Obubra and from Oron-Onitsha), while in the West, roads were built to the railway as it was extended north from Lagos. The railway itself extended its service area by constructing roads from its major stations to neighbouring towns (Onakomaiya, 1981).

The first motorable road in Nigeria was built in 1906 from Ibadan to Oyo which thus became linked by a railway - operated road transport service. This was followed by similar services from Oshogbo to Ife, Ilesha and Ogbomosho, and Ede to Iwo (Onakomaiya, 1981). By the year 1914, there were 3,200 kilometers (2,000 miles) of motorable roads in the country.

Road construction suffered some setback during the first world war and during the construction of the Eastern railway line (Port-Harcourt - Kaduna) soon after the war. It also suffered same setbacks

during Nigerian Civil war (1967 - 1970). During this period, there was a sharp decline in the implementation of government policy on roads as a result of the concertration of all efforts on the prosecution of the war. The existing major roads, especially in the South, were put to excessive use by heavy military vehicles and long trailers whose importation was encourage in order to cope with the backlog of export products waiting evacuation by road to the ports owing to the closure of the Eastern Railway line and the port of PortHarcort (Onakomaiya, 1981).

In the second National Development plan launched immediately after the civil war, the general policy on transport was to promote coordination and rationalization of investment decisions in the transport sector (Onakomaiya, 1981).

2.2 Highway Safety Consideration

Generally, an accident rate in Nigeria highways is commonly ranked as the worst in the entire world. Such as unenviable position has prompted the federal government to constitute recenlly (year), the Road Safety Corps in order to minimize the carnages on the highways. However, recent and past experience with the corps tends to suggest

government pre-occupation with the obvious recklessness exhibited by most motorists, as frequently In their utmost zeal to outspeed and overtake other vehicles even at dangerous horizontal and vertical curves.

It is also worthy of note that the attention of government agents occasionally shifts to the continuous presence of highway, of seemingly rickety vehicles thought to have long qualified to be written off. The causes of accidents on the highway are in fact legion. Lunatic driving is generally attributed to inadequacy of education and a deficiency of training, skill and experience requisite for professional highway motoring. The maintenance of existing highway also contribute to the accident trend.

The statistics of accidents in Kogi State will show an increase in the number of persons involved. The peculiar trend observed may be explained as by the increasing traffic situation, loading, weight and volume, and the maintenance operation on the highway. (T.M. Oguara 2010)

Table 2. 1. Road accident data for Kogi State

Year	Fatal Accident	Serious Accident	Minor Accident	Total	Accident/ per sons Killed	Casualties Injured
2000	268	276	163	707	429	940
2001	253	221	136	610	289	816
2002	299	162	104	565	352	925
2003	306	170	105	581	569	1,103
2004	366	186	112	664	562	965
2005	355	193	94	642	513	1,535
2006	248	170	71	489	430	741
2007	244	120	123	487	390	702
2008	209	156	105	470	345	754
2009	290	206	118	614	290	725
TOTAL	3,038	2,360	1,131	5,620	4,176	9,104

Source: Federal Road Safety Commission Lokoja, Kogi State.

2.3 Historical Background of Pavement Maintenance

In Nigeria, before independence, there was a unified ministry of works known then as Public Works Department (PWD). There were three regions namely East, West and North, each of which had its own ministry of works, while federal ministry of works had the sole responsibility of maintenance of Trunk "A" roads, Local Government looked after their own roads known as council roads, (Oglesby, 1982).

After the 1974 takeover of trunk "B" roads. Nigeria was divided into seventeen maintenance zones each of which was manned by the district highway maintenance Engineer, following the recommendation of Messrs. Kampsax report on highway maintenance for Nigeria, (Oglesby, 1982). Each of the maintenance districts was responsible for the gradual implementation of improved and effective road network within the districts and was handled by state ministries of works on bchalf of federal ministry of works on urgency basis. (Oglesby, 1982).

Recently the Petroleum Special Trust Fund (P.T.F.) maintained a lot of roads across the country, and the World Bank is also maintaining the road by multi-state road project in some selected states and federal roads, which are still being maintained under this special scheme (Oglesby, 1982).

According to Oglesby and Hicks (1982), about 25% of all highway expenditure goes to maintenance in U.S. In 1960, $2.5 billion frorn the $10.9 billion of highway expenditure per kilometer of a road or street was &700. From the early 1930s to 1960, maintenance cost quadruped because of the increase in VOIU111e and weighl of vehicles. Maintenance was performed by various highway agencies themselves. The principal explanation given was that maintenance work is diverse and therefore required urgent attention.

Similarly, Paul and Radnor (1984) revealed that maintenance personnel faced an enormous challenge in adequately maintaining the vast public roads in U.S. the magnitude of the problem was seen in the size of the maintenance budget for various state highway and transportation agencies. In 1983, more than $5.5 billion was spent by the state for maintenance and traffic services. It is estimated that additional $7.7 billion was spent for maintenance by township and municipalities.

Paul and Radnor further stressed that during the past decades, annual maintenance cost had increase at an average rate of 7.9%. This aggravated the maintenance Engineers task of coping with increase traffic volume and demand for public services.

Atkinson (1986), found out from relevant data that spending on highway maintenance in British in 1986 - 1987), was at an annual level of $200 million for trunk roads and motor ways while $115 million for country roads. The average expenditure per kilometer for principal road was $9100 and for non principal roads $3200.

