# REHABILITATING A FAILING ACCESS ROAD

**A Case Study of IITA FARM, KUBWA, ABUJA**

**BY**

**SULEMAN RASHEED ABDULLAHI**

*PGD/98/99/43*

**DEPARTMENT OF AGRIC ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA NIGER STATE.**

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A PROJECT REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF POSTGRADUATE DIPLOMA (PGD) SOIL & WATER ENGINEERING IN THE DEPARTMENT OF AGRIC ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE.

## CERTIFICATION

This is to certify that this project "Rehabilitating A Failing Access Road" (A Case Study of IITA Farm, Kubwa, Abuja) was carried out by SULEMAN RASHEED ABDULLAHI Under the Supervision of ENGR ALABADAN B.A and submitted to Agric Engineering Department of the Federal University of Technology, Minna in partial fulfilment of the requirement for the Award of Postgraduate Diploma in Soil and Water Engineering.

Name: ENGR. B. A. ALABADAN Signature & Date: 28/8/2000

(Internal Supervisor)

Name: ENGR. (DR.) M. G. YISA Signature & Date:........................

(Head of Department)

Name:.............................. Signature & Date:........................

(External Examiner)

# DEDICATION

This Project Work is dedicated to the remembrance of Late Alhaji Adams Oluyemo whose sad event took place on the day of my Resumption for this PGD Programme.

**ACKNOWLEDGEMENT**

I wish to express my profound gratitude to both Engr Alabadan B.A (My project supervisor) and Engr. Ogbeide F.N of Civil Engineering department, Federal University of Technology, Minna for their professional advice during the course of writing this project report.

I am also indebted to the following for the enormous knowledge they imparted on me during the pursuance of my post graduate studies: Engr. (Dr) M.G. Isah (HOD Agric. Engineering Department), Engr. (Dr.) Adgidzi, Engr. N.A Egharevba, Engr. Mrs osunde, Engr. Dike. Others are Engr. (Dr) Jimoh and Engr. Olufemi.

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# CHAPTER ONE

## 1.0 INTRODUCTION

Rehabilitating a failing access road is a project presentation aimed at solving the prevailing problems of a fast failing farm access road. This 4.3 kilometre road lies in Kubwa satellite town of the federal capital territory and connects among other communities the IITA farm and a few semi-mechanised farm.

The benefit of rehabilitating this road is to accommodate among other implements, tractors and trailers so as to save a great deal of handling of farm produce, manure and equipment all of which depends on the use of roads. This rehabilitation is hoped would draw IITA community out of a state of isolation, help the extraction of farm produce from interior communities and consequently creating a reduction in prices of food items, it would also save travelers and freight time and also create a reduction in road accident.

## 1.1 PREAMBLE

This research work deals with road rehabilitation which entails upgrading and reconstruction works. A background description of the engineering properties involved is provided and guidance is given on procedure to be followed. The phases involved in executing a road project are outlined and attention is drawn to the need to collect good and reliable data and then identify which data and decision are the most important.

## 1.2 AIM

This project is aimed at earning the following benefits; To enhance the expulsion of farm produce from IITA farm and its neighbouring communities, To create a reduction in transportation fare and on prices of food items, To save travelers and freight time and to create economies in road maintenance.

## 1.3 JUSTIFICATION

Since most goods and services are transported by the use of roads, this project is concerned with drawing IITA community out of a state of isolation and more importantly it also enhances the production and extraction of farm produce (from IITA farm) farm which would depend greatly on the use of road. Good roads no doubt promotes Agricultural, Commercial, Educational, Economic and Social activities of any community and may also serve as a revenue generation to the government.

## 1.4 SCOPE OF STUDY

The scope of the project describes the techniques that will be used to rehabilitate a deplorable road. Particular attention is given to the pavement design aspect of the road as this is the focal point where the engineer will make a handsome contribution.

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

Road Note 31[1] is a general design guide for bituminous surfaced roads in developing countries and emphasises good engineering practice which applies Universally. This note specifies that traffic be defined in terms of the equivalent number of standard (8200kg) axles expected to pass over the road during its design life.

In developing countries, road traffic is growing rapidly in volume, size and weight of the vehicles using the roads. The deterioration of paved road is therefore caused by traffic which results from both the magnitude of the individual wheel loads and the number of times these loads are applied. As a consequence, highway engineer concerned with rehabilitating deteriorated road in developing countries require reliable information about the distribution of the axle loads of existing traffic, this information is required to ascertain the existing traffic and to make a better forecast of the anticipated axle which will traverse a particular road in future.

Therefore, for the pavement design in this project work, the Author considered not only the total number of commercial vehicles that will use the road but also the wheel load (axle load) of these vehicles. To do this, (Road Note 40[2]), specifies that the axle load distribution of a typical sample of commercial vehicle using a road must be known. Then from factors derived from the AASHO chart (RN 31[1]) which enable the damaging power of axle load of different magnitude to be expressed in terms of an equivalent number of standard (8200kg) axle loads, the total number of commercial vehicles that will use the road during its design life can be expressed as an equivalent number of standard axle.

Also John[3] in his paper proposes that pavement which are approaching the end of their design life or which are experiencing premature failure due to overloading, fatigue failure or extreme climatic conditions develop cracks within the structure which will in time, reach the surface. These cracks provide a route for water and pollutants to enter the pavement structure and the formation beneath the pavement which results in a rapid deterioration in safety and serviceability. This damage is caused by disruption of the pavement structure and the underlying formation by the hydraulic pressure generated by traffic loading of the saturated materials, by pumping of fine material from the formations which reduces bearing capacity and in the longerterms distruption caused by freeze/thaw cycles affecting the pavement structures and the underlying formation.

All of these trouble can be prevented through good description and selection of quality construction material described below. The drainage solution proposed in this project work would help combat the drainage problem experienced on this road and could serve as a useful guide to similar drainage problem elsewhere.

Also it is common practice in road rehabilitation to try to extend the life of deteriorating pavement by placing a strengthening overlay of bituminous materials on the existing surface, preferably before degradation is too far advanced. However, cracks which are present in the old pavement will propagate through the overlay which in turn will deteriorate. This phenomenon, known as reflective cracking is caused by traffic induced horizontal stress which is set at right angle to the end of the crack. When such stress is intensified at the end of the cracks, they become self propagating and will then developed and damage the overlay. A number of construction methods have been tried in an attempt to control reflective cracking, the main methods currently in use are to use a very thick bituminous overlay by incorporating a polymer or elastomer or by placing a stress absorbing membrane between the old pavement and the overlay.

## 2.1 MATERIAL DESCRIPTIONS

(a) **Surfacing**: The essential requirement of all bituminous surfacing is that they should be waterproof and provide skid resistance surface. Surfacing do not necessarily have to perform a load spreading functions because this can often be done by the underlying layers.

(b) **Surface dressing**: Consist of a single layer of stone chippings bounded to the road surface by thin continuous film of binder. The most common type of binder used are cut back bitumen, but penetration grade bitumen, bitumen emulsion and tar are also employed. The binder is first applied unto the prepared road surface and the chippings are spread on the binder film and are lightly rolled preferably with pneumatic tyred roller to produce a dense mosaic of the virtually single sized stones. Both the chippings and existing road surface should be clean and free from dust to encourage good adhesion. Two surface dressings applied one after the other are commonly used for initial surfacing of newly constructed road.

(c) **Priming**: On newly constructed road base, a prime coat is required prior to applying the surface dressing to bind the surface together and ensure good adhesion of the binder film. The prime coat will normally consist of a low viscosity medium curing cutback bitumen (mc 30 or mc 70) which is sprayed to the surface of the base at a rate of between 0.5lit/$m^2$ and 1.0lit/$m^2$. The rate depends on the degree of absorbency of the base and should be choosen so that the prime penetrates about 3mm - 6mm and dries to a matt surface in 24-48 hours leaving no pool of free bitumen on the surface. It is useful to apply the prime on a damp surface to assist its penetration.

(d) **The Binder**

The viscosity of the binder used is determined by the prevailing ambient temperature when the work is being done, the temperature of the road surface and the type of equipment available for heating and spraying the binder. It is important that a uniform rate of spread of binder is obtained and for this, mechanical distribution are essential. In the tropics, it is best to use the most viscous binder that can be sprayed uniformly with the equipment available and to keep traffic off the dressing until full adhesion has developed. it is also desirable to impose a speed limit of 20km/h on the traffic that uses the road for the first 24 hours.

Typical binder for surface dressing in the tropic are MC800 and MC3000 Cutbacks and 180/200 pen and 80/100 penetration grade bitumen. The amount of binder required depends greatly on the following:

I Size of chippings (Large chipping need more binder).

ii) Shape and absorbency of the chippings (Rounded or absorbent chippings need more binder than cubical or non-absorbent one).

iii) The absorbency of the road surface.

v) The weight of traffic expected (More binder is required when traffic is light than when traffic is heavy).Typical rate of spread of binder ranges between 0.9-1.5 litre per square metre.

## Chippings

The chippings used should be nominally single sized and praferably should be approximately cubical in shape. The choice of the nominal size to be used depends on the softness of the surface being treated and the weight of the traffic expected to use the road. With the passage of time, traffic tends to push the chippings down into the road surface, so that lager chippings should be used on heavily- trafficked and soft surfaces, while smaller chippings should be used on lightly trafficked and hard surfaces.

The size of chippings suitable for surface dressing ranges from 16mm nominal size applied at the rate of approximately $7kg/m^2$ to 20mm nominal size applied at approximately $18kg/m^2$ (8).

