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HIGHWAY WIDENING AND REINFORCING USING ADAPTABLE PAVEMENT DESIGN

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ABSTRACT

The rapid growth of traffic parallels population and living standards, leading to congestion, noise, and air pollution. Increased travel times and fuel consumption accompany these challenges, affecting car independence, comfort, and convenience, while service levels decline. Therefore, it is crucial to enhance existing road lanes by widening them to accommodate increasing traffic volumes. Strengthening and widening the roads will improve service quality, reduce vehicle maintenance needs, decrease travel time, and lower fuel consumption. Ultimately, this enhances passenger services and ensures safer transportation options. Reducing gasoline usage would result in less pollution and a cleaner environment. Smooth traffic flow enhances user convenience, comfort, and improves the aesthetics of roads. The proposed project is recommended for the Vasad to Tarapur SH-8 route, which currently features a flexible pavement design. There is heavy traffic congestion with numerous buses, cars, and commercial vehicles, leading to deteriorating road conditions and poor ride quality. The state highway project, based on Design, Build, Finance, and Operate (DBFO) principles, is improving the 51-kilometer Vasad-Tarapur route. Initially a three-lane road with a 12-meter width, it is being expanded to a six-lane toll road. Funding from the World Bank and commercial financial institutions supports this initiative, aiming to upgrade the existing three-lane highways in line with IRC 81-1997 standards. The current three-lane road will be paralleled by the three-lane road that will be widened to six lanes. According to IRC 37-2001, the flexible pavement design for the proposed pavement is 610mm.The construction process and material selection criteria are applied for quality control. We'll poll people's willingness to pay for the proposed toll road, and we'll declare toll prices in accordance with government regulations.

Keywords: Traffic Growth, Traffic Jams, Pollution, Fuel Consumption, Road Aesthetics, Road Widening, Proposed Improvement, BOT Concept (Build, Operate, Transfer)

1. INTRODUCTION

India possesses the world's second biggest road network, spanning 3.3 million km.

Table 1.1: Road Network in India

Road category	Length(km)	Percentage
Express ways	200 km	2%
National highways(NH)	70,934 km	
State highways(SH)	1,31,899 km	4%
Major district roads (MDR)	4,67,763 km	14%

Village roads	26,50,000 km	80%
Total	33,20,796 km	100%

"Courtesy of Google"

- About 65% of freight and 80% passenger traffic is carried by the roads.
- National Highways constitute only about 2% of the road network but carry about 40% of the total road traffic.

Number of vehicles has been growing at an average pace of 10.16% per annum over the last five years. Due to constant increase in number of vehicles and the quality of roads is not up to the standards and the level of service is reducing. The congestion and travel time is increasing. The number of accidents is increasing. Transportation is uneconomical due to increase in fuel consumption and maintenance cost of vehicle. Deteriorated road condition reduces comfort and safety of passengers. Low quality of road cannot give aesthetic value. Improper drainage facilities affect life and durability of pavement. Transportation plays an important role in national development. Good quality of transport infrastructure is essential for social, economic, cultural, agricultural, business, occupational development of inhabitants of country. Hence strengthening and widening of road network is necessary.

Transportation occupies high space in modern life. Advancement in all spheres of life has been to a large extent influenced by transportation facility. Transportation is best thought of as a tool to transport good and peoples from one place to another. Investment in highways or other facilities generates benefit in the form of lowering the transportation cost for making movement and also enhances the level of Gross Domestic Product (GDP) through mobilization of unemployed factors of production thus enabling economic growth and development.

State highways can be regarded as the intermediate goods used in the production of final goods. Due to improvement in transportation network, reduction in transportation costs can be realized in numerous ways, such as reduction in travel time, decrease in vehicle operating costs, increased safety and reduction in the level of air and noise pollution. In addition to reduction in transportation cost, it also increase comfort to passengers and also enhancing land value.

1.1. REVIEW OF PAST STUDIES

To understand the work plan and to formulate the methodology two detailed feasibility reports given below have been studied.

1) Detail feasibility study for Vadodara-Halol Toll Road

2) Detail feasibility study for Bagodara-Bhavnagar Road

1.1.1. VADODARA-HALOL TOLL ROAD

Vadodara Halol Toll road is one of the first initiatives commissioned as a part of the vision 2010 – an ambitious plan to attract private sector participation in the Infrastructure sector of Gujarat. It is the first state highway project based on a commercial format in the country on a Build, Own, Operate and transfer (BOOT) basis and paves the way for undertaking a large number of projects on this format in the country and the state. Vadodara-Halol stretch of 31.7 km long has been widened and strengthened from two lanes to a four lane toll road with provision of toll free service road on either side of toll road to cater to the local and slow moving traffic. This project is funded on commercial format by rising resources from Banks and Financial Instructions.

1.1.2. BAGODARA BHAVNAGAR ROAD

Figure 1: strengthening and widening of (Bagodara –Rajkot) road project

The Bagodara-Bhavnagar is the important roads in Ahmedabad and Bhavnagar district of Gujarat state. The project road provides connectivity to the commercial hub like Alang ship breaking yard, Dholera Port, Ghogha Port and other major industrial centre like IPCL at Bhavnagar with the NH-8 running between Delhi and Mumbai. The study has accorded project road, as on most priority road in the state. Bagodara - Dhandhuka - Vallabhipur - Bhavnagar Road is comprises of two state highways i.e. SH-1 & SH-36 having total length 127.700 km. State Highway -1 starts from Bagodara Junction with NH-8 at Km. 61/400 and ends near Tagadi village at Km. 113/000 having total length of 51.600 km. State Highway . 36 starts near Tagadi village at Km. 113/000(end point of SH-1) and ends at Bhavnagar at Km. 189/100 having total length of 76.100 km.

The Gujarat State Road Development Corporation Ltd. has accordingly taken up this road for widening and strengthening on economic considerations with private sector participation. For this purpose, the GSRDC entrusted SAI Consulting Engineers Pvt. Ltd. to prepare a feasibility study for Four Lanning of Bagodara- Bhavnagar Road. The feasibility study of the project road covers: (i) inventory of road and structures; (ii) socio-economic profile of the project influence area; (iii) traffic projections; (iv) Pavement and material investigations; (v) pavement design and improvement proposals; (vi) initial environment and social impact assessment; (vii) preliminary cost estimate.