2.3.1 Types of Maintenance Activities

Maintenance system is usually adopted to suit the staff, roadmen, plant vehicles, material and finance available at the time. Procedures and reporting system are arranged considering the staff number or caliber available to carry them out, plant and vehicle can be maintained. Simple procedure that can be understood by all staff and operated within the limitations of personnel, plant and materials available. The maintenance Engineer should have a long term plan for improving the system, albeit in stages so that the system can be regarded as more resources become available from time to time. Training which is an important aspect in the maintenance Engineer's organization help in updating existing staff to new methods, plants and materials, to train in specialist operations, to improve supervision, train new personnel and also provide on the job training. Trained

personnel would reduce the maintenance Engineer's lead considerably, thereby bringing the work load of the maintenance into the classification listed below.

(i) Assessment or Requirement: That is assessmg what is required to be done in physical terms.

(ii) Allocating Resources: This determines priorities, estimating cost, staff, plants, equipments and material to carry out the work efficiently and cost effectively.

(iii) Monitoring Checking: that the work is carried out efficiently and the end result is satisfactory. This is most important as all three clạssification leads to this end result.

For the purpose of management, the most convenience way to classify maintenance activities in terms of their frequency (Paquette, 1967).

(i) Routine Maintenance: This required continuity of a maintenance operator on a regular basis or on every road whatever its engineering characteristics or traffic volume. The work involves patching of portholes, repair of drains and bridge maintenance.

(ii) Periodic maintenance: This is maintenance carried out at intervals of several years, it may be seasonal, and the work involves bush clearing, sheet cover, lane marking, erection of kerbs, also it involves patching of potholes and overlaying of Carriageway with Asphalt.

(iii) Emergency Repair: This IS maintenance work which are needed urgently on a road to keep it open to traffic.

(iv) Recurrent Maintenance: This required at intervals during the year with frequency that depends on the volume of traffic using the road.

In the past, the view has been widely held that road maintenance activities are difficult to plan, administer and are notoriously prone to inefficiency. This view is now gradually being modified in the length of recent efforts in bringing modern management techniques to bear on maintenance activities. The advantages to be derived from introducing a management system into maintenance operation are many but the important ones are:-

(i) The ability to predict work to be carried out by a maintenance unit within a specific period.

(ii) The setting of uniform plan by specified level of maintenance throughout the area.

(iii) The execution by maintenance crew of planned work In accordance with schedule.

(iv) The preparation of actual and a realistic budgetary estimate.

(v) The comparison between work and actual field achievement in order to rectify any shortcoming (Paquette, 1967).

2.3.2 Road Maintenance Management Concept

Road maintenance can be defined as all the operations which "enables the upkeep of a road and related features (ditches, embankment structures etc) in a condition close to its initial condition and to improve an old road to its desired condition (Paquette, 1967).

For a new road, the initial condition is that which existed upon final acceptance of the work. For an old road, the desire condition is determined in the light of the highway and the traffic after the "execution of rehabilitation works preceding maintenance (Paquette, 1967).

The sole purpose of maintenance therefore is to keep the road in a safe satisfactory condition for traffic at all times.

The definition of highway maintenance indicates that it is a function of preserving, repairing and restoring a highway and keeping it in condition safe, convenient and economic use. Maintenance include both physical maintenance activity and traffic service. The physical maintenance activities such as patching, filling joint, mowing etc and traffic service such as painting, pavement marking, erecting erOSIOn barriers etc. It does include major rehabilitation of reconstruction activities, such as widening of the road bed or extensive resurfacing projects.

Highway maintenance programmes are designed to offset the effect of weather, vandalism, organic growth, and traffic wear and damage, as well as deterioration due to the effects of aging features and design reconstruction faults.

Inspite of vigilant and determined efforts to maintain the serviceability of a highway, there comes a time when ITIaJor rehabilitation of facility is required. The rehabilitation work termed "betterment" is not considered as maintenance but the period of routine activity before and after maintenance.

There are four general classes of roadway maintenance and construction activities.

The survey groups, carnes out an inventory. Inspection of *the route* to investigate *the defects,* and noting *the* extent, causes and necessary requirement for such routes. Report *are* then written and investigation observed and a programme has to *be* set by *the* engineer in charge as to how *the* maintenance operation is to be carried out.

The office groups are to analyze reports from survey group, indicate the order of priority as to how the maintenance operation is to be carried out. Material required is estimated and *the* available fund is also taken into consideration. When *the* maintenance required is minor, a *crew* from *the* Federal Roads Maintenance Agency is deployed to carry out *the* operation by direct labour. In cases where *the* maintenance is a major requirement, *the* contract can be awarded to contractors, sub-contractors depending on the funds available.

The supervision groups, are to ensure that proper maintenance operation is carried out on the route in question. The implementation of *the* maintenance activities is supervised by a headman of each maintenance crew taken out into the site.

2.5 Pavement Evaluation and Management

Highway agencies have for years collected pavement condition data to make maintenance and rehabilitation decision. This generally was done on a project by project basis. The data were used to determine which project to maintain or rehabilitate, and what action was required to correct the observed pavement deficiencies. Decisions were made on a year to year basis, generally in an environment where resources (both manpower and money) are more adequate than they are today.

In the 1940s and 1950s, reliance was on visual inspections to establish type), extent and severity of distress and to establish maintenance and rehabilitation programs. In the late 1950s and early 1960s, roughness meters to measure ride quality, deflection test equipment to measure structural adequacy, and skid test devices to measure surface friction came into play so that objective data could bc collected and used together (or separately) with visual surveys to make maintenance and rehabilitation decisions. In the 1970s, many highway agencies began to realize that they could no longer mange their roadways on the basis of field observations alone. As a result

they have now developed objective methods of evaluation to establish that:

1. What project are presently In need of maintenance or rehabilitation?
2. What type of maintenance or rehabilitation is required now.
3. What maintenance or rehabilitation strategy should be undertaken now and in the future to minimize life cycle costs (construction, maintenance and user costs) or maximize net benefits (Oglesby, 1982).

