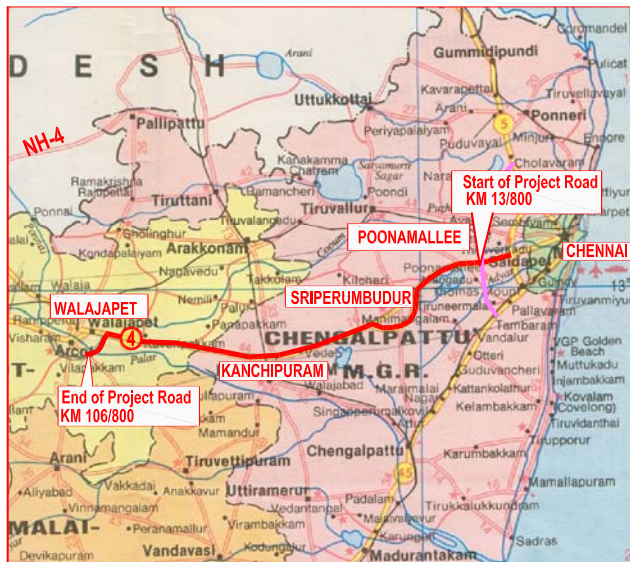


NATIONAL HIGHWAYS AUTHORITY OF INDIA

(Ministry of Shipping, Road Transport & Highways)

Consultancy Services for Preparation of Feasibility
Report for 6-Laning of Walajapet-Poonamallee Section
of NH-4 in the State of Tamil Nadu

Revised Final Feasibility Study Report

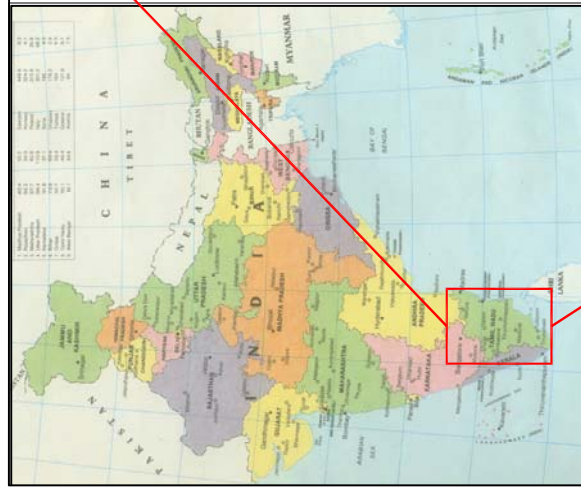
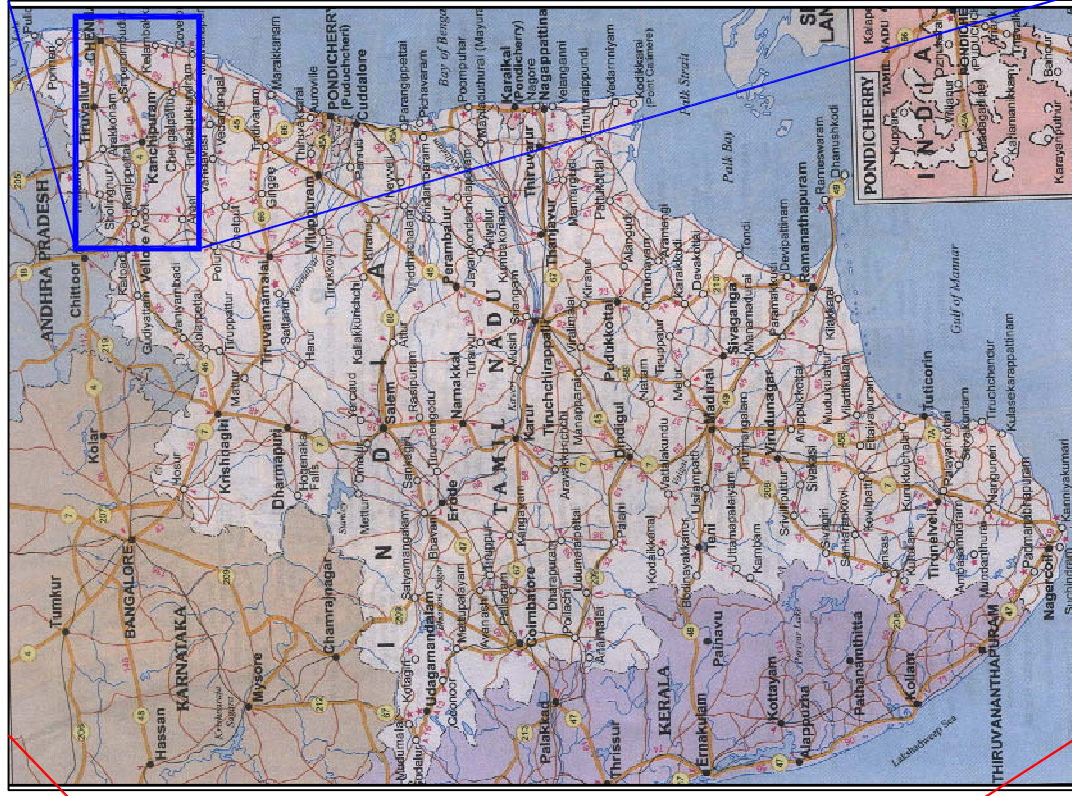


Volume-I: Main Report

February - 2011



rites BHAWAN
PLOT NO. 1, SECTOR - 29,
Gurgaon - 122001, Haryana, INDIA.



Legend:

Project Road (NH-4)



**NATIONAL HIGHWAYS
AUTHORITY OF INDIA**

Consultancy Services for Preparation of Feasibility Report for
6-Laning of Poonamallee-Walajpet Section of NH-4 in the state of
Tamil Nadu

Drq. No. RITES/HW/NHA/6682-30/NH-4/FSR/KP/01

Not to Scale

SCALE

Key Plan

Date: February 2011



**Consultancy Service for Preparation of Feasibility Report for 6/8
Laning of Walajapet to Poonamallee Section of NH-4 in the State of
Tamil Nadu.**

FINAL FEASIBILITY STUDY REPORT

Volume-I : Main Report

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Executive Summary

Executive Summary

0.1 General

The project road is starting from Poonamallee i.e. intersection with Chennai Bypass and ends at Walajapet Bypass i.e. intersection with NH-46 and main corridor from Bangalore to Chennai. The project road passes through the districts of Vellore and Kanchipuram. The project road is dual 2-lane highway throughout.

The Ministry of Road Transport and Highways (MoRT&H), Government of India, has decided to take up the development of 4-lane divided Carriageway of this National Highway in order to have safe and efficient movement of traffic under DBFO contract. The consultancy Contract has been awarded to RITES LTD, Gurgaon to carry out the Feasibility Study for retrofitting the 6-lane over existing 4-lane of the NH-4.

0.2 Objectives

The main objectives of the Consultancy services are:

- ✚ Enhance safety of the traffic, the road users and the people living close to the highway;*
- ✚ Enhance operational efficiency of the highway;*
- ✚ Fulfilment of the access requirement of the local population;*
- ✚ Minimal adverse impact on the road users and the local population due to construction; and*
- ✚ Feasible and Constructible options for the project with least cost options.*

0.3 Scope of Services

The scope of consultancy services includes:

- ✚ Maximum utilization of existing facilities*
- ✚ Study of Constraints*
- ✚ Economic, constructible and manageable solutions*
- ✚ Proposals with minimum land acquisition and high safety for road users*
- ✚ Retrofitting a 6-lane cross section over existing 4-lane*
- ✚ Validation of as built drawings*

0.4 Design Standard

The formulation of the design standards is required in order to avoid any inconsistency in design from one section to the other and provide desired level of service and safety. For this project, it is proposed to follow Design Standards given in Manual of Specifications and Standards for Six Laning of National Highways through Public Private Partnership and shall be used as main guidelines along with other relevant IRC codes, guidelines and special publications, and MORTH circulars as applicable to National Highways. Wherever the said standards are silent, the following standards shall be referenced and the one considered the best and most relevant adopted are:

- ✚ American Association of State Highway and Transport Officials (AASHTO) standards,*
- ✚ British Standards,*
- ✚ Any other National or International Standard as considered suitable.*

0.5 Engineering Survey and Investigations

The basic source of data is as built drawings. Consultants had collected the hard copies of the drawings of the project road as well as soft copy and material report during their reconnaissance survey. Detailed project reports of the entire project are found from the client's site offices. Further, a detailed topography survey was carried out for the entire project road and accordingly the plan and profiles have been prepared. The plan and profile prepared have been validated with the as-built drawings.

Following engineering surveys and investigations other than traffic surveys have been carried out to analyse the viability of the project and prepare a comprehensive report.

- ✚ Inventory and Condition Survey of Road and Pavement;
- ✚ Topographic Survey;
- ✚ Pavement Investigations;
- ✚ Soil and Materials Investigations;
- ✚ Inventory, Condition Survey of road, and structures
- ✚ Geotechnical investigations

The project Road starts from km 13.80 at Poonamallee, and end at km 106.80 at Walajapet.

The condition survey shows the project road generally falls under fair to good condition. The average width of the road is found to be 2x8.75m. The alignment traverses through plain terrain and average embankment height in the order of 1.0 to 2m. At some locations, the embankment height is observed as 6m only at approaches to bridge and structures.

The soil for construction of embankment and sub-grade is available from road side borrows areas. The soil is categorised as Silty-sand-gravel (as per AASHTO class A2) with little or no plasticity after carrying out the required tests.

0.6 Traffic Surveys

The project road from Poonamallee to Walajapet of NH-4 has been divided into traffic homogeneous links presented in **Table 0.1**:

Table 0.1: Homogenous Links

Link No.	Homogeneous Link	Chainage (km)		Length (km)
		From	To	
L41	Poonamallee – Sunguvachatram	13.80	48.40	34.60
L42	Sunguvachatram – Kanchipuram	48.40	74.80	26.40
L43	Kanchipuram – Walajapet	74.80	106.80	32.00

Required traffic surveys have been carried out on the project corridor in order to identify present and likely future scenarios and to device suitable remedial measures and to evolve appropriate design method.

The traffic surveys conducted for this project include:

- ✚ 7 day 24 hours classified traffic volume count at 3 locations.
- ✚ Turning Movement Surveys for 12 hours at 10 intersections.
- ✚ Axle Load Survey for 24 hours at one location.
- ✚ Origin and Destination Survey for 24 hours at one location.
- ✚ Speed-Delay Surveys for the entire project road.

✚ Pedestrian/ animal crossing count.

✚ Truck terminal surveys.

Traffic Volume and Composition

The Annual Average Daily Traffic (AADT) after making suitable adjustment for the seasonal variation factor at different survey locations and is presented in **Table 0.2**:

Table 0.2: Annual Average Daily Traffic

Link	Car	Mini Bus	Full Bus	LCV	2A Truck	3A Truck	Arti-culated	Car+Bus+Truck	All Vehicles
L41	8200	1576	3719	2667	3591	2058	852	22662	29414
L42	9624	1135	3947	2877	4139	2587	802	25110	31231
L43	7501	791	1955	1212	3754	2190	651	18055	24579

Origin – Destination Analysis

Origin and Destination analysis brings out that Zones 1, 2, 3 and 4 viz. Chennai, Kanchipuram and Vellore District serve as major Origin/Destination for traffic (more than 60 %) on the project road. The through traffic from/to outside of PIA is very negligible. The movements of the vehicles in the Project Influence Area (PIA) are summarized in **Table 0.3**:

Table 0.3: Movement of Vehicles in PIA

Zones	% Traffic			
	Car	Bus	LCV	Truck
Traffic with in PIA (with in Zones 1, 2, 3 & 4)	83.6%	90.9%	79.7%	66.0%
Traffic from Outside to PIA (from Zones 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 & 15 to Zones 1, 2, 3 & 4)	10.9%	4.3%	6.8%	21.0%
Traffic from PIA to Outside (from Zones 1, 2, 3 & 4 to Zones 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 & 15)	5.5%	4.7%	13.5%	12.9%
Through Traffic (Outside PIA)	0.0%	0.0%	0.0%	0.1%

Axle Load Survey

Analysis of Axle Load data reveals highly skewed VDF pattern against direction. A weighted analysis against type of vehicles on the road brings out an overall VDF of 3.76 against IRC: 37 recommended value of 3.5 for National Highways for plain terrain. Summary of Axle load frequency analysis has been presented in **Table 0.4**:

Table 0.4: Summary of Axle Load Frequency

S. No.	Vehicle	Towards Chennai		Towards Walajapet		Bothways Average	
		Sample Size (%)	VDF	Sample Size (%)	VDF	Sample Size (%)	VDF
1	LCV	7.93%	0.08	8.80%	0.19	8.43%	0.14
2	2A Truck	8.32%	4.99	5.15%	1.64	6.63%	3.21
3	3A Truck	12.40%	13.60	6.70%	4.28	8.95%	7.94
4	Articulated	7.40%	9.76	4.70%	6.77	6.35%	8.40
Freight traffic Composition		LCV@ 19%, Truck 2A @ 58%, Truck 3A@ 17% & Articulated 6%		LCV@ 21%, Truck 2A @ 54%, Truck 3A@ 22% & Articulated 3%		LCV@ 20%, Truck 2A @ 46%, Truck 3A@ 20% & Articulated 4%	
All Vehicles			5.94		2.10		3.76

Traffic Assignment

The project envisages the improvement and widening of existing 4-lane road to 6-lane carriageway facility. Therefore, apart from normal traffic, other forms of traffic like generated traffic are expected to contribute towards the increase in traffic volume.

Generated traffic @ 10% of normal traffic is assigned on the first year of operation and growing at normal traffic growth rate.

Growth Rates

Traffic projection for the project road is based on combined performance of both the states. Accordingly, traffic growth rates are estimated and compared with other National Highway projects in the region and presented in **Table 0.5**.

Table 0.5: Adopted Growth Rate for Traffic forecast

S. N.	Period	Growth Rate (%)			
		2 W	Car	Bus	Truck
1	2009 – 13	14.00	12.60	9.10	9.80
2	2014 – 18	12.00	10.60	7.10	7.80
3	2019 - 23	10.00	8.60	5.10	5.80
4	2024 - 28	8.00	6.60	5.00	5.00
5	2029 - 33	6.00	5.00	5.00	5.00
4	Beyond 2033	5.00	5.00	5.00	5.00

Traffic Projection

The summary of traffic in year of opening, at every 5 Years up to 2038 and at the end of design life of 20 years (2031) for all three links is presented in **Table 0.6**.

Table 0.6: Traffic Projection

Year	2W	3W	Car	Bus		LCV	Truck			Total	
				Mini	Full		Medium	Heavy	Artic	nos.	pcu
Link 1 (L41): Poonamale - Sunguvachatram (34.60 Km)											
2008	5480	1055	8200	1576	3719	2667	3591	2058	852	29198	53385
Composition	18.77 %	3.61 %	28.08 %	5.40 %	12.74 %	9.13 %	12.30 %	7.05 %	2.92 %	100 %	
2012	9256	1495	13182	2233	5269	3876	5219	2991	1238	44759	78966
2013	10551	1631	14842	2436	5748	4256	5731	3284	1360	49840	87124
2018	20454	2590	27019	3776	8910	6816	9177	5259	2177	86118	143390
2021	27225	2934	34607	4384	10344	8072	10869	6229	2579	107242	173109
2028	48403	4137	56184	6180	14583	11532	15527	8899	3684	169127	258041
2031	57648	4789	65039	7154	16882	13349	17974	10301	4265	197402	299523
2033	64774	5280	71706	7887	18612	14718	19817	11357	4702	218853	330832
2038	82670	6739	91517	10066	23754	18784	25292	14495	6001	279317	422235
Link 2 (L42): Sunguvachatram - Kanchipuram (26.40 Km)											
2008	4650	1080	9624	1135	3947	2877	4139	2587	802	30841	58556
Composition	22.16 %	2.47 %	37.28 %	2.60 %	9.03 %	7.32 %	10.53 %	6.58 %	2.04 %	100 %	
2012	7854	1530	15471	1608	5592	4182	6016	3760	1166	47178	86602
2013	8953	1669	17420	1754	6101	4591	6606	4129	1280	52503	95542
2018	17356	2588	31711	2719	9457	7353	10578	6611	2050	90423	157162
2021	23101	3004	40617	3157	10978	8708	12527	7830	2427	112349	189642
2023	27953	3318	47903	3487	12127	9747	14022	8764	2717	130039	215613
2028	41072	4235	65940	4451	15477	12440	17897	11186	3468	176165	282109
2031	48917	4902	76334	5152	17917	14401	20717	12949	4014	205304	32762
2033	54963	5405	84158	5680	19753	15877	22841	14276	4426	227380	361322
2038	70148	6898	107410	7250	25211	20263	29152	18221	5649	290201	461149

Table 0.6: Traffic Projection

Year	2W	3W	Car	Bus		LCV	Truck			Total	
				Mini	Full		Medium	Heavy	Artic	nos.	pcu
Link 3 (L43): Kanchipuram - Walajapet (32.00 Km)											
2008	4978	999	7501	791	1955	1212	3754	2190	651	24031	43905
Composition	20.71 %	4.16 %	31.21 %	3.29 %	8.14 %	5.04 %	15.62 %	9.11 %	2.71 %	100 %	
2012	8408	1415	12058	1121	2770	1762	5456	3183	946	37119	65261
2013	9585	1544	13577	1223	3022	1934	5991	3495	1039	41410	72091
2018	18581	2393	24716	1895	4684	3097	9594	5597	1664	72221	119395
2021	24731	2779	31657	2200	5438	3668	11362	6628	1970	90433	144696
2023	29924	3069	37336	2430	6007	4106	12718	7419	2206	105216	164658
2028	43969	3917	51394	3102	7666	5241	16232	9469	2815	143805	216781
2031	52367	4535	59495	3591	8874	6067	18790	10962	3259	167940	251686
2033	58840	5000	65594	3959	9784	6688	20716	12085	3593	186259	278036
2038	75097	6381	83716	5052	12487	8536	26440	15424	4585	237719	354852

0.7 Bridges/Structures

All existing bridges and structures are in fair to good. At proposed bridge locations geotechnical investigations has been carried out and using the test result of investigations the validation of the existing design has been completed. 6 minor bridges (1 bridge on one side and 5 bridges on both sides) out of total 13 are proposed on service roads at existing locations.

0.8 Horizontal Alignment

As mentioned in the TOR the horizontal geometry has not been proposed for modification and as such the existing geometry has been followed with minor adjustment of centreline in the stretch between km 93.00 and km 93.300, where ROW is asymmetry.

0.9 Vertical Alignment / Gradient

The vertical alignment is mostly flat with the gradients in the range of 0.5 percent to 1.5 percent except at the bridge approaches where the gradients are in excess of 3.0 percent. Vertical geometrics have been proposed at the locations of proposed underpasses and flyovers.

0.10 Elevated Structures / Flyovers / Underpasses

The project road traverses through heavily built up section in Sriperumbudur between (km 41 and km 43), where the consultant proposed a 3 km long elevated structures in Draft Feasibility Report to avoid the acquisition of additional land and demolition of a number of structures such as Rajiv Gandhi Memorial, Ayurvedic Medical College, Hotel owned by Tamil Nadu Tourism Development Corporation, Graveyard etc.. However, on restructuring, the proposed elevated structure has been replaced by flyover at Sriperumbudur Junction (km 41.350) and two vehicular underpasses (42.150 & 42.250).

9 numbers (including Sriperumbudur junction at km 41.350) of flyovers of (both sides) 100m / 75m length proposed at major junctions and 1 flyover for right carriageway parallel to the existing flyover at km 18.070 proposed. 15 numbers of Vehicular underpasses with vertical clearance of 5.0m are proposed with 10.5m span.

0.11 Cattle crossing and pedestrian crossing

22 numbers of Pedestrian underpasses/ Cattle crossings with vertical clearance of 3.0m with 4.0m span are proposed at the locations where pedestrians tend to cross the road and on rural areas where Cattle are found to be grazing.

0.12 RoBs

The broad gauge line, Arakkonam – Kanchipuram crosses the project road at km 72.150, where already ROBs have been constructed for 2x3-lane. Though they are not to the standard (as per manual) as far as their cross sections are concerned, yet the consultant is not proposing widening because of complicity in design and construction methodology as discussed with the client.

0.13 Slip/ Service Road

On restructuring the project, Service road proposed have been deleted and only slip roads at flyovers/ VUP locations have been retained for smooth entry and exit from Main carriageway to the cross roads. Total length of Slip/ service road is 30.305x2 km.

0.14 Validation of As-Built Drawings

As a part of the validation of the as built drawings, consultants have visited the site and the drawings were validated as per the existing scenario of the project corridor. The additional road utilities such as metal beam crash barrier, side drain/Toe drain/median drain, oil outlets, shops, buildings under construction, religious structures, cross roads and other development in land use pattern were found out and it has been incorporated in the validated set of drawings. The consultants observed at few locations Pick up bus stops were under construction during their site investigation. The consultant team member recorded the same which were already constructed. But the construction of pickup stops were in progress, therefore one may find more number of pick up bus stops after our report is submitted.

The radii of few substandard horizontal curves were verified at site using arch-chord method. At site length of chord was measured using 30 m tape and at the same time offset at centre was measured using 3 m steel tape. Using geometric properties of circle, radius of the curve has been derived. The consultant carried out the detailed topographic survey for the entire length of the project road. Using the topographic survey maps the consultant validated as built drawings in terms of the bearing of the alignment and levels. It is found that they are in order.

0.15 Preliminary Design

The preliminary design of project road alignment and geometry are presented in chapter 10. The assignment involves retrofitting of 6-lane over existing 4-lane. The existing alignment and geometry has been kept unchanged unless they are absolutely warranted. Change in Vertical Geometry been made at the locations, where underpasses and elevated corridor are proposed.

Broadly two major types (Rural and Urban) of cross section have been proposed to retrofit the 6-lane over existing 4-lane arrangements. However, as per the existing scenario proposed cross section has been modified to suit the requirement.

Critical locations: *Along the project road corridor the consultant has identified some critical locations. They are approximately at km 41-42 (Rajiv Gandhi Memorial, Sriperumbudur) and km 93.0-93.30 (Ocheri). At these locations after through study, the consultant proposed elevated highway as an alternative proposals to enhance the safety. But, due to restructuring of the project, the proposed elevated highways have been replaced with flyovers at these two locations.*

Pavement Design

The design of overlays for the existing carriageway pavement has been done taking into account the strength of the existing pavement based on detailed pavement investigation including BBD Testing. The strengthening (overlay) requirements for the existing road pavement have been worked out based on IRC Guidelines considering average deflection values for design homogeneous sections.

Construction of new pavement will be applied for Widening on existing formation and additional new formation as per site condition for accommodating additional lane, paved shoulders and width for kerb shyness. For this case, the existing sub grade shall be prepared to required compaction, and the CBR of existing sub grade at 97% of MDD shall apply.

CBR of borrow materials are found more than 9 except one sample. CBR value of 9 is adopted for pavement design.

New pavement has been designed based on 20 years design traffic.

The composition of initial pavement has been worked out on the basis of IRC: 37-2001 recommendations while satisfying the requirements of AASHTO method of design. Thus, proposed composition initial pavement for various links is given as in **Table 0.7 and 0.8**.

Table 0.7: Adopted Pavement Composition: 6-Lane Divided Carriageway

Component Layer	Material Type	Strength coefficient	Thickness of Pavement Layer, mm		Remarks
			L42	L41 & L43	
Surfacing Course	BC	0.425	50	50	For 10 years design life
	DBM	0.380	145	135	
Base Course	WMM	0.140	250	250	For 20 years design life
Sub base	GSB	0.120	200	200	
SN Provided			5.33	5.18	
Sub grade (500mm) CBR			> 9% soaked		

Note: BC= Bituminous Concrete, DBM= Dense Bituminous Macadam, WMM= Wet Mix Macadam, GSB= Granular Sub- base course

The proposed overlay composition of initial requirement is given in **Table 0.9..**

Table 0.8: Proposed Overlay Thickness and Composition

Component Layer	Material Type	Structural co-efficient	Thickness of Pavement Layers, mm		Remarks
			L41&L43	L42	
Surfacing Course	AC	0.425	50	50	For 10 years deign life
	DBM	0.38	-	50	
SN Provided			0.84	1.58	

Service Road Pavement Composition

It is proposed to provide service road along the proposed partially access controlled project road on both sides to accommodate the movement of the local traffic at selected road sections. The pavement composition adopted for the construction of service road is presented in **Table 0.09**.

Table 0.09: Adopted Pavement Composition - Service Road

Type of Construction	Pavement Composition	
	Material Type	Thickness (mm)
New Construction	BC	50
	DBM	65
	WMM	250
	GSB	200
	Sub grade (500mm) CBR	9% soaked

However, the bituminous courses of BC and DBM have been reduced to 25mm and 50mm respectively as insisted.

0.16 Safety Appurtenances

Crash barrier, Road Studs, Road sign and markings have been provided at required locations and Truck parking areas/Rest Areas have been proposed at desired locations as safety measures.

0.17 Integrated Proposed Scheme

As per TOR the consultant is required to prepare the layout of the 6-lane facility clearly spelling out the feasible engineering, technological and management solutions (without detailed design). While evolving these solutions, the consultant always kept in mind that main focus of the assignment is to retrofitting a 6-lane cross-section over the existing 4-lane cross-section and to provide a safe, efficient and improved highway.

The proposed scheme is formulated keeping in view the following objectives

-  *To augment the capacity of existing road and attain the desirable level of service (B) and to enhance the operational efficiency.*
-  *To enhance the safety of the traffic, the road users and the people living close to the highway*
-  *To provide uninterrupted flow of through traffic in the project corridor*
-  *To segregate the through traffic completely from local traffic movement.*
-  *To provide the feasible and constructible options for the project without being prohibitively expensive.*
-  *In view of above the consultant proposed the following major safety features:*
-  *Service road along the project road corridor in the urban/ built-up stretches except at location of major bridges and ROBs.*
-  *Vehicular/Pedestrian Underpasses*
-  *Flyovers*
-  *Entry/Exit Ramps*

0.18 Environmental Impact Assessment

Public consultations were held with Project Affected Persons (PAPs), stakeholders and the general public to determine their view about the proposed road and incorporate their suggestions while finalizing the alignment. A local level consultation was held at Ocheri, Senneerkuppam, Senthamangalam, Sriperumbudur, Irrungattukottai, Poonamallee, Vanagram, Santhavellore, Chettiarpettai and Kaveripakkam along the project road. The people were generally in favour of construction of road, as it would reduce traffic congestion and improves socio-economic status of the area. In stead of widening of existing 4-lane road, elevated roads have been suggested in congested area.

Environmental Monitoring Plan

To ensure the effective implementation of the EMP during construction and operation stage, the monitoring plan have been framed which provides basis for evaluating the efficiency of mitigation and enhancement measures and suggest further actions that need to be taken to achieve the desired effect. The objectives of environmental monitoring programme are:

-  *Evaluation of the efficiency of mitigation and enhancement measures;*
-  *Updating of the actions and impacts of baseline data;*

- ✚ Adoption of additional mitigation measures if the present measures are insufficient;
- ✚ Generating the data, which may be incorporated in environmental management plan in future projects.

For this project, NHA will be responsible for obtaining required clearances and for securing a tree removal and replanting permit from Forest Department. It will also need to confirm that contractors have appropriate and valid permits to use local water supplies as well as to construct and operate plants such as Hot Mix Plant, batch and rock crushing etc. In addition, NHA will be responsible for implementing all the mitigative measures during the design, construction and operational stage of the project as defined in the EMP.

Environmental Budget

Tentative environmental budget for the various environmental management measures proposed in the EMP is approximately Rs. 4,81,75,000 (Rupees Four Crore Eighty One Lakh Seventy Five Thousand only).

0.19 Social Impact Assessment

The social impact assessment and resettlement planning has following aspects:

- ✚ Census and base line Socio-economic survey of the potentially affected structures/households
- ✚ Public consultation at various places, particularly market places, temples, churches and other C. P. Rs
- ✚ Minimize accidents, access to better connectivity and smooth vehicular movement.

The survey as well as public consultations were organized with a view to finding out:

- ✚ The negative impacts on the persons affected by the project would be avoided or minimized.
- ✚ Affected persons and the beneficiary population/ communities will be informed and consulted about the project and its design where the negative impacts are unavoidable.
- ✚ People's participation will be undertaken in planning and implementation of the project.
- ✚ All information related to resettlement plan and implementation will be disclosed to the project affected persons/ communities. Base line data was collected within a strip of 30 m to either sides in rural areas and 30 m to either side in urban areas to get information about the proposed corridor of impact.

0.20 Cost Estimate

Cost estimate is an important component of the feasibility study as it provides vital input to economic and financial evaluation of the project. The cost estimation have been prepared for the project road taking into account of retrofitting the 6-lane/8-lane over existing 4-lane section including strengthening of the existing pavement, reconstruction/ widening of cross drainage structures, longitudinal lined drains, road furniture, bus bays etc. as per the guidelines in the manual. Over and above these construction costs, provision has been made for social and environmental costs and land acquisition costs for widening, truck lay-byes/ rest areas and bus-bays and toll plazas.

The cost of various components of proposed road widening between km 13.80 and km 106.80 are calculated separately and are shown in the **Table 0.10**.

Table 0.10: Project Cost

<i>Bill No.</i>	<i>Item of Works</i>	<i>Cost in Rupees</i>
A	Civil Works	
1	Site Clearance and Dismantling	28,424,937
2	Earthwork	563,049,986
3	Sub-base and Base Courses	441,891,340
4	Bituminous Courses	1,714,106,568
5	Bridges and Structures	2,899,652,479
6	Cross Drainage Structures	223,905,500
7	Service Roads	535,305,029
8	Drainage and Protective Works	616,315,620
9	Improvement of Junctions	236,996,341
10	Road Appurtenances	190,822,964
11	Road Side Amenities	83,500,000
12	Toll Plaza	80,000,000
13	Lighting for urban area and intersections etc.	59,946,900
	Sub-total for Civil Works (A)	7,673,917,664
	Cost per km for Civil Works	82,515,244
B	Non-civil Works	
14	Land Acquisition	894,529,071
15	Relocation of Utilities	118,800,000
16	Environmental Improvement	49,223,750
17	Rehabilitation and Social	57,610,000
	Sub-total for Non-civil Works (B)	1,120,162,821
	Cost per km for Non-civil Works	12,044,762
	Total Cost (A+B)	8,794,080,485
	Cost per km	94,560,005
C	Independent Consultant's Fee @0.5 % on Total Cost (A+B)	43,970,402
	Grand Total (A+B+C)	8,838,050,887
	Cost per km	95,032,805

Cost of Road and Bridge works (including Underpasses) i.e. cost of main carriageway, service road, road side drainage, traffic signs and marking, earth retaining structures, road safety works, toll plaza etc. including costs of construction of service road bridges, overpass, underpasses and culverts worked out to be Rs. **767.392 Crores** after restructuring.

The total project cost (Civil Works and Non-civil Works) including Land acquisition, Environment improvement and Rehabilitation works out to be Rs. **883.805 Crores**.

Chapter -1

Introduction

CHAPTER – 1

Introduction

1.1 General

The State of Tamil Nadu is situated in the southern part of India. The state has many distinctions by way of high literacy, promotion of family planning, industrialization and agricultural development. The state has a transportation network consisting of railways, roads and airways, which form the lifeline for the economic and social activities of the state. Road transport is a dominant mode in the state for goods and passengers.

The state of Tamil Nadu is the land of Temples and Temples is the eleventh largest state in India. It is situated on the southern tip of the Indian Peninsula, bounded on the east by the Bay of Bengal, on the South by the Indian Ocean, on the West by Kerala and Karnataka and on the north by Andhra Pradesh. The State of Tamil Nadu is also the gateway to the south. The average temperature in the state varies between 18°C to 30°C and the best season for tourists is from November to February.

Tamil Nadu has about 1000 km long coastline abounds in magnificent beaches and beach resorts. Tamil Nadu has 28 districts and the project road passes through the districts of Kanchipuram and Vellore. Four National Highways i.e. NH-4, NH-5, NH-45 & NH-205 originates/terminates at the state capital Chennai. Other National Highways i.e. NH7, NH-7A, NH-45A, NH-45B, NH-46, NH-47, NH-49, NH-66, NH-67, NH-68, NH-208, NH-209, NH-210 also passes through the state of Tamil Nadu.

Recognising the need for improvement of arterial routes, the Ministry of Shipping, Road Transport & Highways (MoSRT&H)) acting through the National Highways Authority of India (NHAI) has decided to convert existing 2x2 lane of Walajapet to Poonamallee Section of NH-4 into 2x3 lane to be executed as BOT (Toll) Project on DBFO Pattern under NHDP Phase V (LOT 2) which connects two metropolitan cities of Chennai & Bangalore. The objective is to upgrade the road section between Walajapet and Poonamallee Road section of NH-4 from km 106.800 at Walajapet i.e. the junction of NH4 with NH-46 to km 13.800 at Poonamallee i.e. the junction of NH-4 with Chennai Bypass 6-lane divided carriageway.

RITES have been entrusted with Consultancy services for preparation of Feasibility Study Report for 6-Lanning of Walajapet to Poonamallee Section of NH-4 in the State of Tamil Nadu to be executed as BOT (TOLL) on DBFO under NHDP Phase-V (LOT-2) by National Highways Authority of India vide letter No. NHAI/NHDP-V/MC-II/BOT/DPR/17/82 dated 18th February 2008.

The Contract Agreement between NHAI & RITES Ltd., was signed on 13th March 2008 and the consultancy services have commenced w.e.f. 27th March 2008.

The State's climate is extremely hot. On the whole, it is moist in the districts along the coastline and dry in other districts. The intensity of the climate has been reduced by the Indian Ocean and the Bay of Bengal. At its peak, the temperature touches 45°Celsius or even sometimes more. The south-west monsoon lashes the State from mid June and continues till September end.

1.2 Need for Augmenting Transport Facility

The growths of goods movement and passenger mobility in India have led to a considerable rise in vehicle population. The industrial and agricultural developments have led to higher transport demand. With the land space becoming more scarce and expensive, provision of new transport corridors becomes difficult. The growing mismatch between the vehicle population and availability of road infrastructure has resulted in traffic congestions, reduced level of service and accidents. The deficiencies in the existing road network need to be removed since they caused enormous loss to the Nation by way of high vehicle operating costs, delay in passenger and freight movements and accidents. Recognising the need for improvement of arterial routes, the Ministry of Road Transport and Highways (MoSRT&H) acting through the National Highways Authority of India (NHAI) has embarked on the National Highway Development Project (NHDP) which comprises Golden Quadrilateral connecting four Metros of Delhi, Mumbai, Chennai and Kolkata and North South Corridor from Srinagar to Kanyakumari and East West Corridor from Silchar to Porbandar. Also, NHAI has decided to take up development of various National Highways Corridors under 10,000 km (NHDP-Phase III) programme, in the country, where there is need for augmentation of road capacity due to significant increase of traffic and importance of place. The proposed road section is part of NHDP – Phase V corridor as “partially access controlled highway” facility.

1.3 Objective and Scope of Assignment

The main objective of the consultancy services is to establish the technical, economical, and financial viability of the project and prepare Feasibility Report for rehabilitation and upgrading of the existing 2x2-lane National Highway NH-4 from Walajapet to Poonamallee section to 2x3-lane carriageway configuration.

The viability of the project shall be established taking into consideration the requirements with regard to rehabilitation, upgrading and improvement based on highway design, pavement design, provision of service roads wherever necessary, type of intersections, rehabilitation and widening of existing and construction of new bridges and structures, quantities of various items of works and cost estimates and technical schedules for BOT Bid Documents.

The Feasibility Report would inter-alia include preliminary highway design, design of flexible pavement and overlay for pavement, preliminary design of bridges, grade separated structures, underpasses, ROB's (GADs only), preliminary design of service roads, quantities of various items, preliminary working drawings, preliminary cost estimates, economic and financial viability analyses, environmental and social feasibility and their respective action plans and documents required for tendering the project on commercial basis for international/local competitive bidding. The project road is shown in **Fig 1.1: Key Plan**.

The NHAI has appointed M/s RITES Ltd., as Consultant for the preparation of Feasibility Report of the NH-4 road section from Walajapet and Poonamallee Road section of NH-4 from km 106.800 at Walajapet i.e. the junction of NH4 with NH-46 to km 13.800 at Poonamallee i.e. the junction of NH-4 with Chennai Bypass in the state of Tamil Nadu. The section comprised of widening and strengthening to 6-lanes of Walajapet and Poonamallee road section of NH-4 in the state of Tamil Nadu.

The scope of services shall cover the following major tasks:

- The project road shall be designed with the facility of partially access-controlled road;
- Carrying out detailed topographic survey and fixing control stations;
- Carrying out geo-technical investigations and exploration of subsoil investigations for structures;
- Identification of borrow areas and quarries; Exploration of potential source for construction materials;
- Carrying out Volume Count Survey and O-D surveys, Axle Load, intersection volume count, speed-delay study, roughness survey etc.;
- Design of bypasses/realignments; improvement proposals to substandard geometric; new service roads;
- Preliminary design of new flexible and overlay of flexible pavements;
- Preliminary design of bridges, scheme of grade separated structures (Flyover/Viaducts/Underpass/ROB), culverts and cross drainages (GADs only);
- Rehabilitation measures for the improvement of existing cross drainages and bridges;
- Preparation of preliminary drawings;
- Preparation of strip plans;
- Preparation of land acquisition plan and report;
- Preparation of utility relocation plan;
- Preliminary design and proposals for road and traffic safety features; road furniture and arboriculture and landscaping;
- Proposals and design of wayside amenities; toll plaza; weighing stations;
- Preparation of rate analysis; preliminary quantity estimation and preliminary cost estimates and Feasibility Report;
- Preparation of technical schedules;
- Completion of bidding activities of the BOT bid;
- Evaluation of BOT bids;
- Post award queries upto financial close.

1.4 Status of the Study

1.4.1 Mobilisation of Key Professionals

The contract Agreement between NHAI and RITES was signed on 13th March 2008. The letter to commence the work was given by NHAI on 17th March 2008. Immediately the Consultants mobilized the teams for conducting different aspects of the study. The team for the present study comprising of the Senior Highway Engineer/Team Leader, Highway-cum-Materials Engineer, Bridge Engineer, Traffic-cum-Safety Expert, Geo-technical Engineer, Senior Survey Engineer, Environmental Specialist and Social Expert. These personnel were assembled in Gurgaon, head quarters of RITES to formulate an effective work programme for the successful completion of the project to the entire satisfaction of the client.

Several Meetings were also held with Project Directors, NHAI, PIU, Chennai/Vellore and also at Delhi office from time to time to streamline the work programme and effective completion of the work.

1.4.2 Mobilisation of Other Professionals

The team identified for the project were mobilised to site to carryout the various engineering field studies i.e. road inventory, pavement condition, inventory and condition survey for bridges and culverts, classified traffic volume count surveys, origin and destination surveys, speed-delay studies, roughness survey, Benkelman beam deflection test, material investigation etc. A list of professional mobilised at Head Quarter is enclosed as Statement 1.1.

1.4.3 Site Office

RITES had established the site office in Chennai for the entire field activities operation and the team availability during the period at the said office. With the completion of all field activities, the site office has been closed.

1.5 Inception Report (IR) and Strip Plans with Alternatives

Inception Report and Strip Plans was submitted vide our letters no. RITES/HW/NHA1/Walajapet-Poonamallee_NH-4/6682-30/2008 dated 30.04.08 and 30.08.08 respectively.

1.6 Draft Feasibility Report

This Draft Feasibility Report has been submitted vide our letter no. RITES/HW/6682-30/2008 dated 31.01.2009.

1.7 Final Feasibility Report

This Final Feasibility Report was submitted based on the detailed discussion with NHA1 officials on 05 March 2009 and subsequent confirmation to our letter no. RITES/HW/6682-30/2008 dated 12 March 2009 by telephone on 17 April 2009.

1.8 Revised Final Feasibility Report

This Revised Final Feasibility Report is being submitted after restructuring the project based on the detailed discussion with NHA1 officials on 10 January 2011 and subsequent confirmation by telephone on 24 February 2011.

1.9 Survey Equipment, Geo-tech facilities and other Essential Infrastructures

With mobilisation of expert team to the project site, sophisticated equipments were also mobilised at site for the smooth and effective field progress and the detail list of the equipment available and in use at site were:

S. No.	Field Survey Equipments	Quantity
A.	ROAD TESTING EQUIPMENT	
1.	Benkelman Beam and Accessories	4 no. (Pavement Deflection Test)
2.	Vehicle Mounted Bump Integrator	1no. (Road Roughness Test)
3.	Portable Axle Load Pads	2 no. (Axle Load Test)
4.	Field Density Apparatus - Rapid Moisture Meter - Weighing Balance - Sand Replacement apparatus - Core Cutter and accessories	(Field Density and Field Moisture Content Test)
5.	Digital camera	1 no.
6.	Lap top Computers	4 no.
7.	MX Road Software	2 no.
8.	Hand Held GPS	1 no.
B.	TOPOGRAPHIC SURVEY	
1.	DGPS R3	1 set
2.	Total Station (Sokkia: 5000 & 6000)	4 no.
3.	Auto Level / Digital levels	2 no.
4.	Hand Held GPS	1 no.
5.	Mobile Cell phone	4 no.
6.	Walkie – talkie wireless sets (KENWOOD)	3 sets (2 no. each)
7.	Lap top Computers	2 no.

Statement 1.1: Mobilisation of Key and Other Professionals

Following key personnel and other professionals were mobilized in the project:

1. Key Professionals:

S. No.	Name of Engineer	Designation
1.	Mr. V. Krishnamurthy	Sr. Highway Engineer-cum-Team Leader
2.	Mr. Manoj Kumar	Highway-cum-Materials Engineer
3.	Mr. Tapas Mukherjee	Bridge Engineer
4.	Mr. S. K. Popli	Traffic Engineer-cum-Safety Expert
5.	Mr. R. K. Sud	Geo-technical Engineer
6.	Mr. Raj Kumar	Sr. Survey Engineer
7.	Mr. M. P. Mondal	Environmental Specialist
8.	Mrs. Rita Dey	Social Expert

2. Additional Key professionals:

S. No.	Name of Engineer	Designation
1.	Mr. Manirul Islam	Sr. Highway Engineer
2.	Mr. Sagar Banerjee	Bridge Engineer
3.	Mr. Barnali Roy	Highway Engineer / Mx Expert
4.	Ms. Sharmistha Chatterjee	Bridge Engineer
5.	Mr. Md. Iklaq	Quantity Surveyor / Documentation Expert

3. Sub Key Professionals:

S. No.	Name of Engineer	Designation
1.	Mr. Kapoosh Gupta	Assistant Highway Engr/ Mx Expert
2.	Mr. R K Singh	Bridge Engineer
3.	Mr. Ran Vijay	Drainage Engineer
4.	Mr. Vijay Kumar	Materials Engineer
5.	Mr. Deepak Singh Rana	Survey Engineer

4. Other Professionals:

S. No.	Name of Engineer	Designation
1.	Mr. Manoj Kumar Singh	Quantity Surveyor
2.	Mr. Neeraj Kumar Singh	Bridge Engineer
3.	Ms. Sucheta Mondal	Geotechnical Engineer
4.	Mr. Naresh Kumar Sharma	Material Engineer
5.	Ms. Monika Tyagi	Highway Engineer
6.	Mr. Deepak Rawat	TA
7.	Mr. Vishal Barjo	Highway Engineer
8.	Mr. Pankaj Gupta	Highway Engineer
9.	Mr. Soumen Panja	TA

Chapter -2

Project Description

CHAPTER - 2

Project Description

2.1 General

The project road for conducting Feasibility Report for widening and upgrading of existing 2x2-lane carriageway of National Highway-4 (NH-4), from km 13.800 to km 106.800 (Poonamallee – Walajapet) road section in Tamil Nadu to 2x3-lane carriageway configuration. Existing 2x2-lane carriageway lies in the state of Tamil Nadu and starts from Poonamallee Junction with Chennai Bypass at (km 13.800) and terminates at Walajapet (km 106.800). Total length of the project road is 93 Km. Project road falls in flat/plain terrain.

The project road section of National Highway (NH-4) passes through districts of Vellore and Kanchipuram. Some important townships falling on the way are Walajapet, Kaveripakkam, Damal, Thripukuzhi, Vedal, Ocheri, Sriperumbudur and Poonamallee. The project road has got its importance due to the connection provided between two metropolitan cities of Chennai & Bangalore. The Project Road Sections on National Highway No. 4 provides connectivity between Poonamallee (Start of Project road at km 13.800) to Walajapet (km 106.800) in the state of Tamil Nadu. The project road is situated between latitude 12°55'60"(N), longitude 79°22'60"(E) at Walajapet and latitude 13°02'54"(N), longitude 80°6'27"(E) at Poonamallee, and located on the Eastern part of Tamil Nadu.

2.2 The Project Road

The project road is starting from Poonamallee i.e. intersection with Chennai Bypass and ends at Walajapet Bypass i.e. intersection with NH-46. The project road passes through the districts of Vellore and Kanchipuram. The length of the project road is about 93km. The road traverses through the flat/plain terrain. The project road section has 2x2-lane configuration with flexible pavement. This is one of the important routes connecting two metropolitan cities of Bangalore and Chennai through NH-4. Other important heritage places in and around the project road are Vellore, Ranipettai, Kaveripakkam, Kanchipuram, Sriperumbudur and Vedal etc.

There is only one broad gauge (BG) railway line at km 72.500 of the project road which has been provided with 2x3-lane ROB.

2.2.1 Road Section and Pavement

The project road starts at Poonamallee i.e. intersection with Chennai Bypass and ends at Walajapet Bypass i.e. intersection with NH-46 in the district of Vellore. During reconnaissance survey it is found that the project road length is around 93m. The project road is comprised of 2x2 lane carriageway (7.0m carriageway) and 1.5m paved and 1.5~2.0m earthen shoulder on either side. The project road alignment traverses through flat/plain terrain.

The project road has been constructed recently and opened to traffic in the year 2003-2004 and 2006-2007 from Km 70.394 to 106.800 and Km 13.800 to 70.394 respectively. The project road has bituminous surfacing of 50mm+ DBM 130mm+ water mix macadam (WMM) base of 250mm. The project road pavement condition is rated as excellent. The existing cross-drainages are recently

constructed and in good condition. The settlements/ towns/ villages and the congested locations along the project road are presented in **Table 2.1**:

Table 2.1: List of Service Road

S. N.	Chainage (Km)		Service Lane		Village Name
	From	To	Left	Right	
1	17.390	17.450	6.00	7.50	Seennerkuppam
2	17.450	18.115	6.00	7.50	Seennerkuppam
3	18.115	18.500	7.50	7.50	Seennerkuppam
4	18.500	22.225	7.50	7.50	Poonamallee
5	22.225	22.290	7.50	7.50	Poonamallee
6	33.800	34.000		7.50	Katrumbatram
7	34.000	34.690	7.50	7.50	Katrumbatram
8	34.690	34.710		7.50	Katrumbatram
9	34.710	35.250		7.50	Katrumbatram
10	35.250	35.364		5.00	Irrangatukotti
11	40.900	41.175	6.50	6.50	Sriperumbudur
12	41.175	41.225	6.0-12.0	4.00	Sriperumbudur
13	41.225	41.300	10.0-12.0	4.00	Sriperumbudur
14	41.300	41.330	3.0-10.0	3.50	Sriperumbudur
15	41.330	41.475	3.50	3.00	Sriperumbudur
16	41.475	41.500	4.00	3.50	Sriperumbudur
17	41.500	41.745	4.00	3.50	Sriperumbudur
18	41.745	41.750	4.0-6.0	4.0-6.0	Sriperumbudur
19	41.750	41.790	4.0-6.0	4.0-6.0	Sriperumbudur
20	41.790	41.800	6.00	6.00	Sriperumbudur
21	41.800	41.860	6.00	6.00	Sriperumbudur
22	41.860	41.950	6.00	6.00	Sriperumbudur
23	41.950	42.100		6.00	Sriperumbudur
24	42.100	42.972	6.00	6.00	Sriperumbudur
25	42.972	43.000	5.50		Sriperumbudur
26	43.000	43.050	5.50		Sriperumbudur
27	43.050	43.100	4.80		Sriperumbudur
28	43.100	43.155	4.50		Sriperumbudur
29	43.155	43.845	4.00		Sriperumbudur
30	45.300	46.700	7.00		Sriperumbudur
31	49.970	50.220	4.00		Mambakkam
32	63.125	63.175	4.00	4.00	Rajakulam
33	63.175	63.600	4.00	4.00	Rajakulam
34	63.600	63.900	4.00	4.00	Rajakulam
35	63.900	64.020	4.00	4.00	Rajakulam
36	64.020	64.080		4.00	Rajakulam
37	64.080	64.115		4.00	Rajakulam
38	71.565	72.100	7.50	7.50	Chettiyar
39	72.200	72.700	4.50	4.00	Chettiyar
40	87.020	87.045		4.00	Perumali Pakkam
41	87.045	87.450		4.00	Perumali Pakkam
42	87.500	87.650		1.4-4.0	Perumali Pakkam
43	88.825	89.125	4.00	4.00	Avalore
44	89.125	89.300	2.8-7.0	2.0-7.0	Avalore
45	93.020	93.100	4.0-5.0		Avalore

S. N.	Chainage (Km)		Service Lane		Village Name
	From	To	Left	Right	
46	93.100	93.450	5.00	5.00	Ocheri
47	93.450	93.685		4.50	Ocheri
48	98.045	98.120		6.00	Kaveripakkam
49	98.120	98.175		6.00	Kaveripakkam
50	98.175	99.100	4.00	4.00	Kaveripakkam
51	100.265	100.360	4.70	4.00	Sumaithangi
52	100.360	100.500	4.70	4.00	Sumaithangi
53	100.500	100.900	3.80	4.00	Sumaithangi
54	106.675	107.000		5.00	Ranipettai

2.2.2 Alignment and Geometric

The existing road has 2x2 lane configuration in its entire length. There are around 114(RC-01) & 77(RC-02) horizontal curves. These curves are generally suites for a design speed of 80-100 kmph, hence these need not to be redesigned. Road geometry has been found to be generally conforming to the National Highway standards. Plate 1 to Plate 15 depicts the existing condition of the project road, major and minor bridges, culverts and other road side features.

