Planning and Designing of Bypass Road For Coimbatore City

A Project Report

Submitted by

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1998-99

Department of Civil Engineering

Kumaraguru College of Technology

Coimbatore-641 006

Kumaraguru College of Technology

Coimbatore - 641 006.

Department of Civil Engineering

Certificate

This is to Certify that this Project Entitled

PLANNING AND DESIGNING OF BYPASS ROAD FOR COIMBATORE CITY

has been submitted by

Mr....

in partial fulfilment of the requirements for the award of Degree of Bachelor of Engineering in the Civil Engineering of the Bharathiar University, Coimbatore - 641 046

during the academic year 1998-99

(Guide) **(Head of Department)**

Certified that the Candidate was Examined by us in the Project Work.

Viva-Voce Examination held on ____________

University Register Number ____________

(Internal Examiner) **(External Examiner)**

Dedicated to Our Beloved Parents

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SYNOPSIS

The development of a more energy-efficient and less environmentally damaging road transport system is an urgent policy goal for most world economies. The increase in number of intersections leads to travel delays, environmental, safety degradation and the energy losses. The development of Coimbatore in various fields has resulted in a heavy congestion of traffic. At present Coimbatore City traffic is facing problems of road congestion, air pollution, accidents and wastage of fuel. Therefore moving in and around Coimbatore City becomes a problem for the road users.

So as a remedial measure it becomes necessary to provide a bypass road for Coimbatore NH-47 to decrease the Lorry traffic inside the city. Therefore it is necessary to provide a bypass for Coimbatore city, a stretch of road 27.76Km long, skirting Coimbatore on NH-47 between Salem and Palghat which connects other major roads like Pollachi road, Trichy road etc.,

This project deals with planning and designing of a by pass road with various features like design of curves, bridges and the quality control tests.

Introduction

1. INTRODUCTION

1.1 GENERAL

COIMBATORE - Cotton City, it is one of the third largest city in Tamilnadu next to Chennai and Madurai. The population of the city increases because of its industrial and educational development. The city is in its dynamic state of growth and it is expecting strides in industrial development. Since the standard of living is high, it plays a significant role in the development of the country and the state. The city has been bringing a worthy amount of foreign exchange by its exports of Textile Machinery's, Motors, Pumps, Garments, Handloom products, etc.,

1.2 NEED FOR THE STUDY

The phenomenal growth of industry, trade combined with heavy inflow of public as well as vehicles from other parts of the state, the Coimbatore city has resulted in a lot of traffic and transportation problems, particularly at Gandipuram and Ukkadam zone- the nerve centers of the cotton city. Due to the increase in population of the Coimbatore City, we require a safety and less time consuming route.

Hence Town Planning Department takes a categorywise vehicular traffic volume at different stations. From table 1.2.1 it was found that the lorry traffic through Avinashi, Pollachi and Palghat road is more when compared to other road.

Therefore in order to reduce the lorry traffic coming inside the City, we need a Bypass for Coimbatore NH-47.

TABLE 1.2.1

CATEGORYWISE VEHICULAR TRAFFIC VOLUME AT CORDON STATIONS

CORDON OUTER AND INNER	CATEGORY OF VEHICLES(IN NUMBERS)									TOTA
	BUS	LORRY	LCV	CAR	AUTO	TW	CYCLE	C.R	CART	
METUPPALAYAM ROAD	1140	1148	304	1676	85	1954	1680	5	55	8047
SATHY ROAD	384	565	196	435	17	706	866	13	37	3219
AVINASHI ROAD	1523	3815	943	3068	45	1709	817	0	24	11944
TRICHY ROAD	814	1512	665	1617	55	1311	775	0	42	6791
PODANUR-CHETIPALAYAM ROAD	136	250	66	133	17	352	284	3	54	1259
POLLACHI ROAD	972	780	308	1154	16	855	457	3	20	4565
PALGHAT ROAD	611	2674	421	1306	8	929	468	10	35	6462
SIRUVANI ROAD	341	288	151	472	85	1040	719	11	70	3177
THONDAMUTUR ROAD	208	180	141	260	33	1007	916	10	71	2826
MARUDAMALAI ROAD	264	29	15	393	35	895	505	0	45	2181
THADAGAM ROAD	138	533	51	263	63	684	534	1	91	2358

INNER CORDON

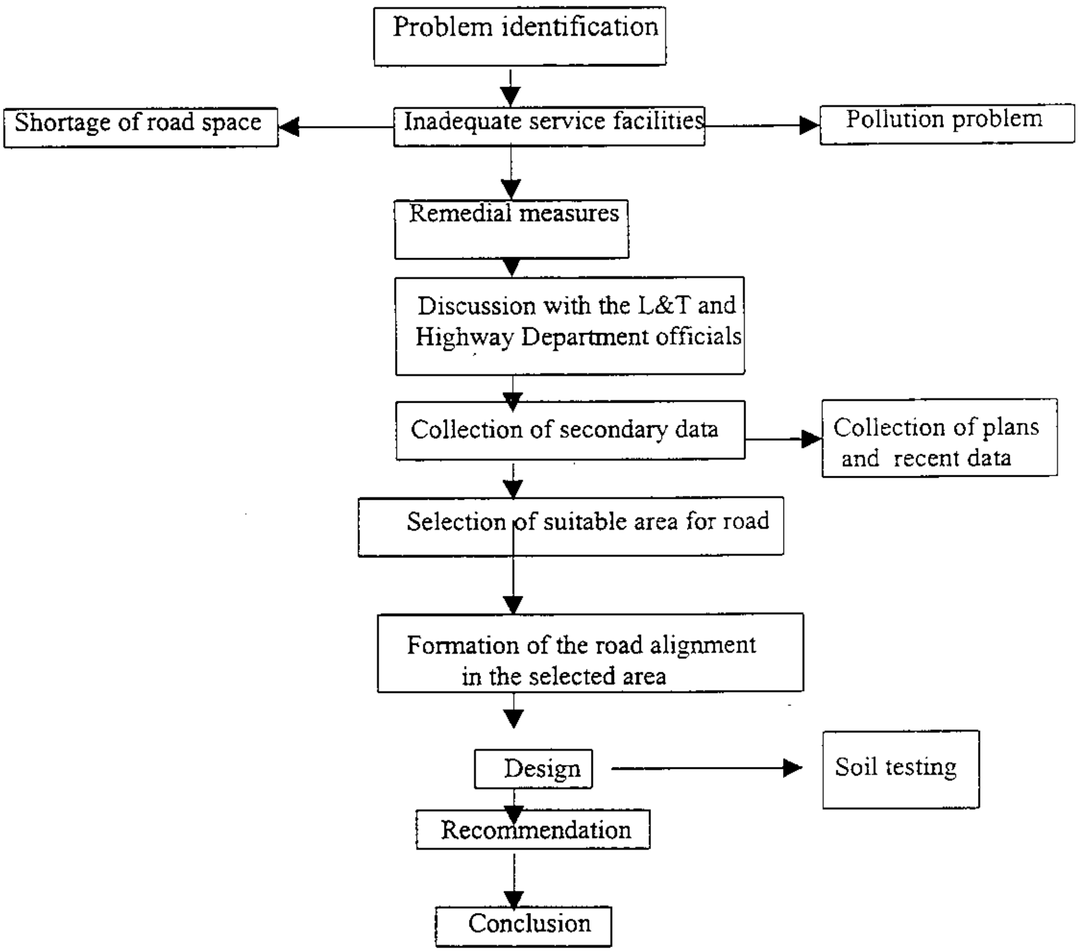
METTUPALAYAM ROAD	1833	1674	570	3305	488	5421	5399	13	167	18870
SATHY ROAD	698	408	272	720	175	2716	3174	7	180	8350
VILANKURICHI ROAD	108	97	67	168	47	1051	1057	0	26	2621
AVINASHI ROAD	1774	3730	989	4501	354	5640	3133	17	92	20230
TIRCHY ROAD	1411	1870	774	1943	145	2984	2376	4	131	11638
NANJUNDAPURA M RD	66	431	168	514	151	1843	2189	4	56	5422
PALGHAT ROAD	3997	6094	1609	5327	1633	9754	9368	8	653	38443
PERUR ROAD	933	333	395	846	461	2732	2416	27	295	8438
MARUDAMALAI ROAD	653	479	338	2444	913	9851	9787	14	183	24662
THADAGAM ROAD	469	731	191	1491	375	5034	5897	8	215	14411
THONDAMUTHUR RD	188	105	107	330	156	1584	2034	3	82	4589

SOURCE: COMPREHENSIVE TRAFFIC AND TRANSPORTATION STUDY FOR COIMBATORE.

1.3 OBJECTIVES

- To relieve the traffic congestion inside the Coimbatore City, by diverting the through traffic.
- Road accidents occur in direct proportion to the amount of traffic on the roads and hence it should be minimised.
- To reduce the journey time and thus we can save the wear and tear of the vehicles.
- To achieve a better fuel efficiency in reducing the travel distance.
- To avoid the pollution inside the city.

1.4 METHODOLOGY



1.5 SITE SELECTION CRITERIA

From the traffic data available, the site for the proposed bypass road has the following salient features:

- The proposed site connects other major roads like Pollachi, Trichy etc.,
- A reduction in running time is noticeable with the advantage of reducing Lorry traffic inside the city makes the site highly suitable for the proposal.
- The material used for the construction work is available near by the site, which satisfies the need
- This route comprises less agricultural lands when compared to the other routes selected for this project.

ABOUT THIS PROJECT:

The Bypass takes from Km 141.200 on NH-47 Neelambur and ends at 171.200 Km near Madukkarai.The Bypass will intersect SH-8 and SH-10 at Km 20.500 &7.102 on its alignment (REFER FIG 1.20). It goes over Broad gauge tracks at Km 22.360 and crosses Meter gauge track at Km 10.960.It also includes one Major Bridge over Noyyal, Minor Bridges, Hume Pipe Culverts and Box Culverts.

The Bypass is divided into four stretches. In this study 0.000 Km which starts Chainage at Madukkarai end.

TABLE NO.: 1.5.1

STRECHES	CHAINAGE
1.	0.000 Km to 7.00 Km
2.	7.000 Km to 14.00 Km
3.	14.00 Km to 20.78 Km
4.	20.78 Km to 27.76 Km

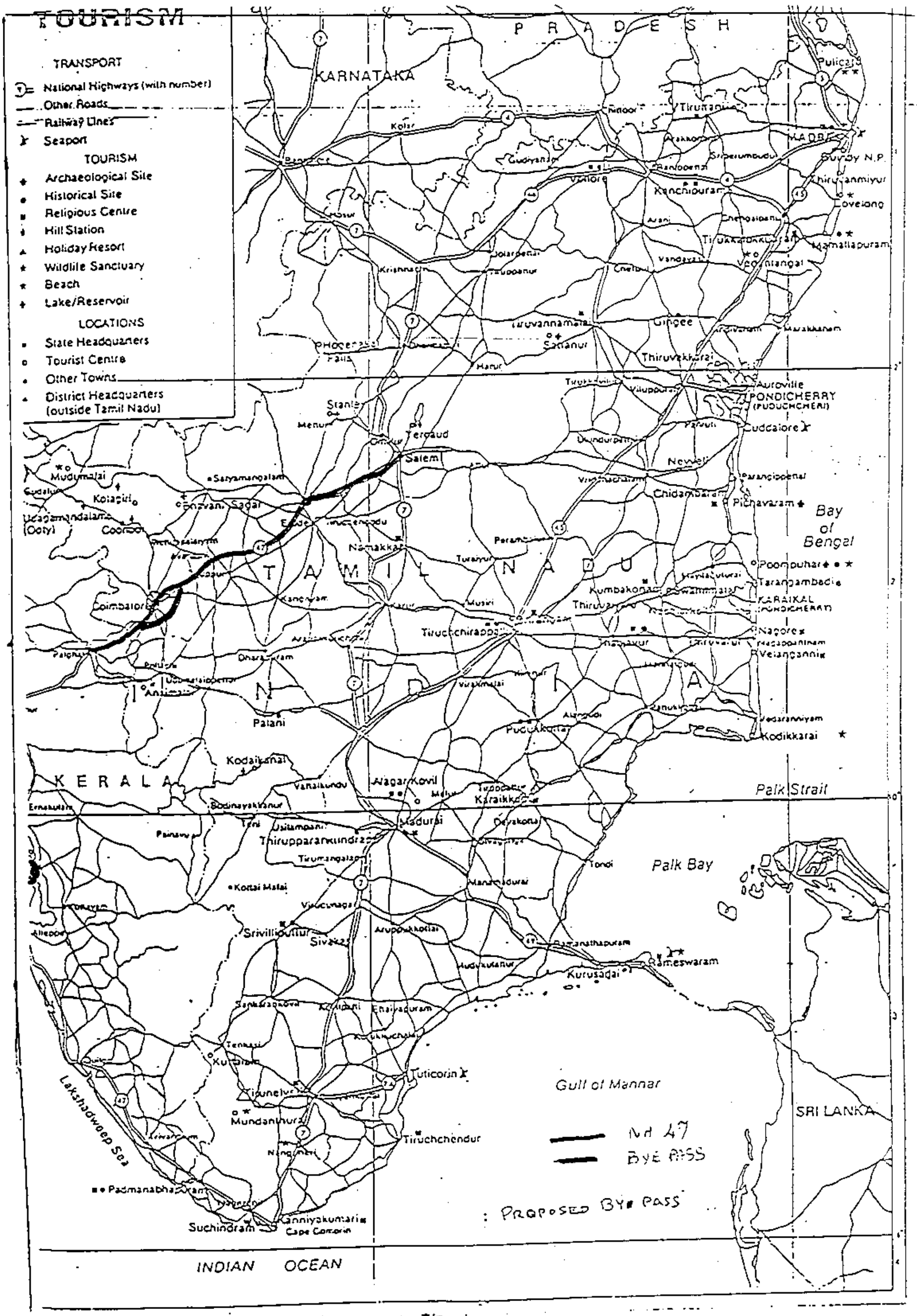
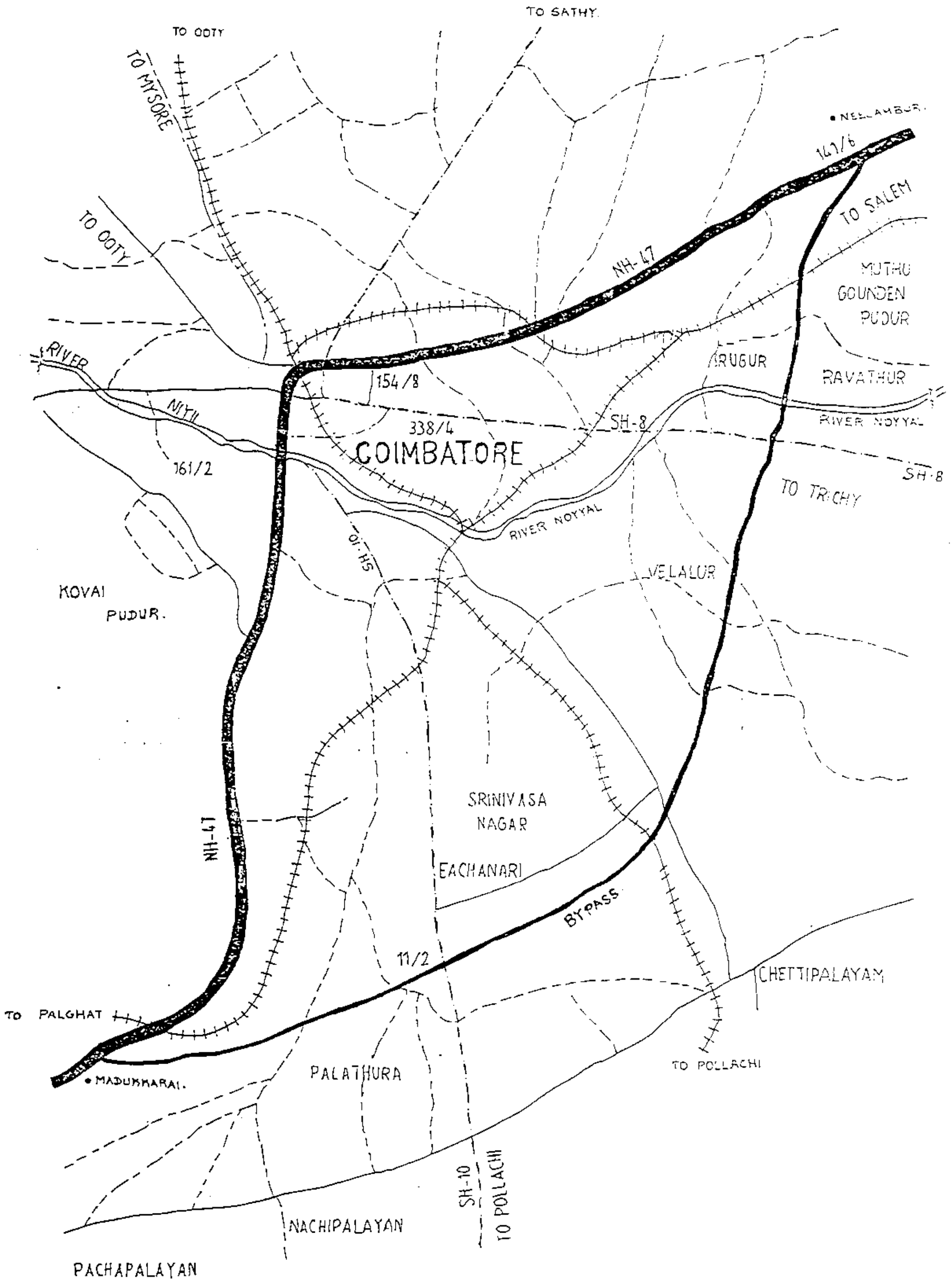

TOURISM
TRANSPORT
National Highways (with number)
Other Roads
Railway Lines
Seaport
TOURISM
Archaeological Site
Historical Site
Religious Centre
Hill Station
Holiday Resort
Wildlife Sanctuary
Beach
Lake/Reservoir
LOCATIONS
State Headquarters
Tourist Centre
Other Towns
District Headquarters (outside Tamil Nadu)
PRADESH
KARNATAKA
Kolar
Pulicat
Tiruttani
MADRAS
Guindy N.P.
Thiruvanmiyur
Kovelong
Mamallapuram
Kanchipuram
Sriperumbudur
Vellore
Arani
Chengalpattu
Vedanthangal
Hosur
Krishnagiri
Tiruvannamalai
Sattanur
Gingee
Thiruvakkarai
Harur
Hogenakal Falls
Auroville
PONDICHERRY (PUDUCHCHERI)
Cuddalore
Neyveli
Chidambaram
Pichavaram
Bay of Bengal
Stanley
Mettur
Yercaud
Salem
Mudumalai
Kotagiri
Udagamandalam (Ooty)
Coonoor
Sathyamangalam
Bhavani Sagar
Erode
Namakkal
Coimbatore
Palghat
Pollachi
Anaimalai
Palani
Kodaikanal
TAMIL NADU
INDIA
Karur
Musiri
Perambalur
Tiruchirappalli
Kumbakonam
Thanjavur
Poompuhar
Tarangambadi
KARAIKAL (PONDICHERRY)
Nagore
Velanganni
Vedaranniyam
Kodikkarai
Pudukkottai
Alangudi
Dharapuram
KERALA
Ernakulam
Alleppey
Bodinayakkanur
Nagar Kovil
Karaikkudi
Madurai
Thirupparankundram
Tirumangalam
Devakottai
Sivaganga
Manamadurai
Tondi
Palk Strait
Palk Bay
Kottai Malai
Srivilliputtur
Sivakasi
Aruppukkottai
Ramanathapuram
Rameswaram
Kurusadai
Sankarankovil
Ettayapuram
Tenkasi
Kuttalam
Tirunelveli
Tuticorin
Gulf of Mannar
SRI LANKA
Lakshadweep Sea
Mundanthurai
Tiruchchendur
Nanguneri
Padmanabhapuram
Suchindram
Kanniyakumari
Cape Comorin
INDIAN OCEAN
NH 47
BYE PASS
: PROPOSED BYE PASS

FIG NO-1-10


TO SATHY.
TO OOTY
TO MYSORE
NELLAMBUR
141/6
TO SALEM
TO OOTY
NH-47
MUTHU
GOUNDEN
PUDUR
IRUGUR
RAVATHUR
RIVER
NIYIL
154/8
338/4
SH-8
RIVER NOYYAL
COIMBATORE
161/2
SH-8
TO TRICHY
RIVER NOYYAL
SH-10
VELALUR
KOVAI
PUDUR.
SRINIVASA
NAGAR
NH-47
EACHANARI
BYPASS
11/2
CHETTIPALAYAM
TO PALGHAT
TO POLLACHI
MADUKKARAI.
PALATHURA
SH-10
TO POLLACHI
NACHIPALAYAN
PACHAPALAYAN

Geometric Design and Pavement Layers

2. GEOMETRIC DESIGN

INTRODUCTION:

Geometric design is an aspect of highway design dealing with the visible dimensions of a roadway. The safe, efficient and economic operation of a highway is governed to a large extent by the care with which the geometric design has been worked out.

2.1 HIGHWAY CLASSIFICATION:

The highway system is generally classified into various distinct groups. The highways are basically of two types namely urban and rural (non-urban). The Urban system is classified into Expressways, arterial and sub-arterial, collector and local streets. Rural roads classified into National Highways, State Highways, district and village roads.

National highways are the main highways running through the length and breadth of the Indian territory, connecting ports, capitals of states and including roads of strategic and military importance.

