STUDIES AND DESIGN OF FARM ACCESS ROAD.

(CASE STUDY: BARMO FARMS 850M)

BY

YUSUF MOHAMMED HABIB

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CERTIFICATION

This project title, farm access roads by Yusuf Mohammed Habib meet the regulation governing the Award of PGD agricultural Engineering (Soil & Water Engineering Option) with Federal University of Technology, Minna S.E.E.T.

Project Supervisor .... Engr. (Dr.) M.G Yisa

.... Head of Department

.... Engr. (Dr). M.G. Yisa

.... External Supervisor

....

DEDICATION

I hereby dedicate this project to my family, friends and relations and the entire human race.

ACKNOWLEDGEMENT

I gratefully acknowledged the courage and aid I received from fellow Nigerians who assisted me in this thesis. May Almighty Allah bless the knowledge acquired and make it useful to the entire human –race and me.

I further express my thanks to Engr. (Dr.) M.G. Yisa my project Supervisor for his guidelines and efforts in giving solutions to problems encountered. My colleagues in Civil Engineering Department Ministry of Works & Housing Minna for their individual contributed efforts and ideas for the achievement of this goal.

Finally my special thanks goes to all lecturers and staff of department of the Agricultural Engineering.

May Almighty Allah reward you all abundantly.

ABSTRACT

Access road studies and design is mainly carried out so as to improve access between farm to farm and community to community. In this work, physical inspection of the case study road was conducted to identify the existing features of the road.

The total length of the road was measured and recorded as 850m length. Survey of the road was conducted at interval of 50m and as well as collecting details required for vertical and horizontal curves. All the features identify during the inspection were recorded. The design made on the horizontal alignment was based on the survey carried out on site and details of formation levels. Soil samples was taken from the site for test in the laboratory. The test such as liquid limit, plastic limit, sieve analysis and CBR test are all carried out in this thesis and has been highlighted.

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CHAPTER ONE

1.0 INTRODUCTION

Like many other developing third world countries, unsurfaced or earth roads constitute a significant proportion of the national road network in Nigeria. Up to 70% of the rural roads in Nigeria are unsurfaced and these roads will definitely remain unsurfaced for a very long time to come because of the colossal amount of money that is required to provide surfaced roads to the entire Nigeria rural areas where more than 80% of the population live.

Earth roads built with tropical soil are not common feature of the national road network of the industrialized countries and as a result, very little attention has been paid to researchers in the design, construction and maintenance of earth roads.

Road network of the State:- There are three kinds of road network in Niger State. They are federal state and local government area roads. There are 1720km of federal roads in the state, of which 1550km are Bitumen and the rest is laterite. The state government has a total of 1337 km length of roads out of which 453km are bitumen and the remaining 884 kms are laterite type and local government areas has a total of 7,160 km of earth tracks except 616 km of laterite type of road. Generally, the popular mode of transport in the state is by road.

1.1 JUSTIFICATION

Agricultural extension workers find it difficult to reach the rural farming families in the interior to advice on the new technology and improved method of farming because of lack of all weather earth roads which is the major factor militating against agricultural development. Carrying of farm input i.e fertilizer, pesticides and insecticides become more difficult. Transportation of the harvested crops to the market become difficult and tedious.

Finally, the studies and design brought out of this thesis will help in solving the problems above.

1.2 OBJECTIVE OF THE WORK

The objectives of this thesis are:-

- To improve the quality of life of rural populace.
- To have good access to carry farm input to the farm and carry the harvested produce to the market.
- To reduce transportation cost to the minimum which will stimulate the integration of rural markets.

CHAPTER TWO

2.0 LITERATURE REVIEW

Access roads are required to enable the inhabitations of a farm to move freely from their farm to other farms and it also links one home to another home and to major adjoining highways. Both pedestrian and vehicular access have to be considered. The size, spacing and layout of the paths, roads are normally determined by a planning agency which takes into account the site topography and generally accepted design standards for road widths.

Any access road for pedestrians or vehicles requires a smooth surface, free of constructions or holes, which is passable in wet weather or immediately after storm conditions. The particular type of surfacing used in designed to meet the normal anticipated loading from vehicles.

Underneath any road, despite its surfacing there are compacted solids which have to distribution the vehicle loads. If these soils are saturated with excess storm water, their bearing capacity is dramatically reduced which eventually leads to failure of the road surface. (A. Cotton and R. Franceys: Services for Shelter 1991)

Geometric design data for the rural roads being designed should be consistent with the traffic volume, composition of traffic, design speed and access control. This manual is a summary of the designed problems. (" A Policy on Geometric Design of Rural highway" by American Association of States Highway Officials AASHO)

Compaction and drainage are certainly the two most important factors in the constructions of earth roads and hence soil considerations in earth roads, should involve the evaluation of all parameters that directly or indirectly influence these two factors. (Industrial Engineering Unit of Cordec University of Port Harcourt: Design & Construction of Rural Roads).

Selection of farm access road. Area to be served and benefit to the rural community in terms of conveying their farm product to the city or nearby market after the harvest. The roads will provide access to areas of high agricultural potentials and priority will be given to areas where other development programme is taken place. Traffic survey will be considered during the design of any road so as to know the present traffic density.

Design of Horizontal alignment in which tentative decisions of alternative routes will be taken and comparison of a gradient and availability of materials at the site. Avoiding too much curves as much as possible and where curve is not avoidable and is of radius less than 30m, we introduce super-elevation. Where the straight alignment may pass through extremely difficult terrain (Rocks and Swamp) which should be avoided to minimise construction cost.

Design of vertical curves in such a way to avoid too much cut and fill so as to suite the labour base/light equipment supported method and to get a good gradient and a nice camber of the road. The final road camber should be 5%. (UNDP/ILO Training Programme on Labour - Based Construction and Maintenance 1990)

Design of the cross-section of the road to achieve a good camber of 5% gradient. The laterite surfacing should not be less than 15 cm thickness and the materials for both sub-base and base course should come from approved borrow pits. Borrow pits should not be too far from the road way. The materials should undergo laboratory test such as liquid limit test, plasticity test, sieve analysis, and CBR test. The width of the road should not be less 6.0m with proper drains on both sides.

Location of culverts at appropriate position and gradient, to drain water under the road. Where culverts are not necessary or for economic reason we provide turnouts. The quality of concrete should be good. Adequate drainage system will be provided and avoiding poor drainage which is the most frequent cause of failure of our roads.

The road is design to suite the rural community both during dry and wet season and easy maintenance at all weather. (Y.M. Habib Project Presented at NDE/UNDP workshop on labour base/light equipment workshop at Epe Lagos State 1990)

The design of this farm access road is based on the type of vehicle that will go into the farm and come out of the farm. Such vehicles are low bed, tractors, combine harvester, bulldozer etc. The road terminate only at the farm and its design in such away that when construction with the recommended material, it will serve all year round minimum maintenance cost.

CHAPTER THREE

3.0 METHODOLOGY

3.1 GEOMETRIC DESIGN: This is primarily concerned with the relating the physical element of the feeder roads or highway to the requirement of the driver and the vehicles.

Features which have to be considered in geometric design are primarily, horizontal and vertical curvative and the cross-section element. Proper geometric design will inevitably reduce the number and severity of highway accident while ensuring high traffic capacity with the minimum of delay to vehicles.

The aim should be to design a facility that blends harmoniously with the topography and not one that leaves an ugly scar on an otherwise pleasand landscape. When geometric design is improperly carried out, it may result in early obsolescence of the new highway with consequent economic loss to the community.

3.2 HORIZONTAL ALIGNMENT: This is one of the most important considerations in highway design. In general, existing track was followed on this project. There is more emphasis on the removal of unsuitable soil areas and high cutting and filling to make it more economical.

The maximum comfortable speed on a horizontal curve is primarily dependant upon the radius of the curve and the superelevation of the carriage way. In addition, vehicle speeds and safety on high-speed roads are aided by the pressure of such features as extra-carriage way width at the curves themselves and the insertion of transition curves between straight and curves.

3.3 **DESIGN SPEED:** Design speed is a speed selected to ensure efficient vehicle operation having regard to the influence of the physical features of the highway. It is the maximum safe speed that can be maintained over a specified section of highway when conditions are so favourable that the design features of the highway govern. I choose 64Kmph; because it's a rural road.

3.4 **SIGHT DISTANCE:** There are two types of sight distances namely:

(i) Stopping Sight Distance (SSD)

(ii) Overtaking Sight Distance (OSD) or passing sight distance.

3.5 **STOPPING SIGHT DISTANCE:** This is the distance the vehicles require to come to a stop after perceiving an object on the road and after the application of brake. In other words stopping sight is measured from the driver's eyes, which are assumed to be 1.14m above the surface of the pavement to an object 0.15m on the road. (F.M.W Highway Design Manual Part I)

3.6 **OVERTAKING SIGHT DISTANCE (OSD):** This is the horizontal distance that, a high speeding vehicle are to accelerate and overtake a slow speeding vehicle in a traffic station.

3.7 **RADIUS OF CURVATURE:** For a design speed of 64Kmph the minimum radius.

$$R_{min} = \frac{V^2}{127.14\,(0.12 + (0.19 - 0.000625v)}$$

$$= \frac{64^2}{127.14\,(\,0.12 + (\,0.19 - 0.000625 \times 64)}$$

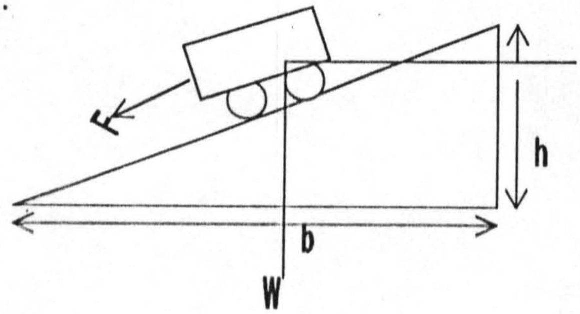
$$= 119m.$$

But I choose 180m for worst condition.

3.8 **SUPERELEVATION:** When a vehicle passes from straight to a first curve it experience a radical outward thrust called centrifugal force $\frac{Wv^2}{gv}$ where W is its own weight.

This centrifugal force always acts in a horizontal direction and its effect is to push the vehicle off the track.

To minimise these effect, it is a common practice to raise the outer edge of the road. This raised amount called superelevation. See diagram below.



$$F = \frac{Wv^2}{gR}$$

W	=	Weight of the vehicle.
V	=	Design Speed
F	=	Centrifugal Force $= \frac{WV^2}{gR}$
g	=	9. 81m/sec
R	=	Radius of the circular curve
b	=	Equivalent width of road.
h	=	Superelevation.

$$\frac{h}{b} = \frac{P}{W} = \frac{Wv^2}{WgR} = \frac{V^2}{gR}$$

$$R = \frac{V}{127.14\,(e+f)}$$

R = 180m, V = 64 and f = 0.19 – 0.000625 x 64 = 0.15

$$\therefore 180 = \frac{64}{127.14\,(e + 0.15)}$$

$180 \times (127.14e + 19.071) = 64^2$

$22885.2e + 3432.78 = 64^2$

$22885.2e + 3432.78 = 4096$

$$\therefore W_e = \frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}}$$

Design Speed $V = 64$Km/hr.