## Road Layer

These are generally the main structural element of a road and they are:

a. Base Layer

b. Subbase layer and

c. Subgrade layer.

(a) The Base layer: This is a layer of very high stability and density. It's principal purpose includes providing good shaped surface on which to lay the wearing course and also to distribute the stresses created by wheel loads acting on the wearing surface so that the stresses transmited to the subgrade will not be sufficiently great to result in excessive deformation of that foundation layer. The character of the bases must be such that it is not damaged by capillary water and or frost action. Base material may compose of gravel or crushed rock or granular material treated with asphalt, cement or lime flash stabilizing agent.

(b) Subbase layer: This is a layer between the base and formation level, the quality of the material used for subbase does not need to be as high as those for base layer. Most common material for use are naturally occurring (unmodified) gravels and gravel-sand-clay mixtures, sometimes cement or lime stabilized soil are used.

The objective of this layer include to give a further and final distribution of load into the subgrade to provide adequate thickness of frost resistant material and to provide working platform on which to lay the base layer during construction.

(c) subgrade layer: This is the foundation layer, the structure that must eventually support all the loads which come unto the pavement. In some cases, this layer will be the natural earth surface while in other case and more usual instances, it will be compacted soil existing in a cut section. In the fundamental concept of the action of flexible pavement, the combined thickness of subbase (if used), base and wearing course must be great enough to reduce the stresses occurring in the subgrade to values that are not sufficiently great to cause excessive distortion of the subgrade soil layer. Also, (Road Note 2[4]) proposes table 1 below as 'Potential for equipment and labour applied on road maintenance."

Table 1: Potential for equipment and labour applied to road maintenance

| ACTIVITY | POTENTIAL FOR | |
|---|---|---|
| | EQUIPMENT | LABOUR |
| Ditch clearing and cutting | Good (*) | Good (*) |
| Clearing & minor repair to culvert & Bridges | Poor | Good |
| Building scour control | Poor | Good |
| Repair of structures | Poor | Good |
| Grading unpaved surfaces | Good (Skilled)++ | Impracticable |
| Dragging & Brushing of Unpaved Surfaces | Good | Poor |
| Patching, Sanding or local sealing of bitum-surfacing. | Poor | Good |
| Filling on Unpaved surfaces and slopes | Poor | Good |
| Grass cutting | Good (**) | Good |
| Manufacturing signs | Fair (+) | Good(+)Skilled++ |
| Repairing and replacing traffic signs | Poor | Good |
| Road line markings | Good | Fair |
| Stockpiling gravel | Good | Fair |
| Regravelling gravel surfaces | Good | Fair |
| Stockpiling chippings | Good | Poor |
| Surface dressing | Good (Skilled)++ | Fair (skilled)++ |

Source RN2[4]

NOTES:( *) The potential in these activities is dependent upon suitable design of the ditch cross-section. V-shaped ditches are suitable for maintenance by grader whereas flat bottomed ditches are suitable for maintenance by hand or by mechanical shovel.

(**) The potential in this activity is dependent on the width of the shoulder and presence of obstructions such as road furniture and culvert headwalls.

(+) Some methods of manufacture may require the use of specialised plant (Eg vacuum application of reflective sheeting to sign plates).

(++) The expression 'skilled' implies that specific training of operative is essential.

In choosing between equipment based and Labour based method, consideration should be given to the standard of work achieved by each method as well as to costs and to the way in which the work is organised. It is not always necessary for labour-based operations to have the same standards of finish that can be obtained by equipment. (4)

## 2.2 ROAD HISTORY

Nobody can say precisely when was the inception of road because some records were lost in the midst of antiquity. Most certainly however, the ancient trails deliberately choosened and travelled by ancient man and his pach animals were the fore runners of the road as it is today.

As man developed, the desire for communication increases so inevitably that these trails reffered to above formed pathways and from pathways to recognised travelways. The invention of the wheel over 5000 years ago made special construction of hard surface capable of carrying concentrated and greater loads necessary.

These above statement reveals that road construction has achieved certain sophistication many thousand of years ago and therefore it is pertinent to construct a road which will satisfactorily carry the projected traffic loading at minimum cost. (5)

## 2.3 TYPES OF ROADS

Roads are classified as follows:

(a) Paved roads and

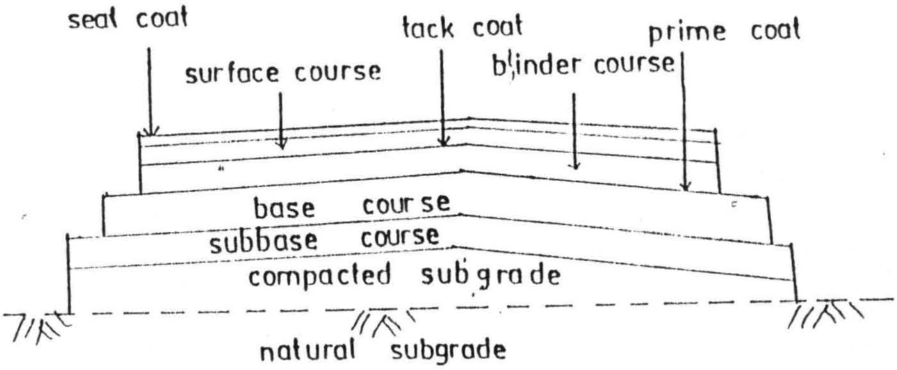
(b) Unpaved roads.

Paved roads: This class of road is further divided into

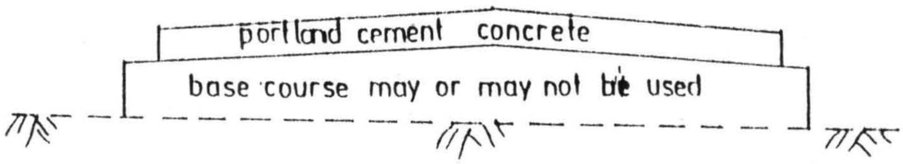
1. FLEXIBLE AND
2. RIGID pavements.

The flexible pavement may consist of a relatively thin wearing surface built over a base course and subbase courses and they rest upon the compacted subgrade. In contrast, rigid pavements are made up of cement concrete and may or may not have a base course between the pavement and subgrade. See fig. 1a and b

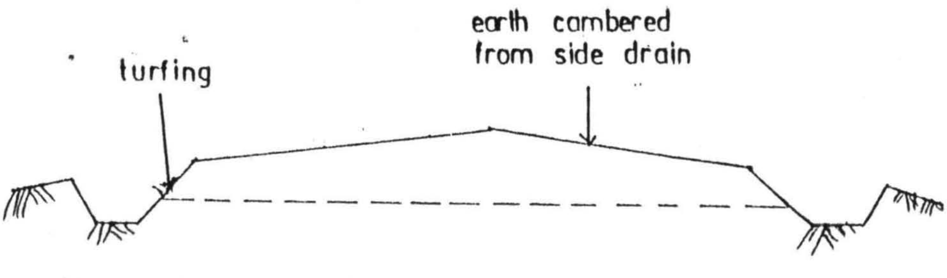
The essential difference between the two types of pavements, is the manner in which they distribute the load over the subgrade. The rigid pavement, because of its rigidity and high modulus of elasticity, tends to distribute the load over a relatively wide area of soil; thus a major portion of the structural capacity is supplied by the slab itself. The




(a) COMPONENTS OF FLEXIBLE PAVEMENT.




(b) COMPONENT OF RIGID PAVEMENT.




(c) PROPERLY MAINTAINED EARTH TRACK.

Fig 1 TYPES OF ROADS

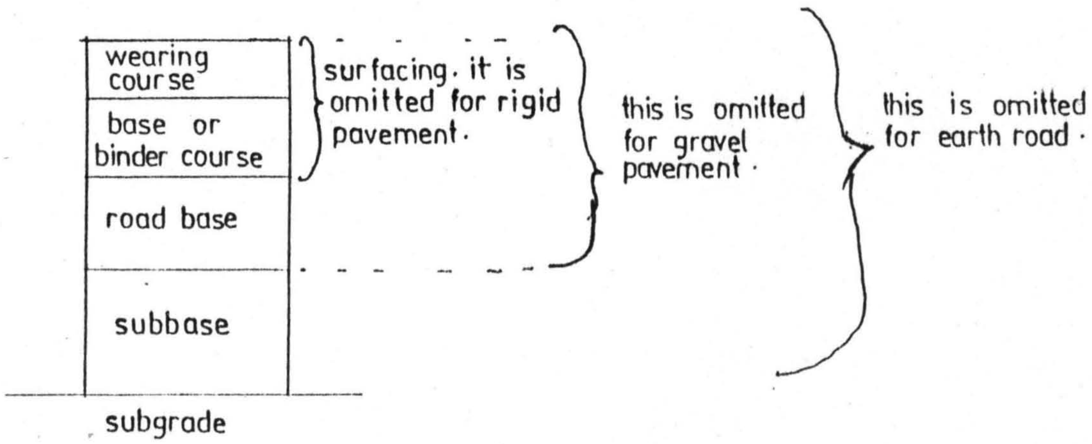



Fig. 2 SHOWING PAVEMENT DESCRIPTION.

major factor considered in the design of rigid pavements is the structural strength of the concrete. For this reason, minor variations in subgrade strength have little influence upon the structural capacity of the pavement. (6)

**Unpaved Roads**: (Earth & Gravel Roads). These are roads constructed by removal of top soil and filling with suitable earth or gravel materials, it may be mechanically stabilized to carry traffic loadings.

**Earth Roads**: This have no added pavement and layers are therefore not structurally designed. Their performance depends strongly on their cross-sectional shape, material properties, location in the terrain and drainage facilities incorporated in the design. (See fig 1c).