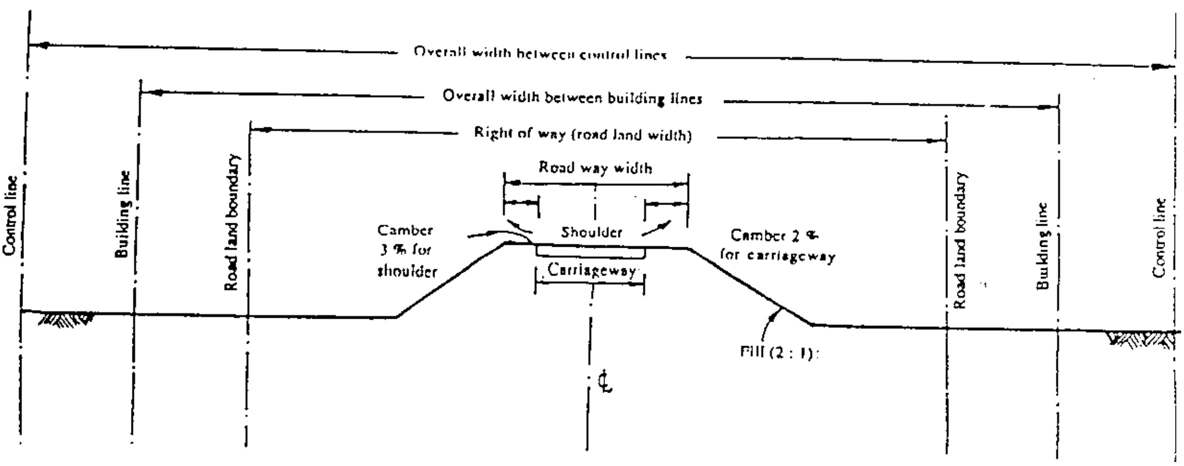
*SURVEYS: Survey helps to collect the data and information based on spot and field observations. The basic data to be collected (1)the present land use (2)population growth (3)traffic system (4)industrial position (5) economic base. All the secondary data for the study has been collected from authorities regarding the road.

(a).Topography : Topography and physical features play an important role in the location and design of Highway. The classification of terrain is normally done by means of the cross slope of the country. According to the available cross slope, the terrain classified as a rolling terrain since the slope is 10 to 25 %.

(b). Speed: The value of highway is largely indicated by the speed, safety and convenience afforded by the facility for travel. Design speed is the maximum safe speed that can be maintained over a specified section of highway when conditions are so favorable that the design features of highway govern.

From IRC specifications for a NH (rolling terrain), Ruling/maximum design speed is 100 K.P.H.

2.2 CROSS SECTIONAL ELEMENTS: The c/s elements in highway design pertain to those features which deal with its width. They embrace aspects such as right-of-way width, roadway width, shoulders, camber etc.,



(a)Right-of-way : It is the width of land secured and preserved to the public for road purposes.According to the IRC specifications for NH(plain terrain) Right-of-way width provided is about 45 meters.

(b)Roadway width: From current Indian practice,the width of roadway provided for (plain terrain) two lane NH is 12.0 meters.

(c).CARRIAGEWAY WIDTH : The width of traffic lane governs the safety and convenience of traffic and has a profound influence on the capacity of road. In India for two lane pavements carriageway width provided is 7.0 meters wide.

2.3 SHOULDERS:

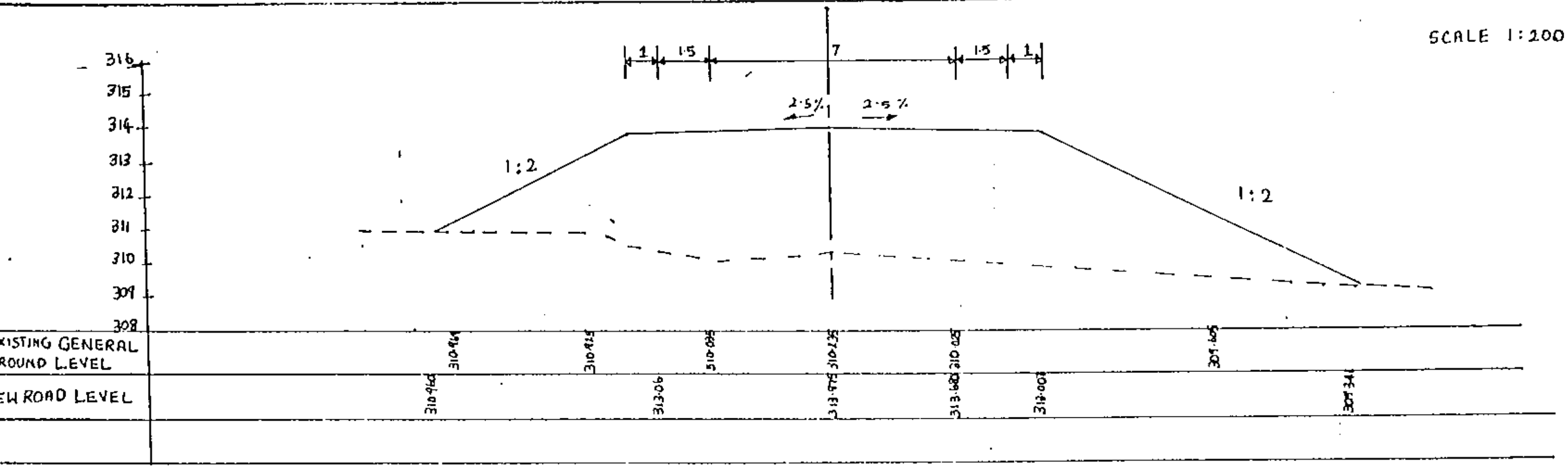
The shoulder is the portion of the roadway which is intended for accommodation of stopped vehicles, emergency use and lateral support of base and surface courses. Current Indian practice for 2-lane roads suggests a shoulder width of 2.5 meters for rural roads.

CAMBER: Camber also known as cross slope, facilitates drainage of the rainwater on the pavement laterally. The amount of camber to be provided depends upon the smoothness of the surface and the intensity of rainfall. Camber prescribed by IRC for Thin bituminous surfacing is 2.0 to 2.5 %.

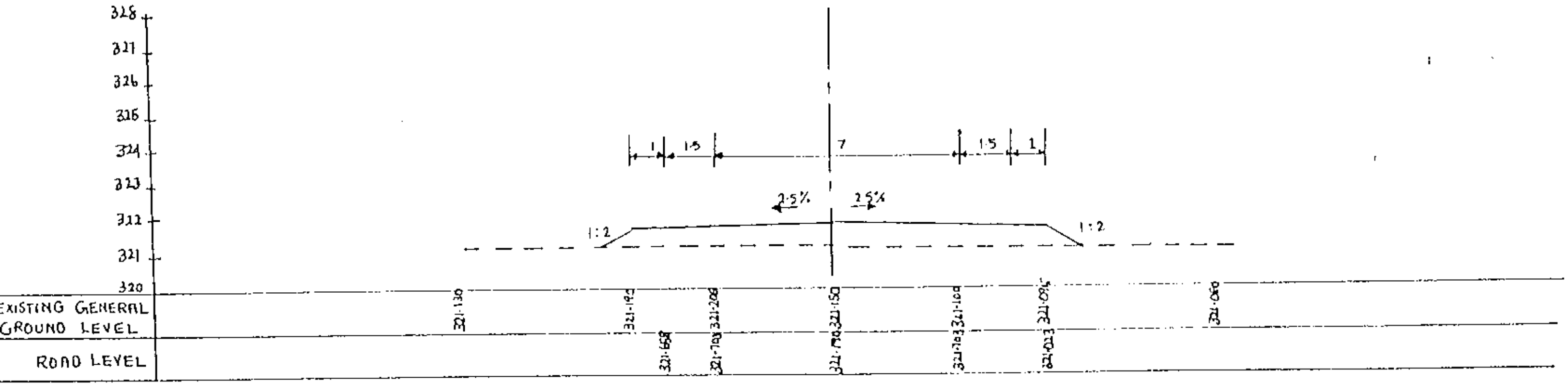
2.4 TYPICAL CROSS SECTION OF THE ROADWAY:

Typical cross section of the 2-lane national highway (L/S and C/S) is as shown below.

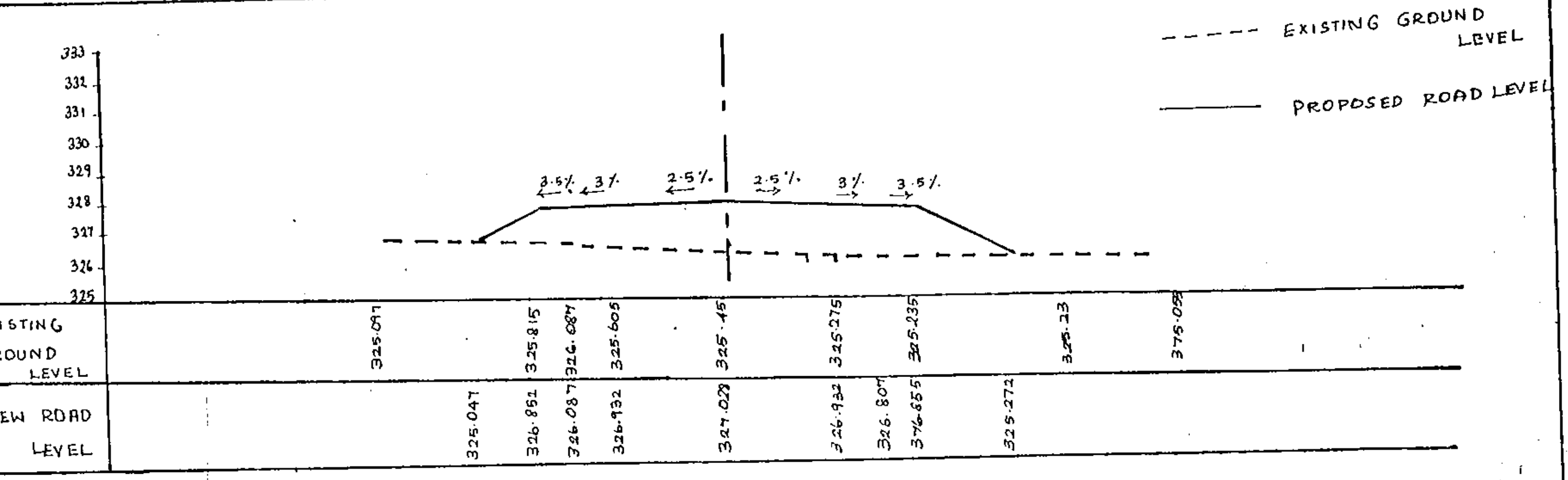
SCALE 1:200.



C.S AT KM 0·500

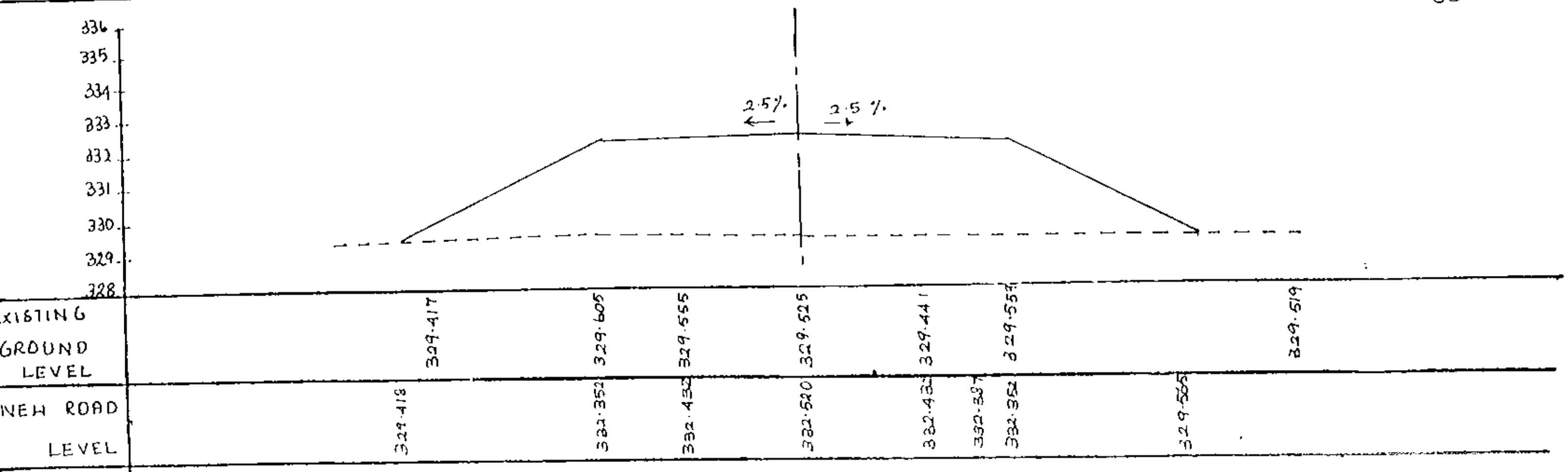


C.S AT KM 1·000

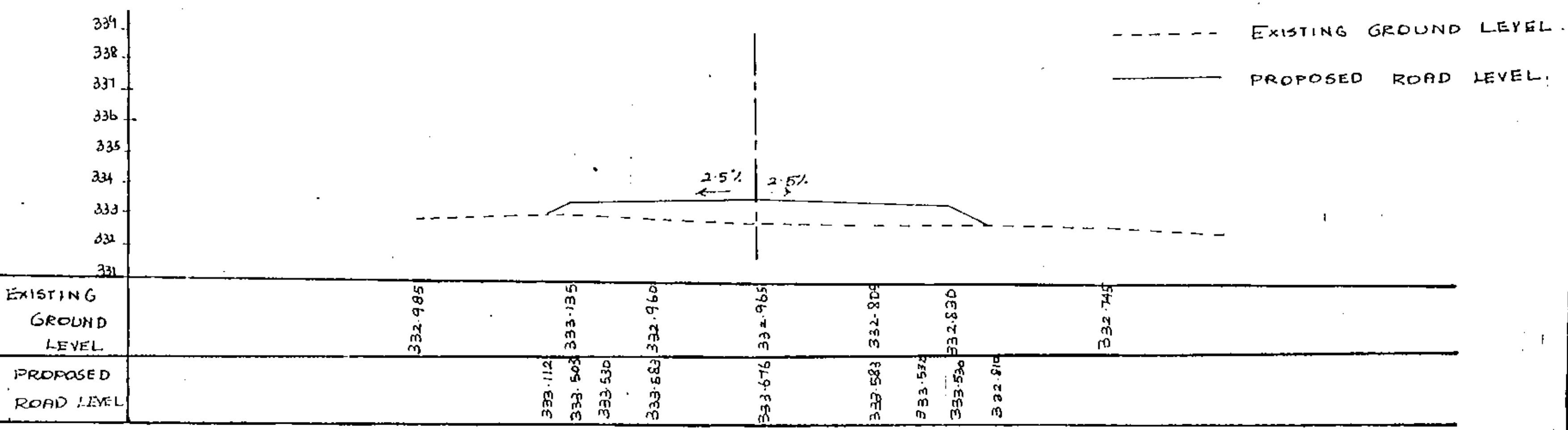


CS AT KM 2.000

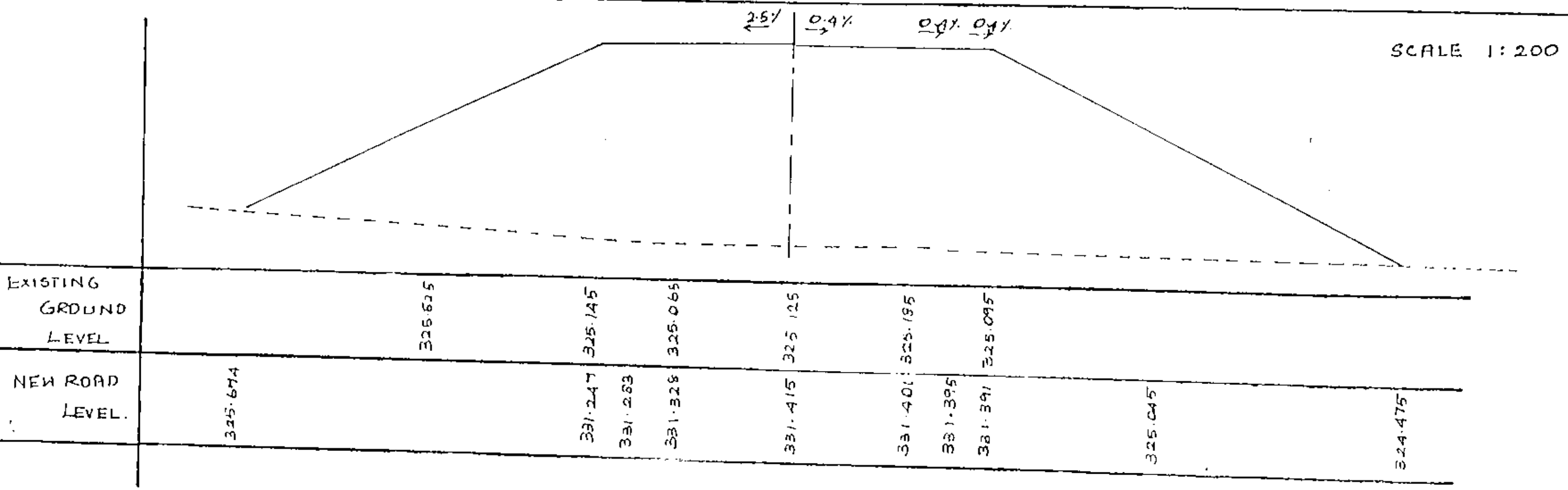
SCALE 1:200



C.S AT KM 2.500



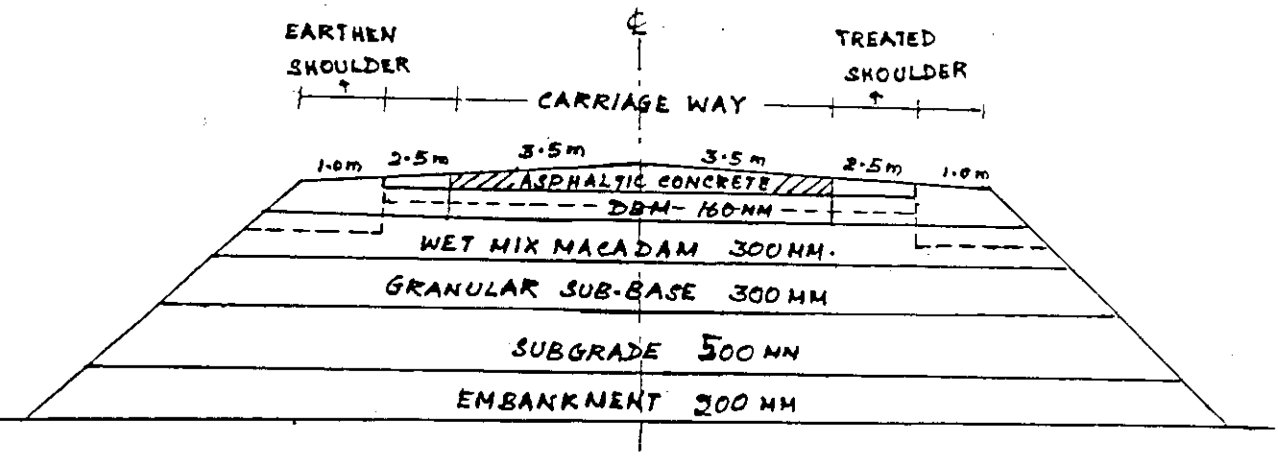
CS AT KM 3.000



CS AT KM 3.500

2.5 PAVEMENT LAYERS:

A Highway pavement is designed to support the wheel loads imposed on it from traffic moving over it. A Flexible pavement is one which has low flexural strength. Thus the external load is largely transmitted to the subgrade by the lateral distribution with increasing depth.



DETAILS OF PAVEMENT LAYERS.

(1) EMBANKMENT: The road pavement directly rests on artificially prepared soil subgrade and thus derives considerable strength from the subgrade. The embankment height is so selected that the bottom of the pavement is at least 0.6 to 1.0 m above the level of water-table or high flood level. The thickness of embankment provided for the proposed road is about 200 mm . The soil which is used in the embankment can be tested for its quality control as described in the next chapter.

(2)SUBGRADE: The subgrade is the compacted natural earth immediately below the pavement layers. The top of the subgrade is also known as the formation level. According to IRC specifications the thickness of subgrade layer provided is about 500 mm (fig 100.1 IRC). It can be split into three layers. First layer is of 200 mm thick, second and third layers are of 150 mm thick each. Material used is below 25 mm.

(3)SUB-BASE: Sub-base are the layer constructed above the sub grade of the pavement .The materials shall be laid in one or more layers as sub-base or lower sub-base and upper sub-base(termed as sub-base hereinafter).

a. Granular sub-base: This may be provided in two layers of 150 mm thick each. The material used in the sub-base is according to the IRC specifications. CBR values should be greater than 30 %, tested and the result is given in next chapter. Material used is 40 mm, 20 mm and moorum.

b. Wet mix macadam sub-base: Thickness of WMM is two layers of 150 mm thick each. According to the IRC specifications the thickness of a single compacted layer should not be less than 75mm.The materials used in this layer is like the previous one. Material used is 40 mm, 20 mm, 12 mm and below.

FUNCTIONS OF SUB-BASE LAYER:

- To minimize the damaging effects of frost action .
- To provide additional help to the base and surface courses in distributing the loads.
- To prevent intrusion of fine-grained road-bed soils into base courses.

(4) BASE COURSE: The base is the medium through which the stresses imposed are distributed evenly. This can be laid immediately below the surface course.

1. Dense bitumen macadam: According to the IRC specifications the thickness for a single course should be 50 to 100 mm. Physical requirements of the aggregate can be tested and compared with IRC specifications such as abrasion, aggregate impact value etc. Material used is less than 12 mm.

FUNCTIONS OF BASE COURSE:

- To act as the structural portion of the pavement and thus distributes the load.
- If constructed directly over the sub-grade to prevent intrusion of sub-grade soils into the pavement.

(5) SURFACE COURSE: The topmost layer is the surfacing the purpose of which is to provide a smooth, abrasion resistant, dust proof and strong layer. According to the specifications the thickness of layer provided is about 40 mm thick.

1.ASPHALTIC CONCRETE: Asphaltic concrete is a pavement specification composed of a thoroughly controlled hot-mixed material having as ingredients (1) graded mineral aggregate (3) filler (3) bitumen.

Advantage: Durability, Imperviousness, Load spreading property, Quickly openable to the traffic and Good skid resistance.

Design

3.1 Design of Curve

A regular curve path followed by a railway/ highway alignment is called a curve. It may be either circular, parabolic/ spiral and is always tangential to the two straight direction at its ends.

Transition Curve:

A transition curve or easement curve of varying radius introduced between a straight and a circular curve or between two branches of a compound curve are reverse curve.

