Design of Culvert with Realignment of the Road

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Abstract: Highway plays an important role in transportation, economic needs of the country and also helps general population to reach their destination in time in an efficient way. But if the road alignment is not proper it causes in convenience to the public as well as negative impression to travelers and tourists about the country, which is not good for the country's economic health. Culvert on the other hand helps as a passage of river flow as well as a connecting link to the other shore of the river and also helps in the transportation, helping both in economic growth and time saving. This project deals with realignment of road as per IRC standards and design of a culvert passing by the project road.

Keywords —Realignment of road, culvert design and analysis, highway, IRC, Kani's method

I. INTRODUCTION

1.1: Objectives of Pradhanmantri Gram Sadak yojna (PMGSY): Generating increased agricultural incomes and productive employment opportunities, Rural road connectivity is a key factor for rural development by promoting entrée to economic and social services. It sets the target of:

Achieving all weather road admittance to every village with population more than 1000, Providing all weather road admittance to all the villages with population more than 500.

1.2: All weather Road

This is a VR category road having BT surface with formation width 7.5 m and carriage way width of 3.75 m with existing CD works.

1.3: Core Networks

A core network consists of routes and links routes, 'Core Networks' is termed for the rural road network necessary to provide the basic admittance to all the villages. Link routes are the one which have dead ends terminating on habitats, while through routes come about from the convergence of two or more Link Routes and emerge on to a major road or to a market centre.

Studies illustrate 85-90% of rustic trips to market centers, core network is expected to be a cost effective intangible frame work for venture and managing purposes, particularly in the circumstance of insufficient resources.

1.4: Geography

This road has existing BT surface where land acquisition is not required. This road passes through a plain terrain.

1.5: Climatic Condition

This block of area falls under moderate climatic condition.

1.6: The Sub Project Road

This road passes through a plain terrain. This is a VR category road having BT surface with formation width 7.5 m and carriage way width of 3.75 m with existing CD works.

II. LITERATURE SURVEY

G S Kalimaras, L Brino, found out the best highway alignment, as of before it would have been difficult to find the best alignment for the project using multi criteria analysis.

The article by Salvatore cafiso, alessandro di graziano and bhagwan persuade, brings out the best policies that can be adopted for accident control and best way to reduce the accident on the highway, which is main problem in the present time.

Tom masoespossito, raffle Mauro presents the speed production of the current highway lying in rural category, which is dependent on the geometric road features.

Peter g gipps, Kevin Q helped us knowing how to make cost effective road and also in addressing environmental issues.

Said M Easa established particular grades of road according to geometric specifications.

K W Ogden determined the safety effect of paving shoulders in rural roads. Data were obtained on the location, condition and cost of recent shoulders paving projects.

M J Rayll brought to us the bridges culverts and causes of degradations and various forms of it.

Bao Guo Chen and Liang Sun cleared the concept of reinforced concrete culverts under high fill and their wide use in highways and railways.

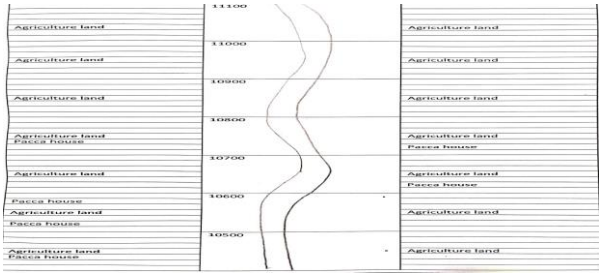
Manoj K Jha presents an overview of met heuristic application in highway and infrastructure planning and design based on genetic algorithms and colony optimization.

Tien Fang Fwa, Kumares C Sinha delt with comprehensive approach of allocation of various highway pavement costs in unfield and consistent manner.

Deepak varadarajan, Md Najafi presented that usually the maintenance part of the culvert is to access the estimate design life of the culvert.

 DOI : 10.35291/2454-9150.2019.0090

The article by M S Kang, J A Chun the method to design the culvert for critical design period, hydraulic design approach was proposed to optimize dimensions and hydraulic structures.

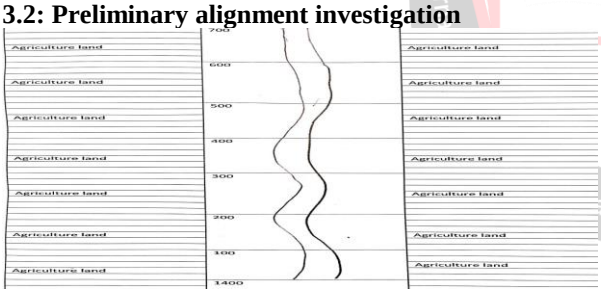


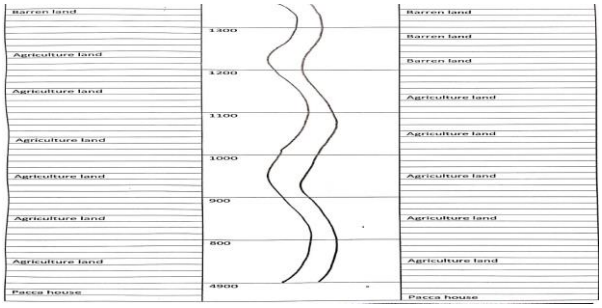
3. PLANNING AND BASIC DESIGN CONSIDERATION