$n = 2$ lanes

$L = 6.1$m

$R = 180$m

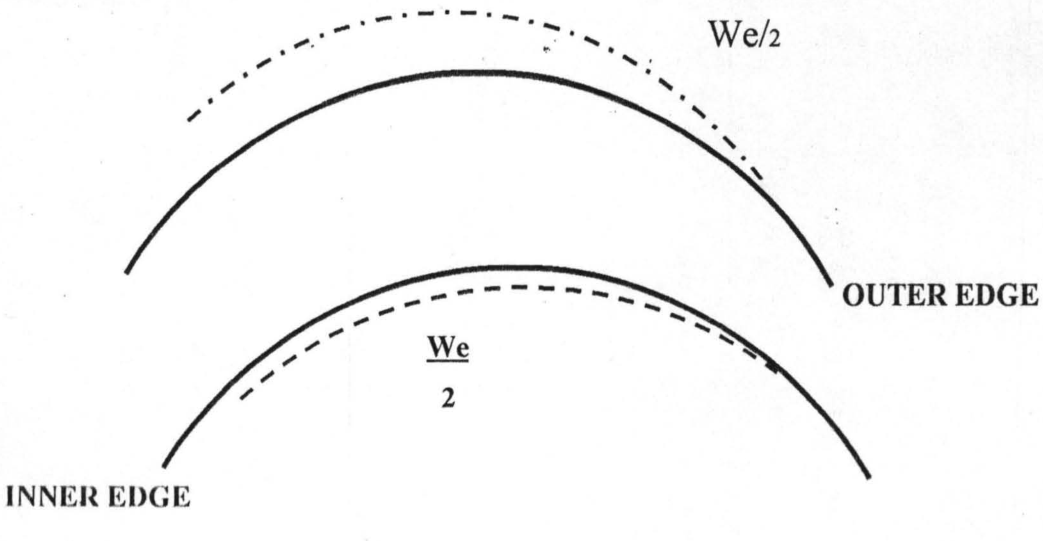
$$\therefore W_e = \frac{2 \times 6.1^2}{2 \times 180} + \frac{64}{9.5\sqrt{180}}$$

$0.21 + 0.5 = 0.71$m

$We = 0.71\text{m} \times 1000 = 710$mm

$$We = \frac{710}{2} = 355\text{mm}$$

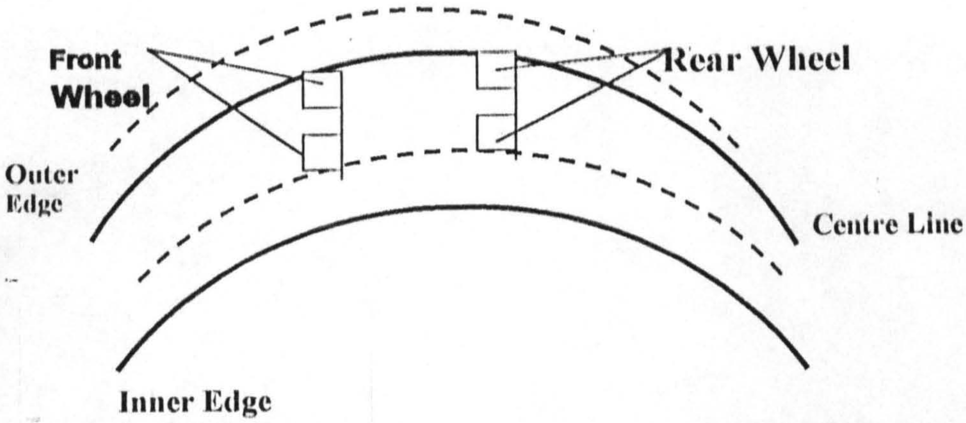
The total extra widening is distributed equally on the inner and outer edges of the pavement as shown in the sketch below.



$$\therefore e = \frac{4096 - 3432.78}{22885.2} = 0.03 \text{ its } 0./c.$$

Since its within the range 0.02 – 0.12

3.9 EXTRA WIDENING OF CIRCULAR CURVES



Extra widening of a highway pavement along a circular curve is applied for the following reasons:

(i) The front wheel track off shorts.of that of the rear outer wheel track as shown in the figure above.

(ii) Psychologically, a driver always tries to keep away from the above edge.

(iii) To keep a clear distance between two vehicles in a 2-lane traffic.

Extra widening :We" =Mechanical widening due to fixed axles + psychological axles widening.

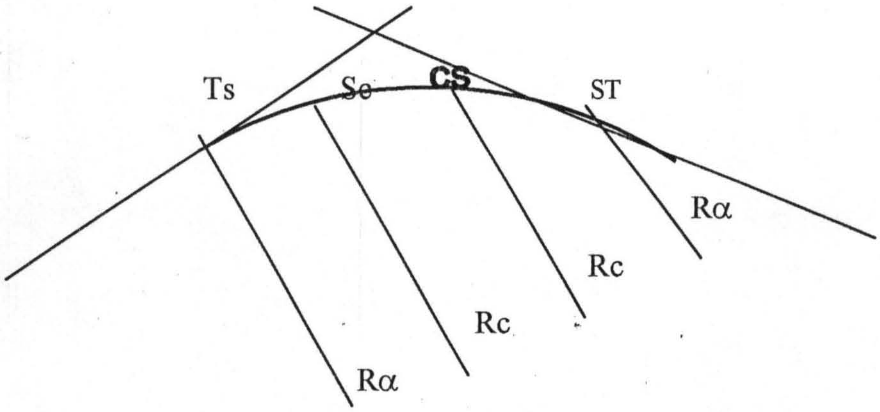
3.10 **TRANSITION CURVE:** The change in the direction of a vehicle from a straight path on the target sections of the alignment to a curve one on the circular curve cannot be made instantaneously since the driver has to alter the position of the steering wheel movement gradual so as to avoid abrupt changing in gradual acceleration which can cause discomfort to passengers. The transition curve is normally introduced between a straight target and the circular curve.

The purpose of a transition curve is as follows:

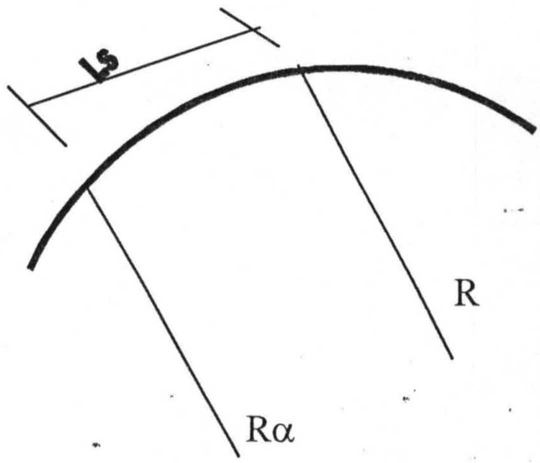
(i) To enable the driver to maintain his correct length position at high speed.

(ii) To allow the superelevation to be applied gradually.

(iii) Improve the general appearance of the road.



3.11 **ELEMENT OF TRANSITION CURVE:**



Ls = length of transition curves (metres) measured along the tangent.

D = Deflection angle measured from the tangent points.

$$Ls = \frac{V^3}{46.7Rc}$$

V = design speed (Kmph)

Rc = Radius of circular curve in metre.

C = Ratio of centrifugal acceleration which depends on the speed.

C is between 0.3 – 0.6m/sec for highways.

$$C = \frac{73}{V + 64} \quad \text{me/sec (Ashworth)}$$

Empirical equation by AASHO.

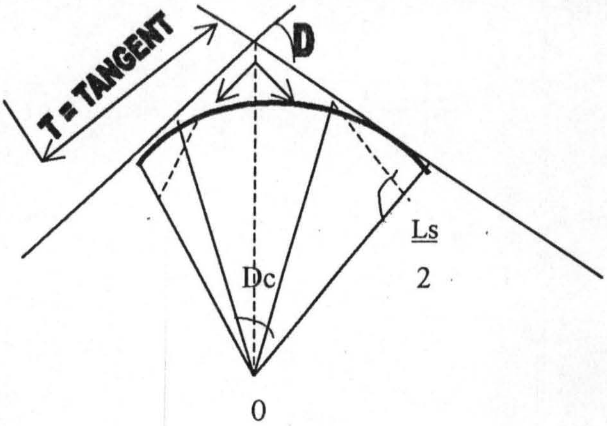
Where V = design speed

R = Radius of the circular curve.

$$C = \frac{73}{64 + 64} = 0.57$$

$$\therefore Ls = \frac{64^2}{46.7 \times 180 \times 0.57} = 54.7m$$

3.12 ELEMENTS OF COMBINE CURVE



Elements

D = Deflection angle which can be determine from compass survey

Dc = Central angle for the circular curve. = D – 2g

Lc = length of the circular curve. $\frac{RDc}{180}$

Ls = Transition curve length

S = Shift = $\frac{Ls^2}{24R}$

T = $(R + S) \text{ Tan } \frac{\varphi}{2} + \frac{L}{2}$

There are two major ways of setting out the transition curve namely:-

3.13 **CUBIC SPIRAL:** In a transition curve which was to be set out in the field by using theodalite.

For design purpose.

$$= \frac{1800Ls^2}{RLs} \quad \text{(minutes)}$$

$$= \frac{9.55c^2}{RL} \quad \text{(in degrees)}$$

Deflection angle = 30^0

Radius of the curve = 180m

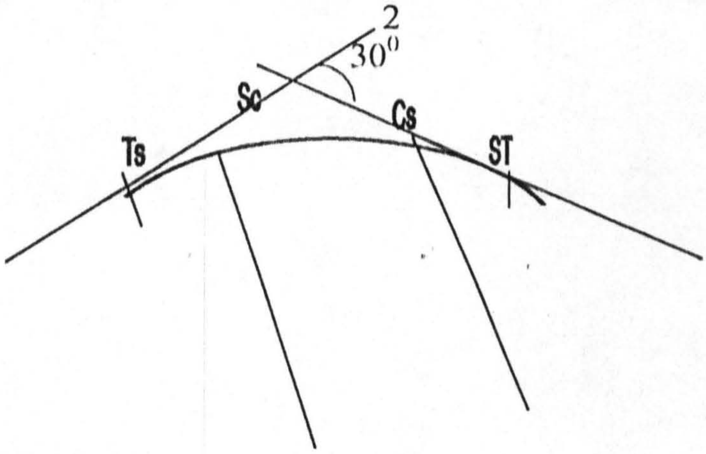
Design Speed = 64km/hr.