2.6 Role of M~intenance Engineer

One of the key persons in any maintenance organization is the professional engineer who is responsible for running the organization at District or operational level. Although the district or maintenance Engineer will usually be constrained to work within whatever management system is operated by his department, there is invariably scope for improving the cost effectiveness of the use of the resources available for road maintenance.

By adopting the same professional approach towards road maintenance as to any other engineering activity, he can inspire his

staff to improve on their own performance. The maintenance Engineer should therefore show a personal commitment to maintenance work by regularly inspecting the roads under his control and making his staff aware of his interest, by getting out of the office and into the field as much as possible, the Engineer will be able to get to know his road network thoroughly and will readily identify trouble spots and other areas o difficulty. He will be able to assess priorities and will gain first hand knowledge of what maintenance has actually been carried out, instead of having to rely on reports from others. He will also see the quality of the maintenance work carried out and will be able to use his professional skill and expertise to solve problems on-the-spot as they arise. Seeing him actually on site will give a boost to staff morale and this will result in an improvement in both the quality and quantity of work done. If there is one single factor which influences the standard of road maintenance more than all others, it is the attitude of the engineer responsible. (P. N. Ndoke 2007)

The engineer will find it difficult to follow this advice if he is overburdened with routine administrative work, and it is essential that he delegates such activities to clerical and administrative staff as much as possible. The Engineer will require adequate trained staff to

carry out his instruction and he will need to arrange for supervisors, foremen, and specialist artisans to attend qualitative training courses to enhance their performance. Accordingly, the Maintenance Engineer must arrange for on-the job training for labourers and other junior staff.

Roads generally are experisrve to build. They repay their initial investment only by means of long term care and maintenance. A well-maintained road system brings important social and economical benefits. These benefit includes:

(i) The transport links on which development are kept In good working order.

(ii) Roads have a longer life span of service because their surfaces do not deteriorate rapidly.

(iii) Vehicles operating cost are reduced because traffic is able to run smoothly.

(iv) Transport operation are safer and more reliable.

The supply of maintenance equipment and vehicle IS usually organized as a separate department function and will be beyond the control of the maintenance Engineer. Lack of suitable vehicles is alway a major factor in maintenance organizations that arc

inefficient. The maintenance Engineer must be aware of the importance of proper maintenance of equipment and vehicles and should actively concern himself with the organization of this, as far as departmental procedures allows.

The work of district or maintenance Engineer falls into three categories.

(i) Allocation of Resources: Estimation of manpower, materials and equipment required for different task, determining priorities and allocating resources to ensure cost-effective results.

(ii) Assessment of Requirement: Establishing what need is to be met physical terms.

(iii) Monitoring: Checking that the work is done produces the desired results. (Road note 2,1981)

CHAPTER THREE

MATERIAL AND METHODS

3.1 Description of Project Sites

(a) Adankolo Ring Road is a single carriageway which is 7.5km long with a width of 7.30m and is surface dressed. It has no shoulder on both sides. The carriageway has lateritic sub-base and Base of 150mm thickness each. There are some sections that has existing Reinforced concrete lined Drain and some has earth Drains.

(b) Government house road is au-shaped carnageway which intercepts, Nataco - Kaduna junction road within Lokoja Town. The road is dualized and is 8 km long and a width of 7.30 on each carriageway. It has lateritic Base and sub-base of 150mm thickness each. It has an Asphaltic surface as wearing course. The shoulder is 1.5m each at both carriageway and ıs surface Dressed. It has manifesting potholes in some locatins.

(c) Nataco - Kaduna Junction Road is 16km and is also Dualiscd up to Nigerian Army Barracks with the remaining 5km as single carnageway. The road was formerly under Federal Ministry of Works but has now been taken over by Kogi State Ministry of

Works for maintenance purposes. The carnageway width is 7.30m both sides and a shoulder width of 2.75m each which is surface Dressed but the carriageway is on Asphalt surface.

(d) Ganaja - Lokoja Road is 7.5km and currently being dualized by Kogi State Government. Is has a strong base and Asphaltic surface with surface dressed shoulder of 2.75m each.

(e) The Aliyu Obaje Road which span from unity bank junction - Adankolo junction is 1.8km long and carriageway width of 7.30m. It has lateritic sub-base/base 1.50mm thickness. It has a shoulder which has a width of 1.5m each.

3.2 Methodology

In order to obtain adequate information on maintenance of roads In Kogi State, both primary and secondary sources of data will be used.

The primary sources of data will be accomplished by carrying out the reconnaissance survey, inventory studies and site inspection of the selected roads. In order to assess the failure location, numbers and the state of deterioration on the pavement surface, so also their causes and the preferred remedial action to be taken on these roads defects.

3.2.1 Data Collection

(a) Distresses

Snap shots of all the roads were taken to show the nature of failure involved and the measurements.

(b) Quantification / Qualification of Distresses

The numbers of potholes per chainage considered were counted as well as their sizes measured and a summary presented as in the table. Cracks were also measured and classified as either, severe, minor, based on their diameters in which a severe crack represent one with diameter greater than 3mm.

Plate I Potholes along Adankolo Ring Road.

~ The secondary source of data includes, information from seminar reports, workshops, published reports, magazines, official records such as officefile and textbooks.