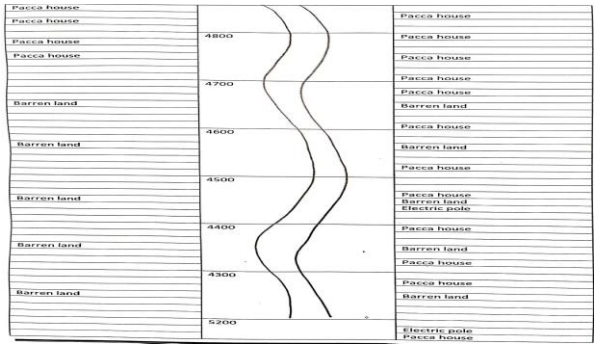
3.1: KEY MAPS

Site Location: PalayamAruakurichi road, near Karur dist, Tamilnadu

3.2: Preliminary alignment investigation



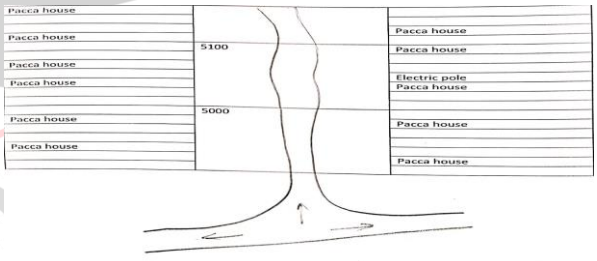


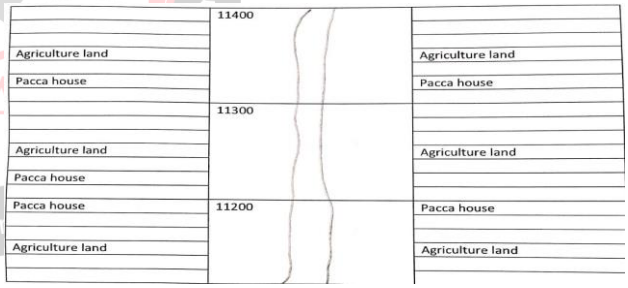


7. Chainage 7.2 km.

8. Chainage 8.0 km.

9. Chainage 8.7 km.





3.3: Site Photographs

4. Chainage 3.0 km.

5. Chainage 5.0 km. one arm T-intersection facing Karur

6. Chainage 6.0 km.

 DOI : 10.35291/2454-9150.2019.0090

1. Chainage 0.00 km. Starting of Alignment

2. Chainage 0.5 km.

3.Chainage 1.5 km.

10. Chainage 9 km.

11.Chainage 9.7 km.

12.Chainage 10.5 km.

13. Chainage 11.3 km.

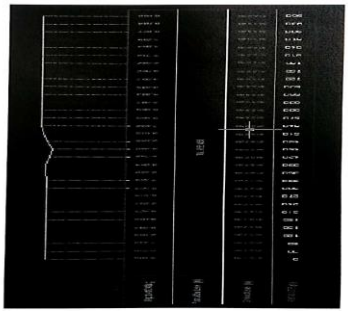
14. Chainage 11.8 km.

3.4: Road Design Brief

Sl.	Location	Issue	Design Solutions
1	Ch. 0.00 to 0.96 km.	The proposed road having existing BT surface in 3.75 Mt. is not fair and formation width Av. 5.00 Mt. No existing CD works.	For strengthening and profile correction 50 mm M.P.M., 20 mm carpet and sealcoat is proposed. Earthwork for widening from 5.0 to 6.0 Mt. is proposed .
2	Ch. 4.3 to 4.78 km	The proposed road having existing BT surface in 3.75 Mt. is not fair and formation width Av. 6.30 Mt. No existing CD works.	For strengthening and profile correction 50 mm M.P.M., 20 mm carpet and sealcoat is proposed.
3	Ch. 10.5 to 11.46 km	The proposed road having existing BT surface in 3.75 Mt. is not fair and formation width Av. 5.80 Mt. No existing CD works.	For strengthening and profile correction 50 mm M.P.M., 20 mm carpet and sealcoat is proposed.

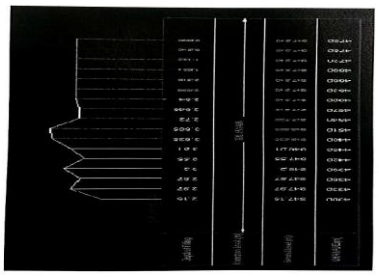
3.5: longitudinal Section of Highway

1. Fromchainage 0-0.96 km



3. Fromchainage 10.5-11.46 km

2. Fromchainage 4.3-4.78 km



III. TOPOGRAPHIC SURVEY

4.1: General

Using chain, compass and level, Topographic survey accurate to ground realities was done. With reference to IRC: SP 19-2001, IRC: SP 20, IRC: SP 13 and international practices, the domestic standards, work events and quality sketch were prepared and followed during the above survey.

4.2: Traversing

Having angular measurement accurateness of +/- 1 sec, traversing was done by total station for presented BT road.

4.3: Leveling

Leveling was done by considering temporary bench mark (TBM) at Ch. 0.

4.4: Cross Section and Detailing

Cross sections were taken at 25 m interval and at curved portions closer intervals were taken for the presented road.

4.5: Data Processing – N/A

4.6: List of TBM

1] On top of fixed stone at Ch. 0. m.
2] On top of fixed stone at village of Madurai.

4.7: Checklist

Given indication pillars - No
Given TBM with north-east - No
Carried out Traverse survey - No
Carried out Cross section and detail - Yes

IV. SOIL AND MATERIALS SURVEY

5.1: General

Following the guidelines of IRC: SP 20:2002 and IRC: SP 72-2007 and other relevant IS codes, the soil and material exploration was done. The probable sources of borrow area for soil and excavation (quarry) sites were identified.

5.2: Soil Sample Collection and Testing

At 2 locations per km, soil samples were collected all along and around the road alignment from the adjoining borrow areas as well as one sample was collected from the existing road. For all the collected samples, classification tests for soil like grain size analysis and Atterberg's limit was carried

 DOI : 10.35291/2454-9150.2019.0090

out. Due to discrepancy in soil type, Standard Procter Test and the analogous 4 days soaked CBR test was carried out either for least of one test per km for soil samples of same group or more tests. The following tests were done;
As per IS: 272 (part 4) – 1985- Grain size analysis
As per IS: 2720 (part 5)1985- Atterberg's limit
As per IS: 2720 (part 16) – 1980- Standard Proctor density test
As per IS: 2720 (part 16) – 1985- 4 days soak CBR test
For CBR 3 samples were taken.