The project road has flexible pavement throughout the length. It is a two-lane highway. Existing pavement consists of average 7 m in width, there are two pockets of existing 4- lane; one is at Dhandhuka town from Km. 104/300 to Km. 105/800 and at Vallabhipur village from Km. 162/200 to Km. 162/800. There are seven locations where existing 2-lane carriageway is upgraded to 4-lane with paved side shoulder. The pavement condition of the stretches varies from fair to poor condition. The existing road passes through predominantly barren land with patches of agricultural industrial, commercial and other built-up Crass. Terrain of the section is generally characterized as plain for entire length.

All existing geometric deficiencies in vertical and horizontal profile of the existing alignment have been removed and entire project road has been designed for 85 kmph design speed. However, on tight locations, improvement has been limited to 65 Kmph, especially in urban locations. In general, the existing horizontal and vertical alignment of the project road is considered adequate. There are only a few areas, where only remedial works are required to improve the alignment. The number of horizontal curves on the project road is total 92 out of which 21 curves are found to be with inadequate sight distance, generally lesser than those specified in the IRC Standards for the specified category of road. The widening of the project road for 4 laning with paved shoulder is for entire project road. Based on the approved geometric standards and formulated horizontal plan of the proposed four lane with paved side shoulder it is essential to provide vertical profile improvement to the existing sub-standard at various locations on the project roads. In Project road section average filling of 1.34 is required in 7 km length with construction of new ROB.s at existing Railway level crossing. There are 75 major and minor intersections in this project road section. In this 13 are major junction out of all these one underpass is proposed at Lothal Junction at Km. 72/960 because of proposed R.O.B and remaining 12 major

junction will be improved. In Pavement Design Crust thickness of new pavement has been designed for 10% CBR for this section and 34 to 61 msa traffic with design period of 15 year. Service Road has been designed based on 15 years design life and 20 msa traffic. The respective composition, given in IRC: 37-2001 for such situation has been adopted. New pavement design is carried out based on IRC: 37.

Based on the results of the Traffic analysis, Bagodara-Bhavnagar road had been considered for widening and strengthening to four laning with paved shoulder under private sector investment.

2. LITERATURE REVIEW

Yash p badwe, Sanket t chavan, Atish d kambale, Mahesh k masalge (2022) Soil samples are tested with and without a geo-grid layer using both laboratory and simulated field CBR tests. The geo-grid layer's position in the mould is varied. Using geo-grid increases the sub-grade's CBR value, reducing pavement thickness by 35-38%. Factors such as soil plasticity, geo-grid tensile capacity, and the effects of soaking and unsoaking on CBR are investigated. Geo-grids effectively enhance soil bearing capacity through reinforcement.

Murad Y Abu-Farsakh, Qiming Chen, Milad Saghebfar (2022) Cyclic plate load testing assessed the benefits of adding geosynthetics to pavements over soft subgrades. A 305 mm diameter steel plate was subjected to a cyclic load at 0.77 Hz. The results show that geosynthetics significantly reduce pavement rutting. The segment with twin geosynthetic layers performed best among the six studied. The benefits of geosynthetic reinforcement are evaluated using the AASHTOWare Pavement ME Design Guide, considering construction variances.

Keif, O., Schary, Y., & Pokharel S.K (2015) Geosynthetics technology, such as high modulus (stiff) geocells, can lead to more sustainable transport infrastructure. Research, testing, field trials, and case studies have shown that geocells improve pavement performance and achieve sustainability goals. This report reviews recent research on high-modulus geocell-reinforced bases made of Novel Polymeric Alloys (NPA). NPA geocells enhance the strength and rigidity of flexible pavements, as evidenced by higher structural layer modulus, reduced lower layer stresses, and decreased surface degradation. Field tests confirm that NPA geocells increase the modulus of road foundation layers, reduce structural thickness, and allow the use of recycled or on-site materials.

Minimol Korulla, Ashish Gharpure & Pietro Rimoldi (2015) In soft soils, geogrids are commonly used to stabilize road bases, both paved and unpaved. Existing design techniques often lack detailed guidance on the number of geogrid layers needed and their mechanical properties. A new design approach using a four-layer model—comprising asphalt (binder and wearing course), base, subbase, and subgrade—has been developed. This method incorporates geogrid construction for road base stabilization. Techniques such as the AASHTO approach, the Giroud-Han method, and the Leng-Gabr method can be used to determine the base and/or subbase thickness. The proposed design method allows for the calculation of tensile forces in the geogrids due to various factors.

Sarah R.Jersey, Jeb S. Tingle, Gregory J. Norwood, Jayhyun Kwon, and Mark Wayne (2012) Accelerated traffic loads were used to test pavement constructions. Permanent surface deformations and pavement stiffness were measured regularly. The results showed that geogrid-reinforced pavements outperformed unreinforced control pavements. Traffic benefit ratios and effective base course structural coefficients were developed for pavement structure comparison.

Priyam Saxena, Derek Tompkins, Lev Khazanovich, and Jose Tadeu Balbo (2010) Cementitious stabilization of aggregates and soils can effectively increase the stiffness of base and subbase layers, reducing subgrade rutting and improving the fatigue behavior of asphalt surface layers. However, it may cause issues like fatigue and shrinkage in the stabilized layers. While many studies have evaluated these materials experimentally, few have linked layer performance with mechanical characteristics. The Mechanistic–Empirical Pavement Design Guide (MEPDG) provides a theoretical framework for modeling pavements with cementitiously stabilized materials (CSMs). Significant advancements are needed to match the modeling quality of flexible and rigid pavements in MEPDG for semirigid pavements.

3. OBJECTIVE

To evaluate a pavement section using IRC method in terms of its structural adequacy and performance. To develop high speed corridors. Measurement of deflection using BBD survey on existing road to determine thickness of overlay. Conducting traffic volume study for base year and derivation of MSA. Traffic Impact study of proposed road.