Radial acceleration = 0.57m/sec

Chainage I =300m

Tangent length = $R \tan \frac{\varphi}{2}$

$= 180 \times \tan \frac{30^0}{2} = 51.96m$

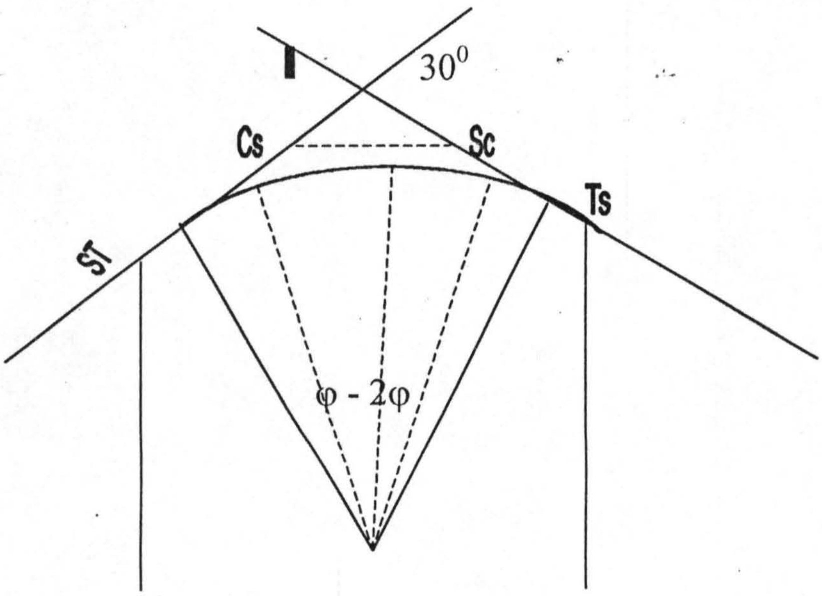


1[st] Transition Curve

This has been calculated = 54.7m

Shift 'S' $= \frac{L^2}{24R}$

$S = \frac{Ls^2}{24R} = \frac{54.7^2}{24 \times 180} = 0.69m$



3.14 TANGENTIAL LENGTH

$$T = (R + S)\tan\frac{\varphi}{2} + \frac{L}{2}$$

$$(180 + 0.69)\tan\frac{30^0}{2} + \frac{54.7}{2}$$

52.16 + 27.35

<u>79.51</u>

Chainage Ts

Ts = Chainage of I – tangential length

300 – 79.51

<u>220.49m</u>

Sc = Chainage TS + length of transition curve.

220.49 + 54.7

<u>275.19m</u>

3.15 SETTING OUT FOR TRANSITION CURVE NO 1

Chainage (M)	**Chord**	**Chord Length L^2 (M)**	**$\frac{1800L}{\pi RLS}$ (Min)**	**Total Deflection Angle**
300	0	0	0	360^0-00-00"
310	10.00	10.00	5.82'	359^0-54'-11"
320	10.00	20.00	23.27'	359^0-30'-55"
330	10.00	30.00	52.37'	358^0-38'-33"
340	10.00	40.00	93.10'	357^0-5'-27"
350	10.00	50.00	145.46'	354^0-39'-59"
354.7	4.70	54.7	174.10'	351^0-45'-53"

$$\varphi max = \frac{Ls}{2R} = \frac{54.7}{2 \times 180} \times \frac{180}{\pi} = 8.705$$

$$= 8^0 - 42' - 18"$$

3.16 LENGTH OF CIRCULAR CURVE

Lc = R(φ - 2φ max)

180 (30 – 2 x 8.71) $\quad 2264.4 \times \frac{\pi}{180}$

$= 2264.4 \times \frac{\pi}{180}$

= 39.53m

Chainage at Sc = Chainage Ts + Length of transition curve.

275.19 + 39.53

314.72m

Chainage at Cs = Chainage at Sc + Length of circular curve.

= 314.72 + 39.53

354.25m

3.17 TABULATED DATA FOR SETTING OUT CIRCULAR CURVE

$\frac{(T^{\wedge} \times 180 \times 60)}{2\pi R} = \frac{1718.9 \times T^{\wedge}}{R}$

CHAINAGE	CHORD	DEFLECTION ANGLE	TOTAL DEFLECTION ANGLE
314.72	0	0	0
320.00	5.28	$\frac{1718.9 \times 5.28}{180}$ =50.42'	0 – 50'-25"
330.00	10.00	$\frac{1718.9 \times 10.00}{180}$ = 95.49'	2^0-25'-54"
340.00	10.00	95.49'	4^0-1'-23"
350.00	10.00	95.49'	5^0-36-52"
354.25	4.25	40.59'	6^0-17'-27"

(φ - 2φ max) $= \frac{30 - (2 \times 8.71)}{2}$

$= 6.29^0$

= 6^0 – 17'-24"

Chainage at ST = Chainage Cs + length of transition curve.

354.25 + 54. 7

<u>408.95m</u>

3.18 TABULATED DATA FOR SETTING OUT OF TRANSITION CURVE NO. 2

POINT	CHANINAGE (m)	CHORD	CHORD LENGTH (m)	$\frac{1800L^2}{\pi RLs}$	TOTAL DEFLECTION ANGLE
ST	408.95	0	0	0	00-00-00
	400.00	8.95	8.95	4.66'	0^0-4'-40"
	390.00	10.00	18.95	20.89'	0^0-20'-54"
	380.00	10.00	28.95	48.76'	0^0-48'-46"
	370.00	10.00	38.95	88.27'	1^0-28'-16"
	360.00	10.00	48.95	139.42'	2^0-19'-25"
	3.54.25	5.75	54.70	174.1'	2^0-54'-6"

φ max/3 = max

$$\frac{Ls}{2R} \times \frac{180}{\pi} = \frac{54.7}{2 \times 180} \times \frac{180}{\pi} = \frac{8.71^0}{3} = 2.90^0$$

$= 2^0$-54'-12"

3.19 **SOIL INVESTIGATION:** The purpose of soil test is to determine the following:

(a) To investigate the nature of the soil in its constituents, the various minerals that it contains.

(b) To find out whether these material are good enough for construction purposes when the soil act as natural foundation.

(c) To determine the water table below the ground level.

(d) To investigate other possibilities and suitability for the construction if required locally materials.

(e) To investigate the road bed (sub-grade) and to provide necessary information concerning the soil characteristic so as to provide adequate and economical design.

3.20. TEST CARRIED OUT ON THE SOIL: The following types of soil test were carried out on the soil samples collected from the project site (Barmo Farms) at 1.0m depth dug into the ground, they are

(i) Sieve analysis test

(ii) Atterberg limit test

(iii) Moisture content

(iv) B.S. heavy compaction. California Bearing Ratio test (C.B.R.)

(See appendix for the result for various test)

3.21 SIEVE ANALYSIS TEST: A soil sample of 1000g weight is passed through various sieve sizes and weight of sample retained is taken and also percentage passing.

3.22 LIQUID LIMIT TEST: The liquid limit of a soil is moisture content expressed as a percentage by weight of the oven dry soil at boundary between the liquid and solid states. In the course of the test, a soil part consisting of a mixture of water and soil passing the 4.76mm B.S
sieve is placed in the cup and divided with a special wedge scaped cutting tool. By means of a cam on a shaft turned by handcrank, the brass cup is raised through a height of 1cm and then dropped sharply on the hard base.

The device has been calibrated so that 25 drops of the cup at the rate of two drops per second. The liquid limit of soil is then taken as the moisture content at which the groove cut in the soil in the pat closes for a length of 13mm after 25 blows:

3.23 PLASTIC LIMIT: The plastic limit of a soil is the moisture content expressed as a percentage of the oven dried sample, of the air dried material passing the 4.76mm B.S. sieve at the time that the soil water mixture has been rolled into a thread 3mm diameter and it begin to crumble at this size.

3.24 COMPACTION TEST: In the modified proctor test which I use, a 4.5kg rammer falls 45.8cm and a total of 25 blows is applied to each five layers. A new soil sample is then prepared, an additional increment of water is added and the procedure repeated. The test is continued until the weight of a compacted sample in the mould is less than that obtained in the proceeding measurement.

3.25 C.B.R. TEST: The C.B.R. test is a penetration, which can be expressed as a percentage of the penetration resistance to that of a standard value of crushed stone.

Generally, the C.B.R. at 0.1. inch penetration is used for design purposes. The C.B.R. penetration is done both at the top and bottom of compacted soil sample in the mould.

3.26 PAVEMENT DESIGN: This involves finding suitable thickness of surface course, base course, and sub-base to satisfy the prevailing traffic, soil and other necessary conditions. The thickness of the different elements comprising pavement is determined by the C.B.R. values.

The C.B.R. test is a penetration test, which can be expressed as a percentage of the penetration resistance to that of a standard value for crushed stone. Generally, the C.B.R. at 0.1. inch penetration is used for design purposes.

In this design procedure, it is assumed that stress distribution through the pavement is independent of the quality of the various layers in each layer of the pavement must be of higher quality than the layer below it.

The materials to be used in this pavement design on the soil which will serve as natural foundation for the pavement has been tested and evaluated to have a minimum of C.B.R of 8% after soaking for 4 days. Therefore a minimum C.B.R of 8% has been selected for the foundation.

Traffic volumes plays a very important role in geometric and structural design of good pavement. For certain types of roads e.g residential and associated developments, it is quite common for accurate data not to be available, and a detailed traffic survey may not be justified. In such instances, the transport and road research laboratory recommended that the following initial values be assumed.

S/No	TYPES OF ROAD	Estimated Traffic Floor in Each Direction. 10mm veh/day
1.	Cul-de-sac and minor residential roads.	10
2.	Through roads and roads carrying regular bus routes involving up to 25p.s.v/day in each direction.	75
3.	Major through roads carrying regular bus routes involving 25-50 p.s.v/day in each direction.	175
4.	Main shopping centre of a large development carrying goods deliveries and main through roads carrying more than 50 p.s.v./day in each direction	350

On the table above, residential road with 10 commercial veh/day is more suitable for my case study road design.

3.27 **DESIGN CURVE READING:** Referring to the flexible pavement design curve, the projected volume falls between 0-15 in the traffic classification table. (highway design manual Part I) Whereby A is to be used for the design.

3.28 **DATA FOR CBR VALUES**

Sub-grade 8%
Sub-base 13.6%
Base course 78.8%

The required pavement thickness I is obtained considering C.B.R value of 8% for sub-grade material (sandy clay) is given from graph A.