5.3: Analysis of Test Results

CBR value = 4.0%

Penetration(mm)	Load(kg)	Penetration(mm)	Load(kg)
0	0	3	56.5
0.5	5	4	67.5
1	16.2	5	75.2
1.5	28	7.5	89
2	40	10	99.5
2.5	48.5	12.5	106.5

V. TRAFFIC SURVEY

6.1: General

On the accomplished or analogous type of PMGSY road in the environs of the project road, 3 days, 24 days traffic volume count was carried out for upgrading the presented road. The classified volume count survey was carried out in accord with the TOR and appropriate codes (IRC: SP 19-2001, IRC: SP 20, IRC: SP 72:2007).

6.2: Traffic data and analysis

The traffic count done was classified into various vehicle categories as specified below;
Powered (motor) vehicles comprising light, medium and heavy commercial vehicles such as trucks, buses, tractors, jeep, two wheelers etc.
Non powered (motor) vehicles comprising cycles, rickshaw, cycle van, animal cart etc.
During traffic counts, the numbers of laden and unladed commercial vehicles were recorded. Traffic count was done during monsoon season.
Average daily traffic at Ch. 0.00

SR NO.	Type of vehicle	Day 1	Day 2	Day 3	Average
1	Car, jeep, van	250	210	260	240
2	Auto Rickshaw	150	130	270	150
3	Scooters	180	150	320	180
4	Bus/Minibus	50	40	60	50
5	Trucks	50	40	60	50
6	Tractos with trailors	240	20	250	230
7	Tractor without trailor				
8	Cycles	460	380	480	440
9	Hand cart				
10	Bullock cart	80	70	80	80
11	Pedestrian	620	790	540	650
Total commercial vehicle per day (cpvd)					230
Total motorized vehicle per day		920	770	1010	900
Total non-motorized vehicle per day		540	450	560	520

6.3: Traffic Growth Rate and Forecast

Average daily traffic at Ch. 0.00

SR NO.	Type of vehicle	ADT	AADT	Average
1	Car, jeep, van	990	885	6%
2	Auto Rickshaw			
3	Scooters			
4	Bus/Minibus			
5	Trucks			
6	Tractors with trailers			
7	Tractor without trailer			
8	Cycles			
9	Hand cart			
10	Bullock cart			
11	Pedestrian			
Total commercial vehicle per day (cpvd)				230
Total motorized vehicle per day				900
Total non-motorized vehicle per day				520

VI. ADOPTED GEOMETRIC DESIGN STANDARD

7.1: General

Corroborating to PMGSY guiding principle and the rule as stated in IRC-SP 20:2002, the geometric design standards for this project are considered. Recommended design standards as stated below.

Terrain : plane
Design speed : 40-50 km
Roadway width : 7.5 m
Carriageway width : 3.75 m

7.2: Shoulders

It was proposed to have shoulder width of 1.125 m with selected soil.

7.3: Sight Distance

In geometric design, the safe stopping sight distance is applicable. As per the IRC recommendations, for the present road the sight distance ideals are as follows:

Design speed (KM/HR)	Safe stopping sight distance(M)
20	20
30	30
40	45
50	60

7.4: Radii for Horizontal Curves

As per the IRC recommendation, the minimum radius for the horizontal curve for this project is as follows;

Terrain Category	Radius of horizontal curve (m)	
	Ruling minimum	Absolute Maximun
Plain	90	60

7.5 Vertical Alignment

A least gradient of 1 in 30 for drainage purpose is assumed for the design of the vertical alignment of this road as the existing road is in plain terrain and vertical alignment has been designed well within ruling gradient.

7.6: Side Slope

For this rural road where embankment height is less than 3 m, side slope is 1.5:1

7.7: Right of Way

The requirement of right of way as specified in IRC SP 20:2000

Road classification	Type of terrain	Open area		Builtup area	
		Normal	Range	Normal	Range
Rural roads(vr and odr)	Plain and rolling terrain	15	15-20	15	15-20

7.8: Camber and Superelevation

Surface type	Camber Low rainfall	Camber high rainfall
Earth road	4	5
Wbm gravel road	3.5	4
Thin BT road	3	3.5
Rigid pavement	2	2.5

VII. PAVEMENT DESIGN

8.1: General

Technically sound, environment affable and economically realistic highway alignment are the fundamental intend of a

 DOI : 10.35291/2454-9150.2019.0090

good highway geometric design. The resulting sections deals with requisite points, that control highway alignment, design of cross section, highway geometric design and methodology, design of miscellaneous items.

Total No. of CVD = HCV + MCV
7 + 16 = 23
23

11) Value of VDF(As per SP 72:2007 pg no. 10 Clause no. 3.44(iv)

	Laden	Unladen
a) For HCV	2.86	0.31
b) For MCV	0.34	0.02

12) Equal Standard Axel Load (ESAL) to
To (of HCV) = ((HCV/2) x 2.86) + ((HCV/2) x 0.31)
((7/2) x 2.86) + ((7/2) x 0.31)
11.09

To (of MCV) = ((MCV/2) x 0.34) + ((MCV/2) x 0.02)
((16/2) x 0.34) + ((16/2) x 0.02)
2.88

To 11.09 + 2.88 = 13.97
As per SP 72:2007 Pg. No. 10 Clause No. 3.444(iv)

N = To x 365 $\frac{[(1+0.01r)^n - 1]}{0.01r}$ x L

13.97 x 365 $\frac{[(1+0.06)^{10} - 1]}{0.06}$ x 1

13.97 x 365 $\frac{[(1.06^{10}) - 1]}{0.06}$ x 1

8.2: Pavement Design Approach

8.2.1: Design Life

A design life period of 10 years was considered for the purpose of flexible and granular pavement design.

8.2.2: Design Traffic

As shown in the section 5.2, the typical yearly daily traffic for the breach year as well as total marketable vehicle per day was considered.