4. CASE STUDIES

4.1. BAGODARA-VASAD EXPRESSWAY

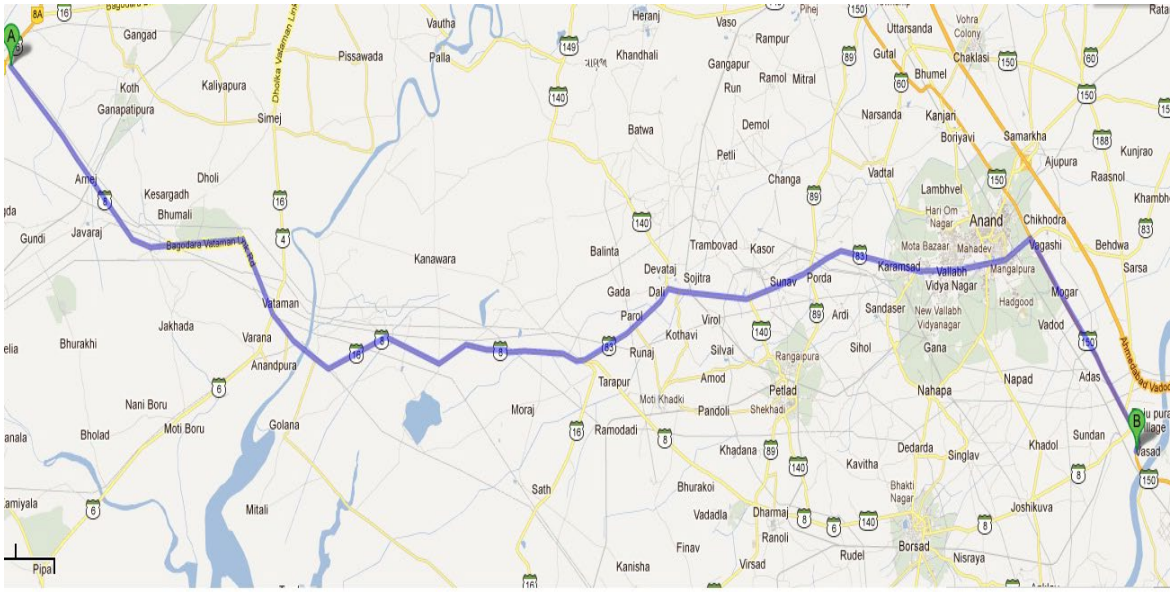

Figure 4.1: Bagodara-Vasad State highway "Courtesy of Google maps"

4.2. INTRODUCTION

The Gujarat Government is planning to develop a high speed six lane road corridors between Bagodara in Ahmedabad district and Vasad in Anand district.

The Bagodara-Vataman-Tarapur-Vasad road which passes through the districts of Ahmedabad and Anand's administrative boundaries is one of the most important highways that link Saurashtra, central Gujarat and south Gujarat. The state government has planned to convert the present two and three lane road in to a six-lane one, considering the corridor's high density now which is expected to increase in the coming years.

The corridor has a total length of 101.90 km, beginning near Bagodara and moving through Vataman in Ahmedabad district and crossing Tarapur, Borsad, Adosar and Vasad in Anand before finally terminating at Vasad near the NH-8. The present two or three lane structure is being upgraded to make it two lane with paved shoulders of 2.5 mtrs covering a total carriage way of 12 mtrs. The entire corridor is expected to be upgraded to six lanes based on divided carriageway configuration. Besides, two toll plazas are also expected to be constructed on the corridor.

Presently, 30 mtrs width is available throughout the corridor and the state government is in process of acquiring sufficient road width of up to 60 mtrs, depending on availability, to accommodate divided carriageway facility in the six lane road.

The BOT project is estimated to cost around Rs 884 crore. The Feasibility study of the project corridors covers:

- socio-economic profile of the project influence area;
- traffic projections;
- inventory of road and structures;
- pavement and material investigations;
- design proposals;
- Initial environment and social impact assessment.

4.3. PROJECT ROAD DESCRIPTION

The Project corridor starts from Bagodara and finishes at Vasad. The highway passes through the major towns namely Vataman, Tarapur and Borsad. SH-8 traverses through administrative boundaries of two districts namely Ahmedabad and Anand serving highly rich agricultural and industrialized areas of Anand District and joining NH – 8 at Vasad. SH – 8 (Bagodara – Wataman – Tarapur – Vasad Road) serves as an important link connecting Central Gujarat and Mumbai to Saurashtra region. The Project Highway has significant traffic flow advantages in terms of it being on the natural trade route between key sea-ports on Western Coast / Southern India. It serves key sea-ports in Saurashtra/Kutch like Pipavav, Porbandar, Kandla, Mundra etc. Mega Projects in the Project Influence Area, like Delhi-Mumbai Industrial Corridor (DMIC), Savli Industrial Estate etc, are expected to be developed, which would lead to additional traffic and substantial growth.

One of the key industrial regions planned as part of the DMIC is the Ahmedabad Dholera Special Investment region (SIR). The Dholera SIR falls in the influence area of the project highway located at approximately 40 km from the project highway. The proposed developments in the Dholera SIR include development of green field port, development of shipyard (development of ship building/ repairing facilities), export oriented industrial units/ Special Economic Zones (SEZ) (for developing automobile/auto component, electronics and others) , integrated logistics hub with container freight station with multi modal logistics infrastructure etc. The average daily traffic is expected to range between 20,000 to 17,000 passenger car units.

The project corridor has been taken up for development under program of State's selected corridors on BOT basis through Public Private Partnership scheme. Geographical coordinates of Bagodara are Latitude: 22° 49' 36.55344" N, Longitude: 72° 22' 35.60304" E and Vasad are 22° 27' 0" N, 73° 4' 0" E.

4.4. TERRAIN CLASSIFICATION

The project corridor alignment mainly traverses through plain terrain. The road mainly passes through agricultural area except some portion where rocks exist. The existing horizontal alignment in plain area where some other stretches needs to be improved from sight distance criterion.

Table 3.1: Details of Terrain

Section of the Road	Length		Type of Terrain
	From (km)	To (km)	
Bagodara-Vasad (SH-08)	0	101.90	Plain

4.5. MAJOR TOWN AND VILLAGES

There are number of town & villages along the project corridor. The following table provides a list of main towns and villages along the Project road:

Table 3.2: Major Town and Villages

S.NO	Name of Town/Village	KM
1	Bagodara	0
2	Vataman	29.250
3	Tarapur	42.8
4	Borsad	84.5
5	Vasad	101.9

4.6. CARRIAGEWAY DETAILS

The existing carriageway width varies from 10 m to 12 m with 2.5 m paved shoulders on both sides in various stretches.

4.7. SHOULDER DETAILS

The existing shoulders provided along the project corridor are of different type and with different combination in various sections.

The paved shoulder of width varying from 2.5 m to 3 m is provided in most of the stretches of the road.