I = 245mm

Consider the sub-base (C.B.R 13.6%) = 5-8" =145mm

Consider the base course of (C.B.R 78.8%) = 100mm

3.29 **MINIMUM PAVEMENT THICKNESS:** The summary of this chapter is that, the sub-grade soil has a C.B.R value of 8%, sub-base thickness is 145mm and is of compacted leterite soil of 13.6% C.B.R and base course thickness of 100mm well graded gravel of 78.8% CBR value.

Now the minimum thickness of the pavement above the 'sub-grade level is 245mm

SOIL LABORATORY — Compaction-test

Laboratory:

execut by/date

calcul by/date

Lab. No.	chainage borrow-pit		position	depth (m)	material: sub-grade	fill	sub-base	base
	type of material	*Base*						X

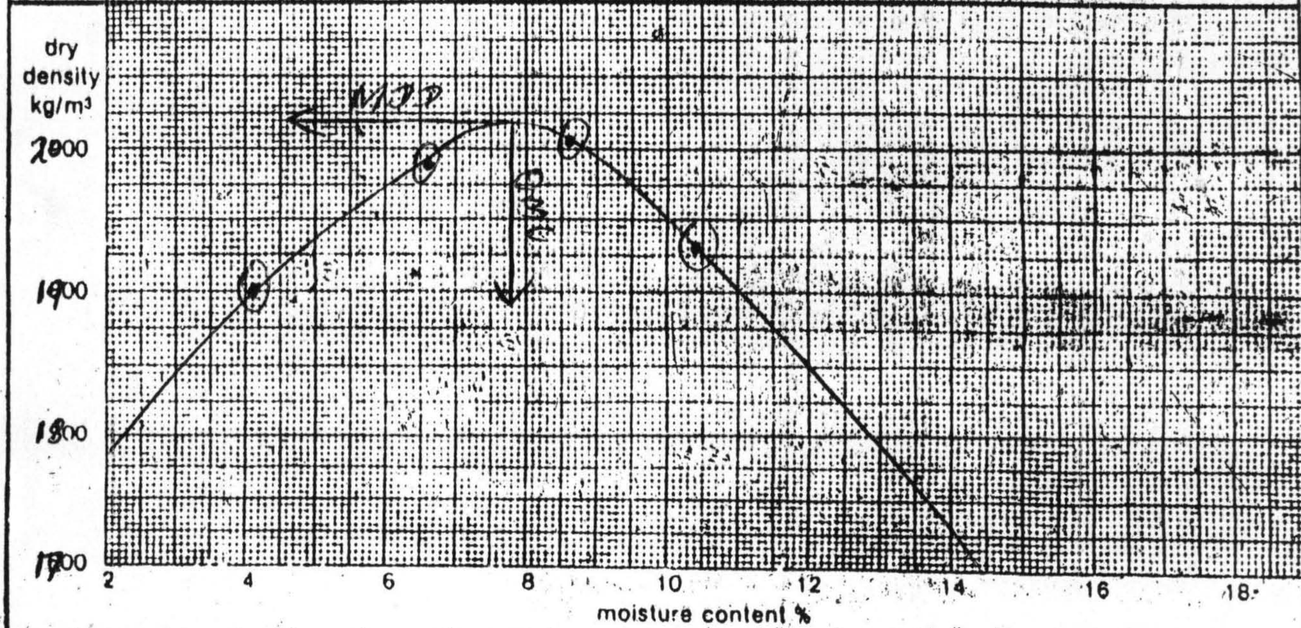
MDD		OMC		comp eff	5/27	mould volum	2180 cm³

a	mould No.									
b	water added	%	2%		4%		6%		8%	
c	wet soil + mould	g	7556		7873		7991		7886	
d	mould alone	g	3244		3244		3244		3244	
e	wet soil alone	g	4312		4629		4747		4642	
f	wet density	kg/m³	1978		2123		2177		2129	
g	bowl No.		15	18	19	23	29	22	13	8
h	wet soil + bowl	g	76	71	72.1	67	72.4	67.7	76	79.1
i	dry soil + bowl	g	74	70	70	65	70	65	72	75
j	bowl alone	g	36	35	36	36	35	34	34	35
k	water alone	g	2.0	1.0	2.1	2.0	2.9	2.7	4.0	4.1
l	dry soil alone	g	38	35	34	29	35	31	38	40
m	moisture content	%	5.3	2.9	6.2	6.9	8.3	8.8	10.5	10.3
n	average moisture content	%	4.1		6.6		8.6		10.4	
o	dry density	kg/m³	1900		1992		2005		1928	

$e = c - d$ $\quad k = h - i$, $\quad m = \frac{k}{l} \cdot 100$

$f = \frac{e}{vol} \cdot 1000$ $\quad l = i - j$ $\quad o = \frac{f}{100 + n} \cdot 100$

remarks
MDD = 2020 Kg/m³
OMC = 7.8%



remarks:

Signed ______ For ______

Signed ______ Engineer's Representativ

CBR -test

factor 2.27

SOIL LABORATORY

Laboratory:

exect. by /date:	
calcul. by /date:	

Lab. No.	chainage borrow. pit:		position	depth(m)	material			
					sub grade	fill	sub-base	Base
	type of material:	Base						X

MDD		OMC		comp. eff.	5/27	mould volum	2180 cm³

standard load KN	time minutes	penetration mm	dail readings: mould No. top	mould No. bottom	mould No. top	mould No. bottom
	0.00	0.00	/	/		
	0.25	0.25				
	0.50	0.50	83	95	188	216
	0.75	0.75				
	1.00	1.00	100	130	227	295
	1.25	1.25				
	1.50	1.50	165	174	375	395
	1.75	1.75				
11.50	2.00	2.00	200	220	454	499
	2.25	2.25				
13.24	2.50	2.50	250	340	568	772
	2.75	2.75				
	3.00	3.00	345	420	783	953
	3.50	3.50				
17.60	4.00	4.00	430	540	976	1226
	4.50	4.50				
19.96	5.00	5.00	650	735	1476	1668
	5.50	5.50				
22.20	6.00	6.00	830	830	1657	1884
	6.50	6.50				
	7.00	7.00	880	910	1998	2066
	7.50	7.50				
26.30	8.00	8.00				

ection made (x)

ected ding for	2.50 mm penetration	568	772		
	5.00 mm penetration	1476	1668		
R at	2.50 mm penetration	42.9	58.3	50.6	
	5.00 mm penetration	73.9	83.6	78.8	

rage CBR(Top & Bottom)

R at2.50 mm penetration = ______

R at 5.00 mm penetration = ______

CBR Value = 78.8%

rks

Signed ______ For:

Signed ______

FMW Repr.

LTD.

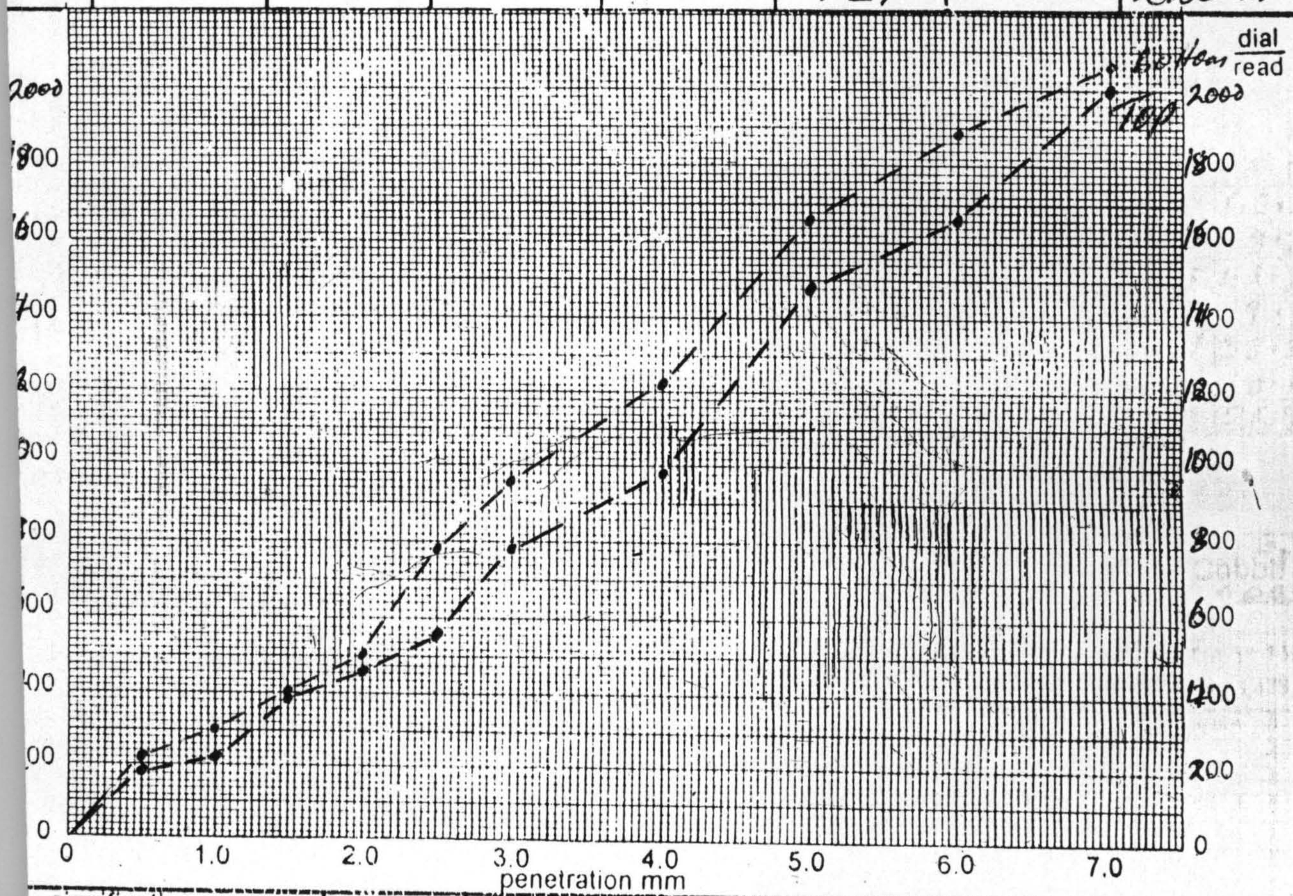
CBR

boratory:

execut. by/date:
calcul. by/date

No.	chainage borrow-pit:		Position	depth (m)	material			
					sub-grade	fill	sub-base	base
	type of material:	Base						X