MAP OF KOGI STATE SHOWING FEDERAL STATE ROADS

Plate II Potholes along Ganaja-LokojaRoad.

Plate III Wide cracks along Nataco - Kaduna Junction Road.

Plate IV Potholes along Aliyu Obaje Road

Plate V Distressed and badly damaged section along Lokoja- Okene Road

Plate VI Edge deformation along Nataco - Kaduna Junction

Plate VII Distressed section along Government House Road

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; Plate VIII Failed Section along Nataco - Kaduna Junction

3.2.2 Sample Calculation for Potholes and Crack Areas.

A 30 - meter Tape was used to measure the Dimension Tables of the potholes and the areas calculated as follows:

Adankolo Ring Road chanage 0 + 000 - chanage 7 + 500

(i) Potholes Location (Condition survey)

Table 3.1 Potholes on Adankolo Ring Road

SINo	Chainage	Length (m)	Width (m)	Area (m-']
01	0+000 - 7+500	3.50	1.35	4.73
02	" "	4.20	1.36	5.71
03	" "	3.20	2.50	8.00
04	« «	3.30	1.80	5.94
05	" «	2.00	2.00	4.00
06	" "	1.50	1.50	2.25
07	" «	2.50	2.0	5.00
08	" "	1.60	1.20	1.92
09	" «	1.40	0.80	1.12
10	" "	1.30	1.10	1.43
11	" "	2.00	1.50	3.00
12	« "	0.80	0.65	0.52
13	" "	2.50	1.63	4.08
14	« "	3.15	2.10	6.62
	Total Area of Potholes			54.32

Area of potholes IS calculated as length x Breath as shown above.

(ii) Percentage Cracked Area (Ch.O + 000 - Ch.7 + 500)

Length of road segment = 7500mm

Width of carriage way = 7.30m

Area = 7500 x 7.30 = 54,750m2

Total measured cracked area = 535 x 7.30 = 3,905.50m2

Percentage cracked Area = $\frac{3905.50 \times 100}{54,750 \quad 1}$

% Cracked area = 7.13%

TABLE 3.2: Inventory Studies on Adankolo Ring Road

Chaingc (km)	Description 0f Failure	State 0f Deterioration	No of Potholes	Approx area of Potholes	(Yo Cracks Area
0+000+500	Potholes. Edge Damage Pavement Cracks	Severe Failures	5	10m2	5%
0-1-500-1 +000	Edge Cracks. Potholes Range Should	Minor Failures	1	21m-	(i%
1+000-1 +500	Pavement. Cracks Potholes	Minor Failures	1	13m-	8%
1·1500-2+000	Eroded Shoulder. Portholes	Severe failures	2	2m-	4%
2-1000-2+500	Pavement Cracks. Alligator Crazing. Range Shoulder, Potholes	Minor Failures	-	-	4%
2+500-3+000	Edgc Cracks. Washout Shoulder	Minor Failures	-	-	3%
3+000-3+500	Pavement Cracks. Alligator Crazing. Ranged Shoulder. Potholes	Minor Failures	5	4 111-	10%
3+500-4+000	A IIigator/Cracks, Potholes	Minor Failures	1	1.32111-	7%
4+000-4+500	Eroded Shoulder Pavement Cracks	Minor Failures	-	-	12%
4-1500-5+500	Eroded Shoulder Pavement Cracks	Minor Failures	-	-	14%
5+000-5+500	Washout Shoulder Pavement Cracks	Minor Failures	-	-	6%
5+500-6+000	Pavement Cracks Wash Out Shoulder. Pavement Cracks	Minor Failures	1	3 m	5%
6+000-6+500	Pavement Cracks Eroded Shoulder	Minor Failures	-	-	7o"u
6+500-7+000	Pavement Cracks Eroded Shoulder	Minor Failures	-	-	100,u
7+000-7+500	Public Utility-Cut Edgc Da~~gc	Minor Failures	-	-	61-O
	TOTAL		14	S4.:r~	Avcragc % cracked = 7.13%

TABLE 33 Inventory Studies on Nataco - Kaduna Junction Road

Chainge (m)	Description of Failure	State of Deterioration	No of Potholes	Approx area of Potholes (111~)	% Cracked Area
0+000-1+0000	Potholes. Edge Damage Pavement Cracks	Severe Failures	60	250 M2	18.75%
1+000-2-1000	Potholes. Edge Damage. Pavement Cracks. Potholes	Major Failures	13	11/5 M2	5%
2 1000-3+000	Potholes. Pavement Cracks	Minor	2	1.2 M2	11%
J-IOOO-4+000	Washout Shoulder Pavement Cracks Potholes	Minor	:3	10	7%
5+000-5-1000	Pavement Cracks. Side Road Refuse.	Minor	I	1.5 M2	4%
5+000-6+000	Pavement Crack Potholes.	Minor	2	I .2 1\112	8%
6+000-7+000	Pavement Cracks	Minor	-	-	3%
7+000-8+000	Edge Cracks Washout Shoulder.	Minor	-	-	10%
8-1000-9+000	Pavement Cracks	Minor	-	-	5%
9+000-10+000	Potholes Edge Cracks.	Minor	I	0.5 M2	4%
10+000-11+000	Potholes. Pavement Cracks Ranged Shoulder	Severe Failures	7	2 M2	4%
11+000-12+000	Pavement Cracks/ Potholes.	Minor	28	110	14%
12 I 000-13+000	Edge Cracks Pavement Cracks Potholes.	Minor	8	25	8%
IJI 000-141000	Pavement Cracks/ Potholes	Minor	4	10	10%
14+000-15+000	Pavement Cracks/Potholes	Minor	3	11	(i0;;,
15+000-16+000	Pavement Cracks Potholes		7	30	4%
	TOTAL	Minor	139	567.4	J\vcragc % Cracked = 7.6'!l;,