8.2.3: Determining applications of ESAL

13.97 x 365 $\frac{[\quad 0.79 \quad]}{0.06}$ x 1

67137.49

As per IRC:SP:72-2007 Fig. 4 Pavement Design Ctalouges for 4.0% CBR and ESAL 100000 to 200000
Pavement thickness = 325 mm
As per IRC:SP:72-2007 Pg. No. 16 Fig 4 Design catalogues as under

Column1	Column2
	20 mm
	Carpet and Sealcoat
275 mm	Existing Crust(Average)
50 mm	MPM

Considered are only marketable vehicles with a gross loaded weight of 3 tonns or more. The design traffic value was measured in terms of increasing number of standard axles to be carried during the design life of the road. The number of commercial vehicle of different axel loads are transformed to number of standard axel repetitions by a multiplier called the vehicle damage factor (VDF). As the traffic volume of rural road does not demand load survey, an analytical VDF value was considered. For scheming the VDF, the following categories of vehicles were measured as suggested in paragraph 3.4.4 of IRC: SP 72-2007;
Laden heavy/medium commercial vehicles.
Unladen/partially loaded heavy/medium commercial vehicles.
Over loaded heavy/medium commercial vehicles.

8.2.4: Sub grade CBR

The sub grade CBR ranging 4 % was considered and the traffic cataract in the moderate traffic category.

8.3: Pavement Composition

Flexible Pavement: The design thickness of pavement and its composition was calculated by referring figure 4 (Pavement Design catalogue) of IRC: 72-2007.
The pavement layers provided are given below;

Top layer	Premix Carpet with Type C seal coat	20 mm
Strengthening	MPM	50 mm
Total thickness		70 mm

PAVEMENT DESIGN

Where
T = Av. No. of commercial vehicle per day of lean season
t = Duration of Harvesting season = 75
n = 1 (As per Sp 72:2007 Pg No. 34)

710 + $\frac{1.2 \times 1 \times 710 \times 75}{365}$

885

10) Average Daily Traffic
Considering Growth of Traffic @ 6.0%
ADT = AADT x(1.0 +.06)^2
885 x 1.12
994.3
SAY 995

From the given traffic count data the proportions of HCV and MCV out of the ADT of 995 work out as under

Heavy commercial vehicle(HCV) = (ADT x FULL SIZE TRUCK/Total ADT peak season)
995*10
1420
7.007
Say 7

PAVEMENT DESIGN

1)	Ground water level	25.00	mt.
2)	Average rainfall	854	Mm
3)	CBR	4.20%	
4)	Dry density	1.85	
5)	Assume initial growth rate	6.00%	
6)	design life(n)	10	years
7)	Duration of harvesting season(t)	75	Days
8)	Average daily traffic(ADT)	Peak Season	Lean Season (50% of peak)
a)	Animal drawn cart	80	
b)	Bicycle	440	
c)	Full size truck and bus	100	
d)	Agricultural Tractors, Trailors and Jugads	230	
e)	Cars and Jeeps	240	
f)	Motor Cycle	180	
g)	Auto Rickshaw	150	
	TOTAL	1420	710

9) Average Annual Daily Traffic(AADT)
(As per SP 72:2007 Page No. 8 Clause No. 3.4.1)
AADT T + 1.2 x N x T x 1
= 365

VIII. PROTECTIVE WORKS AND DRAINAGE

9.1: General

Proposed road passes through plain terrain so no protective work necessary.

9.2: Road side Drain

Road side drain is proposed by cutting inside earth in required portion.

IX. LAND REQUIREMENTS

10.1: General

The existing road is a BT surface road. Thus the project road is a renewal project. The existing Right of Way (ROW) is ranging from 15 m to 25 m.

10.2: Proposed ROW

In accordance with the IRC: SP 20-2002, the width of carriageway has been considered as 3.75 m. The total road way width is limited to 6 m with 1.125 earthen shoulder on either side of carriage way. Depending upon the embankment height, the planned ROW ranges from 15 m - 25 m and the planned ROW is even less than 10 m in some stretch of habitat areas and in areas having tree cultivations.

X. TRAFFIC MANAGEMENT AND ROAD SAFETY MEASURES

11.1 Road Furniture

PMGSY logo sign board
km stones and 200 m stones
Road sign, village name and junction board

11.1.1: Road Markings: N/A

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11.1.2: Caution, Mandatory and Informative Signs

In accord with the IRC: 67-2001 rule of road signs, PMGSY sign board, road sign and village name boards were provided depending on the circumstances and purpose they perform.

11.1.3: Stones indicating Kilometer and Hectometer

In accord with the IRC: 8-1980 guidelines, the particulars of kilometer stones were provided, both regular and fifth kilometer stones as per the schedule, on both sides of the roads.

In accordance with the IRC: 26-1967 guidelines, the particulars of 200 m stones are provided and positioned on the same side of the road where km stones were provided.

11.1.4: Delineators and Object Markers: N/A

11.1.5: Guard Posts and speed breakers: N/A

11.2: Temporary Traffic Control: N/A

11.3: Road Safety CheckList

1) To the full road width, a minimum of 100 mm thick pavement of GSB layer is constructed

XI. SPECIFICATIONS

The construction equipments such as motor grader, rotavator towed by tractor, wheeled roller, mechanical mixer fixed with water measure devices; excavators etc were used as per the guidelines of NNDA.

The construction methods such as preparation of earth work, embankment work, sub grade, sub base, base, shoulder, surfacing and structural works meet the terms of MORD and IRC specifications.

XII. ENVIRONMENTAL ISSUES

For the proposed road alignment, environmental susceptible area (National park, wildlife sanctuary, protected/ reserved forest, wet land etc), assembly camp, permit/ clearance requisite prior to commencement of municipal work (NOC, CFE, CFO), measures to control erosion, drainage systems and materials used were considered seriously.