DD		OMC		comp. eff.	5/27	mould volum.	2180 Cm3



signification		before soak	after soak
ws layer eff.	–		
uld No.	–		
ter added	%	7.8	
soil + mould	g	7938	
uld alone	g	3244	
soil alone	g	4694	
density	kg/m³	2153	
ll read	%		
pation	%		
rage CBR	%		

	signification		before soak		after soak	
k	bowl No (top/bott.)	–	29	8		
l	wet soil + bowl	g	65.7	72.3		
m	dry soil + bowl	g	63.4	70.0		
n	bowl alone	g	35	35		
o	water alone	g	2.3	2.3		
p	dry soil alone	g	28.4	35.0		
q	moisture content	%	8.2	6.6		
r	average moisture c.	%	7.4			
s	dry density	kg/m³	2005			

remarks

000 o = l · m p = m · n q = o/p · 100 s = g/(100 + c) · 100

Engineer's Representative

Sieve-Analysis

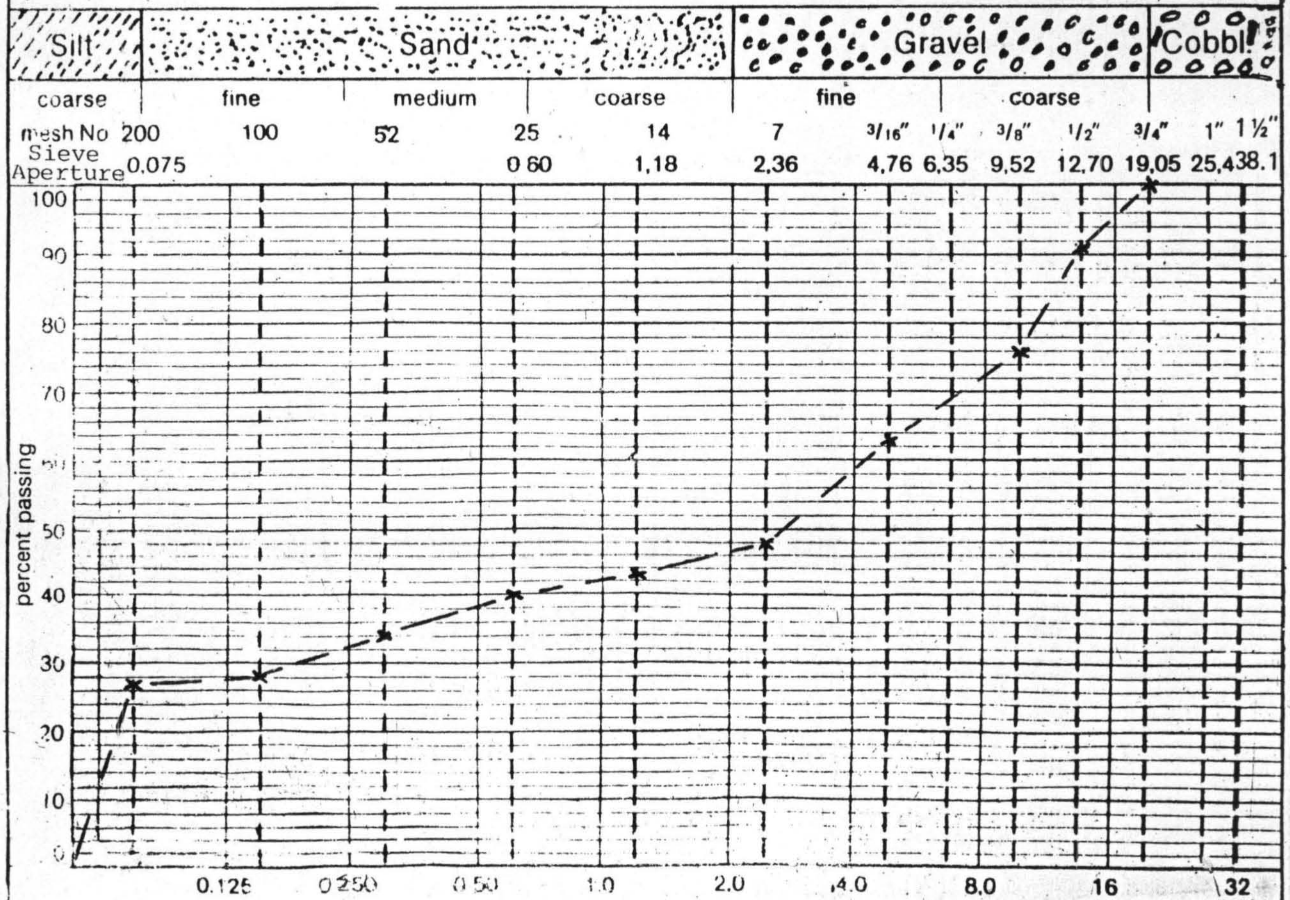
Laboratory:

execut. by/date		
calcul. by/date		

Lab. No.	chainage borrow pit:		position	depth (m)	material: sub-grade	fill	sub-base	base
	type of material	Base						X
	weight of soil taken for sieve analysis = 500 g							
	weight of soil taken for wet washing passing 4.76 mm sieve = g							

determination of moisture-content	bowl No.	g	
	wet soil + bowl	g	
	dry soil + bowl	g	
	bowl alone	g	
	water alone	g	MC = water / dry soil x100
	dry soil alone	g	= ______ %
determination of dry-soil-weight	bowl No.	g	
	wet soil + bowl	g	
	bowl alone	g	
	wet soil alone	g	
	dry soil alone	g	▸500 g = B
	Note: dry soil = Wet soil / (1 + 0.01 MC %)	g	
washing through mesh 200	washed oil + bowl	g	
	bowl alone	g	
	washed soil alone	g	▸ g = C
	outwashed soil < 0.075 mm ø	g	g = B – C ⟶

B.S. Sieve mm	mesh No.	retained g	retained %	passed %
38.1	1½"			
25.4	1"			
19.05	¾"	—	—	100
12.70	½"	43.5	8.7	91.3
9.52	3/8"	78.5	15.7	75.6
4.76	3/16	61.5	12.3	63.3
2.36	7	75.5	15.1	48.2
1.18	14	27.5	5.5	42.7
600 mic	25	15.0	3.0	39.7
300 mic	52	29.5	5.9	33.8
150 mic	100	28.5	5.7	28.1
75 mic	200	6.0	1.2	26.9
Bottom		134.5	26.9	



SOIL LABORATORY

me: ____________________ Sample Number ____________________

te: ____________________ Sheet Number ____________________

IUID AND PLASTIC LIMIT
TERMINATIONS
ATA AND COMPUTATION SHEET

Base

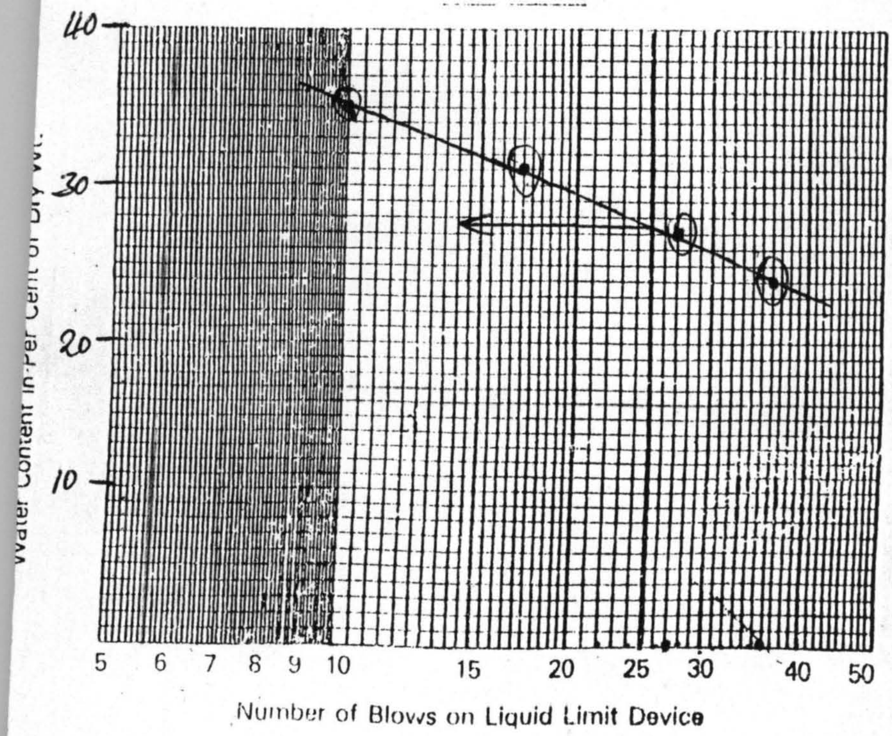
LL = Liquid Limit Test PL = PLastic Limit Test

Type of Test		LL	LL	LL	LL	LL
Container Number		14	11	25	16	
Number of Blows		10	17	27	36	
Wt. Sample + Tare Wet		51·2	43·7	50·3	51·4	
Wt. Sample + Tare Dry		47·	48	47	48	
Wt. of Water		4·2	3·7	3·3	3·4	
Tare		35	36	35	34	
Wt. of Dry Soil		12	12	12	14	
Water Content		35·3	30·5	27·1	24·0	

Type of Test			PL	PL	PL	
Container Number			28	35		
Number of Blows						
Wt. Sample + Tare Wet			43	42		
Wt. Sample + Tare Dry			42	41		
Wt. of Water			1·0	1·0		
Tare			35	35		
Wt. of Dry Soil			7	6		
Water Content			14·3	16·7		

Avg = 15·5

FLOW CURVE



RESULTS

Liquid Limit = 27·5 %

Plastic Limit = 15·5 %

Plasticity Index = 12·0 %

Flow Index = ________ %

Toughness Index = 10·7 % (L/S)

Remarks: ____________________

Signed ____________________

Signed ____________________
Engineer's Representative

SOIL LABORATORY

Compaction-test

Laboratory:

execut by/date

calcul by/date

Lab. No.			position	depth (m)	material: sub-grade	fill	sub-base	base
	chainage borrow-pit							
	type of material	fill				X		