TABLE 3 4 Inventory Studies on Govemmen tH ouse Road

Chaingc (m)	Description of Failure	State of deterioration	No of Potholes	Approx Area of Potholes	% Cracked Area
0+000-0+500	Pavement Cracks	Minor	-	-	6%
0-1500-1 +000	Pavement Cracks	Minor	-	-	..J.%
1-+-000-1+500	Pavement Cracks Potholes	Minor	I	0.5m2	4%
1+500-2+000	Pavement Cracks Potholes	Minor	2	1.2m2	10%
2-1000-2+500	Pavement Cracks	Minor	-	-	7%
2+500-3+000	Pavement Cracks Potholes	Minor	-	1.5m2	3ri
3+000-3+500	Pavement Cracks Potholes, Edge Cracks	Minor	2	1.2m2	8%
3+500-4+400	Pavement Cracks	Minor	-	-	5%
41-000-4+500	Pavement Cracks	Minor	-	-	5%
4+500-5+000	Edge Cracks. Washout Shoulder	Minor	-	-	12%
5+000-5+500	Potholes. Alligator Crazing	Minor	I	0.2m2	7%
5+500-6+000	Potholes Pavement Cracks	Minor	I	0.5m2	4%
6 1-000-6-500	Pavement Cracks	Minor	-	-	4%)
()1-500-7+000	Potholes Pavement Cracks	Minor	/	1.51112	J0/o
7+000-7+500	Potholes Pavement Cracks	Minor	-	-	4%
7+500-8+000	Pavement Cracks. Potholes	Minor	2	2.0	4%
	TOTAL	Minor	14	8.60I'v12	A vcragc % cracked = 6.25%

TABLE 3 5 Inventory Stu dies on Ganaja-Lokoja Road

Chaingc (m)	Description of failure	State of Deterioration	No of Potholes	Approx area of Potholes	% Cracked Area
0+000-0+500	Pavement Cracks. Potholes	Minor	2	Sm"	4%
0+500-1 +000	Pavement Cracks	Minor	2	10 m	9%
1 1000-1 +500	Pavement Cracks J\lli!:2tnr C~ll'.illg	Minor	-	-	6%
I ~500-2+000	Potholes	Minor	1	1.5m-	5%
2+000-2+500	Pavement Cracks	Minor	-	-	7%
2+500-3+000	Pavement Cracks	Minor	-	-	7%
3+000-3+500	Potholes. Pavement Cracks	Minor	2	7.5 m-	12%
3+500-4+000	Pavement Cracks	Minor	-	-	4%
4+000-4+500	Pavement Cracks	Minor	-	-	7%
4+500-5+000	Potholes. Pavement Cracks	Minor	1	2.5 rn	14%
5+000-5+500	And Pavement Cracks Pothole	Minor	-	-	3%
5 I 500-6 I 000	Pavement Cracks Pothole	Minor	5	12 111-	X%
6+000-6+500	Pavement Cracks	Minor	1	3.2 m"	10%
6+500-7+000	Pavement Cracks/ Potholes ,	Minor	-	-	4%
7+000-7+500	Pavement Cracks. Potholes	Minor	3	9.0 m	5%
	TOTAl,		17	53.5m-	Average % cracked = 6.87%

TABLE 3 6 Inventory Studies on Aliyu Oba e Road

Chaingc (rn)	Description or Failure	State or Deterioration	No or Potholes	Approx or Potholes	0/0 Cracked Area
0+00-0+ 100	Pavement Cracks	Minor			4%
0+ 100-0+200	Pavement Cracks	Minor			9%
0+200-0+ 300	Potholes. Alligator Crazing	Minor			6%
0+ 300-0+400	Potholes	Minor			5%
0+400-0+500	Pavement Cracks	Minor			5%
0+500-0+600	Pavement Cracks	Minor			7%
0+600-0+ 700	Potholes, Pavement Cracks	Minor	2	1.2 m	12%
0+ 700-0+800	Pavement Cracks	Minor			4%
0 I R00-0 I<)00	Pavement Cracks	Minor			7%
()I()00-1 -I-00()	Potholes. Pavement Cracks	Minor			14(~-()
1+000-1 + 100	Pavement Cracks	Minor			3%
1+100-1 +200	Pavement Cracks Potholes	Minor			8%
1+200-1 +300	Pavement Cracks. Potholes	Minor			10%
1+300-1 +400	Pavement Cracks	Minor			4%
1+400-1 +500	Pavement Cracks	Minor			5%
1+500-1 +600	Pofholcs. Pavement Cracks	Minor	2		JCY0
1+600-1 +700	Potholes, Pavement Cracks	Minor	1	0.36 m:	5%
1-1-700-I-800	Potholes Pavement Cracks	Minor	2		2%
	TOTAL		11	7.76 m	Average cracked area 6.28%