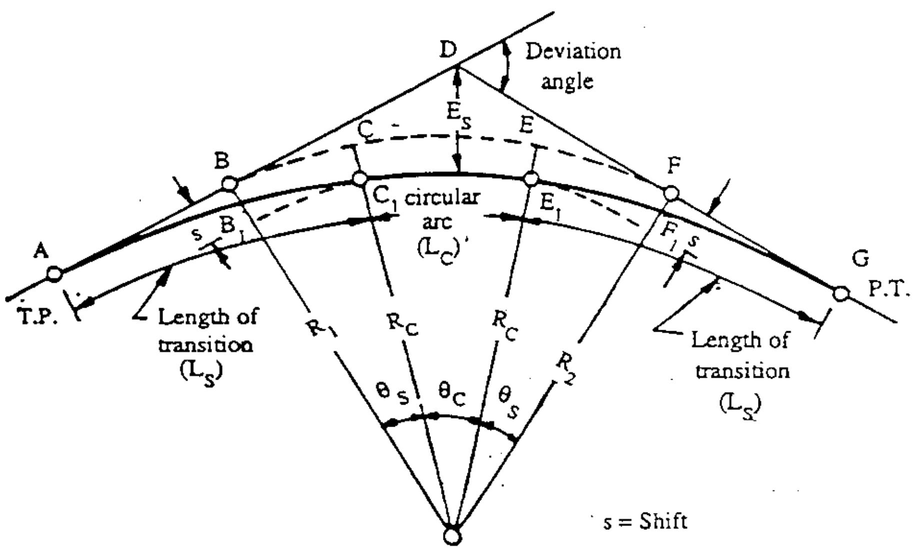
Functions:

1. To provide a medium for the gradual introduction or change of the required super elevation.
2. To accomplish gradually the transition from the tangent to the circular curve, so that the curvature is increased gradually from zero to specified value.

CHAINAGES OF CRITICAL POINTS OF HORIZONTAL CURVES

Project : NH - 47 Coimbatore Bypass Road

Curve No.	Deviation Angle °	'	"	Type of curve	Chainages BS	BC	AC	EC	ES
1.	17	23	38	RH	0/001.80	0/66.80	0/176.98	0/287.16	0/352.16
2.	42	29	42	LH	3/505.00	3/575.00	3/836.66	4/098.330	4/168.33
3.	15	52	00	LH	19/988.00	20/058.80	20/119.92	20/181.84	20/251.16
4.	20	01	14	LH	21/477.63	21/572.63	21/652.34	21/652.34	21/747.34
5.	40	29	30	RH	25/450.52	25/520.52	25/741.70	25/962.88	26/032.88
6.	12	9	00	RH	27/501.79	27/571.79	27/632.21	27/692.63	27/762.63



Simple curve design

Details :

Radius of circular curve = 800 m
Design speed of vehicle = 100 Kmph.
Chainge at the intertion pt = 3851.2 m.

Design :

i) Length of the spiral $L_s = \frac{0.0215v^3}{C_R}$

$$C = \frac{80}{75 + V}$$

R = Radius of the circular curve
R = 800 m
V= Velocity = Design speed = 100 Kmph

$$L_s = \frac{0.0215 \times 100^3}{0.457 \times 800} = 58.80 \text{ m}$$

ii) Super elevation e $= \frac{v^2}{22 R}$

$$C = \frac{100^2}{225 \times 800} \times 100$$

$$= 5.56 \%$$

iii) Spiral angle $\varnothing_s = \frac{L_s \times 180}{2\Pi R} = \frac{58.80 \times 180}{2\Pi \times 800} = 2^\circ 6' 20.2''$

iv) Deuiation angle of circular curve $\Delta_C = \Delta - 2\varnothing_s$

$$= 42^\circ 29' 42'' - 2 \times 2^\circ 6' 20.2''$$

$$= 38^\circ 17' 15.4''$$

v) Tangent distance $(T_s) = \left[(R+S)\ \Delta/2 \right] + \frac{L_s}{2}$

$$\text{Shift } (s) = \frac{(L_s)^2}{24\,R}$$

$$= \frac{(58.80)^2}{24\,(800)}$$

$$= 0.180$$

$$Ts = (800 + 0.180) \tan \frac{42^\circ 29' 42''}{2}) + \frac{58.80}{2}$$

$$= 340.532$$

(vi) Length of circular curve $Lc = \frac{\Pi R\,(\Delta - 2\varnothing)}{180} = 523.33$

Chainage pts:

Chainage at A = 3505 m

Add length of Ac = 346.16 m

Chainge of C = 3851.16 m

Subtract tangent length C = 340.532 m

Chainage at T_1 = 3510.628 m

Add length of curve = 523.33 m

SUPER ELEVATION DETAILS FOR CURVE No.2

Chainage	Finished Road Level	% of Slope	
		Left Camber Width	Right CammberWidth
3.470	331.346	2.500	2.500
3.480	331.369	2.500	1.986
3.490	331.393	2.500	1.191
3.500	331.416	2.500	0.397
3.510	331.439	2.500	-0.397
3.520	331.462	2.500	-1.191
3.530	331.485	2.500	-1.986
3.540	331.508	2.780	-2.780
3.550	331.532	3.574	-3.574
3.560	331.555	4.369	-4.369
3.570	331.578	5.163	-5.163
3.580	331.601	5.560	-5.560
3.590	331.624	5.560	-5.560
3.600	331.647	5.560	-5.560
3.610	331.671	5.560	-5.560
3.620	331.694	5.560	-5.560
3.630	331.717	5.560	-5.560
3.640	331.740	5.560	-5.560
3.650	331.763	5.560	-5.560
3.660	331.786	5.560	-5.560
3.670	331.809	5.560	-5.560
3.680	331.833	5.560	-5.560
3.690	331.856	5.560	-5.560
3.700	331.879	5.560	-5.560
3.710	331.902	5.560	-5.560
3.720	331.925	5.560	-5.560
3.730	331.948	5.560	-5.560
3.740	331.972	5.560	-5.560
3.750	331.995	5.560	-5.560
3.760	332.018	5.560	-5.560
3.770	332.041	5.560	-5.560
3.780	332.064	5.560	-5.560
3.790	332.087	5.560	-5.560
3.800	332.111	5.560	-5.560
3.810	332.134	5.560	-5.560
3.820	332.157	5.560	-5.560
3.830	332.186	5.560	-5.560

SUPER ELEVATION DETAILS FOR CURVE No.2

Chainage	Finished Road Level	% of Slope	
		Left Camber Width	Right CammberWidth
3.850	332.226	5.560	-5.560
3.860	332.250	5.560	-5.560
3.870	332.273	5.560	-5.560
3.880	332.296	5.560	-5.560
3.890	332.319	5.560	--5.560
3.900	332.344	5.560	-5.560
3.910	332.389	5.560	-5.560
3.920	332.456	5.560	-5.560
3.930	332.544	5.560	-5.560
3.940	332.654	5.560	-5.560
3.950	332.785	5.560	-5.560
3.960	332.937	5.560	-5.560
3.970	333.090	5.560	-5.560
3.980	333.243	5.560	-5.560
3.990	333.396	5.560	-5.560
4.000	333.550	5.560	-5.560
4.010	333.703	5.560	-5.560
4.020	333.856	5.560	-5.560
4.030	334.010	5.560	-5.560
4.040	334.163	5.560	-5.560
4.050	334.316	5.560	-5.560
4.060	334.469	5.560	-5.560
4.070	334.623	5.560	-5.560
4.080	334.776	5.560	-5.560
4.090	334.929	5.560	-5.560
4.100	335.083	5.428	-5.428
4.110	335.236	4.633	-4.633
4.120	335.389	3.839	-3.839
4.130	335.567	3.045	-3.045
4.140	335.696	2.500	-2.251
4.150	335.849	2.500	-1.456
4.160	336.002	2.500	-0.662
4.170	336.145	2.500	-0.132
4.180	336.274	2.500	-0.927
4.190	336.390	2.500	-1.721
4.200		2.500	2.500

DESIGN PARAMETERS OF HORIZONTAL CURVES

VE No.	TYPE OF CURVE	CURVE PARAMETERS														
		Δ			Radius of circular curve	Øs			Δc			Length of spiral	Length of circular curvel	Tangent distance	Shift	Speed Kmph	% Sperelevatio
		°	'	"		°	'	"	°	'	"						
1.	RH	17	23	38	940	1	58	52	13	25	54	65.0	220.36	176.32	0.187	100	4.73
2.	LH	42	29	42	800	2	30	25	37	28	52	70.0	523.33	346.16	0.255	100	5.56
3.	LH	15	52	00	700	2	51	54	10	08	12	70.0	123.84	132.59	0.292	100	6.35
4.	LH	20	01	14	500	2	26	37	09	08	00	95.0	79.73	135.89	0.752	100	7.00
5.	RH	40	29	30	725	2	45	58	34	57	34	70.0	442.36	302.50	0.282	100	6.13
6.	RH	12	09	00	900	2	13	42	07	41	36	70.0	120.84	130.80	0.227	100	4.94

DESIGN OF BRIDGE

Girder bridge:

Clear width of roadway = 7m

Span centre to centre of bearings = 20m

Live load = class A and class AA

Average thickness of bearing coat = 8cm

Solution :

Three girders are provided at c/c distance of 2.5m. Kerbs 0.6m wide are provided. C/S of the bridge as shown in fig.A.Rib with of 30cm is provided for longitudinal beams. Cross girders are provided at every 5 m to connect longitudinal beams. The breadth of cross girders provided is 30 cm.

Thickness of slab is assumed as 20cm. For interior pannels the thickness of cantilever slab is assumed as 24 cm at junction with rib and 14cm at junction with kerb.The weight of railing is assumed as 70 kg/m.

Cantilever will be designed by effective width method and interior pannels by Pigeaud's theory.

Dimensions of interior pannels are 2.5m x 5m. concrete mix M200 is used for deck slab and M150 for girders.

IMPACT FACTORS for design of slab :

Class AA loading = 25 % ,For class A loading max. impact factor=50.0%

Design of cantilever portion :

DEAD LOAD B.M :

Items	Load / M run kg.	Distance of C.G for the edge of cantilever	Moment kg.M
Parapet	70	1.375	96.25
Kerb	0.44x0.6x1x2400 = 633.6	1.15	728.64
Wearing coat	0.08x0.85x2200 = 149.6	0.425	63.58
Slab rectangular	0.14x0.85x2400 = 285.6	0.425	121.38
Slab triangular	½ x 0.85 x0.10x2400=102	0.283	28.9
	Total load	1240.8 kg	D.L.B.M = 1038.75 kg /m

LIVE LOAD B.M :

Class AA loading :

Minimum clearance of class AA loading from kerb is 1.2m hence, this loading will not come in cantilever portion.

Class A loading ;Average thickness of cantilever slab

$$= \frac{14+24}{2} = 19cm$$

Distance of C.G of load from edge of cantilever , X= 0.425 m (FIG.1)

Effective width of slab = 1.2x + bw

= 1.2 x 0.425 (0.325 +2 x 0.05)

= 0.51 + 0.485= 0.995 m

Load per metre width of slab $\frac{11.4/2}{0.995} = 5.728t$

Dispension width along span of cantilever

$$= 0.5 + 2\ (0.08 + 0.19) = 0.5 + 0.54 = 1.04 \text{ m}$$

Some portion of dispension width goes beyond edge of cantilever.

Dispension width in cantilever portion

$$= \frac{0.54}{2} + 0.5 + 0.1 = 0.87 \text{ m}$$

Portion of load in cantilever

$$= 0.578 \times \frac{0.87}{1.04} = 4.79 \text{ t}$$

$$\text{B.M} = 4.79 \times \frac{0.87}{2} = 2.083 \text{ t.m}$$

B.M including inpact = 1.5 x 2083 = 3124.5 Kg.m

Total B.M = 3124.5 + 1038.75 = 4163.25 kg/m

Effective depth = $\frac{\sqrt{4163.25 \times 100}}{12.13 \times 100}$ = 18.52 cm

Provide overall depth of 24 cm with effective depth of 20.9 cm

Area of steel required = $\frac{4163.25 \times 100}{12.13 \times 100}$ = 18.52 cm

Provide overall depth of 24 cm with effective depth of 20.9 cm

$$\text{Area of steel required} = \frac{4163.25 \times 100}{1400 \times 0.87 \times 20.9} = 16.35 \text{ cm}$$

provide 12 mm dia bars at 6 cm c/c distance

Distribution steel : Distribution reinforcement is to be provided for 0.3 times live load moment plus 0.2 times dead load moment.

$$M = 0.3 \times 3124.5 + 0.2 \times 1038.75 = 1145.1 \text{ kg.m}$$

$$\text{Effective depth} = 20.9 \times - 0.6 - 0.4 = 19.9 \text{ cm}$$

$$A = \frac{1145.1 \times 100}{1400 \times 0.87 \times 19.9} \quad 4.724 \text{ cm2}$$

Half reinforcement is to be provided at top and half at bottom. 8mm dia bars at 10 cm centres are provided both at top and bottom.

SHEAR:

Live load shearing including impact = 4.79 x 1.50 = 7185 kg

Dead load shear = 1240.8 kg

Total shear = 8425.8 kg

$$\text{Shear stress} = \frac{8425.8}{100 \times 0.87 \times 20.9} = 4.63 \text{ kg / cm2}$$

It is safe.

DESIGN OF INTERIOR PANELS :

Dead weight of slab per square metre = 1 x 1 x 0.2 x 2400 = 480 kg

Dead weight of bearing coat = 1 x 1 x 0.08 x 2200 = 176 Kg

Total D.L. = 656 kg / m2

Live load :Class AA bracked vehicles : one wheel is pleased in the centre of panel. (FIG. 2)

Thickness of wearing coat = 0.08m

U = 0.85 + 2 x 0.8 = 0.01m ; V = 3.6 + 2 x 0.8 = 3.76 m

$$\frac{U}{B} = \frac{1.05}{2.5} = 0.404$$

$$\frac{V}{L} = \frac{3.76}{5} = 0.752$$

$$\frac{L}{B} = \frac{5}{2.5} = 2$$

Reffering to Pigeaud's curve {K = 2}

$M_1 = 9.8 \times 10^{-2}$, $M_2 = 2.2 \times 10^{-2}$

Moment alond M_B = $W (M_1 + 0.15M_2)$

$$= \frac{70000}{2}(9.8 \times 10^{-2} + 0.15 \times 2.2 \times 10^{-2})$$

= 3545.5 kg.m

As the slab is continuous B.M. taken for design will be 0.8 times M_B

B.M. including input and continuing factor = 1.25 x 3545.5 x 0.8

M_B = 3545.5 kg.m

$M_L = (70000/2)*(2.2 \times 10^{-2} + 0.15 \times 9.8 \times 10^{-2})$ = 1284.5 kg.m

B.M. including impact and continuity factor

= 1.25 x 1284.5 x 0.8 = 1284.5 kg.m

Shear : Dispension in the direction of span

= 0.85 + 2 (0.85 + 0.20) = 1.41 m

For max. shear load is kept such that whole dispension is in the span.

Load is kept at 1.41 / 2 = 0.705 m. from the edge of beam.

Effective width of slab = Kx (1-x/l) + bw

Breadth of cross girder = 30 cm Therefore, effective width of slab = 2.56 x 0.705 (1 - 0.705 / 2.2) + 3.6 + 2 + 0.08 = 5m

Load per metre width = 70000 / 2 x 5 = 7000 kg

Shear force = 7000 x (2.2 - 0.705) / 2.2 = 4760 kg

Shear force including impact = 1.25 x 4760 = 5950 kg

Class AA wheeled vehicle : there are two possibilities which should be investigated for finding the maximum B.M. in the panel. First possibility is when two loads of 3.75 tonnes each and two loads of 6.25 tonnes each symmetrically placed about two centre line as shown in fig3.second position is when two loads of 3.75 tonnes each and 4 loads of 6.25 tonnes each are placed at the centre.(FIG.4)

However, on actual analysis in this case it is seen that first case gives maximum B.M. and thus calculation for first case only are shown.

U_1 = 0.30 + 2 x 0.08 = 0.46 m

V_1 = 0.15 + 2 x 0.08 = 0.31 m

The analysis for this case is done as given below. For each load

M_1 and M_2 for

1. $u = 2 (u_1 + x)$ and $v = 2 (v_1 + y)$ and multiply by $(u_1 + x) (v_1 + y)$

2. $u = 2x$ and $v = 2y$ and multiply by xy.

3. $U = 2\,(u_1 + x)$ and $v = 2y$ and multiply by $y\,(u_1+x)$

4. $U = 2x$ and $v = 2\,(v_1+y)$ and multiply by (v^1+y)

For design B.M_s subtract [(ii) + (iv)] from [(I) +(ii)] and multiply by $\frac{w_1}{u_1 v_1}$

(i) $u = 2\,(0.46 + 0.07) = 1.06$

$v = 2\,(0.31 + 0.445) = 1.51$

$$\frac{u}{B} = \frac{1.06}{2.50} = 0.424$$

$$\frac{u}{B} = \frac{1.51}{5} = 0.30$$

Referring to graph of K = 1.6

$M_1 = 14 \times 10^{-2}$; $M_2 = 7 \times 10^{-2}$

These are to be multiplied by 0.53 x 0.755 modified values are

$$\frac{u}{B} = \frac{1.06}{2.50} = 0.424.$$

$$\frac{u}{L} = \frac{0.89}{5} = 0.424$$

From graph $M_1 = 26 \times 10^{-2}$; $M_2 = 12.9 \times 10^{-2}$

These are to be multiplied by 0.07 x 0.445

Modified valves are M_1 = $26 \times 10^{-2} \times 0.07 \times 0.445 = 0.8099\ 10^{-2}$

M_2 = $2.9 \times 10^{-2} \times 0.07 \times 0.445 = 0.4018 \times 10^{-2}$

(iii) U = 2 (0.46 + 0.07) = 1.06

V = 2 0.445 = 0.89

$$\frac{u}{B} \quad \frac{1.06}{2.50} = 0.425$$

$$\frac{V}{L} \quad \frac{0.89}{5} = 0.178$$

From graph, M_1 = 15.4×10^{-2} ; $M_2 = 11 \times 10^{-2}$

These are multiplied by 0.53 x 0.445

Modified values are M_1 = $15.4 \times 10^{-2} \times 0.53 \times 0.445 = 3.56 \times 10^{-2}$

M_2 = $11 \times 10^{-2} \times 0.53 \times 0.445 = 2.594 \times 10^{-2}$

U = 2 x 0.07 = 0.14

V = 2 (0.31 + 0.445) = 0.51

$$\frac{V}{L} = \frac{0.89}{5} = 0.178$$

From graph, $M_1 = 20.2 \times 10^{-2}$; $M_2 = 8 \times 10^{-2}$

These are to be multiplied by 0.07 x 0.755

Modified values are M_1 = $20.2 \times 10^{-2} \times 0.07 \times 0.755 = 1.067 \times 10^{-2}$

$$M_2 = 8 \times 10^{-2} \times 0.07 \times 0.755 = 0.4228 \times 10^{-2}$$

Design values of M_1 and M_2 are

$$M_1 = 2.801 \times 10^{-2} + 0.4018 \times 10^{-2} - 2.594 \times 10^{-2} = 1.7849 \times 10^{-2}$$

$$M_2 = 2.801 \times 10^{-2} \times 0.4018 \times 10^{-2} \times - 2.594 \times 10^{-2} - 0.4228 \times 10^{-2}$$

$$= 0.186 \times 10^{-2}$$

B.M. due to load is $W / u_1 v_1 \; (M_1 + 0.15 M_2)$

Total M_B is due to 4 loads $= \dfrac{2 \times 6250}{0.31 \times 0.46}(1.7849\text{x}10^{-2} + 0.15\text{x}0.186\text{x}10^{-2})$

$$+ \frac{2 \times 3750}{0.31 \times 0.46}(1.7849\text{x}10^{-2} + 0.15\text{x}0.186\text{x}10^{-2})$$

$$= 2294.38 \text{ kg.m}$$

B.M. including impact and continuity factor

$$= 1.25 \times 2294.38 \times 0.8 = 2294.38 \text{ kg.m}$$

Total M_L due to 4 loads $= \dfrac{2 \times 6250}{0.31 \times 0.46}(0.186 \times 10^{-2} + 0.15 \times 1.7849 \times 10^{-2})$

$$+ \frac{2 \times 3750}{0.31 \times 0.46}(1.7849\text{x}10^{-2} + 0.15\text{x}0.186\text{x}10^{-2})$$

B.M. including impact and continuity $= 1.25 \times 636.32 \times 0.8 = 636.32$

Second position of loads is not investigated as it gives less bending moments.

