PROPOSED NEW ROAD CONSTRUCTION FROM KUJILIYAMPATTI TO FATHIMANAGAR- A CASE STUDY

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ABSTRACT

Rural roads act as basic lifeline of Country's development. Their construction not only act as a connectivity between villages, but also serve a prime importance in increasing agricultural productivity, employment, etc.. The main theme of this proposal is providing a shortest route between Sethurapatti road and Fathima nagar, Trichy, India, with less interaction with the highway NH-45(B) so as to avoid accidents. Longitudinal and cross sectional levelling were done on the selected alignment for cutting and filling detailing. Soil samples were collected from the site and Specific gravity, Water content, Atterberg's limit, Particle size determination, Proctor compaction and CBR tests were conducted on the collected soil. The soil has been concluded as a well graded non-plastic sandy soil with 10.3% OMC, 22.16% CBR value. The proposed road is designed as a flexible pavement using CBR and IRC method and a total thickness of 150mm (T) has been arrived. The design was purely based upon CBR and CVPD values. The crust consists of only two layers which are base course and wearing course. Each layer of crust has been provided by proper thickness in accordance with rural road manual IRC: SP: 20-2002 and IRC: SP: 37-2012.

Key words: Longitudinal and cross sectional levelling, Flexible pavement, IRC:SP: 20-2002, CBR, CVPD, Disturbed sample.

1. INTRODUCTION

Rural roads are the tertiary road system in total road network which provides accessibility for the rural habitations to market and other facility center, that too for villages present near Highways rural roads act as short route between villages without the reach of highway are of great importance. The study area covers NH-45(B),(Trichy to Madurai national highway), Sethurapatti, Kujiliyampatti, Trichy, India. There is an existing road connecting Sethurapatti village to the NH-45(B). Kujiliyampatti is an village present at 2Km distance from the existing Sethurapatti road. Fathima nagar is a head village of the surrounding and most of the major markets, and access to other needs like hospitals, shops are available there. So, people from Kujiliyampatti and Sethurapatti have to reach Fathima nagar to satisfy their needs. The barrier between the Fathima nagar and Sethurapatti is just a dense forest cover, with some earth roads, but they are unsafe for vehicles to travel. This study is planned for the well being of the people from Kujiliyampatti and Sethurapatti villages .The people have to take the existing Sethurapatti road and travel through the NH-45(b) [Madurai-Trichy National Highway], to reach Fathima nagar. This takes a long time in travelling to Fathima nagar. Also, a report shows an average of 1-5 accidents per 6 months along the NH-45(b) and Sethurapatti road junction. So, there is a need for,

- Shortest route between Sethurapatti road and Fathima nagar
- A road without direct reach to the Highway NH-45(b)

2. SITE ANALYSIS

The Area present in between the villages is a dense forest cover. However, there are 3 Earth roads present over the forest cover, connecting the villages. But they are unsafe for vehicles to pass through and only pedestrians, cycles can take the route, since the road width is small and the level of the road involves too much undulations. So, we aimed at selecting a alignment among the 3 existing earth roads and extending them as per Rural road provisions and make it possible and safe for vehicles to pass through. The alignment for shortest and economical Rural Road should be decided only after conducting proper surveys and investigations as per IRC SP:20-2002 specifications. As per codal procedure, first the 3existing earth roads are analyzed through ground reconnaissance. Various features like presence of natural, artificial obstructions, Cross drainage works, type of soil available, etc.., are analyzed.