4.8. EXISTING RIGHT OF WAY

The existing right of way (ROW) varies from 26 m to 45 m for entire length, except in Town/village potions where ROW is not adequate due to encroachments.

Table 3.3: Details of Right of Way

Section of the Road	**Length**		**Right of Way width**
	From (km)	**To (km)**	
Bagodara-Vasad (SH-08)	0	101.90	26m to 45m

4.9. EXISTING ALIGNMENT GEOMETRICS

There are number of horizontal curves and few of them have to be corrected to bring them to proper design standards. Few horizontal curves are on steep gradient and also in cut portion, which are found substandard with respect to sight distance criterion as per MORT&H Standards.

4.10. INTERSECTIONS

There are total 49 Nos. of intersections, which are either major or minor one, have been observed along the Project road.

4.11. ROAD CONDITION

As per visual assessment of the project corridor, the condition of existing road varies from section to section.

4.12. STRUCTURE/ROAD FURNITURE INVENTORY

During field surveys details regarding existing structures and road sign boards provided along the project corridor were collected. It is found from the observation and data collection that, structures are situated within/ nearby existing right of way in urban sections or at important intersections only.

The rural sections of the project corridor are free from structures, but right of way is encroaching by farmers at certain locations. In addition the same, data regarding sign boards provided by the department along the project road was collected, which reveal that still additional sign boards are required for proper guidance to the road user.

5. METHODOLOGY

5.1. FLEXIBLE PAVEMENT DESIGN FOR WIDENING

The CBR Method of Pavement Design for multi-layer pavements of granular material is recommended by IRC 37-2001 "Guidelines for the Design of Flexible Pavements" and procedure for widening of flexible pavement is given below:

- To find out initial traffic of commercial vehicles per day by conduction traffic volume count
- To determine traffic growth factor by studying the past trends of traffic growth
- Design life of Pavement
- To find out Vehicle Damage Factor to convert the number of commercial vehicles of different axle loads and axle configuration to the number of standard ale load repetition. It may be obtained by conducting axle load survey.
- To find out distribution factor of traffic over the carriageway
- To determine design traffic in cumulative number of standard axles (msa) by following formula.

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

- To determine total pavement thickness and crust composition by charts/graphs with respect to CBR and cumulative number of standard axles.

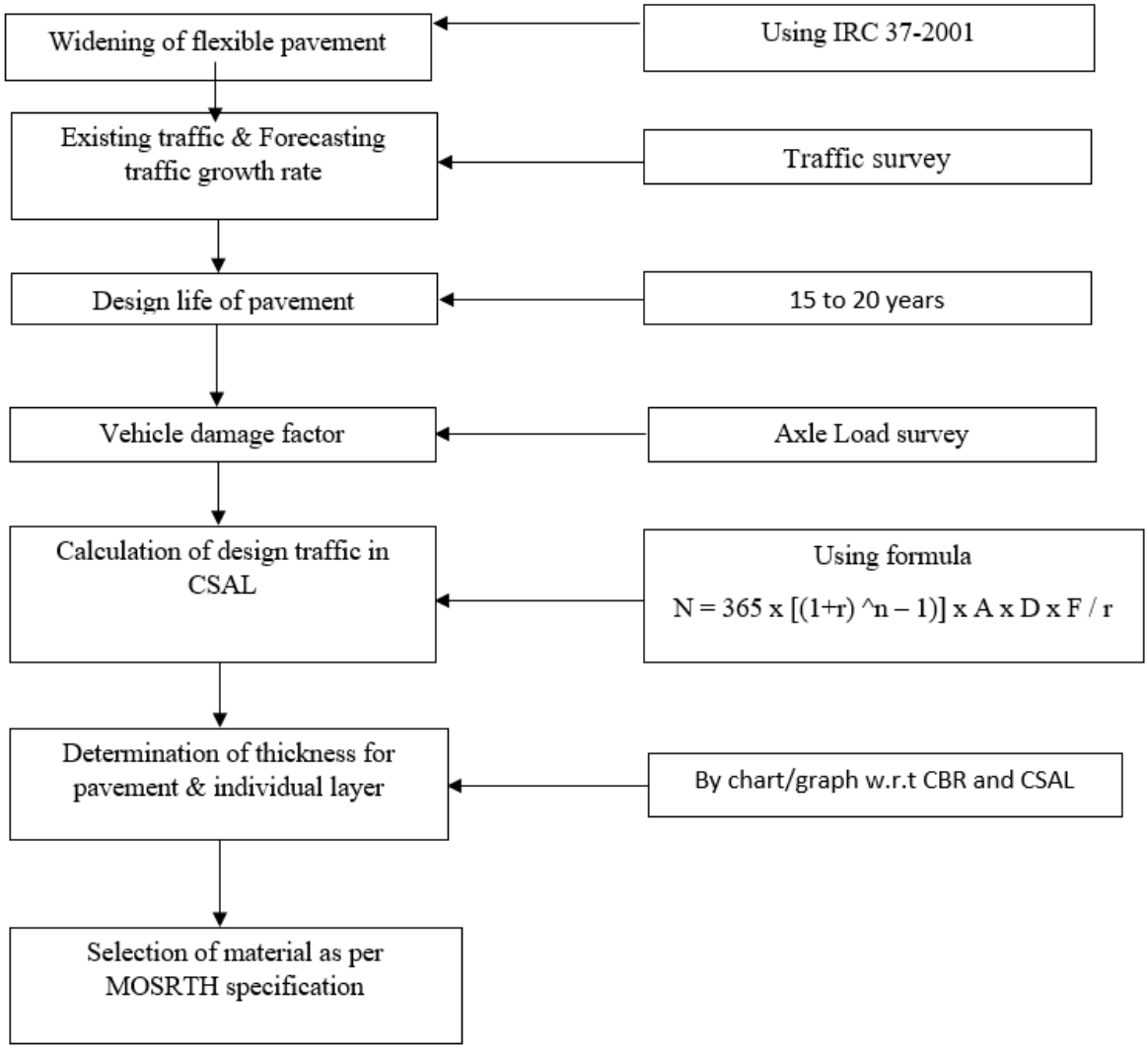

Fig: 5.1shows the flowchart of design procedure for the widening of flexible pavement

5.2. OVERLAY DESIGN ON EXISTING FLEXIBLE PAVEMENT

IRC 81-1997 "Guidelines for Strengthening of Flexible Road Pavement using Benkelman Beam Deflection Technique" is used for design of overlay on existing pavement. Procedure for the design of overlay on existing pavement is given below

- To find out initial traffic of commercial vehicles per day by conduction traffic volume count
- To determine traffic growth factor by studying the past trends of traffic growth
- Design life of Pavement
- To find out Vehicle Damage Factor to convert the number of commercial vehicles of different axle loads and axle configuration to the number of standard ale load repetition. It may be obtained by conducting axle load survey.
- To find out distribution factor of traffic over the carriageway
- To determine design traffic in cumulative number of standard axles (msa) by following formula.