**Gravel Roads**: Roads that are surfaced with gravel to provide traction for vehicles in wet weather at relatively low cost. Surfacing with gravel also retards the increase in deformation of the surface but regular reshaping is needed as part of recurrent maintenance activities. Even when badly deformed, gravel roads can normally carry traffic successfully as drivers try to avoid deformed areas by choosing different wheel paths, but vehicle operating costs will be increased considerably as gravel roads deteriorate. Gravel roads normally have properly designed and built drainage structures compared with earth roads and provide all-weather instead of seasonal access (See Fig 2).

Gravel roads are rarely designed in the structural sense, usually a fixed thickness of gravel (150mm or 200mm) is used irrespective of climate, subgrade strength or traffic loading conditions and this is replenished periodically as it is worn out. (4)

**Choice of Paved Road Construction Type**: Where a paved road is necessary, there are two basic types of construction that can be used.

In the past, flexible pavements with an asphalt surfacing have normally been used in most tropical countries because they have provided a more economic solution. However with variation in oil prices affecting the cost of using bitumen, the cost of using rigid pavements constructed with cement concrete has become more competitive particularly, in those countries having their own cement manufacturing capability.

The choice between Flexible and Rigid pavements should be made on consideration of the likely cost of both construction and maintenance, the pavement life and effect on road user costs. (8)

2.4 **Type of Road Failures** Failures on a road are classified under two main classes namely:

(a) Structural failure and

(b) Functional failures

(a) **The Structural Failure**: This includes collapse of pavement structure or a breakdown of one or more of the pavement component in such a magnitude to render the pavement incapable of sustaining the loads running on them.

**Major Causes Associated to Pavement Structural Failure**

Some causes associated to pavement failure includes; inadequate design parameters, Bad Construction, Excessive traffic loading, improper alignment and Drainage deficiencies.

i. Excessive traffic loadings:- The excess loads outside the expected traffic loads for which the road is designed can cause excessive shear stress above the shear strength of the soil thus, resulting to road failures in form of warping or cracks or general deformation of layers.

ii. Bad constructions:- Failure could arise out of the followings:

a) The use of unsuitable materials (Dirty aggregate)

b) Improper mix ratio of materials

c) Deficient compaction value.

iii. Improper Road Alignment:- Road may also fail as a result of (a) Non-provision of camber (b) wrong slopes at cutting/filling etc.

iv. Drainage deficiencies:- This is the effect of surface and subsurface water infiltration, the effect of these on roads causes cracks, pot-holes, sliding and weakness in road beds etc.

<u>**Other Causes**:-</u> The climatic condition as well as environmental conditions may cause surface irregularities and structural weakness e.g frost heaving (Rise/fall), volume change of soil due to wetting and drying, also breakup and dis-integration of paving materials resulting from freezing and thawings e.g the scaling of rigid pavement may result from non-durable aggregates and can caused or aggravated by the application of salt for ice removal. Subgrade are also susceptible to climatic condition while inadequate soil analyses are also prime cause of pavement failure.

(b) <u>**The Functional Failure**:</u> This failure may or may not be accompanied by structural failure but in such that the pavement will not carry out its intended functions without causing discomfort to passenger or without causing high stresses in the vehicle that passes over its surface.

**Functional Failures Associated to Roads are**:

(a) Rutting-depression i.e about 10mm deep and may seems negligible when visualising the road but causes unsmooth driving due to settlement of the materials.

(b) Corrugation: This is the segregation of fill material into compacted ridges with depression in between.

(c) Dusty problem (peculiar in dry season) and

(d) Erosion problem (peculiar in Rainy Season). (5)

## CHAPTER THREE

## 3.0 METHODOLOGY

When constructing or rehabilitating engineering projects, there is a choice between using technology dominated by mechanical equipment or dominated by labour. Here emphasise is on the use of both labour and equipment based methods. Manual methods were used to identify site condition, collect soil samples and traffic datas and some of these datas particularly the soil sample were further tested with mechanical based equipment in the laboratory.

## 3.1 TRAFFIC SURVEY

This provides technical data on which the design of the highway will be based. A traffic survey of one kind or the other will be required otherwise a false assessment of the potential traffic requirement of the road resulting in most of the road being unable to handle the volume of traffic on completion.

### (a) Type Of Traffic Volume Survey:

There are two methods of conducting traffic volume survey namely:

1. Traffic manual count and
2. Automatic counter operated from tube.

### i Traffic Manual Count Method:

This method was adopted by the author for 4-days on (8 hourly) daily. Here, the volume of traffic using the road can be measured by counting vehicles using a fixed point in one or both direction, the passing of a vehicle is recorded by the author on a special form known as classified traffic census form (See specimen in appendix ii).

ii. **Automatic Count Method:**

Here, the passing of vehicle can be recorded automatically by special equipment used in conjunction with some form of vehicle detector. The type commonly used is the pneumatic detector which consist of a length of thick wall rubber tube fasten to the surface of the road and perpendicular to the direction of traffic flow. the passage of a vehicle over the cable transmit a pressure purse through the tube which operates an electrical contact on the diaphram switch so actuating a counter which is arranged to register every passage in order to a corresponding one count per vehicle.

## 3.2 SOIL SURVEY

This forms an important part in the design of a road as it is one of the major determinants of foundation treatment requirement for highways. Therefore, relevant tests were performed in the laboratory in order to determine the engineering properties of the soil and to ascertain the capabilities of the various components of the pavement(9).

a) **Determination Of Existing Moisture Content**

The moisture content is defined as the weight of water contained in a given soil mass compared with the ovendry weight of the soil and its usually expressed as a percentage.

In the laboratory, moisture content is usually determined by selecting a small representative sample of soil and placing it in a 'tared container'. Care is taken not to allow loss of water through evaporation.

**Method**

The weight of the wet soil sample and container are determined and the sample is then brought to constant weight by drying for 24 hours in an oven at a temperature between 100°c and 110°c after constant weight has been attained, the sample is taken from the oven and cooled in a desiccator and the oven dried weight of the sample is determined and all weights are recorded in grams. (4).

i. **Objective Of Determining Existing Moisture Content**

The value of moisture content determines the compaction value obtainable on site and maximum compaction obtained at optimum moisture content

(b) **Compaction Test**

Compaction is the process of mechanically pressing together the particles of a soil to reduce the proportion of air voids and increase the soil density. the moisture content at which maximum dry density (MDD) is obtained for a given amount of compaction is known as the optimum moisture content (OMC).

**Apparatus:** B.S Cylindrical metal mould, Extension-collar, Scoop, Rammer, Weigh balance, Drying oven, trowel, mixing tray, sample extruder and straight edge.

**Method:** 3000g of an air dry soil sample which was passed through sieve 20mm was thoroughly mixed with water starting with 5½ % (165mls) of water to give a fairly low moisture contact.

A specimen was formed by compacting the well-mixed soil in a B.S mould with the extension-collar attached. The compaction is in 3 layers and each layer being given 25 blows from a 2.5 kg rammer with a head diameter of 50mm and falling freely from 300mm above the top of the soil. During the process of compaction, the mould was placed on a rigid base. After completion of compaction, the extension-collar was removed and the top of the mould which should not project more than 6mm was carefully trimed level with the mould using a straight edge. The weight of the mould and specimen were recorded. A portion of the specimen was taken from both the top and bottom for moisture content determination. The compacted soil was broken down and mixed with the rest of the original soil. Reasonable increase of water about 2½% was added and the test repeated. This procedure is continued until the weight of the wetsoil in the mould passes a value and then begin to decrease. A graph of moisture content against dry density is then plotted to obtain maximum dry density ($P_d$ max.) at optimum moisture content (OMC).

**Estimating The Subgrade Strength**

The strength of road subgrade is commonly assessed in terms of the 'Californina Bearing Ratio' (CBR) of the subgrade soil and this is dependent on the type of the soil, its density and its moisture content.

The density of the subgrade soil can be controlled within limits by compaction at a suitable moisture content at the time of construction. the moisture content (MC) of the subgrade soil is governed by the local climate and the depth of the ground water table below the road surface. For designing the thickness of a road pavement, the strength of the subgrade should be taken as that of the subgrade soil at a moisture content equal to the wettest moisture condition likely to occur in the subgrade after the road is opened to traffic (1).

**California Bearing Ration (CBR)Test**

This test was carried out in the laboratory to determine the criteria with which the pavement under analysis has to be designed. It should however be noted that the CBR test is not practicable if the material to be investigated contains an appreciable amount of material coarser than 3/4 inch.

**Apparatus:** Cylindrical metal mould, metal rammer, a balance sensitive to 1gm, A palette knife, A straight edge, A 3/4 inch. Sieve and receiver, metal-tray, sample extruder and Apparatus for moisture content determination.

**Method:** 6kg of the soil sample was weighed and poured into the mixing tray. The optimum moisture content of the sample calculated from compaction test was measured and used for the rough mix. the Cylindrical mould was then filled with the sample and compacted in 5 layers with each layer given 62 blows of 4.5kg rammer. the sample was then levelled off to the top of the mould and weighed. Both the compacted sample in the mould and the two collars were fixed on the penetrating machine and the standard plunger was forced into the sample at constant rate of 12.5mm/min. Measurement of applied load and plunger penetration were made at regular intervals, the CBR for the sample was obtained by dividing the plunger loads at penetrations of 2.5mm and 5.0mm by the loads given at the same penetrations on a standard clean crush stone. The loads given by the soil under test are expressed as percentage of the standard load and the lower value of the two is taken as the CBR value for design.