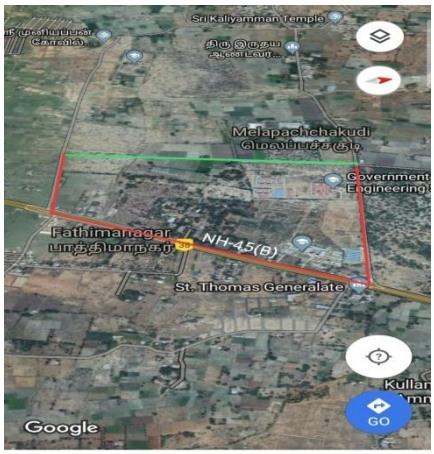


Fig.1 Satellite view on the Alternate Alignments

The results are as follows, Route-1 includes more direction changes, so more curves has to be provided, which affects the overall economy of the project, also the span of the route is more and width is too small, so it is neglected. Route-2 includes more natural obstructions like natural Rocks and this route is denser with vegetal cover, so cutting of trees will be more and the cost for the removal of obstructions will be more. Route-3 includes more undulations in level, but there is minimum change in direction over the alignment and there are no natural obstructions, span is short, cutting of trees are minimum so this alignment is selected for the proposal.

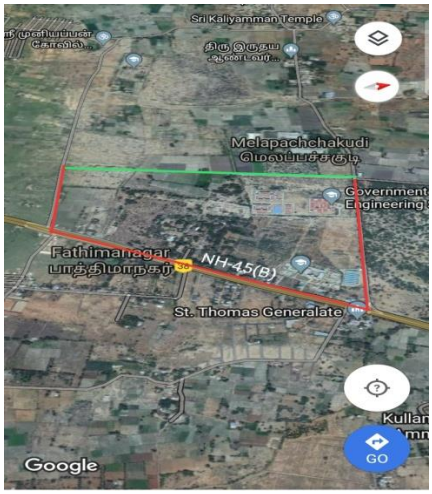
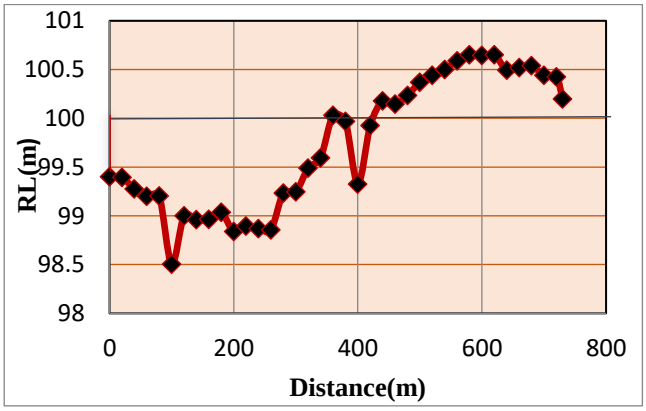


Fig.2 Alignment selected for the Proposal

- Existing Route
- Alignment chosen for the Project

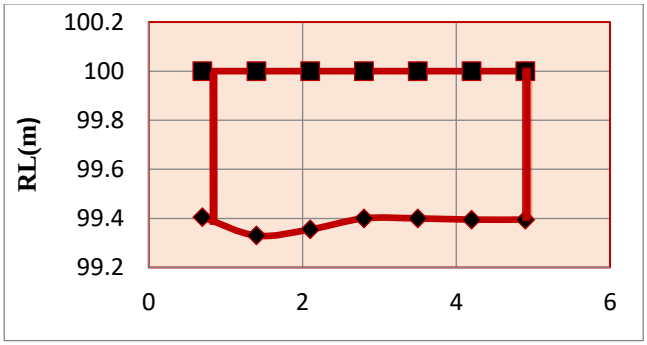
3. SURVEYING

Longitudinal and cross sectional levelling were conducted on the selected alignment. The main objectives of the levelling survey is to arrive at the cutting and filling details and finally to arrive at the cost of the proposal (if required). The survey consists of marking centre line on the alignment. The levelling survey can be carried out using suitable survey equipments, such as, Dumpy level, Tape etc.. Levels should be taken along the traverse and across it. Levels along the centre line should be taken at intervals of 20 m for LS. Cross sectional levelling is taken at every 100-250m interval (for plain terrain). Here 100m is taken as Datum.