Existing ROW along the project road varies between 40m to 60m (20-30m either side from centreline of the existing road) with exceptions at the locations of towns and built-up areas where the same has been noted as low as 40m.

2.2.3 Bridges and Cross Drainage Structures

The inventory data for the existing cross drainage structures, culverts and bridges were carried out. The existing culverts are mostly widened for 2x3 lane configuration formation and are in good condition. The project road has 1 Major bridge, 12 Minor bridges, 235 culverts and the summary of the same is given below in **Table 2.2**:

Table 2.2: Summary of Existing Bridges and Culverts

Length	Vented / Non-vented Causeway	Culverts			Bridges		
		Pipe	Slab	Total	Minor	Major	Total
93km	Nil	144	91	235	12	1	13

Major Bridges

There is only 1 major bridge in this project. Details like location; span arrangements etc. of the existing major bridges are tabulated in **Table 2.3** below.

Table 2.3: Major Bridge

SI.NO	LOCATION(KM)	TYPE OF BRIDGE	SPAN ARRANGEMENT(M)	TOTAL WIDTH(M)
1	27.211	MAJOR	5 X 14	31.75

Minor Bridges

There are 12 minor bridges in the existing project road. Details of the existing minor bridges are tabulated in **Table 2.4** given below.

Table 2.4: Minor Bridge

Sl.NO	LOCATION(KM)	TYPE OF BRIDGE	SPAN ARRANGEMENT(M)	TOTAL WIDTH(M)
1	30.945	MINOR	1 x 25	34.25
2	30.995	MINOR	1 x 25	33.77
3	39.435	MINOR	2 X 14	32.09
4	44.489	MINOR	1 X 8.75	35.46
5	56.905	MINOR	1 X 21.0	32.86
6	59.108	MINOR	2 X 10	32.09
7	67.463	MINOR	4 x 10	32.00
8	92.218	MINOR	2 X 14 + 1 X 20.25	32.00
9	100.157	MINOR	4 X 6.0	28.20
10	101.247	MINOR	1 X 10	30.50
11	103.637	MINOR	1 X 17.4	32.00
12	106.683	MINOR	1 X 10	17.50

2.3 Traffic on the Project Road

Based on the intensity of the traffic, the project road can be divided into following three homogenous links:

Table 2.5: Homogeneous Links

Link Id	Description	From – To (Km)	Length (Km)
L41	Poonamallee to Sunguvachatram	13.80 – 48.40	34.60
L42	Sunguvachatram to Kanchipuram Junction	48.40 – 74.80	26.40
L43	Kanchipuram Junction to Walajapet	74.80 – 106.80	32.00
Total Length Of Project Road			93 Km

There is high traffic flowing in the Link L42 due to big industrial establishments along the project road. The traffic intensity is less in the Link L41 than Link L42 and it further reduces in the Link L43. Special Economic Zones (SEZs) are coming up in the Link L41 and L42, which will further enhance the traffic intensity on the project road in future after the project implementation.

2.4 Major / Minor Junctions

The project road consists of various cross roads and detailed inventory of the same is in progress. Some of the important major/minor junctions are given in **Table 2.6** below:

Table 2.6: Junctions

Location (Km)	Direction (Left / Right)	Road No. / Type	Carriageway Width (m)	Remarks
13.800	LHS	BT	2 x 7.00	To Tambaram
14.525	LHS	BT	3.5	To Village

Location (Km)	Direction (Left /Right)	Road No. / Type	Carriageway Width (m)	Remarks
14.875	RHS	BT	7.5	To PMR Institute Of Technology(Ambature)
15.414	LHS	BT	3.5	To Velappanchavadi Village
15.565	LHS	BT	3.5	To VRL-Logistic Ltd.
16.194	LHS	BT	5.5	To Numbel
16.290	RHS	BT	3.5	To Trirkadu
16.472	LHS	BT	3.5	To Kendiya Vihar
16.761	LHS	BT	3.5	To Poonamallee
16.944	LHS	BT	3.5	To Village
17.055	RHS	BT	3.5	To Village
17.447	RHS	BT	3.5	To Village(below flyover)
17.546	LHS	BT	7.5	To Poonamallee(below flyover)
17.800	RHS	BT	6	To Shunmuga Road
18.063	LHS	BT	2 * 7	To Porrur/ Poonamallee
18.957	RHS	BT	3.5	To Village
19.171	RHS	BT	2 * 3.5	To Avadi(Below Flyover)
19.168	LHS	BT	2 * 3.5	To Poonamallee(Below Flyover)
20.663	LHS	BT	3.5	To RRB Energy Ltd.
20.936	RHS	BT	3.5	To Vidya Academy
20.944	LHS	BT	3.5	To Poonamallee Market
21.590	LHS	BT	3.5	To Poonamallee
22.294	LHS	BT	3.5	To Poonamallee
23.281	LHS	BT	7.5	To Nazarathpettai Village
24.181	LHS	BT	3.5	To Village
24.404	RHS	BT	7	To Thiruvallir/Tirupati(SH-50)
24.575	LHS	BT	3.5	To Company
25.125	RHS	BT	7	To A.M Industries
25.357	LHS	BT	3.5	To Company
25.829	LHS	BT	3.5	To Sambaramma
26.125	RHS	BT	7.5	To Tirvijhi
26.770	LHS	BT	3.5	To Janta Timber & Saw Mill
27.445	RHS	BT	7	To Korindo Factory
28.310	LHS	BT	3.5	To ELIMS Nagar
28.722	LHS	BT	7	To Company
28.861	LHS	BT	7	To St. Johns School
29.097	RHS	BT	3.5	To Pleasant Days Family Resort
30.135	RHS	BT	3.5	To Village
31.510	RHS	BT	5.5	To Kandalam
33.946	LHS	BT	2 * 3.5	To Hyundai
34.699	LHS	BT	2 * 20	To Hyundai
35.254	LHS	BT	3.5	To Jeans KNIT Ltd.
35.971	RHS	BT	7.5	To Global Suhaimi Ltd.
36.414	RHS	BT	3.5	To Achieve Company
36.468	LHS	BT	3.5	To Engg. College
37.188	LHS	BT	7	To Powergrid
37.571	RHS	BT	2 * 7	To Venkateshwar Engg. College
37.939	RHS	BT	3.5	To S.S.S Industries
39.114	LHS	BT	3.5	To Village

Location (Km)	Direction (Left /Right)	Road No. / Type	Carriageway Width (m)	Remarks
39.106	RHS	BT	3.5	To Village
39.169	LHS	BT	3.5	To Village
39.245	RHS	BT	7	To Sriperumbudur
39.300	LHS	BT	3.5	To Netaji Nagar
40.031	LHS	BT	7	To Company
40.145	LHS	BT	3.5	To Village
40.455	RHS	BT	3.5	To Sriperumbudur
41.369	RHS	BT	7.5	To Sriperumbudur(Bypass Ends)
41.918	LHS	BT	3.5	To Village
42.143	LHS	BT	3.5	To Tambram
42.280	LHS	BT	7	To Chengalpattu
43.220	RHS	BT	7	To Coromondal
43.300	LHS	BT	11	To Nokia
43.844	LHS	BT	8	To Company
43.873	RHS	BT	7	To Parker Company
44.150	RHS	BT	3.5	To Maamallan Institute
45.224	LHS	BT	5.5	To Aerovision Electronics Ltd.
45.824	LHS	BT	2 * 7.5	To Sipcot Industrial Area
45.973	LHS	BT	7.5	To Saint Gobain Glass
46.903	LHS	BT	3.5	To Mambakkam Village
48.328	LHS	BT	3.5	To Motorola
48.433	RHS	BT	7	Sunguvachatram (Bypass Starts)
48.665	LHS	BT	7	To Motorola
50.008	LHS	BT	7.5	To Dell
50.225	LHS	BT	7.5	To Wallajabad
50.225	RHS	BT	7.5	To Sunguvarchataram
50.858	RHS	BT	7	To Sunguvarchatram Junction(Bypass Ends)
52.513	LHS	BT	3.5	To Santhavellore
52.666	RHS	BT	3.5	To Company
53.716	RHS	BT	3.5	To Anubhav Greenrich Village
54.019	LHS	BT	3.5	To Pappankuzhi Village
56.656	RHS	BT	3.5	To Keranavellore Village
57.400	RHS	BT	3.5	To Ramanujapuram Village
57.535	RHS	BT	3.5	To Pillaichatram Village
57.706	LHS	BT	3.5	To Green Line Farm House
58.349	RHS	BT	2 * 7	To L & T Company
59.905	RHS	BT	3.5	To Village
60.255	LHS	BT	3.5	To Village
60.606	RHS	BT	3.5	To Chinnaiyan Chattram
60.606	LHS	BT	3.5	To Chinnaiyan Chattram
62.158	LHS	BT	3.5	To Chingadivakkam Village
62.413	LHS	BT	3.5	To Yakangulam Village
63.338	LHS	BT	3.5	To Village
63.549	LHS	BT	3.5	To Village
64.194	LHS	BT	5	To Village
64.268	RHS	BT	5	To Village
65.500	LHS	BT	3	To Village

Location (Km)	Direction (Left / Right)	Road No. / Type	Carriageway Width (m)	Remarks
65.718	RHS	BT	5	To Vedal Village
65.969	LHS	Broken BT	4	To Built Up Area
66.269	RHS	BT	4	To Village
66.694	RHS	BT	5	To Vedal Village
66.744	LHS	BT	3.5	To Village
67.969	RHS	Broken BT	5	To Village
68.147	LHS	Broken BT	3	To Village
68.500	RHS	BT	2 * 7.5	To Meenakshi Medical College
68.970	LHS	BT	3.5	To Village
69.272	LHS	BT	3	To Village
69.422	LHS	BT	3	To Govt. Cancer Hospital
69.747	LHS	BT	4	To Karapet Village
70.297	RHS	BT	7	To Punnarigare Village
70.315	LHS	BT	7	Kanchipuram Junction
71.315	RHS	BT	4	To Village
72.150	LHS	BT	7	To Kanchipuram
72.150	RHS	BT	7	To Arrakonam
72.800	RHS	BT	3.5	To Sitherumeri Village
73.177	RHS	BT	4	To Village
73.497	LHS	BT	4	Towards Kanchipuram
73.492	RHS	BT	4	To Koraram Vajver
75.128	LHS	BT	4	To Village
75.154	RHS	BT	4	To Krishaveni Nagar
76.204	LHS	Broken BT	5	To Thirumalai Engg. College
76.708	RHS	BT	5	To Village
76.954	LHS	BT	7	To Kanchipuram
77.345	RHS	BT	4	To Village
77.895	RHS	BT	4	To Krishna Puram
78.575	RHS	BT	4	To Village
79.200	RHS	BT	7	To Balluchetram Village
79.750	RHS	BT	4	To Musaravakkam Village
79.750	LHS	BT	4	To Baluchetty Village
80.025	LHS	BT	4	To Thiruppukuzzi Village
80.025	RHS	BT	6	To Balluchetram Village
80.725	RHS	BT	7	To Balluchetram Village
82.450	LHS	BT	5.5	To Damal Village
83.925	LHS	BT	6	To Field
85.010	RHS	BT	4	To Village
85.750	LHS	BT	3.5	To Ponniammanpattarai Village
87.410	RHS	BT	4	To Poiganallu Village
87.425	LHS	BT	4	To Perumbalipakkam
87.525	RHS	BT	7.5	To Perumbalipakkam Village
89.975	LHS	BT	4	To Canara Bank- Kalathur
91.910	LHS	BT	6	To Village
92.995	RHS	BT	7	To Arakonam

Location (Km)	Direction (Left /Right)	Road No. / Type	Carriageway Width (m)	Remarks
94.075	LHS	BT	4	To Village
95.290	RHS	BT	3.5	To Village
96.350	RHS	BT	4	To Village
97.325	RHS	BT	3.5	To Village
97.695	RHS	BT	4	To Kondabaram Village
97.890	LHS	BT	4	To JCK Nagar
98.290	LHS	BT	4	To Thirupar Kadal Village
98.290	RHS	BT	4	To Kaveripakkam Village
100.210	RHS	BT	4	To Village
100.325	RHS	BT	3.5	To Village
100.615	LHS	BT	4	To Village
100.700	RHS	BT	3.75	To Village
102.020	RHS	BT	3.5	To Village
102.860	LHS	BT	3.5	To Poondi Village
103.460	RHS	BT	5	To Bagaveli Village
104.450	LHS	BT	3.75	To Chennasamuthram Village
105.895	RHS	BT	4	To Musiri Village
106.075	LHS	BT	5	To Ranipettai Village
106.535	RHS	BT	10	To Walajapet

2.5 Bypass and Realignment

The project road is having existing 2x2-lane carriageway configuration in its entire length. There are several important villages/towns/habitations along the existing alignment in Poonamallee -Walajapet- road section. Some of these sections have already provided with bypass to avoid the habitation/ congestion. No new bypass has been envisaged for the project road.

2.7 Toll Plaza

There are two toll plazas at Km 37.800 and Km 104.900 already existing along the project road. The configuration of the both toll plazas are 2x5 lanes.

2.8 Widening / Improvement Proposals

It is important to define the various design elements and factors, which would govern the functioning of the Partially Access Controlled Highway. These factors can be broadly grouped under the following:

- Cross-sectional layout;
- Land-use and access control;
- Geometric design
- Pavement;
- Drainage;
- Bridges and structures;
- Flyover/Overpasses/Underpasses;
- Traffic control and safety measures;
- Wayside facility; and,
- Arboriculture & Aesthetics.

As per scope of services, a scheme has been prepared for upgrading of existing 2x2-lane carriageway of National Highway-4 (NH-4), from km 13.800 to km 106.800 (Poonamallee – Walajapet) road section in Tamil Nadu to 2x3-lane carriageway configuration and converting the same into a partially access controlled highway and providing grade separated intersections.

The existing road traverses through flat/plain terrain to the entire length of the project road. The project road is running from west to east side of Tamil Nadu. The detailed reconnaissance of the project road indicates that generally the ground elevation increases for Poonamallee to Walajapet direction as it goes away from the Chennai i.e. Indian Ocean towards Bangalore. The existing 2x2 lane to be widened to 2x3 lane, with the provision of additional 1-lane on either side of the existing carriageways, which would satisfy the project requirements.

In order to convert the existing 2x2 lane road into 2x3 lane configurations as “partial access controlled facility”, it is essential to provide service road on both sides all along the project road.

As the existing 2x2 lane project road to be converted into 2x3 lane configuration with “partial access controlled facility”, there will be requirement of conversion of major at grade intersection into grade-separated intersection. Minor junctions and junctions with low category of roads need to be grouped and provided with access at appropriate locations through Underpass/Flyover/ROB.

Pedestrian Subways and cattle crossings shall be proposed as per the requirements.

2.9 Toll Plaza

Toll Plaza shall be designed and located as per the project requirement and in consultation with NHAI and revenue authorities. The existing toll plaza may be abandoned if required in the improved Scenario.

2.10 Project Road Constraints

During detailed inventory and reconnaissance survey, efforts have been made to identify the critical sections such as sharp horizontal curves, sub-standard geometrics and major junctions to propose a cost-effective proposal of a road of 2x3 lane carriageway configuration.

The existing scenario of the project road has been dealt with in detail in the preceding paragraphs of this chapter and the existing situation avoids any improvement along the existing alignment due to various reasons encountered as listed below:

- Restricted roadway (limits the provision of service roads, underpasses etc.);
- Location of the existing alignment;
- Restricted ROW;
- Major utilities (water, oil, gas pipelines and high tension lines etc.)

The existing ROW of the project road as informed by NHAI is presented in **Table 2.7**:

Table 2.7: Existing ROW

Sl. No.	Chainage (Km)		Existing ROW (m)	Remarks
	From	To		
1	13.800	18.000	45.00	Interchange under construction At Ch. Km.13.800
2	18.000	22.400	60.00	
3	22.400	26.000	45.00	Flyover Under construction At Ch. Km. 22.400
4	26.000	38.000	50.00	Toll Plaza At Ch. Km. 37.800
5	38.000	41.000	60.00	
6	41.000	43.000	40.00	Left side Rajeev Gandhi Memorial Compound wall At Ch. Km. 41.550
7	43.000	49.000	50.00	
8	49.000	51.400	60.00	
9	51.400	63.000	50.00	
10	63.000	64.000	40.00	
11	64.000	70.400	50.00	
12	70.400	87.000	60.00	ROB At Ch. Km 72.275
13	87.000	89.000	60.00	
14	89.000	92.700	60.00	
15	92.700	93.500	55.00	Left Side ROW 20.0 m & Right Side ROW 35.0 m From CL
16	93.500	98.000	60.00	
17	98.000	101.000	60.00	
18	101.000	104.000	60.00	
19	104.000	107.000	60.00	Toll Plaza At Ch. Km 104.900

As a result of detailed reconnaissance survey along the road alignment and due to the various existing constraints, the Consultants recommend the following:

- to widen the existing carriageway configuration of 2x2 lane to 2x3 lane;
- to provide service road all along the project road;
- to convert major at-grade intersections with underpasses/flyover (to make project road partial access controlled);
- geometric improvement (if required);

The proposed improvement would thus have the better performance and the advantages as under:

- Smooth and fluent vertical and horizontal geometry;
- Segregation of Local and through traffics;
- Up gradation of Safety aspects by minimisation of accidents;
- Up gradation of the riding quality;
- Facilities/Wayside amenities provided to the commuters leading to the enhancement of the Level of comfort.

Chapter -3

NHAI's Overview

CHAPTER – 3

Overview of NHAI's Organisation and Activities

3.1 National Highways Authority Of India (NHA)

The National Highway Authority of India (NHA) Act was enacted by Parliament in 1988 with the objective of creating a central authority to develop, maintain and manage the National Highways in the country. The National Highways Authority of India (NHA) came into existence with effect from 15th June 1988 but became operational only in February 1995.

3.2 Organisation

NHA is an autonomous corporate body of Government of India under the Ministry of Shipping, Road Transport and Highways (MoSRT&H). The Authority consists of the Chairman, not more than five full time members and not more than four part time members, all of whom are appointed by the Government of India.

The organizational setup of NHA is given in **Annexure-A**.

At the Headquarters, NHA has the following functional divisions:

- Administration
- Finance
- Technical
- Corridor Management
- Environmental and Social Development
- Vigilance
- The Field formation comprises of:
 - Project Implementation Units (PIU)
 - Corridor Management Units (CMU)

3.3 Objectives

NHA's mission is to meet the nation's need for the development, maintenance and management of the National Highways network to world class standards within the strategic policy framework set by the Government of India for economic growth and promotion of well being and quality of life of the people.

Towards this end, the NHA is mandated to:

- maintain and manage the National Highways so as to ensure safe, efficient and environmentally sound movement of people and goods.
- extend, improve, maintain and operate the NH network in support of the economic development of the country.
- implement externally and domestic funded road programmes in an efficient, effective and timely manner.
- seek viable ways to involve the private sector in the provision, maintenance and operation of National Highways.
- encourage research and develop effective liaison with institutions involved in research on road related issues.
- provide a congenial environment including landscaping, tree plantation and pleasant roadsides to ensure safe, comfortable and pleasant driving.
- provide en-route amenities for the road users.

3.4 Project Financing and Cost Recovery Mechanisms

The sources of project finance and cost recovery mechanisms available with the NHAI are:

- capital grant or loan provided by Government of India
- dedicated accruals from the corpus formed by the levy of cess on petrol and diesel viz. the Central Road Fund.
- Loan assistance from external funding agencies like World Bank, Asian Development Bank, Japanese Bank of International Co-operation.
- Borrowings from the market by issue of bonds, debentures and other such instruments and by setting up its own companies/ Special Purpose Vehicles (SPVs).
- Funds from private sector through Build, Operate and Transfer schemes and other variations thereof
- Toll collections
- Lease of roadside land
- Charges for advertisements and hoardings, and
- Income from investments in the securities of the Central Government or other appropriate instruments.

3.5 Policy Initiatives for Attracting Private Investment

The Government of India has taken the following policy initiatives for attracting private investment in road development projects:

- Government will carry out all preparatory work including land acquisition and utility removal. Right of way (ROW) to be made available to concessionaires free from all encumbrances.
- NHAI / GOI to provide capital grant upto 40% of project cost to enhance viability on a case to case basis
- 100% tax exemption for 10 years and 30% relief for next 5 years, which may be availed of in 20 years.
- Concession period allowed up to 30 years
- Arbitration and Conciliation Act 1996 based on UNICITRAL provisions.
- In BOT projects entrepreneur are allowed to collect and retain tolls.
- Duty free import of specified modern high capacity equipment for highway construction.

3.6 National Highways Development Project (NHDP)

The road network of India is comprised of Expressways – 200 km, National Highways - 66,590 km, State Highways -1,28,000 km, Major District Roads - 4,70,000 km and Rural and ODR's - 26,50,000 km totaling to 33.4 lakhs km (approx). The National Highway network comprises less than 2% of the total length of roads in the country but has to carry over 40% of the total traffic across the length and breadth of the subcontinent. Consequently, for realizing India's ambitious growth plans in the 21st century, it is critical that this invaluable asset is substantially upgraded to maximize effectiveness. The NHDP is a major initiative towards capacity enhancement of the National Highways, both in qualitative and quantitative terms. The project envisages 4/6 lane Golden Quadrilateral linking Delhi-Kolkata-Chennai-Mumbai-Delhi, North-South corridor connecting Srinagar (J&K) to Kanyakumari (Tamilnadu), an East-West Corridor connecting Silchar to Porbandar, as well as roads connecting Major Ports totaling

about 26,469 kms. National Highways Authority of India is implementing it at an estimated cost of Rupees 64,634 crores.

3.6.1 Golden Quadrilateral (GQ)

This covers Delhi-Kolkata-Chennai-Mumbai-Delhi (**Annexure-B**) involving 5,846 km of road and costing Rs.25,055 Crores.

3.6.2 North-South & East-West Corridors (NS-EW Corridors)

From Srinagar (J&K) to Kanayakumari and Silchar to Probandar (**Annexure-C**), involving a distance of 7,300 km and costing Rs. 34,189 crores.

3.6.3 Other Works including Port Connectivity to Major Ports

The major ports (Haldia, Paradip, Vishakapatnam, Chennai, Tuticorin, Cochin, Mangalore, Mormugoa, Jawahar Lal Nehru Port, Kandla), (**Annexure-D**) are also to be connected by about 380km of roads. Other projects involve about 945 km of road.

3.6.4 Fund Requirement

The sources of funds for the implementation of the NHDP have been envisaged as follows:

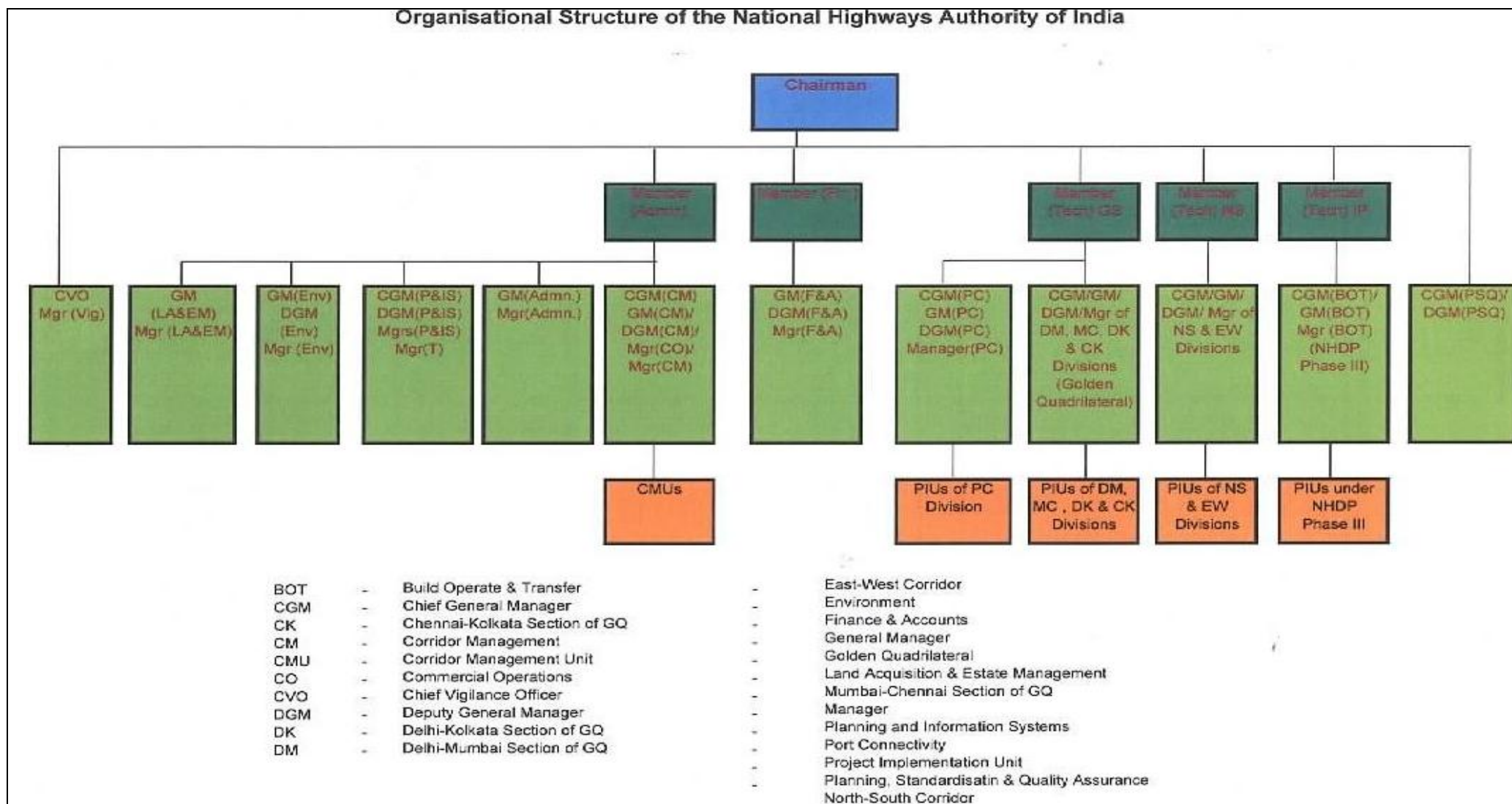
Source	Amount (Rs. Crores)
Cess (CRF)	20,000
World Bank/Asian Development Bank Loan Assistance	20,000
Market Borrowings	12,000
Private Sector	6,000
Total	58,000

3.6.5 Status of NHDP & Other Projects as on December 2007

Description	NHDP					Port Connec-tivity	Other s	Total by NHA I
	GQ	NS-EW Ph-I&II	NHDP Phase IIIA	NHDP Phase V	NHDP Total			
Total Length (Km)	5,846	7300+	5,498	6,500	25,144	380	945 [^]	26,469
Already 4 Laned (Km)	5,431 ^{**}	840	30	-	6,301	111	287	6,699
Under Implementatio n (Km)	415	5,054	1,090	148	6,707	248	638	7,593
Contracts Under Implementatio n (Km)	35	318+	17	2	192	8	16	216
Balance Length for award (Km)	-	1,306 [^]	4,378 [^]	6,352	12,036	21	20	12,077

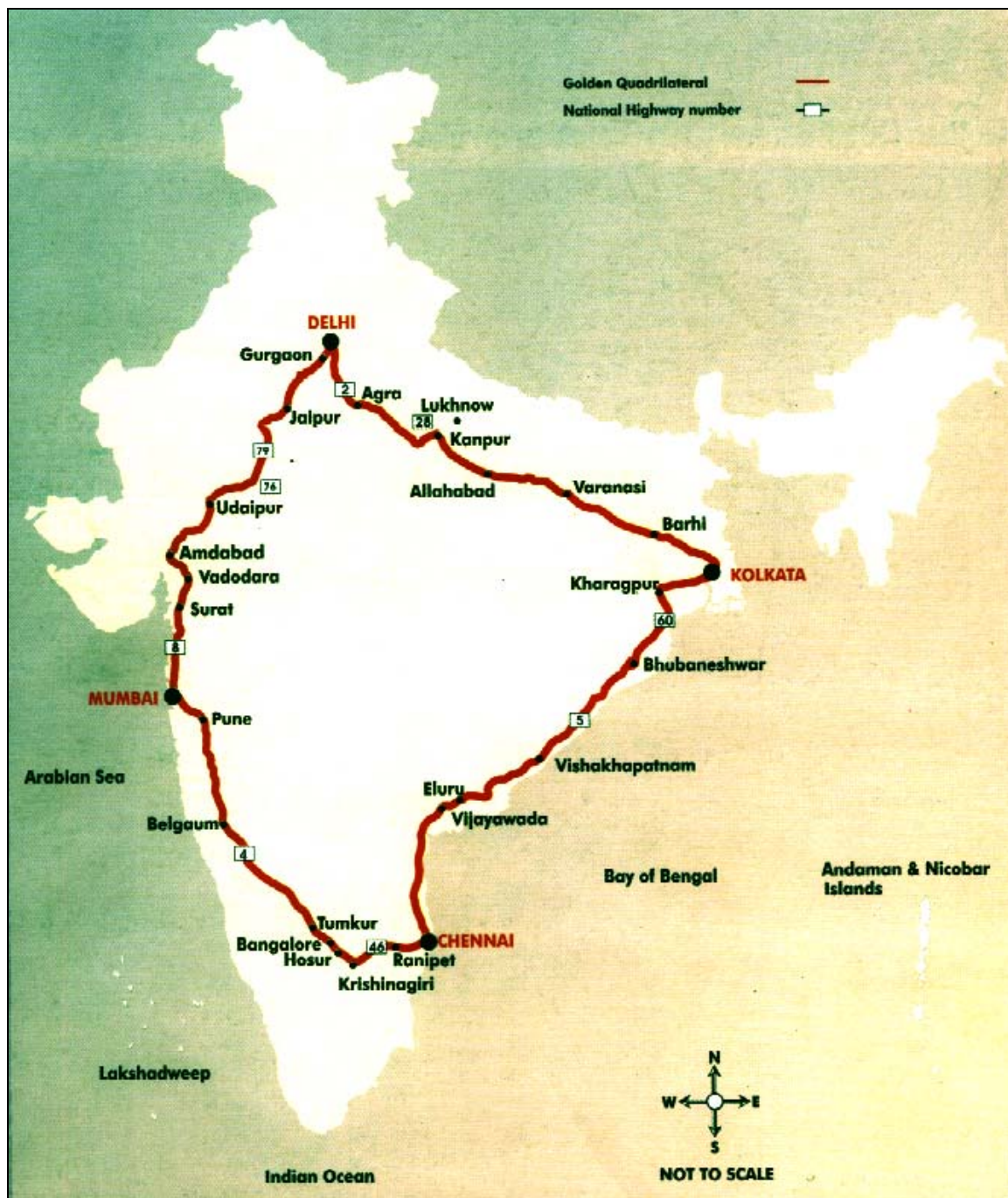
** Out of 5,431km, 5,079km includes BC layer and 352km upto DBM. [^] The difference in length is because of change in length after award of works. +Out of 7,300km, 981km length is in Phase-I and remaining length is in Phase-II. Against

981km, 840km length was 4 laned. Actual length at present excluding 442km common length with GQ is 7,274km. However, this may change again after preparations of DPRs. The original approved length of Corridors is 7,300km.



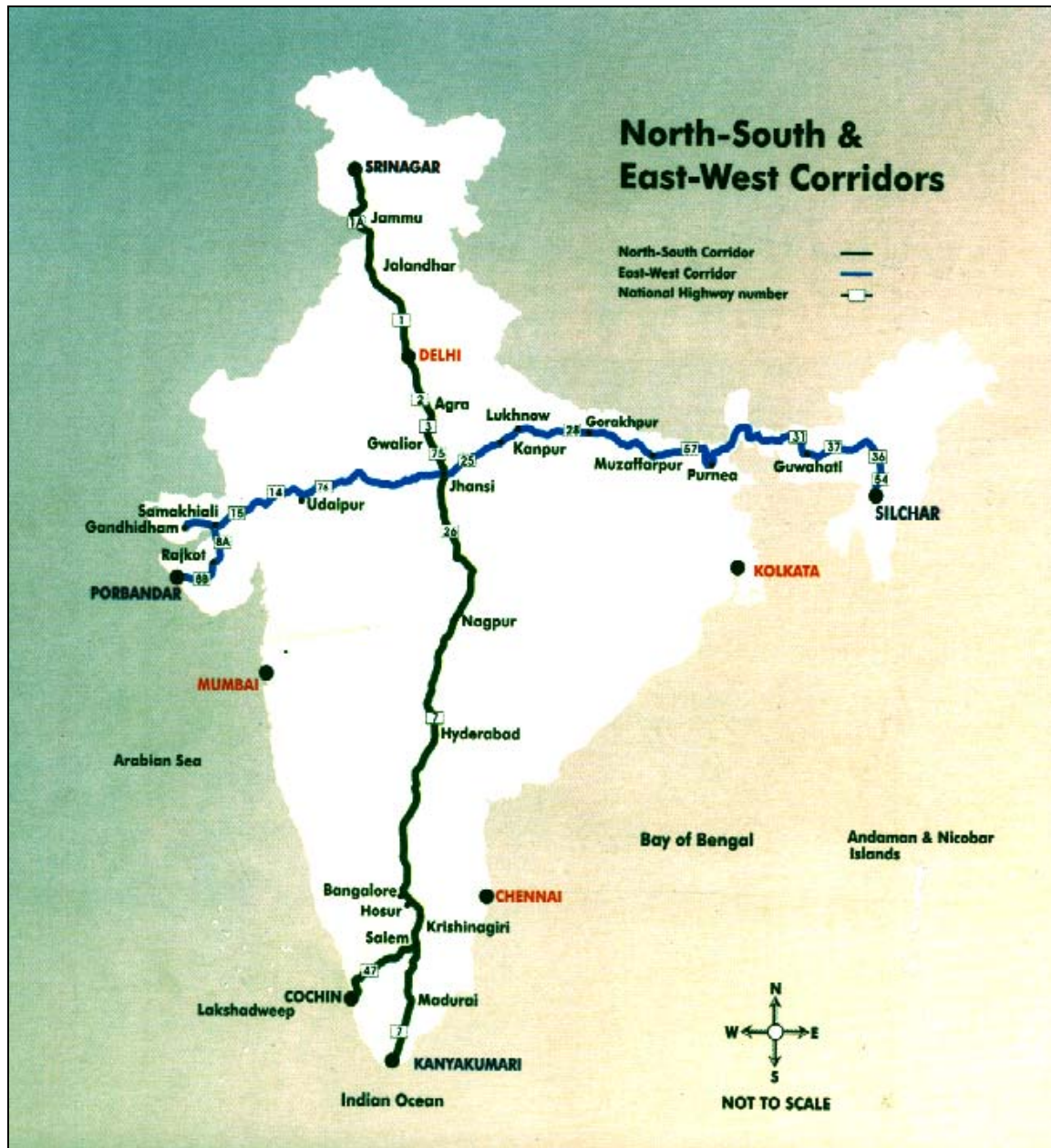
Annexure-B

Golden Quadrilateral



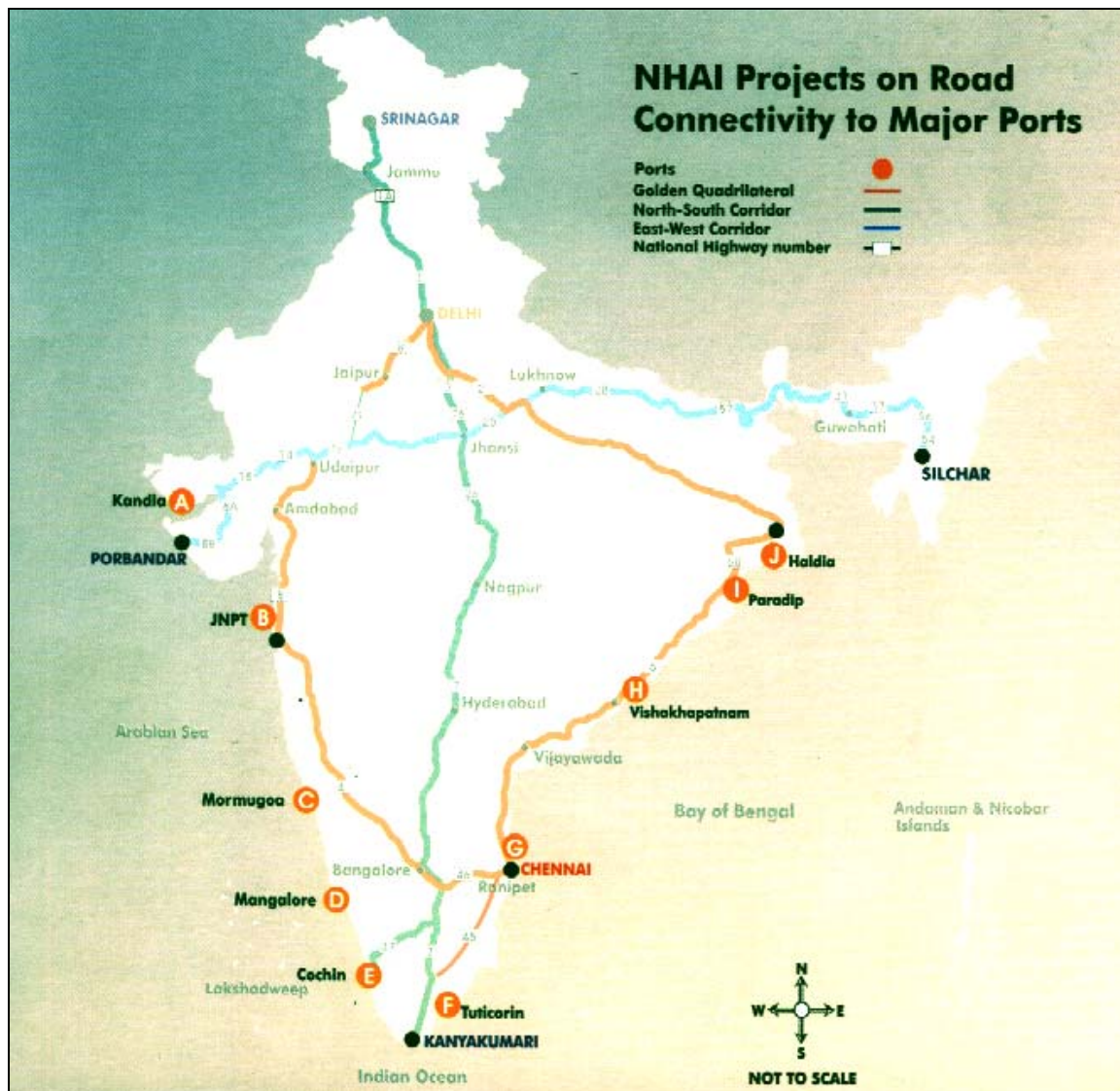
Annexure-C

North-South and East-West Corridors



Annexure-D

Road Connectivity to Major Ports



Chapter -4

Socio – economic Profile

CHAPTER – 4

Socio Economic Profile

4.1 Geography

Tamil Nadu is situated on the southeastern side of the Indian peninsula. It is bounded on the east by Bay of Bengal, in the south by the Indian Ocean, in the west by the states of Kerala and Karnataka and in the North by the Karnataka and Andhra Pradesh. The land mass of the state can be divided into two natural divisions, (1) The Eastern coastal plain and (2) The hilly region along the North and the West.

Along the whole length of the western part, the sea varying at a distance from, 80 to 160 km runs the range of the Western Ghat, a steep and rugged mass averaging 1220 metres above the sea level and rising to 2440 metres at the highest point. The Palghat Gap about 25 km in width is the only marked break in the great mountain wall. To the south of this gap, the range is known as Annamalai (Elephant Hills).

Palani Hills is on the east, on which the famous hill station Kodaikanal is situated. The slopes of the Western Ghat are covered with heavy ever green forests. The Nilgiris and the Annamalai are the hill groups with the maximum height. In the famous Ootacamund area of the Nilgiris district, is the highest peak Doddabetta, 2640 metres above the sea level. Ootacamund is known as the 'Queen of hill stations' in India. Almost every district has a hill-station or a sea-side resort.

4.2 History

Tamil Nadu which holds in itself a land, a language and a culture existed since the prehistoric times. Human settlement here is said to have existed coterminous to the civilizations in other parts of world. Tamil Nadu was earlier known as Tamilhanu. The existence of ports such as Arikamedu, Karipattinam, Korkai were proofs of the Tamilians advancement in establishing relations with other regions of the world. The Tamilians were said to be of Dravidian origin and they originally resided in the North-West. With the advancement of the Indo-Aryans, the Dravidians were pushed to south. The Sangam literature is the basis of Tamil History, culture and organizations from the 3rd century AD. The Cholas, the Pallavas, the Pandyas and the Cheras had their influence on Tamil Nadu and established their kingdoms. The Pallavas established their reign at Kanchipuram in about the 4th century AD. They held power over the land of the Tamils from 6th and 9th centuries. At the end of the 9th century, the Cholas established themselves and they extended their empire and also established contacts with South East Asia.

In the 13th century, the Pandyas dominated. The establishment of the Vijayanagar Empire brought the downfall of the Pandyas. This empire ruled till the 16th century preserving and promoting Hindu culture. The Muslim powers influenced this region politically. The Marathas also influenced Madurai and Thanjavur till the advent of the English who wrested power from the French. During the 17th and the 18th centuries, conflicts started between the trading companies of Europe for control of the major parts in the east. The British managed to control this region in the 19th century. This region was under the

domain of the East India Company and continued till independence after which the three states of Tamil Nadu, Andhra Pradesh and Orissa were formed. The region under the jurisdiction of the Madras Presidency formed into a single unit and named Tamil Nadu in 1969.

4.3 Climate

Tamil Nadu has a tropical climate with no wild swing between summer and winter temperature. April and May are the hottest months with the mercury often soaring above the 40 °C. Coastal regions also get uncomfortably warm and humid during these months but the nights are usually cool, thanks to the sea breeze that sets in during the afternoons. Summer temperatures are quite equable at the foothills of the ghats. But the most pleasant are the hills stations where the maximum temperature rarely rises above the mid twenties in summer. 'Winter' falls between November-February when the climate is pleasantly cool unless you wish to visit the hill stations, in which case you will need woollens. Minimum temperatures in the plains rarely dip below 20 °C while in the hills the mercury may drop to 5 °C or below.

In Tamil Nadu, the rainy season is between October and December when the north-east monsoon brings rain in spurts. The average annual rainfall, ranges between 25 and 75 inches (635 and 1,905 mm) a year. Highest precipitation occurs in the Nilgiris and other hill areas with the least in the Ramanathapuram and Tirunelveli districts.

The district wise average annual rainfall data from the year 1997 to 2002 are presented hereunder, in **Table 4.1**.

Table 4.1: District wise normal rainfall and rainfall (In Millimetre)

Sl. No.	District	Normal Rainfall	Year	
			2004-05	2006-07
1	2	3	4	5
1.	Chennai	1298.1	1187.4	1379.9
2.	Kanchipuram	1252.1	1038.5	1055.0
3.	Thiruvallur	1152.8	925.2	1144.1
4.	Cuddalore	1235.8	1561.9	1308.0
5.	Villupuram	1029.4	1224.0	1000.4
6.	Vellore	917.0	805.7	861.7
7.	Thiruvannamalai	1046.6	1134.1	934.6
8.	Salem	898.0	814.2	807.9
9.	Namakkal	776.5	689.7	810.4
10.	Dharmapuri	853.1	872.7	734.0
11.	Krishnagiri	863.5	872.7	637.1
12.	Coimbatore	711.4	814.8	627.7
13.	Erode	694.4	799.6	725.3
14.	Tiruchirapalli	1695.7	973.3	1524.7
15.	Karur	761.5	814.0	727.5
16.	Perambalur	742.2	918.0	527.2
17.	Pudukottai	949.6	1002.2	698.3
18.	Thanjavur	921.5	1201.6	712.2
19.	Thiruvarur	1053.0	1648.7	811.1

Sl. No.	District	Normal Rainfall	Year	
			2004-05	2006-07
1	2	3	4	5
20.	Nagapattinam	1341.7	1661.4	1136.3
21.	Madurai	1129.9	1010.7	946.8
22.	Theni	840.0	820.4	668.0
23.	Dindigul	833.5	1124.2	593.8
24.	Ramanathapuram	831.6	1313.9	751.1
25.	Virudhunagar	821.2	744.9	839.6
26.	Sivagangai	829.6	1197.2	868.1
27.	Tirunelveli	876.0	1103.3	941.3
28.	Thoothukudi	736.9	935.1	1076.6
29.	The Nilgiris	1695.7	1839.3	838.4
30.	Kanyakumari	1006.0	1111.8	1370.6

Source: Statistical Handbook of Tamil Nadu, 2007

4.4 Area and Population

The state of Tamil Nadu has an area of 130,058 sq. km. and a population of 62.41 million. There are 30 districts, 385 blocks and 16,317 villages. The State has population density of 480 per sq. km. (as against the national average of 312) with 44.04 percent living in urban areas. The decadal growth rate of the state is 11.72% (against 21.54% for the country) and the population of the state continues to grow at a much slower rate than the national rate.

The population data such as total population, decadal growth rates, density, sex ratio, literacy and percentage of urban population of Tamil Nadu and India from the year 1901 to 2001 are given below in **Table 4.2**.

TABLE 4.2: GROWTH OF POPULATION – TAMIL NADU AND INDIA - 1901 TO 2001

Sl. No.	Year	Total population (lakh)		Decadal Growth Rate		Density (Persons Per Sq. Km.)		Sex Ratio (Females per 1000 males)		Literacy Rate		Percentage of Urban Population	
		India	Tamil Nadu	India	Tamil Nadu	India	Tamil Nadu	India	Tamil Nadu	India	Tamil Nadu	India	Tamil Nadu
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1901	2383.96	192.53	-	-	77	148	972	1044	5.35	7.6	10.8	14.2
2	1911	2520.93	209.03	+5.75	+8.57	82	161	964	1042	5.92	9.2	10.3	15.1
3	1921	2513.21	216.29	-0.31	+3.47	81	166	955	1029	7.16	10.4	11.2	15.9
4	1931	2789.77	234.72	+11.00	+8.52	90	180	950	1027	9.5	11.3	12	18.0
5	1941	3186.60	262.68	+14.22	+11.85	103	202	945	1012	16.1	16.2	13.9	19.7
6	1951	3610.88	301.19	+13.31	+14.75	117	232	946	1007	18.3	20.8	17.3	24.4
7	1961	4392.35	336.87	+21.64	+11.85	142	259	941	992	28.3	31.4	18	26.7
8	1971	5481.60	411.99	+24.80	+22.30	177	317	930	978	34.5	39.5	19.91	30.3
9	1981	6863.29	484.06	+24.66	+17.54	216	372	934	977	43.6	54.4	23.34	33.0
10	1991	8433.88	558.59	+23.86	+15.39	267	429	927	974	52.2	62.7	25.71	34.2
11	2001	10270.15	624.06	+21.34	+11.72	324	480	933	986	65.4	73.5	27.78	43.9

Source: Statistical Handbook of Tamil Nadu, 2007

Classification of population by economic activity according to results of the 2001 Census reveals that out of the total population of 624.06 lakh in the state, 237.6 lakh are main workers, 41.20 lakh are marginal workers and 345.3 lakh are non-workers. Thus main workers constitute about 38.07 per cent of the total population and marginal workers constitute about 6.60 per cent of the total population of the state. Among males 51.92 per cent are main workers and 5.72 per cent are marginal workers, while among females 24.04 per cent are main workers and 7.49 per cent are marginal works. Out of total workers, 18.35 per cent are cultivators, 30.98 per cent are agricultural labourers, 5.38 percent are engaged in household industries and 45.29 per cent are engaged in other economic activities. Thus about 49.33 per cent working population are engaged in agriculture (i.e. cultivators and agricultural labour).

According to 2001 Census, the population of Scheduled Castes and Scheduled Tribes in the State is 118.6 lakh (19 per cent) and 6.51 lakh (1.04 per cent) respectively. About 70.07 per cent the Scheduled Castes population was enumerated in rural areas and the remaining 29.93 per cent in the urban areas. The corresponding proportions for Scheduled Tribes were 84.62 per cent and 15.38 per cent respectively.

4.2 Economy

Since the early nineties, the Government of India has initiated a number of reform measures in various sectors to liberalize the economy and make it conducive to rapid growth. As a result of liberalization, the economy is on the growth path reflected by a low inflation rate and growing foreign exchange reserves, while most of the South East Asian countries had suffered serious economic crises due to currency melt down in the late 1990's. The state has registered a healthy growth rate between 2003-04 and 2006-07 The Net State Domestic Product (NSDP) of the State from the year 1999-00 to 2006-07 is given below in **Table 4.3**.

Table 4.3: Net State Domestic Product (Rs. in Crore)

Year	Current Prices	Constant Prices (Base: 1999-00)	Percent growth over previous year	
			Current prices	Constant prices
1	2	3	4	5
1999-00	119,367	119,367	-	-
2000-01	130,129	125,917	+9.02	+5.49
2001-02	131,281	123,546	+0.88	-1.88
2002-03	138,145	124,306	+5.23	+0.61
2003-04	153,997	132,058	+11.47	+6.24
2004-05	174,804	147,093	+13.51	+11.39
2005-06	194,528	157,842	+11.28	+7.31
2006-07	214,187	169,462	+10.11	+7.36

Source: Statistical Handbook of Tamil Nadu, 2007

The NSDP at factor cost at constant (1999-00) prices in 2006-07 has been estimated at Rs. 169,462 crore as against Rs. 157,842 crore in 2005-06 showing a growth of +7.36 percent during the year ending in 2007. At current prices, the NSDP in 2006-07 is estimated at Rs. 214,187 crore as against Rs. 194,528 crore in 2005-06 showing a growth of +10.11 per cent during the year.

4.2.1 Agriculture

In the state's economy, agriculture contributes nearly 13.38 percent to the Net State Domestic Product in 2006-07. According to the land use, the net area sown in the year 2005-06 is 52,43,839 hectares forming 40.25 percent of total area of the state. The net area under irrigation is 29,20,000 hectares, which is around 55.68 percent of the net area sown and 44.32 percent depend on monsoons. The production statistics of principal crops in the state are shown in **Table 4.4**.