# CHAPTER FOUR

## 4.0 RESULTS AND DISCUSSIONS

It should be recall that an assessment of the strength of the subgrade soil over which the road would pass and an estimation of the amount of traffic that will use the road over a selected design life are prerequisite when planing or re-aligning an existing road so as to enable the road to perform satisfactorily without deformation during its design life. Therefore, the result of the soil and traffic surveys conducted in this project work is carefully analysed below.

4.1 **SOIL ANALYSIS**

(a). **Table II Shows The Determination Of Existing Moisture Content Of The Road Materials**

| TEST NO. | 1 | | 2 | | 3 | |
|---|---|---|---|---|---|---|
| Material No. | Base | | Subbase | | Subgrade | |
| Depth of Sample | Base | Layer | Subbase | Layer | 1.0 metre | |
| Container No. | 116 | 77 | 54 | 03 | 65 | 38 |
| Weight of Wet Soil Plus Container $W_1$ | 40.4 | 43.9 | 37.2 | 43 | 41.6 | 42 |
| Weight of dry Soil Plus container $W_2$ | 37.7 | 41.0 | 33.4 | 38.1 | 37.4 | 37.7 |
| Weight of Container Wc | 9.5 | 8.8 | 9.5 | 9.4 | 8.9 | 9.4 |
| Weight of Moisture | 2.7 | 2.9 | 3.8 | 4.9 | 4.2 | 4.3 |
| Weight of Dry Soil | 28.2 | 32.2 | 23.9 | 28.7 | 28.5 | 28.3 |
| M.C(%)= $\frac{W_1-W_2}{W_2-W_c}$ x 100 | 9.57 | 9.01 | 15.9 | 17.07 | 14.74 | 15.19 |
| Average M.C | 9.29% | | 6.49% | | 14.97% | |

b. **Compaction**: test objective: It is aimed at reducing the proportion of air voids and increase the soil density (See result of Compacting below) - Where

$M_1$ = mass of mould

$M_2$ = mass of mould + Soil

W = moisture Content (as decimal)

Bulk density ($P_b$) = $\frac{M_2-M_1}{10^3}$ mg/m³

$$\text{Dry density } (P_d) = \frac{P_b}{1+W} \text{ mg/m}^3$$

i $\quad \frac{1.748}{1+0.083} = 1.61$

ii $\quad \frac{1.920}{1+0.109} = 1.73$ etc

The graph shown below reveals the maximum dry density ($P_d$ max) at optimum moisture content (OMC).

(See graph in Fig 3) MDD = 1.794

OMC = 13.12

c. **Result Of CBR Experiment**

The CBR value is calculated at both 2.5mm and 5.0mm penetration as follows.

i. Convert the proving ring dial gauge reading to force by multiplying the reading by ring factor and in some machines you take the reading of the applied force directly

ii. Divide this value by 13.24 for 2.5mm penetration and 19.96 for 5.0mm penetration.

NOTE: These values 13.24 and 19.96 are constant factors as they are the corresponding values of penetration for crushed stone on which the test is based.

$$\text{CBR } (\%) = \frac{\text{Applied Force}}{13.24 \text{ or } 19.96} \times 100$$

*FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA,*

CIVIL ENGINEERING DEPARTMENT

DETERMINATION OF THE MOISTURE/DENSITY RELATION OF SOIL USING STANDARD*/HEAVY* COMPACTION

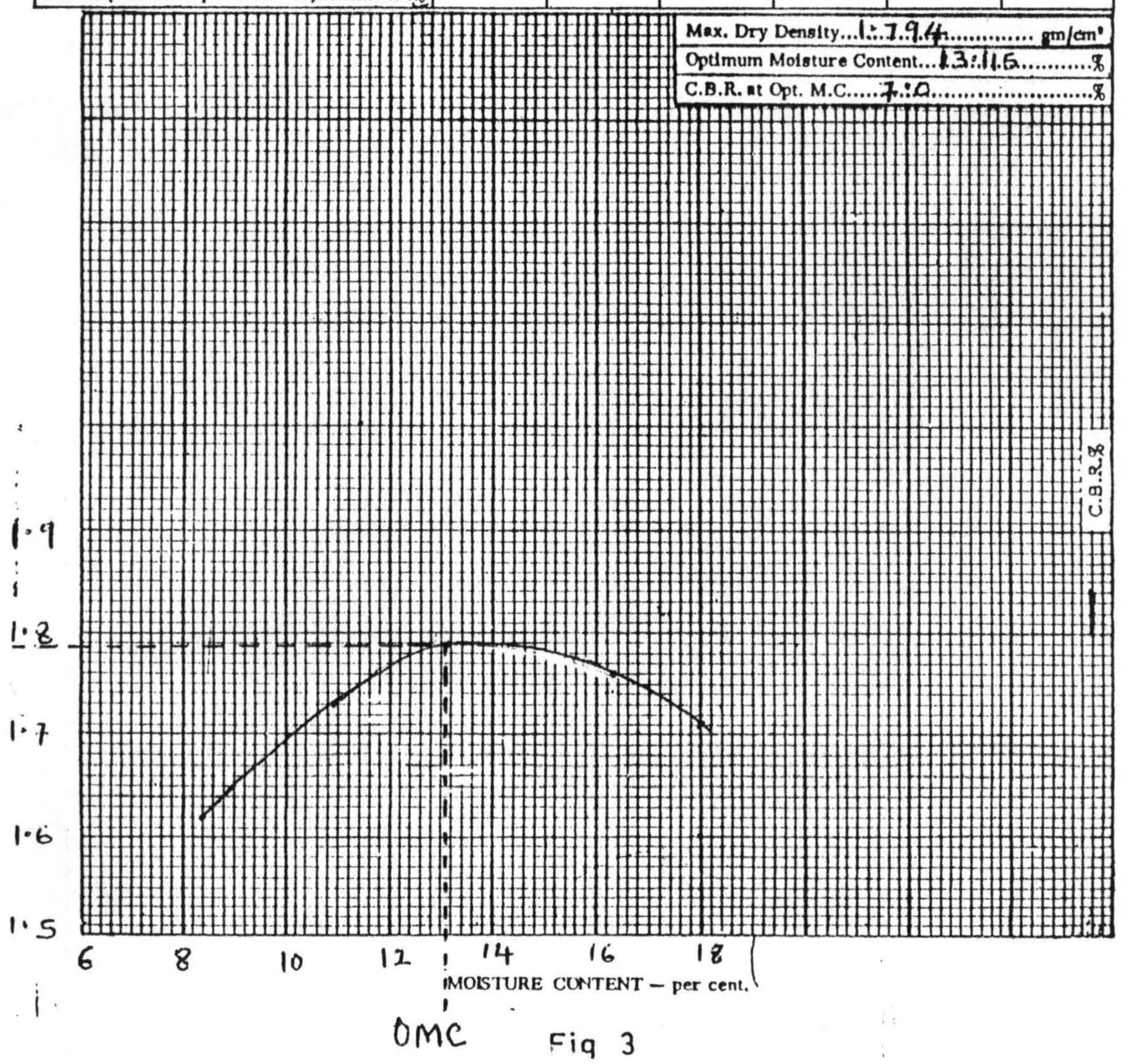
Job. REHABILITATION .... Sample No. SUBGRADE ..... Operator.. SULEMAN R.A
Site...... KUBWA ............. Depth... 1.2m ................ Date.. 02 - 02 - 2000
Amount retained on 20mm B.S. Sieve.........g..... Total weight of sample....... 3000 g.....
B.S.*/C.B.R.* Mould....................................................*Delete the inappropriate word

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Wt. of mould and wet soil..........($W_2$)..........g.... | 3768 | 3940 | 4047 | 4060 | 4029 | | |
| Wt. of mould..........................($W_1$)..........g.... | 2020 | 2020 | 2020 | 2020 | 2020 | | |
| Wt. of wet soil..............($W_2 - W_1$)..........g.... | 1748 | 1920 | 2027 | 2040 | 2004 | | |
| Bulk density $\gamma = \frac{W_2 - W_1}{X}$ .................. gm/cm³ | 1.748 | 1.920 | 2.027 | 2.040 | 2.004 | | |

MOISTURE CONTENT DETERMINATIONS

| Container No. | 54 | 16 | 29 | 40 | 83 | 202 | 48 | 52 | 84 | 02 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wt. of wet soil and container.................g.... | 41.0 | 32.5 | 38.8 | 30.9 | 27.4 | 37.8 | 36.1 | 39.0 | 33.9 | 41.5 | | |
| Wt. of dry soil and container.................g.... | 38.5 | 30.7 | 35.8 | 28.8 | 25.3 | 34.5 | 32.3 | 34.8 | 30.6 | 36.5 | | |
| Wt. of container.................................g.... | 9.5 | 8.5 | 9.4 | 8.8 | 9.3 | 9.3 | 8.8 | 9.5 | 8.7 | 8.7 | | |
| Wt. of dry soil ($W_d$)............................g.... | 29.0 | 22.2 | 26.4 | 20.0 | 16.0 | 25.2 | 23.5 | 25.3 | 21.9 | 27.8 | | |
| Wt. of moisture ($W_m$) ...........................g.... | 2.5 | 1.8 | 3.0 | 2.1 | 2.1 | 3.3 | 3.8 | 4.2 | 3.4 | 5.0 | | |
| Moisture content 100 $W_m/W_d$.....................% | 8.62 | 8.11 | 11.36 | 10.50 | 13.13 | 13.10 | 10.17 | 16.60 | 17.44 | 17.48 | | |
| Average moisture content (m)...................% | 8.365 | | 10.930 | | 13.115 | | 16.385 | | 18.00 | | | |
| Dry density $\gamma_d = 100\gamma/100+m$.......... gm/cm³ | 1.619 | | 1.730 | | 1.794 | | 1.759 | | 1.711 | | | |
| C.B.R. (mean of top and bottom)..............% | | | | | | | | | | | | |

Max. Dry Density... 1.794 ............ gm/cm³
Optimum Moisture Content... 13.116 ..........%
C.B.R. at Opt. M.C..... 7.0 ......................%




MOISTURE CONTENT — per cent.