XIII. ANALYSIS OF RATE

14.1: Estimation of materials and cost for highway construction and maintenance

SR. NO.	DESCRIPTION	UNIT	QUANTITY	RATE (RS.)	AMOUNT
	TACK COAT				
	iii) Providing and applying tack coat with bitumen emulsion (RS-1) using emulsion distributor at the rate of 0.25 to 0.3 kg per sqm on the prepared granular surfaces treated with primer& cleaned with hydraulic broom as per technical specification clause 503				
	unit=sqm				
	taking output = 1750sqm				
	a)labour				
	Mate	Day	0.04	250	10
	Mazdoor (unskilled)	Day	1.00	250	250
	b)Machinery				
	hydraulic broom@ 1250 sqm/hr	Hour	1.40	450	630
	air compressor 210 cm	Hour	1.40	450	630
	emulsion pressure distributor @ 1750sqm/ hr	Hour	1.00	1000	1000
	c) Material				
	bitumen emulsion (Rs-1)@0.275kg/sqm	t	0.48	42,000	20,160
	d) Contractor's profit & overheads @12.5% on (a+b+c)				2835
	cost of 1750 sqm = a+b+c+d				25515
	Rate per sqm (a+b+c+d)/1750				14.58 (a)
	Haulage excluding loading & unloading				
	case-I surface road				
	haulage of materials by tipper excluding cost of loading,unloading and stacking				
	Rate/t.km				2.3
	Rate/M.T./km of bitumen emulsion with 425km.lead	Km.	675.0	2.3	1552.5
	for one sqmQty=0.275kg	Kg.	0.275	1.552	0.427 (a)
	total rate= A+B				15.007

SR. NO.	DESCRIPTION	UNIT	QUANTITY	RATE (RS.)	AMOUNT
	Modified Penetration Macadam				
	Construction of penetration macadam over prepared base by providing a layer of compacted crushed coarse aggregate using chips spreader with alternate applications of bituminous binder and key aggregates and rolling with a three wheel 80-100 kn static roller to achieve the desired degree of compaction as per Technical Specification Clause 506				
	AS 50 mm thick				
	Unit = sqmt				
	Taking output = 4500 sqm (225 cum)				
	i)Bitumen				
	a) Labour				
	Mate	Day	0.32	250	80
	Mazdoor (unskilled)	Day	6.0	250	1500
	Mazdoor (skilled)	Day	2.0	275	550
	b) Machinery				
	Hydraulic self-propelled chips spreader both for aggregates and key aggregates @ 1500 sqm per hour for 4500 x 2 sqm	Hour	6.0	3200	19200
	Bitumen pressure distributor for @1750 sqm per hour	Hour	2.57	1200	3084
	Tipper 5.5 cu capacity for carriage of aggregates from stockpile to chip spreader	Hour	10.0	400	4000
	Three wheel 80-100 kn static roller	Hour	22.5	650	14625
	Front end loader 1 cum bucket capacity	Hour	6.00	925	5550
	c) Material				
	Bitumen @1.75 kg per sqm	t	7.87	50,000	393500
	40 mm size MC metal @0.06 cum per sqm (M-07) (without conveyance)	cum	270.00	600	130200
	12 mm size stone chips @0.018 cum per	Cum	81.00	625	50625
	d) Contractor's profit & O.H. @12.5% on (a+b+c)				77864.25
	Cost of 4500 sqm = a+b+c+d				7,00,778.25
	Rate per sqm = (a+b+c+d)/4500				155.73 (a)

	Total rate = a+b+c+d+e+f+g				170.46

SR. NO.	DESCRIPTION	UNIT	QUANTITY	RATE (RS.)	AMOUNT
	30 mm thick open graded premix carpet using bituminous (penetration grade modified bitumen) binder				
	Providing, laying and rolling of open-graded premix carpet of 30 mm thickness compressed to 15.2 mm using mm aggregates either using penetration grade bitumen (s-90) to required line, grade and level to serve as wearing course on a previously prepared base, including mixing in a suitable plant, laying and rolling with a three wheel 80-100 kn static roller and finishing the surface to camber and grades to be followed by seal coat of type B as per Technical Specification Clause 508				
	Case-II by mechanical means				
	i)Bitumen (S-90)	Sqm			
	Taking output = 4000 sqm (80 cum)				
	a) Labour				
	Mate	Day	0.32	250	130
	Mazdoor (unskilled)	Day	10.0	250	2500
	Mazdoor (skilled)	Day	3.0	275	825
	b) Machinery				
	HMP 30/40 t per hour	Hour	6.0	6000	36,000
	Electric generator set 125 KVA	Hour	6.0	800	4800
	Front end loader 1 cum bucket capacity	Hour	6.0	925	5550
	Tipper 5.5 10t capacity paver finisher	Hour	3.64	400	1456
	Three wheel 80-100 kn static roller	Hour	6	950	5700
	c) Material				
	Bitumen (S-90) @14.6 kg per 10 sqm	t	5.84	50,000	2,92,000
	5.6 mm to 22.4 mm chipping 13.2 mm to 5.6 mm @0.27 cum per 10 sqm	Cum	108.0	625	67,500
	d) Contractor's profit and O.H. @12.5 % on (a+b+c)				53,375.63
	Cost of 4000 sqm = a+b+c+d				4,80,336.6
	Rate per sqm = (a+b+c+d)/4000				120.08 (a)
	i) loading aggregate MC Metal by mechanical means including a lead up to 30 m	Cum			42
	For 4500 sq of work MC metal	Cum	108.0		

	i) loading aggregate MC Metal by mechanical means including a lead up to 30 m	Cum			42
	For 4500 sq of work MC metal required	Cum	351.00		
	For one sqm of work MC metal required	Cum	0.078		
	Hence loading charge for MC metal	Cum	0.078	42	3.276 (a)
	ii) Loading of bitumen drums by manual means including a lead up to 30 m	Cum			120
	For 4500 sq of work bitumen required	t	7.87		
	For one sqm of work bitumen required	t	0.00175		
	Hence loading charge for bitumen	t	0.00175	120	0.21 (c)
	iii) Unloading of aggregate (MC metal) by mechanical means	Cum			5.1
	For 4500 sq of work MC metal required	Cum	351.00		
	For one sqm of work MC metal required	Cum	0.078		
	Hence unloading charge for MC metal	Cum	0.078	5.1	0.39 (e)
	ii) Unloading of bitumen drums by manual means including a lead upto 30 m	Cum			72.55
	For 4500 sq of work bitumen required	t	7.87		
	For one sqm of work bitumen required	t	0.00175		
	Hence unloading charge for bitumen	t	0.00175	72.55	0.126 (f)
	Haulage excluding loading and unloading				
	Case-I : surfaced road				
	Rate per t.km				
	60.00 km. lead rates per cu. M.	km	60.00	2.3	138
	Rate per sq. M./km = (a)* 0.0078		0.078	117.3	9.14 (d)
	40 mm = 270 cu. M.				
	12 mm = 81 cu. M.				
	Total = 351 cu. M. /4500 sq. M.				
	Hence = 0.007 cu. M./sq. M.				
	Haulage charge for asphalt for				
	425.00 km. Lead	Km	425.00	2.15	913.75
	For one sq. M. Asphalt required 1.75 kg	Kg	1.75	0.91375	1.6 (g)