Shear due to class AA wheeled vehicle : dispension width in direction of span = 0.3 + 2 (0.20 + 0.08 + 0.03 + 0.56) = 0.86 m

Loads are placed such that outermost load is at distance of 0.86 / 2 = 0.43 m. from edge of the beam. The position of loads for maximum shear is shown fig.Effective width for first wheel , (FIG:5)

$$= Kx\,(1\text{-}x/l) + bw$$

$$= 2.56 \times 0.43\,(1\text{-}\ 0.43 / 2.2) + 0.30 + 2 \times 0.08 = 1.36\text{m}$$

But centre to centre distance of two sheels is 1.2 m and thus effective widths will overlap.Average effective width for one wheel

$$= \frac{1.2 + 1.36}{2} = 1.28 \text{ m}$$

Load per metre width of slab

$$= \frac{3750}{1.28} = 2930 \text{ kg}$$

Eff. width for second wheel =2.56 x 1.03 (1-10.3 / 2.2) + 0.46=1.888 m

But centre to centre distance of two wheels is 1.2 m and thus effective widths overlap.

$$\text{Average effective width for one wheel} = \frac{1.2 + 1.888}{2} = 1.544 \text{ m}$$

$$\text{Load per metre width of slab } \frac{6250}{1.544} = 4045 \text{ kg}$$

Portion of W3 in span $\frac{7240}{0.86} = 0.75$ kg

shear force at the edge $= 2930 \frac{(2.2 - 0.43)}{2.2} + 4045 \times \frac{1.17}{2.2} + \frac{7240}{0.86} \times 0.75$

$\times \frac{0.75}{2} \times \frac{1}{2.2} = 5565$ kg

Shear force including impact = 1.25 x 5565 = 6956 kg

Class A loading : for maximum BM one wheel of 5.7 tonnes shold be pleased at the centre of span and other at 1.2 m. from it as shown in fig. Imaging load $W_3 = W_2$ is placed on the other side of W_1 to make loading symmetrical. B.M. at centre of panel will be that due to W_1 plus half due toloadW$_2$andW$_3$. (FIG:6)

B.M. due to load W_1

$U = 0.5 + 2 \times 0.08 = 0.66$ m ; $V = 0.25 + 2 \times 0.08 = 0.41$ m

$\frac{u}{B} \quad \frac{0.66}{2.5} = 0.264$

$\frac{V}{L} \quad \frac{0.41}{5} = 0.082$

From graph, $M_1 = 19.8 \times 10^{-2}$; $M_2 = 16 \times 10^{-2}$

$M'B = W (M_1 + 0.15 M_2)$

$= 5700 (16 \times 10^{-2} + 0.15 + 19.8 + 10^{-2})$

B.M. due to w_2

$U_1 = 0.5 + 2 \times 0.08 = 0.66$ m ; $V_1 = 0.25 + 2 \times 0.08 = 0.41$ m

$U = 0.66 \quad V = 2 (0.995 \times 0.41) = 2.81$

$$\frac{u}{B} \quad \frac{0.66}{2.5} = 0.264$$

$$\frac{V}{L} \quad \frac{2.81}{5} = 0.562$$

These are to be multiplied by 1.405,Modified values are

$M_1 = 18.54 \times 10^{-2}$; $M_2 = 4.49 \times 10^{-2}$

$$\frac{u}{B} \quad \frac{0.66}{2.5} = 0.264$$

$$\frac{V}{L} \quad \frac{1.99}{5} = 0.398$$

From graph

$M_1 = 15.0 \times 10^{-2}$; $M_2 = 5 \times 10^{-2}$

These are to be multiplied by 0.995,Modified values of M_1 and M_2 are

Modified values are $M_1 = 18.54 \times 10^{-2} - 14.925 \times 10^{-2} = 3.615 \times 10^{-2}$

$M_2 = 4.49 \times 10^{-2} \times 4.975 \times 10^{-2} = 0.485 \times 10^{-2}$

$M'B = W/V\ (M_1 + 0.15\ M_2)$

$= 5700/\ 0.41\ (3.615 \times 10^{-2} + 0.15 + 0.485 \times 10^{-2}) = 502.57$ kg.m

$M'L = 5700/\ 0.41\ (0.485 \times 10^{-2} + 0.15 + 3.615 \times 10^{-2}) = 142$ kg.m

Total B.M due to two loads will be

M_B = 1266+503 =1769 Kg.m ; M_L = 1082+142 = 1224 Kg.m

B.M including impact and continuity, M_B = 1.50X0.8 = 2122.8 Kg.m

B.M including impact and continuity, M_L=1.50X1224X0.8= 1468.8 Kg.m

Shear due to class A loading

Dispersion width in the direction of span = 0.50+2(0.2+0.08) = 1.06m

for maximum shear load should be placed at a distance of

$\frac{1.06}{2}$ = 0.50m from the edge. In this position second load will be on the other beam.

$$\text{Effective width} = kx\left(\frac{1-x}{l}\right) + b_w$$

$$= 2.56 \times 0.53 \left(\frac{1-0.53}{2.2}\right) + 0.25 - 2 \times 0.08$$

$$= 1.05+0.41 = 1.46\text{m}$$

Distance between two wheels in widths overlap.

Average effective width per wheel

$$= \frac{1.46+1.2}{2}$$

$$=1.33\text{m}$$

Load per metre width of the beam

$$= \frac{5700}{1.33} = 4275Kg.$$

Shere force = $4275 \frac{(2.2-0.53)}{2.2} = 3245$ Kg.

S.F including impact = 1.50x3245 = 4867.5 Kg.

Design live load B.Ms and S.F :-

M_B = 3545.5 Kg.m due to class AA tracked vehicle.

M_L = 1468.8 Kg due to class A loading.

S.F = 6956 Kg due to class AA wheeled vehicle.

Dead load :-

Dead load per square metre = 656 Kg/m^2

D.L B.M will be found by pigeaud's method

Total load on panel = 5x2.5x656 =8200Kg

$\frac{u=1}{B}$, $\frac{v=1}{L}$ as the panel is loaded with uniformly distributed load.

$M_1 = 4.9 \times 10^{-2}$; $M_2 = 1.5 \times 10^{-2}$

$M_B = 8200 (4.9 \times 10^{-2} + 0.15 \times 1.5 \times 10^{-2}) = 420.25$Kg.m

Taking actual B.M, 0.8 time value to account for continuity

M_B = 0.8x420.25 336.2

$M_L = 8200 (1.5 \times 10^{-2} + 0.15 \times 4.9 \times 10^{-2}) = 183.35$

B.M taking into consideration effect of continuity

Dead load shear force in assumed as= $\dfrac{656 \times 2.2}{2}$ = 721.6 Kg

Total M_B due to D.L and L.L = 2122.8+336.2 = 2459 Kg.m

Total M_L = 1468.8+146.68 = 1615.48 Kg.

Total S.F = 8200 + 721.6 = 8921.6Kg

Design of section :-

Effective depth required = $\sqrt{\dfrac{2459 \times 100}{12.13 \times 100}}$ = 14.23 cm

Provide overall depth of 20cm with effective depth of 16.9cm

A_t for M_B = $\dfrac{2459 \times 100}{1400 \times 0.87 \times 16.9}$ = $11.94 cm^2$

provide 12mm ∅ bars at 90mm c/c distance.

Effective depth for M_L = 16.9-0.6-0.5 =15.8cm

$A_t = \dfrac{1615.48 \times 100}{1400 \times 0.87 \times 15.8}$ = $8.39 cm^2$

provide 10mm ∅ bars at 10cm centres.

Check for shear :-

$$\frac{8921.6}{100 \times 0.87 \times 15.8} = 6.067 \text{ Kg/cm}^2$$

safe.

* Design of Longitudinal Girders :

Distribution of live loads on longitudinal beams for B.M.

Classs A loading : Reaction on the girders will be maximum when the eccentricity is maximum. Eccentricity will be maximum when the loads are very near to the kerb. Position of loads for maximum eccentricity is as shown in fig.All the girders are assumed to have the same moment of inertia.Reaction factor for outer girder , (FIG. 7)

$$R_A = \frac{4 W_1}{3} \left[1 + \frac{3 I}{2 I \times 2.5^2} \times 2.5 \times 0.59 \right] = 1.805 W1$$

$$R_B = \frac{4 W_1}{3} [1 + 0] = \frac{4 W_1}{3}$$

If W is also load, wheel load $W_1 = W/2$

Reaction factor for outer girder $= \dfrac{1.805}{2} W = 0.9025 W$

Reaction factor for inner girder $= \dfrac{4}{3} \times \dfrac{1}{2} W = 0.6667W$

Class AA loading : Position of loads for maximum eccentricity is shown in fig. 8.

$$R_A = \frac{2\ W_2}{3}\ [\ 1 + \frac{3\ I}{2\ I \times 2.5^2} \times 2.5 \times 0.59\ ]$$

$$R_B = \frac{2\ W_1}{3}\ [\ 1 + 0.45\ ] = 0.9667\ W_2$$

$$\text{Reactions on outer girder } R_B = \frac{2\ W_2}{3}$$

If W is axle load, wheel load $W_2 =$ W/2

Reaction factor for inner girder { 2/3 }x { W/2 } = {W/3 }

Dead load from slab per girden = 2 x 1240.8 + 656 x 5.3

= 5958.4 kg

It is assumed that dead load is shared equally by all the girders.

$$\text{Dead load per girder} = \frac{5958.4}{3} = 1986.13 \text{ kg}$$

Impact factors : Span = 20 m

Impact factor for class AA loading = 10 %

Impact factor for class A loading = 4.5 /6 + L

$$= \frac{4.5}{6 + 20} = 0.173$$

Live load B.Ms and S.F. at different sections will be found for class AA bracket vehicle and class A loading. Class AA wheeled vehicle is not considered as it does not produce work effect.

Live load bending moment : Centre of span. (FIG. IL1)

Class AA loading: Position of load is as shown.

$$\text{B.M.} = \frac{5 + 4.1}{2} \times 70 = 318.5$$

B.M. including impact and reaction factor for outer girder.

$$= 318.5 \times 1.1 \times 0.4833$$

$$= 169.32 \text{ t.m.} = 169324 \text{ kg/m}$$

for outer girder = 116783 kg .m

Class A loading : Position of loads for maximum B.M. at caentre of span is shown in fig.

$$\text{B.M.} = \frac{11.4 \times 5 + 11.4 \times 8.8}{10} + 2.7 \frac{4.5 \times 5}{10} \quad \frac{2.7 \times 5.6 \times 5}{10}$$

$$+ \frac{6.8 \times 2.7}{10} \times 5 + \frac{6.8 \times 5.7}{10}$$

$$= 149.355 \text{ t.m.}$$

B.M. including impact factor and reaction factor for outer girder.

$$= 149.355 \times 0.9025 \times 1.173 = 158.112 \text{ t.m}$$

B.M. including impact factor and reaction factor for inner girder.

$$= \quad 149.355 \times 0.666 \times 1.173 = 116.80 \text{ t.m.}$$

it is seen that maximum B.M. for inner girder and outer girder is given y class AA cracked vehicle.

Maximum L.L. moment for outer girder = 169324 kg.m

Maximum L.L. moment for iner girder = 116783 kg.m.

Quarters span :

Class A loading : position of load for maximum B.M. is as shown in fig. IL2.

$$\text{B.M.} = \frac{4 + 3.325 \times 70}{2} = 256.31 \text{ t.m}$$

B.M. including impact factor for outer girder.

$$= \quad 256.37 \times 1.1 \times 0.4833 = 136.293 \text{ t.m.}$$

B.M. including impact factor for inner girder.

$$= \quad 256.37 \times 1.1 \times 1/3 = 94 \text{ t.m.} = 94000\text{kg.m.}$$

Class A loading : Position of loads for maximum B.M. as shown in fig.

$$\text{B.M} = 11.4 \times 4 + 11.4 + \frac{13.8 \times 4}{15} + \frac{6.8 \times 6.5 \times 4}{15}$$

$$+ \frac{6.8 \times 3.5 \times 4}{15} + \frac{6.8 \times 0.5 \times 4}{15} = 125.46 \text{ t.m}$$

B.M. including impact factor for outer girder

$$= \quad 125.54 \times 0.9025 \times 1.173 = 132.90 \text{ t.m.}$$

B.M. including impact factor for inner girder

$$= 125.54 \times 0.6667 \times 1.173 = 98.17 \text{ t.m.}$$

Maximum B.M. is given by class AA loading.

Maximum live load B.M. for outer girder = 99820 kg.m

Maximum live load B.M.for inner girder = 68.340 kg.m

Live load shear : Maximum shear at al section is given by class AA bracket vehicle for maximum shear at support, load should be as near the support as possible. The length of the load is 3.6m. whole of load will lie between suport and first cross - girder. L.L. shear at support is found by the method described earlier.for intermediate section shear will be found by drawing influence lines. The reaction factors shear at intermediate sections.The position of centre line of load for maximum shear force is showing fig. Let P_A, P_B and P_L be the loads coming on the longitudinals considering the slab as simply supported. (FIG - 9)

$$P_A = W_1 \frac{2.5 - 0.725}{2.5} = 0.75 W1$$

$$P_B = W_1 \frac{0.75\ W_1}{2.5} + \frac{(2.5 - 0.275)\ W_1}{2.5}$$

$$= 0.29\ W_1 + 0.89\ W_1$$

$$1.18\ W_1$$

$$P_B = W_1 \frac{0.275\ W_1}{2.5} = 0.11\ W_1$$

Due to P_A shear force at A = $R_{A'}$

$$= \frac{0.71\ W_1 \times 2.2}{5}$$

$$R_Q = \frac{0.71\ W_1 \times 1.8}{2.2}$$

Due to P_B shear force at

$$B = R'B = \frac{1.18\ W_1 \times 2.2}{5} = 0.5192$$

$$R_R = 1.18 \times \frac{1.8}{2.2} = 0.531\ W_1$$

Due to $P_{C,}$ shear force at C

$$= R'c \frac{0.11\ W_1 \times 2.2}{5} = 0.0484\ W_1$$

The loads on the cross girder (i.e.) R_Q, R_Q, and Rs are ti be distributed by normal courbon's theory.

$$EW = 0.3195\ W_1 + 0.531\ W_1 + 0.0396 = 0.8901\ W_1$$

Let x be the distance of C.G. of loads from Q.

$$X = \frac{0.531\ W_1 \times 2.5 + 0.0396\ W_1 \times 5}{0.8901\ W_1}$$

$$= 1.713$$

Eccentricity e = 2.5 + 1.713 = 4.213 m

$$F_Q = \frac{0.8901\ W_1}{2} \{1 + \frac{3 \times 0.75 \times 2.5}{2 \times 2.5^2}\} = 0.430\ W_1$$

$$F_R = \frac{0.9\ W_1}{3}\{1+0\} = 0.3\ W_1$$

Due to F_Q , R_A = 0.430 x 15 / 20 = 0.3225 W_1

Due to F_R , R_B = 0.3 W_1 x 15 / 20 = 0.225 W_1

Therefore, total reduction on outer girder = 0.3124 + 0.3225 = 0.6349 W_1

Total reduction on the inner girder = 0.5192 + 0.225 W_1 = 0.7442 W_1

Maximum S.F. at support including impact for outer girder.

$$= 1.1 \times 0.6349 \times \frac{0.9\ W_1}{3} = 24443.65 \text{ kg}$$

Maximum S.F. at support including impact for inner girder.

$$= 1.1 \times 0.7442 \times \frac{70000}{2} = 28651.7 \text{ kg}$$

* Shear at centre of span : Position of load for maximum shear is shown in influence line diagram in fig. 3.21. IL3.

S.F. =((1/2+1/2+7.4/10)/2)X10000 = 30450 kg

S.F. including impact for outr girder.

= 1.1 x 0.4833 x 30450 = 16188.133 kg

S.F. including impact for inner girder = 1.1 x 1/3 x 30450 = 11165 kg

Shear at 3/8th span

$$\text{S.F.} = \frac{5/8 + 5/8 \times 8.4/12.5}{2} \times 70000 = 36575 \text{ kg}$$

S.F. including impact for other girder= 36575 x 0.4833 x 1.1=19444.36 kg

S.F. including impact for inner girder = 36575 x 1/3 x 1.1 = 13410.83 kg

Shear at quarter span :

$$S.F. = \frac{3/4 + 3/4 \times 11.4/15}{2} \times 70000 = 46200\text{kg}$$

S.F. including impact factor for other girder
$=1.1 \times 0.4833 \times 46200 = 24561.31$ kg

S.F. including impact factor for inner girder

$$= 1.1 \times 1/3 \times 46200 = 16940 \text{ kg}$$

Dead load B.M. and S.F:
Assume depth of rib as 1.4 m

Width of rib per metre run $= 1 \times 0.3 \times 1.4 \times 2400 = 1008$ kg

Cross girders are provided at centre, quarter points and at the supports, width of each cross girders is 30 cm and depth 1.4 m

Width of each cross girder $= 1 \times 0.3 \times 1.4 \times 2400 = 1008$ kg

Reaction from deck slab on each cross section $= 1986.13$ kg

Total load per metre run of girder $= 1986 + 1008 = 2994$ kg

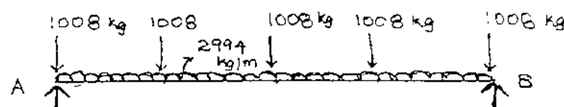
B.M. at centre of span

$$= \frac{2994 \times 20 \times 20}{10} + 1008 + 5 + \frac{1008}{2} \times 5$$

$$= 129840 \text{ kg.m}$$

$$\text{B.M. at quarter span} = 2994 \times 10 \times 5 - 2994 \times 5 \times 2.5 + 1008 \times 5 + \frac{1008}{2}$$

$$= 119835 \text{ kg.m.}$$



Dead load shears at support

$$= \quad 2994 \times 10 + \frac{1008}{2} = 31452$$

Dead load shear at quarter span

$$= \quad 31452 - 2994 \times 5 \quad = 16482 \text{ kg.}$$

Dead load shear at 3/8th span

$$= \quad 3152 - 2994 \times 8 = 16485 \text{ kg.}$$

$$= \quad 6492$$

$$\text{dead load shear at centre of span} = \frac{1008}{2} = 504 \text{ kg}$$

Design bending moment and shear forces :

Outer girder :

Total B.M at centre of span = 169324 + 129840 = 299164 kg.m

Total B.M. at quater span= 99820 + 119835 = 219655 kg.m

Total shear force at support = 24443.65+ 31452 = 55895.65 kg.m

Total shear force at quarter span = 24561.3 + 16482 = 41043.3 kg.m

Total shear force at 3/8 th span = 19444.36 + 119835 = 25936.36 kg.m

Total shear force at centre of span = 16188.33 + 504 = 16692.33 kg

Inner girder :

Total B.M. at centre of span = 116783 + 129840 = 246623 kg.m

Total B.M. at quarter span = 68340 + 76896 = 145236 kg.m

Total shear force at support span= 28651.7 + 31452 = 60103.7 kg.m

Total shear force at quarter span = 16940 + 16482 = 32972 kg.

Total S.F. at 3/8th span = 13416.83 + 6492 = 19902 kg

Total S.F. at mid span = 11165 + 504 = 11669 kg

Design of section :

Outer girder : Max B.M. = 299.164

The beam us designed as T-beam , Assume effective depth as 145 cm

Assume lever arm = 0.9 x 145

$$A_t = \frac{299164 \times 100}{0.9 \times 145 \times 1400} = 163.74 \text{ cm}^2$$

Provide 20 bars of 32 mm dia. As provided = 168.89 cm^2

Check for stresses : flange width will be least of

i. 12 d_s + b = 12 x 20 + 30 = 270 cm

ii. c/c = 2.5 m = 250 cm

iii Span /3 = 2000/3 = 666.67

Therefore, B = 250 cm

For checking stress average thickness of flange is assumed as 20 cm. The concrete mix used for slab is M 200 and the girders M150. As the whole compression is assumed to be taken by

Assume N.A. to lie in web , 250 x 20 (n - 10) = 13x 168.89(145 – n)

$$\frac{5000}{13 \times 168.89}(n - 10) = 145 - n$$

$$2.28\,n - 22.80 = 145 - n$$

$$3.38\,n = 167.80$$

$$n = 49.64 \text{ cm}$$

Lever arm a,

$$= d - \frac{d_s}{2} + \frac{d_s^2}{6\,(2n - d_s)} = 145 - 10 + \frac{20 + 20}{6\,(2 \times 49.64 - 20)}$$

$$= 135.84 \text{ cm}$$

$$\text{B.M.} = \frac{B\, d_s\, C_d\,(1 + n - n_s)}{N} \times a$$

$$C_a = 27.579 \text{ kg / cm}^2$$

Area of steel required at quarter span

$$= \frac{219655}{1400 \times 0.9 \times 145} = 120.22 \text{ cm}^2$$

15 bars of 32 mm dia are required

Check for shear and bond : Maximum shear at support

$$= 55895.65 \text{ kg}$$

Assume effective depth as 150 cm at support and lever arm as

$$\text{E 0 required for bond} = \frac{55895.65}{10 \times 0.9 \times 15.0} = 41.40 \text{ cm}$$

Number of 32 mm dia bars required $= \dfrac{41.40}{\pi \times 3.2} = 5.14$ nos.

At least 6 bars are to be taken straight

Shear stress at support $= \dfrac{55895.65}{30 \times 0.9 \times 15.0} = 13.8$ kg/cm^2

Shear stress at centre of span $= \dfrac{16692.83}{30 \times 135.98} = 4.12 > 5$

No shear reinforcement is required

Shear stress as 3/8th span $= \dfrac{25936.36}{30 \times 0.9 \times 145} = 6.62 > 5$

Bars are bent in sets with two bars in each set at every 0.95 m. five sets of bent up bars are provided. Bent up bars will be effective upto 5 x 0.95 = 4.75 m. from support. At every section two sets of bars i.e. 4 bars are effective as the bars are bent at spacing of 0.707a. Shear taken by bent up 32 mm dia bars

$= 4 \times 8.04 \times 1400 \times 0.707 = 31800$ kg

Net shear force at support for which shear reinforcement is to be provided

$= 55895 - 31800 = 24095$ kg

Using 10mm dia 2 legged stirrups

Spacing = (2x0.785x1400x0.87x150)/24095 =11.90 cm

Provide 10 mm dia 2 legged stirrups at 11cm centres upto 3.8 m from support. After 3.8 m from support only two bars are effective.

Shear taken by two bars = 16188.63 kg

Net shear at quarter point for which stitt ups are required

$$= \quad 41043.30 - 16188.63 = 24854.67 \text{ kg}$$

10mm dia stirrups at 10 cm centre are provided between 3.8 m and 4.10m from support beyond 4.10 m from support no bar is effective.

Providing 12 mm dia 2 legged stirrups,

$$\text{Spacing} = \frac{2 \times 1.13 \times 1400 \times 0.9 \times 145}{41043.3} = 11.1\text{cm}$$

As the shear at 4.7 m is less than that at quarter span, provide 12 mm dia 2 legged stirrups at 13 cm centres upto 6m from support.

Shear force at 3/8th span= 25936.36

Using 12 mm 9.2 legged stirrups spacing

$$\text{Spacing} = \frac{2 \times 1.13 \times 1400 \times 0.9 \times 145}{25936.36} = 15.1$$

Provide 12 mm dia stirrups upto 7.5m from support. In the remaining portion provide 12 mm dia stirrups at 50cm centres.

INNER GIRDER:

Maximum B.M. at centre = 246623 kg.m

$$\text{Area of steel required at centre} = \frac{246623 \times 100}{1400 \times 0.9 \times 1} = 134.98 \text{ cm}^2$$

Provide 16 bars of 32 mm diametre

CHECK FOR SHEAR AND BOND

Maximum shear at support = 60103.7 kg

Assume effective depth as 150 cm at support

E0 required for bond = $\dfrac{58777}{10 \times 0.9 \times 150}$ = 44.52 kg/cm^2

Number of 32 mm dia bars required = $\dfrac{58777}{10 \times 0.9 \times 150}$ = 4.42 cm

<u>6 bars of 32 mm dia are taken straight</u>

Shear stress at support = $\dfrac{58777}{30 \times 0.9 \times 150}$ = 14.5 kg/cm^2

Shear stress at centre of span = $\dfrac{11669}{30 \times 0.9 \times 14.5}$ = 2.98 kg/cm^2

Shear stress at 3/8th span = $\dfrac{19902.83}{30 \times 0.9 \times 145}$ = 4.90 kg/cm^2 <5

No shear reinf is required b/w mid span and 3/8th span.Bars are bent in sets at every 0.95m, with two bars in each set. Four sets of bent up bars are provided. Bent up bars will be effective upto 4 x 0.95 = 3.8m. from support. At every section two sets of bars i.e. bars are effective as the bars are bent at spacing of 0.707a.