Table 4.4: Production of Principal Crops
 (In thousand Tonnes)

SN	Name of Crop	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
1	2	3	4	5	6	7	8	9	10
	Food Grains	9,412	8,843	8,617	7,689	4,460	4,312	6,146	6,116
A.	Cereals	9,108	8,552	8,304	7,418	4,260	4,111	5,930	5,939
1	Rice	8,141	7,532	7,366	6,584	3,577	3,223	5,062	5,209
2	Cholam	369	346	306	275	211	246	252	231
3	Cumbu	206	241	170	153	89	172	124	95
4	Ragi	241	246	259	235	140	176	154	132
B	Pulses	304	291	313	271	200	201	216	177
C	Oilseeds	1,623	1,384	1,423	1,296	735	947	1,039	1,129
1	Gingelly	53	66	65	46	28	29	34	31
2	Groundnut	1,570	1,318	1,358	1,250	717	918	1,005	1,098

Source: Statistical Handbook of Tamil Nadu, 2007

The total livestock population of Tamil Nadu is about 245.70 lakh and poultry population is 865.91 lakh (Livestock Census 2004). There are 139 veterinary hospitals, 1167 dispensaries and 22 clinical centres for livestock in the state of Tamil Nadu (2006-07).

4.4.2 Fishery

The fishery units like freezing plants, cold storage facilities and fisheries training centers have been developed in the state both by government and private institutions. The statistics of fish production in the state is presented in **Table 4.5**.

Table 4.5: Production of Fish
 (In Metric Tonne)

Type	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07
1	2	3	4	5	6	7	8
Inland		59,267	68,802	77,561	86,851	155,943	160,171
Marine	372,402	373,861	379,214	381,148	307,693	389,714	392,191

Source: Statistical Handbook of Tamil Nadu, 2007

4.4.3 Forestry

The forest area in the state is 22,883.51 sq. km. forming 17.59 percent of the land area of the state. This includes 19,444.60 sq. km. of reserved forests. Major forest products are Timber, Pulpwood and Firewood. The production statistics of major forest products are shown in **Table 4.6**.

Table 4.6: Major Forest Products

(In Metric Tonne)

SN	Product	2005-06	2006-07
1	2	3	4
1	Teakwood	7749	6411
2	Pulpwood	93394	29594
3	Firewood	20549	63105
4	Sapwood	94	97
5	Heartwood	332	616
6	Water bark	3439	446
7	Charcoal wood	575	-
8	Babul	48149	80029
9	Cashew	176	4160
10	Tamarind	904	3878
11	Others	839	677181
Bamboo ('000)		149	3.7

Source: Statistical Handbook of Tamil Nadu, 2007

4.4.4 Minerals

The major minerals produced in the state of Tamil Nadu are Phosphorus, Coal and Silica Sand. The contribution from minerals in the state economy is very nominal. The statistics of the minerals produced in the state are given in **Table 4.7**.

Table 4.7: Production of Minerals

(Quantity in Thousand Tonnes and Value in Lakh Rupees)

SN	Minerals	2004-05		2005-06	
		Quantity	Value	Quantity	Value
1	Lignite	21,567	169,340	20,437	160,467
2	Natural Gas (UT)	628	18,840	868	26,040
3	Petroleum (Crude)	391	21,779	385	21,445
4	Bauxite	309,910	335	299,613	305
5	Ball Clay	4,920	7.38	6,953	10.43
6	Dunite	11,648	26.31	26,418	34.99
7	Felspar	4,033	8.91	2,518	6.55
8	Fire Clay	43,160	34.76	29,912	21.17
9	Garnet	578,863	1,487	662,530	1,747
10	Graphite	44,010	122	58,530	179
11	Gypsum	9,097	22.34	-	-
12	Limestone	15,199	18,369	15,555	19,589
13	Lime Kankar	467,721	8,653	341,429	334
14	Magnesite	311,203	3,059	287,058	4,360
15	Quartz	11,055	35.89	12,210	38.56
16	Silica Sand	11,531	15.10	32,438	106.28
17	Steatite	3,120	4.68	750	1.13
18	Sulphur	19,874	-	43,852	-
19	Vermiculite	1,854	44.03	1,416	33.63
20	Minor Minerals	-	6,090	-	6,090
All Minerals		-	240,485	-	240,809

Source: Statistical Handbook of Tamil Nadu, 2007

4.4.5 Industry

The government of Tamil Nadu has given due importance to the growth of the large-scale industry to make full use of liberalization policy of the government of India. In case of small-scale industry, there is substantial growth in the recent past. The statistics of large-scale industry and small-scale industry is shown in **Table 4.8 and 4.9** respectively.

Table 4.8: Large-Scale Industry

Year	No. of factory	Employment (Nos.)	Value of input (Rs. in crore)	Value of output (Rs. in crore)	Net value added (Rs. crore)
1	2	3	4	5	6
1988-89	14,423	905,000	15,291	19,701	3,658
1989-90	14,766	942,000	18,591	24,367	4,866
1990-91	15,938	1,081,000	20,890	27,702	5,805
1991-92	15,506	1,229,000	25,290	32,496	6,065
1992-93	16,651	1,075,000	29,381	38,377	7,674
1993-94	18,099	1,152,000	35,002	45,200	8,846
1994-95	19,177	1,375,000	44,364	57,752	11,562
1995-96	19,301	1,211,000	52,200	67,478	13,205
1996-97	19,202	1,266,000	57,560	74,212	13,487
1997-98	19,406	1,348,000	75,920	89,654	10,363
1998-99	20,478	1,169,000	57,376	73,996	12,321
1999-00	20,217	1,108,000	76,335	94,549	14,788
2000-01	20,601	1,136,000	83,268	103,539	16,536
2001-02	18,912	1,096,000	76,153	94,360	14,521
2002-03	19,550	1,125,000	88,734	108,075	15,100
2003-04	20,246	1,162,594	106,080	129,937	19,101
2004-05	21,053	1,268,335	132,569	159,507	21,567

Source: Statistical Handbook of Tamil Nadu, 2007

Table 4.9: Small-scale Industry

Year	No. of Factory	Employment	Capital Investment (Rs. Crore)	Value of output (Rs. Crore)
1	2	3	4	5
2000-01	420,000	3,000,000	12,500.00	21,537.00
2002-03	449,000	3,142,000	12,569.24	89,781.00
2003-04	475,000	3,418,000	13,291.50	94,939.80
2004-05	489,000	3,526,000	14,397.31	99,496.77
2005-06	511,351	3,593,382	16,102.51	103,911.64
2006-07	530,552	3,703,408	16,816.92	105,979.51

Source: 1. Department of Industries and Commerce, Chennai - 5.
 2. Economic Survey, GOI, New Delhi.

4.4.6 Electricity

Power sector in Tamil Nadu has been given a priority recently by the government, as the power shortage is a major bottleneck for the development of the state.

The total installed capacity of electricity in the state has been increased from 6,090 MW in 1992-93 to 10,098 MW in 2006-07. The Generation of Electricity in the State has been increased from 16,958 MKWH in 1992-93 to 29,481 MKWH (Million Kilo Watt Hour) in the year 2006-07.

The per capita consumption of electricity during the year 2006-07 was 960 KWH.

All villages (16317) in the state of Tamil Nadu as on 31.03.2005 have been electrified, which is 100 percent.

Table 4.10: Development of Electricity

Year	Installed Capacity (MW)	Annual Gross Generation (MKWH)	Purchases (MKWH)	Per Capita Consumption (KWH)
1	2	3	4	5
1992-93	6,090	16,958	7,257	370
1993-94	6,158	17,628	8,087	380
1994-95	6,578	19,917	9,158	390
1995-96	6,908	21,975	9,146	410
1996-97	6,908	22,953	9,747	420
1997-98	6,916	23,066	10,999	430
1998-99	7,120	22,141	13,031	452
1999-00	7,204	23,549	14,764	480
2000-01	7,513	25,147	16,617	510
2001-02	7,924	25,562	18,358	708
2002-03	8,268	24,929	21,263	740
2003-04	9,319	24,114	25,384	780
2004-05	9,531	26,450	25,895	815
2005-06	10,031	26,915	29,091	860
2006-07	10,098	29,481	33,357	960

Source: Statistical Handbook of Tamil Nadu, 2007

4.4.7 Tourism

Tamil Nadu is the land of the Tamils and it has a history that dates back to several thousand years. It is a land where traditions and culture blend and continue to live in harmony. The state abounds in monuments and temples that are ancient and each has its own story of religious, artistic and cultural accomplishment and specialty waiting to be heard.

Tamil Nadu offers an endless array of attractions to the tourist by way of Long beaches, a wealth of ancient temples and viharas, hill stations, rich flora and fauna. Kanchipuram, Madurai, Meenakshipuram, and Ramesawram combine religious and architectural marvels; Indira Gandhi National Park & Sanctuary, Guindy National Park head a long list of wildlife parks and sanctuaries.

Tamil Nadu has a long coastline that stretches nearly a 1000 kms. The Coromandel Coast, along the Bay of Bengal, boasts of many ideal locations for sun and surf. Golden sands of the beach are dotted with coconut palm and casuarina groves. The sea washes ashore pebbles and shells and the gentle breeze sways the yachts and catamarans into the deeper waters of the sea and the waters form small dunes on the shore. Crabs play hide-and-seek by coming out of one burrow, and taking refuge in another. Sea gulls hover in the sky and then rest on the sails of the fishing boats. There are many more breathtaking sights that will please you and hold you spell bound in Tamil Nadu.

The state has many temples dedicated to Lord Muruga and some of these are in rarefied environs. The journey to the Aruppadaai Veedu or the Six Houses of Lord Muruga may be arduous but it has its own rewards. The six abodes of Lord Muruga are located in Thiruthani, Swamimalai, Thiruchendur, Pazhamudhir Cholai, Tirupparankundram and Palani. All these places are well connected by road and other means of transport.

In Tamil Nadu during 2005, 32,339,478 domestic and 1,179,319 foreign tourists visited the state. During 2006, 39,214,721 domestic and 1,335,661 foreign tourists visited the state registering a substantial increase of 20.98 percent in tourist arrivals. The state government has considered major improvement measures to attract the domestic as well as foreign tourists.

4.4 Social and Community Services

Education has been acknowledged to have a multiplier effect on other social sectors like health, women development, employment, child development, labour etc. It has also of great instrumental value in the process of economic growth and development. Education not only improves the quality of life of the people, it also provides opportunities for progress.

4.5.1 Education

The literacy rate (73.5 percent) of Tamil Nadu is above the national average (65.4). The female literacy rate is 64.4 percent against national average of 54.16 percent, in case of male; it is 82.4 percent compare to the national average of 75.8 percent. To eradicate the illiteracy, the government has introduced a policy named "Education for All", which makes it compulsory for parents to send their ward to school. The primary, secondary and higher secondary schools in 2006-07 are 43272, 5095 and 4736 respectively. The number of colleges is 1023 in 2006-07.

4.5.2 Health

Tamil Nadu has not made good progress in the field of basic health facilities in the last decade. The government has put more emphasis on improvement of health by taking several health programmes recently. There are 329 hospitals, 215 dispensaries, 1417 primary health centres, 8683 Health sub-centres and 13 other medical institutions in the state of Tamil Nadu in 2006-07.

4.5.3 Housing

The economically weaker sections have been given due attention in the matter of housing. Tamil Nadu Slum Clearance Board was set up in 1970 for the clearance and improvement of slum areas by providing one room tenements for the people leaving in slums, which is being implemented in the urban areas in Tamil Nadu.

The Tamil Nadu Slum Clearance Board over the last 2 years has constructed 12877 tenements under various schemes. During the next 3 years Tamil Nadu Slum Clearance Board has programmed to construct over 60,000 houses under various schemes in the urban areas of Tamil Nadu at a total cost of Rs. 2000 Crore.

4.5.4 Transport Infrastructure

4.5.4.1 Railways

The total route length of railway lines in the State is 2317 km of Broad Gauge and 1624 km of Metre Gauge. Out of total route length, 950 km is electrified as on 2006-07

The Southern Railways headquarters is in Chennai. Large part of Indian Peninsula covering the states of Tamil Nadu, Kerala, Pondicherry, a major portion of Karnataka and a small portion of Andhra Pradesh falls in its network.

Chennai, the capital city in the state is connected to both broad and Metre gauge rail network of the country. There are 528 railway stations in the state. Main railway stations in the State are Chennai, Madurai, Tiruchirapalli, Salem, Coimbatore, etc. The city is linked with broad gauge railway lines to cities like New Delhi, Mumbai, Kolkata, Cochin, Thiruvananthapuram, Hyderabad, Bangalore, Coimbatore, Lucknow, Guwahati etc. Meter gauge rail services are there in Chennai, Tuticorin, Madurai, Rameshwaram and Tirunelveli.

4.5.4.2 Roads

Road Network of Tamil Nadu is most widespread extending around 170000 km. Private and government buses well connect the whole of Tamil Nadu. The State Express Transport Corporation connects Chennai with Karnataka, Kerala, and Andhra Pradesh Apart from this a number of national and state highways make traveling very easy from major metropolis like new Delhi, Kolkata, Mumbai.

The total length of roads in the State has been increased from 151137 kms in 2000-01 to 191947 kms in 2006-07. Out of the total road length of 191947 kms, the length of surfaced roads is 154959 kms (81 per cent). The 36988 kms of un-surfaced roads constitute about 19 per cent of the total road length. The following **Table 4.11** gives the categories of road from the year 2001-02 to 2007-08 in the state.

Table 4.11: Length of Roads

(In km)								
Sr. No.	Categories	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
1	2	3	4	5	6	7	8	9
1.	National Highways	3758	3758	4183	4183			4462
2.	State Highways				7223			
3.	Major District Roads				7376			
4.	Other District Roads				41156			
	Total		92008	96529	102433		154959	

4.5.4.3 Motor Vehicles

The number of registered motor vehicles has increased from 43.94 lakh in 1999-00 to 89.73 lakh in 2006-07, showing annual growth of 10.74 per cent over the year 1999-00. About 83 per cent of the total registered vehicles were motorcycle class vehicles (two wheelers). **Table 4.12** gives the Number of vehicles registered class-wise from the year 1999-00 to 2006-07 in the State. Examination of the pattern of annual growth rates registered by different types of vehicles showed that trucks, buses, cars/taxis, and motor cycles have grown at 9.18 percent, 7.75 percent, 11.56 percent and 10.72 percent respectively.

Table 4.12: Number of Motor Vehicles Registered

SN	Class of Vehicles	As on 31 st March								
		1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	Annual Growth rate (%) 1999-00 to 2006-07
1	2	3	4	5	6	7	8	9	10	11
1	All Freight	183476	188238	189050	195047	204886	220016	272756	339334	9.18
2	Bus	25861	28958	29941	32061	33508	33930	38710	43609	7.75
3	Car/Taxi	505196	550369	592263	640775	682134	734899	924581	1086221	11.56
4	Motor Cycle	3679525	4163002	4600565	5084043	5547755	6106057	6750328	7503426	10.72
	Total	4394058	4930567	5411819	5951926	6468283	7094902	7986375	8972590	10.74

4.5.4.4 Civil Aviation

Chennai has an international airport which links it with all the capital cities in India and also it is linked intra state with Trichy, Madurai, Salem and Coimbatore. This has made the whole of the state of Tamil Nadu easily reachable. You can plan to visit any part of the state. The Chennai International Airport is well connected with more than 19 countries in the world and has 169 direct flights weekly. International airlines from countries like Sri Lanka, Dubai, Germany, Jakarta, Malaysia, England, Maldives, Saudi Arabia, and Singapore arrive here. Moreover industrial development has increased passenger traffic and freight traffic, lending more importance to this airport. In addition, the state has many aerodrome located in different regions of the state.

4.5.4.5 Port

Tamil Nadu has three major ports at Chennai, Ennore and Tuticorin, as well as one intermediate port, Nagapattinam, and seven minor ports, Rameswaram, Kanyakumari, Cuddalore, Colachel, Karaikal, Pamban and Valinokkan which are currently capable of handling over 73 million metric tonnes of cargo annually (24 per cent share of India). All the minor ports are managed by the Tamil Nadu Maritime Board. Chennai Port is an artificial harbour situated on the Coromandel Coast in South-East India and it is the second principal port in the country for handling containers. Ennore Port was recently converted from an intermediate port to a major port and handles all the coal and ore traffic in Tamil Nadu. The volume of cargo in the ports grew by 13 per cent during 2005. The ports are in need of improvement and some of them have container terminals privatized.

4.6 Economic Prospective

4.6.1 Past Growth

The past performance of the state economy of Tamil Nadu has been studied by analyzing time series data on NSDP and income originating from the main economic sectors. Average annual growth rates for different time periods are worked out from regression equations fitted to time series data of state incomes at constant (1999-00) prices for NSDP, agriculture and manufacturing. The growth rates obtained for different time periods are shown in **Table 4.13**.

Table 4.12: Growth Rate of State Income (%)

Period	NSDP	Primary	Secondary	Tertiary
1999-00 to 2006-07	5.13	1.47	4.11	6.66
2000-01 to 2006-07	2.07	0.57	3.81	6.88
2001-02 to 2006-07	6.52	1.57	7.26	7.61
2002-03 to 2006-07	8.06	7.84	7.01	8.55
2003-04 to 2006-07	8.67	11.11	6.54	9.04
2004-05 to 2006-07	7.33	7.41	6.51	7.67
2005-06 to 2006-07	7.36	4.53	6.93	8.24

The state of Tamil Nadu achieved an average growth rate of 5.13 percent in the last seven year period i.e. 1999-00 to 2006-07. The state has lagged behind the national average growth rate of GDP during the same period. The secondary (manufacturing, electricity and construction) sector has shown an impressive growth rate over different periods of time, 7.01 percent since 2002-03 and 7.26 percent since 2001-02. The primary (agriculture and mining) sector of state showed growth rate of 1.47 percent since 1999-00 and impressive growth rate of 7.84 percent since 2002-03.

4.6.2 Future Growth

The state economy of Tamil Nadu has exhibited the growth rate since 1999-00 of 5.13 percent. The growth rate since 2002-03 was 8.06 percent. The tenth five-year plan (2002-07) had set a target of 8 percent for the national economy as well as for the state of Tamil Nadu which has been achieved. The eleventh five-year plan (2008-12) has set a target of 8.38 percent for the national economy. The targeted growth rate of 8.38 percent is being revised to around 8 percent due to slowdown on global economy. Accordingly, the state government in its eleventh five-year plan has decided to keep a target of 8 percent annual growth. The state plan targets appear most likely in the present circumstances. Hence, in view of the past (tenth five-year plan) performance of the state, it is likely that the state economy will be able to achieve an average annual growth rate of 8 percent during 2008-12. The state economy will strengthen to continue to grow at 7 percent atleast during 2008-12 before decelerating at around 6 percent. As against this, in the pessimistic scenario of low growth, the state income will be stabilizing at 5 percent. In the optimistic scenario of high growth, the state economy will continue to have growth rate of 8.5 percent in 2008-13 and decelerate to 7.0 percent in later years.

The primary sector has exhibited a growth rate of 1.47 percent since 1999-00. The performance of agricultural sector is dependent on monsoons and it is difficult to predict its future. The eleventh five-year plan of the national economy has set a target of 4.0 percent for agricultural sector in the state. However, the eleventh five year plan for the state has geared up for a target of 4.0 percent during 2008-012 before decelerating to 3.0 percent during 2013-18 and 2.5 percent thereafter. In the pessimistic scenario, this sector will have growth rate of 3.0 percent, with an exception in 2008-12 when it will touch a high of 3.5 percent and later decelerate to 2.0 percent. In case of optimistic scenario of high growth, the agriculture sector will grow at 4.0 percent initially then decelerate to 3.5 percent.

The secondary sector of Tamil Nadu has exhibited a growth rate of about 4.11 percent since 1999-00. The eleventh five-year plan of the national economy has set a target of 9.2 percent for the state. The state of Tamil Nadu in its eleventh five-year plan has decided to keep a target of 9.2 percent for this sector. Recently, the state is geared to transform itself into a competitive

industrial economy. The state government is taking major steps towards providing infrastructure of high quality on a large scale and developing industrial corridors as areas of excellence. The state of Tamil Nadu has enjoyed a third position during the last few years as far as attraction of large and medium industries are concerned. Keeping all these under consideration, it is expected that the manufacturing sector of the state will certainly grow at 9.0 percent till 2013 before decelerating in later years. In pessimistic scenario, growth rate will vary between 7.5 and 6.0 percent. In case of optimistic scenario of high growth, the manufacturing sector will grow at 10 percent till 2013 and later slowly decelerate to 8.0 percent beyond 2018.

The perspective growth rates for NSDP, agriculture and manufacturing sectors for the state of Tamil Nadu for three scenarios are shown in Table 4.14.

Table 4.13: Future Growth Rates

(In percentage)

Period	Pessimistic Scenario-Low Growth			Base Case (most likely Scenario)-Medium Growth			Optimistic Scenario-High Growth		
	NSDP	Agriculture	Industry	NSDP	Agriculture	Industry	NSDP	Agriculture	Industry
2008-13	5.0	3.5	7.5	8.0	4.0	9.0	8.5	4.0	10.0
2013-18	4.5	3.0	7.0	7.0	3.0	8.0	8.0	3.5	9.0
Beyond 2018	4.0	2.0	6.0	6.0	2.5	7.0	7.0	3.0	8.0

Chapter -5

Design Standards

CHAPTER – 5

Design Standards and Specifications

5.1 General

The various design elements and factors, which govern the functioning of any highway, can be broadly grouped under the following:

- Cross-sectional layout;
- Land-use and access control;
- Geometric design, alignment and profile;
- Pavement design;
- Drainage;
- Bridges and structures/ROBs/RUBs/viaducts;
- Interchanges and intersections;
- Traffic control and safety measures;
- Wayside facilities;
- Aesthetics;
- Socio environmental design and mitigation;
- Service and side roads;
- Pedestrian facilities.

The basic design philosophy is based on the consideration of providing suitable alignment, cross-sectional layout, geometric, safety and partially access control to cater to the fast and uninterrupted movement of through traffic. It is also based on the consideration that the widening proposals should be to the extent feasible within the present Right of Way.

The objectives for 6-laning with upgrading and rehabilitation works of the project as “partially access controlled highway” is:

- Segregation of fast moving and slow moving traffic;
- Segregation of through traffic from local traffic;
- Mobility and safety of NH users and cross traffic;
- Satisfy traffic carrying capacity for 25 years (2007-2031);
- Avoiding or limiting traffic disruption during construction activity;
- Facilities for pedestrians to travel along and across the NH sections.

The consultants have designed in the past several National Highway projects in India, which have been taken up for widening to 6 lanes under civil and BOT projects. A review of those projects in respect of design standards is considered useful in formulating the standards for the present project. The design standards would comply with the relevant IRC codes, as adopted in similar projects of NHAI and as proposed by NHAI for this particular project.

5.2 Geometric Design Standards

Design standards for the highways call for an in-depth study of available and internationally adopted criteria for economy and safety. The consultants initiated the study in this direction and the broad criteria emerging out of them, and proposed for the project road are given in this section. The relevant standards consulted include:

- **IRC**

IRC: 5-1998

For General Features of Design

IRC: 6-2000

For Loads and Stresses

IRC: 18-2000	For Pre-stressed Concrete Road Bridges
IRC: 21-2000	For Reinforced Concrete Design
IRC: 28-1967	For Construction of Soil Stabilised Roads with Soft Aggregates in Moderate & High Rainfall Areas
IRC: 36-1970	For Earthen Embankments
IRC: 37-2001	For Pavement Design
IRC: 38-1988	For design of horizontal curves for highways and design tables
IRC: 54-1974	For Lateral and Vertical Clearance at Underpasses
IRC: 62-1976	For Control of Access on Highway
IRC: 64-1990	For Capacity of Roads in Rural Areas
IRC: 65-1976	For Traffic Rotaries
IRC: 66-1976	For Sight Distance on Rural Highways
IRC: 73-1980	For Geometric Design Standards for Rural Highways
IRC: 75-1979	For Design of High Embankment
IRC: 78-2000	For Substructure and Foundations
IRC: 81-1997	For Strengthening of Flexible Road Pavements
IRC: 83-1987 (Part II)	For Elastomeric Bearings
IRC: 83-2002 (Part III)	For POT-Cum-PTFE Bearings
RC: 86-1983	For geometric design for urban roads in plains
IRC: 108-1996	Traffic Predictions on Rural Highways
IRC: SP: 13-2004	Guidelines on the design of Small Bridges and Culverts
IRC: SP: 19-2001	For Survey, Inventory and Preparation of Road Projects
IRC: SP: 23-1983	For Vertical Curves for Highways
IRC: SP: 44-1994	Highway Safety Code

- **AASHTO**

Guide for Design of Pavement Structure, 1993.

A Policy on Geometric Design of Highways and Streets, 1990

- **Ministry of Shipping, Road Transport & Highways**

Manual for Specifications and Standards for Six Laning of National Highways through Public Private Partnership (PPP), Government of India, Department of Road Transport & Highways

5.2.1 Terrain

The project stretch under consideration passes through flat/plain terrain. The design speed is the guiding criteria for correlating features such as sight distance, curvature and super elevation upon which the safe operation of the vehicle depends. The design speeds for plain terrain have been proposed as tabulated in **Table 5.1**:

Table 5.1: Design Speed

Ruling	100 km/hr.
Minimum	80 km/ hr.

5.2.2 Cross-Sectional Elements

5.2.2.1 Right of Way (ROW)

The desirable width of road land (right of way) for the stretches of project road, located in open areas and built up areas is as given in **Table 5.2**:

Table 5.2: Desirable Road Land widths

Terrain	Open areas		Built up area	
	Normal	Exceptional	Normal	Exceptional
Flat/Plain	60		45	

In present case, the project requirement is to provide 2x3-lane carriageway configuration. 2x3-lane carriageway would be designed and accommodated in pair at locations where the proposed improvement would need minimal height/depth of construction of banks/cuts on the terrain.

A minimum right-of-way (ROW) width of 60m is desirable for the National Highway for widening of existing road. As per new policy of NHAI, the ROW in proposed bypasses should be minimum 60m. No new bypass is being proposed in this project. The ROW is required to be suitably increased to accommodate, junctions, interchanges, rest areas, toll plazas etc.

The existing ROW, in general, along the project road is around 45-60m except for few built-up locations, where it is found to be around 40m. Accordingly various typical cross sections are proposed for the construction of 2x3-lane carriageway configuration “partially access controlled highway”.

5.2.2.2 Traffic Lanes, Carriageway Width and Shoulders (Cross Section)

The highway is proposed to be upgraded to 6-lane with service road all along the project road. The Consultants have studied various alternatives provided/proposed in similar projects and other design standards and are of the opinion that the minimum effective roadway width for the project road derived and recommended as in **Table 5.3**:

Table 5.3: Cross-sectional elements for Main Carriageway

6-Lane Highway		2 x 10.5m = 21.00m
Edge Strip		2 x 0.25 = 0.50m
Median Width	Built – up areas	1.30m
	Rural areas	4.50m
Shoulder Width	Paved	2 x 1.50m = 3.00m
	Earthen	2 x 2.00m = 4.00m
Roadway Width	6-Lane Highway	29.80m/33.00m

Camber / Cross Fall

The values of camber proposed to be applied on straight (i.e. without super-elevation) sections would be as given in **Table 5.4**.

Table 5.4: Camber / Cross-fall

Element	Camber
Carriageway & Paved Shoulder	2.5 %
Unpaved (Earthen) shoulder	3.0 %

On curves, the shoulder on the high side of super-elevated portion shall be provided with reverse slope from the super-elevated carriageway portion. At the

same time it should not be too great to give break in the cross slope. The rate of change between pavement cross slope and outside shoulder should not exceed 5%.

Service Roads

Service road shall be proposed for the entire length of the project road except for the long rural stretches for effective segregation of traffic and to enforce partial access control measures. Carriageway width of 7.0m is proposed with footpath of 1.5m/2.50m width depending on local traffic movement expected. A separator of 1.5m/ 2.0m is proposed. Details of service road geometric standards are discussed under paragraph 5.2.8.

Median Width

A median width of 4.5m raised, flanked with 0.5m paved on either side is proposed to be adopted. The 0.5m paved median or “fast-side shoulder” allows for increased kerb shyness over the 0.25m provided by the MoRT&H circular. In built up areas and where adequate land width is not available, the raised median may be restricted to 1.3m. *However, on the insistence of NHAI, the kerb shyness has been reduced to 0.25m.*

5.2.3 Horizontal Alignment

Horizontal alignment essentially comprises of three major elements: tangent sections, circular curve and transition curve elements. A balanced control on the above elements is required to provide safe and continuous flow of vehicles under the general traffic conditions. The horizontal alignment of the existing 2x2 lane project road shall be followed up to maximum extent and wherever there will be need to improve the existing alignment, the design parameters governing the curve elements will be as in **Table 5.5**:

Table 5.5: Design Parameters for Horizontal Curve

SN.	Design Elements	Design Speed, Km / h		
		Flat / Plain / Rolling Terrain		
		100	80	65
1	Radius of Horizontal curve			
	• Ruling/Absolute Minimum	360/230 m	230/155 m	155/90 m
	• No transition curve	2000m	1200 m	800 m
2	Max. super elevation (e)	5.0%	5.0%	5.0%

Minimum Transition Length

The minimum transition length for a curve radius of 360m in flat/plain terrain should be 120m and 95m for speeds of 100 km/hour and 80 km/hour respectively. In case of curve radius of 230m, the minimum transition length should be 95 m for the speed of 80 km/hour.

The minimum transition length for different speeds and curve radii shall be as in **Table 5.6**:

Table 5.6: Minimum Transition Length

Speed	Curve radius (m)	Minimum transition length (m)
100 km/hour	360	120
80 km/hour	230	95

Broken-back curves will be avoided to the extent possible. Minimum curve length would be 150m for a deflection angle of 5 degrees and this would be increased by 30 metres for each one-degree of decrease. No curve is required for deflection angle of less than one degree.

Grade Compensation at Curves

At horizontal curves, the gradients would be eased by an amount known as the 'grade compensation', which is intended to offset the extra tractive effort, involved at curves. This may be calculated from the following formula:

$$\text{Grade Compensation (per cent)} = (30 + R)/75$$

Subjected to a maximum of 75/R, Where, R = Radius of the curve in metres

Since grade compensation is not necessary for gradients flatter than 4 percent, when applying grade compensation correction, the gradients need not be eased beyond 4 percent.

Widening at Curves

At sharp horizontal curves, it is necessary to widen the carriageway to facilitate safe passage as given in **Table 5.7**:

Table 5.7: Extra Widening at Curves

Radius of Curve (m)	Up to 40	41 to 60	61 to 100	101 to 300	Above 300
Extra Width (m) – Two lane road	1.5	1.2	0.9	0.6	Nil

Stopping Sight Distance

- a) For speed 100 km / hour: 180 m
- b) For speed 80 km / hour: 120 m

In case of valley curves, the distance, which should be illuminated by vehicle headlight during travel, should not be less than 180 m. For this purpose, the height of head light above road surface shall be taken as 0.75 m.

Setback Distance at Horizontal Curves

The minimum setback distance from the centre line of the carriage way to the object obstructing the line of sight will be as under:

Parameters	Setback distance
a) V = 100 km/hr. S = 180 m R = 360 m	13 m

- b) $V = 80 \text{ km/hr.}$
 $S = 120 \text{ m}$ 9 m
 $R = 230 \text{ m}$
 $V = \text{Design speed in km / hr.}$
 $S = \text{Safe stopping sight distance}$
 $R = \text{Radius of curve}$

Where horizontal and summit vertical curves overlap, the design should provide for the required sight distance both in vertical directions along the pavement and in horizontal direction on the inside of the curve.

5.2.4 Vertical Alignment

Standard considerations of designing the vertical alignment with smoothness in longitudinal profile, infrequent change of grades, avoidance of short valley curve in an otherwise continuous profile, avoidance of broken back grade lines, carrying the decks of small structures following the same profile as the flanking road section, and co-ordination with horizontal alignment, will be followed. Detailed design of vertical curves will be carried out as part of the Feasibility Report for the Project.

There are two major elements in vertical geometry of an alignment *i.e.* longitudinal gradient and vertical curve. The following gradients for Flat/Plain terrain conditions are given in **Table 5.8**.

Table 5.8: Gradients for Flat / Plain Terrains

Classification of Gradient	Gradients for Different Terrain
	Plain / Rolling
Ruling gradient	3.3% (1 in 30.0)
Limiting gradient	5% (1 in 20.0)
Exceptional gradient	6% (1 in 15.0)

Gradients up to the “ruling gradient” would be used as a matter of course in design. The limiting gradients would be used where topography of a place compels this course or where the adoption of gentler gradients would add enormously to the cost. Further, the steepest gradient or “exceptional gradient” is meant to be adopted only in very difficult situations and for short lengths not exceeding 100m at a stretch.

Check would be applied on overall gradients, as the rise in elevation over a 2-km length shall not exceed 120m in project terrain.

The vertical curve would be provided at all grade changes exceeding those indicated in **Table 5.9**.

Table 5.9: Minimum Length of Vertical Curves for Different Speeds

Design Speed (km / h)	Maximum grade change (percent) not requiring a vertical curve	Minimum length of vertical curve (m)
80	0.6	50
100	0.5	60

5.2.5 Lateral and Vertical Clearances

Lateral and vertical clearances for the roads at the locations of underpass and grade-separators are proposed as per Indian Roads Congress Standards IRC: 54-1974, IRC: 73-1980 and IRC: 5-1998. The recommended lateral and vertical clearances for the project are given in **Table 5.10**:

Table 5.10: Lateral and Vertical Clearances

Road Category	Lateral Clearance (m)		Vertical Clearance (m)
	Normal	Exceptional	
Vehicular Underpasses			
National/ State Highways	10.5	7.5	5.0
Major/Other District Roads	10.5	7.5	5.0
Non-Vehicular Underpasses			
Village Roads	4.0	-	2.5 – 4.5
Non-vehicular crossings	4.0	-	2.5 – 4.5

5.2.6 Standards for Interchange Elements

Access Control

In order to offer a high-speed corridor for through traffic, there is a need for partial control of access. The accesses are provided through predetermined openings for side roads or through grade separated interchanges. New bypasses proposed as fully access controlled facility.

The design standards of the interchange elements viz. direct ramps, loops; speed change lanes are given hereunder:

Speed, Radius and Sight Distance

The proposed design standards for these elements are compiled in **Table 5.11**.

Table 5.11: Speed, Radius and Sight Distance for Interchange Elements

	Design Speed (km / hr)	Radius (m)	Stopping Sight Distance (m)
Desirable (Ramp)	80	230	120
Desirable (Loop)	60	130	80

The desirable values are normally meant for Direct Ramps and diagonal connections, whereas the minimum values are for loops.

Gradient

Maximum gradients proposed are:

Desirable = 4%
 Absolute Maximum = 6%

Summit and Valley Curves

Both summit and valley curves would be designed as per stopping sight distance subject to a minimum length equal to $0.6 V$, where V = Design Speed in km/h.

Cross Sectional Elements

The desirable carriageway width for three lanes is 10.5m. The width of shoulders i.e. treated and un-treated would be 1.5 m and 2.0 m respectively. The recommended cambers are 2.5% and 3.0% for carriageway and untreated shoulder portions, respectively.

Length of the Speed Change Lanes

The lengths of the speed change lanes recommended are given in **Table 5.12**:

Table 5.12: Speed Change Length

Description	Design Speed (km / hr)	Radius	Stopping Sight Distance	Speed Change Lane	
				Acceleration Lane (m)	Deceleration Lane (m)
Ramp	80	230	120	300	130
Loop	60	130	80	400	150

5.2.8 Standards for Service Road

The following design standards are proposed for parallel service roads where required are given in **Table 5.13**:

Table 5.13: Cross-sectional elements for Service Roads

Design Speed (km / h):	Desirable:	40
	Minimum:	25
Horizontal Radius (m)	Desirable:	130
	Minimum:	60
Gradient (%)	Ruling:	3.0 %
	Maximum:	3.3 %
	Underpass approaches	2.0% (Ruling) 3.3% (Maximum)
Carriageway	Two lane:	7.00 m
Shoulder	Paved	2x0.50m
Footpath	Desirable:	2.50 m
	Minimum:	1.50 m
Separator between service road and main carriageway	Minimum:	1.50m/2.00m
Extra Widening	To be provided at flares for Underpass approaches, adequate turning radius, U-turn facility etc., as per requirement	

5.3 Design Service Volume

5.3.1 General

The prevailing roadway and traffic conditions that influence the traffic flow in a particular segment would include the geometric features, lane width, lateral clearances on edges of carriageway, percentage composition of various traffic category and driver characteristics. Restricted lane width and lateral clearance influence the traffic flow as the vehicles would be forced to travel closer and shy away from the roadside objects resulting in reduced speed. The project road is proposed with 3.5m wide lanes and 1.5m wide paved shoulders. The horizontal and vertical profiles of the access - controlled highway would be designed adequately to meet the design speed requirements. Therefore, it is proposed to follow the capacity norms recommended in the IRC publication 64-1990-'Guide lines for capacity of Roads in Rural Areas.'

5.3.2 Design Service Volume for Two Lane, Four Lane and Six Lane Facility

The IRC 64-1990 has recommended the design service volumes as given in **Table 5.14**:

Table 5.14: Design Service Volume as per IRC: 64-1990

Carriageway Width	Terrain	Curvature (degree / km)	Design Service Volume (PCU / Day)	
			LOS B	LOS C
Two Lane	Plain	a) Low (0-50) b) High (> 51)	15000 12,500	-
2x2 lane	Plain	Low (0-50)	35,000(1.5m earth shoulder) 40,000(1.5m paved shoulder)	49,000(1.5m earth shoulder) 56,000(1.5m paved shoulder)
2x3 lane	Plain	Low(0-50)	52,500(1.5m earth shoulder) 60,000(1.5m paved shoulder)	73,000(1.5m earth shoulder) 84,000(1.5m paved shoulder)

The capacity values mentioned above relate to LOS (Level of Service) B. Normally, it will not be desirable to adopt LOS C on dual carriageway. These values of Design Service Volume have been kept in view while considering improvement proposals for the project road.

5.4 Pavement Design

6.4.1 General

The general design procedure is to be based on the prevalent practices in the country and abroad. The pavement will be designed in accordance with IRC: 37 -2001 "Guidelines for the Design of Flexible Pavement". The design of pavement will be checked using semi-mechanistic approach recommended in "Guide for Design of Pavement Structure", American Association of State Highway and Transportation Officials (AASHTO), 1993.

5.4.2 Construction Methods and Maintenance.

Construction and Improvement of the proposed highway generally conform to the Specifications for Road and Bridge Works (fourth revision-August 2001) of MoRT&H to ensure higher level of service with minimum interference to the traffic. Modifications in certain aspects e.g. sub-grade compaction; pavement materials, shoulder, quality control, etc. are required to suit the requirements of the proposed pavement and shoulder construction. The construction methods would include proper equipment, plant and machinery for achieving quality and efficiency, and these will be dealt in detail in framing specifications and guidelines during detailed engineering stage.

5.4.3 Sub-grade Strength

The existing 2X2-lane section of the project road would need strengthening, and the proposed widening to 2x3-lane carriage way will be built from embankment onwards. Wherever new formation is built, adequate freeboard would be ensured. The sub-grade strength and other parameters related to checks on the sub-grade soil would be examined in a comprehensive manner during preparation of preliminary design report. Broad field checks have been carried out for the purpose of preliminary design for this report.

5.4.4 Material Characteristics

The pavement will be proposed to have granular base and sub-bases with asphalt surfacing courses. To determine the strength characteristics, preliminary material investigation and analyses of laboratory test results would be done during the detailed design stage. For other materials like bitumen, cement, etc. standard values would be assumed. All materials would be tested before incorporation in works during actual execution.

5.4.5 Overlay Design

In the case of design of overlay on existing pavements, the design both by CBR and Benkelman Beam Deflection methods would be compared and suitable recommendations will be made.

5.4.6 Design Traffic

The traffic along the various sections of the project road would be worked out on the basis of the traffic studies carried out under the present study. The design life of the pavement would be proposed for 25 years (2008-2032) for flexible pavement with 2011 as the year of opening to traffic (first year of operation).

The design traffic will be estimated in terms of equivalent 8.16 t standard axles expected on the design lane.

5.4.7 Structural Design

Pavement structure would be designed based on the sub-grade strength, material characteristics and the design traffic. The pavement thickness requirements would be worked out as per the following methods:

IRC 37: 2001
IRC 81: 1997

Guidelines for Design of Pavement Structure, AASHTO, 1993

Shoulder Composition

It is envisaged that the shoulders of the project road would serve as a parking bay for disabled vehicles and as a part of carriageway during any repair and maintenance works on the regular carriageway. Besides, strong shoulder is a pre-requisite to provide adequate lateral support to the edges of pavement to ensure satisfactory structural performance and improved capacity. Any joint on the edge of pavement due to difference in layer thickness and differences in composition between carriageway and shoulder may allow surface water to penetrate to the sub-grade, which would be detrimental to the structural strength of the carriageway pavement. In view of the above, paved shoulders on outer side of the carriageway have been proposed with similar layer composition as proposed for the main carriageway.

6.5 Preliminary Design of Structures

6.5.1 Type of Structures

The structures are classified based on their functional use. The structures for the project road are classified as given below:

i) Drainage Structures

- Major Bridges
- Minor Bridges
- Culverts

ii) Grade Separators

- Overpasses
- Road/Rail over Bridges (RUBs/ROBs)
- Underpasses (Vehicular/Non-Vehicular)

The Bridges having an overall length varying from 6 m to 60 m are termed as minor bridges and those having an overall length more than 60 m are termed as major bridges.

The structures carrying the cross roads above the project road are termed as overpasses and the structures carrying the cross roads below the project road are called underpasses. Box type structures are generally proposed at important village road crossings.

5.5.2 Design Loading

The preliminary design of the bridges shall be based on the most critical combination of various loads, forces and stresses that can co-exist as per the provisions of IRC: 6-2000. The allowable stresses and the permissible increase in stresses for various load combinations shall be adopted as per the relevant IRC codes.

5.5.3 Carriageway Live Load

- a) New structures carrying the proposed project road shall be designed for 3-lanes of Class-A loading or one lane of 70-R wheeled/tracked loading plus one lane of Class-A loading whichever produces the most severe effect.
- b) Structures carrying cross roads of 2-lane carriage way shall be designed for 2-lanes of Class-A loading or one lane of 70-R wheeled/tracked loading whichever produces the most severe effect.

Tractive and Braking Force

The tractive and braking forces shall be considered as per the provisions of clause no. 214 of IRC: 6-2000.

Footpath Live Load

The footpath live load shall be considered as per the provisions of clause no. 209 of the IRC: 6-2000. The intensity of the footpath loading shall be considered as 500 Kg/sqm as per clause no. 209.1 of IRC: 6-2000.

Wind Forces

The effect of wind as per clause no. 212 of IRC: 6-2000 shall be considered for the design of the various components of the bridge.

Seismic Forces

Project road passes through Seismic Zones-II. Seismic forces shall be calculated in accordance with clause no. 222.5 of IRC: 6-2000.

Buoyancy Effects

The following buoyancy effects are proposed to be considered wherever applicable for the design of various components of the bridges are:

- For Foundations : 100 %
- For Substructure below water level : 15 %

5.5.4 Codes and Publications

The following codes and publications (latest editions) shall be used for the design of bridges and other structures:

Specifications for Road and Bridge Works (4th Revision, 2001)

IRC: 5-1998	For General Features of Design
IRC: 6-2000	For Loads and Stresses
IRC: 18-2000	For Pre-stressed Concrete Road Bridges
IRC: 21-2000	For Reinforced Concrete Design
IRC: 78-2000	For Substructure and Foundations
IRC: 83-1987 (Part II)	For Elastomeric Bearings
IRC: 83-2002 (Part III)	For POT-Cum-PTFE Bearings

5.5.5 Grade of Concrete

The following minimum grades of concrete will be proposed for minor bridges, major bridges and other structures-

- M-15 for PCC members of Bridges/ Structures less than and equal to 60 m in length in moderate conditions
- M-20 for PCC members of Bridges/ Structures less than and equal to 60 m in length in severe conditions
- M-25 for PCC members of Bridges/ Structures more than 60 m in length in moderate conditions
- M-30 for PCC members of Bridges/ Structures more than 60 m in length in severe conditions
- M-20 for RCC members of Bridges/ Structures less than and equal to 60m in length in moderate conditions
- M-25 for RCC members of Bridges/ Structures less than and equal to 60m in length in severe conditions
- M-35 for RCC members of Bridges/ Structures more than 60m in length in moderate conditions
- M-40 for RCC members of Bridges/ Structures more than 60m in length in severe conditions
- M-35 for PSC members of Bridges/ Structures more than 60m in length in moderate conditions
- M-40 for PSC members of Bridges/ Structures more than 60m in length in severe conditions

5.5.6 Anti-corrosive Treatment

Provision of anti-corrosive treatment to reinforcement bars would be made due to severe climatic conditions of the project site.

5.5.7 Superstructure

Major Bridge

Depending upon individual span length, PSC/RCC T-Beam and slab type or RCC/PSC Voided Slab super-structure would be provided.

Minor Bridge

It is proposed to keep minor bridges as simply supported. Depending upon individual span length, solid slab or PSC/ RCC T-beam and Slab type or RCC/PSC Voided Slab super-structure would be provided for the minor bridges. Solid slab superstructure would be proposed for individual span length upto 10.0m. For span length greater than 10.0m, PSC/RCC T-beam and slab /voided slab will be proposed.

ROB's /Grade Separators

For the span configuration with minimum vertical clearance required from railway considerations would be proposed. Abutment will be kept outside the railways ROW. Depending upon individual span length type of super-structure would be adopted.

For Grade separators depending upon individual span length type of superstructure would be adopted.

5.5.8 Bearings

It is proposed to provide POT-Cum-PTFE bearing for major bridges/ROBs. For minor bridges, the type of bearing is selected based on individual span length. For solid slab superstructure (upto individual span length of 10.0m), tarpaper bearings will be proposed. For RCC T-beam and slab superstructures with individual span length more than 15.0m POT cum PTFE bearing will be proposed. For RCC T-beam and slab superstructure having individual span length less than 15.0m elastomeric bearings will be proposed.

5.5.9 Substructure

For major bridges and minor bridges, RCC solid wall type abutments and circular pier with cantilever pier cap/wall with semi circular cut water type piers will be proposed. ROB will be proposed with circular column type abutment and pier with reinforced earth (RE) walls.

Seismic restrainers will also be provided on pier/abutment cap as the project road falls in the Seismic Zone – II.

5.5.10 Foundation

Open foundations and pile foundations have been considered and the most appropriate foundation based on the availability of founding strata to withstand the super and sub-structure loads, will be proposed.

5.5.11 Deck Levels of Structures

The deck levels of the structures carrying the project road have been proposed based on the following parameters:

- Vertical clearance required above the cross roads;
- Vertical profile of the proposed project road and
- Vertical clearance required above the high flood level.

Chapter - 6

Engineering Survey and Investigations

CHAPTER - 6

Engineering Surveys and Investigations

6.1 General

As per scope of services, a scheme has been prepared for upgrading of existing 2x2-lane carriageway of National Highway-4 (NH-4), from km 13.800 to km 106.800 (Poonamallee – Walajapet) road section in Tamil Nadu to 2x3-lane carriageway configuration and converting the same into a partially access controlled highway and providing grade separated intersections.

As explained in the preceding Chapters, the entire project road length of National Highway Section totalling a length of 93 Km has been divided into the three homogenous links. Based on the intensity of the traffic, the project road can be divided into following three homogenous links.

Table 6.1: Homogeneous Links

Link Id	Description	From – To (Km)	Length (Km)
L41	Poonamallee - Sunguvachatram	13.800 – 48.400	34.60
L42	Sunguvachatram - Kanchipuram	48.400 – 74.800	26.40
L43	Kanchipuram - Walajapet	74.800 – 106.800	32.00
Total Length of Project Road			93 Km

6.2 Primary Surveys and Investigations

Following field surveys and investigations carried out during Feasibility Study & Preliminary Project Report stage during May-July 2008 in the forms of:

- ◇ *Inventory*
 - *Road*
 - *Cross Drainage Structures*
 - *Bridges & Structures*
- ◇ *Condition Surveys*
 - *Pavement*
 - *Cross Drainage Structures*
 - *Bridges & Structures*
- ◇ *Pavement Investigations*
 - *Sub-grade Investigation*
 - *Soil and Construction Material Investigations*
 - *Benkelman Beam Deflection Test*
- ◇ *Sub-soil Investigations*
- ◇ *Topographic Survey*
 - *Re-alignment*
 - *Bypasses*
 - *Built-up & Congested Areas*
 - *Improvement of Major Intersections*
 - *Bridges & Structures*
- ◇ *Traffic Surveys*
- ◇ *Environmental & Social Surveys*

Traffic studies include 7-day Classified Volume Count carried out during Feasibility Study.

6.3 Approach for Field Investigations

The consultants adopted a sound engineering approach based on a clear understanding of the Terms of Reference and the relevant planning and systems approach.

The Team: The consultants selected key and sub professionals from a pool of engineers with extensive experience in the fields of planning, programming field studies and investigations, design for major highway projects. The selected personnel have wide exposure in international and domestic projects.

Communication: Consultant had series of meetings, discussions and site visits with the Project Directors, NHAI at Chennai in order to get details of project, constraints and other relevant first hand information. Consultants have maintained close and efficient communication with NHAI and other concerned departments and agencies and worked as an integral part of the whole system responsible for the successful implementation of the project. All the proposals such as Bypasses, re-alignment, widening, social, environmental, special problem etc., were also discussed with NHAI and PWD officials.

Existing Data and Information: The Consultant carried out a study of all the earlier relevant reports and also the data and information on transport characteristics and costs, design standards, traffic loading behaviour, pavement performance, construction and maintenance of roads.

Reconnaissance and Inventory were carried out along the project road corridor to have in-situ data & information. This Chapter deals with the field surveys and investigations i.e. Detailed Topographic Survey, Sub-grade Investigation, Soil & Construction Material Survey, Sub-soil Investigation etc.