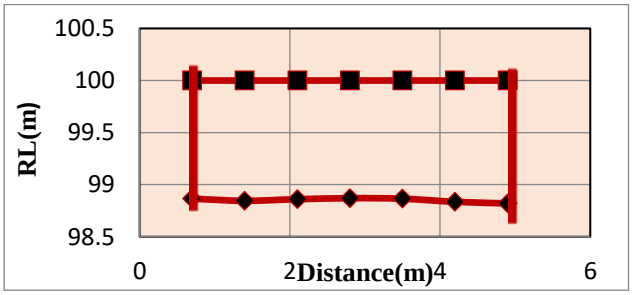


Graph 1: longitudinal sectioning along the alignment

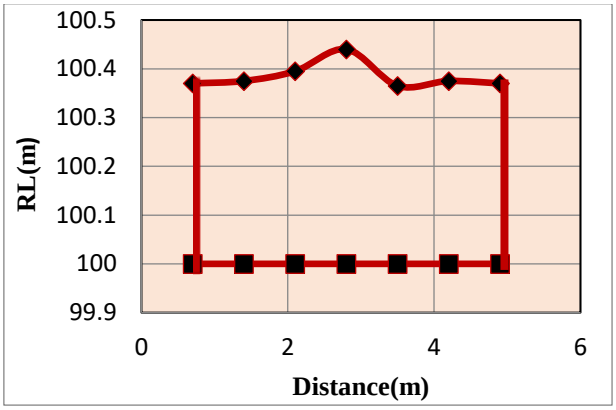
(0m to 730m, Sectioning at each 20m span)



Graph 2: Cross sectional levelling at '0m'



Graph 3: Cross sectional levelling at '250m'



Graph 4: Cross sectional levelling at '500m'

4. SOIL TESTS, RESULTS AND INFERENCE

Soil is one of the most important pavement materials, that too sub grade soil plays a most important role. Factors like Natural water content, Grain size distribution, etc.., directly contributes towards the strength of sub grade soil. So soil testing on the site of construction of pavement is important. Soil testing are done in accordance to IS 2720 codal specifications and results are related with Indian rural roads manual IRC: SP 20-2002.

4.1 Water content determination (Oven drying method) (According to IS 2720-1969: Part 2)

Table 1 Determination of Water content

Description	Trial 1	Trial 2
Empty weight of container (W_1) (g)	15.5	15.5
Weight of container+ wet soil (W_2) (g)	96.5	99.5
Weight of container+ Oven dry soil (W_3) (g)	89	90.5
Weight of moisture (W_2-W_3) (g)	7.5	9
Weight of dry soil (W_3-W_1) (g)	73.5	75
Water content (W_2-W_3) /(W_4-W_1)	10.2%	12.0%

Result: Water content of the soil sample =12.0%

4.2 Specific gravity of soil (Pycnometer method)

(According to IS 2720-1985: Part 3)

Observation:

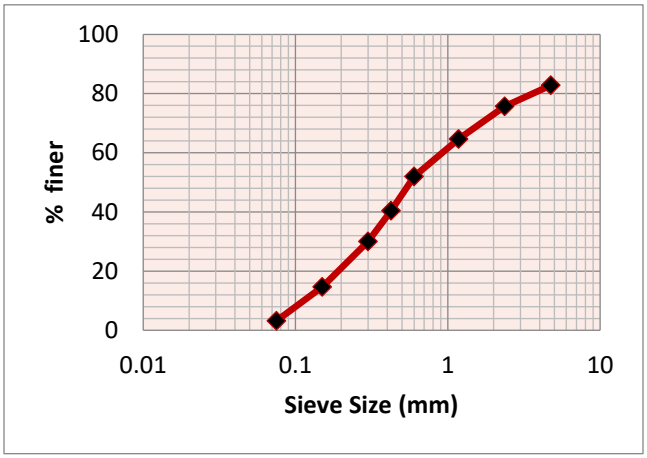
Quantity of soil taken = 200g
Empty weight of Pycnometer (w1) = 629g
Empty weight of Pycnometer +Oven dry soil (w2) = 1286.7g
Weight of Pycnometer +Oven dry soil +Water(w3) = 1836.5g
Weight of Pycnometer +Water (w4) = 1455.5g
Specific gravity of soil sample = (w2-w1)/(w4-w1)-(w3-w2)
G =2.370