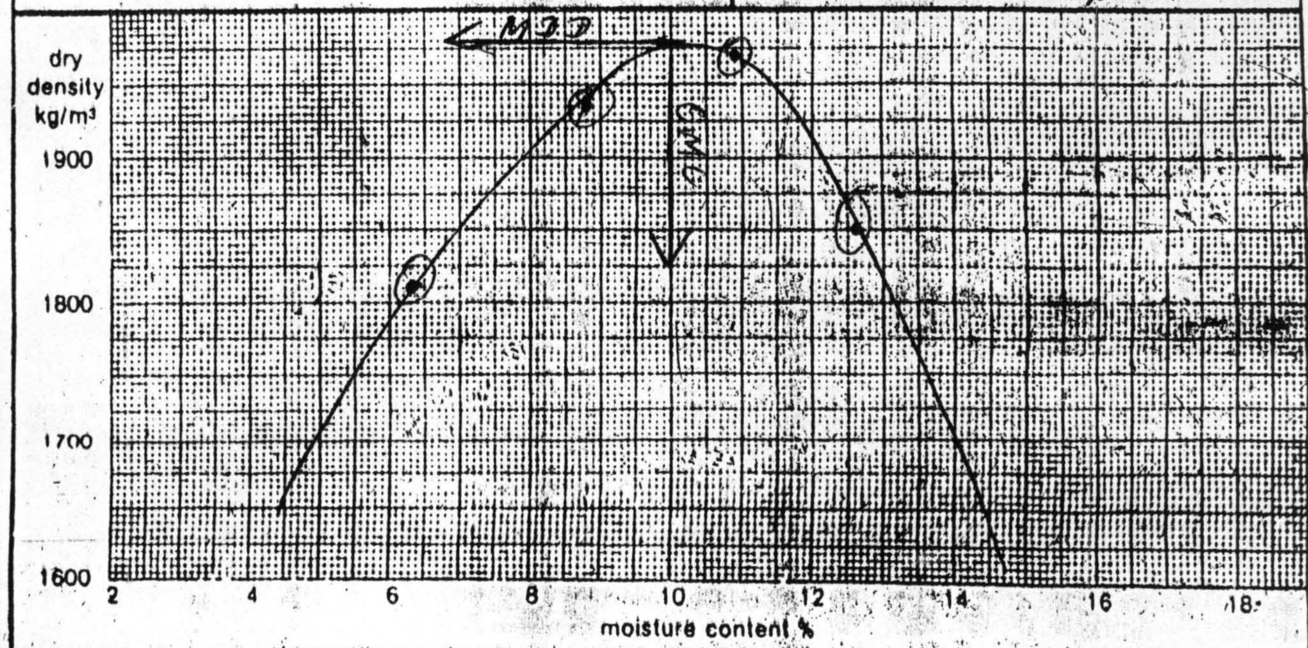
MDD		OMC		comp eff	3/25	mould volum	1006 cm³

a	mould No.									
b	water added	%	4%		6%		8%		10%	
c	wet soil + mould	g	3776		3935		4018		3914	
d	mould alone	g	1842		1842		1842		1842	
e	wet soil alone	g	1934		2093		2176		2072	
f	wet density	kg/m³	1922		2105		2189		2084	
g	bowl No.		25	18	31	15	1A	2A	4A	3A
h	wet soil + bowl	g	83.9	80.8	93.8	87.1	72.5	64.7	66.3	68.7
i	dry soil + bowl	g	81	78	89	83	68	61	62	64
j	bowl alone	g	35	35	34	36	27	27	27	27
k	water alone	g	2.9	2.8	4.8	4.1	4.2	3.7	4.3	4.7
l	dry soil alone	g	46	43	55	47	41	34	35	37
m	moisture content	%	6.2	6.4	8.8	8.8	11.0	10.8	12.4	12.8
n	average moisture content	%	6.3		8.8		10.9		12.6	
o	dry density	kg/m³	1809		1935		1974		1851	

$e = c - d$ $\quad k = h - i$ $\quad m = \frac{k}{l} \cdot 100$

$f = \frac{e}{vol} \cdot 1000$ $\quad l = i - j$ $\quad o = \frac{f}{100 + n} \cdot 100$

remarks: MDD = 1980 kg/m³
OMC = 10.0%



remarks:

Signed
For

26

Signed
Engineer's Representativ

26

CBR -test

SOIL LABORATORY

Laboratory:

exect. by /date:
calcul. by /date:

Lab. No.	chainage borrow. pit:		position	depth(m)	material: sub grade	fill	sub-base
	type of material:	fill				X	

MDD		OMC		comp. eff.	3/25	mould volum	2180 cm³

standard load KN	time minutes	penetration mm	dail readings: mould No. top	mould No. bottom	mould No. top	mould No. bottom
	0.00	0.00	—	—		
	0.25	0.25				
	0.50	0.50	10	25	23	57
	0.75	0.75				
	1.00	1.00	24	35	54	79
	1.25	1.25				
	1.50	1.50	34	60	77	136
	1.75	1.75				
11.50	2.00	2.00	45	70	102	159
	2.25	2.25				
13.24	2.50	2.50	55	82	125	186
	2.75	2.75				
	3.00	3.00	68	100	154	227
	3.50	3.50				
17.60	4.00	4.00	81	120	184	272
	4.50	4.50				
19.96	5.00	5.00	100	138	227	313
	5.50	5.50				
22.20	6.00	6.00	125	145	284	329
	6.50	6.50				
	7.00	7.00	153	168	347	377
	7.50	7.50				
26.30	8.00	8.00				

correction made (x)

corrected reading for	2.50 mm penetration	125	186		
	5.00 mm penetration	227	313		
CBR at .	2.50 mm penetration	9.4	14.0	11.7	
	5.00 mm penetration	11.4	15.7	13.6	

Average CBR(Top & Bottom)
CBR at2.50 mm penetration = ____________
CBR at 5.00 mm penetration = ____________

CBR Value = 13.6%

remarks

Signed ____________

For:

Signed____________
FMW Repr.

Sieve-Analysis

Laboratory:

execut. by/date

calcul. by/date

Lab. No.			position	depth (m)	material			
	chainage borrow pit:				sub-grade	fill	sub-base	base
	type of material	fill						
	weight of soil taken for sieve analysis = 300 g					X		
	weight of soil taken for wet washing passing 4.76 mm sieve = g							

determination of moisture-content	bowl No.		g
	wet soil + bowl		g
	dry soil + bowl		g
	bowl alone		g
	water alone		g
	dry soil alone		g
determination of dry-soil-weight	bowl No.		g
	wet soil + bowl		g
	bowl alone		g
	wet soil alone		g
	dry soil alone		g
	Note: dry soil = $\frac{\text{Wet soil}}{1 + 0.01\ \text{MC}\ \%}$		g
washing through mesh 200	washed oil + bowl		g
	bowl alone		g
	washed soil alone		g
	outwashed soil < 0.075 mm ø		g

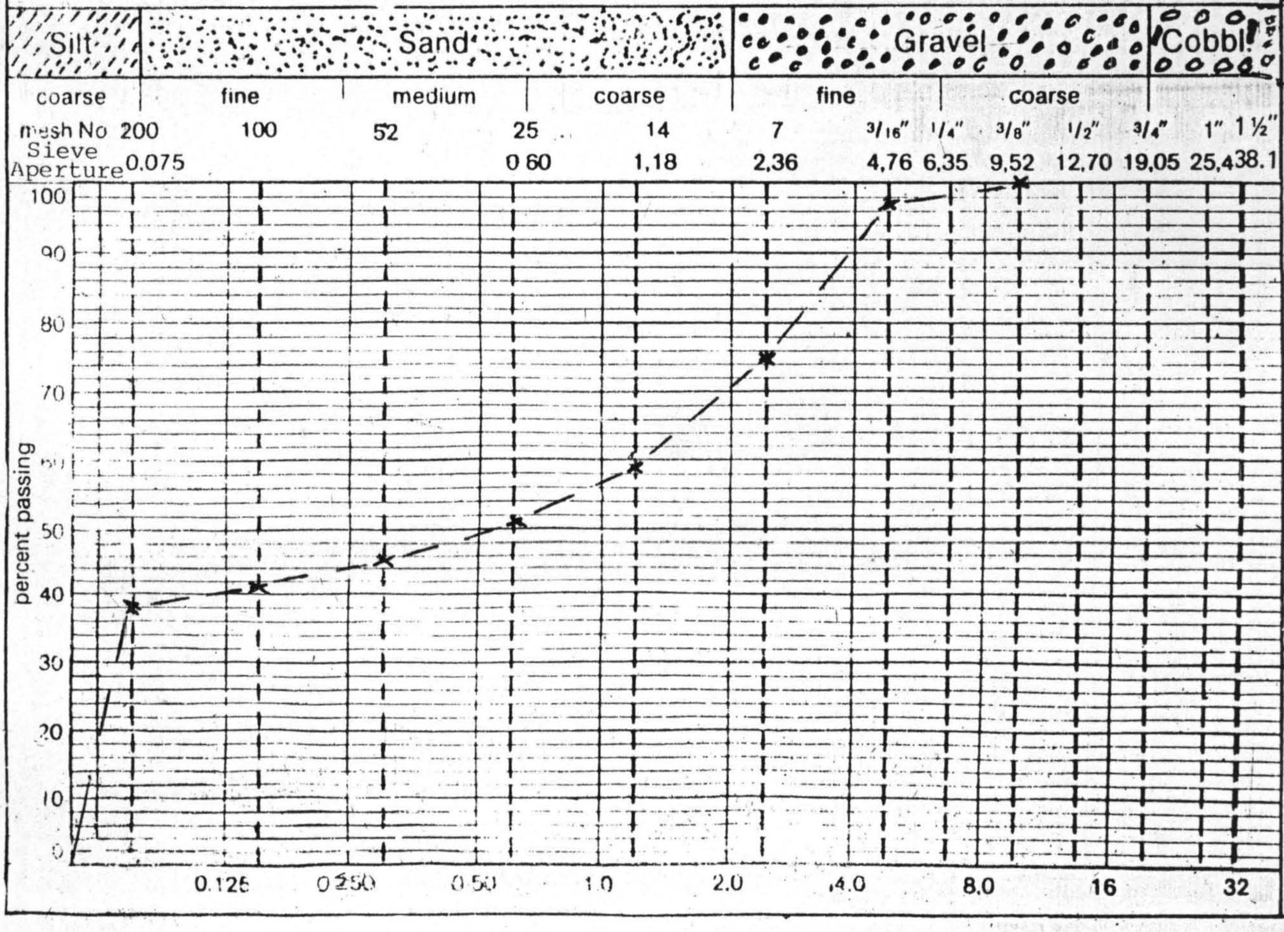
$$MC = \frac{\text{water}}{\text{dry soil}} \times 100 = \_\_\_\_\_\ \%$$

▸ 300 g = B

▸ g = C

g = B – C →

B.S. Sieve mm	mesh No.	retained g	retained %	passed %
38.1	1 ½"			
25.4	1"			
19.05	¾"			
12.70	½"			
9.52	3/8"	—	—	100
4.76	3/16	8.1	2.7	97.3
2.36	7	68.1	22.7	74.6
1.18	14	45.6	15.2	59.4
600 mic	25	24.9	8.3	51.1
300 mic	52	18.0	6.0	45.1
150 mic	100	12.9	4.3	40.8
75 mic	200	9.9	3.3	37.5
Bottom		112.5	37.5	