N = 365 x [(1+r) ^n – 1)] x A x D x F / r

- To record dial gauge readings, temperatures etc by conducting Benkelman Beam Deflection Survey (BBD).
- To determine moisture content of soil samples collected during BBD survey.
- To determine temperature variation factor.
- To determine moisture content factor from graphs given in IRC 811997.
- To determine characteristic deflection by the following formula.

  Dr = $\bar{x}$ + 2σ for Major Arterial Roads

  Dc =$\bar{x}$+σ for All other Roads

  Mean Deflection x = $\frac{\sum x}{N}$

- To determine overlay thickness from Fig 9 of IRC 81-1997 in terms of bituminous macadam construction.
- To convert thickness in to DBM/AC following formula is used.

1 cm of Bituminous Macadam = 0.7 cm of DBM/AC.

Fig: 5.2 show Flow Chart of Overlay Design for Existing Carriageway.

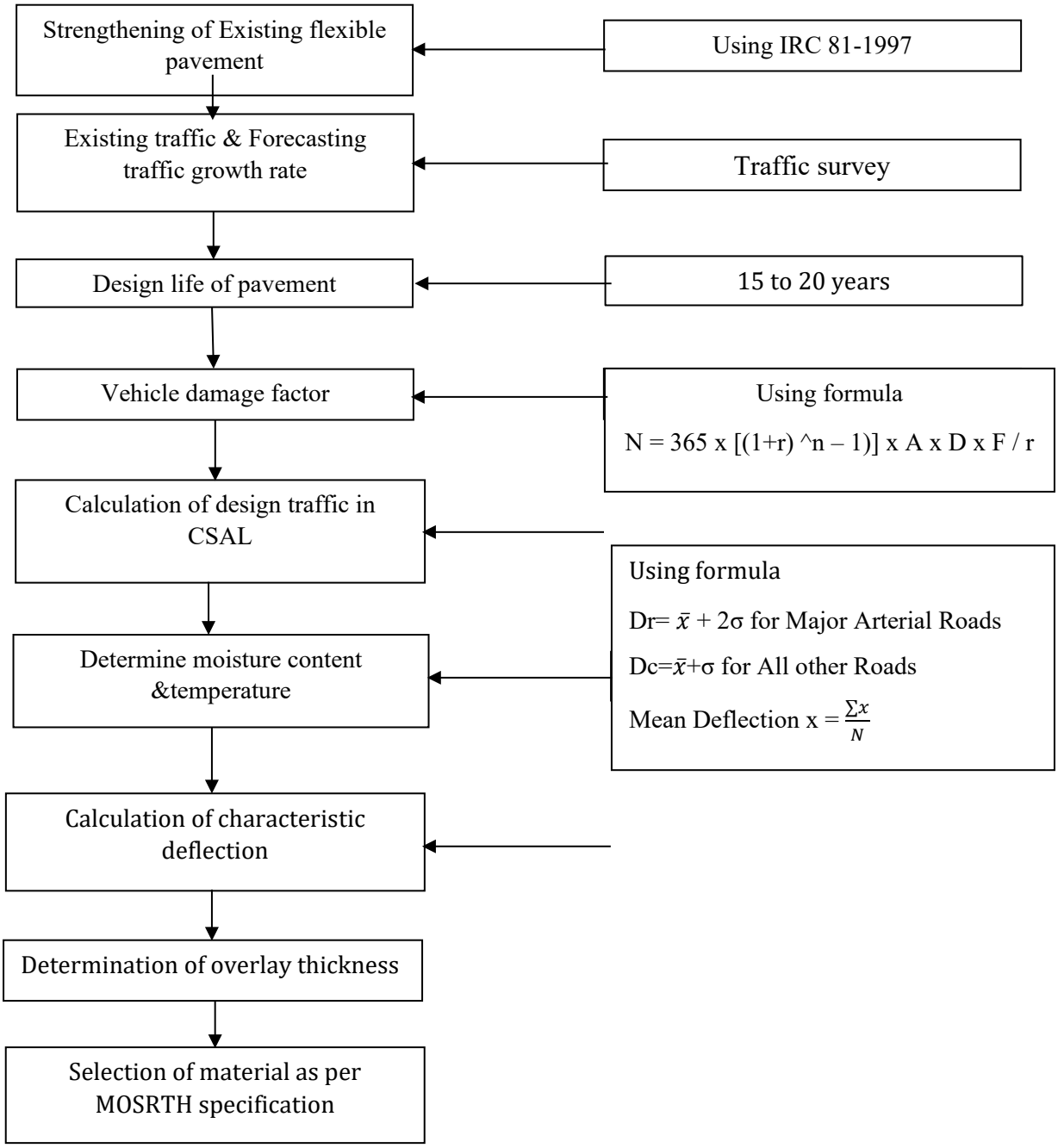

Figure: 5.2: Flow Chart of Overlay Design for Existing Carriageway (IRC 81-1997).

6. RESULTS ANALYSIS AND DESIGNING

6.1. FLEXIBLE PAVEMENT DESIGN FOR WIDENING

The CBR Method of Pavement Design for multi-layer pavements of granular material is recommended by IRC 37-2001 "Guidelines for the Design of Flexible Pavements" and procedure for widening of flexible pavement is given below:

6.1.1. TRAFFIC VOLUME COUNT

Initial traffic of commercial vehicles per day by conducting traffic volume count is given in Appendix 1:

- Traffic volume count survey is been carried out manually for 24 hour in both the direction of highway for continuously 3 days at Vataman Toll plaza situated at 29.250 km from Bagodara.
- Traffic Volume count of different vehicle like Motorcycle, Three wheeler, Car, Bus, Truck, Tempo, Tractor, Road machinery etc is been conducted andAverage Daily Traffic (A.D.T) is been calculated by taking the average of traffic volume count that is been conducted for 3 days of all the vehicles as shown in table and pie-chart.