6.4 Inventory

6.4.1 Road Inventory

A detailed inventory was carried out along the project road corridor in order to collect relevant information in respect of:

- ◇ *Terrain (plain/rolling/hilly)*
- ◇ *Land-use (built-up/agriculture/forest/industrial/barren)*
- ◇ *Name of village/town/city*
- ◇ *Formation width*
- ◇ *Carriageway details*
 - *Type (bituminous/cement concrete/gravel/earthen)*
 - *Width*
 - *Condition (good/fair/poor/very poor)*
- ◇ *Shoulder*
 - *Type (bituminous/cement concrete/gravel/earthen)*
 - *Width*
 - *Condition (good/fair/poor/very poor)*
- ◇ *Embankment height/depth of cut*
- ◇ *Cross road details*
 - *Location*
 - *Road no*
 - *Type (bituminous/cement concrete/gravel/earthen)*
 - *Width*
 - *Direction of crossing*
- ◇ *Utilities/services/facilities*
- ◇ *Rivers/streams/water courses*
- ◇ *Railway crossing*

- ◇ Reserved forest area
- ◇ Other environmentally sensitive features
- ◇ Any other feature not covered above

Right of Way (ROW)

The available right of way ROW is varying between 40m-60m all along the project road. The proposed cross sectional elements have been designed to accommodate within the available ROW. However, ROW is required to be suitably increased to accommodate junctions, terminating points, flyovers, rest areas, toll plazas, etc. and therefore it is proposed to acquire land at these locations. The existing ROW of the project road as informed by NHAI is presented in **Table 6.2**:

Table 6.2: Existing ROW

S. N.	Chainage (km)		Existing ROW (m)	Remarks
	From	To		
1	13.800	18.000	45.00	Interchange under construction At Ch. Km.13.800
2	18.000	22.400	60.00	
3	22.400	26.000	45.00	Flyover At Ch. Km. 22.400
4	26.000	38.000	50.00	Toll Plaza At Ch. Km. 37.800
5	38.000	41.000	60.00	
6	41.000	43.000	40.00	Left side Rajeev Gandhi Memorial Compound wall At Ch. Km. 41.550
7	43.000	49.000	50.00	
8	49.000	51.400	60.00	
9	51.400	63.000	50.00	
10	63.000	64.000	40.00	
11	64.000	70.400	50.00	
12	70.400	87.000	60.00	ROB At Ch. Km 72.275
13	87.000	89.000	60.00	
14	89.000	92.700	60.00	
15	92.700	93.500	55.00	Left Side ROW 20.0 m & Right Side ROW 35.0 m From CL
16	93.500	98.000	60.00	
17	98.000	101.000	60.00	
18	101.000	104.000	60.00	
19	104.000	107.000	60.00	Toll Plaza At Ch. Km 104.900

Terrain and Land Use

The existing road based on the land use pattern can predominantly be divided into two parts i.e. one consists of Poonamallee – Kanchipuram Bypass which includes Built-up/Industrial land and another consists of Kanchipuram Bypass – Walajapet which basically includes Agricultural/Barren land. Terrain of the project area is Flat and plain. Details of terrain and land use are given in **Table 6.3**:

Table 6.3: Terrain and Land Use

S. N.	Chainage (Km)		Village Name	Land Use
	From	To		
1	13.800	15.000	Venagram	Built Up
2	15.000	16.000	Velappanchavadi	Built Up
3	16.000	18.000	Velappanchavadi	Built Up
4	18.000	20.000	Poonamallee	Built Up
5	20.000	22.000	Poonamallee	Built Up
6	22.000	23.000	Poonamallee	Built Up
7	23.000	25.000	Poonamallee	Built Up
8	25.000	28.000	Pappanchatram	Built Up
9	28.000	33.000	Pappanchatram	Built Up
10	33.000	34.000	Katrumbatram	Built Up
11	34.000	38.000	Katrumbatram	Industrial
12	38.000	43.000	Sriperumbudur	Built Up
13	43.000	47.000	Sriperumbudur	Industrial
14	47.000	51.000	Mambakkam	Industrial
15	51.000	53.000	Santavilure	Agricultural
16	53.000	54.000	Santavilure	Built Up
17	54.000	57.200	Senthamangalam	Agricultural
18	57.200	57.800	Pillaichatram	Built Up
19	57.800	58.200	Pillaichatram	Agricultural
20	58.200	58.900	Pillaichatram	Industrial
21	58.900	60.500	Pillaichatram	Agricultural
22	60.500	60.700	Chinnaiyan Chatram	Built Up
23	60.700	63.200	Chinnaiyan Chatram	Agricultural
24	63.200	64.200	Rajakulam	Built Up
25	64.200	65.800	Vedal	Industrial
26	65.800	68.400	Vedal	Agricultural
27	68.400	69.600	Karaipettai	Built Up
28	69.600	71.100	Chettiyar	Agricultural
29	71.100	73.900	Dimma Samudram	Built Up
30	73.900	79.200	Tulangulam Thandalam	Agricultural
31	79.200	80.100	Baluchetty Chatram	Built Up
32	80.100	80.700	Baluchetty Chatram	Agricultural
33	80.700	82.000	Damal	Built Up
34	82.000	86.900	Damal	Agricultural
35	86.900	88.100	Perumbulipakkam	Built Up
36	88.100	88.600	Perumbulipakkam	Agricultural
37	88.600	89.400	Avalore	Built Up
38	89.400	90.300	Chitengi	Agricultural
39	90.300	91.100	Chitengi	Built Up
40	91.100	92.700	Chitengi	Agricultural
41	92.700	93.800	Ocheri	Built Up

S. N.	Chainage (Km)		Village Name	Land Use
	From	To		
42	93.800	96.500	Ocheri	Agricultural
43	96.500	97.200	Kondapuram Colony	Built Up
44	97.200	97.900	Kondapuram Colony	Agricultural
45	97.900	99.700	Kaveripakkam	Built Up
46	99.700	100.900	Ramapuram	Built Up
47	100.900	102.700	Sumaithangi	Agricultural
48	102.700	103.100	Vaniyachattaram	Built Up
49	103.100	104.300	Malamore	Agricultural
50	104.300	105.800	Chennasamuthram	Built Up
51	105.800	106.200	Thenkalapathangal	Built Up
52	106.200	106.800	Ranipettai	Agricultural

6.4.2 Cross Drainage Structures

A detailed reconnaissance and inventory was carried out along the project road corridor in order to collect relevant information in respect of:

- ◇ Culvert No.
- ◇ Location (km)
- ◇ Type of Structures (pipe/slab/box/arch)
- ◇ Span Arrangement and Total Waterway (no. x length, m)
- ◇ Carriageway Width (m)
- ◇ Width of Culvert (m)

6.4.3 Bridges and other Structures

There are 18 existing structures along the project road. The stretch of NH-4 has Minor bridges, Grade Separator, Underpasses, ROB, Flyover and Major Bridge. Details of these Structures in terms of numbers are given below:

Table 6.4: Summary of Structures

S. N.	Section	Major Bridge	Minor Bridge	ROB	Grade Separators / Flyovers	Underpass	Total
1.	13/800 – 106/800	1	12	1	2	2	18
	Total = >>	1	12	1	2	2	18

Major Bridges

There is only 1 major bridge in this project. Details like location; span arrangements etc. of the existing major bridges are tabulated in **Table 6.5**:

Table 6.5: Major Bridge

SN	Location (Km)	Span Arrangement(M)		Total Width (m)	Proposed Improvement of existing Bridge for 6-Lane Configuration
		Old Existing Bridge (M)	New Constructed Bridge (M)		
1	27.211	7X10	5X14	31.75	Only minor repairs for the Bridge structures. Widening/Reconstruction of the bridge on service road

Minor Bridges

There are 12 minor bridges in the existing project road. Details of the existing minor bridges are tabulated in **Table 6.6** given below:

Table 6.6: Minor Bridges

S.N.	Location (Km)	Span Arrangement(M)		Total Width(m)	Proposed Improvement for all Existing Bridge For 6-Lane Configuration
		Old Existing Bridge (m)	New Constructed Bridge (m)		
1	30.945	1X8.420 + 2X8.500	1x25	34.25	Minor Repairs, Widening / Reconstruction of minor bridge for service road.
2	30.995	4X5.8	1x25	33.77	Minor Repairs, Widening / Reconstruction of minor bridge for service road.
3	39.435	4X6.7	2X14	32.09	Minor Repairs, Widening / Reconstruction of minor bridge for service road.
4	44.489	1X8.7	1X8.75	35.46	Minor Repairs, Widening / Reconstruction of minor bridge for service road.
5	56.905	3X6.8	1X21.0	32.86	Minor Repairs
6	59.108	2X10	2X10	32.09	Minor Repairs, Widening / Reconstruction of minor bridge for service road.
7	67.463	4x10	4x10	32	Minor Repairs, Widening / Reconstruction of minor bridge for service road.
8	92.218	7x6.75	2X14 + 1X20.250	32	Minor Repairs
9	100.157	NIL	4X6.0	28.2	Minor Repairs
10	101.247	1X10	1X10	30.5	Minor Repairs
11	103.637	3x5.75	1X17.4	32	Minor Repairs
12	106.683	NIL	1X10	17.5	Minor Repairs

Grade Separators / Flyovers and Underpasses

There are one existing Grade Separator, one existing Flyover and two existing Underpasses along the project road. The details are given in **Table 6.7**:

Table 6.7: Flyovers and Underpasses

S. N.	Location (Km)	Structure Type	Span Arrangement	Carriageway Width (m)
1	18.100	Grade Separator	20.0+40.0+20.0	11.0
2	19.195	Underpass	2x10.0	27.0
3	22.400	Flyover	20.0+40.0+20.0	11.0
4	50.270	Underpass	1x10.0	27.0

6.5 Condition Surveys

Consultants have carried out condition surveys of existing features specific to the alignment in the following respect in order to assess structural and functional adequacy of the project road:

- ◇ Road and Pavement
- ◇ Cross Drainage Structures
- ◇ Bridges & Structures
- ◇ Riding Quality (Surface Unevenness)

6.5.1 Pavement Condition Survey

A detailed visual pavement condition survey was carried out along the project road corridor in order to collect relevant information about the following:

- ◇ Riding quality (good/fair/poor/very poor)
- ◇ Pavement condition
 - Cracking (%)
 - Ravelling (%)
 - Potholing (%)
 - Rut (none/moderate/severe)
 - Patching (%)
- ◇ Shoulder condition (fair/poor/failed)
- ◇ Embankment condition (good/fair/poor)
- ◇ Road side drain (non existing/partially functional/functional)
- ◇ Special Problem

Visual pavement condition surveys were carried out supplemented by simple measurements. Additional care/attention was accorded to the sections showing more distresses.

Riding Quality

Riding Quality were measured based on various pavement distresses and travelling comfort in G/F/P/VP categories. The condition of the project road can be visualised such that 99.89% of the project road length does not have any potholes. Riding Quality data has been presented in **Table 6.8**:

Table 6.8: Pavement Condition – Riding Quality

Package	Length (km)	Riding Quality (G/F/P/VP)			
		Good	Fair	Poor	Very Poor
Poonamallee-Walajapet, NH-4	93	92.7	0	0.3	0

Pavement Condition

Cracking

Pavement distress cracking was measured in % area. The condition of the project road length can be visualised such that 11.7% of the project road length is having cracking distress between 0 and 10. The detailed pavement distress cracking data has been presented in **Table 6.9**:

Table 6.9: Pavement Condition – Cracking

Package	Length (km)	Cracking (% Area)			
		0-10	10-20	20-30	>30
Poonamallee-Walajapet, NH-4	93	10.9	0	0	0

Ravelling

Pavement distress ravelling was measured in % area. The condition of the project road length can be visualised such that 0.96% of the project road length is having ravelling distress between 0 and 5. The detailed pavement distress ravelling data has been presented in **Table 6.10**:

Table 6.10: Pavement Condition – Ravelling

Package	Length (km)	Ravelling (% Area)		
		0-5	5-20	> 20
Poonamallee-Walajapet, NH-4	93	0.9	0	0.3

Pothole

Pavement distress ravelling was measured in % area. The condition of the project road length can be visualised such that 99.89% of the project road length does not have any potholes. The detailed pavement distress pothole data has been presented in **Table 6.11**:

Table 6.11: Pavement Condition – Pothole

Package	Length (km)	Pothole (% Area)			
		Nil	< 0.1	0.1-1	>1
Poonamallee-Walajapet, NH-4	93	92.9	0	0	0.1

Patching

Pavement distress patching was measured in % area. The condition of the project road length can be visualised such that 99.73% of the project road length does not have any patching. Patching data has been presented in **Table 6.12**:

Table 6.12: Pavement Condition – Patching

Package	Length (km)	Patching (% Area)		
		Nil	< 20	> 20
Poonamallee-Walajapet,NH-4	93	92.75	0	0.25

Shoulder Condition & Edge Drop

Conditions of Shoulder were also collected based on the following criteria:

- ◇ *Pavement edge drop & Shoulder condition (fair/poor/failed)*
 - *pavement edge drop < 50mm*
 - *edge break <100mm, fair shoulder*
 - *edge break 100-300mm, poor shoulder*
 - *pavement edge drop >150mm*
 - *edge break >300mm, failed shoulder*

Shoulder condition were measured based on F/P/Failed categories. The detailed shoulder condition data has been presented in **Table 6.13**:

Table 6.13: Shoulder Condition

Package	Length (km)	Shoulder (F/P/Failed)		
		Fair	Poor	Failed
Poonamallee-Walajapet,NH-4	93	93	0	0

Edge drops condition were measured based on in mm. The detailed shoulder condition data has been presented in **Table 6.14**:

Table 6.14: Edge Drop

Package	Length (km)	Edge Drop (mm)		
		0-50	50-150	>150
Poonamallee-Walajapet,NH-4	93	91.8	1.2	0

Embankment Condition

The entire project road length is having low height of embankment (0 to 1.5m) except for the approaches of major bridges and structures. Embankment has been protected by providing stone pitching on slopes for approaches of bridges and structures.

The detailed embankment condition data has been presented in **Table 6.15**:

Table 6.15: Embankment Condition

Package	Length (km)	Embankment (G/F/P)		
		Good	Fair	Poor
Poonamallee-Walajapet,NH-4	93	87.3	5.6	0.1

Road Side Drains

The entire project road passes through plain terrain. Side drain data has been summarised in **Table 6.16**:

Table 6.16: Side Drain

Package	Length (km)	Side Drain (NE/PF/F)		
		Non-Existing	Partially Functional	Functional
Poonamallee-Walajapet,NH-4	93	50.795	30.075	12.13

6.5.2 Cross Drainage Structures

Detailed condition surveys have been carried out for all the cross drainage structures using visual means supplemented by simple measurements, local inquiries and discussions with NHAI & PWD officials. The data so collected have been compiled so as to make an assessment concerning the structural and hydraulic adequacies of the existing structures. The consultants have also collected and compiled the available data concerning cross drainage structures along the project road from the PWD.

Some of the cross drainage structures are generally in satisfactory condition both structurally and hydraulically. Only minor repairs will make them sound.

A detailed condition survey for cross drainage structure was carried out along the project road in order to collect relevant information in respect of:

- ◇ Slab/Pipe/Box/Arch
- ◇ Head Wall
- ◇ Wing Wall/Return Wall
- ◇ Parapet/Handrail
- ◇ Presence of Scour
- ◇ Inlet
- ◇ Outlet
- ◇ Adequacy of Waterway
- ◇ Protection Works
- ◇ Special problem, if any

There are 235 cross drainage structures comprising of 144 pipes and 91 slabs on the project road.

Table 6.17: Details of Existing Culverts

Contract Package	RCC Pipe Culvert				RCC Slab		Total
	Single Pipe	Two Pipe	Three Pipe	Four Pipe	Slab	Slab + Arch	
Poonamallee-Walajapet,NH-4	118	25	0	1	91	0	235

6.5.3 Bridge and other Structures

The bridge condition survey was carried out so that both qualitative and quantitative aspects of the distresses/deficiencies could be examined. Conditions of the following components of the bridges were evaluated:

- ◇ Wearing coat, kerb, footpath and railing;
- ◇ Expansion joints;
- ◇ Drainage system and spouts;

- ◇ *Reinforced concrete deck with special reference to distresses such as cracking, leaching, spalling of concrete from soffit and edges;*
- ◇ *Exposed reinforcement and corrosion;*
- ◇ *Bearings;*
- ◇ *Abutments, piers, wing walls and return walls;*
- ◇ *Hydraulics with special reference to adequacy of waterway, change in flow pattern, erosion/degradation of bed/banks and condition of protective works.*

5.5.3.1. Condition of Bridges

Superstructure

All the bridges in the project area are having RCC superstructures. All the bridges are in good condition.

Wearing Coat

The bituminous concrete wearing coat of thickness 50mm has been provided on the bridges. They are in good condition in all the bridges.

Kerb

The condition of kerb is generally good.

Footpath

Footpaths have been provided for all the bridges. The general condition is fair. Minor repairs may be necessary for few footpaths.

Railing

The railings are of RCC. The condition of the railings is generally fair. Only minor repairs are envisaged.

Expansion Joints

Solid slab decks have buried seal joints with mastic boards. It is not possible to check condition of expansion joints because of bituminous overlays, which completely cover the joints. The Girder bridges are having Strip Seal type expansion joints and in good condition as could be seen.

Drainage Spouts

Drainage spouts are provided in all the bridges. The spouts function properly. Replacement of few drainage spouts may be required.

Bearings

The solid slab decks have tarpaper on the abutments and piers. The girders have elastomeric pad bearings. Conditions as assessed from visual inspection are good.

Sub-structure

Most of the existing bridges have RCC Pier/abutments with RCC Pier/abutment caps. There are some bridges particularly in the Kanchipuram-Walajapet section which are having PCC Pier/Abutments/Wing walls. Conditions are generally

satisfactory and only minor repairs have been envisaged for few of them. Abutments have weep holes.

Hydraulics

At most of the sites, growth of vegetation and trees was observed in the riverbed under and around the bridges. However, no serious problem of inadequacy of waterway, degradation of the bed or excessive scour around abutments and piers were observed.

5.5.3.2 Repairs and Rehabilitation of Bridges

Detailed condition survey of the existing bridges was carried out in the month of May – June 2008. The project road has a total length of 93 km along NH -4 sections and crosses a number nallahs and creeks in this stretch. There are 12 minor bridges, one major bridge, one flyover, one ROB, two underpasses and one grade separators on the existing project road. The conditions of the structures are generally satisfactory. No major rehabilitation is required for any of the bridges and other structures. Only minor repairs would be required. The ROB shows distresses in the RE wall portions especially in respect of Bulging which needs to be duly addressed.

6.6 Pavement Investigations

6.6.1 Sub-grade Investigation

The feasibility study for the project road was carried out by RITES during June - October 2008. During the study period, the detail investigations of the existing 2x2-lane road pavement and its composition and the existing sub-grade properties were studied in order to establish a realistic approach to the design.

Investigations were carried out on the project road for the proposed improvement.

Investigations for the soil supporting the pavement on the proposed widening/additional new 2x3-lane road: To establish the existing ground soil properties, and to meet the requirements of ToR, the Consultant carried out the work of borehole for a depths varying from 6.5m to 36 m below ground level. The boreholes were terminated in the cemented silt/ sand /cemented sand /sand stone /medium rock layer after drilling for the required depth.

Results of sub-grade investigations are presented in **Table 6.18** and **Table 6.19**:

Table 6.18: Lab Test Results for Sub-Grade Samples

S. N.	Chainage	Grain Size analysis				Atterberg Limits		Swell %	Shrinkage Limit %	Proctor Results	
		Clay %	Silt %	Sand %	Gravel %	LL	PL			MDD gm/cc	OMC %
1		10.0	38.0	52.0	Nil	22.00	18.00	12.00	14.00	1.99	10.0
2	25.2	16.0	26.0	54.0	4.0	17.00	12.00	8.00	18.00	1.97	13.8
3	32.0	9.0	28.0	51.0	12.0	19.00	12.00	9.00	10.00	2.02	10.8
4	44.0	2.0	15.0	53.0	30.0	NP	NP	Nil	-	2.17	11.1
5	54.00	5.0	16.0	23.0	56.0	4.00	13.00	6.00	4.00	2.05	11.1
6	62.00	8.0	17.0	49.0	26.0	9.00	14.00	9.00	11.00	2.08	10.4
7	73.00	3.0	25.0	62.0	10.0	12.00	8.00	Nil	-	2.03	9.7

S. N.	Chainage	Grain Size analysis				Atterberg Limits		Swell %	Shrinkage Limit %	Proctor Results	
		Clay %	Silt %	Sand %	Gravel %	LL	PL			MDD gm / cc	OMC %
8	84.2	10.0	35.0	41.0	14.0	20.00	14.00	22.00	9.00	2.04	12.3
9	94.2	2.00	25.0	45.0	28.0	NP	NP	Nil	-	2.06	10.4
10	104.0	11.0	21.0	56.0	12.0	21.00	16.00	13.00	10.00	2.02	11.5

Table 6.19: CBR Results for Sub-Grade Samples

S. N.	Chainage	Unsocked Value at			Socked Value at		
		2.5 mm	5.0 mm	7.5 mm	2.5 mm	5.0 mm	7.5 mm
1	-	18.45	13.43	10.76	15.54	11.25	9.50
2	25.200	16.11	11.26	9.61	13.15	10.50	7.43
3	32.000	13.25	11.61	9.20	11.50	9.61	8.20
4	44.000	12.99	10.22	8.66	10.25	8.23	7.05
5	54.000	11.43	11.26	9.74	9.75	9.25	7.45
6	62.000	14.81	10.05	9.33	12.18	9.86	7.12
7	73.000	19.75	13.69	11.23	17.50	11.56	9.75
8	84.200	15.33	11.26	10.69	13.25	10.33	9.45
9	94.200	18.97	13.69	12.05	16.55	11.21	10.84
10	104.000	25.21	18.19	15.03	22.76	15.42	12.23

6.6.2 Geotechnical Investigations and Sub-soil Exploration

6.6.2.1 Bridges /ROBs /Grade Separators /Underpasses

The number of boreholes to be drilled for various structures has been decided based on the reconnaissance of the structures, collection of pertinent data, studying the earlier reports of Geotechnical Investigations conducted during DPR stage of the 4-laning or confirmatory investigation carried out during the execution.

6.6.2.1.1 Number of boreholes for Structures

a) Minor bridges /Vehicular and Non Vehicular Underpasses

For minor bridges, vehicular and non vehicular underpasses it has been decided to drill at least one bore hole at each location. The length of the bore hole as prescribed is given in the following paragraphs to satisfy the technical requirements.

b) Major bridges and ROB's

There is only one major bridge in this project road and the length of the bridge is only 70m. One bore hole has been drilled on the river bed mainly with an aim to validate the subsoil characters detailed in the DPR stage Geo-technical report and the Confirmatory boring report during execution. The only ROB in this project is of six lane width and no widening is predicted thereon so no bore hole has been prescribed for the ROB. For the Grade Separators / Flyovers at least two bore holes per location have been drilled.

6.6.2.1.2 Depth of boreholes

a) Depth of boreholes in rock

o General

In case hard rock is met with at any point during drilling of borehole were terminated by going 3.0 m into hard rock.

o Major bridges/Grade Separators/ROBs

In case hard rock is not met with the boreholes shall be terminated by going 10 m into soft rock.

o Minor bridges/Vehicular and non vehicular underpasses

In case hard rock is not met with, the borehole was terminated by going 5 m into soft rock, as for minor bridges open foundation shall be kept 1.5 m below top of soft rock and a soil strata of 3.5 m below founding level is sufficient for carrying out design of foundation of minor bridges.

b) Depth of boreholes in soil

o Major bridges with open foundations

For Major bridges with open foundations, the depth of borehole has been kept as 30 m, which is adequate because open foundation shall be founded 7- 8 m below ground level and with a approximate footing width of 10 - 12m.

o Major bridges/ROBs/Grade Separators (GS) with well/pile foundations

For Major bridges/ROB/GS with well/pile foundations, the depth of borehole has been kept as 40 m. This depth has been considered by taking into view that pile/well foundation shall be founded 25m /30 m below ground level and with an approximate diameter of well/pile group width of 7m/10 m.

o Minor bridges / Vehicular underpasses

Majority of minor bridges and underpasses are having single span arrangement. For Minor bridges with open foundations, the depth of borehole has been kept as 20 m. This depth has been proposed by taking into view that open foundation shall be founded 5 - 6 m below ground level and with an approximate footing width of 7-8 m.

The following activities were carried out for the geo-technical investigations for the structures:

- ❖ *Drilling of 150/100 mm dia. boreholes.*
- ❖ *Conducting Standard Penetration Tests (SPT) in boreholes, at a vertical interval of 1.5m, and collecting disturbed samples from SPT sampler.*
- ❖ *Undisturbed soil samples (UDS) were collected*
- ❖ *Conducting laboratory tests on disturbed soil samples including grain size analysis, Atterberg Limits, and specific gravity.*
- ❖ *Conducting 'Nx' size rock coring operations in bedrock.*

- ❖ *Conducting laboratory tests on select rock core samples for determination of Uni-axial compressive strength (UCS), Point Load Index, porosity, and water absorption, RQD, Core Recovery etc..*
- ❖ *Conducting chemical analysis on representative soil samples.*
- ❖ *Submitting a detailed geotechnical investigation report including recommendations for foundations of the structures.*

6.6.2.2 Road Works

Geo-technical investigations were carried out along the project road on the proposed widening side. Boreholes were made for a depth varying from 6.5m to 36 m below ground level. The criteria adopted for fixing up the frequency of borehole locations were mainly based on ToR requirement and in support additional boreholes were made at closer intervals where the soil strata has changed and this location was mainly assessed by visual assessment.

Sufficient soil sample were collected at regular depths in each borehole location and following tests were conducted on each soil sample.

- ❖ Grain size distribution;
- ❖ Hydrometer analysis to establish clay content (2μ and 5μ);
- ❖ Natural field density and moisture content;
- ❖ Atterberg Properties (LL, PL & PI);
- ❖ Shear Properties (C, ϕ);
- ❖ Shrinkage Properties; and
- ❖ Soil classification (AASHTO and unified)

6.6.3 Benkelman Beam Deflection Test

The Consultants carried out the deflection test for existing 2x2-lane pavements using Benkelman Beam Deflection technique in accordance with the CGRA procedure given in IRC: 81-1997 ("Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique").

Benkelman Beam Deflection Test was undertaken for entire project road length from May-July, 2008.

Testing was carried out to IRC Standards according to the "Rebound" method, using a truck with an axle load of 8,170 kg. Results gave the maximum rebound deflection. No deflection bowl profiles were measured.

Consultants carried out the deflection test as per the following scheme:

- ◇ *mainline testing; and,*
- ◇ *control section testing*

The deflection tests for the mainline were carried out at every 50 m along the entire project road length. The control section testing was carried out deflection testing for each 100 m long homogenous road segment along the project road sections. The selection of homogenous segment was selected based on the data derived from pavement condition surveys. The total length of such homogenous segments was minimum 100 m per 5 kilometre. The deflection results were recorded in the outer wheel path and then on the inner wheel path for first lane and then for second lane at 50m intervals (staggered) in both directions.

Based on the data collected and analysed, a summary of "Characteristics Deflection" is presented in **Table 6.20**:

Table 6.20: Characteristics Deflection

Project Road	Towards Walajapet				Towards Chennai			
	% Length				% Length			
	Corrected Characteristic Deflection (mm)				Corrected Characteristic Deflection (mm)			
	0 - 0.25	0.25 - 0.5	5 - 0.75	> 0.75	0 - 0.25	0.25 - 0.5	5 - 0.75	> 0.75
Poonamallee - Walajapet, NH-4	0	0	68.87	31.12	0	0	29.62	70.37

6.7 Construction Materials

As per the requirement of ToR, the Consultants have carried out a detail investigation along the project road for the identification of prospective construction materials. Prior to the field study, review of available data and relevant study report was made to have a more realistic approach to the identification of the construction materials. Some of the important steps adopted during construction materials identification are:

- Collection and review of secondary data and relevant study reports;
- Identification, quantification and assessment of prospective construction materials in concurrence to the minimum/economic lead;
- Field identification and quantity confirmation of construction materials sources and its function-ability;
- Collection of sufficient material sample for further laboratory tests;
- Analyses of laboratory test results and its recommendation;

The general steps involved in the identification and requirement of the construction materials, referred to in this section of the report are as under:

- ❖ Material property requirements are first reviewed and discussed as a basis for the development of suitable cost-effective specifications, which may eventually be applied in order to encourage the use of most economic and technically viable locally available materials.
- ❖ Laboratory testing performed in accordance to relevant BIS and IRC specifications.
- ❖ The investigation provides a comprehensive material utilisation and thus forms a guide to establish the availability of suitable construction materials in the close vicinity of the project site, so as to procure such materials in more economical way for optimal utilisation.

6.7.1 Sand

Investigations for the availability of sand are made along the project road. Sand samples were tested in laboratory for gradation, fineness modulus and bulking, which are shown in **Table 6.21**.

Table 6.21: Test Result for Fine Aggregate

1	Grading Results:	
	IS Sieve	% of Passing (Zone II)
	10 mm	100

1	Grading Results:	
	IS Sieve	% of Passing (Zone II)
	4.75 mm	97.3
	2.36 mm	80.9
	1.18 mm	76.3
	600 μ	43.2
	300 μ	15.3
	150 μ	2.4
2	Fineness Modulus:	1.98%
3	Bulking of Sand:	2.65

6.7.2 Crushed Stone Aggregate

Investigations for the availability and suitability of stone aggregate source/quarry are carried out in reference to geological reports and materials survey along the project road. Resources of rock aggregate are surveyed.

Sufficient stone aggregate sample was collected from each source for further laboratory tests and analyses. Stone aggregate samples collected from the prospective quarry are tested for:

- ❖ Aggregate Crushing Value (ACV);
- ❖ Aggregate Impact Value (AIV);
- ❖ Los Angeles Abrasion Value (LAAB);
- ❖ Water Absorption Test;

From the result presented below, it is found that that good quality construction material is available along the project road.

Table 6.22: Laboratory Test Results of Borrow Soil

S. N.	Chainage	Grain Size Analysis (%)				Atterberg Limits (%)		Swell (%)	Shrinkage Limit (%)	Proctor Results	
		Clay	Silt	Sand	Gravel	LL	PL			MDD gm/cc	OMC (%)
1	60	15	9	53	23	19	11	24	12	2.26	11.50
2	-	13	22	61	4	19	11	11	10	2.06	9.10

Table 6.23: CBR Results for Borrow Soil

S. N.	Chainage	CBR VALUES					
		Un-socketed Value at			Socketed Value at		
		2.5 mm	5.0 mm	7.5 mm	2.5 mm	5.0 mm	7.5 mm
1	-	18.45	13.43	10.76	15.54	11.25	9.50
2	25.200	16.11	11.26	9.61	13.15	10.50	7.43

Table 6.24: Test Result for Coarse Aggregate

SI. No.	Description	40 mm	20 mm
1	Impact Value	18.80%	19.56%
2	Water Absorption	0.50%	0.50%
3	Stripping Value	98.50%	98.00%
4	Abrasion Value	16.54%	16.94%
5	Soundness(Using Sodium Sulphate)	1.30%	1.60%
6	Flakiness Index	16.20%	18.60%

6.7.3 Water for Construction

The main source of water in the project corridor is rivers/streams running along and nearby the project road. The project falls in the heavy rainfall zone .Hence construction water is available in abundant quantity. It is essential that the source of water from the river/streams have been tested for its pH-value, Sulphates and Chlorides content and its acceptability as per the standard norms. The test results of water are presented in **Table 6.25**.

Table 6.25: Chemical analysis of Water

Bore Water Sample	Ph	Sulphate SO ₃ (Mg /L)	Chloride (Mg /L)	Alkalinity as Sodium Hydroxide (Mg /L)	Acidity as Hydro Chloric Acid (Mg /L)	Suspended Matter (Mg /L)
1	6.7	87	220	NILL	5.2	4
2	7.0	38	125	NILL	4.4	2
3	6.9	74	224	NILL	7.4	4
4	6.7	42	148	NILL	29.5	7

6.7.4 Bitumen

Bitumen in grade of 60/70, 30/40 is available in sufficient quantity conforming to relevant IS Standards. 60/70-grade bitumen is recommended for project road on consideration of traffic, rainfall and other environmental condition.

6.7.5 Cement

Cement of all varieties/types i.e. Ordinary Portland, Portland Slag, and Portland Pozzolona confirming to relevant IS standards are readily available in the market in sufficient quantity, and also, would be directly supplied by the manufacturer to the project site for such a huge quantum of work and may be at rebated price.

6.7.6 Reinforcement Steel

Reinforcement steel confirming to relevant IS standard is readily available in market.

6.8 Topographic Survey

Consultants have carried out detailed topographic survey along the proposed road alignment using state of art, accurate and sophisticated electronic survey equipment like Global Positioning System (GPS), Total Stations and Digital Levels (Sokkia make, Japan and Leica make, Switzerland).

The topographic survey has been carried out during April 2008 – August 2008.
Major activities carried out are:

- ◇ *A pair of horizontal control points was established along the project road at 5km interval by using Global Positioning System (GPS) (Leica make, Switzerland).*
- ◇ *Topographic survey was carried out by running a closed traverse along the project road. The traverse was closed at every 5km on already established horizontal control points by GPS and the permissible error if any was distributed as per standard procedure.*
- ◇ *Traversing along the project road and existing crossroads for necessary realignments. A strip of approximately 75-100m width was surveyed with all features on the ground. Wider strip of land than the proposed ROW was considered in order to allow refinement of the alignment while preparing final design of alignment using MOSS software.*
- ◇ *Establishment of Bench Marks (BM) at regular intervals along the proposed alignment with necessary checks by fly-back operation. The accuracy of levelling has also been broadly verified with the coordinates available from Total Station data.*
- ◇ *Pair of Reference Pillars is also established along the project road at 200-250m interval with the help of concrete pillars fixed on ground/ on rock/ on permanent feature.*
- ◇ *Taking cross & long sections using level instrument or Total Stations as the case may be for the alignment, existing cross roads, streams, etc.*
- ◇ *X, Y and Z coordinates were established on all GPS control points, Reference and Bench Mark pillars along the project road.*

6.8.1 Bridges

Topographic survey was carried out for the bridges and structures in order to get the land information in respect of:

- ◇ *For minor Bridges: 100 m upstream and downstream of the right of way boundaries.*
- ◇ *For major Bridges: 200 m upstream and downstream of the right of way boundaries or a sufficient distance to define the alignment of the waterway, whichever is greater.*
- ◇ *Longitudinal Section of the Stream*
 - *Major Bridge 250m either side of the existing bridge*
 - *Minor Bridge 125m either side of the existing bridge*

The data collected above was used for hydraulic calculations.

6.8.2 Improvement of Major / Minor Intersections

Detailed survey of the project road sections have been carried out in order to assess the nos., type and importance of the junctions falling on the project road. The data have been used for the improvement of major junctions and other less important junctions.

Flyovers

10 flyovers have been proposed at Chainage 14.870, 18.070 (on right carriageway), 24.400, 34.050, 41.335, 45.755, 48.360, 70.178, 76.820 and 93.063 for the improvement of the major junctions.

Underpasses

Vehicular underpasses have been proposed at suitable locations based on the traffic requirements to improve the minor road intersections. Underpasses have also been proposed for pedestrians/slow moving vehicles and cattle crossings at different locations along the proposed project road based on the local requirements. The proposed vehicular underpasses are of 2-lane width. Location details of the underpasses of various categories as proposed are presented in **Table 6.26**:

Table 6.26: Proposed Underpasses

S. N.	Location (km)	Type of Structure
1	16.300	Vehicular
2	17.060	Pedestrian
3	20.970	Vehicular
4	23.270	Pedestrian
5	26.030	Vehicular
6	28.715	Vehicular
7	30.020	Pedestrian
8	31.600	Vehicular
9	32.880	Pedestrian
10	37.300	Pedestrian
11	39.080	Pedestrian
12	42.150	Vehicular
13	42.250	Vehicular
14	50.270	Vehicular
15	55.650	Pedestrian
16	57.486	Pedestrian
17	60.500	Vehicular
18	63.410	Pedestrian
19	65.590	Vehicular
20	68.500	Vehicular
21	69.330	Pedestrian
22	73.800	Pedestrian
23	78.446	Cattle Crossing
24	79.835	Pedestrian
25	80.776	Vehicular
26	83.446	Cattle Crossing
27	87.508	Vehicular
28	88.699	Pedestrian
29	91.498	Cattle Crossing
30	94.496	Cattle Crossing
31	96.746	Pedestrian
32	98.386	Vehicular
33	99.196	Pedestrian
34	100.666	Pedestrian
35	102.951	Pedestrian
36	104.271	Vehicular
37	105.776	Pedestrian
Total	37 Nos.	

6.9 Environmental and Social Studies

Environmental and Social studies have been carried out for the entire length of the project road in conformity to “Term of Reference” and based on the collected data & its analysis, the reports have been prepared and submitted in separate volumes, “Volume – IV” and their summary is given in “Chapter 12: Social Impact Assessment of the Project” and “Chapter 11: Environmental Impact Assessment”, respectively of Main Report, Volume I.

Chapter - 7

Traffic Surveys and Analysis

CHAPTER - 7

Traffic Survey, Analysis and Forecast

7.1 General

Traffic gets generated as a result of several inter-connected factors; encompassing the prevailing socio-economic conditions such as population, Gross/Net State Domestic Product (GDP/NSDP), vehicle ownership, sectorial economic activities etc.. Traffic forecasting, therefore, requires detailed studies and investigations concerning these factors as well as the magnitude and characteristics of the existing traffic flows and its past trend in respect of nature, composition and growth. Towards this end, the Consultants have undertaken detailed traffic studies and analysis. Various steps followed in this regard are described in the proceeding paragraphs.

7.2 Estimation of Base Year Traffic

The base year traffic pattern is the primary input for determination of future traffic demand of Project Influence Area (PIA). The Consultants have conducted **Origin-Destination (O-D)** and **Classified Traffic Volume Count** surveys to estimate the base year traffic levels in respect of goods and passenger vehicles on the existing road network in terms of vehicle mix, commodity movement and directional flow. For the purpose of traffic estimation and projection, **year 2008** has been taken as **Base Year**.

7.3 Traffic Studies

7.3.1 Primary Surveys

The project road from Poonamallee to Walajapet of NH-4 has been divided into traffic homogeneous links presented in **Table 7.1**:

Table 7.1: Homogenius Links

Link No.	Homogeneous Link	Chainage (km)		Length (km)
		From	To	
L41	Poonamallee – Sunguvachatram	13.80	48.40	34.60
L42	Sunguvachatram – Kanchipuram	48.40	74.80	26.40
L43	Kanchipuram – Walajapet	74.80	106.80	32.00

In order to generate the essential inputs, various traffic surveys were organized on the project road. The surveys carried out with their location and periods have been summarized below:

1. **Classified Traffic Volume Count Survey** (both direction) was carried out for 24 hours for a period of 7 days starting from 22.05.2008 to 28.05.2008 at following locations on NH-4 covering all modes of fast and slow moving vehicles.
 - i. At (km 37.825) : **Station 1**
 - ii. At (km 57.450) : **Station 2**
 - iii. At (km 104.765) : **Station 3**

The above locations were identified on the basis of field reconnaissance and in consultation with the officials of PD, NHAI. The above locations have been shown in **Figure 7.1**.

2. **Origin - Destination Survey** (both direction) was carried out for 24 hours at Km 34.900 on NH-4 for car, bus & truck category on 28.05.2008.

During the Origin and Destination survey all the relevant information was collected from the vehicle operators in pre-designed format by stopping vehicles at random sample basis. The data collected includes vehicle number, origin and destination place, commodity carried, payload, distance traveled, quantity of the commodity etc. The Origin and Destination Survey location has been shown in **Figure 7.1**.

3. **Axle Load Survey** was carried out for 24 hours at Km 36.000 on NH-4 for commercial traffic.

Axle load survey was carried out to arrive at a reasonable estimate of equivalent standard axle load on the project road. The Axle Load Survey location has been shown in **Figure 7.1**.

4. **Turning Movement Survey** for 12 hours was carried out at following ten important junctions:

- i. Ambtattur Junction (Km 14.900) on NH-4
- ii. Tirupati Junction (Km 24.400) on NH-4
- iii. Hyundai Junction (Km 34.030) on NH-4
- iv. Sriperumbudur Junction (Km 39.300) on NH-4
- v. Sriperumbudur Junction (Km 41.350) on NH-4
- vi. Sipkot Junction (Km 45.200) on NH-4
- vii. Sunguvachatram Junction (Km 48.400) on NH-4
- viii. Sunguvachatram Junction (Km 50.800) on NH-4
- ix. Kanchipuram Junction (Km 70.200) on NH-4
- x. Kanchipuram Junction (Km 76.800) on NH-4

The data were collected for 12 hours considering the peak hour traffic movement for all categories of vehicle and analysed for carrying out improvement of the junctions. The turning movement survey locations along the project road have been shown in **Figure 7.1**.

7.3.2 Traffic Survey Results

7.3.2.1 Traffic Volume and Composition

The Hourly Traffic data and Average Daily Traffic (ADT) for classified volume count survey conducted at three stations on the project road is presented in **Volume-II: Annexure**.

The both ways Average Daily Traffic (ADT) and percentage composition of different type of vehicles at all traffic count stations are presented in **Table 7.2 to 7.4**. The summary of both ways ADT observed on homogeneous section on project road is presented in **Table 7.2**:

Table 7.2: Summary of ADT

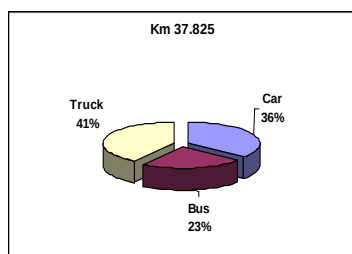
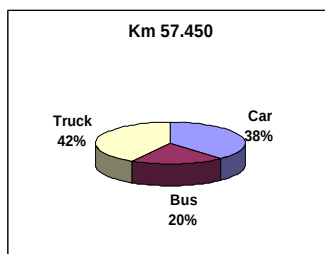
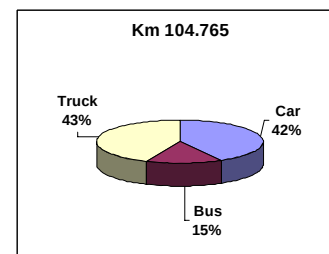
S. No.	Vehicle Type	L41	L42	L43
1	2 Wheelers	5151	4371	4679
2	3 Wheelers	991	1015	939
3	Car	7708	9046	7051
4	BUS	4977	4777	2581
5	LCV	2507	2704	1140
6	TRUCK	6110	7076	6200
7	Other Fast*	73	129	120
8	ALL FAST	27519	29118	22710
9	ALL SLOW	138	255	419
	ADT (in Nos.)	27657	29373	23130
	ADT (in PCUs)	47596	51971	38829

* Other fast vehicles include Agricultural Tractors with/without trailer.

The percentage composition of car, bus and truck in number at different survey locations are presented in **Table 7.3**:

Table 7.3: Percentage Composition of Car, Bus and Truck

S. No.	Location	ADT All vehicles (in Nos.)	ADT Car+Bus+Truck		Percentage composition out of Car+Bus+Truck		
			In Nos.	In %	Car	Bus	Truck
1	Km 37.825	27657	21303	77.0%	36.2%	23.4%	40.5%
2	Km 57.450	29373	23603	80.4%	38.3%	20.2%	41.4%
3	Km 104.765	23130	21303	73.4%	41.5%	15.2%	43.2%



The analyses reveal that percentage of cars is varying between 36% and 42% with minimum at Km 37.825. The percentage of the trucks is varying between 41% and 43% and buses are between 15% and 23% with minimum at Km 104.765.

The percentage composition of LCV, Two Axle Trucks, Multi Axle Trucks and Articulated Trucks at different locations are presented in **Table 7.4**:

Table 7.4: Percentage Composition of Trucks

S. No.	Location	% Composition of Truck			
		LCV	2-Axle	3-Axle	Artic
1	Km 37.825	29.1%	39.2%	22.4%	9.3%
2	Km 57.450	27.7%	39.8%	24.9%	7.7%
3	Km 104.765	15.5%	48.1%	28.0%	8.3%

The LCV percentage among trucks is in the range of 15.5% to 29.1% with minimum at Km 104.765 and maximum at Km 37.825. The percentage of 2-Axle

trucks is in the range of 39.2% to 48.1% with maximum at Km 104.765 and minimum at Km 37.825.

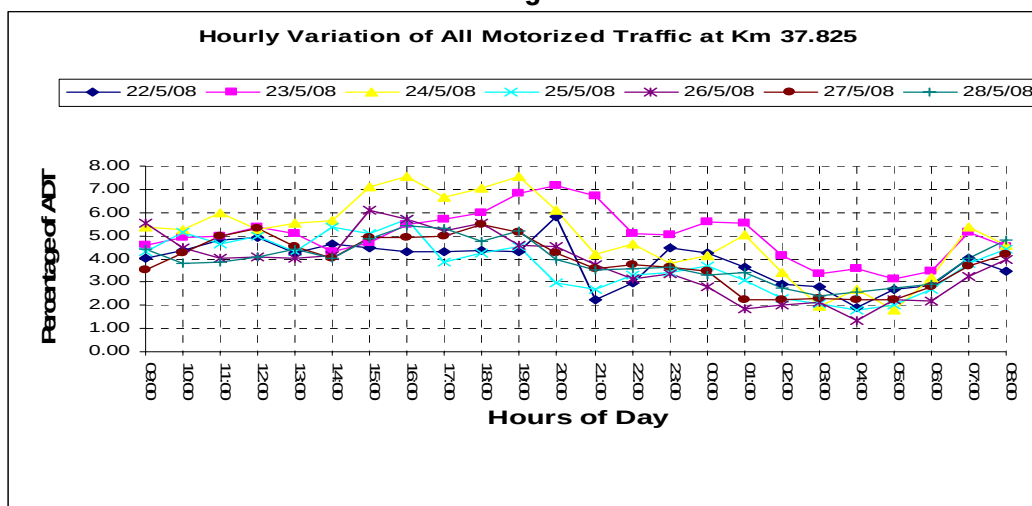
7.3.2.2 Past traffic data

The traffic data (ADT, Both ways) could not be obtained any data from PD, NHAI, Chennai for the past years at locations near by traffic volume count stations of present study conducted by RITES during field surveys as they do not have any data.

7.3.2.3 Hourly Variation / Distribution

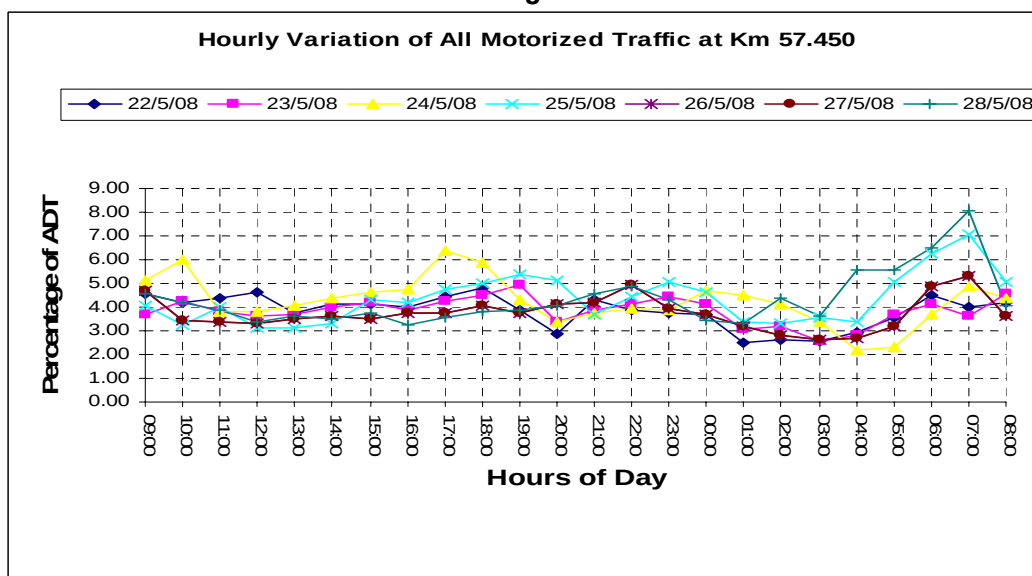
As evident from the hourly variation graphs at **Km 37.825 (Station 1)**, low traffic is between 1% and 3% of ADT during early hours of the day from 01:00am to 05:00am. Peak traffic is about 5% to 7.6% of ADT during afternoon and evening hours from 03:00pm to 08:00pm.

Fig. 7.2



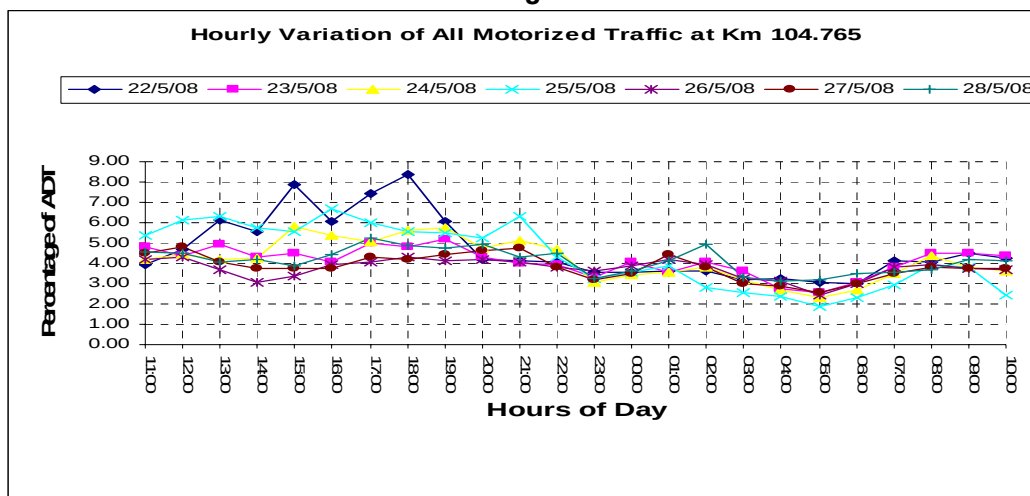
At **Km 57.450 (Station 2)**, low traffic is between 2% to 3% of ADT during early hours of the day from 01:00 am to 5:00am. Peak traffic is about 5% to 8% of ADT during morning hours from 6:00 am to 10:00 am.