Fig 3

**Calculations of Subgrade Strength (CBR value)**

At 2.5mm penetration

$$\text{Top value} = \frac{1.23}{13.24} \times 100 = 9.3\%$$

$$\text{Bottom value} = \frac{1.11}{13.24} \times 100 = 8.4\%$$

At 5.0mm penetration

$$\text{Top value} = \frac{1.57}{19.96} \times 100 = 7.8\%$$

$$\text{Bottom value} = \frac{1.39}{19.96} \times 100 = 6.9 = 7.0\%$$

The lowest of all of these values is 7.0% and this is taken as the CBR value for the design i.e assuming the worst situation. The same test was done for the subbase layer and a CBR value of 7.1% was obtained.

## 4.2 TRAFFIC ANALYSIS

Both Road Notes 29 and 31 prepared by Transport and Road Research Laboratory specify that private cars do not contribute significantly to the structural damage caused to road pavement by traffic. Only the total number and axle loading of commercial vehicles are considered for design purposes and cars are ignored. Commercial vehicles are goods or public service vehicle with unladen weight of 1500kg or more.

Here, the Author did not ignore private cars as it is believed that we are not traffic cultured in Nigeria hence private cars also contribute (however little) to the structural damage of our type of roads.

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA

DEPARTMENT OF CIVIL ENGINEERING

CONTRACT: REHABILITATION WORK

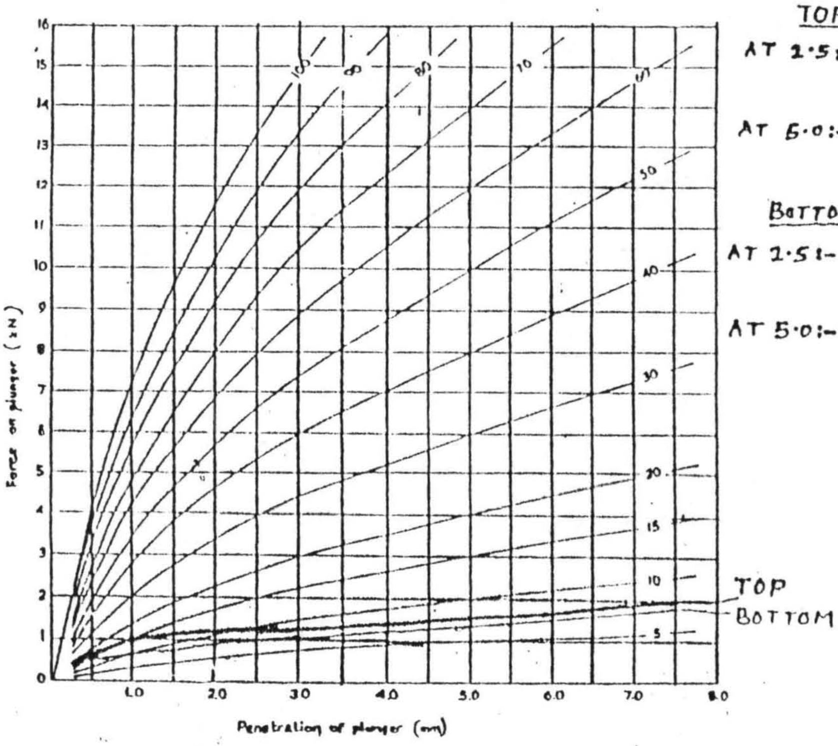
## COMPACTION/C.B.R. TEST

## PROCTOR/B.S./MOD AASHO

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Wt. of cyl. and wet soil – gm(lb) | | | | | | | | | | |
| Wt. of cylinder – gm (lb) | | | | | | | | | | |
| Wt. of wet sample – gm (lb) | | | | | | | | | | |
| Wet density – Kg/m 3 (lb/ft3) | | | | | | | | | | |
| Container No | | | | | | | | | | |
| Wt of cont and wet soil gm (lb) | | | | | | | | | | |
| Wt. of cont. and dry soil gm (lb). | | | | | | | | | | |
| Wt. of water – gm (lb) | | | | | | | | | | |
| Wt. of container – gm (lb) | | | | | | | | | | |
| Water content % | | | | | | | | | | |
| Dry density kg/m3 (lb/ft 3) | | | | | | | | | | |

PENETRATION

| Penetration of plunger | Force on plunger X | X | Penetration of plunger | Force on plunger X | X | Penetration of plunger | Force on plunger | |
|---|---|---|---|---|---|---|---|---|
| mm | Top kN | Bottom kN | mm | Top kN | Bottom kN | mm | Top kN X | Bottom kN X |
| 0.25 | 29 | 40 | 2.75 | 126 | 113 | 5.25 | 161 | 142 |
| 0.50 | 57 | 53 | 3.00 | 129 | 115 | 5.50 | 166 | 142 |
| 0.75 | 89 | 60 | 3.25 | 132 | 118 | 5.75 | 169 | 142 |
| 1.00 | 111 | 67 | [illegible] | 138 | 121 | 6.00 | 183 | 152 |
| 1.25 | 113 | 73 | [illegible] | 139 | 124 | 6.25 | 185 | 155 |
| 1.50 | 115 | 77 | [illegible] | 142 | 127 | 6.50 | 188 | 153 |
| 1.75 | 118 | 83 | [illegible] | 144 | 130 | 6.75 | 190 | 160 |
| 2.00 | 120 | 90 | [illegible] | 149 | 132 | 7.00 | 193 | 162 |
| 2.25 | 121 | 99 | [illegible] | 153 | 136 | 7.25 | 196 | 164 |
| 2.50 | 123 | 111 | [illegible] | 157 | 139 | 7.50 | 200 | 162 |




TOP PENETRATION:

AT 2·5:- $\frac{1\cdot 23}{13\cdot 24} \times 100 \approx 9\cdot 3\%$

AT 5·0:- $\frac{1\cdot 57}{19\cdot 96} \times 100 = 7\cdot 86\%$

BOTTOM PENETRATION:

AT 2·5:- $\frac{1\cdot 11}{13\cdot 24} \times 100 = 8\cdot 4\%$

AT 5·0:- $\frac{1\cdot 39}{19\cdot 96} \times 100 = 7\cdot 0\%$

Fig 4

Therefore, $\frac{200}{8}$ = 25 commercial vehicle per hour

Then, $\frac{200}{8}$ x 24 hours = 600 Commercial vehicle per day (Both directions).

$\frac{600}{2}$ = 300 Commercial vehicle (one-direction).

We now establish the cumulative commercial vehicle expected to use this road during its design life. To do this, the traffic growth rate and the design life must be established to give a multiplying factor thus:

- Chosen design life of 10 years (Author's discretion)
- Use 2.5% traffic growth rate[10].

Relating these two informations together then consult the AASHO (RN31[1]) fig5, to get a multiplying factor which is 0.4. This factors enables the damaging power of axle load of different magnitude to be expressed in term of an equivalent number of standard commercial vehicle.

0.4 x $\frac{300}{100}$ = 1.2 (million) cumulative Commercial vehicle expected to use this road during its design life.

We now convert this value 1.2 (million) cumulative commercial vehicle to standard axle.

Recall that the damaging effect of 100 commercial vehicle is equivalent to 50 (8200kg) standard axle (Design standard in RN31[1]).