Shear taken by 4 bent up bars = 31.800 kg

Net shear for which shear reinforcement is to e provided at supports

= 60103.7 - 31800 = 28303.7

Provide 12 mm dia 2 legged stirrups.

$$\text{Spacing} = \frac{2 \times 1.13 \times 1400 \times 0.9 \times 145}{28303.7} = 14.58 \text{ cm}$$

Provide 12 mm dia 2 legged stirrups at 15 cm centres. This spacing is provided upto 3.8m from support. After 2.85 m from support only two bars are effective but S.F. is less than at support.

Shear force at quarter span = 32972 kg

Providing 12 mm dia 2 legged stirrups.

$$\text{Spacing} = \frac{2 \times 1.13 \times 1400 \times 0.9 \times 145}{32972} = 12.52 \text{ cm}$$

Provide 12 mm dia stirrups at 12 cm, centres between 3.8m from support and 5.0 m from support. Provide 12 mm dia 2 legged stirrups at 20 cm centres between 5.0m and 6.0m from support.

Maximum web reinforcement = 0.15 % of area of web in plan

$$= 0.15/100 \times 30 \times 100 = 4.5 \text{ cm}^2$$

Providing 10 mm dia stirrups

$$\text{Spacing} = \frac{2 \times 0.785 \times 100}{4.5} = 34.8 \text{ cm}$$

Provide 10 mm dia stirrups, at 25 cm centres.Details of inner and outer girder are shown in fig.

DESIGN OF CROSS GIRDER:

Self weight of cross grider = 1008 kg.m

Dead load from slab = 2 x 1/2 x 2.5 x 1.25 x 656 = 2050 kg

This load will be assumed as uniformly distributed load per metre run

$$= \frac{2050}{2.5} = 820$$

Total dead load per metre run = 1008 + 820 = 1828 kg

Girder is assumed to be rigid . (FIG. 11)

Reaction on each

$$= \frac{1828 \times 5}{3} = 3046.67 \text{ kg}$$

For maximum B.M. and S.F. in the cross grider load should be on the cross-grider. The position of load for maximum B.M. in the cross grider is shown in fig. 10.

Load coming on the cross girder = 70000 x {5 - 1.8/2}

= 70000 x {3.1 / 4} = 129150 kg

Cross grider is assumed to be rigid.

Reaction on each longitudinal grider

$$= \frac{129150}{3} = 43050 \text{ kg}$$

Maximum B.M. occursunder the load.

Maximum live load B.M.

$$= \frac{129150}{3} = \text{x } 1.475 \text{ kg}$$

= 63498.75 kg.m

B.M. including impact = 1.1 x 63498.75 = 69848.625 kg.m

Dead load B.M. at 1.475 m from support

$$= 3046.67 \times 1.475 - \frac{1.47}{2}$$

$$= 4500 + 1990 = 2510 \text{ kg.m}$$

$$\text{Total B.M} = 69848.62 + 2510 = 72358.62 \text{ kg.m.}$$

Live load shear including impact

$$= \frac{121150}{3} \times 1.1 = 47355 \text{ kg}$$

Total shear force = 47355 + 3046.67 = 50401

Total cross - girder is designed as T-beam .(FIG.12)

Assume effective depth = 154 cm

$$A_t = \frac{72358.62 \times 100}{1400 \times 0.9 \times 154} = 37.29 \text{ cm}^2$$

Provide 8 bars of 25 mm dia

Shear stress

$$= \frac{50401}{30 \times 0.9 \times 154} = 12.12 \text{ kg/cm}^2$$

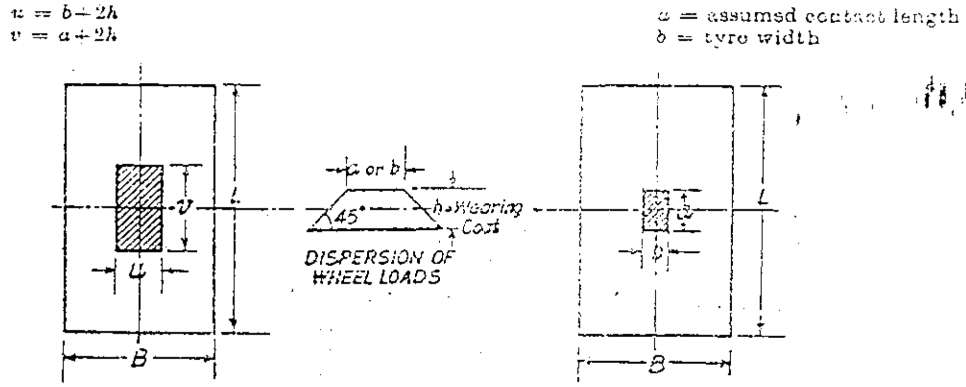
Using 12 mm dia 2 legged stirrups,

$$\text{Spacing} = \frac{1400 \times 2 \times 1.13 \times 0.9 \times 154}{50401} = 8.7 \text{ cm}$$

Provide 12 mm dia, 2 legged stirrups at 8 cm centres

[REINFORCEMENT DETAILS OF BRIDGE ARE SHOWN IN DRAWINGS SECTION]

M. Pigeaud's theory. The curves shown in Fig. 3·3 are based on M. Pigeaud's theory and can be used for calculating bending moments on a panel freely supported along four edges with restrained corners and carrying symmetrically placed load and distributed over some defined area. Wheel loads and concentrated loads are assumed to be dispersed through



Short span B.M. $= W(M_1+0{\cdot}15M_2)$
Long span B.M. $= W(0{\cdot}15M_1+M_2)$
(B.M.S. in kg. m. per metre width)

Fig. 3·2

wearing coat as shown in Fig. 3·2 and values of u and v are obtained. $u = b+2h$, $v = a+2h$. From these values u and v ratios $\frac{u}{B}$ and $\frac{v}{L}$ are calculated, for which the bending moments M_1 and M_2 for unit load are found from curves of Fig. 3·3 for the appropriate value of the ratio of spans $k = \frac{L}{B}$. For a total load of W on the area u by v the B.M. in shorter span is $W(M_1+0{\cdot}15M_2)$ and that in longer span is $W(0{\cdot}15M_1+M_2)$ in kg. m. per metre width of slab. In calculating above B.Ms. the value of Poisson's ratio is assumed as 0·15.

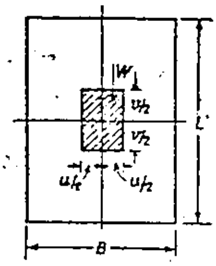
The curves shown in Fig. 3·3 are plotted for k = 1·0, 1·25, 1·414, 1·67, 2·0, 2·5 and infinity. For intermediate values of k, the values of M_1 and M_2 may be interpolated. The curves of $k = 1{\cdot}0$ are applicable in a square panel. $k = \infty$ apply to panel of large length L as compared to breadth B and can be used for determining the transverse and longitudinal bending moments on a long narrow panel supported on two long edges only.

When there are two concentrated loads symmetrically disposed or an eccentric load, the resulting bending moments can be calculated from the rules given in Table 3·1.

Eccentric and multiple concentric loads

Table 3·1

I



Find M_1 and M_2 for

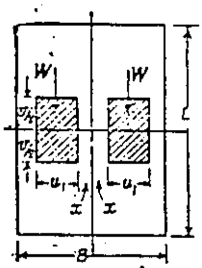
$$\frac{u}{B} \text{ and } \frac{v}{L}$$

Design B Ms. :

$M_B = W(M_1 + 0{\cdot}15 M_2)$

$M_L = W(0{\cdot}15 M_1 + M_2)$

II



Find M_1 and M_2 for

(*i*) $u = 2(u_1 + x)$ and

$v = v$ and

multiply by $(u_1 + x)$

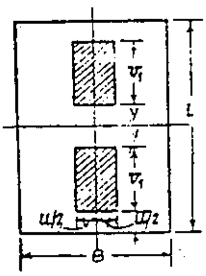
(*ii*) $u = 2x$ and $v = v$

and multiply by x

(*iii*) Deduct (*ii*) from (*i*)

For design B.Ms. M_1 and M_2 = (*iii*) multiplied by $\frac{2W}{u_1}$

III



Find M_1 and M_2 for

(*i*) $u = u$ and $v = 2(v_1 + y)$

and multiply by

$(v_1 + y)$

(*ii*) $u = u$ and $v = 2y$

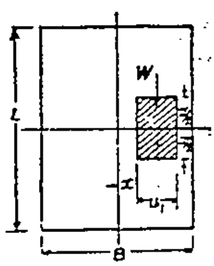
and multiply by y

(*iii*) Deduct (*ii*) from (*i*)

For design B.Ms.

M_1 and M_2 = (*iii*) multiplied by $2W/v_1$.

IV



Find M_1 and M_2 for

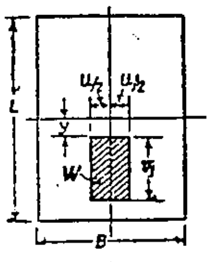
(*i*), (*ii*) and (*iii*) as case II

For design B.Ms.

M_1 and M_2 = (*iii*) multiplied by W/u_1.

Eccentric and multiple concentric loads

V



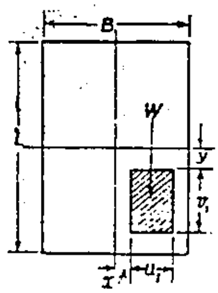
Find M_1 and M_2 for

(*i*), (*ii*) and (*iii*) as case III.

For design B.Ms.

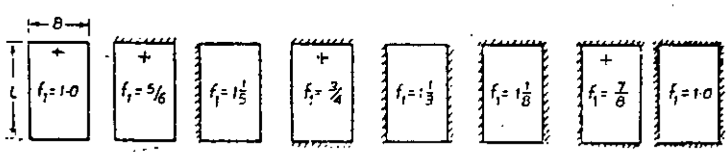
M_1 and M_2 = (*iii*) multiplied by W/v_1.

VI



Find M_1 and M_2 for
(*i*) $u = 2(u_1+x)$ and
$v = 2(v_1+y)$ and
Multiply by
$(u_1+x)(v_1+y)$
(*ii*) $u = 2x$ and $v = 2y$ and
multiply by xy
(*iii*) $u = 2(u_1+x)$ and $v = 2y$
and multiply by $y(u_1+x)$
(*iv*) $u = 2x$ and $v = 2(v_1+y)$
and multiply by $x(v_1+y)$
For design B.Ms. subtract (*iii*)+(*iv*) from (*i*)+(*ii*) and multiply by W/u_1v_1.

Span ratio adjustment



Non-continuous but monolithic with support— ... Continuous over-support......

$k = f_1 \cdot \dfrac{L}{B}$; if in cases marked thus+, $f_1 \; \dfrac{L}{B} < 1{\cdot}0$

Transpose B and L
(and u and v)

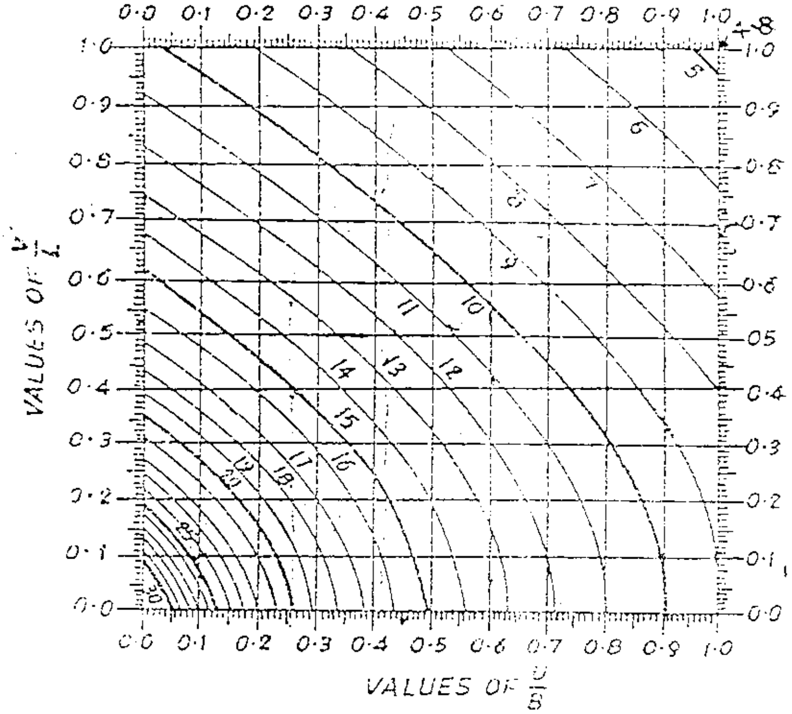
B.M. reduction factor for continuity

Calculate B.Ms. in each direction as if freely supported but with $k = f_1 \dfrac{L}{B}\left(\text{or } k = f_1 \; \dfrac{L}{B} \text{ if} < 1{\cdot}0\right)$ multiplied by the following ;

Co-efficients to give the design bending moments at the specified sections.
Mid Span : Interior span = 0·7 : End span = 0·85
Supports : End support = 0·25 Penultimate = 0·95
Interior (except penultimate) = 0·90

K = 2.0

(a) VALUES OF $M_1 \times 10^2$



(b) VALUES OF $M_2 \times 10^2$

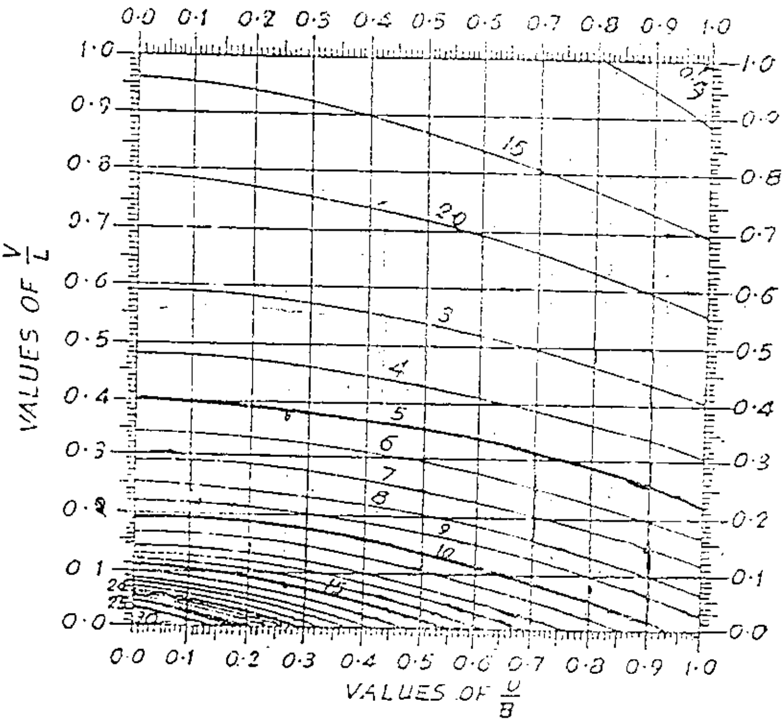


Fig. 3·3 (d)

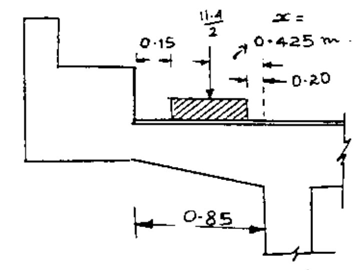


FIG : 1

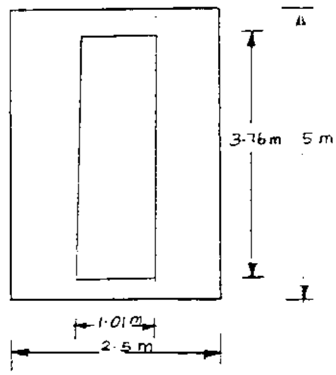


FIG : 2

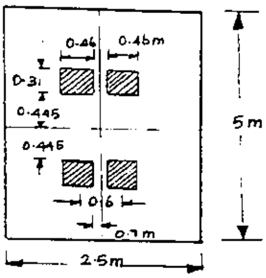


FIG : 3

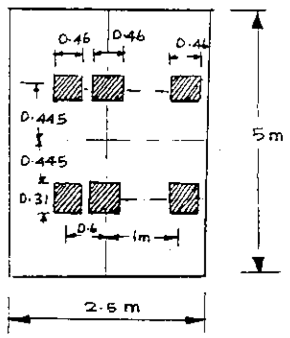


FIG : 4

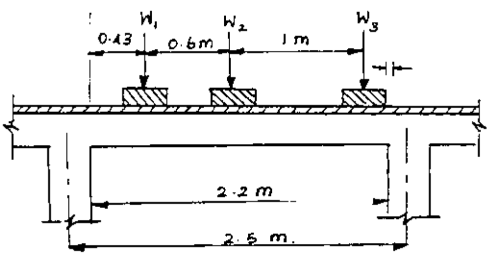


FIG : 5.

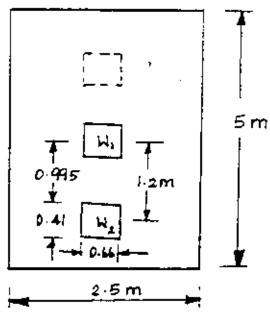
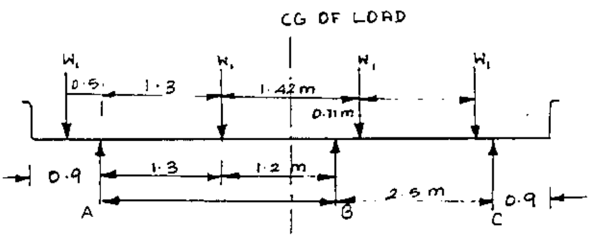
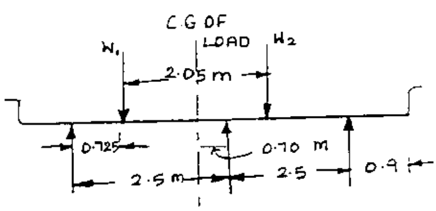


FIG : 6



CLASS A LOADING

FIG : 7



CLASS AA TRACKED VEHICLE.

FIG : 8

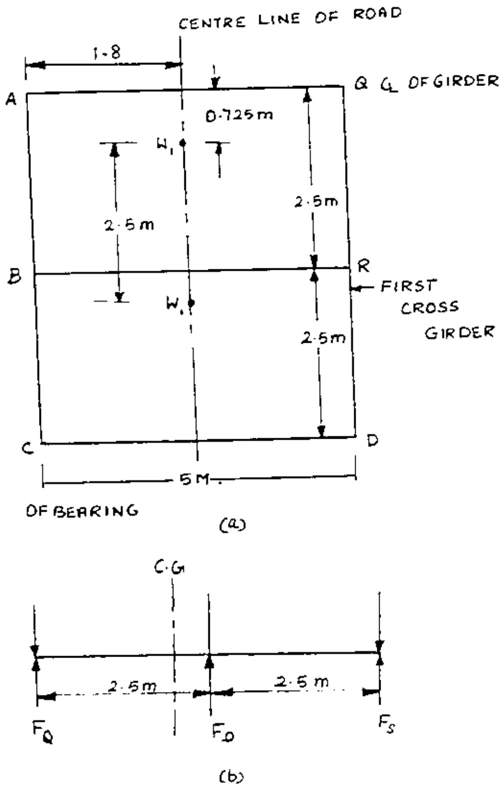


FIG : 9

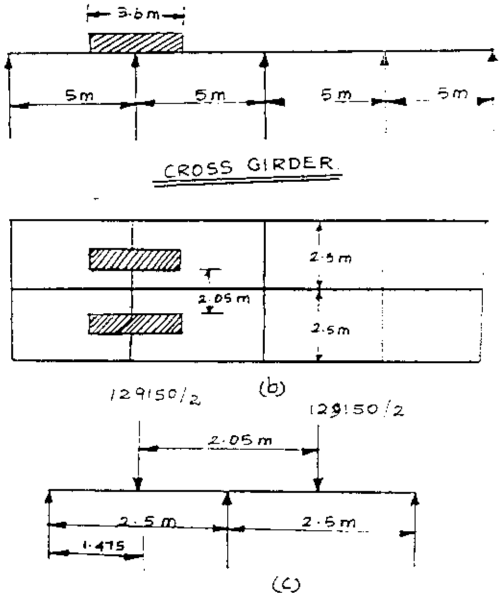


FIG : 10

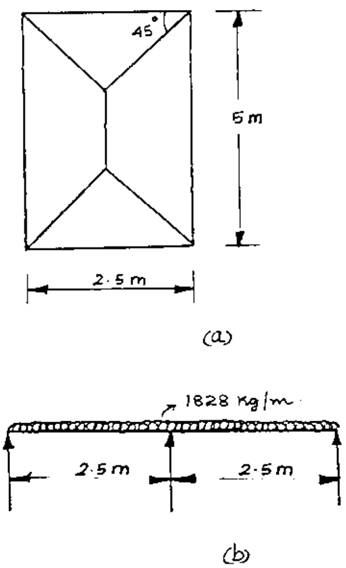


FIG : 11

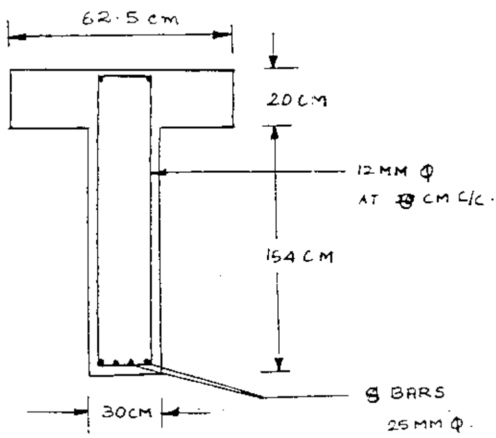
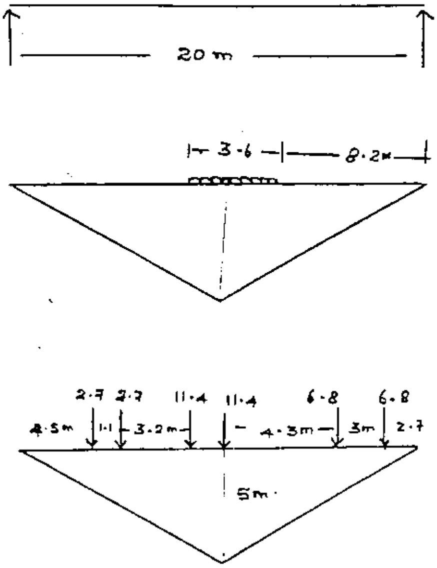
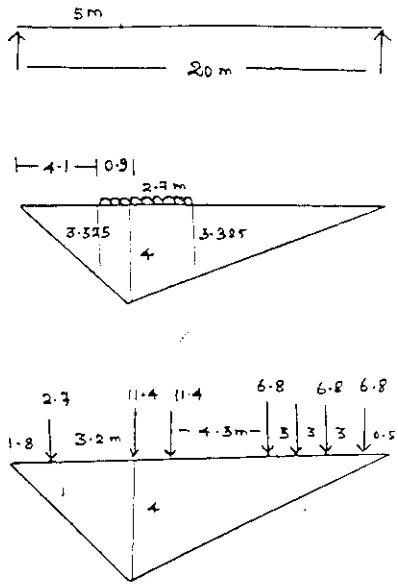


FIG 12



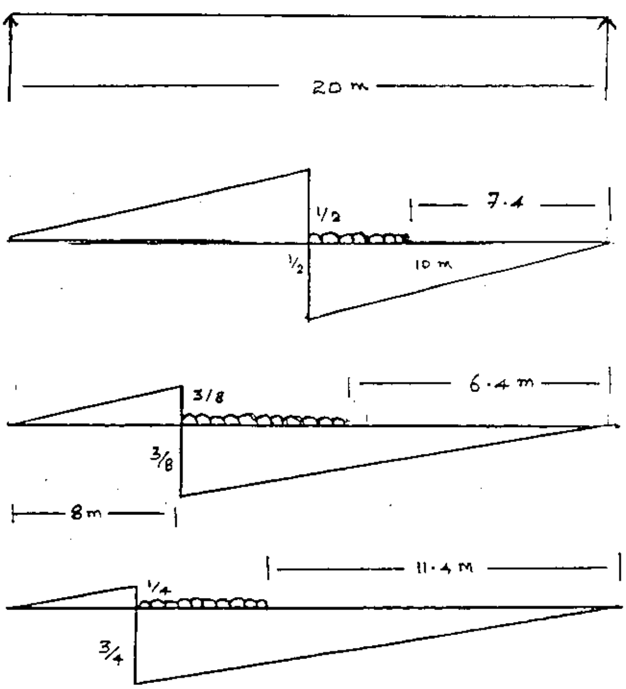
I.L. FOR B.M AT CENTRE OF SPAN.