SOIL LABORATORY

ame: ______________________ Sample Number ______________________

ate: ______________________ Sheet Number ______________________

IQUID AND PLASTIC LIMIT
ETERMINATIONS
ATA AND COMPUTATION SHEET

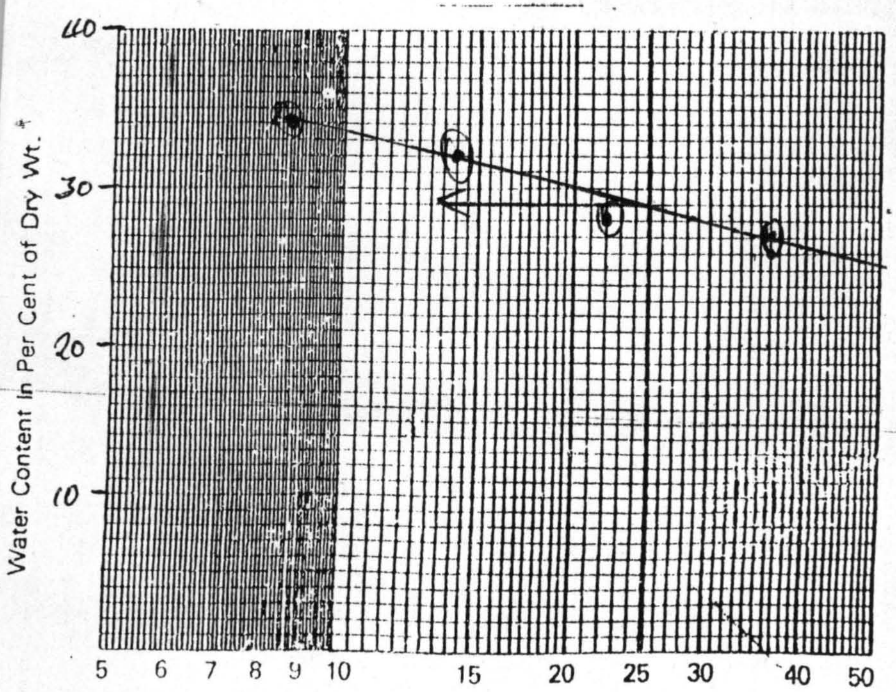
LL = Liquid Limit Test PL = PLastic Limit Test

Type of Test		LL	LL	LL	LL	LL
Container Number		14	25	8	23	
Number of Blows		8	14	22	36	
Wt. Sample + Tare Wet		52·3	54·1	52·0	54·1	
Wt. Sample + Tare Dry		48·0	49·4	48·2	50·1	
Wt. of Water		4·3	4·7	3·8	4·0	
Tare		34·6	34·8	34·6	35·3	
Wt. of Dry Soil		13·4	14·6	13·6	14·8	
Water Content		34·7	32·2	27·9	27·0	

Type of Test			PL	PL	PL	
Container Number			13	19		
Number of Blows						
Wt. Sample + Tare Wet			46·1	48·2		
Wt. Sample + Tare Dry			44·1	46·4		
Wt. of Water			2·0	1·8		
Tare			34·3	35·2		
Wt. of Dry Soil			9·8	11·2		
Water Content			20·4	16·1		

Avg = 18·3

FLOW CURVE



RESULTS

Liquid Limit = 29·0 %

Plastic Limit = 18·3 %

Plasticity Index = 10·7 %

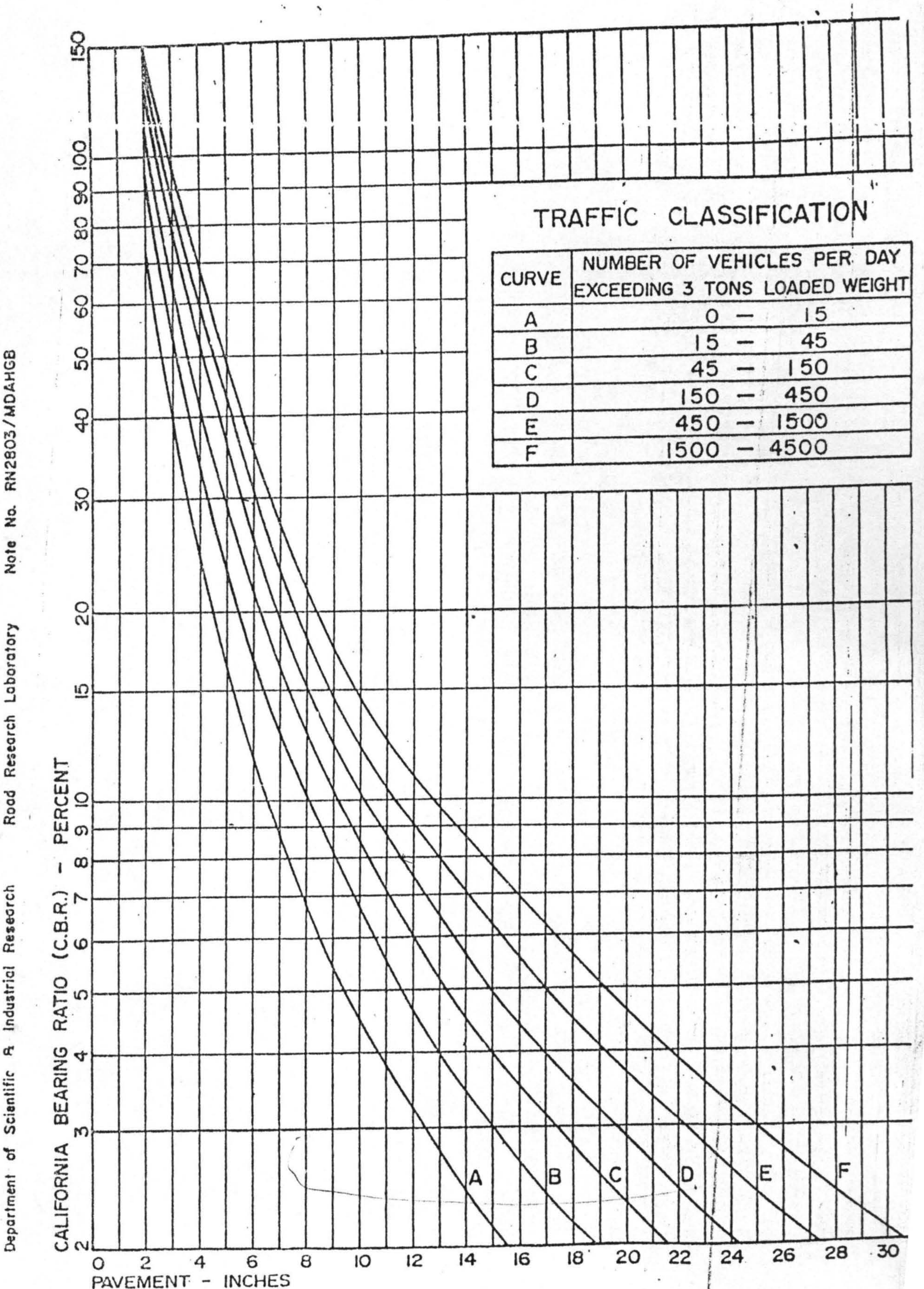
Flow Index = ______ %

Toughness Index = ______ %

Remarks: ______________________

Signed ______________________ Signed ______________________

Engineer's Representative



CURVE	NUMBER OF VEHICLES PER DAY EXCEEDING 3 TONS LOADED WEIGHT
A	0 — 15
B	15 — 45
C	45 — 150
D	150 — 450
E	450 — 1500
F	1500 — 4500

FLEXIBLE PAVEMENT DESIGN CURVE

FIG. 1-306.1

CHAPTER FOUR

4.1 **DRAINAGE DESIGN:** The drainage system for any road can be difficult as the ways and means adopted to provide for the immediate removal of excess surface water or ground water from the vicinity of the road. The provision of an adequate water drainage system is an essential feature of any road scheme. In drainage design, the basic consideration is to protect the highway against damage from storm and sub-surface water. Drainage facilities must be designed to convey the water across, along or away from the highway in the most economical, efficient and practical manner without damaging the highway adjacent property.

This is accomplished by determining the followings:-

(a) The amount and frequency of storm run off.

(b) If detrimental amount of sub-surface water exist.

(c) Natural point of concentration, discharge and other hydraulic controls.

(d) The most efficient disposal facilities consistent with initial cost, importance of the road, maintenance cost and legal obligations.

4.2 **RUN – OFF ESTIMATE**

Run-off estimates shall be based on the rational method, also known as the Lloyd – Dairies formula (C.A.O'Flalauty; Highway Engineering Vol. 2) In this method the run-off is related to the rainfall intensity by the formula.

$$Q = CIA$$

Where :- Q = Quantity of run-off (m^3/sec)

I = Intensity or rate of rainfall (mm/hr)

C = Co-efficient of run-off expressed as a percentage of the imperviousness of the watershed surface.

A = Total drainage area in unit of 1000 (m^2)

The intensity of rainfall storm (I) is a function of the duration of storm. Duration of storm is the time required by the rain water to reach the inlet pipe or open ditch in the drainage area from its furtherest point.

Flow time is the time required by the rain water to flow in the conduit or in the open ditch till it reaches other inlet or final out let.

Consider a catchment area bordering the sides of the road which is 850m long.

	1.5m	6.0m	1.5m	
	A_2	A_1	A_2	

Plan across the road which is the plan of the catchment area

Area = $A_1 + A_2$

A_1 = Pavement (Road) = (Road width) 6.0 x 850 (road length)

A_2 = Drain Area (Assuming a trapazoidal drain) (Drain width) 3.0 x (length of road) 850 = $2550m^2$

Now total area = 5100 + 2550 = 7650 m^2

Taking the run – off co-efficient "C" for pavement

C_1 a = 0.9, Drain C_2 = 0.3

$$\therefore C = \frac{A_1 C_1 + A_2 C_2}{A_1 + A_2}$$

$$C = \frac{5100 \times 0.9 + 2550 \times 0.3}{7650}$$

$$C = \frac{4590 + 765}{7650} = \frac{5355}{7650} = 0.7$$ run off co-efficient

4.3 MANNING FORMULAR

This is the most widely used formula in highway drainage design.

$$V = \frac{1}{n} R^{2/3} S^{1/2}$$

Where:

R = Hydraulic radius

N = Manning roughness

S = The slope at which the run-off will flow.