Result: Specific gravity of soil sample =2.370
Allowable limit: 2.65-2.67 (According to IRC:SP:20-2002,pg:69)
Inference: Since the organic matters in the soil is high, Specific gravity is low

4.3 Particle size Determination (Sieve analysis)
(According to IS460-1962 (IS Sieves),
IS 2720-1985:Part 4 (Grain size analysis))

Table 2 Particle size Determination

Sieve size	Mass retained (g)	Cumulative mass(g)	% error	% Finer
4.75mm	26	51.5	17.167	82.8
2.36mm	21.5	73	24.330	75.67
1.80mm	33	106	35.300	64.67
600 micron	38	144	48.000	52
425 micron	30	179	59.500	40.4
300 micron	31	210	70.000	30
150 micron	76	255.555	85.160	14.84
75 micron	35	290.5	96.800	3.2
Pan	9.5	300	100.000	0



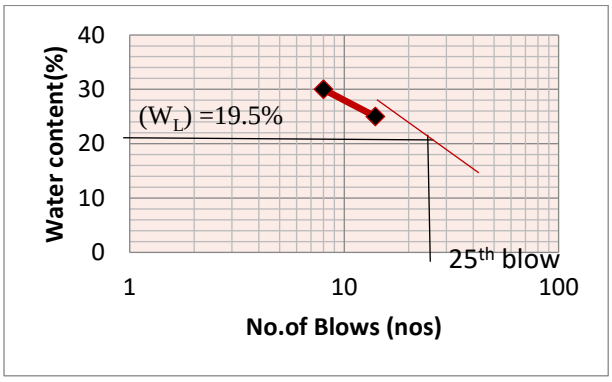
Graph 5: Grain size Distribution curve

Results:
D_{10} =0.12, D_{30} =0.30, D_{60} =0.75, C_u =6.25, C_c =1.00
Inference:
Since C_u >6, C_c =1 to 3, the soil may be termed as " Well graded Sand" – "SW"

4.4 Liquid limit test (Using Casagrande apparatus) (According to IS:9259-1979 (For selection of Grooving tool)) ,IS 2720-1985:Part 5(Determination of liquid limit).

Table 3 Determination of Liquid limit (W_L).

Description	Trial 1	Trial 2
Quantity of sample taken	120g	120g
Quantity of water added to make paste	30ml	25ml
No.of blows obtained	8 stokes	14 stokes



Graph 6: Determination of Liquid limit

Inference:
From the graph the water content corresponding to 25th blow=19.5%
Allowable value:
For non plastic soil= < 70% (According to IRC:SP:20-2002, pg:69, clause 4.4.2)
Result: Liquid limit of soil sample (W_L) =19.5%

4.5 Plastic limit test
(According to IS 2720-1985: Part 5 (Determination of Plastic limit)).
Result:
Since the soil cannot be rolled to a 3mm diameter thread for different water contents in different trails, the soil may be concluded as "Non-Plastic Soil" – "NP"

4.6 Shrinkage limit test
According to IS 2720-1985: Part 6 (Determination of Shrinkage limit).

Observation:
Diameter of shrinkage cup = 47mm
Height of shrinkage cup = 15mm

Table 4 Determination of Shrinkage Limit (W_s).

Description	Trial -1	Trial-2
Empty weight of container (W_1) (g)	30	29
Weight of container+ wet soil (W_2) (g)	75	74.5
Weight of container+ Oven dry soil (W_3) (g)	65.5	63.5
Weight of Oven dry pat (g)	35.5	34.5
Weight of moisture (g)	9.5	11.0
Shrinkage limit	12.68%	11.6%
Shrinkage Ratio	1.42	1.44

Result: Shrinkage limit of soil sample(W_s) = 12.68%
Allowable value: 9-23% (According to IRC:SP:20-2002)

4.7 Determination of Dry density using Proctor compaction
(According to IS 2720-1985: Part 8 (Determination of Water content, Dry density using Heavy Compaction)).