Fig. 7.3



At Km 104.765 (Station 3), low traffic is between 2% and 3% of ADT during early hours of the day from 03:00am to 5:00am. Peak traffic is about 5% to 8% of ADT during day time from 01:00pm to 08:00pm.

Fig. 7.4



Hourly variation graphs for Car, Bus, LCV, Truck and All vehicles are presented in **Volume-II: Annexure**.

7.3.2.4 Directional Distribution

The direction wise average daily traffic as obtained at different locations in the project influence area for Car + Bus + Truck, All Fast and All Vehicles is given in **Table 7.5**:

Table 7.5: Direction Distribution

Vehicle Type	At Station 1 (Km 37.825)			
	To Poonamallee		To Walajapet	
	No	%	No	%
Car+Bus+Truck	10619	49.8%	10683	50.2%
All Fast	13642	49.6%	13877	50.4%
All Vehicles	13711	49.6%	13946	50.4%

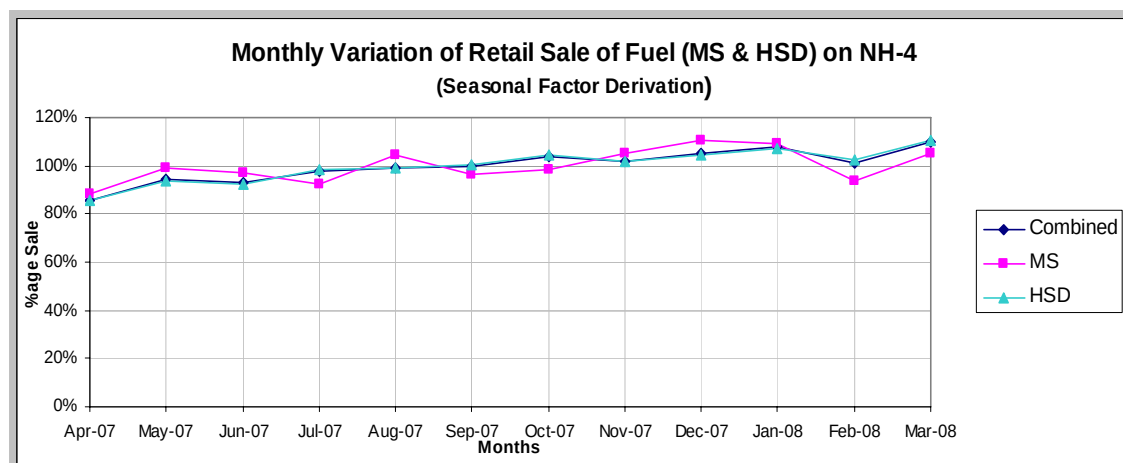
Vehicle Type	At Station 2 (Km 57.450)			
	To Poonamallee		To Walajapet	
	No	%	No	%
Car+Bus+Truck	12511	53.0%	11092	47.0%
All Fast	15374	52.8%	13744	47.2%
All Vehicles	15504	52.8%	13869	47.2%

Vehicle Type	At Station 3 (Km 104.765)			
	To Poonamallee		To Walajapet	
	No	%	No	%
Car+Bus+Truck	8140	48.0%	8832	52.0%
All Fast	10865	47.8%	11846	52.2%
All Vehicles	11101	48.0%	12029	52.0%

The traffic on NH-4 does not indicate any substantial difference in the directional flow. The maximum variation observed has a distribution of 53:47.

7.3.3 Seasonal Variation

Seasonal variation of traffic is caused by geography, climatic condition, harvesting season and major festivity. Seasonal variation trend analysis is carried out for Monthly variation in fuel sale data of “Indian Oil Corporations Limited, Chennai” along NH-4 in Tamil Nadu. The Estimation of seasonal variation of traffic based on monthly fuel (MS and HSD) sale data has been presented in **Fig. 7.5**:



The combined seasonal variation in sale of MS and HSD on NH-4 is in the range of 86% to 110% with lowest in the month of April and highest in month of February.

The traffic survey was carried out in the month of May 2008. Accordingly, a seasonal variation factor of **(1/0.94)** has been taken for further analysis.

7.3.4 Annual Average Daily Traffic (AADT)

The Average Daily Traffic (ADT) is converted to Annual Average Daily Traffic (AADT) after making suitable adjustment for the seasonal variation factor at different survey locations and is presented in **Table 7.6**:

Table 7.6: Annual Average Daily Traffic

Link	Car	Mini Bus	Full Bus	LCV	2A Truck	3A Truck	Arti-culated	Car+Bus +Truck	All Vehicles
L41	8200	1576	3719	2667	3591	2058	852	22662	29414
L42	9624	1135	3947	2877	4139	2587	802	25110	31231
L43	7501	791	1955	1212	3754	2190	651	18055	24579

7.3.5 Origin – Destination Analysis

7.3.5.1 Origin Destination Zones

Seven Origin and Destination (O-D) zones have been outlined keeping in view the influence areas of the project road. The influence areas of O-D zones have been given in **Table 7.7** and presented in **Fig. 7.6**.

Table 7.7: Origin-Destination Zones

S. No.	Description	O-D Zone Code
1	Chennai, Poonamallee, Amabttur	1
2	Sriperumbudur, Tiruvallur	2
3	Kanchipuram	3

S. No.	Description	O-D Zone Code
4	Vellore, Krishnagiri, Dharmapuri and Salem	4
5	Tiruvannamalai	5
6	Villupuram, Pondicherry, Karaikal, Nagapattinam, Thanjavur, Tiruchirapalli, South Arcot	6
7	South-west of Tamil Nadu	7
8	Kerala	8
9	Chittoor	9
10	Tirupati	10
11	Coastal Andhra Pradesh	11
12	Karnataka, Goa, Maharashtra, Madhya Pradesh, Gujarat	12
13	Chattosgarh, Bihar, Jharkhand, Orissa, West Bengal	13
14	North India	14
15	North-Eastern States	15

7.3.5.2 Survey Sample

Origin and Destination survey was carried out for 24 hours for both passenger and commercial vehicles. Sampling technique was used to record data in the field. The sample size covered during the survey for different category of vehicles has been presented in **Table 7.8**:

Table 7.8: Survey Sample

Location	% Sample surveyed - vehicle type			
	Car	Bus	LCV	Truck
Km 39.400	2.10	5.61	14.28	11.75

7.3.5.3 Origin Destination Matrix

The Origin and Destination matrices for Car, Bus and Truck with their zone-wise distribution in percent and in numbers have been presented in **Volume-II: Annexure**.

The movements of the vehicles in the Project Influence Area (PIA) are summarized in **Table 7.9**:

Table 7.9: Movement of Vehicles in PIA

Zones	% Traffic			
	Car	Bus	LCV	Truck
Traffic with in PIA (with in Zones 1, 2, 3 & 4)	83.6%	90.9%	79.7%	66.0%
Traffic from Outside to PIA (from Zones 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 & 15 to Zones 1, 2, 3 & 4)	10.9%	4.3%	6.8%	21.0%
Traffic from PIA to Outside (from Zones 1, 2, 3 & 4 to Zones 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 & 15)	5.5%	4.7%	13.5%	12.9%
Through Traffic (Outside PIA)	0.0%	0.0%	0.0%	0.1%

Origin and Destination analysis brings out that Zones 1, 2, 3 and 4 viz. Chennai, Kanchipuram and Vellore District serve as major Origin/Destination for traffic (more than 60 %) on the project road. The through traffic from/to outside of PIA is very negligible.

7.3.5.4 Commodity Movement

The analysis of Origin and Destination survey data also highlights the commodity movement in the project influence area. The commodities have been divided into 9 categories viz. Perishable goods, Industrial products, food products, petroleum products and chemicals, automobiles and parts, forest products, construction materials, empty vehicles and miscellaneous and provision for the analysis.

The commodity composition as observed during the O-D survey at km 34.900 has been given in **Table 7.10**:

Table 7.10: Commodity Composition

S. No.	Commodity	Trucks		LCV	
		Nos.	%	Nos.	%
1	Empty Vehicles	177	26.8%	159	40.8%
2	Perishable Goods (Fruits, Fish, Milk, Eggs etc.)	26	3.9%	19	4.9%
3	Industrial Products and Goods	107	16.2%	67	17.2%
4	Food Products and House Hold Articles	50	7.6%	35	9.0%
5	Petroleum Products and Chemicals	26	3.9%	16	4.1%
6	Automobiles and Parts	36	5.4%	9	2.3%
7	Forest Products	12	1.8%	7	1.8%
8	Miscellaneous and Provision	60	9.1%	39	10.0%
9	Construction Materials/ Equipment	167	25.3%	39	10.0%
	Total	661	100 %	390	100 %

The empty vehicles have a higher percentage of 40.8% of LCV. Among various commodities, industrial products and goods occupy 17.2% of LCV. The next higher percentage of trucks falls in the category of construction materials and equipment and also Miscellaneous and provision, which are 10.0% respectively. Food products and house hold goods share 9.0% of total LCV. Perishable goods share 4.9%, whereas Petroleum products and chemicals share 4.1% of LCV traffic. Automobile and parts share 2.3% of total LCV.

The empty vehicles have a higher percentage of trucks, which is 26.8%. The next prominent category of commodity is construction material and equipments with 25.3%, whereas industrial products and goods share 16.2% of trucks. Miscellaneous and provision share 9.1% of truck traffic. The food products and house hold articles share 7.6% of truck traffic. The automobile and parts consist of 5.4%. Petroleum products and perishable goods sharers equal percentage of truck traffic, which is 3.9%. Forest products share 1.8% of truck traffic.

Origin and Destination survey reveals that freight traffic towards Walajapet is empty with 48.1% and 46.2 % of truck and LCV respectively and traffic towards Chennai has only 10.6% empty trucks and 21.8% empty LCV. The direction wise commodity composition of LCV and Truck in percent and in numbers is presented in **Volume-II: Annexure**.

7.3.6 Axle Load Survey

Axle load survey was carried out to get the spectrum of vehicle loading pattern and also to arrive at Vehicle Damage Factor (VDF) for pavement design.

Axle load survey was carried out at Km 33.500 (towards Chennai) and km 36.000 (towards Walajapet) for 24 hours. Consultant made use of WL 103 Wheel Load Weigher, a portable low profile instrument manufactured by M/s Haenni & Co.

Ltd., Switzerland. The equipment consists of flat weighing platform with a laterally connected digital display.

Classified volume count was also carried out simultaneously during Axle load survey for expansion of the sampled data collected for various categories of freight vehicle to their individual daily average volume.

The Axle load frequency data presented in **Volume-II: Annexure** was used for working out VDF and loading pattern on the project road. Sampling technique was used for recording the data in the field. Summary of Axle load frequency analysis has been presented in **Table 7.11**:

Table 7.11: Summary of Axle Load Frequency

S. No.	Vehicle	Towards Chennai		Towards Walajapet		Bothways Average	
		Sample Size (%)	VDF	Sample Size (%)	VDF	Sample Size (%)	VDF
1	LCV	7.93%	0.08	8.80%	0.19	8.43%	0.14
2	2A Truck	8.32%	4.99	5.15%	1.64	6.63%	3.21
3	3A Truck	12.40%	13.60	6.70%	4.28	8.95%	7.94
4	Articulated	7.40%	9.76	4.70%	6.77	6.35%	8.40
Freight traffic Composition		LCV@ 19%, Truck 2A @ 58%, Truck 3A@ 17% & Articulated 6%		LCV@ 21%, Truck 2A @ 54%, Truck 3A@ 22% & Articulated 3%		LCV@ 20%, Truck 2A @ 46%, Truck 3A@ 20% & Articulated 4%	
All Vehicles			5.94		2.10		3.76

Analysis of Axle Load data reveals highly skewed VDF pattern against direction. A weighted analysis against type of vehicles on the road brings out an overall VDF of 3.76 against IRC: 37 recommended value of 3.5 for National Highways for plain terrain.

7.3.7 Turning Movement Survey

Turning movement survey was carried out at ten major intersections for 12 hours to grab the peak hour movement. The summary of minimum and maximum traffic flow in PCU/hour has been summarized for all ten major junctions presented in **Table 7.12**. It was observed that peak traffic hours were during morning hours from 8 am to 10 am and evening hours from 4 pm to 6 pm.

Table 7.12: Peak Hour Flow

S. No.	Junction	Flow (PCU/hr)		Direction
		Min	Max	
1	Ambattur Junction (Km 14.900)	1077	3422	Min. from Ambattur Max. from Walajapet
2	Tirupati Junction (Km 24.400)	693	3888	Min. from Tirupati Max. from Chennai
3	Hyundai Junction (Km 34.030)	752	2272	Min. from Hyundai Max. from Chennai
4	Sriperumbudur Junction (Km 39.300)	412	2986	Min. from Sriperumbudur Max. from Chennai
5	Sriperumbudur Junction (Km 41.350)	614	1631	Min. from Sriperumbudur Max. from Walajapet
6	Sipkot Junction (Km 45.200)	224	1551	Min. from Sipkot Max. from Walajapet
7	Sunguvachatram Junction (Km 48.400)	767	3333	Min. from Walajapet Max. from Chennai

S. No.	Junction	Flow (PCU/hr)		Direction
		Min	Max	
8	Sunguvachatram Junction (Km 50.800)	289	1009	Min. from Sunguvachatram Max. from Walajapet
9	Kanchipuram Junction (Km 70.200)	94	997	Min. from Karai Max. from Chennai
10	Kanchipuram Junction (Km 76.800)	232	1055	Min. from Kanchipuram Max. from Walajapet

The summary of detailed analysis is presented in **Volume-II: Annexure**. The Turning Volumes (Peak hour) for all ten junctions are presented in **Fig 7.7**.

7.4 Traffic Assignment

The project envisages the improvement and widening of existing 4-lane divided carriageway to 6-lane divided carriageway facility. Therefore, normal traffic on the project road remains to be the main user of the improved facility. However, other kind of traffic anticipated during the project service life has been discussed under following paragraphs.

7.4.1 Normal Traffic

Normal traffic on the project road is derived from primary survey on the various links. Analysis of the same and Annual Average Daily Traffic (AADT) for individual links has already been brought out in the preceding paragraphs.

7.4.2 Generated Traffic

Project is aimed at providing an efficient facility both in terms of Capacity and Vehicle Operating Costs (VOC). Keeping in view the exiting 4-lane road facility to be improved as access controlled highway, it is expected to generate additional trips on account of saving in VOC and travel time. Further, the project would influence the growth in economic/ commercial activities along the project road.

Considering all the above aspects, generated traffic @ 10% of normal traffic is assigned on the first year of operation and growing at normal traffic growth rate.

7.5 Traffic Forecasts

7.5.1 Forecasting Methodology

For any transportation project traffic growth rate is an essential component required to be estimated reasonably well for the future traffic on the Project Influence area (PIA). When the availability of capital resources is small and has competing demands, the investments in a transport project have to be planned meticulously, keeping in view not only the present demand but also the requirements for the future for a reasonable period.

Traffic forecasting using traffic growth pattern, which is the most important governing factor, in the present state of knowledge can at best be only approximate. Traffic is generated as a result of the interplay of a number of contributory factors like Population, Gross/ Net State Domestic Product, vehicle ownership, agriculture output, fuel consumption etc. to name a few. Any change in the pattern of these factors can only be estimated approximately with a limited degree of accuracy.

There are various factors by which the future traffic demand may differ from that being experienced presently. The major factors affecting the transport demand are as follows:

- i. *Growth in population; and*
- ii. *Economic performance.*

These factors are responsible for normal growth of traffic. All these parameters supported with the findings of the socio-economic indicators and performance, and traffic characteristics are discussed in the following paragraphs, which would form the basis for traffic forecasts.

The mathematical model used for forecasting the growth rates by Log Regression Method for passenger and freight traffic as per IRC: 108-1996 has been given below:

For Passenger Traffic:

$$\text{Log } P_n = \text{log } P_0 + n \times \text{Log } (1+r) \quad \text{----- Equation 6.1}$$

Where, P_0 = Traffic flow in base year
 P_n = Traffic in the n^{th} year
 n = Number of years
 r = Annual growth rate of traffic

For Freight Traffic:

$$\text{Log } P = A_0 + A_1 \times \text{Log } (\text{NSDP}) \quad \text{----- Equation 6.2}$$

Where, P = Traffic Volume
 NSDP = Net State Domestic product
 A_0 = Regression constant
 A_1 = Regression coefficient

7.5.2 Traffic Growth from Socio-Economic Data

The transport demand is estimated from Growth Rate of Population (G_p), Growth Rate of Per Capita Income (G_{PCI}) and Growth Rate of Net State Domestic Product (G_{NSDP}) etc. For passenger vehicles, Growth Rate of Population and Growth Rate of Per Capita Income are considered, whereas for freight vehicles Growth Rates of Gross/ Net State Domestic Product is considered.

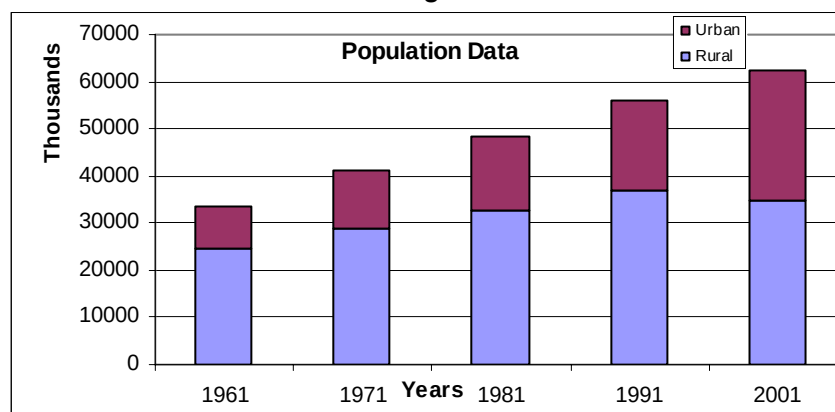
7.5.2.1 Population Growth

The decennial population growth for Tamil Nadu from 1971 to 2001 is given in **Table 7.13**:

Table 7.13: Population Growth

Period	Population			Decennial Growth, %		
	Total	Rural	Urban	Total	Rural	Urban
1961	33686953	24696425	8990528			
1971	41199168	28734334	12464834	2.03	1.53	3.32
1981	48408077	32456202	15951875	1.63	1.23	2.5
1991	55858946	36781354	19077592	1.44	1.26	1.81
2001	62405679	34921681	27483998	1.11	-0.52	3.72

Fig 7.8



The decennial growth rate of population for Tamil Nadu in rural area is showing negative value indicating migration of people from rural to urban area. Also there is a general tendency of decline over the last three decades in total. For the past decade average annual growth of population is at 1.11%, which has been taken for further analysis ($G_p = 1.11\%$).

7.5.2.2 Per Capita Income Growth

The trend analysis for the Per Capita Income (at constant prices) was done by both methods annual compound growth rate method and log regression method. Analysis was carried out for block years as per the available data to arrive at a suitable growth rate. The block wise data is presented in **Table 7.14**:

Table 7.14: Per Capita Income Growth

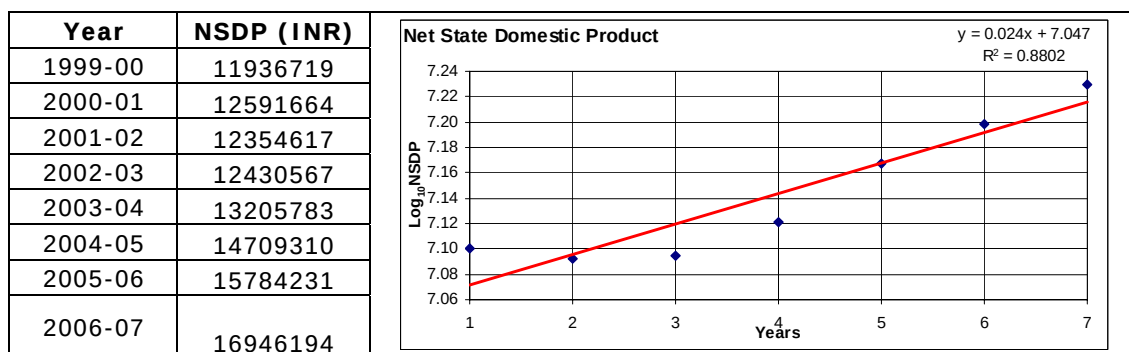
Year	PCI (INR)	
1999-00	19378	
2000-01	20249	
2001-02	19691	
2002-03	19628	
2003-04	20672	
2004-05	22835	
2005-06	24308	
2006-07	25898	

The compound growth rate for Per Capita Income is at 4.23%. Above figure shows Log regression analysis, carried out for Tamil Nadu data based on the Equations 6.1, and yields a value for the growth rate as 4.18%. Thus, a value of 4.18% has been adopted as growth rate of Per Capita Income (G_{PCI}).

7.5.3 Net State Domestic Product (NSDP)

Net state Domestic Product is an indicator of economic strength of the state and the same reflects the growth in freight traffic and overall economic performance of the state. Consultants have made use of both annual compound growth rate and log regression methods to arrive at suitable growth rate to be used for traffic projections. The NSDP values of Tamil Nadu state for a block period from 2000 to 2007 are presented in **Table 7.15**:

Table 7.15: Net State Domestic Product



Above figure shows Log regression analysis carried out for Tamil Nadu on the basis of Equation 6.2 for the block period. The growth rate values obtained for Net State Domestic Product from compound growth method is 5.13% and from Log Regression is 5.68%. Thus, a value of 5.68% has been adopted as growth rate of Net State Domestic Product (G_{NSDP}).

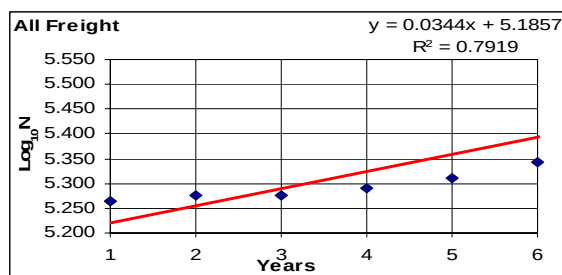
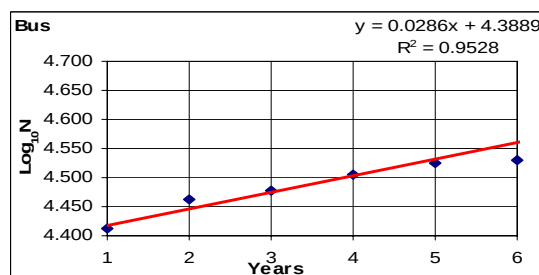
7.5.4 Growth of Registered Vehicles

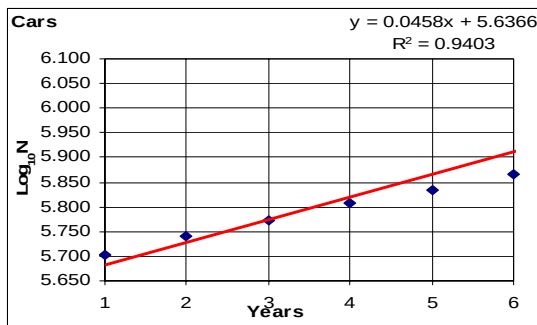
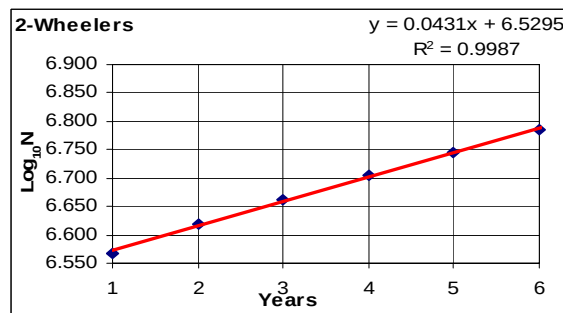
The Number of registered motor vehicles in Tamil Nadu state as per “Statistical Hand Books of Tamil Nadu of respective years” is given in **Table 7.16**:

Table 7.16: Registered Vehicles

Year	Vehicle Type			
	All Freight Vehicles	Buses	Car/Jeep/Taxi	Two Wheelers
1999-00	183476	25861	505196	3679525
2000-01	188238	28958	550369	4163002
2001-02	189050	29941	592263	4600565
2002-03	195047	32061	640775	5084043
2003-04	204886	33508	682134	5547755
2004-05	220016	33930	734899	6106057
2005-06	272756	38710	963286	6750328
2006-07	339334	43609	1086221	7503426

The compound growth rate for All Freight Vehicles, Buses, Car/Jeep/Taxi and Two Wheelers are 9.18%, 7.75%, 11.56% and 10.72% respectively.





The Growth rates as obtained by Log regression method for All Freight Vehicles, Buses, Car/Jeep/Taxi and Two Wheelers are 8.24%, 6.81%, 11.12% and 10.43% respectively. For the further analysis, growth rates values obtained by Log regression method have been adopted.

7.5.5 Transport Demand Elasticity

Transport demand elasticity is one of the methods of establishing relationships between transport demand (i.e. number of vehicles) and the parameters (Prices, Net State Domestic Product, Per Capita Income etc.) affecting the demand for vehicles (passenger and freight). This relationship may remain static or may change in future due to disproportionate changes in the future growth or parameters and/or technological changes in vehicle characteristics. Transport Demand Elasticity is a measure of percentage change in transport demand w.r.t. percentage change in the parameters (such as Prices, Per Capita Income, Population etc.) influencing the demand.

On the basis of the above formulation the Transport Demand Elasticity for passenger and freight vehicles have been estimated by using the following equations:

Elasticity for Passenger Traffic

$$E = \frac{G}{(1 + G_P) \times (1 + G_{PCI}) - 1}$$

Where, E = Elasticity of Transport Demand
 G_P = Population Growth Rate
 G_{PCI} = Per Capita Income Growth Rate
 G = Growth Factor

Elasticity for Freight Traffic

$$E = \frac{G}{G_{NSDP}}$$

Where, E = Elasticity of Transport Demand
 G_{NSDP} = Net State Domestic Product Growth Rate
 G = Growth Factor

Based on the above parameters the Elasticity for Trucks, Bus, Car and 2 Wheelers have been worked out for Tamil Nadu state as given below:

$$E_{TRUCK} = 0.0824 / 0.0568$$

$$= 1.45$$

$$E_{BUS} = 0.0681 / (1.0111 \times 1.0418 - 1)$$

$$= 1.27$$

$$E_{CAR} = 0.1112 / (1.0111 \times 1.0418 - 1)$$

$$= 2.08$$

$$E_{2W} = 0.1043 / (1.0111 \times 1.0418 - 1)$$

$$= 1.95$$

To arrive at a realistic values of Transport Demand Elasticity, a comparison of the elasticities obtained for different category of vehicles from various studies have been made and suitable values adopted for the project are given in **Table 7.17**:

Table 7.17: Transport Demand Elasticity

S. No.	Study Reference	Vehicle category			
		2 W	Car	Bus	Truck
1	Present Project	1.95	2.08	1.27	1.45
2	Similar Project, NH-210 in Tamil Nadu	2.95	2.16	1.54	1.02
3	Similar project NH – 45 in Tamil Nadu	1.65	1.82	1.17	1.26
4	Similar Project NH-4 and NH-46 in Tamil Nadu	2.39	1.72	-	1.30
5	Similar Project NH-67 in Tamil Nadu	2.28	1.63	-0.77	0.94
6	Expressway studies in India	-	1.69	1.30	1.54
7	ADB studies in India	2.10	1.80	1.50	1.30

Transport Demand Elasticity derived for the project road (based on economic parameters) is in broad agreement with the reference studies.

Implementation of the project is aimed at providing better economic facilities that is expected to promote efficient bus transport along with certain shift from personalized vehicular movement. Accordingly, transport demand elasticity values for the project are adopted as shown in **Table 7.18**:

Table 7.18: Adopted Demand Elasticity

S. No.	Vehicle Category	Transport Demand Elasticity
1	2-wheeler	2.0
2	Car/Jeep/Taxi	1.8
3	Bus	1.3
4	Truck	1.4

7.5.6 Projected Traffic and Growth Rates

Traffic growth rates for the project road are estimated on the basis of adopted transport demand elasticity. State Economy of Tamil Nadu has major influence on the project road. Past performance at an average growth of 5.68% is a subdued one. However, Govt. of Tamil Nadu has taken up various measures with active support from Central Government to improve state's economic performance and bring it to the tune of national target.

For the purpose of traffic growth estimation, it may be appropriate to consider average NSDP growth rate as 7.00%, 6.0% and 5.0% for the periods 2008-13, 2013-18 and Beyond 2018 respectively. These NSDP average growth rates result in Per Capita Income growth rates (G_{PCI}) as 5.82%, 4.83% and 3.84% for above mentioned periods respectively. Accordingly, traffic growth rates are estimated and a comparison of these growth rates with other methods viz. based on past traffic data and number of registered vehicles is given below:

Based on socio-economic data: Traffic Growth Rates based on socio-economic profile of Tamil Nadu are as shown in **Table 7.19**:

Table 7.19: Growth Rate

S. No.	Period	Growth Rate (%)			
		2 W	Car	Bus	Truck
1	2009 – 13	14.00	12.60	9.10	9.80
2	2014 – 18	12.00	10.80	7.80	8.40
3	Beyond 2018	10.00	9.00	6.50	7.00

Based on Number of Registered Vehicles: Traffic Growth Rates from number of registered vehicles in Tamil Nadu (data tabulated in 7.5.4) are as shown in **Table 7.20**:

Table 7.20: Growth Rate

S. No.	Period	Growth Rate (%)			
		2 W	Car	Bus	Truck
1	Based on block period from 2000 to 2005	10.43	11.12	6.81	8.24

The Traffic Growth Rates estimated in other National Highway projects in the Tamil Nadu have been presented in **Table 7.21, 7.22** for a general comparison:

Table 7.21: NH-45 (Tindivanam – Tiruchchirapalli Bypass end)

S. No.	Period	Growth Rate (%)			
		2 W	Car	Bus	Truck
1	1998 – 2002	10.00	11.00	6.00	7.00
2	2003 – 2012	9.50	10.50	6.50	7.50
3	Beyond 2013	9.00	10.00	7.50	7.00

Table 7.22: NH-67 Extn. (Karur - Coimbatore)

S. No.	Period	Growth Rate (%)			
		2 W	Car	Bus	Truck
1	2001 – 2005	7.50	7.50	7.50	7.50
2	2006 – 2007	9.00	6.50	6.00	6.50
3	2008 – 2018	9.00	6.50	6.00	6.50

Traffic Growth Rates for Traffic Forecast:

As per Section 7.5.5, where Transport Demand Elasticity values were compared for a number of projects in Tamil Nadu and realistic values were adopted forming the basis for Traffic projections. Hence, the traffic growth rates obtained from Socio-Economic profile have considered for traffic forecasting, which are in general agreement with the growth rates adopted in other projects in Tamil Nadu. Growth rates adopted are given in **Table 7.23**:

Table 7.23: Adopted Growth Rate for Traffic forecast

S. No.	Period	Growth Rate (%)			
		2 W	Car	Bus	Truck
1	2009 – 13	14.00	12.60	9.10	9.80
2	2014 – 18	12.00	10.60	7.10	7.80
3	2019 - 23	10.00	8.60	5.10	5.80
4	2024 - 28	8.00	6.60	5.00	5.00
5	2029 - 33	6.00	5.00	5.00	5.00
4	Beyond 2033	5.00	5.00	5.00	5.00

Estimation of Traffic growth beyond 10-year period is an uncertain exercise as it is difficult to make an objective assessment of economic performance/development activities at this stage. There remain possibilities of higher growth potential as well as resulting lower transport demand elasticity.

The assigned traffic is projected for all three homogeneous sections based on the above growth rates for a maximum period of 30 years (2008-2038) and is presented in **Table 7.4 to 7.6**. The summary of traffic in year of opening, at every 5 Years up to 2038 and at the end of design life of 20 years (2031) for all three links is presented in **Table 7.24**.

Table 7.24: Traffic Projection

Year	2W	3W	Car	Bus		LCV	Truck			Total	
				Mini	Full		Medium	Heavy	Artic	nos.	pcu
Link 1 (L41): Poonamale - Sunguvachatram (34.60 Km)											
2008	5480	1055	8200	1576	3719	2667	3591	2058	852	29198	53385
Composition	18.77 %	3.61 %	28.08 %	5.40 %	12.74 %	9.13 %	12.30 %	7.05 %	2.92 %	100 %	
2012	9256	1495	13182	2233	5269	3876	5219	2991	1238	44759	78966
2013	10551	1631	14842	2436	5748	4256	5731	3284	1360	49840	87124
2018	20454	2590	27019	3776	8910	6816	9177	5259	2177	86118	143390
2021	27225	2934	34607	4384	10344	8072	10869	6229	2579	107242	173109
2028	48403	4137	56184	6180	14583	11532	15527	8899	3684	169127	258041
2031	57648	4789	65039	7154	16882	13349	17974	10301	4265	197402	299523
2033	64774	5280	71706	7887	18612	14718	19817	11357	4702	218853	330832
2038	82670	6739	91517	10066	23754	18784	25292	14495	6001	279317	422235
Link 2 (L42): Sunguvachatram - Kanchipuram (26.40 Km)											
2008	4650	1080	9624	1135	3947	2877	4139	2587	802	30841	58556
Composition	22.16 %	2.47 %	37.28 %	2.60 %	9.03 %	7.32 %	10.53 %	6.58 %	2.04 %	100 %	
2012	7854	1530	15471	1608	5592	4182	6016	3760	1166	47178	86602
2013	8953	1669	17420	1754	6101	4591	6606	4129	1280	52503	95542
2018	17356	2588	31711	2719	9457	7353	10578	6611	2050	90423	157162
2021	23101	3004	40617	3157	10978	8708	12527	7830	2427	112349	189642
2023	27953	3318	47903	3487	12127	9747	14022	8764	2717	130039	215613
2028	41072	4235	65940	4451	15477	12440	17897	11186	3468	176165	282109
2031	48917	4902	76334	5152	17917	14401	20717	12949	4014	205304	32762
2033	54963	5405	84158	5680	19753	15877	22841	14276	4426	227380	361322
2038	70148	6898	107410	7250	25211	20263	29152	18221	5649	290201	461149
Link 3 (L43): Kanchipuram - Walajapet (32.00 Km)											
2008	4978	999	7501	791	1955	1212	3754	2190	651	24031	43905
Composition	20.71 %	4.16 %	31.21 %	3.29 %	8.14 %	5.04 %	15.62 %	9.11 %	2.71 %	100 %	
2012	8408	1415	12058	1121	2770	1762	5456	3183	946	37119	65261
2013	9585	1544	13577	1223	3022	1934	5991	3495	1039	41410	72091
2018	18581	2393	24716	1895	4684	3097	9594	5597	1664	72221	119395
2021	24731	2779	31657	2200	5438	3668	11362	6628	1970	90433	144696
2023	29924	3069	37336	2430	6007	4106	12718	7419	2206	105216	164658
2028	43969	3917	51394	3102	7666	5241	16232	9469	2815	143805	216781
2031	52367	4535	59495	3591	8874	6067	18790	10962	3259	167940	251686
2033	58840	5000	65594	3959	9784	6688	20716	12085	3593	186259	278036
2038	75097	6381	83716	5052	12487	8536	26440	15424	4585	237719	354852

Start of Project Road
KM 13/800

POONAMALLEE

CHENNAI

SRIPERUMBUDUR

KANCHIPURAM

End of Project Road
KM 106/800

WALAJAPET

- Turning Movement Survey Station
- O - D Survey Station
- Axle Load Survey Station
- Traffic Volume Count Station

Chapter - 8

Validation of Engineering Data

CHAPTER – 8

Validation of Engineering Data

8.1 General

This chapter is intended to give brief descriptions concerning the validation of engineering data that has been collected during field investigations. As per the terms of reference (TOR), the validation of existing features has to be carried out by conducting inventory surveys, topographic surveys and geotechnical investigations etc. The as built drawings of the 2x2-laning project shall be the starting point for 2x3-laning proposal. The as-built drawings in hard copy and soft copy were procured from Project Director's Office, Chennai.

Validation of as built features has been carried out. As the project road has been recently constructed, most of the existing features shown in as built drawings are found to be matching. However, the consultants validated the existing features and presented in the subsequent paragraphs.

8.2 Detailed Topographic Survey

Topographic surveys have been conducted for the entire project road as a part of validation. While carrying out the traversing and fly levelling survey team connected the temporary bench mark and GPS pillars to cross verify the levels as indicated in the as built drawing. They were found in order. The topographic survey has been carried out to check the bearings of the centre line and to reconfirm the alignment given in the as built drawings.

The Detailed Topographic survey was conducted for entire length and the stretches where horizontal alignment in terms of bearings and radii were checked are given in **Annexure 8.1**.

The detailed drawings are attached in volume-3.

8.3 Features Identified

From the Detailed Topographic Survey, some additional features on both sides of the road were identified, as for instance Buildings, religious structures, shops, fuelling stations, and detailed features of cross roads, which were developed over time.

With respect to these additional details, the as built drawings for entire project road have been updated. The alignment of the as-built drawings also got cross checked through topographic survey conducted.

8.4 Validation of As-Built Drawing

As a part of the validation for the as built drawings, consultants have visited the site and the drawings were validated based on the existing scenario of the project corridor. The additional road utilities such as metal beam crash barrier, side drain/Toe drain/median drain, fuelling stations, shops, under construction buildings, religious structures, cross roads and change in land use were found out and has been incorporated in the validated set of drawings.

The radii of substandard horizontal curves, wherever existed were verified at site using arch chord method. At site length of chord was measured using 30 m tape and at the same time offset was measured using 3 m steel tape. Using geometric properties of circle, radius of the curve has been derived.

While validating existing fuelling stations based on As-Built Drawings, some additional petrol pumps were identified. Both are listed in **Annexure 8.2**.

Validated guard rails and metal beam crash barrier list is given in **Annexure 8.3**.

Validation of cross roads have been done and presented in **Annexure 8.4**.

In **Annexure 8.5**, validated toe-drain/toe wall/stone pitching/ chute drain details and in **Annexure 8.6**, validated list of truck/bus lay byes are presented.

Underground utilities are validated and presented in **Annexure 8.7**

Pavement crust composition as given in the as built drawings and pavement crust measured after digging the pits during subsoil investigations along the edge of paved shoulder and earthen shoulder is presented in **Annexure - 8.8**

There is no pedestrian / cattle crossing found on the existing road.

Validation of Overhead Gantry Signs are given in **Annexure 8.9**

Validation of Sub-Standard curves is given in **Annexure 8.10**

Annexure 8.11 shows the validation for embankment and RE walls.

The validation of existing drains is given in **Annexure 8.12** and **Annexure 8.13** shows the validation of existing service roads.

Validation of existing bridges, ROBs, Grade Separators/ Flyovers and Underpasses are presented in **Annexure-8.14**

8.5 Validation of Geotechnical Investigations

Geotechnical investigations have been carried out as mentioned in TOR at required locations of proposed underpasses, flyovers and bridges. Based on bore log data, laboratory test results and bearing capacity, the type of foundation and its depth have been determined and used in the preliminary design. Drawings of structures are prepared based on the geotechnical investigation data and interpretation of test results. The geotechnical report is being submitted separately.

In general, the subsoil layers as observed in the confirmatory boring report carried out during execution of the 4-laning of this section as collected from PD, NHA are as follows:

Upto 40 Km from starting of the project road: Medium to dense sand and silt layers upto about 30m depth from the ground level.

From 40km to 100km from the starting of the project: From the GL upto 15-25 m range medium to dense sand and silt layers are existing. A fractured layer of rock designated as Shell has been met with at about 15-25m depth from the ground level.

Beyond 100 Km: Disintegrated rock layers were met with at a shallow depth i.e. around 2-3m below the bed

Similar kind of strata were observed in the bore log details generated from the sub-soil investigations carried out for this project for all these sections i.e upto 40 Km, 40 Km to 100 Km and beyond 100 Km. Only one difference was observed, the disintegrated rock layer which has been classified as Shell in the Confirmatory boring report has been classified as Sand Stone in the present study report.

Annexure 8.1

Validation of Existing Horizontal Alignment

As per As-Built Drawing			As per Survey by Consultant	
Chainage	Radius	Def Angle	Radius	Def Angle
14157	200	36.8494	200	36.704
14441	270	39.5555	270	39.347
14748	360	17.7599	360	17.849
15011	170	29.413	170	29.504
15361	800	5.6668	800	5.651
15721	2000	2.7512	2000	2.774
16116	10000	0.9016	10000	0.856
16578	600	21.6166	600	21.626
16949	8000	0.7216	8000	0.757
17463	700	15.791	700	15.746
17923	200	26.7	200	26.908
18049	not shown	0.23		
18212	300	31.99	300	32.135
18560	4000	1.75	4000	1.915
19091	700	19.8	700	19.801
19499	2000	6.31	2000	6.128
19776	3000	2.61	3000	2.769
20088	3000	3.58	3000	3.277
20559	800	17.39	800	17.518
20921	2000	9.42	2000	8.943
21273	400	18.562	400	18.312
21726	400	40.252	400	40.159
22196	800	5.59	800	5.600
22402	170	54.635	170	54.000
22712	800	18.341	800	18.341
23044	2000	7.333	2000	7.096
23349	500	13.094	500	13.020
23858	275	24.569	275	24.569
24053	275	20.924	275	20.924
24237	360	10.814	360	10.856
24566	8000	0.855	8000	0.770
25173	2000	12.89	1900	12.812
25598	2000	8.559	2000	8.493
26020	4000	1.595	4000	1.653
26406	4000	2.914	4000	3.013
26821	3000	6.2684	3000	6.262
27117	2000	2.3879	2000	2.495
27625	2000	16.0525	2000	16.111
28063	4000	2.09	4000	2.289
28324	10000	0.87	10000	1.019
28977	6000	1.13	6000	1.082
30340	700	27.413	700	27.413
30770	400	29.483	12	29.483
31640	3000	11.42	3000	11.372
32309	1000	12.54	1000	12.603
33019	800	19	800	19.004
33487	2000	3.68	2000	3.360
33923	4000	2.35	4000	2.167

As per As-Built Drawing			As per Survey by Consultant	
Chainage	Radius	Def Angle	Radius	Def Angle
34682	1000	12	1000	12.506
35300	700	32	700	32.090
35750	4000	1.47	4000	1.219
36376	4000	1.35	4000	1.231
37058	2000	13	2000	12.567
37782	2000	4.15	2000	3.710
38017	2000	9	2000	8.385
38414	500	20.19	500	20.322
38791	2000	6.32	2000	6.421
39218	500	24.98	500	25.291
39613	2000	10.805	2000	10.445
40544	400	57.608	400	57.481
40850	600	10.222	600	10.171
41406	300	57.085	300	57.099
42095	300	69.083	300	69.182
42631	700	6.849	700	6.776
42979	400	34.295	400	34.268
44354	3000	2.285	3000	2.265
44801	2500	4.95	2500	4.930
45111	1200	6.03	1200	5.392
45561	1200	7.2	1200	6.580
46616	3000	4.419	3000	4.444
47248	3000	1.476	3000	1.310
47662	400	53.007	400	52.844
48145	500	29.265	500	29.249
48785	2000	5.065	2000	5.064
49244	1000	11.84	1000	11.834
51050	400	67.23	400	67.167
51600	430	65.79	430	65.617
52158	1000	13.13	1000	12.946
52621	2000	3.78	2000	3.871
53433	1200	15.22	1200	14.874
53875	2000	9.27	2000	8.935
54543	600	20.14	600	20.021
54889	2000	7.16	2000	7.077
55071	2000	4.15	2000	4.112
55580	2000	4.97	2000	5.062
55873	2000	3.51	2000	3.619
56336	2000	6.06	2000	6.253
56630	1000	11.99	1000	12.072
not shown	not shown	0.08		
57147	3000	3.68	3000	3.822
57503	400	21.96	400	22.069
57816	2000	4.68	2000	4.798
58423	2000	8.19	2000	8.216
59077	2000	4.2	2000	4.319
59340	800	12.74	800	12.910
60220	400	31.19	400	30.938
60567	500	16.86	500	16.599
61520	2000	7.17	2000	7.238
61935	3000	2.81	3000	2.739

As per As-Built Drawing			As per Survey by Consultant	
Chainage	Radius	Def Angle	Radius	Def Angle
62930	1000	14.448	1000	14.447
63689	6000	0.693	6000	0.682
64053	1000	12.2375	1000	12.212
65389	6000	3.3505	6000	3.307
66643	2000	3.986	2000	3.970
67182	4000	1.072	4000	1.088
67778	2000	6.931	2000	6.918
68853	2000	5.702	2000	5.656
69200	1000	13.249	1000	13.253
69643	1500	11.854	1500	11.841
70246	230	26.568	230	26.907
70425	2000	12	2000	12.462
70825	1000	10	1000	9.511
71175	2000	6	2000	5.783
71350	1000	not shown	1000	1.301
71775	1500	7.15	1500	6.453
72340	not shown	0.19	5000	0.230
72600	2000	2.35	2000	1.872
72750	2000	3.46	2000	2.823
73050	3000	4.22	3000	4.091
73950	2000	6.78	2000	6.853
74275	3000	2.35	3000	2.216
74700	4000	6.34	4000	6.277
75675	2000	10.6	2000	10.602
76150	3000	1.21	2000	1.312
not shown	2000	2.97	2000	2.761
76790	400	28	400	28.600
77450	not shown	not shown	2000	3.034
not shown	2000	2.1	2000	2.725
77850	800	not shown	800	7.492
78150	1000	20	1000	19.553
78500	600	16	600	16.000
not shown	2000	not shown	2000	1.783
79126	800	not shown	800	24.120
80270	500	50.43	500	50.409
80765	500	29.7	500	29.812
not shown	not shown	0.29		
81611	1000	8.63	1000	8.477
82063	1000	8.4	1000	8.594
82297	700	10.48	700	11.125
82675	400	37	400	37.909
83502	400	34	400	34.118
84317	2000	4.71	2000	4.167
84611	1000	10.83	1000	9.781
85041	2000	3.37	2000	2.974
85546	1000	7.94	1000	7.251
86616	2000	3.52	2000	3.162
86.847	1000	not shown	1000	10.745
87000	not shown	not shown	2000	1.955
not shown	not shown	2.29	2000	1.546
87149	2000	1.81		

As per As-Built Drawing			As per Survey by Consultant	
Chainage	Radius	Def Angle	Radius	Def Angle
87501	2000	1.26	2000	1.009
88106	4000	2.52	4000	2.248
88455	3000	2.11	3000	2.043
88655	not shown	not shown	3000	0.705
not shown	3000	2.34	3000	2.318
			2000	2.281
not shown	not shown	0.12		
not shown	not shown	0.73		
90268	600	16	600	15.917
90563	600	17	600	17.496
91121	1000	7.04	1000	6.407
91316	1000	8.57	1000	7.811
92069	2000	1.59	2000	1.283
92181	2000	1.6	2000	1.171
92361	2000	2.56	2000	2.335
92491	2000	3.5	2000	3.023
92986	3500	8.58	3500	7.716
			700	6.347
94100	not shown	not shown	400	23.225
			2000	3.252
not shown	not shown	0.5		
94857	not shown	0.16	2000	0.402
95361	2000	8.72	2000	7.592
95729	360	33	360	33.000
96184	2000	4.77	2000	4.282
97444	3000	1.64	3000	1.465
98195	2000	2.5	2000	2.203
98345	2000	2.51	2000	2.156
98687	not shown	0.05		
99086	3500	1.17		
99258	1500	6.23	1500	6.528
99665	8000	0.49	8000	0.350
100010	not shown	0.8	3000	0.691
100345	not shown	0.15	2500	0.133
100784	3000	5.0	3000	4.423
			3000	1.233
101064	not shown	not shown	1000	3.368
101472	3000	not shown	3000	2.517
101670	5000	0.64	3000	0.625
101910	3000	3.5	2500	3.047
102343	2000	4.33	2000	3.925
102681	500	13.95	500	12.367
102945	500	18.72	500	17.000
103522	5000	0.69		
103854	5000	0.73	5000	0.564
104011	1200	6.28	1800	6.281
104604	not shown	not shown	800	10.395
104861	not shown	not shown	5000	0.732
105201	not shown	not shown	2000	2.016
106235	not shown	not shown	800	8.502
106634	500	41	500	41.000

As per As-Built Drawing			As per Survey by Consultant	
Chainage	Radius	Def Angle	Radius	Def Angle

***Note- Chainage is Continuous**

Annexure 8.2

Validation of Petrol Pumps

SR. NO	Side	As per As Build Drawing		Side	As per Survey by Consultant	
		Chainage (Km)	Remarks		Chainage (Km)*	Remarks
1	-	-	-	LHS	15.870	Indian Oil Petrol Pump
2	-	-	-	LHS	16.120	Hindustan Petroleum Petrol Pump
3	-	-	-	LHS	23.455	Petrol Pump
4	-	-	-	LHS	24.100	Petrol Pump
5	-	-	-	LHS	24.200	Hindustan Petroleum Petrol Pump
6	-	-	-	LHS	26.480	Indian Oil Petrol Pump
7	-	-	-	LHS	28.601	Indian Oil Petrol Pump
8	-	-	-	LHS	28.685	Bharat Petroleum Petrol pump
9	-	-	-	LHS	29.200	Petrol Pump
10	-	-	-	RHS	34.400	Bharat Petroleum Petrol pump
11	-	-	-	LHS	35.652	Petrol Pump
12	-	-	-	RHS	40.210	Indian Oil Petrol Pump
13	-	-	-	LHS	40.225	Bharat Petroleum Petrol pump
14	-	-	-	LHS	42.457	Bharat Petroleum Petrol pump
15	-	-	-	LHS	43.890	Indian Oil Petrol Pump
16	-	-	-	LHS	44.000	IBP Petrol Pump
17	-	-	-	LHS	47.800	Hindustan Petroleum Petrol Pump
18	-	-	-	RHS	51.525	Hindustan Petroleum Petrol Pump
19	-	-	-	LHS	53.037	Petrol Pump
20	-	-	-	LHS	58.824	Reliance Petrol Pump
21	-	-	-	LHS	64.018	Hindustan Petroleum Petrol Pump
22	-	-	-	LHS	64.955	Petrol Pump
23	-	-	-	LHS	65.960	Bharat Petroleum Petrol pump
24	-	-	-	RHS	66.400	Indian Oil Petrol Pump
25	-	-	-	LHS	67.650	Hindustan Petroleum Petrol Pump
26	-	-	-	RHS	71.435	Indian Oil Petrol Pump
27	-	-	-	LHS	80.630	Hindustan Petroleum Petrol Pump
28	-	-	-	RHS	93.200	Bharat Petroleum Petrol Pump
29	-	-	-	LHS	94.700	Bharat Petroleum Petrol Pump
30	-	-	-	LHS	96.725	Indian Oil Petrol Pump
31	-	-	-	LHS	97.128	Indian Oil Petrol Pump
32	-	-	-	RHS	99.600	Reliance Petrol Pump
33	-	-	-	RHS	104.100	Bharat Petroleum Petrol Pump