TABLE 3.7 Cracked Area for Adankolo Ring Road

Chain Age (rn)	Total Carriage Way Area (1112)	% Cracked	Area Cracked
0+000 - 0 + 500	500 x 7.3 =3650 III	5%	182.5 m
0 + 500 - 1+ 000	500 x 7.30 =3650 1112	6%	219 m"
1+ 000 - 1+500	500 x 7.30 =3650 m2	8%	292 m
1+ SOO - :2 + nOG	SO() x 7.:10=:1())() 111-	4(%	I4() 111-
2 +000 - 2 + 500	500 x 7.30 =3650 111-	45	146 111-
2 +500 - 3+ 000	500 x 7.30 =3650 1112	3%	109.5 m
3 + 000 - 3 + 500	500 x *7.30 =36S0* m	10%	365 111-
3 + 500 - 4 + 000	500 x 7.30 =3650 m	7%	255 111-
4+ 000 - 4 + 500	500 x 7.30 =3650 1112	12%	438 m
4 + 500 - 5 + 000	500 x 7.30 =3650 1112	14%	511 111-
5 + 000 - 5 + 500	500 x 7.30 =3650 m2	6%	219 m
5 + 500 - 6 + 000	500 x 7.30 =3650 m	5%	182.5 111-
6+ 000 - 6 + 500	500 x 7.30 =3650 1112	7%	255.5 111-
6 + 500 - 7 + 000	500 x 7.30 =3650 mL	10%	365 111-
7 + 000 - 7 + 500	500 x 7.30 =3650111-	6%	219111-
TOTAL	54750 m	Average cracked area = 7.13%	3,905.50111-

TABLE 3.8 Cracked Area for Nataco - Kaduna Junction Road

Chain Age (rn)	Total Carriage Way Area	% Cracked	Area cracked
0+000 - 0 + 000	100 x 7.3 =3650 1112	518.75%	1368.75 m'
1 + 000 - 2+ 000	100 x 7.30 =3650 m"	5%	365 m
2+ 000 - 3+000	100 x 7.30 =3650 1112	11%	803 111-
3+ 000 - 4 + 000	100 x 7.30 =3650 111-	7%	511 111-
4 +000 - 5 + 000	100 x 7.30 =3650 1112	4%	292111-
5 +000 - 6+ 000	100 x 7.30 =3650 1112	8%	584.111-
6 + 000 - 7 + 000	100 x 7.30 =3650 111-	3%	219111 2
7 + 000 - 8+ 000	100 x 7.30 =3650 111-	10%	73011/
8+ 000 - 9 + 000	100 x 7.30 =3650 m	5%	365 111-
9 + 000 -I 0+ 000	100 x 7.30 =3650 1112	4%	292 111-
10+ 000- I I + 000	100 x 7.30 =3650 111-	7%	51] m:1
I1 + 000 - 12+ 000	100 x 7.30 =3650 m2	]4%	1,0/'__. m-
I2+ 000 - 13 + 000	J 00 x 7.30 =3650 1112	8%	584 111-
13 + 000 - 14 + 000	100 x 7.30 =3650 1112	10%	730 m"
14 + 000 - IS + 500	100 x 7.30 =3650 m2	6%	438 m
I5 +000- 16 + 0.00	100x 7.30 = 3650 IIIL	4%	292111-
Total	116,800 111-	Average % cracked area =7.8	9.106.75 111-1-

TABLE 3.9 Cracked Area for Government House Road

Chain Age (m)	Total Carriage Way Area	0/0Cracked	Area Cracked
0+000 - 0 + 500	500 x 7.3 =3650 m"	6%	219 m2
0 + 500 - 1+ 000	500 x 7.30 =3650 m2	40/0	*146* m"
1+ 000 - 1+500	500 x 7.30 =3650 m"	4%	146 m2
1+ 500 - 2 + 500	500 x 7.30 =3650 m"	10%	365 m2
2 +000 - 2 + 500	500 x 7.30 =3650 *mL*	70/0	*255.5* m"
2 +500 - 3+ 000	500 x 7.30 =3650 m2	3%	109.5 m2
3+ 000 - 3 + 500	500 x 7.30 =3650 m"	80/0	*292* m"
3 + 500 - 4+ 000	500 x 7.30 =3650 m2	5%	*182.5 mL*
4+ 000 - 4 + 500	500 x 7.30 =3650 m"	50/0	182.5 m2
4 + 500 -5+ 000	500 x 7.30 =3650 *mL*	120/0	*438 mL*
5+ 000- 5 + 500	500 x 7.30 =3650 m2	7%	255.5 m2
5 + 500 - 6+ 000	500 x 7.30 =3650 m"	4%	*146. mL*
6+ 000 - 6 + 500	500 x 7.30 =3650 m2	140/0	511 m2
6 + 500 -7 + 000	500 x 7.30 =3650 *mL*	7%	255.5 m2
7 + 000 -7 + 500	500 x 7.30 =3650 m2	4%	*146 mL*
7+500-8+000	500 x 7.30 = 3650 m2	20/0	146 m2
Total	*58,400mL*	Average % 6.39 cracked area	*3,7.23 mL*

TABLE 3.10 Cracked Area for Ganaja - Lokoja Road

Chain Age (m)	Total Carriage Way Area	% Cracked	Area Cracked
0+000 - 0 + 500	500 x 7.3 =3650 m2	4%	146m2
0+ 500 - 1+ 000	500 x 7.30 =3650 m2	9%	328.51112
1+ 000 - 1+500	500 x 7.30 =3650 1112	6%	219.0
1+ 500 - 2 + 500	500 x 7.30 =3650 m2	5%	182.501112
2 +000 - 2 + 500	500 x 7.30 =3650 m2	5%	182.501112
2 +500 - 3+ 000	500 x 7.30 =3650 m2	7%	255.50m2
3+ 000 - 3 + 500	500 x 7.30 =3650 1112	12%	438m2
3 + 500 - 4+ 000	500 x 7.30 =3650 1112	4%	146m2
4+ 000 - 4 + 500	500 x 7.30 =3650 1112	7%	255.501112
4 + 500 -5+ 000	500 x 7.30 =3650 m2	14%	511m2
5+ 000- 5 + 500	500 x 7.30 =3650 1112	3%	109.50m2
5 + 500 - 6+ 000	500 x 7.30 =3650 m2	8%	292m2
6+ 000 - 6 + 500	500 x 7.30 =3650 1112	10%	365m2
6 + 500 - 7 + 000	500 x 7.30 =3650 1112	4%	146m2
7 + 000 - 7 + 500	500 x 7.30 =3650 m?	5%	182.50m2
Total	54,750m-	Average cracked area = 6.87%	3,759.50m-