Observation:

Mould diameter = 150mm

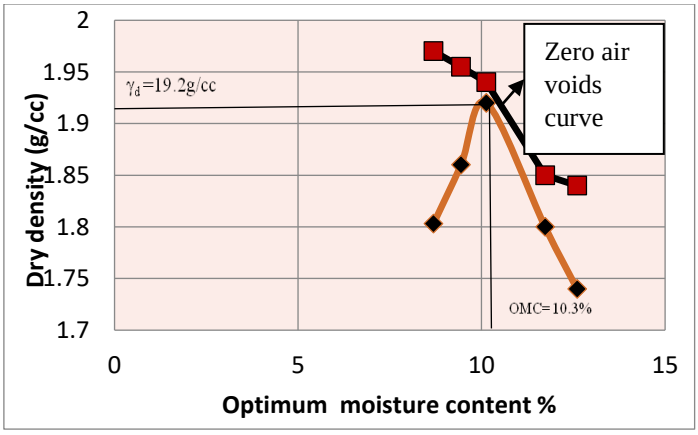
Height of mould= 170mm

Volume of mould=3004.15cm^3

(Dynamic Compaction is used)

Table 5 Determination of Dry Density (γ_d)

Description	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Weight of Base plate + mould (W_1) (g)	7220	7220	7220	7220	7220
Volume of Mould (V) (cc)	3004.15	3004.15	3004.15	3004.15	3004.15
Weight of mould+ Compacted soil (W_2) (g)	13123	13318.42	13558.76	13258.34	13116
$W=W_2-W_1$(g)	5903	6098.42	6338.76	6038.34	5896
Bulk Density (γ_b=W/V) (g/cc)	1.96	2.03	2.11	2.01	1.95
Water content (w) (%)	8.69	9.44	10.13	11.73	1.6
Dry Density ($\gamma_d=\gamma_b/(1+w)$) (g/cc)	1.803	1.86	1.92	1.80	1.74



Graph 6: Determination of Dry density

Results (From Graph),

Maximum Dry Density ($\gamma_{d\,max}$) = 19.2 g/cc

Optimum Moisture content (OMC) =10.3%

Allowable value :

OMC= 8-12% (According to IS 2720-1985: Part 8)

$\gamma_{d\,max}$ = not less than 1.65 g/cc

(According to IRC:SP:20-2002,Table 4.3,Pg:69)

4.8 California Bearing Ratio test

(According to IS 2270 –Part16(1987)).

Observation:

Maximum Dry density = 19.2g/cc

Optimum Moisture Content = 10.3%

Surcharge weight = 2.5 Kg

Wt. of original sample = 6.8 Kg

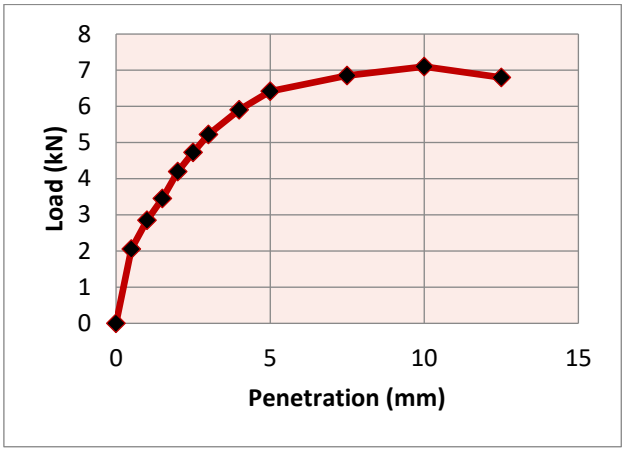
Soaking time = 96 hrs

Wt. of mould = 7.215Kg

Volume of mould = 3004.15cm^3

Table 6 Determination of CBR of soil (Unsoaked)