FIG. IL1



IL FOR POSITION OF MAX. B.M

FIG. IL2.



I.L. FOR S.F AT CENTRE OF SPAN.

I.L. FOR S.F AT 3/8 TH SPAN.

I.L. FOR S.F. AT 1/4 TH SPAN.

DESIGN OF PIER

Solution :

Dead load of superstructure per span

=Dead loan coming from two outer girders and inner girder

= 2x1[2x31452]+2x31452 = 188,712Kg

(It was assumed in the analysis that dead load is taken equally by all girders) =188.712 t

Assume weight of bearings, plates etc. as 10 t.

Total dead load = 198.712 t

From fig 9.8, the distance between the outsides of outermost girders

= 5.0+0.30 = 5.3m.

Minimum pier length required at the top = 5.3+1.2 = 6.5m.

Provide a top length of 7.4 m in straight portions with semiciucular ends as shown in fig.p1. Use 1:3:6 concrete mix for pier. Assume centre of bearings between two girders as 1.0m

Minumum width required at top = 10 + 2 x 0.3 = 1.6m

Provide a concrete pier with top width of 2.0m for straight portion and width of 3.0 m at bottom for straight portion.

Area of pier at tip = $2 \times 7.4 + \pi/4 \times (2)^2 = 17.94$

Area of pier at bottom = $3 \times 7.4 + \pi/4 \times 3^2 = 29.26$

Self weight of pier = $(17.94 + 29.26)/2 \times 8 \times 2.2 = 415.43$

Moment of inertia of pier at base about y axis

$$= (1/12) \times 3 \times (7.4)^3 + 2 \times \{\pi / 128\} \times 3^4 + 2 \times (\pi/8) \times 3^2 \times 3.7^2$$

$$I_{yy} = 202.05 \text{ m4}$$

Moment of inertia about x axis

$$= (1/12) \times 7.4 \times (3)^3 + 2 \times \{\pi / 64\} \times 3^4$$

$$I_{xx} = 20.62$$

Design dead load for pier = 198.72+ 415 = 613.72 t

Stresses due to Dead Load :

Stresses at base due to D.L = 613.72/29.26 = 20.97 t.m2(comp)

Stresses due to Buoyancy :

Weight of pier at high-flood level (fig p2) = 1.925 m (compression)

Area at pier at high flood level

$$= 2.125 \times 7.4 + (\pi/4) \times 2.125^2 = 13.86 + 2.91 = 19.271$$

Submerged volume of pier

$$= \frac{19.271 + 29.26}{2} \times 7 = 169.86$$

Reduction in weight of pier due to buoyancy = weight of displaced water

= 169.86 t

$$\text{Stress at base} \quad \sigma_b = \frac{169.86}{29.26} = -5.80 t/m^2 \text{ (tensile)}$$

Stresses due to live loads :

Reaction due to live loads class AA loading

including impact = 1.1 x 70 = 77t

Maximum bending caused by eccentricity of this load is about x axis.

Maximum B.M. = 77 x 0.5 = 38.15 tm

Maximum and minimum stresses at the base due to this load will be

$$\sigma_t = \frac{77}{29.26} \pm \frac{38.5 \times 1.4}{Ix} = 2.631 \pm \frac{38.5 \times 1.4}{20.62}$$

σ_t = 5.244 t/m^2 compression ; σ_t = 0.017 t/m^2 tension

Stresses due to longitudinal force :

Maximum longitudinal force will occur due to class AA loading

= 0.2 x 70 = 14t

Moment at base at pier due to this force = 14 x 8 = 112 t m

$$\text{Stresses at the base} = \pm\frac{112 \times 1.4}{I_x} \pm \frac{112 \times 1.4}{20.62} = \underline{\pm 7.604}\ t/m^2$$

Stresses due to unequal frictional resistance bearings :

The frictional resistance of the bearings on bridge pier may differ,and this will cause moment on the pier. Assume coefficient of friction as 0.25 at one bearing and 0.22 at other bearing.

Total resistance at one set of bearing with dead and live load

= 0.25 (198.712 + 1.1 x 70) = 68.928 t

Total resistance at other set of bearing due to dead load only

= 0.25 198.712 = 43.716 t

Unbalanced force at the top of the pier = 68.93 – 43.72 = 25.21t

Moment at base = 8 x 25.21= 201.69. t m

$$\text{Shear at the base} = \pm\frac{201.69}{I_v} = \pm\frac{192.56 \times 1.4}{20.62}$$

$$= \pm\ 13.69\ t/m^2$$

Stresses due to wind loads :

Exposed height of the structure = Depth of girder + Thickness of slab + Height of kerb + Height of railing = 1.4 + 0.2 + 0.3 +1.0 = 2.9 m

Exposed area contributing wind pressure per pier

= span x height = 20 x 2.9 = 58 m^2

Assuming average height of about 9 m the wind pressure from table is 88 kg/m^2

1. Wind force on exposed surface $= \frac{58 \times 88}{1000} t = 5.104\ t$

Wind load on class A live load (article 1.9) =Length of train x 300 kg/m

$$= 20.4 \times \frac{300}{1000} = 6.12\ t$$

Total wind force = 5.14 + 6.12 = 11.22 t

2. The design wind load should not be less than 450 kg/m of the loaded structure. Hence mini design wind force

$$= 20 \times \frac{450}{1000} = 9\ t$$

3. The wind force load for design purpose should not be less than 240kg/m^2 for the unbalanced structure. The design wind load from this consideration is

$$= 58 \times \frac{240}{1000} = 13.92\ t$$

condition (3) above gives maximum wind force. Hence this be considered in design.

Assume this to act at mid height i.e. 2.9/2 = 1.45 m from the top of the pier.

Moment at base about y axis M_w = 13.92 x 9.45 = 131.544 t m

Maximum stress at the base at end of straight portion.

$$\sigma_{w1} = \frac{M_w}{I_v} \times 3.6 = \pm \frac{131.544 \times 3.7}{202.5} = \pm 2.4$$

Maximum stress at the edge of pier (point C)

$$= \frac{M_w \times 5.0}{I_v} = \frac{131.544 \times 5.1}{202.05} = \pm 3.32 \ t/cm^2$$

Stresses due to water current :

Using equation 9.1, the water pressure P is given by ,

$$\text{Area of wetted surface} = 7 \times \frac{(2.125 + 3)}{2} = 17.93 \ m^2$$

$$\text{Water pressure} = \frac{1.5 \times 1 \times 17.93 \times 3}{2 \times 9.81} = 12.34 \ t$$

$$P = 12.34 \ t$$

This force is assumed to act at 2/3 height.

Moment at base M_w = $P \times \{2/3\} \times 7 = 12.34 \times \{14/3\} = 57.59m$

Stress at base at edge of straight portion

$$= \frac{M_w}{I_v} \times 3.6 = \frac{57.59x3.7}{202.05} = \pm 1.05 \ t/m^2$$

Stress at the base at the end of the power

$$= \frac{M_w \times 5.0}{I_v} = \frac{57.59x5x5.1}{202.5} = \pm \quad 1.453$$

Total stresses

Under dry conditions :

Total stress : D.L + L.L (eccentric + longitudinal force+ frictional resistance) + wind load

1. At end of straight portion (point A or E) maximum

   = 20.97 + 5.244 + 7.604 + 13.69 + 2.4 + 3.32 = 53.228 t/m^2

2. At end of straight portion (point A or C) minimum

   = 20.97 - 0.0170 - 7.604 - 13.69 - 2.4 - 3.32 = -6.061 t/m^2

3. At end of pier = 20.97 + 3.32 = 24.29 t/m^2

4. At end of pier (F or C) minimum = 20.97 - 3.32 = 17.65 t/m^2

Under wet conditions

1. Total stress = D.L+ Buoyancy + L.L+ W.L + water currents

   = 20.97 + 5.80 + 5.244 + 7.604 + 13.69 + 2.4 + 3.32 = 53.228

2. At end of straight portion (point A or E) minimum

   = 20.97 - 5.8 - 0.0170 - 7.604 - 13.69 - 2.4 - 3.32 = -11.861 t/m^2

3. At end of pier (F or C) max=20.97 - 5.8 + 3.32 + 1.453= 19.943 t/m^2

4. At end of pier (F or C) mini=20.97 - 5.8 - 3.32 - 1.453 = 10.397 t/m^2

Allowable compressive stress in 1:3:6 concrete is 200 t/m^2 in compression and 25 t/m^2 in tension. The stress in pier are within these permissible limits.

DESIGN OF ABUTMENT

ASSUME:

The angle of internal friction of the retained material is 30 degrees. The angle of friction between soil and masory is 20 degrees. As approach reinforced concrete slab is provided to the bridge so that the effect of surcharge may be neglected. Height of the abutment below road level is 5.0 metres. The passive earth pressure infront of the abutment is to be neglected. Density of masory = 2 t/m^2 and density of soil = 1.8 t/m^3

Solution : Distance between outside of outermost girders

$$= 5.0 + 0.30 = 5.3$$

Clear width of road way = 7.0 m

Provide abutment length of 3.0 metres. Provide bed block of 0.30m depth and top width of 0.75 m. provide 0.60m top width for the abutment as shown in fig A1.

Depth of girder and slab = 1.6 m. provide a height of 1.8 m above the bed block as shown in fig A1.

Let x be the projection of abutment of the front. The projection x will be determined from the condition that no tension develops at the base.

1. Dead load from the superstructure. Total dead load

$$= 58 \times \frac{198.112}{2} = 99.356 \text{ t}$$

Load per metre length of abutment

$$= \frac{99.356}{8} = 12.419 \text{ t}$$

Live load from superstructure :

Maximum live load reaction is caused by class AA loading

The position of live load for maximum reaction is shown .

$$\text{Maximum reaction} = 70 \text{x} \frac{[20- \{3.6/2\}]}{20} \quad \frac{70 \text{ x } 14.2}{16} = 63.7$$

Maximum reaction including impact = 1.1 x 63.7 = 70.07

Live load per metre length of abutment = 70.07/8 = 8.758

Total reaction from superstructure per metre length of abutment

= 12.49 + 8.758 = 21.177

2. Self - weight of the abutment. Self weight of the abutment is divided in five segments is shown in fig A1.

Segment 1 = 0.3 x 0.85 x 2.4 = 0.612

Segment 2 = 1/2 x x 2.9 x 2.0 = 2.9x

Segment 3 = 0.75 x 2.9 x 2.0 = 4.35

Segment 4 = 0.6 x 5.0 x 2.0 = 6.00

Segment 5 = 1/2 x 0.75 x 5.0 x 2.0 = 3.75 t

3. Longitudinal forces

Force due to tractive effort = 14 t

Force per metre length = 14/8 = 1.75 t

Force due to temperature charges = 0.15 x load from superstructure

= 0.15 x 21.177 = 3.176 t

Total longitudinal force = 1.75 + 3.176 = 4.926 t

This force acts at level of bearings.

4. Earth pressure Earth pressure is computed from coulomb's formula

$$\tan\theta = \frac{0.75}{5} \quad * 0.15$$

$$\theta = 8.53^0, \quad \alpha = 0,$$

Total active earth pressure = 1/2 x 1.8 x 5 x 5 x k4 cos θ

= 22.5 kA cos θ

$$kA = \frac{\cos2(\varnothing - \theta)}{\cos2\theta(\cos\delta + \theta)\sqrt{\frac{\{1 + \sin(\delta + \varnothing)\sin\varnothing\}}{\cos(\delta + \varnothing)\cos\varnothing}}}$$

= 0.3755

Total active pressure = 22.5 x 0.3753 x 0.9889 = 8.355

Horizontal component of earth pressure

= 8.355 cos (δ +θ) = 8.355 x cos 28.53

= 8.355 x 0.8786 = 7.340

Vertical component of earth pressure = 8.355 x sin 28.53 = 3.990

The earth pressure is assumed to act at 0.42 h = 0.42 x 5 = 2.1 m from the base. The forces acting on the abutment are shown in fig.

The value of x is determined from the condition that no tension develops at base the resultant of all forces must pass through middle third.

Total vertical force :

V = 3.99 + 3.75 + 6.0 + 4.35 + 0.612 + 18.59 + 2.9 x = 37.292 +2.9 x

Moments of all forces about A must be zero.

= 7.34 x 2.1 + 3.99 x 0.315 x 0.5 - 6.0 x 105 + 4.35 x 1.725

+ 21.18 x 1.725 + 0.612 x 1.775 + 4.539 x 3.2 + 2.9x

$$= 21.179 + \frac{-2x}{3} - (37.292 + 2.9x)\ 2/3\ (2.1 + x) = 0$$

$$= x^2 + 23.6201x - 28.7812 = 0$$

Solution of above equation gives x = 1.3614

Maximum pressure at best

$$= 2 \times \frac{\text{Total vertical force}}{\text{Area}}$$

$$= \frac{2 \times (3.99 + 3.75 + 6.0 + 4.35 + 0.612 + 18.59 + 2.9 \times 1.1614)}{2.1 \times 1.1614}$$

= 25 t/m2. This is within permissible limits.

Provide overall base width of

= 2.1 + 1.3614 = 3.46 m say 3.50 metres

LAN OF PIER AT TOP AND BOTTOM

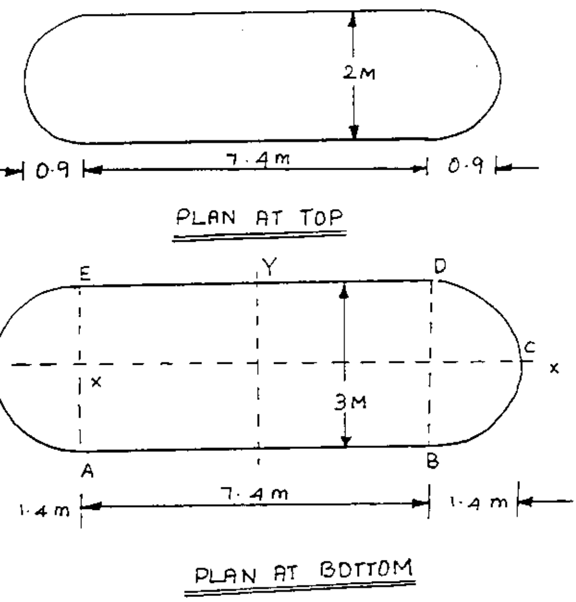
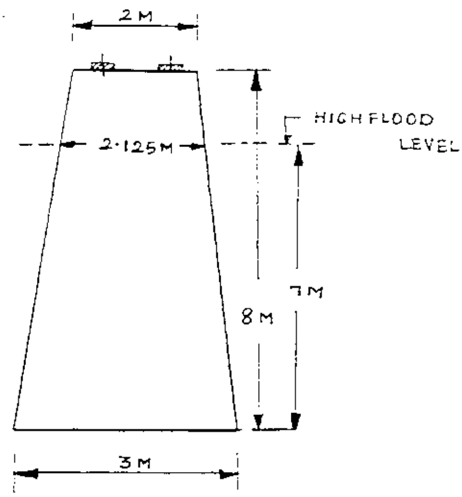
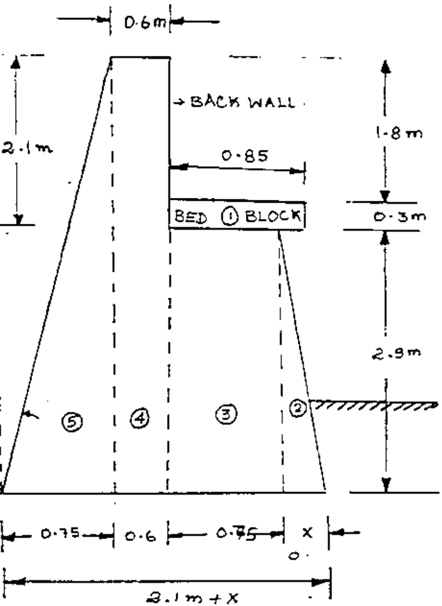


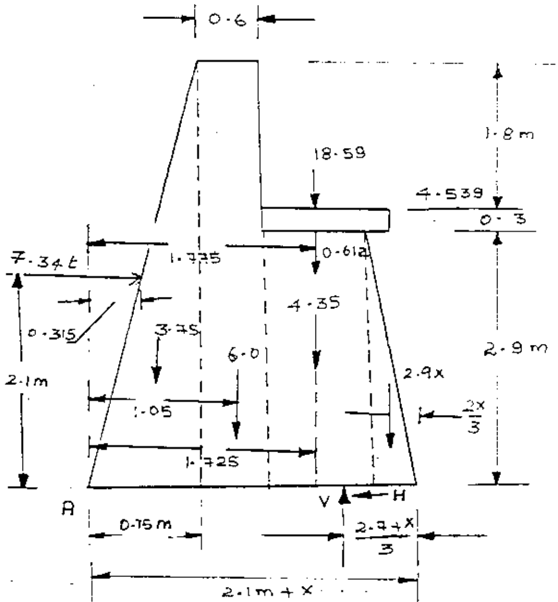
FIG 9.8



SECTION OF PIER

FIG. P2





Quality Control Tests

4. QUALITY CONTROL TESTS

4.1 SIEVE ANALYSIS REPORT

LOCATION : MADUKKARAI

TOTAL WEIGHT OF SAMPLE TAKEN FOR TESTING = 1000gm

SIEVE ANALYSIS

An oven dried sample of soil is separated into two fractions by sieving it through a 4.75mm IS sieve, the portion passing through it is subjected to fine sieve analysis. The flowing set of sieves are used for fine sieve analysis : 4.75,2.35,1.18,.6,.3,0.15,0.075mm IS sieves.

Sieving is performed by arranging the various sieves one over the other in the order of their mesh openings- the largest aperture sieve being kept at the top and the smallest is at the bottom. A receiver is kept at the bottom and a cover is kept at the top of the whole assembly. The soil sample is put on the top sieve, and the whole assembly is fitted on a sieve shaking machine. The amount of shaking depend upon the shape and number of particles. Atlas 10 min of shaking is desirable for soils with small particles. The portion of the soil sample retain on each sieve is weighed. The percentage of soil retained on each sieve is calculated on the basis of the total mass of soil sample taken and from these results, percentage passing through each sieve is calculated. Table shows the specimen observation and calculation sheet.

TABLE NO.: 4.1.1

Sieve Size	weight of mat Retained	%of mat retained	cum % of mat retained	% of passing
4.75	1	0.1	0.1	99.0
2.36	10	1.0	1.1	98.9
1.18	32	3.2	4.2	95.7
0.600	67	6.7	11.0	89.0
0.300	181	18.1	29.1	70.9
0.150	98	9.7	38.9	61.1
0.075	110	11.0	49.9	50.1

GRAVEL : 0.1 %

SAND : 49.8 %

SILT & CLAY : 50.1 %

RESULTS: For the sub-grade and embankment layer soil ,the % of passing of 4.75mm particle size soil should be more than 95 %, this can tested and results are shown in the above table.

4.2 PROCTOR DENSITY TEST

LOCATION :Palathurai.
CHAINAGE AT : 2.80Km.

The object of this experiment is to determine the relationship between water content and dry density of soil using standard proctor test and then to determine the optimum water content and the corresponding maximum dry density for the soil.