	required				
	For one sqm of work MC metal required	Cum	0.027		
	Hence loading charge for MC metal	Cum	0.027	42	1.134 (b)
	i) Loading of bitumen drums by manual means including a lead up to 30 m	Cum			120
	For 4500 sq of work bitumen required	t	5.84		
	For one sqm of work bitumen required	t	0.0014		
	Hence loading charge for bitumen	t	0.0014	120	0.16 (c)

	iii) Unloading of aggregate (MC metal) by mechanical means	Cum			5.1
	For 4500 sq of work MC metal required	Cum	108.00		
	For one sqm of work MC metal required	Cum	0.027		
	Hence unloading charge for MC metal	Cum	0.027	5.1	0.137 (d)
	ii) Unloading of bitumen drums by manual means including a lead upto 30 m	Cum			
	For 4500 sq of work bitumen required	t	5.84		
	For one sqm of work bitumen required	t	0.0014		
	Hence loading charge for bitumen	t	0.0014	72.55	0.1 (e)
	Haulage excluding loading and unloading				
	Case-I : surfaced road				
	Rate per t.km				2.3
	60.00 km. lead rates per cu. M.	km	60.00	2.3	138
	One M.T. covers 23.8 sq. Mt. For 1 sq. Mt. = 0.04 M.T.		0.04	117.3	4.69 (f)
	Haulage charge of asphalt with				
	425.00 km. Lead	km	425.00	2.15	913.75
	For one sq. Mt. Quantity = 1.46 kg		1.46	0.91375	1.33 (g)
	Total rate = a+b+c+d+e+f+g				127.59

SR. NO.	DESCRIPTION	UNIT	QUANTITY	RATE (RS.)	AMOUNT
	SEAL COAT				
	providing &laying seal coat sealing the voids in a bituminous surface laid to the specified levels, grade and cross fall using type C as per technical specification clause 510				
	B. By mechanical Means				
	case-3 : type C				
	1)bitumen(S-90)	Sqm			
	taking output= 7500sqm(67.5)				
	a) labour				
	Mate	Day	0.20	250	50
	Mazdoor (unskilled)	Day	5.0	250	1250
	b) machinery				
	hydraulic self propelled chips spreader	Hour	6.0	3200	19,200
	tipper 5.5 cum capacity	Hour	6.0	400	2400
	bitumen pressure distributor	Hour	6.0	1000	6000
	three wheel 80-100KN static roller	Hour	15.0	650	9750
	c) material				
	bitumen(S-90)@6.50kg/10sqm	t	4.88	50,000	2,44,000
	crushed stone chipping of 6.7mm size 100 per cent passing 9.5mm sieve and retained on sieve applied @ 0.09cum m per 10 sqm	Cum	67.50	425	28687.5
	d) OH & Contractor's profit @12.5% on(a+b+c)				38917.18
	cost of 7500sqm=a+b+c+d				3,50,254.7
	rate per sqm=(a+b+c+d)/7500				46.7 (a)

 DOI : 10.35291/2454-9150.2019.0090

	i) Loading crushed stone by mechanical means including a lead up to 30m	Cum			42
	for 7500sqm of work crushed metal required	Cum	67.50		
	for one sqm of work crushed metal required	Cum	0.009		
	hence loading charge for crushed sand	Cum	0.009	42	0.378
	i) Loading of bitumen drums by manual means including a lead up to 30m	Cum			120
	for 7500 sqm of work bitumen required	t	4.88		
	for one sqm of work bitumen required	t	0.00065		
	hence loading charge for bitumen	t	0.00065	120	0.078
	iii) Unloading crushed stone by mechanical means including a lead up to 30m	Cum			5.1
	for 7500sqm of work crushed metal required	Cum	67.50		
	for one sqm of work crushed sand required	Cum	0.009		
	hence loading charge for crushed sand	Cum	0.009	5.1	0.0459
	iii) Unloading of bitumen drums by manual means including a lead up to 30m	Cum			72.55
	for 7500 sqm of work bitumen required	t	4.88		
	for one sqm of work bitumen required	t	0.00065		
	hence loading charge for bitumen	t	0.00065	72.55	0.047
	haulage excluding loading&				2.3
	case-I: surfaced road				
	for mix material i.e. crushed sand with 60 Km	Km.	60	2.3	138
	for one sqm quantity=.009 cu.m		0.009	138	1.242
	haulage charge of asphalt with 425Km. bitumen lead	Km.	425	2.3	977.5
	for one sq.m quantity= 0.65kg		0.65	0.9775	0.635
	total rate= A+B+C+D+E+F+G				49.12

14.2: Maintenance

Average traffic during design period = (1500+2000/2)
= 1750 nv/day
Average road user cost on existing road per year
= 365*13*1750*40
= Rs 3321.5 lakhs
Average road user cost on improved road per year
= 365*13*1750*35
= Rs 2906.3 lakhs
Total benefit = 3321.5-2906.3
= Rs 415.18 lakhs
Assuming cost of improvement Rs 10, 00,000
Total cost of improvement P = 10*13
= 130 lakhs
CRF (Capital Recovery Factor) = i(i+1)^n/((i+1)^n)-1)
At i = 12% & n=10 yrs
CRF = 0.231
Present annual cost of improvement, Cr = P*CRF
= 130*0.231
= 30.03 lakhs

XIV. DESIGN OF CROSS DRAINAGE WORKS

Slab culvert was selected since;
Span of bridge is less than 8 m, cost of frame work is less,
As per the SBC of the soil.