***Note- Chainage is Continuous**

Annexure 8.3

Validation of Guard Rails and Metal Beam Crash Barrier

S. N.	Side	As per As-Built Drawing			Side	As per Survey by Consultant		
		Chainage (Km)		Remarks		Chainage (Km)*		Remarks
		From	To			From	To	
1	LHS & RHS	17.561	17.655	Pedestrian Guard Rail	LHS & RHS	17.560	17.650	Pedestrian Guard Rail
2	RHS	17.655	18.451	Pedestrian Guard Rail	RHS	17.650	18.447	Pedestrian Guard Rail
3	LHS & RHS	18.451	18.551	Pedestrian Guard Rail	LHS & RHS	18.447	18.546	Pedestrian Guard Rail
4	LHS	18.576	18.760	Pedestrian Guard Rail	LHS	18.570	18.756	Pedestrian Guard Rail
5	LHS	18.700	18.800	Pedestrian Guard Rail	LHS	18.785	18.795	Pedestrian Guard Rail
6	RHS	18.551	18.734	Pedestrian Guard Rail	RHS	18.546	18.730	Pedestrian Guard Rail
7	RHS	18.764	18.800	Pedestrian Guard Rail	RHS	18.760	18.800	Pedestrian Guard Rail
8	LHS & RHS	19.529	19.627	Pedestrian Guard Rail	LHS & RHS	19.526	19.626	Pedestrian Guard Rail
9	LHS & RHS	19.657	20.963	Pedestrian Guard Rail	LHS & RHS	19.650	20.960	Pedestrian Guard Rail
10	LHS & RHS	20.988	22.040	Pedestrian Guard Rail	LHS & RHS	20.983	21.974	Pedestrian Guard Rail
11	LHS	22.040	22.140	Pedestrian Guard Rail	LHS	21.974	22.060	Pedestrian Guard Rail
12	RHS	22.070	22.226	Pedestrian Guard Rail	RHS	22.115	22.220	Pedestrian Guard Rail
13	LHS	22.170	22.236	Pedestrian Guard Rail	LHS	22.115	22.232	Pedestrian Guard Rail
14	LHS	22.252	22.302	Pedestrian Guard Rail	LHS	22.250	22.300	Pedestrian Guard Rail
15	RHS	26.840	27.054	Steel Beam Guard Rail	RHS	26.836	27.136	Steel Beam Guard Rail
16	LHS & RHS	27.054	27.110	Steel Beam Guard Rail	LHS	27.046	27.110	Steel Beam Guard Rail
17	LHS	27.128	27.181	Steel Beam Guard Rail	LHS	27.128	27.181	Steel Beam Guard Rail
18	RHS	27.110	27.173	Steel Beam Guard Rail	RHS	27.110	27.173	Steel Beam Guard Rail
19	RHS	27.251	27.350	Steel Beam Guard Rail	RHS	27.254	27.340	Steel Beam Guard Rail
20	LHS	27.260	27.432	Steel Beam Guard Rail	LHS	27.250	27.422	Steel Beam Guard Rail
21	LHS	30.157	30.330	Steel Beam Guard Rail	LHS	30.155	30.330	Steel Beam Guard Rail
22	LHS & RHS	30.330	30.770	Steel Beam Guard Rail	LHS & RHS	30.330	30.770	Steel Beam Guard Rail
23	LHS	30.770	30.930	Steel Beam Guard Rail	LHS	30.770	30.930	Steel Beam Guard Rail
24	RHS	30.797	30.930	Steel Beam Guard Rail	RHS	30.797	30.930	Steel Beam Guard Rail
25	LHS & RHS	31.081	31.480	Steel Beam Guard Rail	LHS & RHS	31.081	31.480	Steel Beam Guard Rail
26	RHS	31.495	31.500	Steel Beam Guard Rail	RHS	31.495	31.500	Steel Beam Guard Rail
27	RHS	32.359	32.460	Steel Beam Guard Rail	RHS	32.359	32.460	Steel Beam Guard Rail
28	RHS	32.689	32.810	Steel Beam Guard Rail	RHS	32.695	32.810	Steel Beam Guard Rail

S. N.	Side	As per As-Built Drawing			Side	As per Survey by Consultant		
		Chainage (Km)		Remarks		Chainage (Km)*		Remarks
		From	To			From	To	
29	RHS	32.826	32.883	Steel Beam Guard Rail	RHS	32.826	32.890	Steel Beam Guard Rail
30	RHS	32.901	33.066	Steel Beam Guard Rail	RHS	32.912	33.066	Pedestrian Guard Rail
31	RHS	33.089	33.257	Pedestrian Guard Rail	RHS	33.089	33.257	Pedestrian Guard Rail
32	RHS	33.870	34.650	Pedestrian Guard Rail	RHS	33.870	34.650	Pedestrian Guard Rail
33	RHS	34.690	34.880	Pedestrian Guard Rail	RHS	34.690	34.880	Pedestrian Guard Rail
34	RHS	34.910	35.264	Pedestrian Guard Rail	RHS	34.920	35.250	Pedestrian Guard Rail
35	LHS	35.289	35.369	Steel Beam Guard Rail	LHS	35.298	35.375	Steel Beam Guard Rail
36	LHS	35.393	35.461	Steel Beam Guard Rail	LHS	35.400	35.450	Steel Beam Guard Rail
37	LHS	37.587	37.605	Steel Beam Guard Rail	LHS	37.675	37.605	Steel Beam Guard Rail
38	RHS	37.587	37.627	Steel Beam Guard Rail	RHS	37.580	37.610	Steel Beam Guard Rail
39	LHS & RHS	37.662	37.782	Steel Beam Guard Rail	LHS & RHS	37.662	37.790	Steel Beam Guard Rail
40	LHS & RHS	37.827	37.935	Steel Beam Guard Rail	LHS & RHS	37.850	37.945	Steel Beam Guard Rail
41	LHS	37.935	37.989	Steel Beam Guard Rail	LHS	37.945	37.989	Steel Beam Guard Rail
42	RHS	39.140	39.188	Steel Beam Guard Rail	RHS	39.140	39.188	Steel Beam Guard Rail
43	RHS	39.202	39.250	Steel Beam Guard Rail	RHS	39.202	39.250	Steel Beam Guard Rail
44	LHS & RHS	39.380	39.420	Steel Beam Guard Rail	LHS & RHS	39.380	39.413	Steel Beam Guard Rail
45	RHS	39.460	39.604	Steel Beam Guard Rail	RHS	39.460	39.604	Steel Beam Guard Rail
46	LHS	39.460	39.623	Steel Beam Guard Rail	LHS	39.460	39.623	Steel Beam Guard Rail
47	LHS	40.320	40.534	Steel Beam Guard Rail	LHS	40.316	40.534	Steel Beam Guard Rail
48	LHS & RHS	40.900	41.200	Pedestrian Guard Rail	LHS & RHS	40.893	41.214	Pedestrian Guard Rail
49	RHS	41.804	42.050	Pedestrian Guard Rail	RHS	41.837	42.050	Pedestrian Guard Rail
50	LHS	41.804	41.874	Pedestrian Guard Rail	LHS	41.837	41.874	Pedestrian Guard Rail
51	LHS	41.886	41.956	Pedestrian Guard Rail	LHS	41.910	41.975	Pedestrian Guard Rail
52	RHS	42.080	42.557	Pedestrian Guard Rail	RHS	42.080	42.475	Pedestrian Guard Rail
53	LHS	42.080	42.230	Pedestrian Guard Rail	LHS	42.080	42.230	Pedestrian Guard Rail
54	LHS	42.247	42.557	Pedestrian Guard Rail	LHS	42.247	42.557	Pedestrian Guard Rail
55	RHS	42.860	43.050	Steel Beam Guard Rail	RHS	42.860	43.050	Steel Beam Guard Rail
56	LHS	45.314	45.367	Steel Beam Guard Rail	LHS	44.455	44.508	Steel Beam Guard Rail
57	LHS	45.386	45.423	Steel Beam Guard Rail	LHS	44.530	44.565	Steel Beam Guard Rail
58	RHS	45.314	45.367	Steel Beam Guard Rail	RHS	44.462	44.515	Steel Beam Guard Rail
59	RHS	45.385	45.506	Steel Beam Guard Rail	RHS	44.523	44.654	Steel Beam Guard Rail

S. N.	Side	As per As-Built Drawing			Side	As per Survey by Consultant		
		Chainage (Km)		Remarks		Chainage (Km)*		Remarks
		From	To			From	To	
60	-	-	-	-	LHS & RHS	49.670	49.732	Steel Beam Guard Rail
61	-	-	-	-	LHS	50.016	50.070	Steel Beam Guard Rail
62	-	-	-	-	RHS	50.070	20.220	Steel Beam Guard Rail
63	-	-	-	-	LHS	50.070	50.217	Steel Beam Guard Rail
64	-	-	-	-	LHS & RHS	50.235	50.520	Steel Beam Guard Rail
65	LHS & RHS	50.574	50.651	Steel Beam Guard Rail	RHS	50.520	50.750	Steel Beam Guard Rail
66	LHS	50.910	51.435	Steel Beam Guard Rail	RHS	50.844	50.960	Steel Beam Guard Rail
67	RHS	51.000	51.641	Steel Beam Guard Rail	-	-	-	-
68	RHS	51.685	51.870	Steel Beam Guard Rail	-	-	-	-
69	RHS	51.900	51.940	Steel Beam Guard Rail	-	-	-	-
70	LHS	54.403	54.520	Steel Beam Guard Rail	-	-	-	-
71	LHS	54.540	54.581	Steel Beam Guard Rail	LHS	53.488	53.600	Steel Beam Guard Rail
72	LHS	54.598	54.627	Steel Beam Guard Rail	LHS	53.630	53.672	Steel Beam Guard Rail
73	LHS	54.638	54.699	Steel Beam Guard Rail	LHS	54.714	54.776	Steel Beam Guard Rail
74	LHS	56.854	56.995	Steel Beam Guard Rail	LHS	56.751	56.889	Steel Beam Guard Rail
75	RHS	56.939	56.992	Steel Beam Guard Rail	RHS	56.838	56.891	Steel Beam Guard Rail
76	LHS & RHS	57.023	57.064	Steel Beam Guard Rail	LHS & RHS	56.919	56.965	Steel Beam Guard Rail
77	LHS	57.086	57.131	Steel Beam Guard Rail	LHS	56.982	57.025	Steel Beam Guard Rail
78	LHS	57.148	57.165	Steel Beam Guard Rail	LHS	57.043	57.060	Steel Beam Guard Rail
79	LHS	59.136	59.186	Steel Beam Guard Rail	LHS	59.026	59.077	Steel Beam Guard Rail
80	RHS	59.150	59.200	Steel Beam Guard Rail	RHS	59.050	59.100	Steel Beam Guard Rail
81	LHS	59.217	59.277	Steel Beam Guard Rail	LHS	59.114	59.162	Steel Beam Guard Rail
82	RHS	59.237	59.287	Steel Beam Guard Rail	RHS	59.128	59.184	Steel Beam Guard Rail
83	Median	65.670	65.700	Median Barrier	Median	65.562	65.600	Median Barrier
84	Median	66.220	66.250	Median Barrier	Median	66.115	66.143	Median Barrier
85	Median	66.539	66.600	Median Barrier	Median	66.433	66.483	Median Barrier
86	LHS	67.357	67.530	Steel Beam Guard Rail	LHS	67.462	67.517	Steel Beam Guard Rail
87	RHS	67.490	67.543	Steel Beam Guard Rail	RHS	67.462	67.517	Steel Beam Guard Rail
88	LHS	67.588	67.760	Steel Beam Guard Rail	LHS	67.580	67.750	Steel Beam Guard Rail
89	RHS	67.603	67.656	Steel Beam Guard Rail	RHS	67.500	67.550	Steel Beam Guard Rail
90	LHS	70.105	70.230	Steel Beam Guard Rail	LHS	70.080	70.205	Steel Beam Guard Rail

S. N.	Side	As per As-Built Drawing			Side	As per Survey by Consultant		
		Chainage (Km)		Remarks		Chainage (Km)*		Remarks
		From	To			From	To	
91	-	-	-	-	Median	71.440	72.124	Median Barrier
92	-	-	-	-	Median	72.224	72.704	Median Barrier
93	-	-	-	-	RHS	76.760	76.988	Steel Beam Guard Rail
94	-	-	-	-	RHS	79.990	79.242	Steel Beam Guard Rail
95	-	-	-	-	RHS	80.100	80.547	Steel Beam Guard Rail
96	-	-	-	-	LHS	80.077	80.574	Steel Beam Guard Rail
97	-	-	-	-	RHS	80.826	81.030	Steel Beam Guard Rail
98	-	-	-	-	LHS	80.893	80.987	Steel Beam Guard Rail
99	-	-	-	-	RHS	82.376	82.500	Steel Beam Guard Rail
100	-	-	-	-	LHS	82.461	82.500	Steel Beam Guard Rail
101	-	-	-	-	LHS	83.271	83.500	Steel Beam Guard Rail
102	-	-	-	-	RHS	83.300	83.541	Steel Beam Guard Rail
103	-	-	-	-	RHS	83.750	83.935	Steel Beam Guard Rail
104	-	-	-	-	RHS	83.950	84.660	Steel Beam Guard Rail
105	-	-	-	-	RHS	84.675	84.885	Steel Beam Guard Rail
106	-	-	-	-	LHS	84.069	85.047	Steel Beam Guard Rail
107	-	-	-	-	Median	88.550	89.100	Median Barrier
108	-	-	-	-	RHS	90.300	90.362	Steel Beam Guard Rail
109	-	-	-	-	RHS	90.384	90.524	Steel Beam Guard Rail
110	-	-	-	-	RHS	91.800	92.134	Steel Beam Guard Rail
111	-	-	-	-	LHS	92.100	92.134	Steel Beam Guard Rail
112	-	-	-	-	LHS	92.992	92.243	Steel Beam Guard Rail
113	-	-	-	-	RHS	92.992	92.367	Steel Beam Guard Rail
114	-	-	-	-	Median	92.435	93.042	Median Barrier
115	-	-	-	-	LHS & RHS	93.107	93.286	Steel Beam Guard Rail
116	-	-	-	-	LHS	93.286	93.300	Steel Beam Guard Rail
117	-	-	-	-	LHS & RHS	93.300	93.353	Steel Beam Guard Rail
118	-	-	-	-	Median	93.144	93.552	Median Barrier
119	-	-	-	-	RHS	93.893	94.000	Steel Beam Guard Rail
120	-	-	-	-	LHS	93.914	94.045	Steel Beam Guard Rail
121	-	-	-	-	RHS	94.014	94.060	Steel Beam Guard Rail

S. N.	Side	As per As-Built Drawing			Side	As per Survey by Consultant		
		Chainage (Km)		Remarks		Chainage (Km)*		Remarks
		From	To			From	To	
122	-	-	-	-	RHS	94.080	94.115	Steel Beam Guard Rail
123	-	-	-	-	RHS	95.519	95.752	Steel Beam Guard Rail
124	-	-	-	-	LHS	95.453	95.700	Steel Beam Guard Rail
125	-	-	-	-	RHS	95.521	95.754	Steel Beam Guard Rail
126	-	-	-	-	Median	98.420	100.112	Median Barrier
127	-	-	-	-	RHS	100.034	100.060	Steel Beam Guard Rail
128	-	-	-	-	LHS	100.131	10.167	Steel Beam Guard Rail
129	-	-	-	-	RHS	100.119	10.167	Steel Beam Guard Rail
130	-	-	-	-	LHS	100.228	100.237	Steel Beam Guard Rail
131	-	-	-	-	Median	100.142	100.500	Median Barrier
132	-	-	-	-	Median	100.540	100.794	Median Barrier
133	-	-	-	-	LHS	101.136	101.186	Steel Beam Guard Rail
134	-	-	-	-	RHS	101.152	101.186	Steel Beam Guard Rail
135	-	-	-	-	LHS	101.204	101.246	Steel Beam Guard Rail
136	-	-	-	-	RHS	102.500	102.667	Steel Beam Guard Rail
137	-	-	-	-	LHS	103.546	103.154	Steel Beam Guard Rail
138	-	-	-	-	LHS	103.155	103.560	Steel Beam Guard Rail
139	-	-	-	-	RHS	103.137	103.546	Steel Beam Guard Rail
140	-	-	-	-	LHS & RHS	106.600	106.646	Steel Beam Guard Rail
141	-	-	-	-	LHS	103.754	103.933	Steel Beam Guard Rail
142	-	-	-	-	LHS	103.970	104.038	Steel Beam Guard Rail
143	-	-	-	-	RHS	104.673	104.964	Steel Beam Guard Rail
144	-	-	-	-	LHS	107.700	104.787	Steel Beam Guard Rail
145	-	-	-	-	LHS	104.982	105.085	Steel Beam Guard Rail
146	-	-	-	-	RHS	105.014	105.100	Steel Beam Guard Rail
147	-	-	-	-	Median	104.575	104.753	Median Barrier
148	-	-	-	-	Median	105.006	105.216	Median Barrier
149	-	-	-	-	Median	105.267	105.318	Median Barrier
150	-	-	-	-	Median	105.343	105.492	Median Barrier
151	-	-	-	-	Median	105.714	105.816	Median Barrier
152	-	-	-	-	Median	105.914	105.940	Median Barrier

S. N.	Side	As per As-Built Drawing			Side	As per Survey by Consultant		
		Chainage (Km)		Remarks		Chainage (Km)*		Remarks
		From	To			From	To	
153	-	-	-	-	Median	106.013	106.328	Median Barrier
154	-	-	-	-	RHS	106.192	106.347	Steel Beam Guard Rail
155	-	-	-	-	LHS	106.422	106.614	Steel Beam Guard Rail
156	-	-	-	-	LHS	106.670	107.000	Steel Beam Guard Rail

***Note- Chainage is Continuous**

Annexure 8.4

Validation of Cross Roads

S. N.	As per As Build Drawing			As per Survey by Consultant		
	Side	Chainage (Km)	Remarks	Side	Remarks	Surface Type
1	-	13.800	-	LHS	To Tambaram	BT
2	RHS	14.11	TO ADHAYALAMPATTI	RHS	TO ADHAYALAMPATTI	BT
3	LHS	14.3	-	LHS	To Colony	CC
4	-	14.475	-	LHS	To Market	CC
5	LHS	14.516	TO Odara Nagar	LHS	To Village	BT
6	RHS	14.875	To Vanaggaram	RHS	To PMR Institute Of Technology(Ambature)	BT
7	LHS	15.095	-	LHS	To Village	ER
8	LHS	15.445	-	LHS	To Velappanchavadi Village	BT
9	LHS	15.59	To Numbel	LHS	To VRL-Logistic Ltd.	BT
10	LHS	16.245	To Velappanchavadi	LHS	To Numbel	BT
11	RHS	16.3	To Theruverkadu	RHS	To Trirkadu	BT
12	-	16.472	-	LHS	To Kendiya Vihar	BT
13	RHS	16.73	To Theruverkadu	RHS	To Village	BT
14	LHS	16.79	To Vellapanchavadi	LHS	To Poonamallee	BT
15	LHS	16.955	To Puliambakkam	LHS	To Village	BT
16	RHS	17.075	To Velappanchavadi Industrial Area	RHS	To Village	BT
17	RHS	17.75	-	RHS	To Shunmuga Road	BT
18	LHS	18.07	To Porrur/ Poonamallee	LHS	To Porrur/ Poonamallee	BT
19	RHS	18.94	To Senerkuppam	RHS	To Village	BT
20	LHS	19.2	To Poonamallee	LHS	To Poonamallee(Below Flyover)	BT
21	RHS	19.2	To Avadi	RHS	To Avadi(Below Flyover)	BT
22	RHS	20.97	To Parivakkam	RHS	To Vidya Academy	BT
23	LHS	21	To Poonamallee	LHS	To Poonamallee Market	BT
24	LHS	21.6	To Poonamallee	LHS	To Poonamallee	BT
25	LHS	22.33	To Poonamallee	LHS	To Poonamallee	BT
26	LHS	23.275	To Nazarethpet	LHS	To Nazarethpettai Village	BT
27	-	24.18115	-	LHS	To Village	BT
28	RHS	24.421	To Tiruvallur	RHS	To Thiruvallir/Tirupati(SH-50)	BT
29	-	24.575	-	LHS	To Company	BT
30	-	25.125	-	RHS	To A.M Industries	BT
31	LHS	25.36	To Chembarakkam	LHS	To Company	BT
32	LHS	25.84	To Chembarakkam	LHS	To Sambaramma	BT
33	RHS	26.039	To SIDCO	RHS	To Tirvijhi	BT
34	LHS	26.78	To Industrial Area	LHS	To Janta Timber & Saw Mill	BT
35	RHS	26.835	-	RHS	To Village	ER
36	RHS	27.46	To Padurmedu	RHS	To Korindo Factory	BT
37	LHS	28.065	-	RHS	To Built Up Area	CC
38	LHS	28.247	-	LHS	To Village	CC
39	RHS	28.285	-	LHS	To ELIMS Nagar	BT
40	RHS	28.71	To Pazanchur	LHS	To Company	BT
41	LHS	30.029	-	LHS	To Village	ER
42	RHS	30.03	To Chettipedu	RHS	To Village	BT
43	RHS	31.594	To Monnur	RHS	To Kandalam	BT

S. N.	As per As Build Drawing			As per Survey by Consultant		
	Side	Chainage (Km)	Remarks	Side	Remarks	Surface Type
44	LHS	32.1	-	LHS	To Village	CC
45	LHS	32.47	-	LHS	To Village	GR
46	LHS	34.04	To SIPCOT	LHS	To Hyundai	BT
47	LHS	34.7	To Hyundai	LHS	To Hyundai	BT
48	-	35.279	-	LHS	To Jeans KNIT Ltd.	BT
49	LHS	36.465	-	LHS	To Engg. College	BT
50	LHS	36.855	-	LHS	To Electricity Plant	ER
51	LHS	37.182	To Power Grid Corporation	LHS	To Powergrid	BT
52	-	37.94	-	RHS	To Karathanga Road	BT
53	RHS	38.89	To Rajiv Gandhi Institute	RHS	To Rajiv Gandhi Institute	CC
54	-	39.076	-	LHS	To Village	BT
55	-	39.076	-	RHS	To Rajiv Gandhi Engg College	BT
56	RHS	39.2	-	LHS	To Village	BT
57	LHS	39.25	-	LHS	To Netaji Nagar	BT
58	RHS	39.261	To Sriperumbudur	RHS	To Sriperumbudur	BT
59	LHS	40.425	-	RHS	To Sriperumbudur	BT
60	RHS	41.36	To Sriperumbudur	RHS	To Sriperumbudur(Bypass Ends)	BT
61	LHS	41.886	To Katchipattu	LHS	To Katchipattu	BT
62	LHS	42.13	To Tanbaram	LHS	To Tambram	BT
63	LHS	42.247	To Chengalpet	LHS	To Chengalpattu	BT
64	RHS	42.916	-	RHS	To Office	CC
65	-	43.3	-	LHS	To Nokia	BT
66	-	43.852	-	LHS	To Company	BT
67	-	43.818	-	RHS	To Parker Company	BT
68	RHS	44.98	To Vadamangalam	RHS	To Maamallan Institute	BT
69	LHS	47.74	To Mambakkam	LHS	To Mambakkam Village	BT
70	RHS	49.265	To Sunguvarchataram	RHS	Sunguvachatram (Bypass Starts)	BT
71	RHS	50.869	-	RHS	To Village	BT
72	LHS	51.129	To Wallajabad	LHS	To Wallajabad	BT
73	RHS	51.135	To Sunguvarchataram	RHS	To Sunguvarchataram	BT
74	RHS	51.69	To Sunguvarchataram	RHS	To Sunguvarchatram Junction(Bypass Ends)	BT
75	LHS	51.77	-	LHS	To Tamil Nadu Electrical Board	ER
76	LHS	52.03	-	LHS	To Santhavellore	ER
77	LHS	53.35	To Santhavellore	LHS	To Santhavellore	BT
78	RHS	53.51	-	RHS	To Anubhav Greenrich Village	BT
79	LHS	54.86	To Pappankuzhi	LHS	To Pappankuzhi Village	BT
80	LHS	55.605	-	LHS	To Senthamangalam Village	CC
81	LHS	56.507	-	LHS	To Senthamangalam Village	CC
82	RHS	56.67	To Keeranallure	RHS	To Keranavellore Village	BT
83	RHS	57.42	To Pillaichatram	RHS	To Ramanujapuram Village	BT
84	RHS	57.59	-	RHS	To Pillaichatram Village	BT
85	LHS	57.68	-	LHS	To Green Line Farm House	BT
86	RHS	58.35	-	RHS	To L & T Company	BT

S. N.	As per As Build Drawing			As per Survey by Consultant		
	Side	Chainage (Km)	Remarks	Side	Remarks	Surface Type
87	RHS	59.89	To Siruvedal	RHS	To Village	BT
88	LHS	60.6	To Chinnaiyan Cahitram	RHS	To Chinnaiyan Chattram	BT
89	RHS	60.603	To Chinnaiyan Cahitram	LHS	To Chinnaiyan Chattram	BT
90	LHS	62.14	-	LHS	To Chingadivakkam Village	BT
91	LHS	62.385	To Senkankulam	LHS	To sekangulam Village	BT
92	LHS	63.327	To Karur	LHS	To Village	BT
93	LHS	63.48	-	LHS	To Village	BT
94	RHS	63.515	-	RHS	To Village	GR
95	LHS	63.52	-	LHS	To Village	BT
96	LHS	63.875	-	LHS	To Village	CC
97	LHS	63.94	-	LHS	To Village	CC
98	LHS	64.154	To Enathur Chittaianbakkam	LHS	To Village	BT
99	RHS	64.226	To Iluppapattu	RHS	To Village	BT
100	LHS	65.56	-	LHS	To Village	BT
101	RHS	65.688	To Vedal	RHS	To Vedal Village	BT
102	-	65.7	-	LHS	To L & T Company	BT
103	-	65.91	-	LHS	To Built Up Area	BT
104	-	66.234	-	RHS	To Village	BT
105	LHS	66.3	-	LHS	To Village	ER
106	RHS	66.655	-	RHS	To Vedal Village	BT
107	LHS	66.71	To Enathur	LHS	To Village	BT
108	RHS	67.94	To Semanthanaglam	RHS	To Village	BT
109	RHS	68.3	-	RHS	To Village	CC
110	RHS	68.62	To Meenakshi Medical College	RHS	To Meenakshi Medical College	BT
111	-	-	-	LHS	To Village	BT
112	LHS	69.22	-	LHS	To Village	BT
113	LHS	69.293	-	RHS	To Shetiarpetar Village	CC
114	RHS	69.43	To Kanchipuram R.T.O Office	RHS	To Kanchipuram R.T.O Office	
115	LHS	69.44	To Govt Cancer Hospital	LHS	To Govt Cancer Hospital	BT
116	LHS	69.53	To Govt Cancer Hospital	LHS	To Govt Cancer Hospital	BT
117	RHS	69.69	-	LHS	To Karapet Village	BT
118	RHS	70.242	To Karapettai	RHS	To Punnarigare Village	BT
119	LHS	70.27	To Kanchipuram	LHS	Kanchipuram Junction	BT
120	LHS	70.725	-	LHS	To Nurvirdarkid Village	CC
121	RHS	71.08	-	RHS	To Village	BT
122	LHS	72.058	To Kanchipuram	LHS	To Kanchipuram	BT
123	RHS	72.058	To Arakkonam	RHS	To Arrakonam	BT
124	-	72.638	-	RHS	To Sitherumeri Village	BT
125	RHS	72.935	To Stirumed	RHS	To Village	BT
126	LHS	73.235	-	LHS	Towards Kanchipuram	BT
127	RHS	73.24	-	RHS	To Koraram Vajver	BT
128	RHS	73.715	-	RHS	To Village	CC
129	LHS	74.885	-	LHS	To Village	BT
130	RHS	74.91	-	RHS	To Krishaveni Nagar	BT

S. N.	As per As Build Drawing			As per Survey by Consultant		
	Side	Chainage (Km)	Remarks	Side	Remarks	Surface Type
131	LHS	75.95	-	LHS	To Thirumalai Engg. College	BT
132	RHS	76.12	-	RHS	To Village	CC
133	-	-	-	LHS	To Kanchipuram	BT
134	RHS	76.535	-	-	-	
135	RHS	77.04	-	RHS	To Village	BT
136	-	77.59	-	RHS	To Krishna Puram	BT
137	-	78.535	-	RHS	To Village	BT
138	-	79.18	-	RHS	To Balluchetram Village	BT
139	-	79.748	-	RHS	To Musaravakkam Village	BT
140	-	79.748	-	LHS	To Baluchetty Village	BT
141	-	79.96	-	LHS	To Thiruppukuzzi Village	BT
142	-	79.96	-	RHS	To Balluchetram Village	BT
143	-	80.68	-	RHS	To Balluchetram Village	BT
144	LHS	82.6	To Damal	LHS	To Damal Village	BT
145	LHS	84.16	To Damal	LHS	To Damal	BT
146	RHS	85.2	To Panapakkam	RHS	To Village	BT
147	-	85.94	-	LHS	To Ponniammanpattarai Village	BT
148	RHS	87.6	To Perumbulipakkam	RHS	To Perumbalipakkam	BT
149	LHS	87.62	To Perumbulipakkam	LHS	To Perumbalipakkam	BT
150	-	87.715	-	RHS	To Perumbalipakkam Village	BT
151	LHS	90.165	To Kalathur	LHS	To Canara Bank- Kalathur	BT
152	-	92.107	-	LHS	To Village	BT
153	RHS	92.105	To Karuvedu	-	-	
154	LHS	93.565	To Mamanduar	-	-	
155	-	93.185	-	RHS	To Ocheri	BT
156	-	94.06	-	LHS	To Village	BT
157	RHS	95.48	To Periyakarambur	RHS	To Village	BT
158	RHS	96.55	To I.T.I	RHS	To Village	BT
159	-	97.52	-	RHS	To Village	BT
160	-	97.795	-	RHS	To Kondabaram Village	BT
161	-	98.085	-	LHS	To JCK Nagar	BT
162	LHS	98.498	To Thiruparkadal	LHS	To Thirupar Kadal Village	BT
163	RHS	98.498	To Kaveripakkam Village	RHS	To Kaveripakkam Village	BT
164	-	100.188	-	RHS	To Village	BT
165	-	100.628	-	LHS	To Village	BT
166	-	100.673	-	RHS	To Village	BT
167	RHS	102.215	To Kupattmetur	RHS	To Village	BT
168	LHS	103.058	To Poondi	LHS	To Poondi Village	BT
169	-	103.666	-	RHS	To Bagaveli Village	BT
170	-	104.653	-	LHS	To Chennasamuthram Village	BT
171	RHS	106.095	To Musiri	RHS	To Musiri Village	BT
172	-	106.27	-	LHS	To Ranipettai Village	BT
173	RHS	106.76	To Walajapet	RHS	To Walajapet	BT

Annexure 8.5

Validation of Toe Drain/ Chute Drain/ Stone pitching

S. N.	As per As-Built Drawing				As per Survey by Consultant			
	Side	Chainage (Km)		Remarks	Side	Chainage (Km)		Remarks
		From	To			From	To	
1	RHS	26.910	27.173	Chute-Drain	RHS	26.905	27.17	Chute-Drain
2	RHS	30.338	30.770	Chute-Drain	RHS	30.33	30.77	Chute-Drain
3	RHS	30.800	30.930	Chute-Drain	RHS	30.8	30.91	Chute-Drain
4	LHS	30.715	30.928	Chute-Drain				
5	LHS	30.715	30.928	Boulder Pitching				
6	RHS	30.920	30.930	Boulder Pitching				
7	LHS	31.010	31.550	Chute-Drain	LHS	31.103	31.625	Chute-Drain
8	RHS	31.020	31.395	Chute-Drain	RHS	30.02	30.4	Chute-Drain
9	LHS	31.010	31.400	Boulder Pitching	LHS	31.103	31.475	Boulder Pitching
10	RHS	31.010	31.045	Boulder Pitching	RHS	31.103	31.138	Boulder Pitching
11	LHS	14.210	14.280	Toe Drain				
12	RHS	14.010	14.070	Toe Drain				
13	RHS	14.120	14.170	Toe Drain				
14	RHS	14.220	14.240	Toe Drain				
15	LHS	14.310	14.510	Toe Drain				
16	RHS	14.510	14.530	Toe Drain				
17	RHS	14.900	14.990	Toe Drain				
18	RHS	15.120	15.260	Toe Drain				
19	LHS	15.140	15.360	Toe Drain				
20	RHS	15.280	15.360	Toe Drain				
21	LHS	15.455	15.580	Toe Drain				
22	RHS	15.480	15.580	Toe Drain				
23	LHS	15.600	15.800	Toe Drain				
24	LHS	15.820	15.860	Toe Drain				
25	RHS	15.830	15.940	Toe Drain				
26	LHS	15.940	16.000	Toe Drain				
27	LHS	16.008	16.080	Toe Drain				
28	LHS	16.100	16.120	Toe Drain				
29	LHS	16.160	16.240	Toe Drain				
30	LHS	16.520	16.660	Toe Drain				
31	RHS	16.640	16.680	Toe Drain				
32	LHS	16.680	16.760	Toe Drain				
33	RHS	16.760	16.790	Toe Drain				
34	LHS	16.800	16.950	Toe Drain				
35	RHS	16.820	16.950	Toe Drain				
36	LHS	16.980	17.020	Toe Drain				
37	RHS	16.970	17.000	Toe Drain				
38	RHS	17.010	17.050	Toe Drain				
39	Both	17.090	17.170	Toe Drain				
40	LHS	17.170	17.240	Toe Drain				
41	RHS	17.200	17.380	Toe Drain				
42	LHS	17.260	17.400	Toe Drain				
43	LHS	25.040	25.120	Toe Drain				
44	RHS	25.020	25.110	Toe Drain				
45	LHS	25.040	25.120	Toe Drain				
46	LHS	25.140	25.350	Toe Drain				
47	RHS	25.170	25.760	Toe Drain				

S. N.	As per As-Built Drawing				As per Survey by Consultant			
	Side	Chainage (Km)		Remarks	Side	Chainage (Km)		Remarks
		From	To			From	To	
48	LHS	25.450	25.600	Toe Drain				
49	RHS	26.090	26.440	Toe Drain				
50	RHS	26.450	26.490	Toe Drain				
51	RHS	26.540	26.690	Toe Drain				
52	LHS	26.620	26.760	Toe Drain				
53	RHS	26.700	26.730	Toe Drain				
54	RHS	26.745	26.800	Toe Drain				
55	LHS	26.790	27.100	Toe Drain				
56	RHS	26.840	27.180	Toe Drain				
57	LHS	27.300	27.600	Toe Drain				
58	RHS	27.260	27.450	Toe Drain				
59	RHS	27.490	27.640	Toe Drain				
60	Both	27.640	28.000	Toe Drain				
61	LHS	28.020	28.130	Toe Drain				
62	LHS	28.340	28.410	Toe Drain				
63	RHS	28.450	28.485	Toe Drain				
64	RHS	28.500	28.900	Toe Drain				
65	LHS	28.740	28.830	Toe Drain				
66	LHS	28.850	29.200	Toe Drain				
67	RHS	28.980	29.070	Toe Drain				
68	RHS	29.120	29.200	Toe Drain				
69	LHS	29.240	29.260	Toe Drain				
70	LHS	29.280	29.950	Toe Drain				
71	RHS	30.39	30.740	Toe Drain				
72	RHS	30.820	30.920	Toe Drain				
73	LHS	31.380	31.630	Toe Drain				
74	Both	31.630	32.100	Toe Drain				
75	LHS	32.100	32.200	Toe Drain				
76	RHS	32.340	32.480	Toe Drain				
77	Both	32.480	32.826	Toe Drain				
78	LHS	32.826	32.920	Toe Drain				
79	Both	32.920	33.180	Toe Drain				
80	LHS	33.180	33.500	Toe Drain				
81	Both	33.500	33.800	Toe Drain				
82	LHS	33.800	33.920	Toe Drain				
83	LHS	35.270	35.400	Toe Drain				
84	Both	35.400	35.640	Toe Drain				
85	RHS	35.640	35.770	Toe Drain				
86	Both	35.770	36.000	Toe Drain				
87	LHS	36.000	36.500	Toe Drain				
88	RHS	36.500	36.950	Toe Drain				
89	Both	36.950	37.500	Toe Drain				
90	LHS	37.500	37.579	Toe Drain				
91	Both	38.010	38.085	Toe Drain				
92	Both	38.110	38.185	Toe Drain				
93	Both	38.210	38.340	Toe Drain				
94	RHS	38.340	38.450	Toe Drain				
95	Both	38.450	38.640	Toe Drain				
96	LHS	38.640	38.720	Toe Drain				
97	LHS	39.600	39.720	Toe Drain				

S. N.	As per As-Built Drawing				As per Survey by Consultant			
	Side	Chainage (Km)		Remarks	Side	Chainage (Km)		Remarks
		From	To			From	To	
98	RHS	39.660	39.700	Toe Drain				
99	LHS	39.740	39.840	Toe Drain				
100	Both	39.840	40.010	Toe Drain				
101	LHS	40.050	40.190	Toe Drain				
102	RHS	40.010	40.150	Toe Drain				
103	RHS	40.215	40.240	Toe Drain				
104	Both	40.240	40.640	Toe Drain				
105	LHS	40.640	40.705	Toe Drain				
106	Both	40.705	40.890	Toe Drain				
107	LHS	43.000	44.100	Toe Drain				
108	RHS	44.062	44.240	Toe Drain				
109	Both	44.260	44.600	Toe Drain				
110	RHS	44.600	44.860	Toe Drain				
111	Both	44.860	45.300	Toe Drain				
112	RHS	45.314	45.367	Toe Drain				
113	RHS	45.385	45.440	Toe Drain				
114	Both	45.446	46.080	Toe Drain				
115	RHS	46.080	46.160	Toe Drain				
116	Both	46.160	46.360	Toe Drain				
117	LHS	46.360	46.440	Toe Drain				
118	Both	46.440	47.400	Toe Drain				
119	RHS	47.400	47.760	Toe Drain				
120	Both	47.803	48.600	Toe Drain				
121	RHS	48.600	48.700	Toe Drain				
122	Both	48.700	49.240	Toe Drain				
123	LHS	49.240	49.300	Toe Drain				
124	Both	49.300	50.850	Toe Drain				
125	RHS	50.850	51.100	Toe Drain				
126	Both	51.200	51.641	Toe Drain				
127	LHS	51.641	51.740	Toe Drain				
128	RHS	51.740	52.131	Toe Drain				
129	Both	52.131	52.990	Toe Drain				
130	LHS	52.990	53.200	Toe Drain				
131	Both	53.360	55.250	Toe Drain				
132	RHS	55.250	55.380	Toe Drain				
133	Both	55.380	55.440	Toe Drain				
134	RHS	55.560	55.740	Toe Drain				
135	LHS	55.820	55.865	Toe Drain				
136	Both	55.865	56.200	Toe Drain				
137	RHS	56.200	56.300	Toe Drain				
138	Both	56.300	56.995	Toe Drain				
139	RHS	57.025	57.220	Toe Drain				
140	LHS	57.650	57.780	Toe Drain				
141	Both	57.780	58.780	Toe Drain				
142	LHS	58.780	58.850	Toe Drain				
143	LHS	59.000	59.190	Toe Drain				
144	LHS	59.225	60.000	Toe Drain				
145	RHS	59.100	59.195	Toe Drain				
146	RHS	59.235	60.000	Toe Drain				
147	LHS	60.000	60.240	Toe Drain				

S. N.	As per As-Built Drawing				As per Survey by Consultant			
	Side	Chainage (Km)		Remarks	Side	Chainage (Km)		Remarks
		From	To			From	To	
148	LHS	60.365	60.440	Toe Drain				
149	LHS	60.800	61.000	Toe Drain				
150	RHS	60.000	60.400	Toe Drain				
151	RHS	60.660	61.000	Toe Drain				
152	LHS	61.000	62.000	Toe Drain				
153	RHS	61.000	61.040	Toe Drain				
154	LHS	62.000	63.000	Toe Drain				
155	RHS	62.420	63.000	Toe Drain				
156	LHS	63.000	63.220	Toe Drain				
157	RHS	63.000	63.220	Toe Drain				
158	LHS	64.160	65.000	Toe Drain				
159	RHS	64.230	65.000	Toe Drain				
160	LHS	65.000	65.990	Toe Drain				
161	RHS	65.000	66.000	Toe Drain				
162	LHS	66.080	67.000	Toe Drain				
163	RHS	66.000	66.480	Toe Drain				
164	RHS	66.580	67.000	Toe Drain				
165	LHS	67.000	67.530	Toe Drain				
166	LHS	67.585	68.000	Toe Drain				
167	RHS	67.000	67.545	Toe Drain				
168	RHS	67.605	68.000	Toe Drain				
169	LHS	68.000	68.600	Toe Drain	LHS	68.000	68.5	Toe Drain
170	LHS	68.640	69.000	Toe Drain				
171	RHS	68.000	68.510	Toe Drain	RHS	68.000	68.5	Toe Drain
172	RHS	68.630	69.000	Toe Drain				
173	LHS	69.000	69.070	Toe Drain				
174	LHS	69.300	69.390	Toe Drain				
175	LHS	69.530	70.000	Toe Drain	Both	69.45	69.675	Toe Drain
176	RHS	69.000	69.180	Toe Drain	RHS	69.45	69.675	Toe Drain
177	RHS	69.690	70.000	Toe Drain	Both	69.93	70.275	Toe Drain
178	LHS	70.000	70.200	Toe Drain				
179	RHS	70.000	70.200	Toe Drain				
180	Both	70.200	71.350	Toe Drain	Both	70.3	71.765	Toe Drain
181	Both	72.630	85.180	Toe Drain	Both	73.275	71.765	Toe Drain
182					LHS	73.4	73.6	Toe Drain
183					Both	73.6	75.1	Toe Drain
184					Both	81.2	83.6	Toe Drain
185					Both	85.2	86.775	Toe Drain
186					LHS	86.775	86.825	Toe Drain
187	LHS	86.700	87.200	Toe Drain	LHS	87	87.2	Toe Drain
188					LHS	87.4	87.45	Toe Drain
189	Both	88.200	88.830	Toe Drain	Both	87.6	88.66	Toe Drain
190					Both	89	89.075	Toe Drain
191	Both	89.35	92.2	Toe Drain	Both	89.075	90.375	Toe Drain
192					Both	90.45	90.525	Toe Drain
193					Both	91.2	92	Toe Drain
194					Both	92.15	92.5	Toe Drain
195	LHS	92.540	93.020	Toe Drain				
196	RHS	92.700	93.020	Toe Drain				
197					LHS	93.3	93.4	Toe Drain

S. N.	As per As-Built Drawing				As per Survey by Consultant			
	Side	Chainage (Km)		Remarks	Side	Chainage (Km)		Remarks
		From	To			From	To	
198					Both	93.45	93.525	Toe Drain
199					LHS	93.525	93.7	Toe Drain
200					Both	93.7	93.8	Toe Drain
201					Both	93.9	94.1	Toe Drain
202	Both	94.200	98.050	Toe Drain	Both	96	97	Toe Drain
203	Both	99.185	100.195	Toe Drain				
204	Both	101.200	102.200	Toe Drain				
205	LHS	102.200	103.200	Toe Drain				
206	RHS	102.700	103.200	Toe Drain				
207	Both	103.200	103.605	Toe Drain				
208	Both	103.703	104.200	Toe Drain				
209	Both	105.200	105.580	Toe Drain				

Annexure 8.6

Validation of Bus-bays

S. N.	As Per As Built Drawing		As per Survey by Consultant	
	Chainage(Km)	Side	Chainage(Km)*	Side
1	14.205	Left	14.205	Right
2	16.938	Left	16.930	Left
3	17.156	Right	17.156	Right
4	22.053	Right	20.044	Right
5	22.155	Left	20.148	Left
6	23.975	Left	23.965	Left
7	24.030	Right	24.030	Right
8	25.765	Left	25.757	Left
9	25.825	Right	25.855	Right
10	34.855	Left	34.847	Left
11	34.895	Right	34.900	Right
12	38.810	Right	38.860	Right
13	38.960	Left	38.960	Left
14	42.066	Right	42.063	Right
15	51.884	Right	50.986	Right
16	52.254	Left	51.345	Left
17	57.582	Left	57.470	Left
18	57.734	Right	57.630	Right
19	60.432	Right	60.333	Right
20	60.754	Left	60.648	Left
21	63.875	Right	63.767	Right
22	64.274	Left	64.163	Left
23	69.834	Left	69.341	Left
24	69.980	Right	69.885	Right
25	72.825	Left	72.918	Left
26	73.014	Right	73.100	Right
27	81.734	Right	81.632	Right
28	85.895	Right	85.790	Right
29	86.890	Left	86.813	Left
30	87.665	Right	87.560	Right
31	89.285	Right	89.180	Right
32	89.355	Left	89.250	Left
33	90.560	Left	90.480	Left
34	90.655	Right	90.550	Right
35	95.360	Left	95.280	Left
36	95.575	Right	95.470	Right
37	96.510	Left	96.430	Left
38	96.710	Right	96.580	Right
39	99.470	Right	99.290	Right
40	102.950	Left	102.870	Left
41	103.150	Right	103.025	Right
42	104.500	Left	104.400	Left
43	104.700	Right	104.590	Right
44	106.090	Left	106.000	Left

***Note- Chainage is Continuous**

Annexure 8.7

Validation of Underground Utilities

S. N.	As per As-Built Drawing						As per Survey by Consultant					
	Chainage (Km)		OFC Line (m)		Well/Hand pump/Water pipeline		Chainage (Km)		OFC Line (m)		Well/Hand pump/Water pipeline	
	From	To	Left	Right	Left	Right	From	To	Left	Right	Left	Right
1	13	14	-	-	-	-	13	14	1000	0	0	0
2	14	15	-	-	-	-	14	15	1000	0	0	Water Tap-2
3	15	16	-	-	-	-	15	16	1000	0	Well-1	0
4	16	17	-	-	-	-	16	17	1000	0	0	0
5	17	18	-	-	-	-	17	18	500	0	0	0
6	18	19	-	-	-	-	18	19	0	1000	0	0
7	19	20	-	-	-	-	19	20	0	1000	0	0
8	20	21	-	-	-	-	20	21	0	1000	0	0
9	21	22	-	-	-	-	21	22	0	1000	0	0
10	22	23	-	-	-	-	22	23	0	1000	0	0
11	23	24	-	-	-	-	23	24	0	1000	0	0
12	24	25	-	-	-	-	24	25	0	300	0	0
13	25	26	-	-	-	-	25	26	0	0	Water Tap-1	0
14	26	27	-	-	-	-	26	27	1000	0	0	0
15	27	28	-	-	-	-	27	28	1000	727	0	Well-1
16	28	29	-	-	-	-	28	29	1000	1000	0	Well-1, Water Tap-1
17	29	30	-	-	-	-	29	30	1000	1000	0	0
18	30	31	-	-	-	-	30	31	1000	1000	0	Hand Pump-1
19	31	32	-	-	-	-	31	32	1000	1000	0	0
20	32	33	-	-	-	-	32	33	1000	1000	0	0
21	33	34	-	-	-	-	33	34	1000	1000	0	0
22	34	35	-	-	-	-	34	35	1000	1000	0	0
23	35	36	-	-	-	-	35	36	1000	590	0	0
24	36	37	-	-	-	-	36	37	1000	0	0	0
25	37	38	-	-	-	-	37	38	272	0	0	0
26	38	39	-	-	-	-	38	39	1000	0	0	0
27	39	40	-	-	-	-	39	40	1000	0	0	0

S. N.	As per As-Built Drawing						As per Survey by Consultant					
	Chainage (Km)		OFC Line (m)		Well/Hand pump/Water pipeline		Chainage (Km)		OFC Line (m)		Well/Hand pump/Water pipeline	
	From	To	Left	Right	Left	Right	From	To	Left	Right	Left	Right
28	40	41	-	-	-	-	40	41	1000	0	0	0
29	41	42	-	-	-	-	41	42	600	0	0	0
30	42	43	-	-	-	-	42	43	0	0	0	0
31	43	44	-	-	-	-	43	44	1000	0	0	0
32	44	45	-	-	-	-	44	45	1000	0	0	0
33	45	46	-	-	-	-	45	46	1000	0	0	0
34	46	47	-	-	-	-	46	47	1000	0	0	0
35	47	48	-	-	-	-	47	48	1000	0	0	0
36	48	49	-	-	-	-	48	49	1000	0	0	0
37	49	50	-	-	-	-	49	50	1000	0	0	0
38	50	51	-	-	-	-	50	51	1000	0	0	0
39	51	52	-	-	-	-	51	52	1000	0	Well-1	0
40	52	53	-	-	-	-	52	53	1000	0	0	0
41	53	54	-	-	-	-	53	54	1000	500	Well-1	0
42	54	55	-	-	-	-	54	55	1000	1000	0	Well-1
43	55	56	-	-	-	-	55	56	770	851	Water Tank-1	0
44	56	57	-	-	-	-	56	57	855	504	0	0
45	57	58	-	-	-	-	57	58	184	0	0	0
46	58	59	-	-	-	-	58	59	648	0	0	0
47	59	60	-	-	-	-	59	60	0	470	0	0
48	60	61	-	-	-	-	60	61	0	1000	0	0
49	61	62	-	-	-	-	61	62	0	1000	0	0
50	62	63	-	-	-	-	62	63	0	1000	0	0
51	63	64	-	-	-	-	63	64	0	267	0	0
52	64	65	-	-	-	-	64	65	0	1000	0	0
53	65	66	-	-	-	-	65	66	0	1000	0	0
54	66	67	-	-	-	-	66	67	150	1000	0	0
55	67	68	-	-	-	-	67	68	1000	1000	0	0
56	68	69	-	-	-	-	68	69	310	1000	0	0
57	69	70	-	-	-	-	69	70	0	1000	0	0