TABLE 3.11 Cracked Area for Aliyu Obaje Road

Chain Age (m)	Total Carriage Way Area	% Cracked	Area Cracked (1112)
0+000 - 0 + I00	100 x 7.3 =3650 1112	4%	29.2 1112
0 + 100 - 0+ 200	100 x 7.30 =3650 m2	9%	65.7 1112
0+ 200 - 0+300	100 x 7.30 =3650 1112	6%	43.8 1112
0+ 300 - 0 + 400	100 x 7.30 =3650 m2	5%	36.5 1112
0 +400 - 0 + 500	100 x 7.30 =3650 m2	5%	36.5 1112
0 +500 - 0+ 600	100 x 7.30 =3650 1112	7%	51.1 m?
0+ 600 - 0 + 700	100 x 7.30 =3650 1112	12%	87.61112
0+ 700 - 0+ 800	100 x 7.30 =3650 m2	4%	29.2 1112
0+ 800 - 0 + 900	100 x 7.30 =3650 m2	7%	51.1 m?
0 + 900 -I + 000	100 x 7.30 =3650 m?	14%	102.2 1112
1+ 000- 1 + 100	100 x 7.30 =3650 m2	3%	21.91112
1+ 100 - 1+ 200	100 x 7.30 =3650 m2	8%	58.4 1112
1+ 200 - I + 300	100 x 7.30 =3650 1112	10%	73.0 1112
1 + 300 - 1 + 400	100 x 7.30 =3650 1112	4%	[illegible]
I + 400 - I + 500	100 x 7.30 =3650 1112	5%	36.50 1112
1+ 500 - J.+ 600	100 x 7.30 = 3650 m2	3%	21.9 1112
1 + 600 - 1 + 700	100 x 7.30 = 3650 m2	5%	36.50 1112
1 + 700 - 1 + 800	100 x 7.30 = 3650 m?	2%	14.60 1112
Total	13, 140 m?	Average cracked % =6.27	824.90 1112

TABLE 3.12 Maintenance Criteria for Paved Roads

Rut Depth (11111)	Cracking	Potholing	Edge Failure	Action	Programme
Wheel Track Cracks Rutting Less Than I0111111	Wheel Track Cracking Less Than S%	Less Than IS Potholes Per 100mm	Minor	Seal Cracks Patch The Road Edges And Repair Shoulder	Recurrent
-	Wheel Track Cracking Greater Than S%	IS-40 Holes Per 1000111111	Minor	Patch And Over Lay Or Surface Dress Cracked Area	Periodic
Wheel Track Cracks Rutting Less Than 1Smm	Wheel Track Cracking Greater Than 10%	-	-	Surface Dress	Periodic
-	-	More Than 40 Potholes Per 100111111	-	Reconstructio n	Rehabilitati on
Any Cracks Associated With Bun ting :')	-	-	-	Patch And Treat Cracks Depending On Extent	Recurrent! Periodic

3.3 Maintenance Cost

The cost of scaling a m^2 of cracks and patching of potholes per 111~ were gotten from the federal Roads maintenance Agency as

(a) Cost of cracks scaling = N600/M2

(b) Cutting, of potholes filling/ compaction/laying of asphalt =N4,494/m2

Sample Calculation

From the data presented in Table 3.1 to 3.6 total cracked areas for Adankolo Ring Road arterial has bee n calculated and is presented below:

Total length	=	7,500m
Total width	=	7.3m
Area of carriageway	=	54,750m~
Total cracked area	=	3,905,5011l~
Percen tage cracked area	=	7.13%
Cost of sealing crack	=	600 x 3, 905.50
	--	N2, 343,300.00
Total potholes area	=	54.32 m2
Cost of cutting and filling potholes	=	54.32xN4, 494.00
	=	N244,114.08

Total present cost = 2,343,300 + 244,114.08

= 2,587,414.08

From calculation, out of a total area of 54750m2. 3,905.50m2 is cracked (on carriage way) giving a percentage of 7.13% multiplying this by cost of *N600jm2* to seal a crack we have N2,343,300.00 meanwhile a total of 54.32m2 of potholes was calculated from field result for road, carriageway maintenance of Adankolo ring road. However, it can be seen that crack sealing carries a large amount and it will only be advisable to seal them now because cracks will invariably develop to potholes if left unattended to. From Nataco - kaduna Junction road, a total area of 9.106.751112 is cracked. Maintenance cost of sealing is 600 x 9,106.75 = N5,464,050,00 and cost of maintaining the whole potholes IS 567.4x 4494 = N2, 549895.60. A total of N8, 013,945.60 IS needed now [or the carriageway maintenance. It can be seen that crack sealing carries a large amount and it will only be advisable to seal them now because cracks will invariable develop to potholes if left unattended to.