15.1: Design of Slab

BED LEVEL OF STREAM = 100 m
FULL SUPPLY LEVEL = 101 m
BOTTOM SLAB LEVEL = 104.5 m
Materials used M25, Fe 415 steel
Loading = IRC class AA (Tracked vehicles)
Walls - splayed type
CALCULATION OF LINEAR WATERWAY
L=4.75Q^ (1/2)
Rainfall=75.4 mm in 30 min
Intensity of rainfall = (25.4*a)/(t*b)
= (25.4*20)/(50+40)
= 5.64 cm/hr
Discharge = CIA/360
= (0.25*5.64*896*10^6)/360
= 0.406 m3/s
Linear waterway = 4.75*(0.406^0.5)
= 3.026 m2
AFFLUX
x=(v*d)^2((w/c*L)^2-1)/(2g*(d+x))
= ((2.5*3.5)^2)((4.5/(0.9*3.036))^2)-1)/((2*9.8(3.5+x))
X^2+12.25x-2.56=0
x=0.20 m

afflux generally ranges between 200mm to 300mm
DESIGN OF SLAB
Taking Fe 415 steel and M25 concrete , taking basic stress values from IRC 21(2000)
m= modular ratio
n=neutral axis constant = (10*10)/(10*(10+200))
= 0.33
j=lever arm constant = (1-0.33/3
= 0.88
q = moment of resistance = 0.5*10*0.88*0.33
= 1.465 = 1.5
Depth of slab and effective span
Assuming thickness of the slab 80 mm/m span of bridge deck
Overall depth of the slab = 4.5*80 =360 mm
Using 20 mm dia bars and 40 mm clear spacing
Assuming bearing width = 40 mm (as per IRC , for span > 3m)
Effective depth of the slab = 360-40-10 = 310 mm
Effective span is the least of
Clear span + effective width = 4.5 + 0.27 = 4.8 m
Clear span + bearing width = 4.5+ 0.4 + 4.9 m
Effective span = 4.8 m
Dead load bending moment and shear force
Wearing coat of 80 mm thickness is assumed "
Dead load of the slab = 0.32*24 = 7.68

Dead load of wearing coat = 0.08*22 = 1.76
Total = 9.44 kn/m^2
Dead load bending moment = (wl^2)/8
= (9.44*4.8^2)/8
= 27.18 = 28 kn-m
Dead load shear force = 9.44*4.8/8
= 22.7 kn
Live load bending moment and shear force
Dispersed wheel load length = length of contact + 2(overall thickness of slab)
= 3.6 + 2(0.36 + 0.08)
= 4.5 m
Proportional load to be considered
= 4.8 *700/4.5
= 747 kn
Effective width of dispersion
bef= as (1-(l/x))+b
Width of slab = 7.5 +2(0.6)
= 8.7 m
K = b/ l
= 8.7/4.8 = 1.81
From IRC 21(2000) page 52
a = 2.97
x = 4.8/2= 2.4 m

b = 0.85 +2*0.08 = 1.01 m
bef = 2.97*2.4(1-(2.4/2.8))+1.01
= (2.97*2.4*.5)+ 1.01
= 4.57m
For two:
Bef= 2.28+2.05+2.28= 6.61m
The wheel load will have a dispersed area= 4.8*6.61
=31.73kN/m^2
Intensity loading = (1.25*747)/(4.8*6.61) =39.43kN/m^2
Max live load bending moment at centre of slab= (31.73*4.8^2)/8
=91.3KN-M
Design bending moment =dead load B.M+ live load B.M
=28+91.38
=119.38=120kN-m

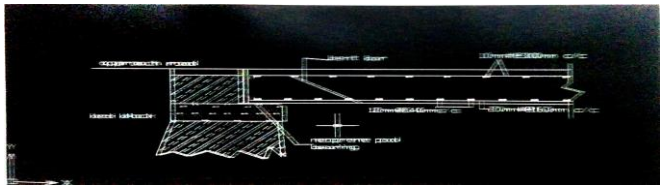
Effective length is 4.8
For two wheels the net effective width is 6.61m
Intensity of loading is 39.43 kN/m^2
Live load shear force=39.43*(4.8/2) =70.63 Kn
Design shear force= dead load shear force + live load shear force
= 22.7+70.63
= 93.33kN

Slab
Effective depth required=√ (120*10^6)/(1.5*1000)
=282.84 mm
Effective depth provided =310mm
Area of longitudinal reinforcement =(120*10^6)/(200*0.9*310)
=2150mm^2
From IS 456
The c/c distance of this reinforcement = (314.2*1000)/2150
=146.14mm
The c/c distance of reinforcement 140 mm can be adopted
Actual steel area of steel provided is 1873 mm^2
Distribution steel should be designed bending moment of
= 0.3*LL moment+ 0.2 DL moment
= (0.3*91.38)+(.2*28)
= 33 kn-m
Effective depth available in the widthwise direction with 12 mm rods
= 310-10-6
=294 mm
Area of distribution steel
=33*10^6/(200*.9*294)
= 623 mm^2
c/cdist of distribution steel
=113.1*1000/623

= 181.4 mm
Check for shear stress
Nominal shear stress
Tv = SF/bd
= (93.33*10^6)/(1000*310)
= 0.30 mpa
As per IRC 21(2000)
For solid slabs, the permissible stress in concrete = kTc
K = Factor depending on concrete grade
P u % steel = 100*As* (As+(1873/2))/pd
= 100*936.5/(1000*310)
= 0.3
From table 12 of IRC 21(2000)
p = 0.3 M30
Tc = 0.226 (interpolation)
K=1 (table 12C)
Tc = 1*0.226 = 0.226 mpa
Tc<Tv , hence ok
Design of kerb
The kerb may be designed for LL of 4 kn/m^2.The min height of kerbmay be taken as 225 mm above road level
Total depth of kerb =360 + 80 + 225
= 665 mm
Assuming footpath on either side 600 mm
LL/m run of the road = 0.6*1*4
= 2.4 kn/m
Dead load = 0.665*0.6*24
= 9.6 kn/m^2
Wt of railings = 0.5/12.5
= 0.4 kg
Bending moment =12.5*(4.8^2)/8
= 36 kn-m
The bending moment is generally taken as 50%
LL bending moment =0.5**91.38
= 45.69 kn-m
Design bending moment = DL BM + LL BM
= 36 + 45.69
= 81.69 kn-m
Hence effective depth required = √((81.69*10^6)/(600*1.5))
= 301 mm
Total depth provided = 665 mm
Using 16 mm steel available depth = 665-30-8=627 mm
Area of steel = (81.69*10^6/200*0.9*627)
= 723 mm^2
No. of bars of 16 mm diameter = (723*4)/(π*16^2) = 3.5 = 4 bars