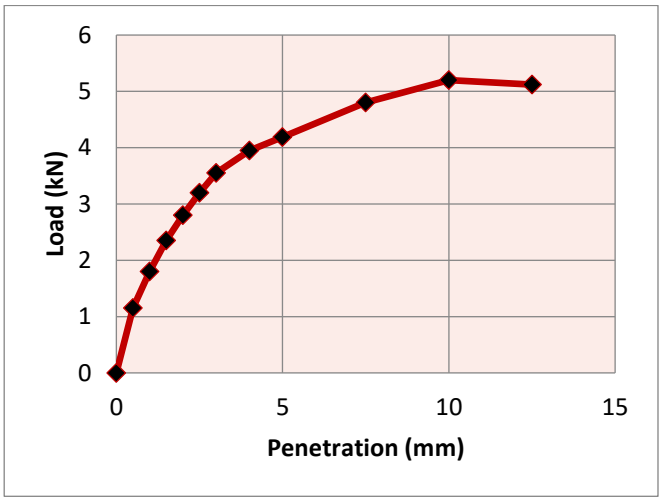
Penetration (mm)	Proving ring Reading (div)	Load on Plunger (kN)	Corrected load (kN)	Standard load (kN)	CBR (%)
0.0	-	-			
0.5	41	2.05			
1.0	57	2.85			
1.5	69	3.45			
2.0	84	4.20			
2.5	95	4.73	4.73	13.70	34.52
3.0	105	5.22			
4.0	118	5.90			
5.0	129	6.42	6.42	20.55	31.23
7.5	137	6.85			
10	142	7.10			
12.5	136	6.80			



Graph 7: Determination of CBR of soil (Unsoaked)

Table 7 Determination of CBR of soil (soaked)

Penetration (mm)	Proving ring Reading (div)	Load on Plunger (kN)	Corrected load (kN)	Standard load (kN)	CBR (%)
0.0	-	-			
0.5	23	1.15			
1.0	36	1.80			
1.5	47	2.35			
2.0	56	2.80			
2.5	69	3.44	3.44	13.70	25.16
3.0	71	3.55			
4.0	79	3.95			
5.0	84	4.19	4.19	20.55	20.38
7.5	96	4.80			
10	104	5.20			
12.5	102	5.12			



Graph 8: Determination of CBR of soil (Unsoaked)

Result:

CBR at 2.5 mm Penetration(Unsoaked sample)=34.52%
CBR at 5 mm Penetration(Unsoaked sample) =31.23%
CBR at 2.5 mm Penetration(soaked sample) =25.16%
CBR at 5 mm Penetration(soaked sample) =20.38%

Inference:

Since, the Soaked CBR will be taken for the design purpose and maximum CBR Value occurred in 2.5mm Penetration,22.16% is taken for Flexible pavement design

Allowable limit :

CBR=20-60%(Based on soil classification)
(According to IRC:SP:20-2002,Table 4.1,Pg:67)

Therefore CBR value of the soil sample=25.16%

5. DESIGN OF FLEXIBLE PAVEMENT

Most of the Indian highways system consists of flexible pavement; there are different methods of design of flexible pavement. In this Proposal, flexible pavement design has been carried on both CBR and IRC method and best of two is taken for design.

5.1 Methodology

1. California state Highway method (CBR Method) [Using CBR value and No.of vehicles per day]
2. Indian Road Congress method (IRC Method) [Using Design Traffic msa (million standard axles) value]