While for government house road, a total area of 3,723m2 IS cracked. Maintenance cost of sealing 3723 x 600 = N2, 233,800.00. While that of potholes is 8,648,40 the total amount needed for

maintenance now is N2,272,448.40. For Ganaja-Lokoja road, a total area of 3,759.50111$_2$ is cracked. The maintenance cost of sealing the crack is N2,255,700.00. total potholes area is 53.50m$_2$ and cost of maintaining the pothole is N240,429.00. The total amount needed for maintenance now is N2,496, 129.0. For Aliyu Obaje road, the total area of 824.90111$_2$ is cracked, the maintenance cost of crack sealing is N494,940,00 while cost of patching potholes is N34,873.44. Total maintenance cost for Aliyu Obaje road is N529, 813.44.

3.4 Construction and Maintenance History

Adankolo ring road was constructed in the year 1996. since than minor routine maintenance was carried out in 2000 by the state ministry of works, another maintenance is presently being contemplated by the state government. Nataco - kaduna junction road was constructed in 1976 and it is 16 km long, No maintenance has been carried out except minor potholes patching. This road links zariagi, Kabba junction to kabba also to okene down to south western & south - southern states.

Ganaja - lokoja road was constructed in 1976 as a carriage way. It is 7.5 km long presently under going dualization by kogi state

Government. It links lokjoja to Ajaokuta and to the casters flank of kogi state. The last maintenance was carried out in 2008. Government House road was constructed in 1994 and is 8km long, the last maintenance was carried out in 2007 by the state ministry of works. All these roads are of economic importance to the local and state governments. Adankolo ring intercepts Nataco - Kaduna junction road which links to other roads within Lokoja Metropolis and extends to other part of the state. An urban portion of about 2km was considered. The Nataco - Kaduna Junction has some Business ventures along it which generates revenue Lokoja Local Government and State Government the same applies to Adankolo ring road, Aliyu Obaje road which also serve as a commercial nerve centre of Lokoja Town.

CHAPTER FOUR

Discussion of Results

This chapter discusses results obtained and a proposal on maintenance to also be made

4.1 Distress

For Adankolo Ring Road, the percentage area was determined as 7.13% total number of potholes counted was 14, while total potholes area of 54. 32m2 was calculated.

For Nataco - Kaduna Junction Road, the percentage cracks area was 8% and total number of potholes counted was 139 and total area of potholes was calculated to be 567.40m2.

While for Government House road, the percentage cracked area was 6.25% and total number of potholes counted was 14 and total area of potholes calculated to be 8.6m2.

For Ganaja - Lokoja road. The percentage cracked area was 6.87% total number of potholes counted was 17 and total area of 53.50m2 was calculated. For Aliyu Obaje road, the percentage cracked area was 6.28% while the number of potholes was counted as 11 and total area of potholes was 7.76m2.

maintenance activities on our roads are carried out as and at when due.

They should be a team to also carryIng out monitoring and evaluation. If cracks develop to potholes, we have seen from the analysis above that the cost of maintenance increases. Therefore, it is advisable to carry out routine maintenance on our roads to avert this problem.

CHAPTER FIVE

Conclusions and Recommendations

This chapter presents the conclusions and recommendations drawn and made from results gotten from the field work.

5.1 Conclusions

From the results obtained, it can be seen that the roads have various degree of deterioration from minor cracks to potholes and edge deformation.

(i) The Adankolo Ring road has about 7.13% of its surface Cracked and has 14 severe potholes with area of 54.42m2

(ii) The Nataco - Kaduna Junction road has about 8% of its surface cracked and has total number of 139 severe potholes with area of 567.40m2

(iii) While Government House Road has about 6.25% of its surface cracked and has total number of 14 potholes with area of 8.60m2

(iv) Ganaja - Lokoja road has about 6.87% of its surface cracked and has 17 number of potholes with area of 53.50m2

(v) Aliyu Obaje road has about 6.28% of its surface cracked and has 11 number of potholes with area of 7.76m2

From maintenance history, it can be seen that adequate maintenance is more machine oriented than labour intensive, labour is becoming more expensrve and less efficient than machine. Consequently, the machine is gradually taking over a lot of the drudgery in road maintenance work.

To obtain necessary increased output from road maintenance labour, it is imperative that the labour force units are constituted into gangs of 18 to 20 labourers instead of the present system of dispersing labour. This, gang working under a section road overseer will be responsible for maintaining approximately 40km of the road.

5.2 Recommendations

In order to resolve the present road maintenance crisis and give it the necessary attention it deserves, the following measures are recommended.

(i) Road maintenance activities should be adequately funded and such funds should be released at the right time for effective use.

(ii) Proper supervision of road maintenance should be carried out.

(iii) Ensured that the right specifications are adhered to during the construction and maintenance stages of the roads.

(iv) Major improvement should be given to maintenance of equipment.

(v) The provision of incentives for better performance should be encouraged by road maintenance management.

(vi) Maintenance standard should be established In vanous government works department.

(vii) Education in maintenance techniques and training should be given to all level of road maintenance personnel.

(viii) There should be effective timely and prompt maintenan.ce works on failed road, as this would be considered as most cost effective.

(ix) Proper attention should be gIven to logistic problems to ease movement to and from site.

(x) A comprehensive and reliable insurance policy should be given to all personnel involved in Road Maintenance activities.

(xi) "Road Funds" for maintenance activities whose operation would be distinct from the conventional budgetary ear

marking of funds for Road works should be established for Federal, States and Local Governments.

(xii) Private public partnership for Road Maintenance should be encouraged by the three-tier of Government.

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