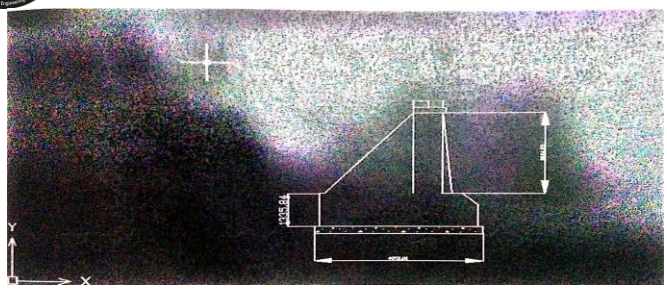
15.2: Cross Section of Slab

15.3: Longitudinal Section of Slab



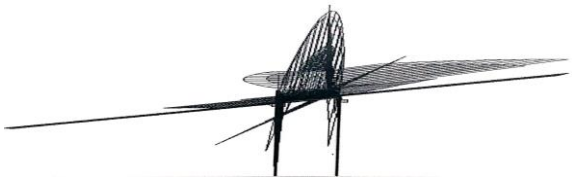
15.4: View of Abutment

 DOI : 10.35291/2454-9150.2019.0090

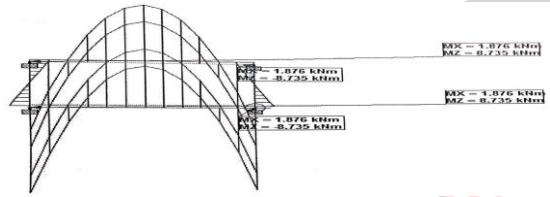


XV. BENDING MOMENT

16.1: Abutment



16.2: Slab



XVI. ESTIMATION OF MATERIALS AND RATE FOR CULVERT AND WING WALLS

17.1: Rate Analysis

Detail of work	No.	Measurement L	B	H	Quantities
Sub-Head I, Earth Work					
1.Excavation for foundations Abutments and floors (10.00 + 10 + 10)	1	7.8	4.5	0.3	9.52
Wing walls	4	4.64	4.64	0.3	27.8
Total					37.02
Sub-Head II, Concrete					
2.Cement concrete 1:4:8 in foundation and floor	1	7.8	4.5	0.2	6.348
Wingwall and floor	4	4.64	4.64	0.3	27.5
Wing walls					
Total					33.84
3.Cement Concrete (1:2:4)					
Parapet coping	2	5.1	0.3	0.225	0.69
Wearing coat over the slab	1	6.15	3.6	0.08	1.97
Total					2.6
4.Reinforced cement concrete (1:2:4) including reinforcements Slab	1	7.3	3.9	0.2	5.26
Total					5.26
Sub-Head III, Brick Work					
5. First class burnt brick laid in cement mortar (1:5) in foundation and superstructure					
Abutment 1st step	2	7.8	0.6	0.225	1.82
Abutment 2nd step	2	7.8	0.4	1.35	24.6
Abutment 3rd step	2	7.8	0.3	3.54	26.67
Wing walls 1st step	4	4.64	0.3	1.35	18.75
Wing walls 2nd step	4	4.64	0.3	2.61	36.19
Wing walls 3rd step	4	4.64	0.3	3.54	49.13
Parapet walls on the slab	2	4.1	0.85	0.28	1.95
Deduct bearing of slab	2	7.5	0.2	0.2	0.54
Total					134.69
Sub-Head IV, Flooring					
6. Brick flooring laid in cement mortar (1:6)	1	7.5	0.4	—	3.7
Total					3.7
Sub-Head V, Finishing					
7. Cement pointing deep variety (1:2)					
Inside the abutment	2	7.5	—	0.5	10.5
Inside the face (1.38 + 2.01+1.38)	2	5.3	—	1.38	15.08
Deduct					
Side openings	2	4.94	—	0.5	7.90
Side faces	1		—	0.2	0.4
Total					26.48
8. Cement pointing flush Floor	1	7.5	4.94	—	33.34
Total					33.34

17.2: Abstract of Cost

Sub-Head of work	Quantity	Unit	Rate (Rs)	Cost (Rs)
Sub-Head I, Earth work				
1. Excavation for foundations	37.02	% cub m	225	8329.5
Sub-Head II, Concrete				
2.Cement concrete in foundations(1:4:8)	33.845	Cub m	170	5692.36
3.Cement concrete (1:2:4)	2.6	Cub m	322	8732
4. Reinforced cement concrete(1:2:4) Including Reinforcement	5.26	Cub m	750	3945
Sub-Head III, Brick Work				
5. First class burnt brick laid in cement mortar (1:5) in foundations and superstructure.	133.28	Cub m	165	21991.2
Sub-Head !V, Flooring				
6. Brick flooring laid in cement mortar (1 :6)	2.7	Cub m	16	43.2
7. Cement pointing deep variety (1:2)	18.18	Cub m	6	109.08
8. Cement pointing flush	33.34	Cub m	6.50	216.71
Total	48930.77			
Add 5% contingencies & P.E				2446.5
Add Premium @ 400%-above C.S.R				205509.08
Total = Rs 256886.5~ Rs 256887				
Rate per meter = 256887/4.94 = Rs 52000				

XVII. CONCLUSION

All weather road access to the village with population more than 1000 was achieved.

A core network consisting routes and links routes was designed to provide the basic admission to all the villages.

Realignment of the road was done considering all the future aspects.

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 DOI : 10.35291/2454-9150.2019.0090