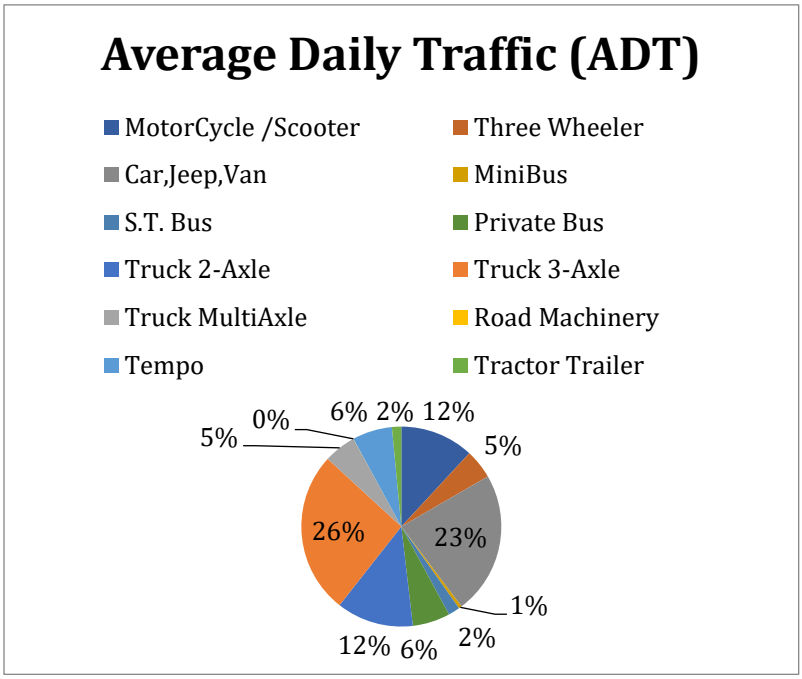

Figure 6.1: Pie chart of Average Daily traffic

Passenger Car Unit (P.C.U) is been calculated by multiplying its factor to A.D.T and by taking the summation of all the PCU of different vehicles we get the total existing traffic on the highway that is 24630.Composition of PCU of different vehicles is been shown in pie chart below:

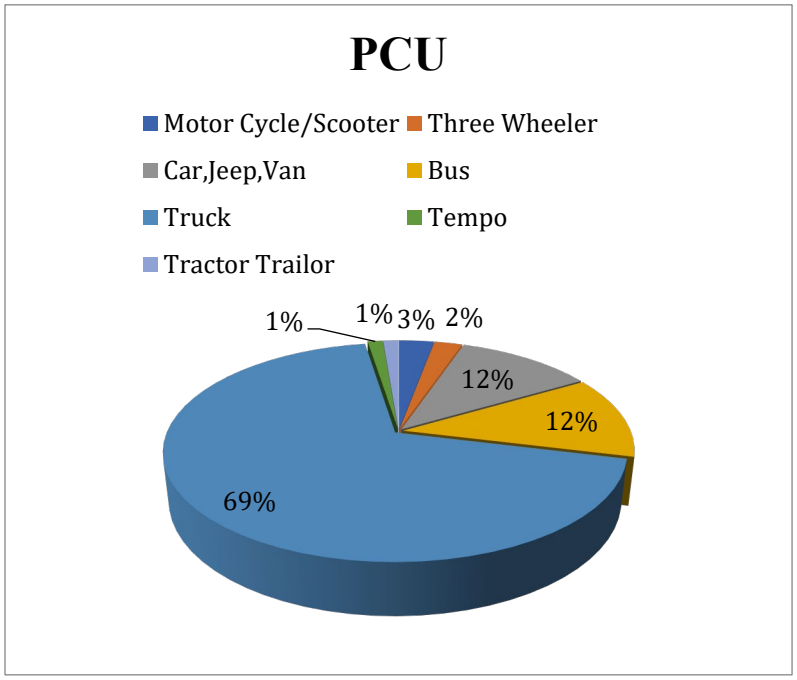

Figure 6.2: Pie chart of PCU

- Existing traffic on SH-08 is more than its Capacity as been specified in MOSRTH Specification so the widening of highway is been essential to accommodate the existing traffic.
- A commercial vehicle per day (C.V.P.D) of Bus, Truck, and LCV is shown in table and its total value is 7404.

6.1.2. TRAFFIC GROWTH FACTOR

By studying the past trends of traffic, traffic growth factor is been taken as 5%.

6.1.3. DESIGN LIFE OF PAVEMENT

Design life (n) of SH-8 is taken 10 years.

6.1.4. VEHICLE DAMAGE FACTOR

Vehicle Damage Factor (V.D.F) values as per IRC 37:2001 based upon different CVPD and Terrain is given in table below:

Table 6.1: Vehicle damage factor

Initial traffic volume in terms of number of commercial vehicles per day	Terrain	
	Rolling/Plain	Hilly
0-150	1.5	0.5
150-1500	3.5	1.5
More than 1500	4.5	2.5

"Courtesy of IRC 37:2001"

6.1.5. LANE DISTRIBUTION FACTOR

For dual three-lane carriageway road, the distribution factor will be 60%.Therefore the traffic in each direction may be assumed to be half of the sum in both directions; Lane Distribution Factor (D) is taken as 0.3

6.1.6. CUMULATIVE NUMBER OF STANDARD AXLE

- The traffic in the year of completion is estimated using the following formula:

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

Where,

P= Number of commercial vehicle as per last count

x= Number of years between last count and year of completion of construction = 2.5

- The design traffic is considered in terms of the cumulative number of standard axle (in the lane carrying maximum traffic) to be carried during the design life of the road. This can be computed using this formula:

$$N = 365 \times [(1+r) ^n - 1)] \times A \times D \times F / r$$

- For different category of vehicles A and N is calculated as shown in Appendix 2.
- Cumulative number of standard axle for initial 10 years of traffic is **50.42 msa**.

6.1.7. CBR

Before conducting CBR test soil should be checked for following test to get exact value of CBR:

Free Swell Index (F.S.I),Grain Size Analysis (G.S.A) ,Liquid Limit (L.L) and Plastic Limit (P.L),Compaction Test

6.1.7.1. FREE SWELL INDEX (F.S.I)

Free Swell Index of subgrade should not be more than 50%.