4.4 SIDE DITCHES

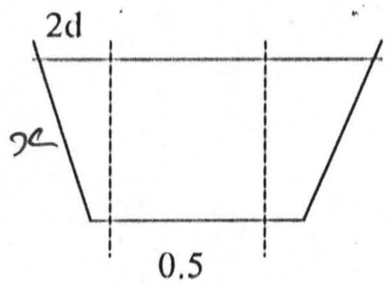
These are normally placed along side of the roadways in order to intercept surface water running off the carriageway and shoulders. In cut section they also serve to prevent water running down the back slopes and invading the roadway. Side ditches are usually V-shaped or trapezoidal in cross-section. Ditch side walls are simply cut to natural angle of repose of the soil and to a depth which is usually between 0.3m to 0.6m

Suggested Value of ultimate impermeability of various types of surfaces (C.A.O'Flahauty: Highway Engineering Vol. 2 Table 2.3 Page 63)

Types of Drainage Area	Impermeability Factor
Concrete or bituminous surface	0.8 to 0.9
Gravel or macadam surface	04 to 0.7
Bare impervious soils	04 to 0.7
Impervious soil with turf	0.3 to 0.6

4.5 HYDRAULIC DESIGN

Assuming a trapezoidal drain with side slope 1 vertical to 2 horizontal and bed width of 0.5m.



The inlet time $= \frac{1000}{1.5} = 666.7$ secs

$= 11.11$ mins

The flow time of distance 850m

$$= \frac{850}{1.5} = 566.67 \text{ sec} = 9.44 \text{ mins}$$

Duration of rainfall is usually taken as inlet time plus the flow time

$$11.11 + 9.44$$

$$= 20.55\text{mins}$$

The value of rainfall intensity for a period of 1 year from the graph of intensity duration curve = 100mm/hr (F.M.W highway Design Manual Part I 1973)

$$Q = CIA$$

Where $C = 0.7$

$I = 100\text{mm/hr}$

$A = 7650\text{m}^2$

$$Q = \frac{0.70 \times 0.1 \times 7650}{60 \times 60}$$

$$Q = 0.149\text{m}^3/\text{sec}$$

Let assume a trapezoidal drain with bed width = 0.5m and side slope = 1:2. Now the area = $\frac{Q}{V}$

When assuming 1.5m/sec non-scouring and non silting velocity

$$A = \frac{Q}{V} = \frac{0.149}{1.5} = 0.10$$

Area = ½ sum of the parallel sides x height

$0.10 = ½ (0.5 + 0.5 +)2d) 2) \times d$

$0.10 = ½ (1d + 4d^2)$

$0.10 = 0.5d + 2d^2$

$2d^2 + 0.5\,d - 0.10 = 0$

$$0.5 + \frac{\sqrt{(0.5)^2 - 4 \times 2\,(.0.10)}}{4}$$

$$0.5 + \frac{\sqrt{0.25 + 0.8}}{4}$$

$$d \quad \frac{0.5 + 1.025}{4} = 0.1313$$

$x^2 = 2d^2 + d^2$

$x^2 = 2\,(0.1313)^2 + (0.1313)^2$

$0.0345 + 0.0172$

$x^2 = 0.0517$

$x = 0.227$

Now the perimeter of the wetted area of the chair

$P = 0.227 + 0.227 + 0.5 = 0.954$

$$R = \frac{A}{P}$$

$$R = \frac{0.10}{0.954} = 0.105$$

Now the bed slope "S"

$$V = \frac{1}{n} R^{2/3} S^{1/2}$$

n = 0.02 from the table 2.4 mannings "n" and max permissible velocity of flow (Highway engineering Vol. II by C.A.O'Flaluerty)

$1.5 = \frac{1}{0.02} \times 0.105^{2/3} \times 5^{1/2}$

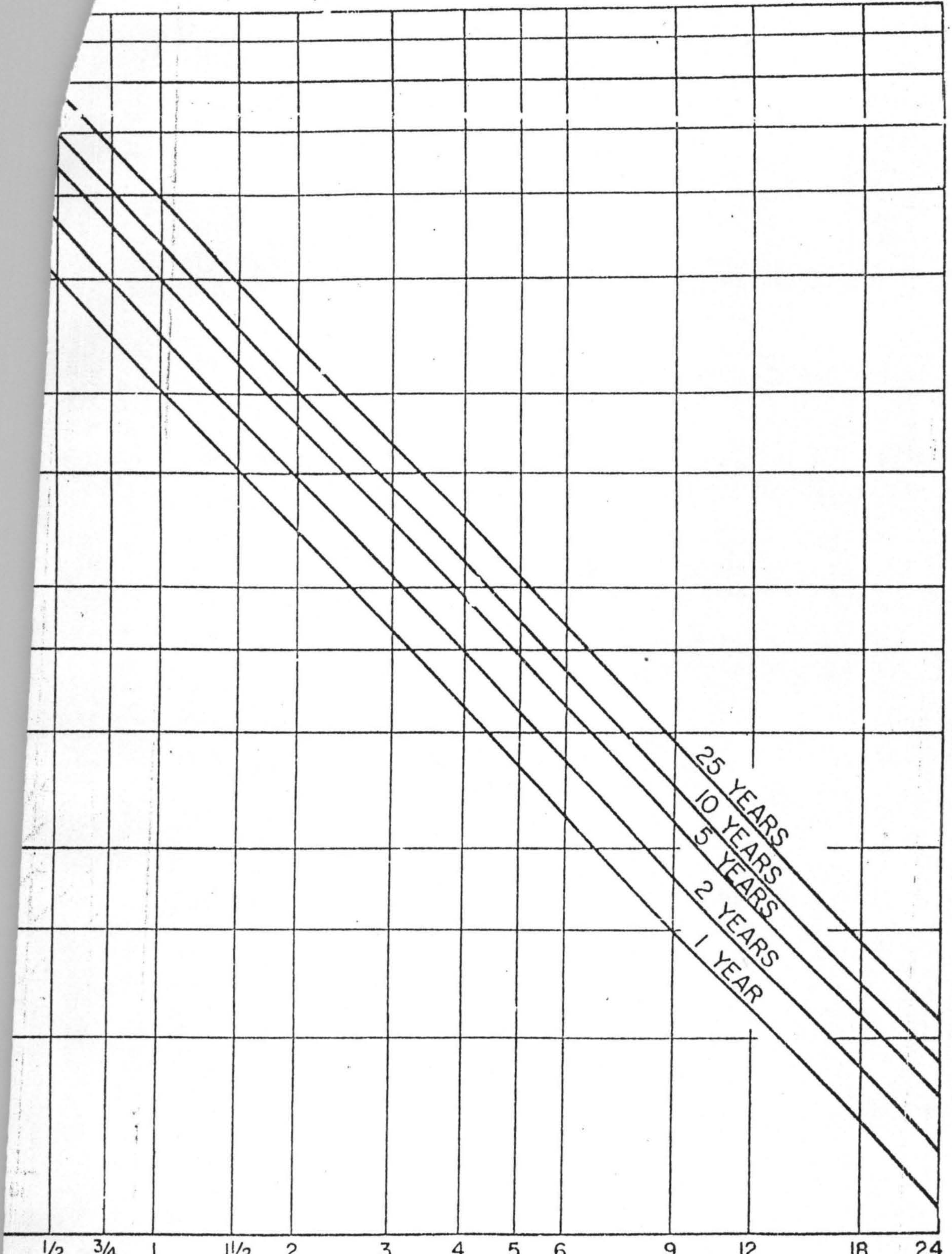
$1.5 = 50 \times .105^{2/3} \times 5^{1/2}$

$1.5 = 50 \times 0.2224 \times 5^{1/2}$

$S^{1/2} = \frac{1.5}{50 \times 0.2224}$

$S^{1/2} = 0.135$

$S = 0.0182$



KANO
RAINFALL INTENSITY – DURATION
BASED ON RECORDS FOR 1938-44
FIG. 1-307.9

CHAPTER FIVE

5.0 ESTIMATE AND BILL OF ENGINEERING MEASUREMENT AND EVALUATION

SITE CLEARANCE

S/NO	DESCRIPTION	QTY	UNIT	RATE	AMOUNT
2.01	Clear site as specified to a width of 10m including all trees of girth n.e 1.5m	8500	M^2	25	212,500.00
2.02	Removal of top soil to the depth of 150mm and dispose as directed.	1275	M^2	450	573,750.00
2.03	Grade and compact sub-grade including shaping of the road as directed.	5,100	M^2	30	153,000.00
2.04	Excavate to any depth in borrow pits including haulage to a distance n.e 1.50km deposit, spread and compact in layers not exceeding 150mm thickness.	765	M^2	700	535,500
	SUB-TOTAL				**N1,474,750**

ROAD WORK

S/NO	DESCRIPTION	QTY	UNIT	RATE	AMOUNT
3.01	Provide, lay and compact naturally occurring laterite materials to a compacted thickness of 245mm as sub-base and base materials including haulage n.e 1.50km	1,249.5	M^3	850	1,062,075.00
	SUB-TOTAL				1,062,075.00
	DRAINAGE STRCUTURE				
4.01	Provide and construct side drains to fall as directed.	1,700	Lm	300	510,000.00
4.02	Provide and construct 900mm diameter pipe culvert to MOW standard including concrete surrounding, headwalls and wingwalls	8	Lm	25,000	200,000
	SUB-TOTAL				**710,000.00**

SUMMARY

(1)	Site Clearance	-	1,474,750.00
(2)	Road Works	-	1,062,075.00
(3)	Drainage Structures	-	710,000.00
			3,246,825.00
	Add 5% Contingency	-	162,341.25
	Grand Total	-	N3,409,166.25

5.1 CONCLUSION AND RECOMMENDATION

In conclusion, a road can only achieve its design life period and carrying capacity if the actual job of construction is properly done, all the materials are of required standard, to the design specifications and always correctly used. And I sincerely believe that the application of the principals brought out in this thesis will conserve natural resources and offer substantial long time savings to those who pay for pavements, while providing facilities that will be more serviceable, last longer and give more comfort and safety to the users.

The existing alignment was also recommended for reconstruction; for the straight and curves found throughout the length of the road does not conform to the specified ruling limits of construction. Attached to the thesis are the recommended designs on longitudinal profile for references.

REFERENCES

1. O'Flaherty C.A. (1974): *Highways and Traffic 2nd Edition Vol. 1 pp 216 – 255*

2. O"Flaherty C.A. (1974) *Highway Engineering 2nd Edition Vol. III PP 63 –302*

3. University of Porthacourt:(1992):- ***Design of Rural Roads and Bridges of Industrial Engineering Unit of cordec University of Porthacourt. PP50-70***

4. Bannister A., Raymond S.(1992):- ***Surveying 6th Edition PP 353 – 379.***

5. Cotton A. P., Franceys R.W. (1991):- ***Services for Shelter and Infrastructure for Urban Low Income Housing. PP45-59***

6. UNDP/ILO: (1990):- ***Training Programme on labour Base Con-Struction and Maintenance of Roads hand-out papers***

7. Federal Ministry of Works (1973):- ***Highway Design Manual part I PP 1-301.03-1.309.***

8. Habib Y.M.(1990):- ***Appropriate Design of Rural Roads:- presented at NDE/UNDP Workshop on lobour Base/light Equipment Workshop at Epe Lagos State.***