PROCEDURE:

About 3Kg of air dried and pulverized soil, passing a 4.75mm sieve, is mixed thoroughly with the small quantity of water. The mixture is covered with wet cloth and left for a maturing time of about 5 to 30 minutes to permit proper absorption of water. The empty mould attached to the base plate is weighed without collar. The collar is then attached to the mould. The mixed and mature soil is placed in the mould and compacted by giving 25 blows of the rammer uniformly distributed over the surface, such that the compacted height of soil is about 1/3 the height of the mould. Before putting the second layer of soil, the top of first compacted layer is scratched with the help of any sharp edge. The second and third layers are similarly compacted, each layer being given 25 blows. The last compact layer should project not more than 6mm into the collar. The collar is removed and the excess soil is trimmed off to make it level with the top of mould. The weight of mould, base plate and the compacted soil is taken. A representative sample is taken from the center of compacted specimen and kept for water content determination. The values are tabulated below:

TABLE NO.: 4.2.1

DENSITY DETERMINATION

SL	DESCRIPTION	I	II	III	IV	V
1	Empty weight of mould (A)			4148		
2.	Volume of the mould (B)			1000		
3.	Weight of mould Compacted Soil (C)	6094	6269	6394	6411	6279
4.	Weight of soil (D)=(C) - (A)	1946	2121	2346	2263	2131
5.	Wet density (D/B)	1.946	2.121	2.241	2.263	2.131

MOISTURE CONTENT DETERMINATION

SL	DESCRIPTION	I	II	III	IV	V
1	Wet soil +container(A)	66.95	54.82	65.31	73.49	81.68
2.	Dry soil + container(B)	65.41	53.16	61.43	68.95	75.69
3.	Weight of water (C = A-B)	1.54	1.66	3.88	4.54	5.99
4.	With of the container (D)	28.93	28.11	28.16	28.75	30.34
5.	Moisture content (%) MC= C/(B-D)	4.2	6.6	11.7	11.3	13...2
6	Dry density DD=WD/(1+(MC/100).	1.867	1.989	2.01	2.033	1.882

Maximum Dry Density: 2.04 g/cc
Optimum moisture Content: 11.3%

RESULTS: From IRC specifications the requirement of maximum dry density for sub-grade and embankment layer soil should not be less than 1.75 g/cc and 1.6 g/cc, from the above tests satisfies the requirement.

4.3 CALIFORINA BEARING RATIO TEST

LOCATION : MADUKKARAI

This test is used for evaluating the stability of soil sub grade and other flexible pavement materials. This penetration test consist of causing a cylindrical plunger of 50mm diameter to penetrate a pavement component material at 1.25mm/min. The load values to cause 2.5mm and 5mm penetration are recorded. These loads are expressed as percentages of standard load values at respective deformation levels to obtain CBR value. The standard load values obtained from the average of a large number of test on crushed stones are 1370 and 2055Kg respectively at 2.5 and 5mm penetration.
the CBR value is calculated using the relation:

CBR(%)=(load sustained by the specimen at 2.5 or 5mm penetration)/(load sustained by standard aggregates at the corresponding penetration level) X 100

TABLE NO.: 4.3.1

PENETRATION (mm)	LOAD (KGF)	CORRECTED LOAD (KGF)	STANDARD LOAD (KGF)
0.00	0		
0.50	62		
1.00	147		
1.50	238		
2.00	308		
2.50	385	405	1370
4.00	574		
5.00	672	685	2055
7.50	777		

CBR of specimen at 2.5 mm penetration : 29.6%
5.0 mm penetration : 30.9%

CBR VALUE : 30.9%

RESULTS: For GSB layer CBR value should be minimum 30 % and for the sub-grade layer it should be more than 10 %, tests conducted and found that it is safe.

4.4 PLASTICITY INDEX TEST

LOCATION : DOCTOR QUARRY

The object of this test is to determine the liquid limit and plastic limit of the soil sample

Liquid limit is defined as the minimum water content at which the soil is still in the liquid state, but has a small shearing strength against flowing. Plastic limit is defined as the minimum water content at which the soil begin to crumble when rolled into thread approximately 3mm in diameter. Plasticity index is the difference between liquid limit and plastic limit. - It is expressed in terms of percentage.

TABLE NO.: 4.4.1

LIQUID LIMIT %

Trial no	1	2	3	4	WP	%
No of drops	34	29	23	19		
Weight of container + Soil.gm	54.56	55.6	53.21	51.63	32.9	35.66
Wt.of container + Dry soil .gm	48.99	50.27	47.91	46.31	32.18	34.98
Wt.of water.gm	5.57	5.33	5.3	5.32	0.72	0.68
Wt.of container gm	27.78	30.74	29.28	28.05	28.11	31.06
Wt.of dry soil gm	21.21	19.53	18.63	18.36	4.07	3.92
Moisture content %	26.3	19.53	18.63	18.26	17.7	17.3

LIQUID LIMIT WL % : 27.805
PLASTIC LIMIT WP % : 17.5

PLASTICITY INDEX IP % : WL – WP = 10.5 %

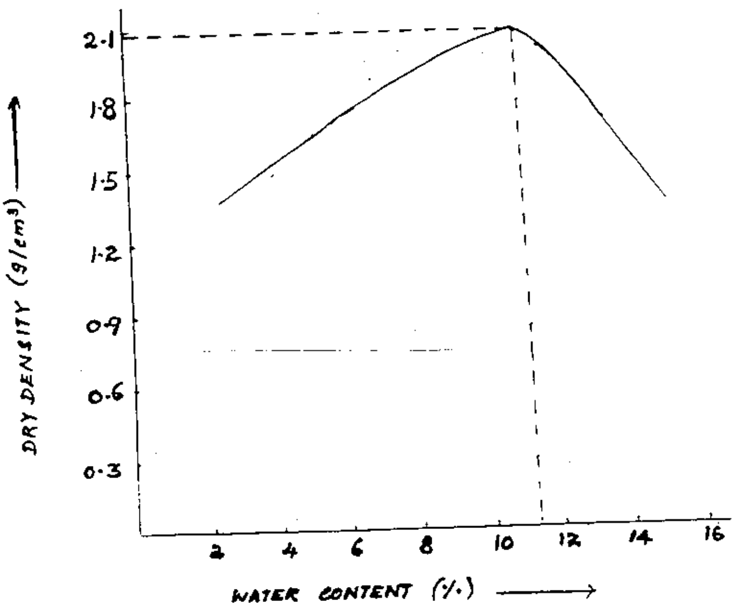
OTHER TESTS:

For the WMM, GSP, DBM and aspaltic concrete layers, the following material tests are conducted and the results are compared with IRC specifications.

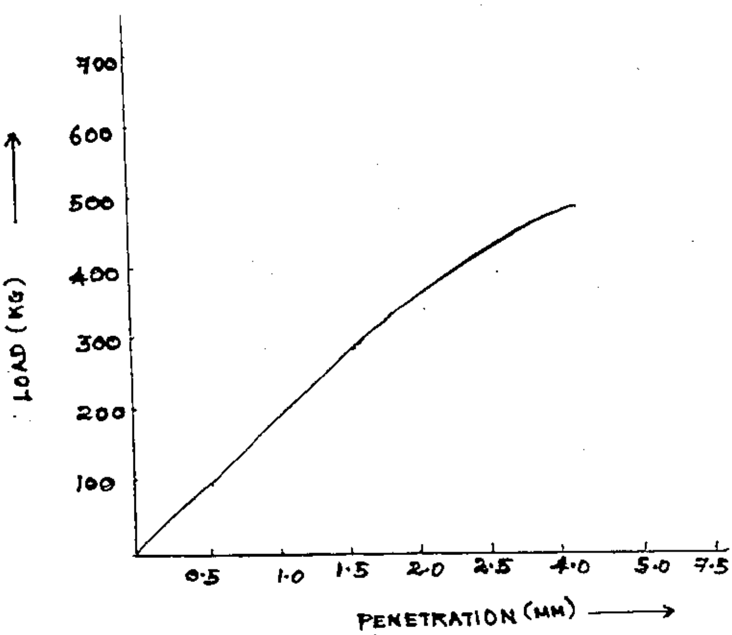
No. 1 Test for Macadam base – Aggregate impact value-maximum 30%.
- L.A Abrasion value – max 40%.

No. 2 Test for bitumen - Penetration at 25 deg. C – 25 to 40.
- Softening point (Ring and Ball method)-50 deg C to 90 deg C

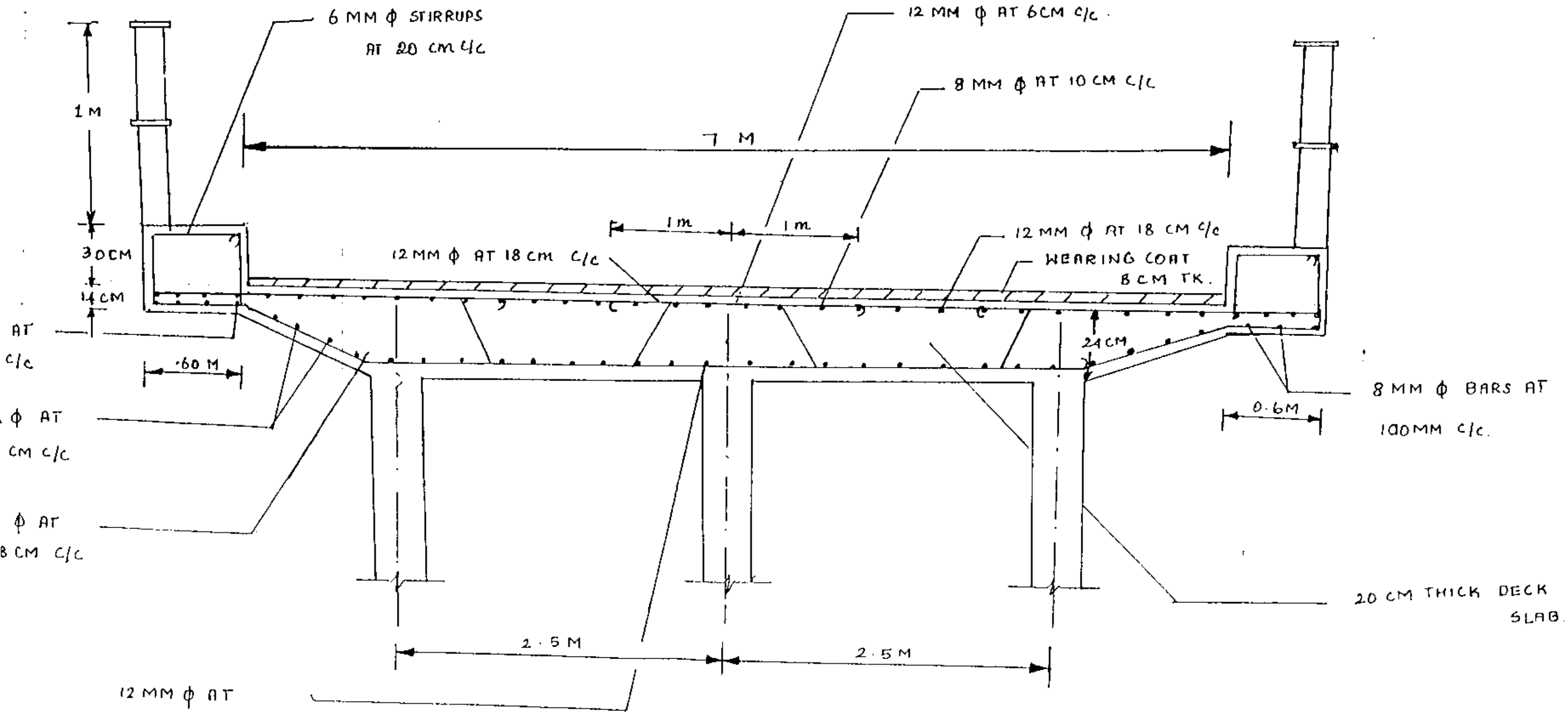
PROCTOR DENSITY TEST



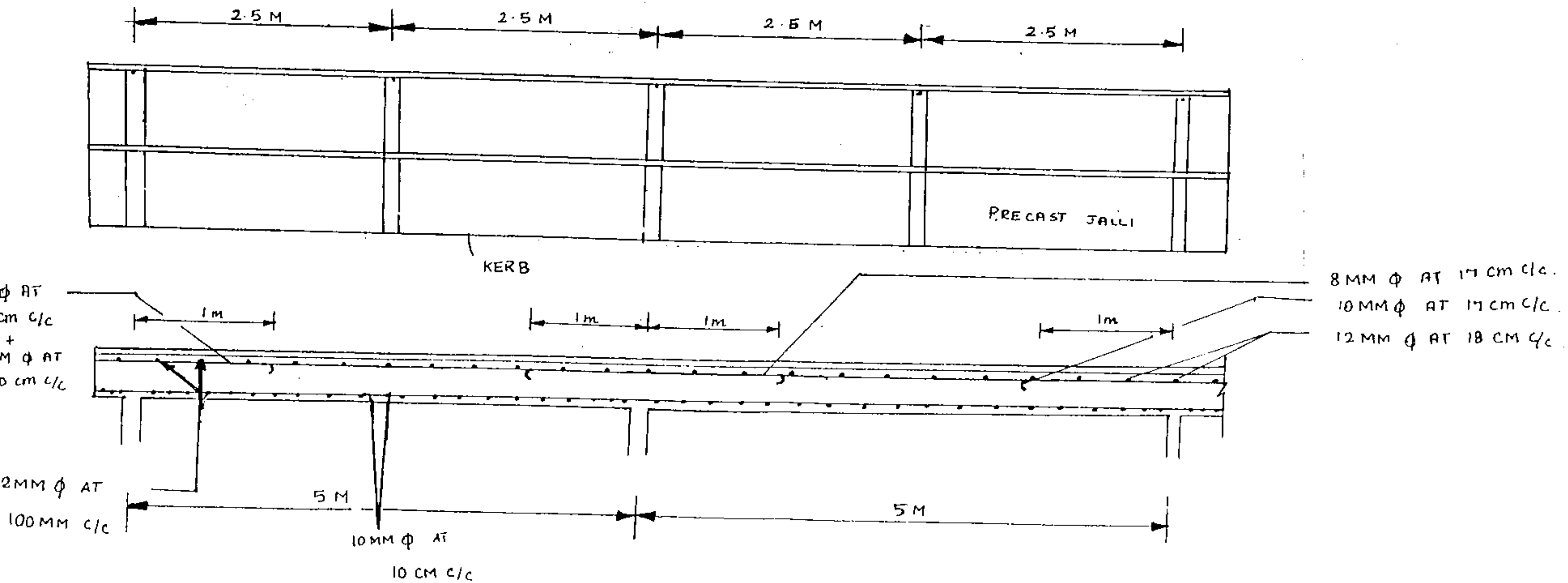
CBR. TEST



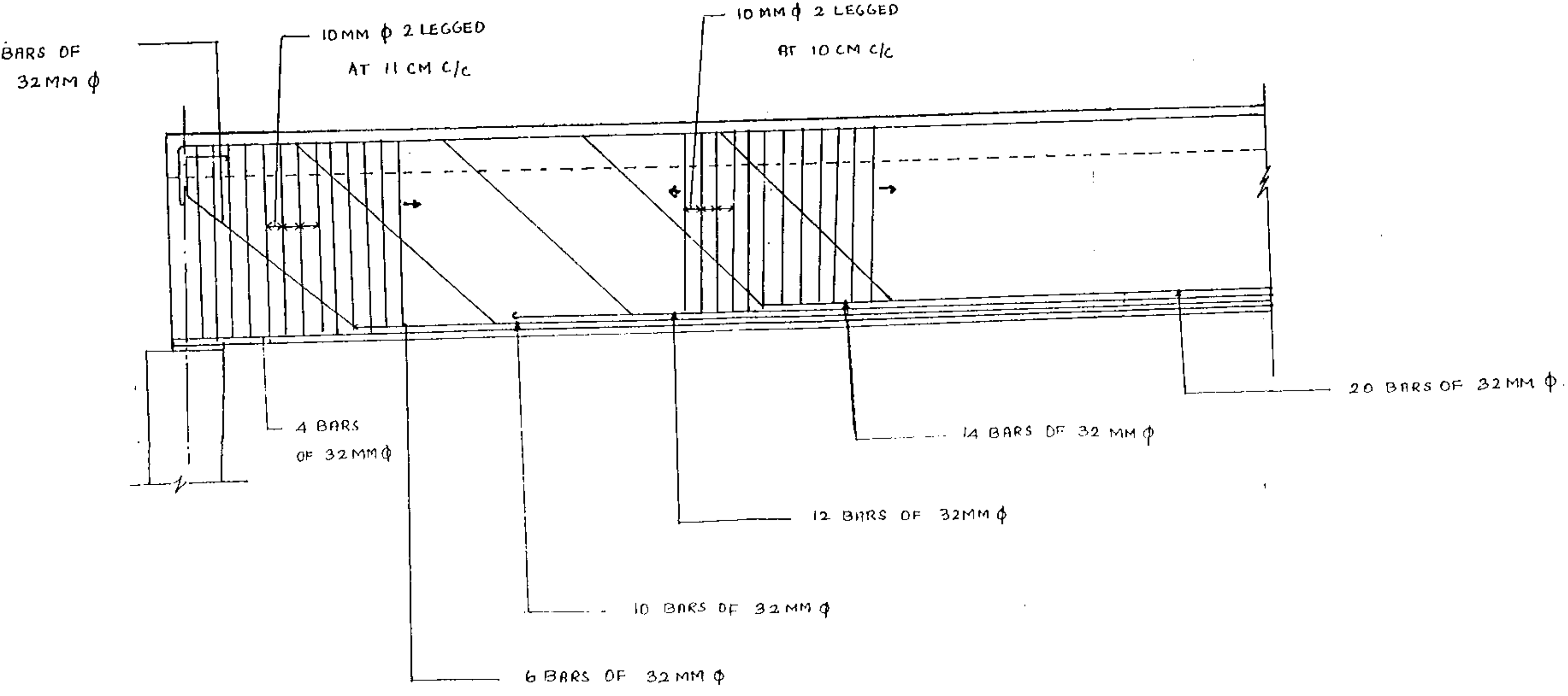
Drawings



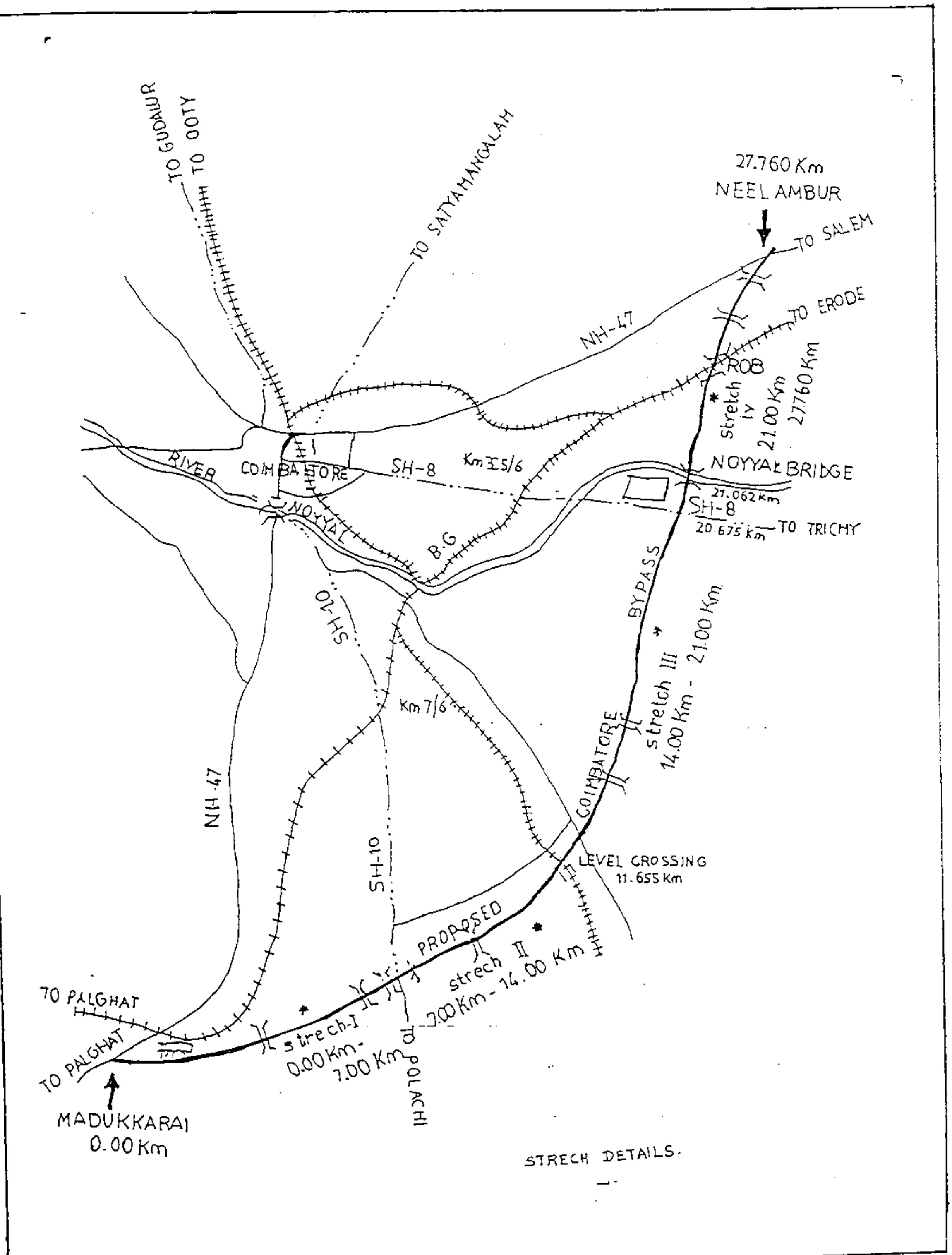
CROSS SECTION OF DECK SLAB



LONGITUDINAL SECTION OF DECK SLAB.