Determination of Free Swell Index of subgrade as per IS: 2720 part 40-1977

Weight of sample taken: 10gm

6.1.7.2. GRAIN SIZE ANALYSIS (G.S.A)

Grain Size Analysis (IS: 2720 Part 40 - 1997)

Weight of sample taken: 1000gm

Table 6.3: Test results of grain sizes analysis of soil.

S.No	Description Of Test	Readings	
1	Vol. Of Soil Specimen in Distilled Water in cc (V_d)	11.50	12.0
2	Vol. Of Soil Specimen in Kerosene in cc (V_k)	10.0	10.0
3	Free Swell Index in Percentage (($V_d - V_k$)/ V_k)x100	15.0	20.0
4	**Average**	**17.50**	

Sieve Size	Weight Retained (gm)	Cum.Weight Retained (gm)	Cum.Weight Retained (%)	Passing (%)	Remark
75mm	0	0	0	100	**Gravel**
20mm	0	0	0	100	
4.75mm	16	16	1.6	98.40	
2.0mm	11	27	2.70	97.30	**Sand**
0.425mm	13	40	4.70	96.0	
0.075mm	334	374	37.40	62.60	
Pan					**Silt & Clay**

Table 6.4: Observation sheet

DESCRIPTION PARTICAL		SIEVE SIZE	PERCENTAGE	Total (%)
Gravel	Coarse	75 mm – 20 mm	0	**1.60**
	Fine	20 mm - 4.75 mm	1.60	
Sand	Coarse	4.75 mm - 2.0 mm	1.10	**35.80**
	Medium	2.0 mm - 0.425 mm	1.30	
	Fine	0.425 mm - 0.075 mm	33.40	
Silt & Clay		0.75 mm Passing	62.60	**62.60**

As per above test performed subgrade of SH-8 is **silty** in nature.

6.1.7.3. LIQUID LIMIT AND PLASTIC LIMIT

Determination of Liquid Limit and Plastic Limit (IS: 2720 Part-5, 1985)

Table 6.5: Observation Sheet of LL and PL

Determination No.	Liquid Limit				Plastic Limit	
	1	2	3	4	1	2

1	**No. of Blows**	33	28	23	16		
2	**Container No.**	2	58	42	20	27	36
3	**Mass of Container (gm)**	37.34	35.36	36.19	34.53	39.52	35.28
4	**Mass of Wet Soil + Container (gm)**	64.31	58.52	61.81	64.66	42.44	41.14
5	**Mass of Container + Oven Dry Soil (gm)**	59.62	54.11	56.46	67.84	42.02	40.26
6	**Mass of Water (gm)**	4.69	4.41	5.35	6.82	0.42	0.88
7	**Mass of Oven Dry Soil (gm)**	22.28	18.75	20.27	23.21	2.50	4.98
8	**Water Content (6) / (7) x 100(W_L) (%)**	21.05	23.52	26.39	29.26	16.80	17.67
Average PL						**17.24**	

Liquid Limit:	**24.90%**
Plastic Limit:	**17.24%**
Plasticity Index:	**7.66%**

Description of Works	**Emb. Sub-Gra.**	**GSB**	**WMM**
MOST Specification Limit	LL < 70 , Pl < 45	LL < 25 , Pl < 6	LL < 25 , Pl < 6

6.1.7.4. COMPACTION TEST

Compaction Test is been performed to determine the maximum dry density and optimum moisture content.

MOISTURE DENSITY RELATIONSHIP (IS: 2720 Part – 8)

Type of Compaction: Dynamic

Type of Method: Modified — Weight of Rammer: 4.89 kg

No. of Blows: 25 — No. of Layers: 5

Table 5.6: Observation sheet of MDD

Water Ad %	**6%**	**8%**	**10%**	**12%**	**14%**
Determination No.	**1**	**2**	**3**	**4**	**5**
Mould No.	1	1	1	1	1
Volume of Mould (V) (cc)	1000	1000	1000	1000	1000
Weight of Mould (m1) (gm)	4187	4187	4187	4187	4187
Weight of Mould + Compacted Soil (m2) (gm)	6112	6202	6296	6280	6228
Weight of Compacted Soil (m3 = m2 –m1) (gm)	1925	2015	2109	2093	2041
Wet Density of Soil (D_w) = m3 / V	1.925	2.015	2.109	2.093	2.041
Container No.	108	106	122	123	110

Weight of Container (gm)	15.39	18.88	19.66	15.97	15.73
Weight of Wet Soil + Container (gm)	57.20	62.20	97.93	66.35	64.20
Weight of Container + Oven Dry Soil (gm)	54.83	59.29	90.90	66.35	58.26
Weight of Water (gm)	2.37	2.91	7.03	5.36	5.94
Weight of Oven Dry Soil (gm)	39.44	40.41	71.24	45.02	42.48
Moisture Content (W) (%)	6.0	7.20	9.87	11.90	13.98
Dry Density of Soil (D_d)= 100 x D_w / (100 + w) (gm/cc)	1.816	1.879	1.919	1.870	1.790

- **Maximum dry density: 1.920 gm/cc, Optimum moisture content: 10.15%**

CALIFORNIA BEARING RATIO (CBR) PENETRATION TEST (SOAKED)

IS: 2720 Part – 16.1987

Date of Casting: 6/3/2012 Proving Ring Capacity: 30 KN

Date of Testing: 10/3/2012 Proving Ring Constant: 3.75 (kg/div)

Penetration Rate: 2.5 mm/min

Table 6.7: Observation sheet of CBR

Penetration (mm)	**Mould No. 1**			**Mould No.2**			**Mould No.3**		
	Dial Gauge Reading (Div)	**Load (Kgf)**	**Corrected Load (Kgf)**	**Dial Gauge Reading (Div)**	**Load (Kgf)**	**Corrected Load (Kgf)**	**Dial Gauge Reading (Div)**	**Load (Kgf)**	**Corrected Load (Kgf)**
0.00	0	0		0	0		0	0	
0.50	6	22.50		5	18.75		4	15	
1.00	18	67.50		17	63.75		18	67.5	
1.50	23	86.25		24	90		25	93.75	
2.00	27	101.25		26	97.5		28	105	
2.50	31	116.25	**8.48**	29	108.75	**8**	30	112.5	**8.2**
3.00	34	127.5		32	120		33	123.75	
4.00	40	150		38	142.5		38	142.5	
5.00	45	168.75	**8.21**	43	161.25	**7.8**	44	165	**8**
7.50	55	206.25		54	202.25		53	193.75	
10.00									
12.50									
CBR of Specimen at 2.50mm (Standard 1370Kg)	**8.48**			**8**			**8.2**		
CBR of Specimen at 5.00mm (Standard 2055Kg)	**8.21**			**7.8**			**8**		
Description Of Works	**Sub Grade**			**GSB**			**WMM**		
MORT&H Specification Limit	**As Per Required Design Parameter**			**30%**			**N/A**		