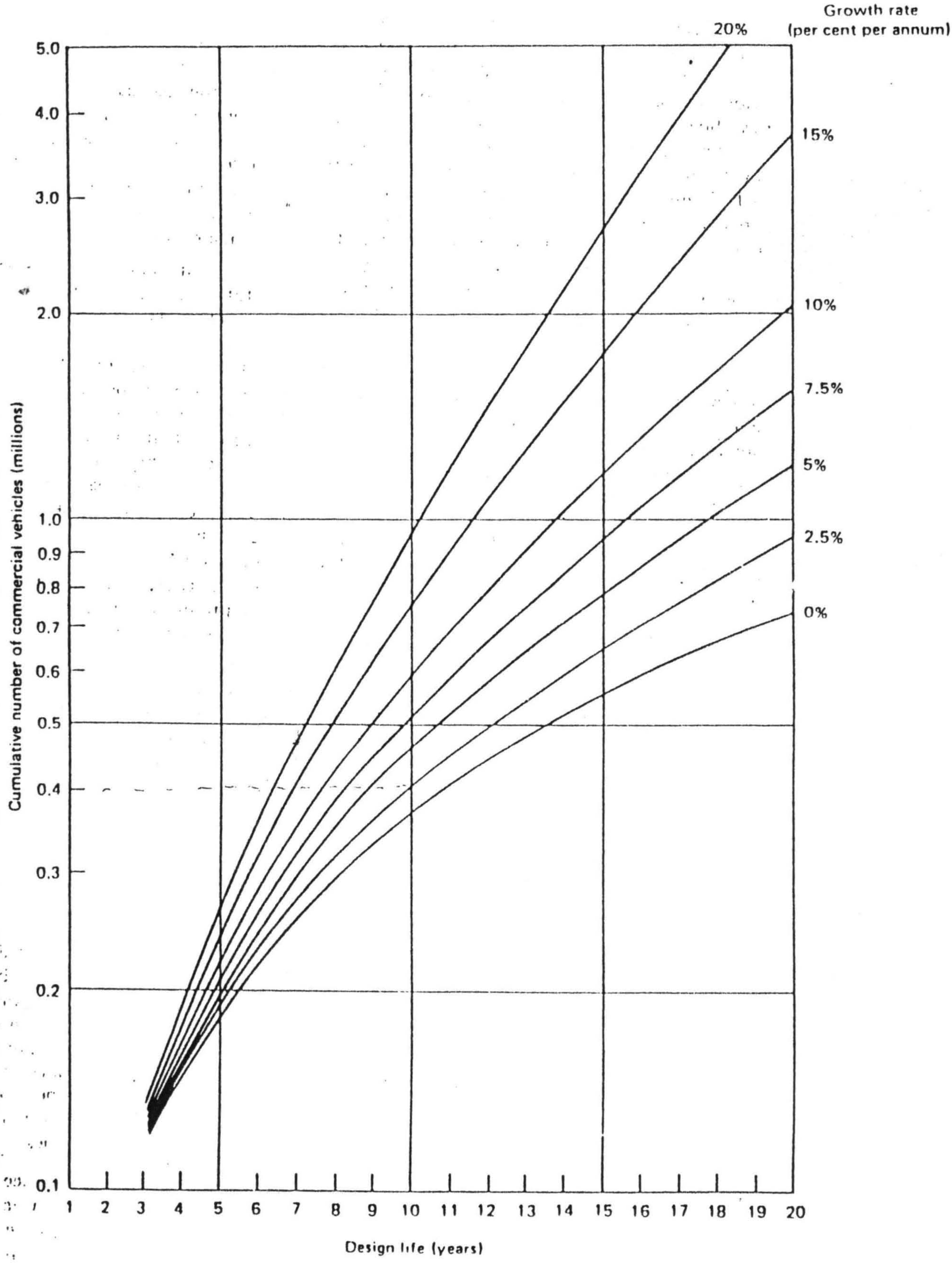



FIG NUMBER OF VEHICLES USING A ROAD DURING DESIGN LIFE AND GROWTH RATE FOR AN ADT OF ONE HUNDRED COMMERCIAL VEHICLES PER DAY IN THE INITIAL YEAR

Fig 5

Therefore, 1No. commercial vehicle =50/100 = ½ standard axle.

1.2 million cummulative commercial vehicle x ½ = 0.6 cumulative nsumber of standard axle (million) then, 0.6 million cumulative number of standard axle should be used in the design.

## 4.3 DISCUSSIONS

From the aforementioned experiment conducted on this road, the tests revealed the followings:

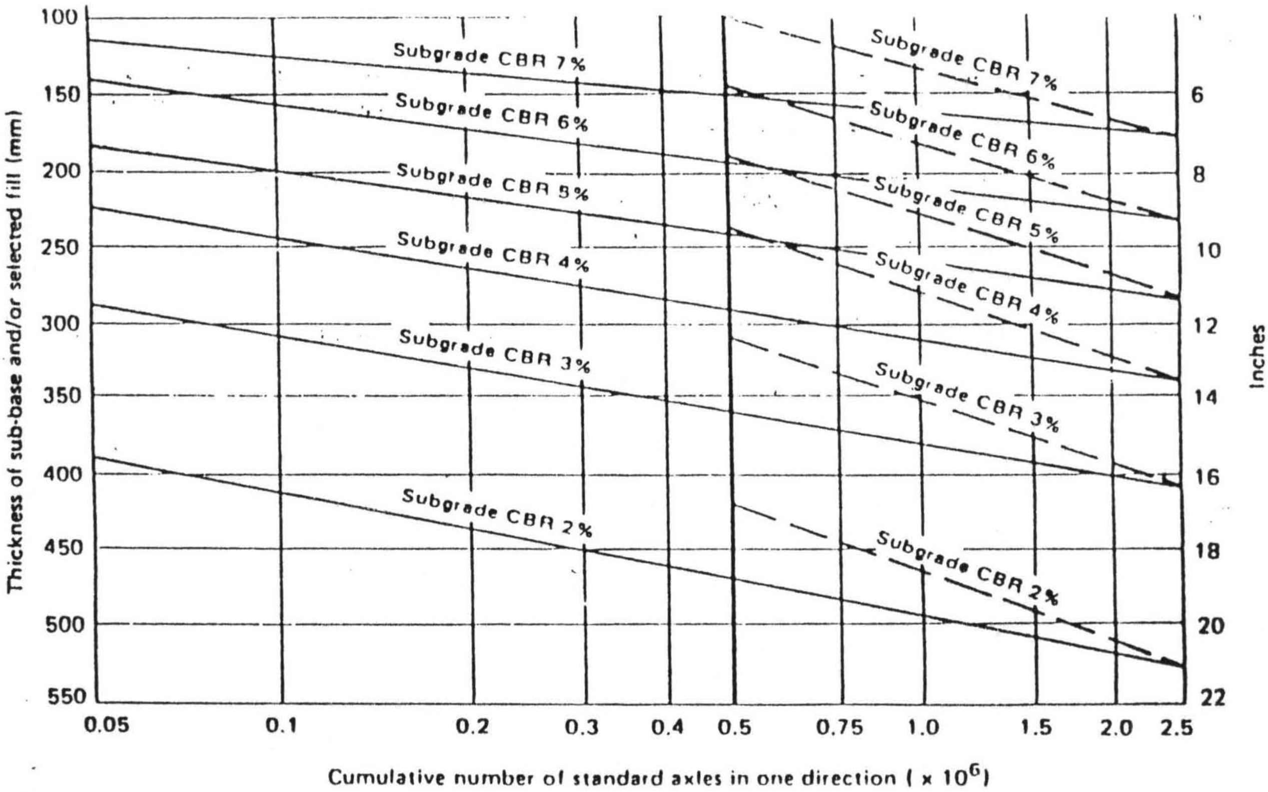
(a) That low quality soil was employed for subbase layer, both the subgrade and the subbase materials have a CBR of 7.0% and 7.1% respectively.

(b) The tests revealed that compaction of the existing road was inadequate.

(c) Traffic volume was underestimated as seen from the thickness of various layers of existing pavement.

(d) Sight inspections revealed that the road lacks effective drainage facilities which enhances rapid deterioration of the pavement structure.

(e) Thorough supervision was lacking and evident from the unevenness of the pavements layers. All of these have been redressed in the proposed reworked design.




If it is desired to provide at the time of construction a pavement capable of carrying more than 0.5 million standard axles, the designer may choose either a 150mm (6in) base with a 50mm (2in) bituminous surfacing or a 200mm (8in) base with a double surface dressing. For both of these alternatives, the recommended sub-base thickness is indicated by the broken line.

Alternatively, a base 150mm (6in) thick with a double surface dressing may be laid initially and the thickness increased when 0.5 million standard axles have been carried The extra thickness may consist of 50mm (2in) of bituminous surfacing or at least 75mm (3in) of crushed stone with a double surface dressing. The largest aggregate size in the crushed stone must not exceed 19mm (¾in) and the old surface must be prepared by scarifying to a depth of 50mm (2in). For this stage construction procedure, the recommended thickness of sub base is indicated by the solid line.

PAVEMENT DESIGN CHART FOR FLEXIBLE PAVEMENTS



Fig 6

## CHAPTER FIVE

## 5.0 PAVEMENT DESIGN

The structural or pavement design of the road is the process in which the various layers of the pavement are selected so that they are capable of supporting the traffic as long as required. The principal elements in this process are the choice of materials and their thickness for each pavement layer.

For structural design, roads can be classified as follows:

i. Unimproved earth roads and tracks

ii. Gravel surfaced roads

iii. Roads incorporating pavement quality concrete Rigid pavement.

iv. Roads incorporating bituminous materials (Flexible pavement)

(Fig 2 Illustrates this).

**Pavement Design Aim:** Pavements are designed to protect the natural ground or subgrade from the high and concentrated load stresses which would be applied to the subgrade by wheels of vehicle, whilst at the same time ensuring that the pavement layers are strong enough to support the traffic.

### 5.1 Factors Affecting Flexible Pavement Design

The structural design of road pavement depends primarily on the following factors:

(a) Strength of the subgrade

(b) Traffic Loading

(c) Materials

(d) Variability and uncertainty in the above three item and in the quality control of the construction process.

In addition, the structural performance of the road will depend on the adequacy of drainage measures within the road structure, the design of the shoulders and the level of maintenance.

(a) **Strength of the Subgrade**: The important factor which controls the pavement thickness is the strength of the subgrade soil. This in turn, depends on the type of soil, its moisture content and the level of compaction (density) achieved during construction. The thickness of pavement required to carry a particular traffic level is very sensitive to subgrade strength when the subgrade is weak, but insensitive to subgrade strength when the subgrade is very strong.

The strength of the subgrade can be changed with time as a result of moisture charges in the soil. Such changes are often associated with poor maintenance and are therefore unpredictable. Designers often include substantial safety factors at this stage of the design process. It is important to estimate the strength of the subgrade under the most likely adverse conditions as discussed in chapter 3 of this project work.

(b) **Traffic Loading:** The second important factor influencing pavement thickness is traffic loading. The damage that vehicles do to a road depends very strongly on the axle loads of the vehicles.

(c) **Materials:** The choice of materials for the construction of the pavement layer is another factor which influences the pavement thickness. This becomes most significant for the design of very heavy trafficked roads and depends on the detailed mechanisms of deterioration for each type of material.