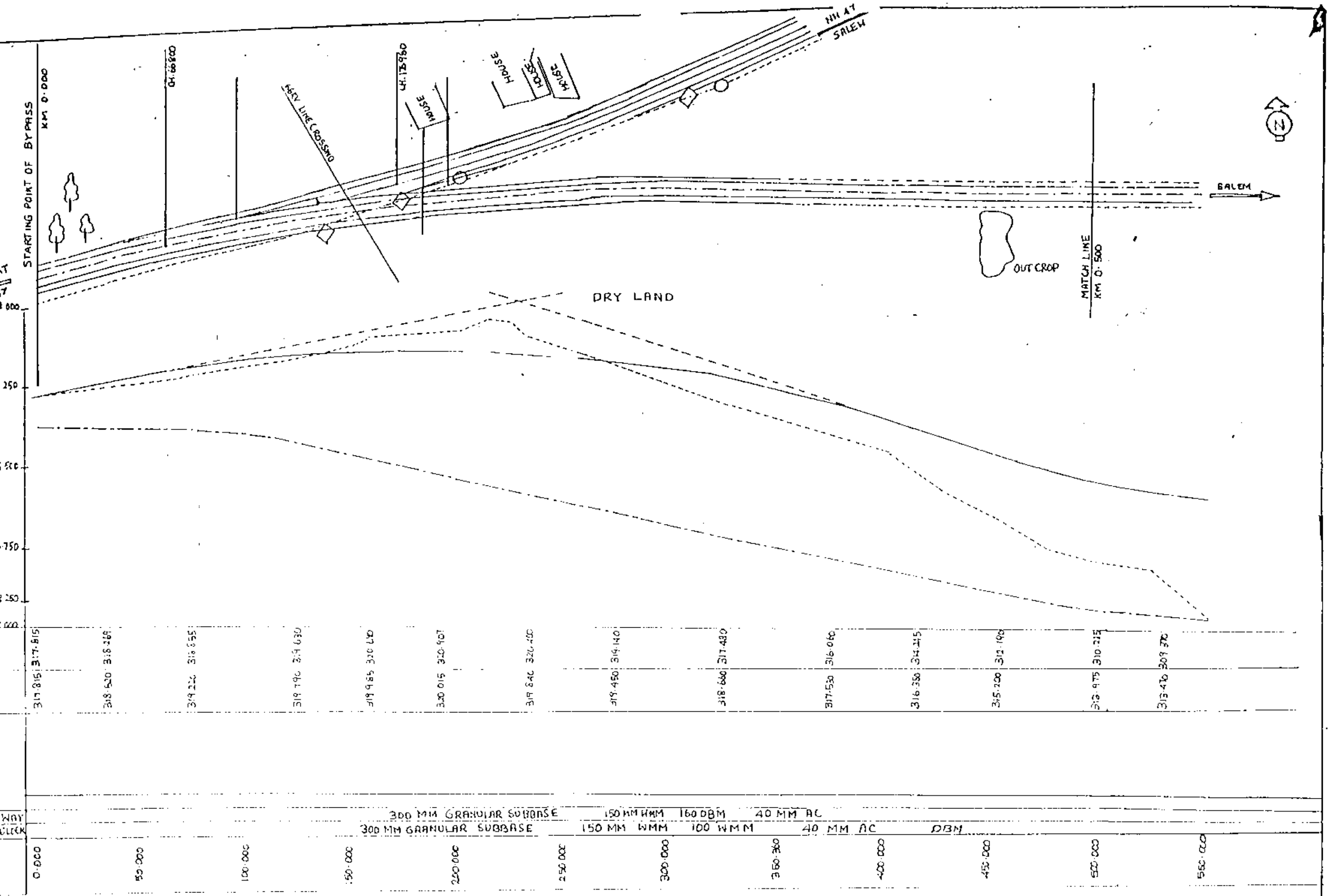


LONGITUDINAL SECTION OF OUTER GIRDER.

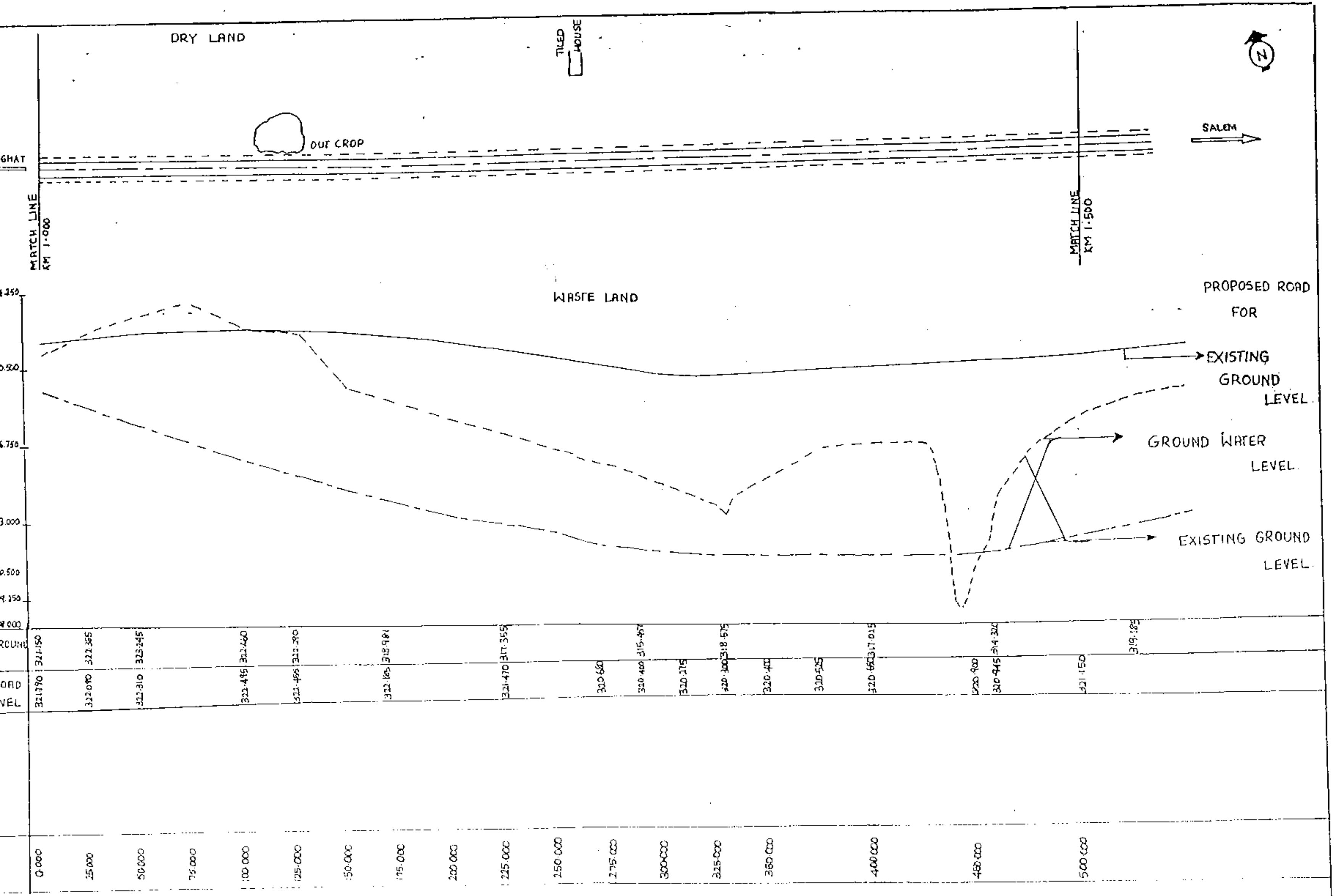


TO GUDALUR
TO OOTY
TO SATYAMANGALAM
27.760 Km
NEEL AMBUR
TO SALEM
TO ERODE
NH-47
ROB
stretch IV
21.00 Km
27.760 Km
COIMBATORE
SH-8
RIVER
NOYYAL
NOYYAL BRIDGE
27.062 Km
SH-8
20.675 Km
TO TRICHY
B.G
BYPASS
SH-10
Km 7/6
stretch III
14.00 Km - 21.00 Km
COIMBATORE
NH-47
SH-10
LEVEL CROSSING
11.655 Km
PROPOSED
strech II
7.00 Km - 14.00 Km
TO PALGHAT
TO PALGHAT
strech I
0.00 Km - 7.00 Km
TO POLACHI
MADUKKARAI
0.00 Km
STRECH DETAILS.

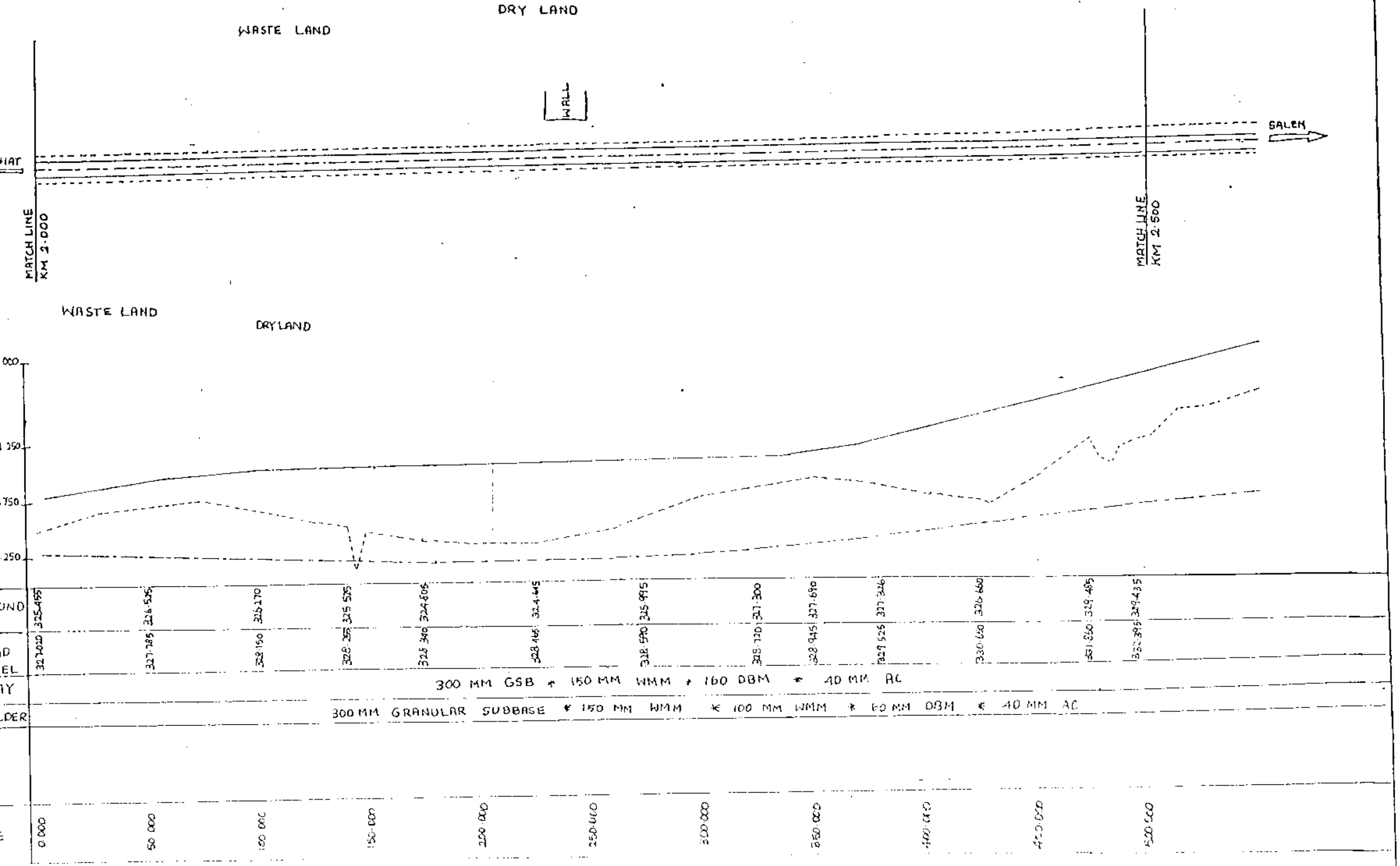
Fig No: 1:20

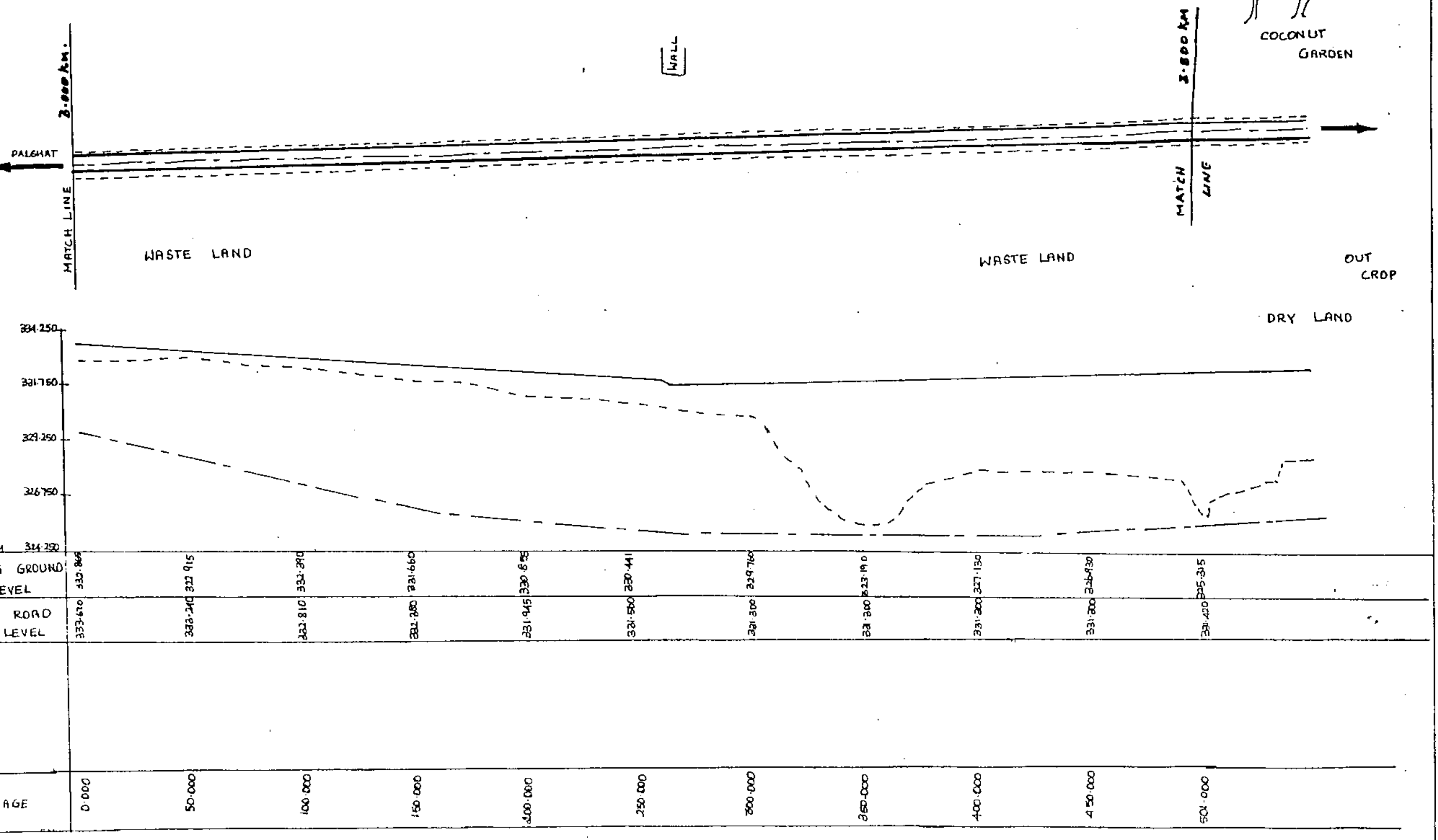


STARTING POINT OF BYPASS
KM 0.000
NH 47
SALEM
HOUSE
HOUSE
HOUSE
HOUSE
66KV LINE CROSSING
OUT CROP
MATCH LINE
KM 0.500
SALEM
DRY LAND
317.815
318.269
318.555
319.030
320.120
320.407
320.450
319.140
317.480
316.060
314.215
312.190
310.215
309.370
317.815
318.620
319.222
319.490
319.985
320.015
319.840
319.450
318.660
317.530
316.350
315.200
313.975
313.470
300 MM GRANULAR SUBBASE
150 MM WMM
160 DBM
40 MM AC
300 MM GRANULAR SUBBASE
150 MM WMM
100 WMM
40 MM AC
DBM
0.000
50.000
100.000
150.000
200.000
250.000
300.000
350.360
400.000
450.000
500.000
550.000

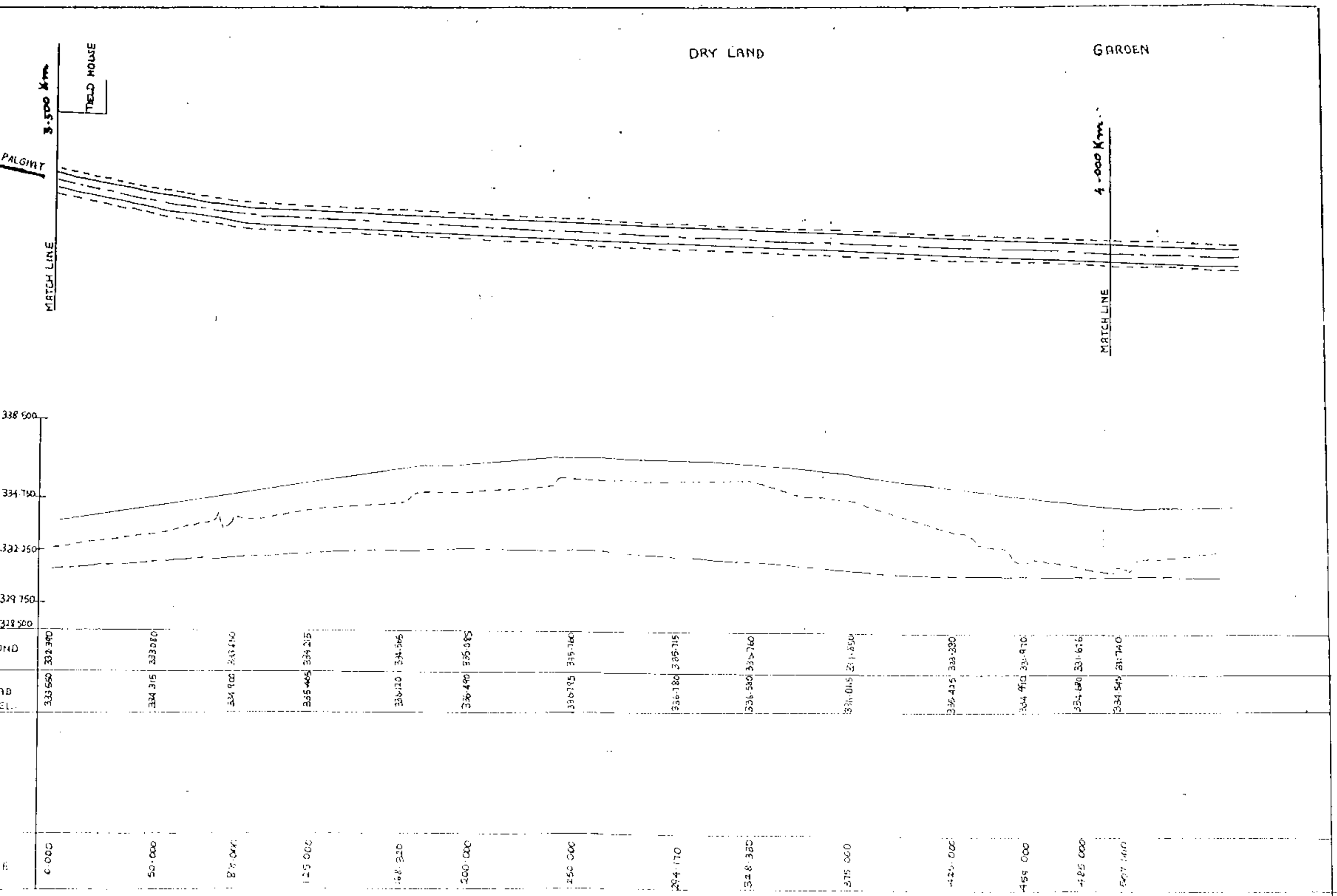


DRY LAND
TILED HOUSE
OUT CROP
GHAT
SALEM
MATCH LINE KM 1·000
MATCH LINE KM 1·500
WASTE LAND
PROPOSED ROAD FOR
EXISTING GROUND LEVEL
GROUND WATER LEVEL
EXISTING GROUND LEVEL


DRY LAND
WASTE LAND
WALL
SALEM
MATCH LINE
KM 2.000
MATCH LINE
KM 2.500
WASTE LAND
DRYLAND
300 MM GSB + 150 MM WMM + 160 DBM + 40 MM AC
300 MM GRANULAR SUBBASE + 150 MM WMM + 100 MM WMM + 60 MM DBM + 40 MM AC



3.000 km.
MATCH LINE
PALGHAT
WALL
3.500 KM
MATCH LINE
COCONUT GARDEN
WASTE LAND
WASTE LAND
OUT CROP
DRY LAND
334.250
331.750
329.250
326.750
324.250
GROUND LEVEL
332.865
332.915
332.390
331.660
330.858
330.441
329.760
323.190
327.130
326.930
325.315
ROAD LEVEL
333.670
333.240
332.810
332.380
331.945
331.560
331.300
331.300
331.300
331.300
331.420
AGE
0.000
50.000
100.000
150.000
200.000
250.000
300.000
350.000
400.000
450.000
501.000



DRY LAND
GARDEN
3.500 Km
FIELD HOUSE
PALGINT
MATCH LINE
4.000 Km
MATCH LINE
338.500
334.750
332.250
329.750
328.500
332.390
333.080
334.215
334.565
335.085
335.760
335.715
335.760
331.850
333.330
331.910
331.616
331.740
333.650
334.315
334.900
335.465
336.120
336.490
336.795
336.180
336.580
331.015
335.425
334.410
334.680
334.545
0.000
50.000
85.000
125.000
188.320
200.000
250.000
294.170
328.380
375.000
425.000
454.000
485.000
507.160

Recommendation

6. RECOMMENDATIONS

We are proud to recommend that this project will be useful for the road user in various aspects as below:

- This Bypass connects 3 major highway hence developments such as residential and commercial will take place along this road project.

- Adoption of locally available materials will give saving in unit cost of road construction in future.

- Since this route is short and hence the travel time is reduced for the road users.

- From the soil data collected, it has been found that this soil is suitable for the future road construction works.

Conclusion

7. CONCLUSION

By diverting the through traffic, the traffic congestion inside the city is very much reduced and gives a clean environment and this project is also economically viable.

In this project a well planned layout with all necessary facilities are prepared. This will facilitate the functioning of the bypass road in a proper manner and hence accidents will be reduced inside the city.

This project is not only for diverting the through traffic but also for the development of the Coimbatore city in a radial pattern.

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