Time	HVC Bus/ truck (Laden)	HVC Bus/truck (UnLaden)	MCV (Agri Tractor Trailor) (Laden)	MCV (Agri Tractor Trailor) (unLaden)	LCV Cars/ Vans/ Jeeps	2- wheelers, cycles
Day	1	1	1	1	1	1
7.00 to 8.00 Am	2	-	2	-	-	4
8.00 to 9.00 Am	-	-	-	4	7	7
9.00 to 10.00 Am	1	-	-	-	5	8
10.00 to 11.00 Am	-	1	1	-	-	2
11.00 to 12.00 Am	2	-	-	3	-	3
12.00 to 1.00 Pm	-	-	-	-	2	5
1.00 to 2.00 Pm	2	-	2	-	-	4
2.00 to 3.00 Pm	-	-	-	-	1	2
3.00 to 4.00 Pm	1	-	-	4	3	1
4.00 to 5.00 Pm	-	1	2	-	5	5
5.00 to 6.00 Pm	-	-	-	-	-	3
6.00 to 7.00 Pm	1	-	1	2	4	1
7.00 to 8.00 Pm	-	2	-	-	-	3
TOTAL	9	4	8	13	27	48

5.2 Pavement layers

According to IRC: SP 20-2002, Clause 5.3.1,If CBR percentage is more than 15%, there is no need to provide Sub-Base. So the crust layer consists of only,

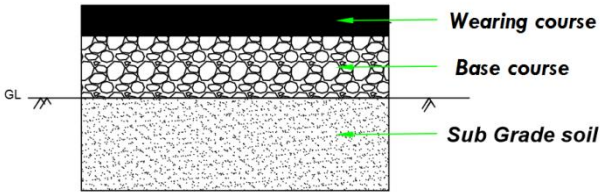


Fig.3 Pavement layers for the proposal

5.3 Design Parameters

Road classification – Village road Design speed - 40Kmph (For plain Terrain) (IRC:SP:20-2002,Table 2.2,Pg:29) Roadway width - 6m (IRC:SP:20-2002,Table 2.5,Pg:30)
Carriage way width - 4m (Min.- 3.75m)
(IRC:SP:20-2002,Table 2.6,Pg:30)
Camber - 3.5%
(IRC:SP:20-2002,Table 2.11,Pg:35)
Side slope - 2H:1V
(IRC:SP:20-2002,Table 2.7,Pg:34)
Shoulder width - 1m
(IRC:SP:20-2002,Clause 2.6.5,Pg:34)

5.4 Traffic Count survey

Table 8 Traffic volume count survey took on 27/02/2019

Commercial vehicles per day (P) = 109 nos.

5.5 Design of flexible pavement by IRC method*(using IRC:37-2012)*

The design traffic is considered in terms of the cumulative number of standard axles in the lane carrying maximum traffic during the design life of the road. This can be computed using the following equation:

$$N= \frac{365X[(1+r)^n-1]}{r} X A X D X F$$

The traffic in the year of completion (A) is estimated using the following formula:

$$A = P(1+r)^x$$

Design Datas:

D = 100% (According to IRC:37-2012,Clause4.5.1,Pg:8) (For single lane road)
F = 1.5 (According to IRC:37-2012,Table 4.2,Pg:8)
(For Plain terrain)
n =10 years (According to IRC:SP:20-2002, Clause 5.2.3, Pg:95) (For Rural roads)
r =5% (According to IRC:SP:84-2009)

Location: On Kujiliyampatti to Sethurapatti road

P =109 nos (From Traffic volume count survey) x = 1 yr

$A = P(1+r)^x = 109(1+0.05)^1 = 114.45$ CVPD.

Therefore, Design Traffic N = 0.79 msa

Inference:

IRC37-2012 has to be referred for traffic of 2msa and above and for traffic below, 2msa- IRC: SP 72-2007 (Guidelines for the design of flexible pavement for Low volume Rural Roads).

Result:

From IRC: SP 72-2007, Pg: 34 the overall pavement thickness is obtained as 100 mm, But according to IRC: SP 20-2002, the min recommended pavement thickness is 150 mm, even if design chart gives lower thickness values. Therefore overall Pavement thickness is obtained as 150 mm (Using IRC method).

5.5 Design of flexible pavement by CBR method(Using IRC SP:20-2002) (From CBR design chart)

Design datas:

CBR= 25.16%
No.of commercial vehicles per day=109
(From Traffic volume count)
(C type curve in CBR design chart (45-150nos.)