(d) **Uncertainty and Variability**

The design must take account of inherent variability in the materials, variability in the quality control, uncertainties associated with climate; In particular, rainfall and depth of water table and uncertainties in future maintenance, future vehicle axle loading and traffic flow level. (1)

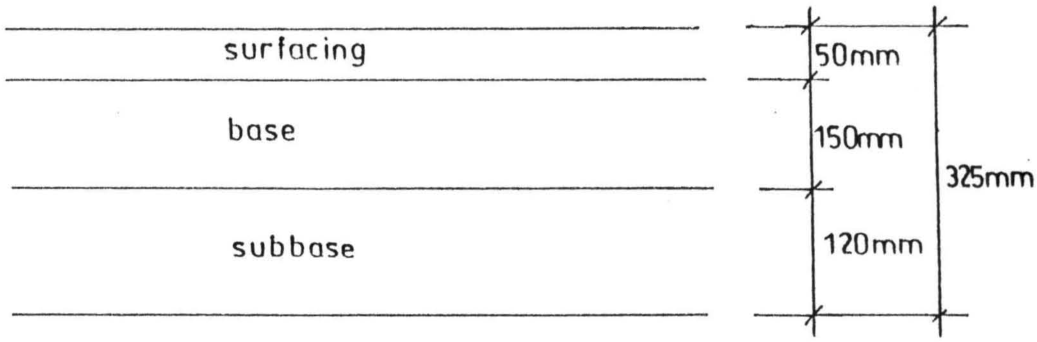
## 5.2 Design Method

i. The California Bearing Ratio (CBR) method was applied for thickness design of the flexible pavement structure. The method used was based on the deformative character of the subgrade soil. The character of the subgrade soil was tested in the laboratory and a given stress that produced the standard penetration of plunger was determined and compared against that of crushed stone.

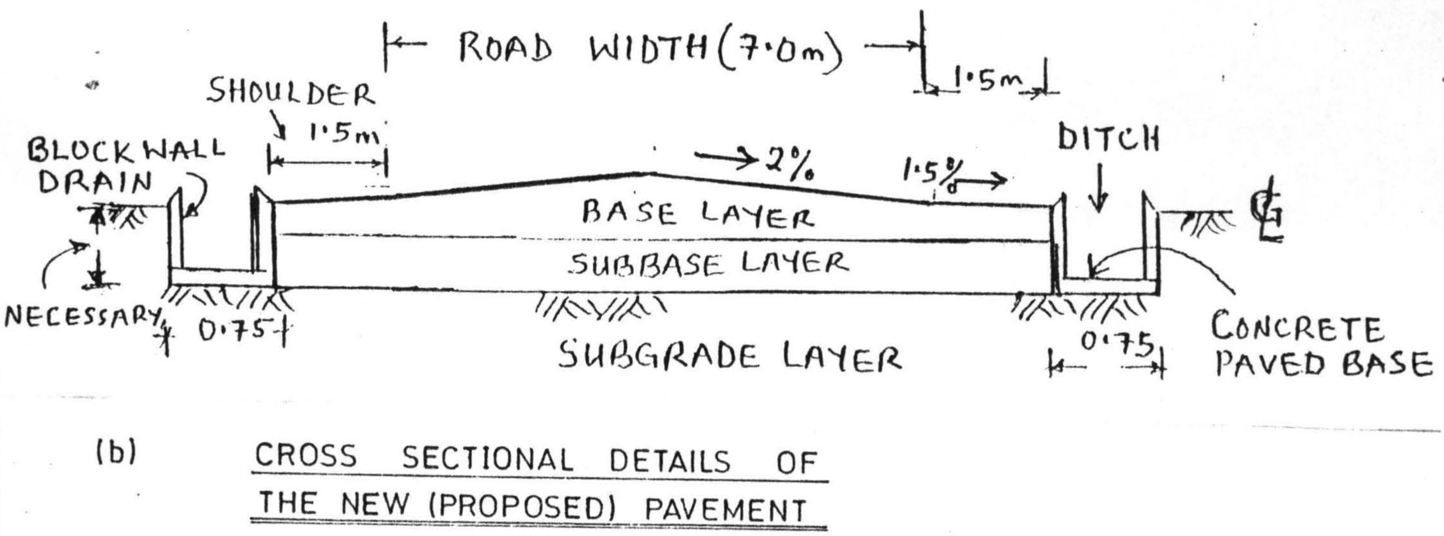
From the soil analysis, a CBR of 7.0% was obtained as subgrade value and is being considered for the flexible pavement design.

**Commercial Vehicle Loading**

Refer to chapter 4 of this project work where the Author gave an estimate of 0.6 million cumulative number of standard axle that will use the road during its design life and all of these values were used in this design.




(a) DIAGRAM OF DESIGNED LAYER OF A FLEXIBE PAVEMENT.




(b) CROSS SECTIONAL DETAILS OF THE NEW (PROPOSED) PAVEMENT

Fig 7

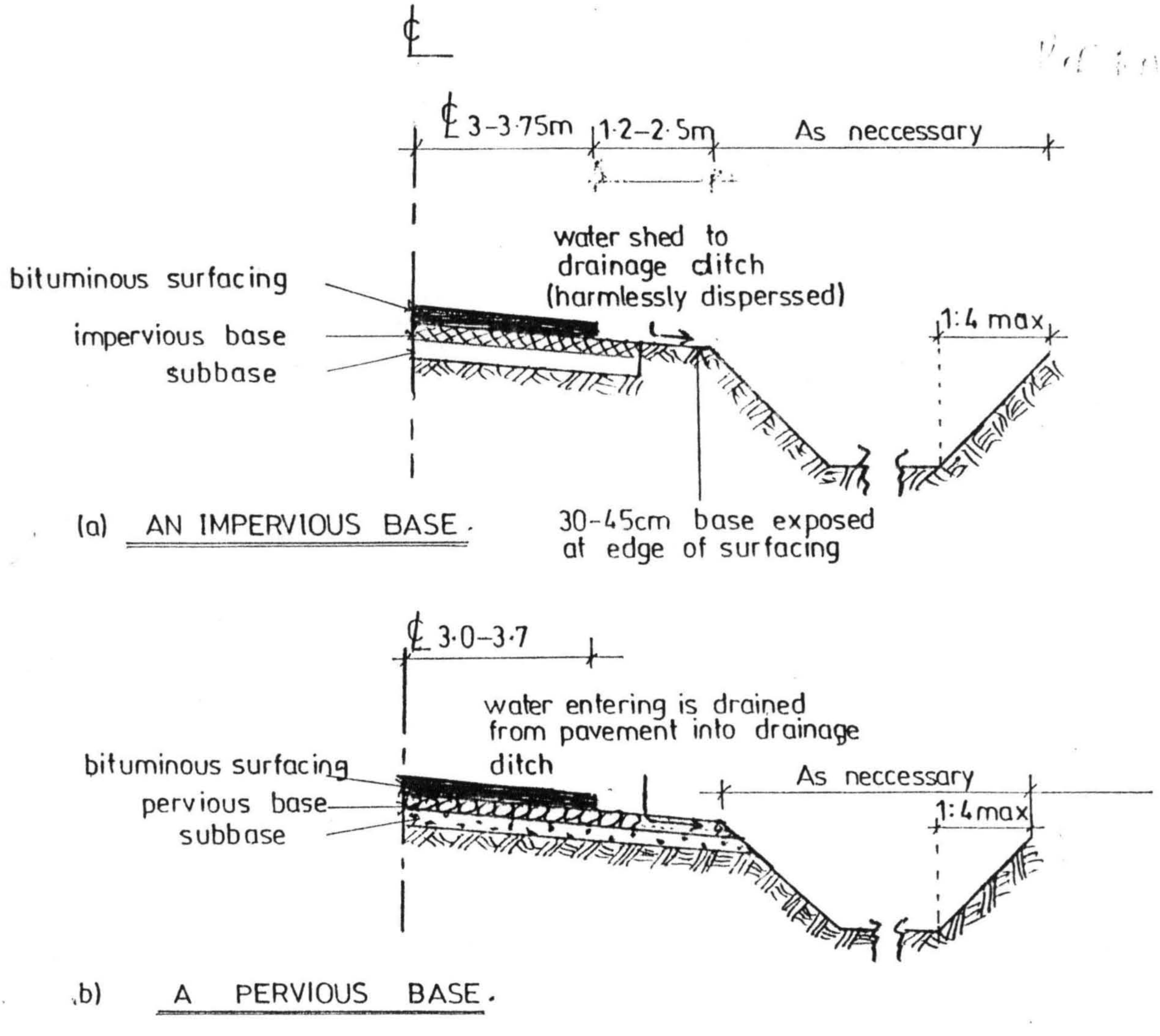
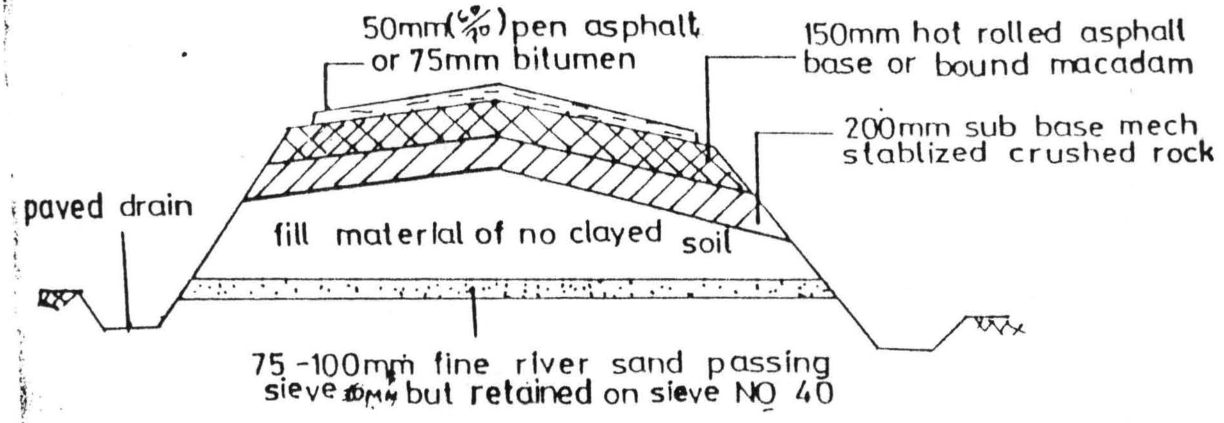
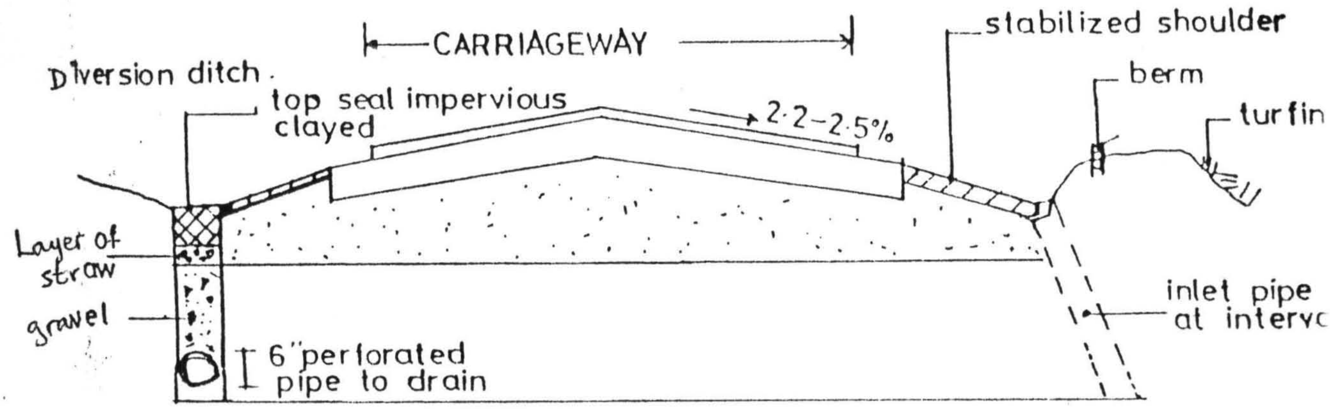