S. N.	As per As-Built Drawing						As per Survey by Consultant					
	Chainage (Km)		OFC Line (m)		Well/Hand pump/Water pipeline		Chainage (Km)		OFC Line (m)		Well/Hand pump/Water pipeline	
	From	To	Left	Right	Left	Right	From	To	Left	Right	Left	Right
58	70	71	-	-	-	-	70	71	572	1000	0	0
59	71	72	-	-	-	-	71	72	1000	1000	0	0
60	72	73	-	-	-	-	72	73	1000	1000	0	0
61	73	74	-	-	-	-	73	74	1900	1000	0	0
62	74	75	-	-	-	-	74	75	2000	1000	0	0
63	75	76	-	-	-	-	75	76	2000	630	0	Well-1
64	76	77	-	-	-	-	76	77	2000	1000	0	Well-1
65	77	78	-	-	-	-	77	78	2000	1000	0	0
66	78	79	-	-	-	-	78	79	2000	1000	0	0
67	79	80	-	-	-	-	79	80	2000	1000	0	0
68	80	81	-	-	-	-	80	81	2000	1000	Water Tap-2	0
69	81	82	-	-	-	-	81	82	1000	1000	0	0
70	82	83	-	-	-	-	82	83	1000	1000	0	0
71	83	84	-	-	-	-	83	84	1000	1000	0	0
72	84	85	-	-	-	-	84	85	1000	0	0	0
73	85	86	-	-	-	-	85	86	1000	1000	0	0
74	86	87	-	-	-	-	86	87	1000	1000	0	Water Tap-2
75	87	88	-	-	-	-	87	88	1000	1000	0	Water Pipe Line-1
76	88	89	-	-	-	-	88	89	1000	1000	0	0
77	89	90	-	-	-	-	89	90	1000	1000	0	0
78	90	91	-	-	-	-	90	91	1000	1000	0	Well-1
79	91	92	-	-	-	-	91	92	1000	1000	0	0
80	92	93	-	-	-	-	92	93	1000	1000	0	0
81	93	94	-	-	-	-	93	94	1000	1000	0	Well-1
82	94	95	-	-	-	-	94	95	1000	1000	0	Well-2
83	95	96	-	-	-	-	95	96	1000	1000	0	Well-2
84	96	97	-	-	-	-	96	97	1000	1000	0	Well-1
85	97	98	-	-	-	-	97	98	1000	1000	0	0
86	98	99	-	-	-	-	98	99	1000	1000	0	Tube Well-1
87	99	100	-	-	-	-	99	100	1000	1000	Water Tank 1	0

S. N.	As per As-Built Drawing						As per Survey by Consultant					
	Chainage (Km)		OFC Line (m)		Well/Hand pump/Water pipeline		Chainage (Km)		OFC Line (m)		Well/Hand pump/Water pipeline	
	From	To	Left	Right	Left	Right	From	To	Left	Right	Left	Right
88	100	101	-	-	-	-	100	101	1000	1000	Water Tap 1	0
89	101	102	-	-	-	-	101	102	1000	1000	0	0
90	102	103	-	-	-	-	102	103	1000	1000	Water Tap 1	Well-1
91	103	104	-	-	-	-	103	104	1000	1000	Well-2	0
92	104	105	-	-	-	-	104	105	300	1000	0	Water Tap-2, HP-1, Well-1
93	105	106	-	-	-	-	105	106	900	1000	Water Tap-1	Water Tap-2
94	106	107	-	-	-	-	106	107	1000	0	0	0

Annexure 8.8

Validation of Pavement Composition

S. N.	Chainage (Km)		As per As-Built Drawing								As per Investigation by Consultant							
			Main Carriageway				Service Road				Main Carriageway				Service Road			
	From	To	BC	DBM	WMM	GSB	BC	DBM	WMM	GSB	BC	DBM	WMM	GSB	BC	DBM	WMM	GSB
1	13.8	17.56	50	130	250	200	50		250	200	50	130	250	200	50		250	200
6	17.56	22	50	130	250	200	50	65	250	200	50	130	250	200	50	65	250	200
10	21	22	50	130	250	200	50	65	250	200	50	130	250	200	50	65	250	200
11	22	33.86	50	130	250	200	50		250	200	50	130	250	200	50		250	200
22	33.86	35.264	50	130	250	200	50	65	250	200	50	130	250	200	50	65	250	200
24	35.264	40.9	50	130	250	200	50		250	200	50	130	250	200	50		250	200
30	40.9	44.75	50	130	250	200	50	65	250	200	50	130	250	200	50	65	250	200
35	44.75	50.86	50	130	250	200	50		250	200	50	130	250	200	50		250	200
42	50.86	51.11	50	130	250	200	50	50	250	200	50	130	250	200	50	50	250	200
43	51.11	63.22	50	130	250	200	50		250	200	50	130	250	200	50		250	200
56	63.22	64.22	50	130	250	200	50	65	250	200	50	130	250	200	50	65	250	200
58	64.22	80	50	130	250	200	50		250	200	50	130	250	200	50		250	200
74	80	93	50	130	250	200	50		250	200	50	130	250	200	50		250	200
87	93	93.88	50	130	250	200	50	65	250	200	50	130	250	200	50	65	250	200
88	93.88	98.03	50	130	250	200	50		250	200	50	130	250	200	50		250	200
94	98.03	99.184	50	130	250	200	50	65	250	200	50	130	250	200	50	65	250	200
96	99.184	100.36	50	130	250	200	50		250	200	50	130	250	200	50		250	200
98	100.36	101.36	50	130	250	200	50	65	250	200	50	130	250	200	50	65	250	200
100	101.36	106.528	50	130	250	200	50		250	200	50	130	250	200	50		250	200
106	106	106.528	50	130	250	200	50	65	250	200	50	130	250	200	50	65	250	200
107	106.528	107	50	130	250	200	50		250	200	50	130	250	200	50		250	200

Annexure 8.9

Validation of Gantry Signs

As per As- Built Drawing				As per Survey by Consultant		
Sl. No.	Chainage	Side	Remarks	Chainage	Side	Remarks
1	14.000	Left	Cantilever Gantry	14.000	Left	Cantilever Gantry
2	14.000	Right	Cantilever Gantry	14.000	Right	Cantilever Gantry
3	17.415	Left	Cantilever Gantry	17.400	Left	Cantilever Gantry
4	24.238	Left	Cantilever Gantry	24.230	Left	Cantilever Gantry
5	49.030	Left	Cantilever Gantry	48.122	Left	Cantilever Gantry
6				51.460		Overhead Gantry
7	69.300	Left	Cantilever Gantry	69.195	Left	Cantilever Gantry
8				70.293		Overhead Gantry
9				104.273		Overhead Gantry
10				106.124		Overhead Gantry
11				106.590	Left	Cantilever Gantry

Annexure 8.10

Validated list of Horizontal Curves having less than Design Speed of 80 kmph

S. N.	Chainage (m)	As per As-built Drawing		As per Surveyed	
		Curve Radius (m)	Design Speed (kmph)	Curve Radius (m)	Design Speed (kmph)
1	14157	200	60	200	60
2	14441	270	60	270	60
3	14748	360	60	360	60
4	15011	170	65	170	65
5	17923	200	50	200	50
6	18212	300	50	300	50
7	22400	170	65	170	65
10	24237	360	60	360	60
11	40544	400	60	400	60
12	40850	600	60	600	60

Annexure 8.11

Validated List of Reinforced Soil Retaining Structures and High Embankment

As per As- Built Drawings					As per Survey by Consultant			
S. N.	Chainage		Side	Remarks	Chainage		Side	Remarks
	From	To			From	To		
1	17.654	18.024	Flyover	Retaining Wall	17.652	18.020	Flyover	Retaining Wall
2	18.111	18.451	Flyover	Retaining Wall	18.110	18.447	Flyover	Retaining Wall
3	18.800	19.183	Underpass	Retaining Wall	18.800	19.184	Underpass	Retaining Wall
4	19.206	19.529	Underpass	Retaining Wall	19.200	19.534	Underpass	Retaining Wall
5	22.440	22.763	Flyover (under const.)	Retaining Wall	22.440	22.756	Flyover (under const.)	Retaining Wall
					30.800	31.500		High Embankment
6	71.590	72.058	ROB	Retaining Wall	71.675	72.135	ROB	Retaining Wall
7	72.080	72.540	ROB	Retaining Wall	72.218	72.630	ROB	Retaining Wall
8	106.429	106.722	Flyover	Retaining Wall	106.429	106.615	Flyover	Retaining Wall
9	106.797	107.120	Flyover	Retaining Wall	106.690	107.014	Flyover	Retaining Wall

Annexure 8.12

Validated List of Surface Lined Drains

S. N.	As per As-Built Drawing				As per Survey by Consultant			
	Side	Chainage (Km)		Remarks	Side	Chainage (Km)*		Remarks
		From	To			From	To	
1	LHS	17.39	25	Covered Drain	LHS	17.35	25	Covered Drain
2	RHS	17.447	25	Covered Drain	RHS	17.38	25	Covered Drain
3	RHS	33.87	35.365	Covered Drain	RHS	33.875	35.325	Covered Drain
4	LHS	34.08	34.553	PCC Open Drain	LHS	34.066	34.66	PCC Open Drain
5	LHS & RHS	40.9	41.28	Covered Drain	LHS & RHS	40.9	41.271	Covered Drain
6	LHS	41.28	41.5	Covered Drain	LHS	41.271	41.495	Covered Drain
7	LHS & RHS	41.5	41.99	Covered Drain	LHS & RHS	41.495	41.995	Covered Drain
8	RHS	41.99	42.173	Covered Drain	RHS	41.995	42.153	Covered Drain
9	LHS & RHS	42.173	42.21	Covered Drain	LHS & RHS	42.153	42.2	Covered Drain
10	RHS	42	42.297	Covered Drain	RHS	42.2	42.3	Covered Drain
11	LHS	42.2	42.865	Covered Drain	LHS	42.3	42.854	Covered Drain
12	RHS	58.89	59.1	Covered Drain	RHS	58.8	59	Covered Drain
13	LHS & RHS	63.5	64.07	Covered Drain	LHS & RHS	63.125	63.98	Covered Drain
14	RHS	64.07	64.22	Covered Drain	RHS	63.98	64.125	Covered Drain
15	RHS	86.992	87.5	Line Drain	RHS	86.96	87.424	Line Drain
16	LHS & RHS	88.857	89.22	Covered Drain	LHS & RHS	88.8	89.152	Covered Drain
17	LHS	93.02	93.46	Covered Drain	LHS	92.93	93.352	Covered Drain
18	RHS	93.175	93.616	Covered Drain	RHS	93.1	93.5	Covered Drain
19	LHS & RHS	98.51	99.12	Covered Drain	LHS & RHS	98.4	99.01	Covered Drain
20	LHS & RHS	100.4	100.983	Covered Drain	LHS & RHS	100.4	100.87	Covered Drain
21	LHS	104.65	105.2	Covered Drain	LHS	104.65	104.97	Covered Drain
22	RHS	104.794	105.58	Covered Drain	-	-	-	-
23	Median	20.45	20.6	Line Drain	Median	20.45	20.6	Line Drain
24	Median	21.15	21.338	Line Drain	Median	21.15	21.33	Line Drain
25	Median	21.623	21.909	Line Drain	Median	21.62	21.9	Line Drain
26	Median	22.303	22.763	Line Drain	Median	22.3	22.763	Line Drain
27	Median	30.605	30.928	Line Drain	Median	30.59	30.925	Line Drain
28	Median	38.347	38.56	Line Drain	Median	38.335	38.55	Line Drain
29	Median	40.295	40.755	Line Drain	Median	40.295	40.755	Line Drain
30	Median	45.385	45.681	Line Drain	Median	45.385	45.68	Line Drain
31	Median	51.13	51.602	Line Drain	Median	50.225	50.77	Line Drain
32	Median	59.226	59.459	Line Drain	Median	59.12	59.35	Line Drain
33	Median	60	60.57	Line Drain	Median	59.9	60.475	Line Drain
34	Median	60.615	60.69	Line Drain	Median	60.5	6.584	Line Drain
35	-	-	-	-	Median	89.35	89.9	Line Drain
36	-	-	-	-	Median	95.92	96.7	Line Drain
37	-	-	-	-	Median	101.2	102.08	Line Drain

***Note- Chainage is Continuous**

Annexure 8.13

Validated List of Service Road

As per As-Built Drawing				As Surveyed by Consultant	
Chainage		Service Road		Service Road	
From	To	Left	Right	Left	Right
17.390	17.450	6.5	7.5	6.0	7.5
17.450	17.650	6.5	7.5	6.0	7.5
17.650	17.655	6.5	7.5	6.0	7.5
17.655	17.800	6	7.5	6.0	7.5
17.800	18.049	6	7.5	6.0	7.5
18.049	18.115			6.0	7.5
18.115	18.500	7.5	7.5	7.5	7.5
18.500	18.800	7.5	7.5	7.5	7.5
18.800	19.525	7.5	7.5	7.5	7.5
19.525	20.000	7.5	7.5	7.5	7.5
20.000	20.600	7.5	7.5	7.5	7.5
20.600	21.000	7.5	7.5	7.5	7.5
21.000	21.300	7.5	7.5	7.5	7.5
21.300	21.625	7.5	7.5	7.5	7.5
21.625	22.225	7.5	7.5	7.5	7.5
22.225	22.290	7.5	7.5	7.5	7.5
33.770	33.800		7.5		
33.800	34.000		7.5		7.5
34.000	34.690	7	7.5	7.5	7.5
34.690	34.710		7.5		7.5
34.710	35.250		7.5		7.5
35.250	35.364		7.5		5.0
40.900	41.175	6	6	6.5	6.5
41.175	41.225	6.0-12.0	4.0-6.0	6.0-12.0	4.0
41.225	41.300	12	3.5	10.0-12.0	4.0
41.300	41.330	10.0-12.0	3.5	3.0-10.0	3.5
41.330	41.475	3.5	3.5	3.5	3.0
41.475	41.500	3.5	3.5	4.0	3.5
41.500	41.745	3.5	3.5	4.0	3.5
41.745	41.750	3.5	3.5	4.0-6.0	4.0-6.0
41.750	41.790	6	6	4.0-6.0	4.0-6.0
41.790	41.800	6	6	6.0	6.0
41.800	41.860	6	6	6.0	6.0
41.860	41.950	6	6	6.0	6.0
41.950	42.100	6	6		6.0
42.100	42.972	6	6	6.0	6.0
42.972	43.000	6		5.5	
43.000	43.050	4		5.5	
43.050	43.100	4		4.8	
43.100	43.155	4		4.5	
43.155	43.845	4		4.0	
43.845	44.795	4			
45.300	46.700			7.0	
50.864	51.120	3.6			
63.125	63.175			4.0	4.0
63.175	63.600	4	4	4.0	4.0

As per As-Built Drawing				As Surveyed by Consultant	
Chainage		Service Road		Service Road	
From	To	Left	Right	Left	Right
63.600	63.900	4	4	4.0	4.0
63.900	64.020	4	4	4.0	4.0
64.020	64.080	4	4		4.0
64.080	64.115		4		4.0
64.115	64.320		4		
71.565	72.100			7.5	7.5
72.200	72.700			4.5	4.0
87.020	87.045				4.0
87.045	87.450		4		4.0
87.450	87.500		4		
87.500	87.650		4		1.4-4.0
88.825	89.125			4.0	4.0
89.125	89.300			2.8-7.0	2.0-7.0
93.020	93.100		6	4.0-5.0	
93.100	93.450		6	5.0	5.0
93.450	93.685		6		4.5
93.685	93.800		6		
98.045	98.120				6.0
98.120	98.175		4		6.0
98.175	99.100		4	4.0	4.0
99.100	99.250		4		
100.265	100.360			4.7	4.0
100.360	100.500	4	4	4.7	4.0
100.500	100.900	4	4	3.8	4.0
100.900	101.000	4	4		
106.675	107.000				5.0

Annexure 8.14

Validated List of Bridges, ROB, flyovers and Underpasses

As per As-Built Drawing										As per Survey by Consultant								
S. N.	Locatio n (Km)	Type Of Crossing	Span Arrangement (m)		Overall Length (m)	Overall Width (m)	Type of Structure			S. N.	Location (Km)	Type of Crossing	Span Arrangement (m)		Overall Length (m)	Overall Width (m)	Type Of Structure	
			OLD C / W	NEW C / W			OLD C / W	NEW C / W					OLD C / W	NEW C / W				
1	18.100	FLYOVER	NIL	1X40+2X20	80	11	NIL	PSC BOX GIRDER		1	18.100	FLYOVER	NIL	1X40+2X20	80	11	NIL	PSC BOX GIRDER
2	19.195	UNDERPASS	NIL	2X10	20	27	NIL	RCC BOX ON GROUND		2	19.195	UNDERPASS	NIL	2X10	20	27	NIL	RCC BOX ON GROUND
3	22.400	GRADE SEPARATOR	NIL	1X40+2X20	80	11	NIL	PSC BOX GIRDER		3	22.400	GRADE SEPARATOR	NIL	1X40+2X20	80	11	NIL	PSC BOX GIRDER
4	27.211	MAJOR BRIDGE	7X10	5X14	70	31.8	RCC SLAB	RCC SLAB+T-BEAM		4	27.211	MAJOR BRIDGE	7X10	5X14	70	31.8	RCC SLAB	RCC SLAB+T-BEAM
5	30.945	MINOR BRIDGE	1X8.420+2X8.5	1X25	25	34.3	RCC SLAB	RCC SLAB+T-BEAM		5	30.945	MINOR BRIDGE	1X8.420+2X8.5	1X25	25	34.3	RCC SLAB	RCC SLAB+T-BEAM
6	30.995	MINOR BRIDGE	4X5.8	1X25	25	33.8	RCC SLAB	RCC SLAB+T-BEAM		6	30.995	MINOR BRIDGE	4X5.8	1X25	25	33.8	RCC SLAB	RCC SLAB+T-BEAM
7	39.435	MINOR BRIDGE	4X6.7	2X14	28	32.1	RCC SLAB	RCC SLAB+T-BEAM		7	39.435	MINOR BRIDGE	4X6.7	2X14	28	32.1	RCC SLAB	RCC SLAB+T-BEAM
8	44.489	MINOR BRIDGE	1X8.7	1X8.75	8.75	35.5	RCC SLAB	RCC SLAB		8	44.489	MINOR BRIDGE	1X8.7	1X8.75	8.75	35.5	RCC SLAB	RCC SLAB
9	50.270	UNDERPASS	NIL	1X10	10	27	NIL	RCC BOX ON GROUND		9	50.270	UNDERPASS	NIL	1X10	10	27	NIL	RCC BOX ON GROUND
10	56.905	MINOR BRIDGE	3X6.8	1X21	21	32.9	RCC SLAB+T-BEAM	RCC SLAB+T-BEAM		10	56.905	MINOR BRIDGE	3X6.8	1X21	21	32.9	RCC SLAB+T-BEAM	RCC SLAB+T-BEAM
11	59.108	MINOR BRIDGE	2X10	2X10	20	32.1	RCC SLAB	RCC SLAB		11	59.108	MINOR BRIDGE	2X10	2X10	20	32.1	RCC SLAB	RCC SLAB

As per As-Built Drawing									As per Survey by Consultant								
S. N.	Location (Km)	Type Of Crossing	Span Arrangement (m)		Overall Length (m)	Overall Width (m)	Type of Structure		S. N.	Location (Km)	Type of Crossing	Span Arrangement (m)		Overall Length (m)	Overall Width (m)	Type Of Structure	
			OLD C/W	NEW C/W			OLD C/W	NEW C/W				OLD C/W	NEW C/W			OLD C/W	NEW C/W
12	67.463	MINOR BRIDGE	4X10	4X10	40	32	RCC SLAB	RCC SLAB	12	67.463	MINOR BRIDGE	4X10	4X10	40	32	RCC SLAB	RCC SLAB
13	72.250	ROB	NIL	2x23.5+1x33	80	31	NIL	RCC SLAB+T-BEAM	13	72.250	ROB	NIL	2x23.5+1x33	80	31	NIL	RCC SLAB+T-BEAM
14	92.218	MINOR BRIDGE	7X6.5	1X20.250+2X14	48.250	32	RCC SLAB	RCC SLAB+T-BEAM	14	92.218	MINOR BRIDGE	7X6.5	1X20.250+2X14	48.250	32	RCC SLAB	RCC SLAB+T-BEAM
15	100.157	MINOR BRIDGE	NIL	4X6	24	28.2	NIL	RCC SLAB	15	100.157	MINOR BRIDGE	NIL	4X6	24	28.2	NIL	RCC SLAB
16	101.247	MINOR BRIDGE	1X10	1X10	10	30.5	RCC SLAB	RCC SLAB	16	101.247	MINOR BRIDGE	1X10	1X10	10	30.5	RCC SLAB	RCC SLAB
17	103.637	MINOR BRIDGE	3X5.75	1X17.4	17.4	32	RCC SLAB	RCC SLAB+T-BEAM	17	103.637	MINOR BRIDGE	3X5.75	1X17.4	17.4	32	RCC SLAB	RCC SLAB+T-BEAM
18	106.683	MINOR BRIDGE	NIL	1X10	10	17.5	NIL	RCC SLAB	18	106.683	MINOR BRIDGE	NIL	1X10	10	17.5	NIL	RCC SLAB

Chapter - 9

Integrated Proposed Scheme

CHAPTER – 9

Integrated Proposed Scheme

9.1 General

This chapter is intended to give brief descriptions concerning the improvement proposal integrating with the existing 2x2-lane highway. The consultant is required to prepare the layout of the 2x3-lane facility clearly spelling out the feasible engineering, technical and management solutions without detailed design as mentioned in TOR. While evolving these solutions, the consultant always kept in mind that main focus of the assignment is to retrofitting the 2x3-lane carriageway configuration over the existing 2x2-lane carriageway configuration with safe, efficient and improved highway.

The proposed scheme is formulated by keeping in view the following objectives:

- Augmentation of the capacity of existing road and attain the desirable level of service (B) with enhance operational efficiency;
- Enhancement of safety of the traffic, the road users and the people living close to the highway;
- Uninterrupted flow of through traffic on the project road;
- Segregation of through traffic completely from local traffic movement.
- The feasible and constructible options for the project without being too expensive.

9.2 Features of the Scheme

Summary of facilities both highways and bridges are given in **Table 9.1 and 9.2:**

Table 9.1: Details of Existing / Proposed facilities

Sr. No.	Particulars		Existing	Proposed (includes existing)
1.	Service/ Slip Road (Km)		27.551 (Left – 13.780 Right – 13.771)	2 x 30.305 (Both sides)
2.	Bus bays (Nos.)		44	49
3.	Toll Plaza (2 Nos.)	At km 37.800 No. of toll lanes	5 on either side	10 on either side
		At km 104.900 No. of toll lanes	5 on either side	8 on either side
4.	Entry Ramps (Nos.)		nil	nil
5.	Exit Ramps (Nos.)		nil	nil
6.	Rest Area (Nos.)		nil	2

Table 9.2: Details of Existing / Proposed Structures

Type of Structure	Existing		Proposal										
			Widening		Rehabilitation		Retained		Reconstruction		New		Total
	LHS	RHS	LHS	RHS	LHS	RHS	LHS	RHS	LHS	RHS	LHS	RHS	
Main Carriageway													
• Minor Bridge	12	12	0	0	0	0	0	0	0	0	0	0	24
• Major Bridge	1	1	0	0	0	0	0	0	0	0	0	0	2
Service Road													
• Minor Bridge	0	0	0	0	0	0	0	0	0	0	0	0	0
• Major Bridge	0	0	0	0	0	0	0	0	0	0	0	0	0
ROB	1	1	0	0	0	0	1	1	0	0	0	0	2
Flyover/ Grade Separator	1	0	0	0	0	0	1	0	0	0	9	10	20
Overpass	1	0	0	0	0	0	1	0	0	0	0	0	1
Vehicular Underpass	2		1 *		0		2		0		14		16
Pedestrian Underpass	0		0		0		0	0	0		18		18
Cattle Crossing	0		0		0		0	0	0		4		4
Pipe Culvert	144												
• 6-lane Carriageway			144		0		0		0		0		144
• Service Road			32		0		0		0		0		32
Slab Culvert	91												
• 6-lane Carriageway			91		0		0		0		0		91
• Service Road			37		0		0		0		0		37

*Adding 1 Box of 10.5x5 adjacent the existing

9.3 Service Road

The service roads were proposed on both sides of the carriageway in built-up areas only as decided by the NHAI to facilitate the movement of local traffic. The need of the service road was assessed through local traffic movement and land use pattern all along the project road. The major towns/ commercial establishments exist along the highway are:

- Poonamallee
- Sriperumbudur
- Sunguvachatram
- Kanchipuram
- Walajapet

Apart from major towns shown above, there are number of villages and commercial establishments scattered throughout the project road. There are isolated rural stretches and the consultant examined their importance and experienced that the service road discontinuity may encourage local traffic to ply on main carriageway. However, based on the discussions with officials of the NHAI, the service road was proposed only at the stretches, where there are commercial establishments, industries, towns and villages. The service road was discontinued at the place, where rural stretch is more than 1km and also Major bridges, ROBs, Toll plazas and certain critical locations. The direct access from cross road to main highway was not proposed. The cross road was connected to the proposed service road to maintain the highway speed throughout. The traffic from service road to main highway was to get access through the entry ramp to main highway with designed acceleration lane. At two locations, the direct access was proposed from the service road to main highway to avoid the demolition of number of structures.

Similarly, exit ramp and direct exit from the main carriageway with designed deceleration lane was provided based on requirement.

However, with the restructuring as insisted by the NHAI / PPPAC, the service roads has been omitted and only slip roads have been provided for the access to the main carriageway from cross roads at the flyovers and vehicular underpass locations.

The Table 9.3 shows the details of existing service road on the Project road. Table 9.4 shows the details of proposed slip roads on the Project road based on the typical Cross sections.

Table 9.3: Details of Existing service roads

Reach (km)		Existing Width (m)	
From	To	Left	Right
17.500	18.115	6.00	7.50
18.115	22.290	7.50	7.50
33.800	34.000		7.50
34.000	34.690	7.50	7.50
34.690	35.250		7.50
35.250	35.364		5.00
40.900	41.000	6.50	6.50
41.000	41.175	6.50	6.50
41.175	41.300	6.00	4.00
41.300	41.330	3.00	3.50
41.330	41.475	3.50	3.00

Reach (km)		Existing Width (m)	
From	To	Left	Right
41.475	41.790	4.00	4.00
41.790	41.950	6.00	6.00
41.950	42.100		6.00
42.100	42.972	6.00	6.00
42.972	43.000	5.50	
43.000	43.050	5.50	
43.050	43.155	4.50	
43.155	43.845	4.00	
45.300	46.700	7.00	
63.125	64.000	4.00	4.00
64.000	64.020	4.00	4.00
64.020	64.115		4.00
71.565	72.100	7.50	7.50
72.200	72.700	4.50	4.00
87.020	87.650		4.00
88.825	89.125	4.00	4.00
89.125	89.300	7.00	7.00
93.020	93.100	4.00	
93.100	93.450	5.00	5.00
93.450	93.685		4.50
98.045	98.175		6.00
98.175	99.100	4.00	4.00
100.265	100.500	4.70	4.00
100.500	100.900	3.80	4.00
106.675	107.000		5.00

Table 9.4: Details of proposed Slip/ service roads

Reach (km)		Proposed Length (km)		Remark
From	To	Left	Right	
14.400	15.400	1.000	1.000	Slip Road
15.900	16.700	0.800	0.800	Slip Road
16.700	17.600	0.900	0.900	Slip Road
17.600	22.400	4.800	4.800	Slip Road cum Service Road
23.000	23.550	0.550	0.550	Slip Road
24.000	24.850	0.850	0.850	Slip Road
25.680	26.380	0.700	0.700	Slip Road
28.300	29.100	0.800	0.800	Slip Road
29.720	30.250	0.530	0.530	Slip Road
31.250	31.950	0.700	0.700	Slip Road
32.580	34.450	1.870	1.870	Slip Road
37.000	37.600	0.600	0.600	Slip Road
38.750	39.400	0.650	0.650	Slip Road
40.850	41.000	0.150	0.150	Slip Road
41.000	42.750	1.750	1.750	Slip Road
45.300	46.155	0.855	0.855	Slip Road
47.960	48.760	0.800	0.800	Slip Road
49.900	50.640	0.740	0.740	Slip Road

Reach (km)		Proposed Length (km)		Remark
From	To	Left	Right	
55.100	56.050	0.950	0.950	Slip Road
57.150	57.800	0.650	0.650	Slip Road
60.150	60.850	0.700	0.700	Slip Road
65.200	66.000	0.800	0.800	Slip Road
68.100	68.900	0.800	0.800	Slip Road
69.730	70.630	0.900	0.900	Slip Road
71.570	72.700	1.130	1.130	Slip Road
76.370	77.270	0.900	0.900	Slip Road
80.380	81.180	0.800	0.800	Slip Road
87.100	87.900	0.800	0.800	Slip Road
92.600	93.800	1.200	1.200	Slip Road
97.900	98.700	0.800	0.800	Slip Road
103.870	104.700	0.830	0.830	Slip Road
Total		30.305	30.305	
		60.610		

9.2.1 Exit and Entry Way from and to Main Highway

Exit and entry way are provided to fulfil the objectives as follows:

- To cater the commuting need for traffic generating and terminating from and to intermediate locations between Poonamallee and Walajapet.
- To provide the opportunity to traffic coming from cross road to merge at desired locations with main traffic on toll road and proceed to distanced destinations.
- To provide the opportunity to main traffic on project road to exit on service road and proceed to desired destinations through cross road junctions with service road.

The locations of entry and exit ways were selected in such manner that there are no structures and minimum additional land to be acquired. The exit and entry ways were placed keeping in view that the local traffic should not interfere frequently with main carriage way. As per manual, there should not be direct entry or exit between main highway and service road. The consultant had tried to maintain the same. But, in certain locations to avoid demolition of a number of structures and acquisition of land along the built up area, the consultant proposed direct entry and exit with proper acceleration and deceleration. Typical templates of entry and exit ramps are shown in **Figure 9.1 and 9.2.**

The locations of exit and entry way along the highway are presented in **Table 9.5.**

Table 9.5: Locations of Exit and Entry Way

S. N.	Location	Entry	Exit
1	14.400	Direct	Direct
2	15.400	Direct	Direct
3	15.900	Direct	Direct
4	16.700	Direct	Direct
5	17.600	Direct	Direct
6	20.670	Direct	Direct
7	21.270	Direct	Direct
8	22.400	Direct	Direct
9	23.000	Direct	Direct
10	23.550	Direct	Direct

S. N.	Location	Entry	Exit
11	24.000	Direct	Direct
12	24.850	Direct	Direct
13	25.680	Direct	Direct
14	26.380	Direct	Direct
15	28.300	Direct	Direct
16	29.100	Direct	Direct
17	29.720	Direct	Direct
18	30.250	Direct	Direct
18	31.250	Direct	Direct
19	31.950	Direct	Direct
20	32.580	Direct	Direct
21	34.450	Direct	Direct
22	37.000	Direct	Direct
23	37.600	Direct	Direct
24	38.750	Direct	Direct
25	39.400	Direct	Direct
26	40.850	Direct	Direct
27	41.750	Direct	Direct
28	42.750	Direct	Direct
29	45.300	Direct	Direct
30	46.155	Direct	Direct
31	47.960	Direct	Direct
32	48.760	Direct	Direct
33	49.900	Direct	Direct
34	50.640	Direct	Direct
35	55.100	Direct	Direct
36	56.050	Direct	Direct
37	57.150	Direct	Direct
38	57.800	Direct	Direct
39	60.150	Direct	Direct
40	60.850	Direct	Direct
41	65.200	Direct	Direct
42	66.000	Direct	Direct
43	68.100	Direct	Direct
44	68.900	Direct	Direct
45	69.730	Direct	Direct
46	70.630	Direct	Direct
47	71.570	Direct	Direct
48	72.700	Direct	Direct
49	76.370	Direct	Direct
50	77.270	Direct	Direct
51	80.380	Direct	Direct
52	81.180	Direct	Direct
53	87.100	Direct	Direct
54	87.900	Direct	Direct
55	92.600	Direct	Direct
56	93.800	Direct	Direct
57	97.900	Direct	Direct
58	98.700	Direct	Direct
59	103.870	Direct	Direct
60	104.700	Direct	Direct

However, in the absence of continuous service road, in addition to the above locations, it is proposed to provide minor at-grade intersection at 81 locations.

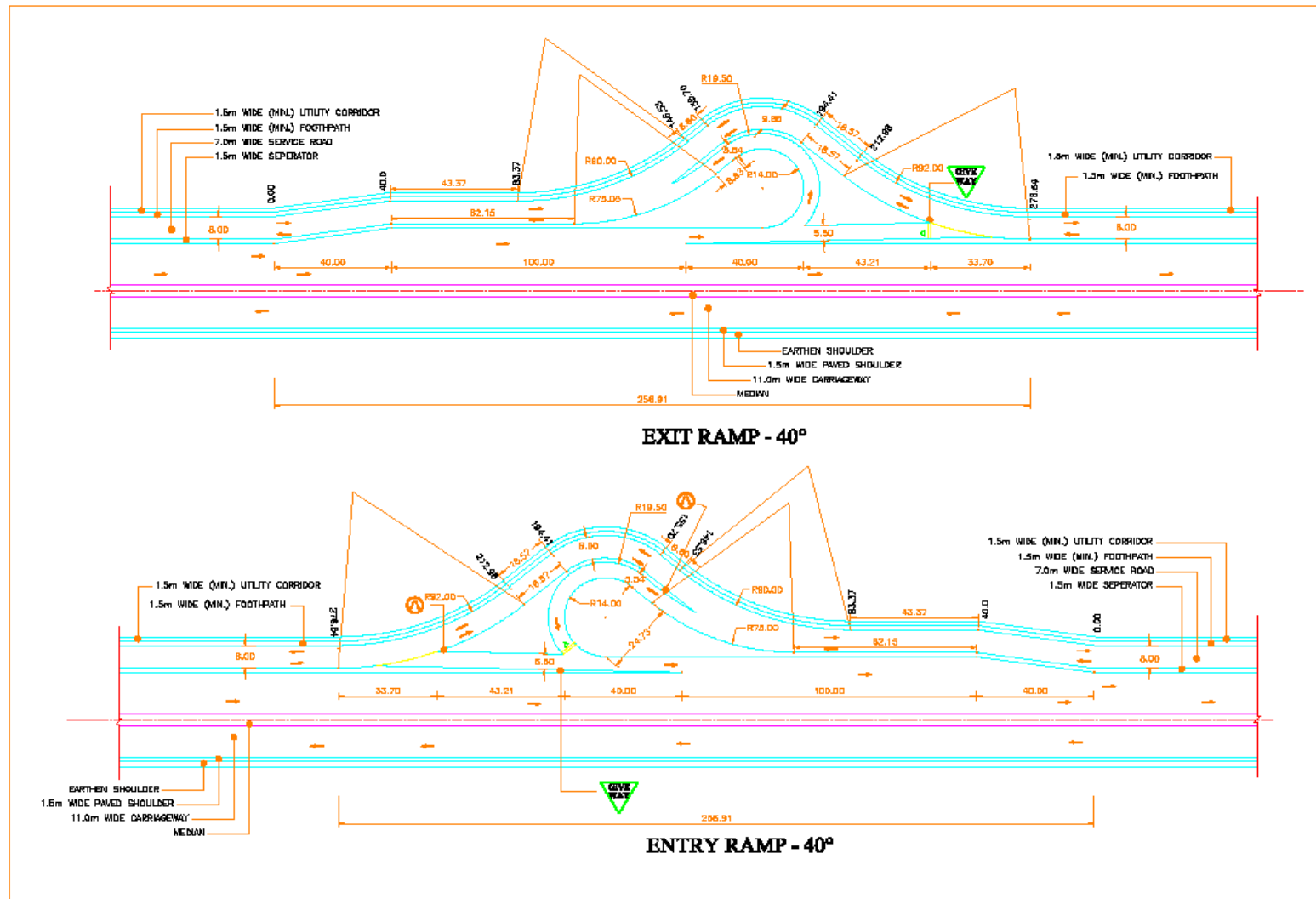


Fig. 9.1: Typical Layout of Exit and Entry Way where Service Road continuous

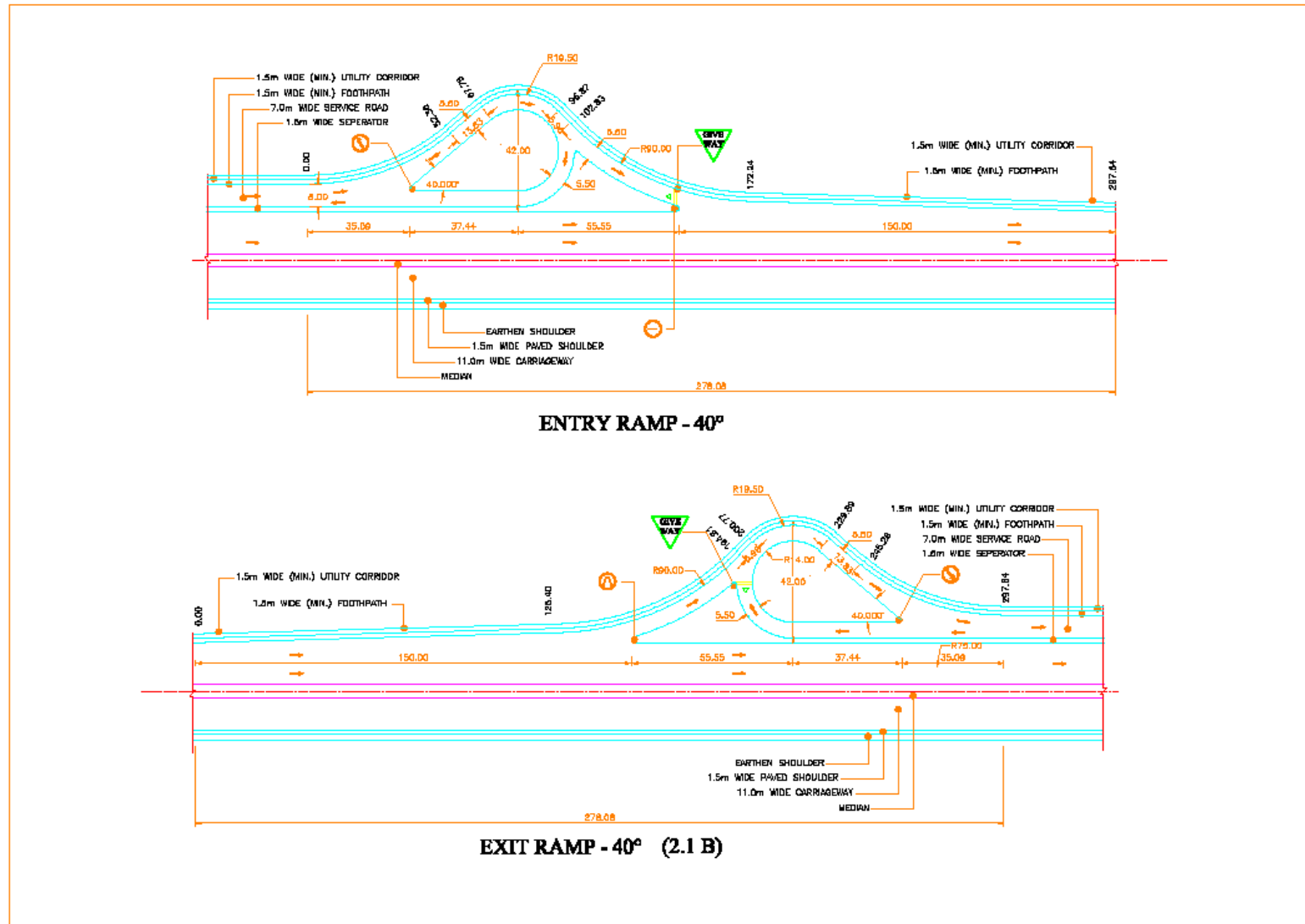


Fig. 9.2: Typical Layout of Exit and Entry Way where Service Road ends/ starts

9.2.2 Bridges

Existing Bridges

There are 13 numbers of existing bridges on the project road consisting of one major bridge, twelve numbers of minor bridges and one existing ROB. All the existing bridges are already with 2x3-lane carriageway; hence they need not be widened. Brief details of existing bridges on the project road are presented in **Table 9.6**, **Table 9.7** and **Table 9.8**.

Table 9.6: Major Bridges

S. N.	Chainage and name of Crossing	Overall length in 'm'	Span Arrangement	Super-structure	Sub-structure	Foundation
1	27.211	70.0	7x10.0m-OC, 5x14.0m-NC	RCC Slab-OC, RCC T-beam Slab-NC	RCC Wall type abutments and pier	Pile foundations

* New Carriageway- NC, Old Carriageway - OC

Table 9.7: Minor Bridges

Sl. No.	Chainage and name of Crossing	Overall length in 'm'	Span Arrangement	Super-structure	Sub-structure	Foundation
1	30.945	25.5	1x8.42+ 2x8.5 -OC, 1x25.0-NC	RCC Solid Slab –OC, RCC T-Beam-Slab -NC	RCC solid wall type pier & abutment	Open Foundations
2	30.995	25.0	4x5.8 –OC, 1x25.0 -NC	RCC Solid Slab –OC, RCC T-Beam -Slab -NC	RCC solid wall type pier & abutment	Open Foundations
3	39.435	28.0	4x6.7 –OC, 2x14.0 -NC	RCC Solid Slab –OC, RCC T-Beam -Slab -NC	RCC solid wall type pier & abutment	Open Foundations
4	44.489	8.75	1x8.7 –OC, 1x8.75 -NC	RCC Solid Slab – OC & NC	RCC solid wall type abutment	Open Foundations
5	56.905	21.0	3x6.8 –OC, 1x21.0 -NC	RCC T Beam – Slab – OC & NC	RCC solid wall type pier & abutment	Open Foundations
6	59.108	20.0	2x10.0 –OC, 2x10.0 -NC	RCC Solid Slab – OC & NC	RCC solid wall type pier & abutment	Open Foundations
7	67.463	40.0	4x10.0 –OC,	RCC Solid Slab – OC	RCC solid wall type	Open Founda

Sl. No.	Chainage and name of Crossing	Overall length in 'm'	Span Arrangement	Super-structure	Sub-structure	Foundation
			4x10.0 - NC	& NC	pier & abutment	tions
8	92.218	48.5	7x6.5 – OC, 1x20.25 + 2x14.0 -NC	RCC Solid Slab –OC, RCC T-Beam - Slab -NC	RCC solid wall type pier & abutment	Old Open Foundations, New Pile Foundations
9	100.157	24.0	4x6.0 - NC	RCC Solid Slab - NC	PCC solid wall type pier & abutment	Open Foundations
10	101.247	10.0	1x10.0 – OC, 1x10.0 - NC	RCC Solid Slab –OC NC	PCC solid wall type pier & abutment	Open Foundations
11	103.637	17.50	3x5.75 – OC, 1x17.4 - NC	RCC Solid Slab –OC, RCC T-Beam - Slab -NC	RCC solid wall type pier & abutment	Open Foundations
12	106.683	10.0	1x10.0 - NC	RCC Solid Slab - NC	PCC solid wall type pier & abutment	Open Foundations

*** New Carriageway- NC, Old Carriageway - OC**

Table 9.8: ROB's

Sl. No.	Chainage	Length of structure in 'm'	Span Arrangement	Super-structure	Sub-structure	Foundation
1	72.250	80	2x23.5+1x33.0	RCC T-Beam - Slab	RCC Trestle Pier , solid Abutment	Pile foundations

Improvement Scheme for Major / Minor Bridges

The existing bridges have 2x3 lane configuration. During the 4-laning of the project road, the bridges on new two lane roads have been constructed with three lane carriageway. The bridges on existing two lane roads have been widened to three lanes simultaneously. Hence, no widening is required for the existing bridges on both the carriageways under the present scheme of improvement.

The road sections, where service roads have been proposed, it is decided to continue the service roads with bridges across the streams of the same length as existing in the main carriageways. The carriageway widths for the bridges as proposed on the service roads are as follows:

- 6-lane portions: 2-lane bridges on the service roads on either side with total width as $(0.50 + 1.50(\text{Footpath}) + 7.50 + 0.50) = 10.0\text{m}$

The clear gap between the deck structures on the individual carriageways have been kept as follows:

- The clear gap between the existing main carriageway decks and the new service road bridges have been kept as 1.0m.

The improvement proposals for the bridges have been presented in the **Table 9.9** and **9.10**:

Table 9.9: Major Bridge

Sl. No.	Location	Span Arrangement	Super structure	SubStructure / Foundations
1	27.216	As given in existing bridge details	As given in existing bridge details	As given in existing bridge details

** Proposed - Minor repairs for Existing Structures

No bridges are proposed on service/ slip road. Improvement Proposal for Existing 12 Minor Bridge Structures needs minor repairs.

Table 9.10: ROB

Sl. No.	Location	Status	Deficiency / Damage	Improvement
1	72.250	Existing	RE Wall Bulging	Repairs

9.2.3 Vehicular Underpasses

Existing Underpasses

There are two numbers of existing underpasses on the project road. All the existing underpasses have 2x3-lanes carriageway and they need not be widened. The locations and span arrangements of existing underpasses have been shown in **Table 9.11**.

Table 9.11: Details of existing Underpasses

Sl. No.	Chainage	Length of structure in 'm'	Span Arrangement	Super-structure	Sub-structure	Foundation
1	19.195	20.0	2x10.0	Double Cell Box	Double Cell Box	Double Cell Box
2	50.270	20.0	2x10.0	Double Cell Box	Double Cell Box RCC type	Double Cell Box

Improvement Proposals

The underpasses have been proposed with full height (5.0m) as mentioned in the 6-laning manual of MORTH. The project road stretch has been proposed to be a partially access controlled highway. The major junctions have been proposed to upgrade to facilitate the manoeuvrability of the traffic by providing deceleration lane and acceleration lane for the traffic exiting from and entering into the main carriageway. The full height (5m) underpasses have been provided at all these major junctions. All other junctions have been treated as minor junctions and have been designed as at-grade junctions with service road.

Most of the cross roads will have no direct access to main carriageway and their junctions are proposed with service road only. Important cross roads which carry appreciable traffic are provided with underpasses and others are proposed to have simple junctions with service road barring few which are proposed to have minor junctions with the project road. Underpasses have generally been proposed in urban/built-up areas or as per the specific requirements where the local traffic is collected through service road. The proposed width of underpass opening is 10.5m with a vertical clearance of 5.0m as per the Manual for 6-laning of MORTH. General layout plan for providing the vehicular underpass/flyover is shown in **Fig. 9.3 and 9.4**. The proposed underpasses are presented in **Table 9.12**.

For Vehicular underpasses as described above a clear opening of 1x 10.5mx 5.5m (height) have been proposed. The provision of a 2-lane carriageway of 7.5m with 2x1.5m footpaths have been kept in the underpasses. Total width of the underpasses is as follows:

- 6- Lane – 31.0m including clear gap at median of 4.0m

Table 9.12: Proposed Vehicular underpasses

S. N.	Location (km)	Width of Opening (m)	Type of Structure
1	16.300	10.50	Vehicular
2	20.970	10.50	Vehicular
3	26.030	10.50	Vehicular
4	28.715	10.50	Vehicular
5	31.600	10.50	Vehicular
6	42.150	10.50	Vehicular
7	42.250	10.50	Vehicular
8	50.270	10.50	Vehicular*
9	60.500	10.50	Vehicular
10	65.590	10.50	Vehicular
11	68.500	10.50	Vehicular
12	80.776	10.50	Vehicular
13	87.508	10.50	Vehicular
14	98.386	10.50	Vehicular
15	104.271	10.50	Vehicular
Total	15 Nos		

*To be widened

9.2.4 Pedestrian Underpass/ Cattle Crossings

Pedestrian underpasses with vertical clearance of 3.0m and clear width of 4.0 m are proposed at the locations where pedestrians tend to cross the road and locations

where cross road exist on either side of the project road. The cattle crossings have been proposed in rural areas, wherever needed with similar configuration as the pedestrian underpasses. Cattle crossings are clubbed with pedestrian underpasses. General arrangement layouts for pedestrian underpasses/cattle crossings are presented in the drawing Volume. The details of proposed pedestrian underpasses and cattle crossings are presented in **Table 9.13**.

Table 9.13: Proposed Underpasses for Pedestrian / Cattle Crossings

S. N.	Location (km)	Width of Opening (m)	Type of Structure
1	17.060	4.00	Pedestrian
2	23.270	4.00	Pedestrian
3	30.020	4.00	Pedestrian
4	32.880	4.00	Pedestrian
5	37.300	4.00	Pedestrian
6	39.080	4.00	Pedestrian
7	55.650	4.00	Pedestrian
8	57.486	4.00	Pedestrian
9	63.410	4.00	Pedestrian
10	69.330	4.00	Pedestrian
11	73.800	4.00	Pedestrian
12	78.446	4.00	Cattle Crossing
13	79.835	4.00	Pedestrian
14	83.446	4.00	Cattle Crossing
15	88.699	4.00	Pedestrian
16	91.498	4.00	Cattle Crossing
17	94.496	4.00	Cattle Crossing
18	96.746	4.00	Pedestrian
19	99.196	4.00	Pedestrian
20	100.666	4.00	Pedestrian
21	102.951	4.00	Pedestrian
22	105.776	4.00	Pedestrian
Total	20 Nos.		