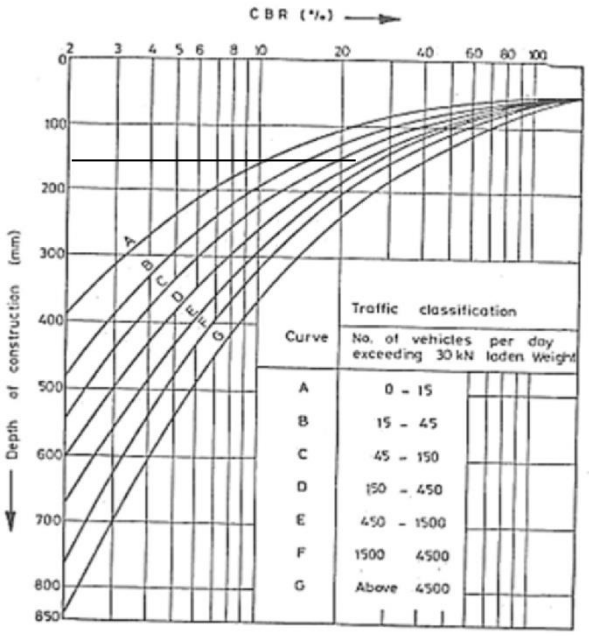


Fig.4 CBR design chart recommended by IRC

Inference
From the graph, for CBR=25.16% and C-type curve the total thickness of Pavement (T) is obtained as 150mm.
Result
Thickness of Pavement using CBR method (T) =150mm

$$T=T_B+T_W=150mm$$

T_B= Thickness of Base course

T_W= Thickness of Wearing course

6. CROSS SECTION OF PAVEMENT

The design has been done in both IRC and CBR method and since both the method gives same value, the overall pavement thickness is adopted as 150 mm

Thickness of Base course:

From CBR design chart, for

CBR of Base course material (20mm sized Aggregates) = 45.32% and P=109nos. the thickness of base course (T_B) is obtained as 100 mm. Therefore, thickness of wearing course, T_W=150-100= 50mm.

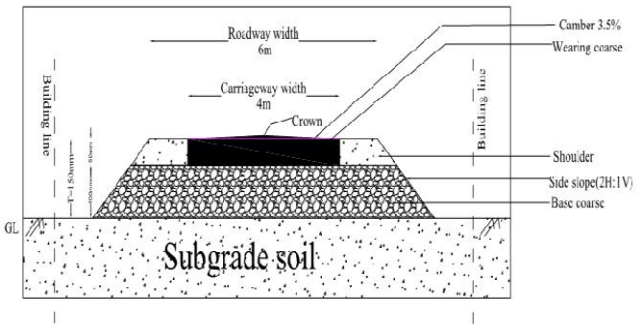


Fig.5 Cross section of the proposed Flexible pavement

7. CONCLUSION

A Rural road construction proposal with proper soil test done as per standard Indian codes has been done. Flexible pavement design has been done conforming to Rural roads manual IRC:SP:20-2002,IRC 37-2001.Lomgitudinal and cross sectional Levelling were done on the alignment for cutting, filling details. Proper and regular maintenance of Pavement is required for functioning up to design life. This study helped in comprehensive understanding on the Levelling survey, Soil test for Pavements and Design of Flexible pavement as per rural roads manual.

9. REFERNCES

1. [1] “Khanna .S.K & Justo C.E (March 2001)”, Highway Engineering, Nem Chand & Bros Publications, Roorkee (U.A), Eighth Edition.

[2] IS 2720 Part-5 “Method of test for Soil Determination of Liquid limit and Plastic limit”.

[3] IS 2720 Part –8 “Method of test for Soil Determination of Water Content, Dry density relation using a heavy Compaction & light compaction”.

[4] IS 2720 Part-16 “Method of test for Soil Laboratory determination of CBR”.

[5] IRC-SP 37-2001, “Guidelines for the Design of Flexible Pavements” IRC, New Delhi.