Determination of Flexible pavement thickness and composition

- As per IRC 37:2001 based on value of CBR and cumulative traffic pavement thickness and its composition is determined

Cumulative traffic: **50.42 msa**

CBR: **8%**

Table 6.8: Pavement design catalogue Based on Pavement Design Catalogue given in IRC: 37-2001 total pavement thickness is shown in fig below:

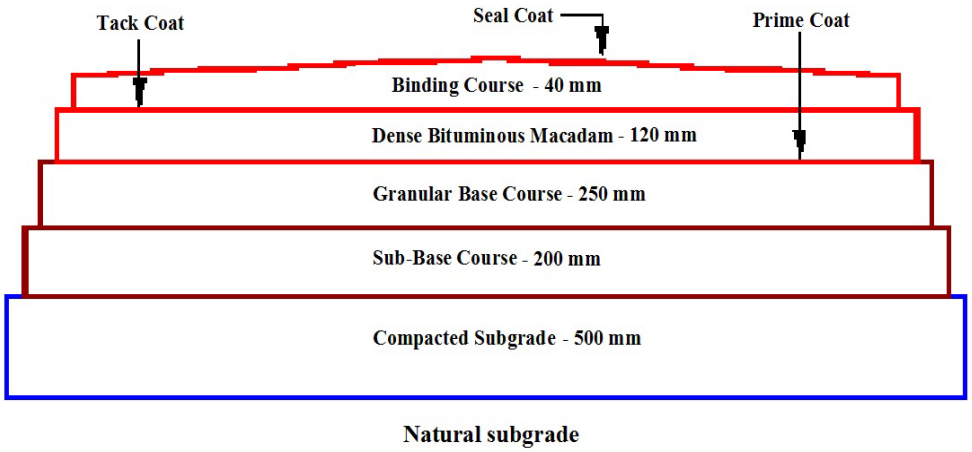

Fig 6.7: Flexible pavement thickness of different layers based on IRC: 37-2001

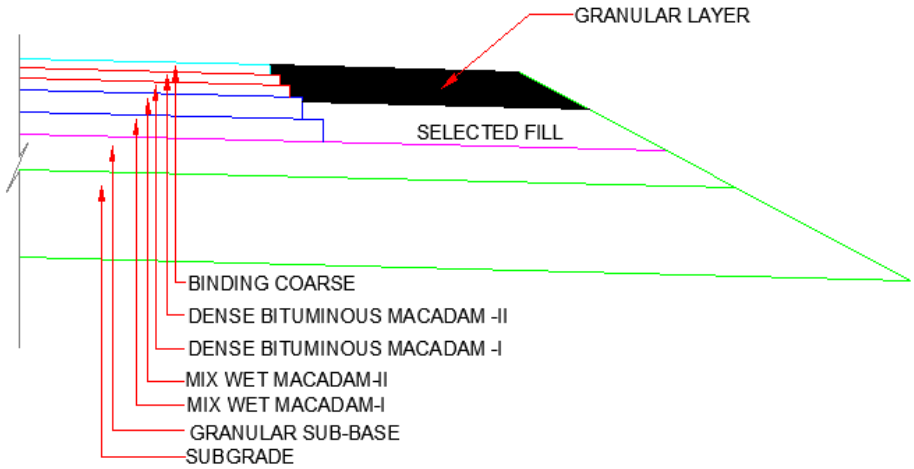

Figure 6.8: Detail cross section of widening portion of SH-8

Typical cross section of SH-8 has been shown in Appendix 3 and Appendix 4 which has been drawn in AutoCAD

6.2. CONSTRUCTION PROCEDURE FOR WIDENING OF SH-8

After drawing the typical cross section of SH-8 the highway has been constructed on actual site in following steps:

- Site Clearance
- Initial Survey Work
- Utilities
- Traffic Arrangements and Control
- Access
- Identification of Sources of Material & Approval
- Roadway Excavation (Box Cutting)
- Construction of Embankment
- Construction of Subgrade
- Construction of Granular Sub Base
- Wet Mix Macadam
- Prime Coat
- Tack Coat
- Dense Bituminous Macadam
- Bituminous Concrete
- Construction of Drains
- Construction of Culverts

7. CONCLUSION

The three-lane SH-8 Bagodara-Vasad route is currently overflowing with traffic. According to MOSRTH specifications for three-lane roads, the traffic volume count at the Vataman toll plaza on SH-8 is 24630 PCU/day, which is more than 20,000 PCU/day. Thus, it has been suggested to enlarge and improve SH-8 to create a six-lane highway. According to MOSRTH specifications, a six-lane road has a capacity of 60,000 PCU per day; therefore, it can comfortably handle traffic for the next ten years or more. According to IS: 2720 Part-16, 1987 testing conducted in an on-site laboratory, the CBR of subgrade is 8%. After three days and twenty-four hours of traffic volume count surveying at Vataman Toll Plaza, the total traffic was 50.42 million metric tonnes. Pavement thickness and composition are calculated as follows in accordance with IRC 37:2001, based on a value of CBR 8% and cumulative traffic of 50.42 msa: Binding course - **40mm** Dense Bituminous Macadam - **120mm** Granular Base Course - **250mm** Sub-Base Course - **200mm** Compacted Subgrade - **500mm** Binding course (40 mm) and dense bituminous macadam (50 mm) are the thicknesses of the flexible overlay that are applied over the current flexible pavement to reinforce it. Without implementation of the project, it takes two hours to travel at 54 km/h during peak hour on SH-8 from Bagodara to Vasad. However, once the project is completed, the vehicle can travel at 74 km/h, saving 30 minutes and increasing its speed by 20 km/h. It is economically feasible to implement this project idea as it is based on BOT in a public-private partnership. The field laboratory has conducted quality control tests in compliance with MORTH specifications. Numerous benefits in terms of social, economic, and environmental situations will arise from the implementation of this project.

CONFLICT OF INTERESTS

None.

ACKNOWLEDGMENTS

None.

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