Fig 8 DRAINAGE OF PAVEMENT LAYERS Ref· RN 31




FILL TREATMENT




CUT TREATMENT

Fig 9 CUT AND FILL TREATMENT AT HIGH WATER TABLE

ii. **DESIGN PROCEDURE**

From Analysis:

i. CBR value = 7.0%

ii. The cumulative number of standard axle = 0.60 (million)

iii. A growth rate of 2½% is used 10

Refer to pavement design chart for flexible pavement (Fig 6 ). This gives the following pavement components for the proposed design.

a. Surfacing = 50mm

b. Base thickness = 150mm

c. Subbase thickness = 120mm.

(See detail in fig 7)

## 4.3 DRAINAGE OF PAVEMENT LAYERS

The road must be designed either to shed water completely or to permit the egress of any water which may enter it. When impermeable base material are used, drainage of the base is not necessary and the cross section shown in Fig 8a below can be adopted but when permeable base material are used particular attention must be given to the drainage of the base layer. Ideally the base and subbase should extend right across the shoulder to the drainage ditches and the surface of the subbase layer should be given a generous crossfall at the shoulders to assist drainage as shown in fig 8b below.

If it will be too costly to extend the base and subbase material across the shoulder, drainage ditches at 3 to 5m intervals should be cut through the shoulder of the road to a depth of 50mm below subbase level. Such ditches should be backfilled with base material or more permeable material and be given a fall of 1:10 to the side ditch. (4)

# CHAPTER SIX

## CONCLUSIONS AND RECOMMENDATIONS

### 6.0 CONCLUSIONS

The problem of rehabilitating a failing access road has been presented giving analysis of factors responsible for roads failures. This farm road if rehabilitated and maintained would improved the agricultural activities of this community and save it from isolation.

Towards this end concerted efforts are required from both the government and the engineers. The government should inject necessary fund and formulate favourable policies for sustainability of roads while the engineers on their part should be prepared to face the challenges of good road design, ensure proper construction, supervision and embibe maintenance culture.

A designed road is said to be satisfactory only if it last its design life before restrengthening is required. The failure of IITA access road is attributed to the following.

i Over economic design: The research reveals that the thickness of existing pavement layers are; 25mm surfacing, 100mm base and 100mm subbase layers respectively and this is contrary to the standard design proposed.

ii The use of poor quality soil material: Soil analysis shows that the same quality of material as subgrade was used for subbase layer i.e they all have a california Beaing ratio of 7.0%. Insufficient compaction was also observed.

iii Underestimated traffic volume: The traffic census conducted on this road indicate that the traffic volume was underestimated. The existing information was based on assumption.

iv Inadequate supervision: This fact is supported from the uneven thickness of the surfacing, base and subbase layers.

v Non existent drainage structure such as culvert on junctions and efficient side drains.

## 6.1 RECOMMENDATIONS

It is possible to construct a road with small amount and yet use a larger amount as time lapses for its maintenance. This problem can be averted if the ideal construction approach is adhered.

The survey and analysis conducted on this road reveals many differences particularly as it affects the design, construction and drainage problem which can be improved through the undermentioned recommendations.

**Soil Survey:** After laboratory test to confirm suitability of the soil used in the construction, the test reveals low quality soil and it is recommended that for a subgrade of 7% CBR value the subbase should have a CBR of not less than 40% for 120mm thickness and the base material should have a CBR value of not less than 60% for a thickness of 150mm as proposed in the new design. Where the subgrade bearing capacity in its natural state is low, then the subgrade requires to be blended by stabilization.

**Pavement Design**

The proposed design in chapter 5 of this project should be complied with by providing a total pavement thickness of 320mm and all materials usually shall be of approved quality and complying with Nigeria Standard.

**Drainage Facilities**

Drainage control on this road is poor and in some places they are nonexistent given rise to erosion, potholes etc. It is now recommended that functional side drain and culvert be provided at specified position. The treatment at highwater table should be in compliance with chapter 5 of this project work.

**Construction Approach**

It is recommended that the construction of this road be accompanied with severe supervision and all the construction materials must be of approved quality and complying with Nigeria standard.

**Upgrading:** Headwall should be provided at the end of culvert (where they are damaged or omitted) and appropriate road signs should be mounted were they are non-existent while damaged ones should be replaced to help reduce accident rate.

It is hoped that if all of these afforementioned recommendations are strictly adhered in compliance with the author's directives, then there is no doubt that this road would perform satisfactorilly well with minimum routine maintenance.

**REFERENCES**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# APPENDICES

# APPENDIX II

**TRANSPORT and ROAD RESEARCH LABORATORY**
OVERSEAS UNIT

**CLASSIFIED MANUAL TRAFFIC COUNT**

Sheet No.

ENUMERATOR: RASHEED S.A

CENSUS POINTS: IITA FARM CORRIDOR

PROVINCE: BWARI | DISTRICT: KUBWA | SITE LOCATION: KUBWA | DAY & DATE: OCTOBER, 1999

| VEHICLE CLASS | HOURS ENDING: MONDAY | TUESDAY | FRIDAY | SATURDAY | TOTALS |
|---|---|---|---|---|---|
| PASSENGER CARS | | | | | |
| LIGHT GOODS | | | | | |
| MEDIUM GOODS | | | | | |
| HEAVY GOODS | | | | | |
| BUSES | | | | | |
| TOTALS | | | | | |
| OTHERS | | | | | |

Fig. 6 FORM FOR RECORDING CLASSIFIED MANUAL TRAFFIC COUNT

APPENDIX II

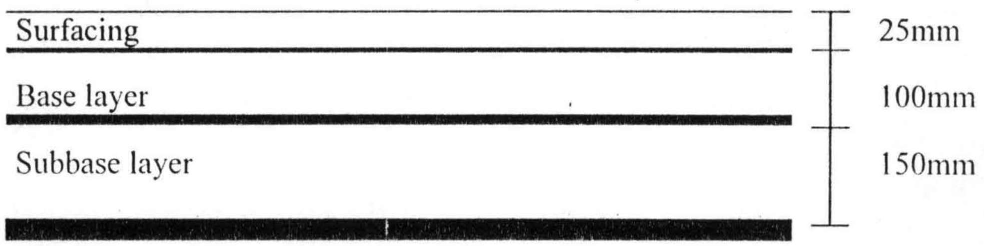
## APPENDIX III

Parameters used in the failed road are:-

(a) Growth rate of 2%.

(b) The cummulateive number of standard axle 0.48 (million).

(c) Decision life of 10 years.




Component of the failed road.

# APPENDIX IV A

Plate 1 Stripping of aggregate from paved road.

Plate 2 Pothole on paved road

Plate 3 Roughness, fatting-up and lack of camber on paved road.

APPENDIX IV B

Plate 4 Standing water and pothole on paved road.

Plate 5 Fatting-up, standing water and debris on paved road.

Plate 6 Roughness and lack of camber on paved road.