9.2.5 Grade Separators / Flyovers

Existing Grade Separators / Flyovers

There is one grade separator and one flyover on the project road. The existing grade separator / flyover have 3-lane carriageway and they need not be widened. The locations and span arrangements of existing grade separators are as presented in **Table 9.14**.

Table 9.14: Details of Grade Separators/Flyovers/ Overpass

S. N.	Chainage	Length of structure in 'm'	Span Arrangement	Super-structure	Sub-structure	Foundation
1	Grade Separator - 18.100 (Left carriageway)	80.0	1x45.0+ 2x20.0	PSC Box Girder	RCC Piers and Abutments	Pile

S. N.	Chainage	Length of structure in 'm'	Span Arrangement	Super-structure	Sub-structure	Foundation
2	Overpass - 22.400 (Poonamallee road flies over the project road)	80.0	1x45.0+2x20.0	PSC Box Girder	RCC Piers and Abutments	Pile

General Scheme for Proposed Flyovers

It has been decided to provide flyovers at the major intersections i.e. intersections with major roads such as State Highways, National Highways and Important Major District Roads to effect an uninterrupted traffic movement in the improved scenario as a permanent solution. The categorization has been done based on the reconnaissance survey carried out on the project road, study of the collected data, discussions with the NHAI authorities substantiated by the turning movement studies. The project road has been taken over the cross road at all these locations with an obligatory span of 40.0m and two side spans of 30.0m each. At grade movements have been taken care of by providing at grade slip roads and properly designed junctions. At km 14.870, 48.360 and 93.06, the flyover arrangements have been modified to 3x25.0m configuration as per the site specific requirements.

The overall formation width of the approach road and the flyovers has been kept same. Accordingly, the formation width of the 2x3 lane structures has been kept as:

- Carriageway = 2x12.50m
- Crash Barriers = 2x2x0.5m crash barriers

Retaining walls have been proposed for the underpasses in general whereas RE walls have been proposed for the Flyovers. The length/height of the retaining walls has been decided as per the site specific requirements.

The details of Proposed Flyovers/ Grade Separators are presented in **Table 9.15**.

Table 9.15: Details of Proposed Flyover / Grade Separators

S.N.	Chainage (km)	Location	Span arrangement (m)	Total Length (m)
1	14.870	Ambattur Road	25+25+25	75
2	*18.070	Poonamallee	20+45+20	80
3	24.400	Tirupati Road	30+40+30	100
4	34.050	Hyundai Motors	30+40+30	100
5	41.335	Sriperumbudur	30+40+30	100
6	45.755	SIPCOT	30+40+30	100

7	48.360	Sunguvachatram	25+25+25	75
8	70.178	Kanchipuram Bypass Start	30+40+30	100
9	76.820	Kanchipuram Bypass End	30+40+30	100
10	93.062	Ocheri	25+25+25	75

***proposed on right carriageway**



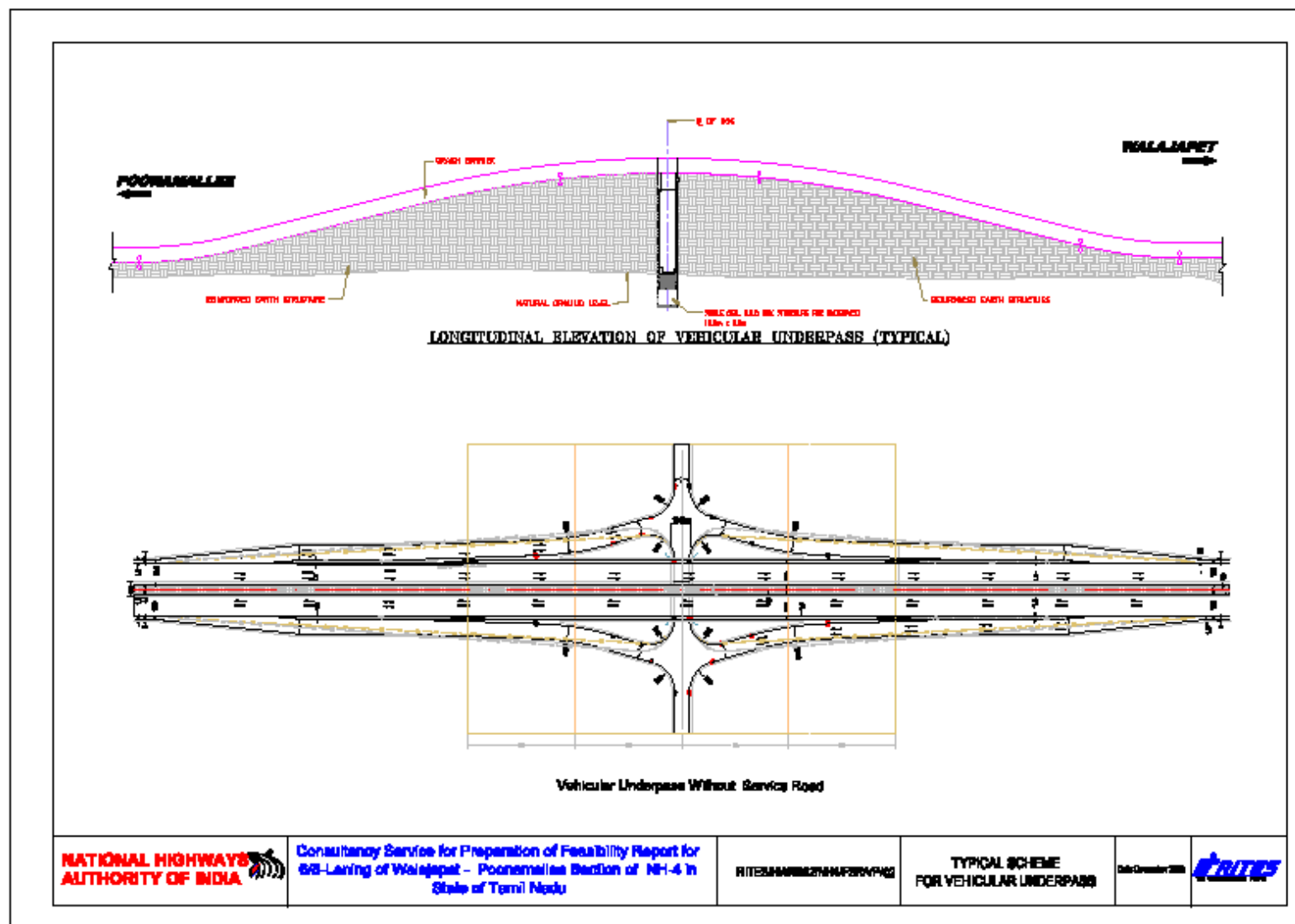


Fig. 9.4: Vehicular Underpass/ Flyover without Service Road

9.2.6 Truck Lay Bys and Bus-Bays

Truck Lay Bys are provided with the facility of parking along the project road. The truck lay byes are located (clubbed) with the rest areas where drivers can take rest also. **Table 9.16** shows the location of truck lay byes / rest area.

To maintain the flow of the main road bus-bays are proposed on service roads. All the existing bus lay byes are also proposed to be relocated on service roads. **Table 9.17** shows the locations of bus byes on the project corridor.

Table 9.16: Proposed Truck Lay Bys

S. N.	Chainage	Sides
1	48.360	Right Side (land available, which needs to be acquired)
2	76.820	Right Side (land available, which needs to be acquired)
3	104.271	Left Side (land available, which needs to be acquired)

Table 9.17: Proposed Bus-Bays

S. N.	Chainage (km)	Left	Right	S. N.	Chainage (km)	Left	Right
1.	14.205	Yes	Yes	24.	72.918	Yes	
2.	16.930	Yes		25.	73.100		Yes
3.	17.156		Yes	26.	81.632	Yes	Yes
4.	20.044	Yes	Yes	27.	85.790		Yes
5.	23.965	Yes		28.	86.813	Yes	
6.	24.030		Yes	29.	87.560		Yes
7.	25.757	Yes		30.	89.180		Yes
8.	25.855		Yes	31.	89.250	Yes	
9.	34.847	Yes		32.	90.480	Yes	
10.	34.900		Yes	33.	90.550		Yes
11.	38.860		Yes	34.	95.280	Yes	
12.	38.960	Yes		35.	95.470		Yes
13.	42.063	Yes	Yes	36.	96.430	Yes	
14.	50.986		Yes	37.	96.580		Yes
15.	51.345	Yes		38.	99.290	Yes	Yes
16.	57.470	Yes		39.	102.870	Yes	
17.	57.630		Yes	40.	103.025		Yes
18.	60.333		Yes	41.	104.400	Yes	
19.	60.648	Yes		42.	104.590		Yes
20.	63.767		Yes	43.	106.000	Yes	Yes
21.	64.163	Yes					
22.	69.341	Yes					
23.	69.885		Yes				

9.2.7 Rest areas

User amenities in the form of rest areas are proposed along the project road corridor. The rest area is 300 x 150 m in size and is generally proposed at 50 km apart on both sides of the carriageway. The area should accommodate the services such as parking, catering, toilets, essential shopping, repair and refueling, highway information etc. In the opinion of the consultant the following four locations are most suitable for rest areas. However on discussion with the

client the consultant is proposing them as tentative locations and it is up to the concessionaire to find out the land for the provision of rest areas. **Table 9.18** shows the tentative location of rest areas along the project corridor.

Table 9.18: Proposed Rest Areas

S. N.	Chainage (Km)	Sides
1	48.360	Right Side (land available, which needs to be acquired)
2	76.820	Right Side (land available, which needs to be acquired)
3	104.271	Left Side (land available, which needs to be acquired)

9.3 Working of Integrated 6-Laning Scheme

9.3.1 Section from km 0 to km 43 (6-Lane Divided Highway)

The section starts at about km 14.00 at Maduravoyal/ Poonamallee and ends at about km. 43.00 at Sriperumbudur. The section is heavily loaded with personalized mode of traffic compare to other two sections and passes through Industrialized/ Special Economic Zone (SEZ) area with colleges, schools etc. Exit and entry ways have been proposed to access the main carriageway from cross road through slip road. No entry and exit ways from / to service road and U turns are proposed inside the city limits to avoid the acquisition of costly land and to avoid dismantling of structures. Direct entry and exit ways from and to cross road has been minimised. At major junction, flyovers are proposed for cross traffic and to take U-turn to move in other direction and in other junctions, underpasses with 5m vertical clearance have been proposed. Flyovers proposed at km 14.870 on Ambattur Road, km 18.070 (Right carriageway) and km 24.400 on Tirupati Road, km 34.050 near Hyundai Motors and km 41.350 at Sriperumbudur/Rajiv Gandhi Memorial to avoid traffic hazards and for safety to users. In addition, pedestrian underpass also proposed at few locations to facilitate the safe movement of pedestrians. There is an existing toll plaza at km 34.800.

9.3.2 Section from km 43 – km 74.80 (6-Lane Divided Highway)

The section starts at about km 43.00 and ends at km. 74.80. There are few villages, industrial establishment, Sunguvachatram town and also Kanchipuram town on left side of project road in this reach. The reach has isolated rural stretches with cultivation at other locations. The section also consists of semi built up to built-up stretches with shops, schools and buildings and heavy industries on both sides. Pedestrian underpasses are proposed at many places to facilitate the people intending to cross the road safely. Vehicular underpass / flyover with 5.0m vertical clearance are proposed at a few locations to facilitate the vehicle to cross and to move in other direction. Rest area is proposed on one side of highway at km 48.360.

9.3.3 Section from km 74.80 – km 107.00 (6-Lane Divided Highway)

The section starts at about km 74.80 and ends at km. 107.00. There are few villages scattered all along this reach. The section has got mix land use of rural and semi urban stretches. Rural stretch has cultivated land, schools, and fuel stations. Semi urban area has got markets and other commercial establishments on both sides of the road. Pedestrian underpasses are proposed at many places to facilitate the people intending to cross the road safely. Vehicular underpass / flyover with 5.0m vertical clearance are proposed at a few locations to facilitate the vehicle to cross and to move in other direction. 6-lane flyover has been proposed for 75m length at km 93.060 in Ocheri town to facilitate safe movement of locals. The Rest area is proposed at km 104.271. There is an existing toll plaza at km 104.900 on this stretch.

9.4 Proposed Right of Way / Land Acquisition

As explained above and in previous chapters, to retrofit 6-lane with proposed scheme over existing 4-lane road, additional land is proposed for acquisition at two locations where accommodation of 6-lane facility was difficult within the present available ROW. In addition, Land is proposed to be acquired at the locations of proposed junction improvement. The information regarding existing ROW was collected from the office of the PD/NHAI Chennai. No information regarding existing ROW is available in the as-built drawings collected from NHAI. Further, the consultant has also measured the existing right of way wherever, it was marked in the form of Right of Way pillar. The additional land to be acquired is then calculated from AutoCAD after putting the proposed 6-laning scheme. The land acquisition requirement is calculated as **17.18 hectares**. The details of additional land to be acquired are tabulated in the following **Table 9.19**.

Table 9.19: Land Acquisition Details

LA Requirement for Exit/ Entry Ramp, Slip Road and Junctions							
Location	Entry	Exit	Land Required (m ²)				Remarks
			Entry	Exit	Junction	Service/ Slip Road	
14.400	Direct	Direct	0	0	32873	5500	Flyover at km 14.870
15.400	Direct	Direct	0	0			
15.900	Direct	Direct	0	0	1800	6000	Underpass at km 16.300
16.700	Direct	Direct	0	0			
17.600	Direct	Direct	0	0	0	0	Service Road Start
20.670	Direct	Direct	0	0	1800	0	Underpass at km 20.970
21.270	Direct	Direct	0	0			
22.400	Direct	Direct	0	0	0	0	Service Road End
24.100	Direct	Direct	0	0	31216	0	Flyover at km 24.400
24.850	Direct	Direct	0	0			
28.300	Direct	Direct	0	0	1800	0	Underpass at km 28.715
29.000	Direct	Direct	0	0			
31.250	Direct	Direct			1800	2450	Underpass at km 31.600
31.950	Direct	Direct					
33.650	Direct	Direct	0	0	20750	0	Flyover at km 34.050
34.450	Direct	Direct	0	0			
40.850	Direct	Direct	0	0	0	0	Junction at km 41.335
41.750	Direct	Direct	0	0			
41.900	Direct	Direct	0	0	1468	0	Underpass at km 42.150
42.750	Direct	Direct	0	0	803	0	Underpass at km 42.250
45.100	Direct	Direct	0	0	11814	0	Flyover at km 45.755
46.155	Direct	Direct	0	0			
48.000	Direct	Direct	0	0	11138	0	Flyover at km 48.360
48.745	Direct	Direct	0	0			
49.900	Direct	Direct	0	0	2450	0	Underpass at km 50.270
50.900	Direct	Direct	0	0			
63.000	Direct	Direct	0	0	0	10000	Service Road Start
64.050	Direct	Direct	0	0	0		Service Road End
65.200	Direct	Direct	0	0	1800	0	Underpass at km 65.590
66.000	Direct	Direct	0	0			
68.000	Direct	Direct	0	0	1800	0	Underpass at km 68.500
68.850	Direct	Direct	0	0			
69.778	Direct	Direct	0	0	14670	0	Flyover at km 70.178
70.640	Direct	Direct	0	0			

LA Requirement for Exit/ Entry Ramp, Slip Road and Junctions							
Location	Entry	Exit	Land Required (m ²)				Remarks
			Entry	Exit	Junction	Service/ Slip Road	
71.565	Direct	Direct	0	0	0	0	Service Road Start
72.700	Direct	Direct	0	0	0	0	Service Road End
76.240	Direct	Direct	0	0	3563	0	Flyover at km 76.800
77.500	Direct	Direct	0	0			
80.200	Direct	Direct	0	0	1800	0	Underpass at km 80.776
82.000	Direct	Direct	0	0			
86.400	Direct	Direct	0	0	1800	0	Underpass at km 87.508
87.900	Direct	Direct	0	0			
92.700	Direct	Direct	0	0	4555	0	Junction at km 93.060
93.700	Direct	Direct	0	0			
98.000	Direct	Direct	0	0	1800	0	Underpass at km 98.386
98.736	Direct	Direct	0	0			
103.870	Direct	Direct	0	0	1800	0	Underpass at km 104.271
104.700	Direct	Direct	0	0		0	
Total			0	0	153300	18450	

In addition to the above, about 15 hectares of Land is required to be acquired for Rest areas at three locations.

Chapter - 10

Preliminary Design

CHAPTER – 10

Preliminary Design

10.1 General

This chapter is intended to give brief descriptions concerning the various improvement proposals for the up-gradation of existing 4-lane divided carriageway facility of NH-4 to 6-lane divided carriageway configuration. These improvement proposals are based on the findings from various engineering features carried out on the project roads such as Traffic Survey and Analysis (Chapter-7) and Engineering Surveys and Investigations (Chapter-6). These features are discussed in detail in the concerned chapters.

As it is envisaged to develop the existing 4-lane divided carriageway configuration to 6-lane divided carriageway configuration with the facility of partially access controlled road in order to ensure high speed of travel with comfort and safety, the Project Road has been proposed to have design provisions compatible with National Highway Standards.

Improvement proposals for a highway essentially consist of two components, geometric and structural. Geometric improvement deals with visible dimensions of roadway and is dictated by the traffic and economic considerations. Geometric design involves several design elements such as horizontal and vertical alignment consideration, sight distance considerations, cross sectional elements, lateral and vertical clearances, intersection treatment, control of access etc. The structural component deals with the pavement and embankment design aspects, i.e., the ability of the highway to adequately carry and support the vehicle/ wheel loads over the design period.

The improvement proposals for the proposed widening to 6-lane configuration system include the provisions for the following major items:

- *Widening Proposals;*
- *Geometric Improvements;*
- *Pavement;*
- *Road Junctions;*
- *Bridges and Cross-Drainages;*
- *Special Problems; and*
- *Road Appurtenances;*

10.2 Geometric Design

The existing road sections have 4-lane dual carriageway configurations in its entire length (excepting the bridges/ flyovers and its approaches, where it has 6-lane dual carriageway). The project road section based on the terrain is given as under:

Road Section	Terrain	Road ID	Section
Poonamallee - Walajapet	Plain	NH-4	Km 13.80 – Km 106.80

The road section has in general smooth geometry excepting few locations wherein sharp bends are present. The project road has several built up and congested areas along its length. To avoid these constraints, Consultant did proposed elevated 6-lane highway around the congested locations of Sriperumbudur (Length = 2000m) and Ocheri (Length = 300m). But, to cut down the cost of the project highway, flyovers have been proposed at these two locations replacing elevated highway as suggested by the Client/ NHAI. The proposed widening / improvement would confirm the

alignment to the Design Standards proposed for the Project road as discussed in detail in Chapter-5 of this volume.

10.2.1 Design Parameter

Design Speed, Cross-sectional elements

The design speed is the guiding criteria for correlating the features such as sight distance, curvature and super elevation upon which the safe operation of the vehicle depends. The design speeds for Flat/Plain terrain in rural condition as per IRC: 73 have been proposed as under:

Table 10.1: Design Speed (Km / h)

Flat / Plain Terrain	
Ruling	Minimum
100	80

Table 10.2: Cross-Sectional Elements

6-lane highway		2 x 10.5 m = 21.0m
Kerb shyness		2 x 0.25m = 0.50m
Median	Built – up areas	1.30m
	Rural areas	4.50m
Shoulder Width	Paved	2 x 1.50m = 3.00m
	Unpaved	2 x 2.00m = 4.00m
Roadway Width	6-Lane Highway	29.80m/33.00m
Camber / Cross Slope	Main carriageway/Service Road/Paved Shoulder	2.50 %
	Earthen Shoulder	3.50 %
Proposed ROW	Improvement along existing alignment (existing ROW: 40~60m)	60m

The project road passes through plain/flat terrain and built up/congested areas. An effort has been made to accommodate the proposed 6-lane cross sectional elements within the available right of way (ROW) to minimise the acquisition of land. In general, the additional lanes has been added on either side of the existing carriageway keeping unaffected the existing 4.5m median in the open areas and 1.3 m median in the built-up and town areas.

The consultant has proposed cross sections for Rural and Urban areas to retrofit the 2x3-lanes over existing 2x2-lanes arrangements. However as per the existing scenario proposed cross section has been modified to suit the requirement.

Typical cross sections proposed for the project road under different site conditions are presented in **Fig: 10.1 to 10.12**.

Service Roads

Service roads are proposed for the urban/ built-up areas for effective segregation of traffic and to enforce access control measures. Suitable width of 5.5/7.0m for carriageway as service road is proposed to facilitate the slow moving/local vehicles in built-up areas only. The service road and the main carriageway are separated by 0.6m/1.5m raised separator.

10.2.2 Alignment Design

The entire geometric design has been based on the ground modelling by highway design software MOSS/MX. The design of proposed 2x3-lane carriageway configuration alignment has been carried out by the consultants using various design modules contained in “MX Road/Renew”.

10.2.2.1 Horizontal Alignment

The preliminary design of project road alignment and geometry are presented in this section. The assignment involves retrofitting 2x3 lanes over existing 2x2-lanes. The existing alignment and geometry has been kept unchanged unless they are absolutely warranted. The reaches having less than the design speed of 80kmph is presented in **Table 10.3**.

Table 10.3: Horizontal Geometry

Reach (km)		Existing Design Speed (kmph)	Remarks
From	To		
14.000	15.090	50 - 65	Existing Right of way is 45m and Within the Chennai Metropolitan area
17.840	18.320	50	Intersection with Flyover and within the Chennai Metropolitan area
22.210	22.510	70	Intersection with Flyover and within the Chennai Metropolitan area
23.750	24.300	50 - 65	Existing right of way is 45m and passing through heavily built-up area
40.280	42.230	65	Existing right of way is 40m. Rajiv Gandhi Memorial on left side and Medical college & burial ground on right side.

The Change in Horizontal Geometry envisaged at a couple of locations to avoid reverse curve with proposed scheme.

Stretches between km 14.000 and km 15.090

The stretches between km 14.000 and km 15.090 passes through the congested area of Maduravoyal/ Vanagram that are part of the Chennai metropolitan areas and there are four substandard curves to negotiate at 50km per hour speed. Throughout this area, average 45m ROW is available. On both side of the ROW, there are commercial establishment all along the stretches. To avoid acquisition of additional land and commercial establishments also considering the city limit, the existing alignment having design speed of 50-65 kmph have been kept unchanged. Project Director, Chennai was also in the same opinion.

Stretches between km 17.840 and km 18.320

At this stretch, the existing structures of the 3-lane flyover is in straight portion between the two curves with design speed of 50kmph on its immediate approaches, which have been recently constructed. Moreover, this stretch is within the city limit of Chennai Metropolitan area and has commercial establishment on both sides. In view of the above, it is proposed to keep the existing alignment unchanged.

Stretches between km 22.210 and km 22.510

The existing alignment at this stretch with design speed of 70kmph passes through under flyover, which has been recently constructed. There are commercial/industrial establishments abutting the right of way. Therefore, it is proposed to keep the existing alignment unchanged.

Stretches between km 23.750 and km 24.300

The stretch between km 23.750 and km 24.300 passes through the congested area of Nazarethpettai, where there are commercial/ industrial establishments abutting the existing right of way. This stretch falls under the Chennai metropolitan areas. To avoid acquisition of additional land and commercial establishments also considering the extended city limit, the existing alignment having design speed of 50-65 kmph have been kept unchanged. Project Director, Chennai also of the same opinion.

Stretches between km 40.280 and km 42.230

Existing right of way is 40m in the stretch between km 41.000 and km 43.000. Rajiv Gandhi Memorial on left side and Medical College and burial ground on right side. The Rajiv Gandhi Memorial being of national importance, many tourists visit the place by parking their vehicle on road side causing congestion, traffic hazard as well as accident prone area. The existing alignment in stretch between km 40.280 and km 41.600 is proposed to be improved to a design speed of 80kmph. But this improvement will involve demolition of hotel owned by Tamil Nadu Tourism Development Corporation Ltd. and also acquisition of additional land to the tune of 10,000 m². Considering the traffic safety, which is of prime importance, and also optimising the acquisition of additional land and commercial establishments, it was recommended that an elevated highway in the stretch between km 41.000 and 43.000 would be appropriate with or without realignment between km 40.280 and 41.600. But, to cut down the cost of the project highway, flyover has been proposed at this location replacing elevated highway as suggested by the Client/ NHAI.

Stretches between km 92.700 and km 93.500

Existing right of way is 20m on left side and 34m on right side. This stretch of 800m passes through congested market area of Ocheri town. There many commercial establishments abutting the right of way. To accommodate the proposed 2x3-lane carriageway configuration with service road, the centre line is proposed to be shifted by 5m on the side having 34m wide of right of way. Further, a stretch of 300m (km 93.000 to km 93.300) was proposed to be elevated to prevent accidents, which occurs quite frequently as well as facilitate the locals to continue to earn their livelihood through the existing business in this local market. But, to cut down the cost of the project highway, flyover has been proposed at this location replacing elevated highway as suggested by the Client/ NHAI.

10.2.2.2 Vertical Alignment / Gradient

Change in Vertical Geometry proposed at the locations, where underpasses and elevated corridor are proposed. The gradients up-to ruling gradient has been adopted as a matter of course of design. Since the project road is passing through plain terrain, nowhere the proposed vertical gradient is exceeding 3.3%.

10.3 Vehicular / Pedestrian / Cattle Underpasses and Flyovers

The Consultants have proposed 2 types of underpasses. Type 1 - non vehicular underpasses, proposed for the pedestrian and cattle crossings with a clear height of 3.0m and a clear width of 4m. Type 2 - vehicular underpasses, proposed at locations where the Consultants have found light commercial/ heavy vehicles (not articulated long vehicles) are crossing the project road through median cut. The clear vertical and horizontal openings have been proposed as 5m and 10.5m respectively as per the 6-laning manual of MORTH.

The flyovers are proposed at major intersections such as those with NH, SH and Major District Roads (MDR). The clear height of the flyovers has been proposed as 5m as specified in the 6-laning manual of MORTH with three spans of 25m or 30m+40m+30m span configuration.

Details of the underpasses/ flyovers of various categories as proposed are mentioned in **Table 10.4 & Table 10.5**.

Table 10.4: Vehicular and Non-Vehicular Underpasses

S. N.	Location (km)	Width of Opening (m)	Type of Structure
1	16.300	10.50	Vehicular
2	17.060	4.00	Pedestrian
3	20.970	10.50	Vehicular
4	23.270	4.00	Pedestrian
5	26.030	10.50	Vehicular
6	28.715	10.50	Vehicular
7	30.020	4.00	Pedestrian
8	31.600	10.50	Vehicular
9	32.880	4.00	Pedestrian
10	37.300	4.00	Pedestrian
11	39.080	4.00	Pedestrian
12	42.150	10.50	Vehicular
13	42.250	10.50	Vehicular
14	50.270	10.50	Vehicular
15	55.650	4.00	Pedestrian
16	57.486	4.00	Pedestrian
17	60.500	10.50	Vehicular
18	63.410	4.00	Pedestrian
19	65.590	10.50	Vehicular
20	68.500	10.50	Vehicular
21	69.330	4.00	Pedestrian
22	73.800	4.00	Pedestrian
23	78.446	4.00	Cattle Crossing
24	79.835	4.00	Pedestrian
25	80.776	10.50	Vehicular
26	83.446	4.00	Cattle Crossing
27	87.508	10.50	Vehicular
28	88.699	4.00	Pedestrian
29	91.498	4.00	Cattle Crossing
30	94.496	4.00	Cattle Crossing
31	96.746	4.00	Pedestrian
32	98.386	10.50	Vehicular
33	99.196	4.00	Pedestrian
34	100.666	4.00	Pedestrian
35	102.951	4.00	Pedestrian
36	104.271	10.50	Vehicular
37	105.776	4.00	Pedestrian
Total	37 Nos.		

Table 10.5: Flyovers

Sl. No	Location		Span	Remarks
	km	Description		
1	14.870	Ambattur Road Intersection	25m + 25m + 25m	2x3-lane
2	*18.070	Poonamallee Road	20m + 45m + 20m	1x3-lane
3	24.400	Tirupati Road Intersection	30m + 40m + 30m	2x3-lane
4	34.050	Hyundai Intersection	30m + 40m + 30m	2x3-lane
5	41.335	Sriperumbudur Junction	30m + 40m + 30m	2x3-lane
6	45.755	SIPCOT Industrial Area	30m + 40m + 30m	2x3-lane
7	48.360	Sunguvachatram Junction	25m + 25m + 25m	2x3-lane
8	70.200	Kanchipuram Bypass Start Junction	30m + 40m + 30m	2x3-lane
9	76.820	Kanchipuram Bypass End Junction	30m + 40m + 30m	2x3-lane
10	93.063	Ocheri Junction	25m + 25m + 25m	2x3-lane

*On right carriageway

10.4 Pavement

Based on the field studies and analysis of data, the improvement, rehabilitation and upgrading requirements for the Project Road have been identified. This report presents salient features concerning these requirements.

The scope of pavement improvement envisaged for the project includes:

- ◇ New pavements for 6-lane carriageway.
- ◇ Strengthening and widening of existing carriageway

10.4.1 Design Parameters

The performances of pavements are affected by several factors. These factors include:

- ◇ environment;
- ◇ design life;
- ◇ design traffic loading;
- ◇ sub-grade type and characteristics;
- ◇ road construction material type and their characteristics;
- ◇ construction technology; and,
- ◇ construction and maintenance standards.

The methodology and the values adopted for the different design parameters are described in paragraphs that follow.

10.4.1.1 Design Life

The pavement design is generally done in two stages:

1. Design life Construction (Single Stage)
2. Stage Construction

The pavement design as per IRC 37:2001 requires design life for National Highways/State Highways to be 15 years and for Expressways and Urban Roads for 20 years.

The Sub-Base and Base layer requirement is uniform in both 15/20 years scenario. The consultant has carried out pavement design for Base & Sub-Base for 20 years and for stage construction for 10 years for surfacing layers. The designed SN for both options is tabulated in the table 'SN requirement for pavement (AASHTO-1993 & IRC 37-2001)'. The SN thus desired for the options are comparable and there would not be much savings in pavement layers thickness requirements. Hence, for the simplicity of design and project analysis, the consultant recommends 20 years of Design life.

Asphalt Surfacing

However, because of cost considerations and also to take into account the adverse effects of oxidation on the structural life of asphalt, surfacing courses including the binder courses have been designed for a 10-year life. During this period of 10 years, functional (cosmetic) overlays in the form of thin asphalt concrete surfacing would be required to provide a good riding surface and also to retard further deterioration of the pavement.

For a 20-year design life, the pavement would require a structural overlay to cater to the traffic loading for the 10-year period beyond the original design.

Base and Sub-Base

The base and sub-base courses of the pavement have been designed for the full design period of 20 years.

10.4.1.2 Design Traffic Loading

Cumulative Number of Standard Axles

The traffic loading in terms of the cumulative number of standard axles for the given period has been computed using the following relationship:

$$N_s = \sum_i^{DL} \sum_i^n \frac{365 ADT_i \left[(1 + GR_i)^{DL} - 1 \right]}{GR_i} VDF_i$$

where,

N_s is cumulative number of standard axles for the period under consideration.

ADT_i is average daily traffic for vehicle category "i" in the initial year.

GR_i is growth rate for vehicle category, "i".

VDF_i is vehicle damage factor in terms of equivalent number standard axles for vehicle category, "i".

DL is design life, year.

Design Traffic

Traffic for pavement design purpose constitutes of commercial vehicles of > 3.0 tonnes gross vehicle weight. The base year traffic in different categories for various links is estimated and projected by adopted growth rates for the entire design period and presented in Chapter-7.

Design Lane Traffic

Project road is being improved as 6-lane divided carriageway facility. Therefore, design lane traffic is determined by application of:

- ◇ Directional distribution factor of 0.55, and
- ◇ Lane Distribution factor of 0.60

Although traffic has been observed to be evenly distributed in either direction (refer Chapter-7), considering long design life, it is felt appropriate to consider a little skewed distribution of traffic. Lane distribution factor of 0.60 is adopted as suggested

by Indian Roads Congress guidelines, IRC: 37-2001 for 3-lane carriageway and found appropriate in view of centre seeking tendency of traffic.

Vehicle Damage Factor

The vehicle damage factor derived from the axle load survey analysis in Chapter 7- "Traffic Survey, Analysis and Forecast" and adopted for the pavement design is given in **Table 10.6**.

Table 10.6: Vehicle Damage Factor

Vehicle Category	VDF
Light Commercial Vehicle (LCV's)	0.14
Truck 2 - Axle	3.21
Truck 3 - Axle	7.94
Articulated	8.40

Computation of Design Traffic Loading

Based on the preceding discussions, the traffic loading in terms of cumulative number of equivalent 8.16 t standard axle loads have been computed for the period, 2012-2031 for the project road.

While working out the number of cumulative equivalent standard axles (ESA), the following assumptions have been made:

- ◇ Implementation of the project would be taken up in the year 2009 and that the upgraded road with 6-lane divided carriageway would be opened to traffic in the year 2012; and,
- ◇ One structural overlay would be provided after the tenth year.

The estimated traffic loading is calculated and details are given in Table 10.7 (a) to 10.7 (c). Equivalent Standards Axles for the traffic homogenous sections are shown in **Table 10.8**.

Table 10.8: Abstract of traffic loading

Description	Equivalent Standard Axles (ESA)	
	10 Years (2012-21)	20 Years (2012-31)
Poonamallee - Sunguvachatram (34.60 Km)	104.28	277.21
Sunguvachatram - Kanchipuram (26.40 Km)	120.68	320.81
Kanchipuram - Walajapet (32.00 Km)	103.33	274.69

10.4.1.3 Sub-grade Type and Characteristics

As per the test results, the sub-grade soil along the existing alignment is mostly Silty-sand-gravel (as per AASHTO class A2) with little or no plasticity. Soaked CBR on sub-grade samples is mainly more than 9%. Details of sub-grade characteristics are presented in Chapter-6: Engineering Surveys and Investigations. Summary of existing sub-grade strength is presented in **Table 10.9**.

Table 10.9: Sub-grade Characteristics

Table 10.3: Sub-grade Characteristics												
Total Samples	Liquid Limit		Plasticity Index			NP	CBR Soaked			CBR Un-soaked		
	>=35	<35	<10	10-20	>20		<9	9-11	>12	<10	10-12	>12
Test results of Sub-grade soil												
10	10	0	8	0	0	2	1	8	1	0	6	4

The test results (maximum CBR) show that there is sub-grade soil available along the corridor having more than 9% CBR value. Accordingly, the CBR value of 9 has been adopted for design.

There has been a general consensus in the profession about the use of resilient modulus as the parameter most suitable to represent the sub-grade soil characteristics. The resilient modulus is a measure of the elastic property of soil recognising certain non-linear characteristics. It is generally accepted as the material property which can be used in the mechanistic analysis of multi-layered systems for predicting roughness, cracking, rutting, faulting etc. (AASHTO, 1993).

For the project, the in-situ modulus of sub-grade soil has been worked out as 15000 psi using the expression proposed by Heukelom and Komp (1962) which is as given under:

$$\text{In-situ Resilient Modulus, } M_R = 1500 \times \text{CBR} = 10500 \text{ psi}$$

Since soaked CBR is taken, no reduction for relative damage due to rains has been considered.

10.4.2 Design of New Pavement

10.4.2.1 Design of Pavement Structure as per IRC: 37-2001

The pavement design chart given in IRC: 37-2001 is applicable for the traffic loading upto 150 msa. The projected cumulative design axle load along the project road is varying from 103.3 msa to 120.7 msa for 10 years design life and 274.7 msa to 320.8 msa for 20 years design life period.

Using the design chart/ Table extrapolated for the projected traffic loading for different road section, the total pavement thickness requirements for the design CBR value of 9% are as given below. The thickness evaluation is as per the chart given in IRC: 37-2001 (Fig: 1 & 2) is presented in **Table 10.10**.

Table 10.10: Pavement Thicknesses

Design Sub Grade CBR (%)	Cumulative Traffic (msa)	Thickness of Pavement Layers, mm				Equivalent Structural Number (SN)
		Wearing Course	Binder Course	Granular Base	Granular Sub-Base	
9	5	25 (SDBC)	50	250	150	3.25
9	10	40	50	250	200	3.74
9	30	40	95	250	200	4.41
9	50	40	115	250	200	4.71
9	100	50	135	250	200	5.18
9	150	50	155	250	200	5.48

Note: SN co-efficient of 0.120, 0.140, 0.380 and 0.425 is considered for granular sub base, base course and bituminous surfacing respectively.

10.4.2.2 Design of Pavement as per AASHTO (1993)

Design Considerations

The AASHTO design method requires the parameters to take into account the following aspects:

- ◇ pavement performance;
- ◇ traffic;
- ◇ sub-grade soil strength;
- ◇ materials for construction;
- ◇ environment;
- ◇ drainage; and,

◇ reliability.

The AASHTO (1993) relationship used for the design of flexible pavement is as under:

$$\log_{10}(W_{18}) = Z_R S_o + 9.36 \log_{10}(SN + 1) - 0.20 + \frac{\log_{10} \left[\frac{\Delta PSI}{4.2 - 1.5} \right]}{0.40 + \frac{1094}{(SN + 1)^{5.19}}} + 2.32 \log_{10}(M_R) - 8.07$$

where,

W_{18} is predicted number of 18000 pound equivalent single axle load application.

Z_R is standard normal deviate.

S_o is combined standard error of the traffic prediction and performance prediction.

ΔPSI is difference between the initial design serviceability index, p_o , and the design terminal serviceability index, p_t .

M_R is resilient modulus.

SN is structural number indicative of the total pavement thickness required:

$$= \sum a_i D_i m_i$$

where, a_i is i^{th} layer coefficient.

D_i is i^{th} layer thickness (inch).

m_i is i^{th} layer drainage coefficient.

The m_i values recommended by AASHTO (1993) are as in **Table 10.11**.

Table 10.11: Drainage Coefficient

Drainage Quality	m _i value / % of Time Pavement Structure is Exposed to Moisture Levels Approaching Saturation			
	< 1%	1-5%	5-25%	> 25%
Excellent	1.40-1.25	1.35-1.30	1.30-1.20	1.20
Good	1.35-1.25	1.25-1.15	1.15-1.10	1.00
Fair	1.25-1.15	1.15-1.05	1.00-0.80	0.80
Poor	1.15-1.05	1.05-0.80	0.80-0.60	0.60
Very Poor	1.05-0.95	0.95-0.75	0.75-0.40	0.40

For the present design, the value of m_i has been taken as 1.0 corresponding to drainage quality as "Good" with the pavement structure exposed to >25% of time exposed to moisture approaching saturation.

The M_R values of unbound granular materials have been estimated using the following relationship (AASHTO, 1993):

$$M_R = k_1 \theta k_2$$

where,

θ is the stress state. The values of " θ " within the base courses vary depending on the resilient modulus of soil and the asphalt layer thickness. The values used in the design are (AASHTO, 1993) presented in **Table 10.12**.

Table 10.12: Values of ' θ '

AC Thickness (inch)	Roadbed Soil Resilient Modulus, M_R (psi)		
	3000	7500	15000
< 2	20	25	30
2 - 4	10	15	20
4 - 6	5	10	15
> 6	5	5	5

k_1, k_2 are regression coefficients which are dependent of the material type used in the pavement courses. The suggested values of k_1 and k_2 are given in **Table 10.13**.

Table 10.13: Regression Coefficient

Moisture Condition	k_1 (Note 1)	k_2 (Note 1)
Base		
Dry	6000 - 10000	0.5 - 0.7
Damp	4000 - 6000	0.5 - 0.7
Wet	2000 - 4000	0.5 - 0.7
Sub-Base		
Dry	6000 - 8000	0.4 - 0.6
Damp	4000 - 6000	0.4 - 0.6
Wet	1500 - 4000	0.4 - 0.6

Note: (1) Range in k_1 and k_2 is a function of the material quality. For this important project, it is envisaged that high quality materials would be used and strict quality control of works would be imposed.

Based on the above considerations and also keeping in view the ISOHDM (1995) recommendations, the following values of layer coefficient for the different pavement materials have been adopted for pavement design: Pavement structural strength and layer strength coefficient derived from various agencies is presented in **Table 10.14**.

Table 10.14: Structural Strength & Coefficient

Pavement Material	a_i	M_R (psi)
Asphalt Concrete (AC)	0.425	400,000
Dense Bituminous Macadam (DBM)	0.380	300,000
Wet Mix Macadam (WMM)	0.140	30,000
Granular Sub base (GSB)	0.120	15,000

The values of Z_R and S_o have been assumed based on the following:

- ◇ The pavement is for a heavily trafficked rural highway, which has been designed for Service Level "B". The overall reliability level for the facility has, therefore, been assumed as 90 per cent. For a two-stage strategy i.e. initial pavement plus one overlay, the design reliability for each stage should be $0.90^{0.50}$ or 0.95 per cent.
- ◇ The value of the normal deviate, Z_R , corresponding to 95 per cent reliability has been taken as -1.645 (AASHTO, 1993)
- ◇ The overall standard deviation suitable for the design of flexible pavements range between 0.40 and 0.50. The overall standard deviation, S_o , has been taken as 0.40 on the assumption that the projection of the future traffic represents the most likely scenario.

The values of initial serviceability index, p_i , and terminal serviceability index, p_t , have been assumed as under:

- ◇ The p_i value of 4.5 has been adopted on the basis of the consideration that the implementation of the project would be done with strict adherence of quality control norms for materials and works.
- ◇ For this heavily trafficked important road, the value of the terminal serviceability index, p_t , i.e., the lowest acceptable level of serviceability before the resurfacing would be necessary has been taken as 2.5.

Road Bed Modulus

The selected borrow materials exhibit a CBR of 8-12% (Soaked) and 10-14% (Un-soaked). The existing soil sub-grade shows CBR values in the range of 8-12% (Soaked) and 10-14 (Un-soaked). For design purpose, CBR value of 9% (soaked) has been considered to be rational.

Road Bed Modulus, $M_R = 1500 \times 9 = 13500$ psi

Since soaked CBR is taken, no reduction for relative damage due to rains has been considered.

Design of Pavement

The thickness requirements for the pavement have been worked out based on the preceding discussions. The basic steps followed for the computation of the composition requirements are as under:

Calculation of W_{18} (axle load) for different SN Value

For different SN values, the Cumulative Standard Axles (W_{18}) have been calculated and given in **Table 10.15** (As per AASHTO).

Table 10.15: Structural Number and Axle Load

Design Parameters		Axle Loading W_{18}	Structural Number SN
Reliability	S_o		
-1.645	0.4	13.9	4.20
		16.3	4.30
		19.1	4.40
		22.4	4.50
		26.2	4.60
		30.5	4.70
		35.4	4.80
		41.1	4.90
		47.6	5.00
		55.0	5.10
		63.4	5.20
		73.0	5.30
		83.9	5.40
		96.3	5.50
		110.3	5.60
		126.2	5.70
		144.0	5.80
		164.2	5.90
		186.9	6.00
		212.4	6.10
		241.0	6.20
		273.1	6.30
		308.9	6.40
		349.0	6.50
		393.8	6.60

Note: W_{18} is cumulative number of equivalent standard axle.

10.4.3 Proposed Pavement Composition

Initial Pavement Composition - 6 Lane Divided Carriageway

As explained earlier, the bases and sub-bases have been designed for the full design life of 20-years, while the surfacing course has been designed for a design life of 10 years. A structural overlay is proposed to be provided after 10 years of service life.

The SN requirements for 20-year and 10-year periods for different links are compared in respect of both IRC and AASHTO of design as shown in **Table 10.16**.

Table 10.16: SN Requirement for Pavement (IRC: 37-2001 and AASHTO-1993)

Link ID	Description	Structural Number (required)			
		10 Years		20 Years	
		IRC 37	AASHTO	IRC 37	AASHTO
L41	Poonamalle-Sunguvachatram	5.18	5.55		
				6.00 *	6.30
L42	Sunguvachatram-Kanchipuram	5.33	5.67		
				6.30 *	6.43
L43	Kanchipuram - Walajapet	5.18	5.55		
				6.00 *	6.30

* Extrapolated value as the chart is limited to 150 msa in IRC: 37-2001

It may be observed that both the design method compares well in respect of SN requirement for new pavement with AASHTO method requiring additional SN of 0.13-0.37 over IRC design.

Therefore, the composition of initial pavement has been worked out on the basis of IRC: 37 - 2001 recommendations, while satisfying the requirements of AASHTO design. Thus, proposed composition initial pavement for various links is given in **Table 10.17**.

Table 10.17: Adopted Pavement Composition: 6 Lane Divided Carriageway

Component Layer	Material Type	Strength coefficient	Thickness of Pavement Layer, mm		Remarks
			L42	L41 & L43	
Surfacing Course	BC	0.425	50	50	For 10 years design life
	DBM	0.380	145	135	
Base Course	WMM	0.140	250	250	For 20 years design life
Sub base	GSB	0.120	200	200	
SN Provided			5.33	5.18	
Sub grade (500mm) CBR			> 9% soaked		

Note: BC= Bituminous Concrete, DBM= Dense Bituminous Macadam, WMM= Wet Mix Macadam, GSB= Granular Sub- base course

Structural Overlay Composition (after 10 years)

Based on present traffic estimates, structural overlay composition after 10 years of service life is worked out as:

- ❑ 50mm BC + 50 mm DBM for L41 and L43
- ❑ 50mm BC + 60 mm DBM for L42

However, it is suggested that a fresh structural evaluation of pavement may be taken up during 10th year of service life to assess remaining life of various pavement layers in order to derive appropriate strengthening requirements along with fresh traffic estimation for the future period.

Pavement Composition - 8 Lane Divided Carriageway for Link L41

If the Link L41 (km 13.8 to km 43.00) of the project road is improved as 8 lane divided carriageway of National Highway standards for the entire design life period, then the recommended pavement composition shall be as in **Table 10.18**.

Table 10.18: Adopted Pavement Composition: 8 Lane Divided Carriageway

Component Layer	Material Type	Strength coefficient	Thickness of Pavement Layer, mm	Remarks
			Section I	
Surfacing Course	BC	0.425	50	For 10 years design life
	DBM	0.380	125	
Base Course	WMM	0.140	250	For 20 years design life
Sub base	GSB	0.120	200	
SN Provided			5.03	
Sub grade (500mm) CBR			> 9% soaked	

Note: BC= Bituminous Concrete, DBM= Dense Bituminous Macadam, WMM= Wet Mix Macadam, GSB= Granular Sub- base course

10.4.4 Design of Overlays for Existing Carriageway

10.4.4.1 IRC: 81 –1997 Method

The design of overlays for the existing 2x2-lane/ 2x3-lane carriageway pavement has been done taking into account the strength of the existing pavement. The strength of the existing pavement has been determined using Benkelman Beam Deflection testing as per guidelines given in IRC: 81-1997.

The detailed analysis of Benkelman Beam deflection data has been given in Chapter-6, Engineering Survey and Investigations.

The sections of the existing road homogenous with respect to Benkelman strength have been identified. The overlay has been worked out for 10 years life i.e. from 2012-2021. The deflection value is ranging from 0.48mm to 0.93mm with an average value of 0.74mm.

Figure 9 of IRC: 81-1997 (enclosed Fig: 10.11) yields the following results based on msa and characteristic deflection (CD), as given in **Table 10.19**:

Table 10.19: Bituminous Overlay

Cumulative msa	Characteristic Deflection (mm)	Bituminous Overlay required (mm)	Equivalent SN
2012-2021			
L41: Poonamallee (km 13.80) – Sunguvachatram (km 48.40)			
104.28	0.68	90	0.87
L42: Sunguvachatram (km 48.40) – Kanchipuram (km 74.80)			
120.68	0.85	120	1.16
L43: Kanchipuram (km 74.80) – Walajapet (km 106.80)			
103.33	0.69	90	0.87

Before implementing the overlay, the existing surface shall be corrected and brought to proper profile by filling the cracks, potholes, ruts and undulations. No part of the overlay design thickness shall be used for correcting the surface irregularities.

10.4.4.2 Effective Thickness Method (AASHTO Method)

The determination of overlay thickness in this method is based on drop in structural number of the existing and new pavements.

The basic concept is that the required thickness (or SN) of the overlay is the difference between the thickness (or SN) required for a new pavement and the effective thickness (or SN) of the existing pavement. The procedure assumes that as the pavement deteriorates and uses part of its total life, it behaves as if it were an increasingly thinner or weaker pavement. The effective thickness (or SN) is based on the type, condition and thickness of each component layer.

The consultants have collected the pavement condition data and details of existing pavement structure. The details of these are given in Volume-2 Annexure (Data & Analysis). The existing pavement has been constructed in about 2 years back and there is no variation in pavement composition. Following layer coefficients for the existing pavement layer materials have been used to calculate the effective structural Number of the existing pavement:

Bituminous Concrete	0.30
Dense Bituminous Macadam	0.30
Wet Mix Macadam	0.14
Granular Sub-base	0.12

The Structural Number of proposed overlay (SN_{overlay}) for the pavement has been worked out as per the following formula.

$$SN_{\text{overlay}} = SN_{\text{reqd.}} - SN_{\text{eff}}$$

The Structural Number of the pavement required to carry the anticipated traffic loading of msa over the next 10 years for individual road link was calculated and presented in **Table 10.20**.

Table 10.20: Summary of SN required and SN overlay

SN effective	SN required	SN overlay
<i>L41: Poonamallee (km 13.80) – Sunguvachatram (km 48.40)</i>		
4.33	5.18	0.85
<i>L42: Sunguvachatram (km 48.40) – Kanchipuram (km 74.80)</i>		
4.33	5.33	1.00
<i>L43: Kanchipuram (km 74.80) – Walajapet (km 106.80)</i>		
4.33	5.18	0.85

Thus the existing pavement in various road sections is deficient by a Structural Number varying from 0.85 to 1.00, which should be provided by the overlay.

The proposed overlay composition of initial requirement is given in **Table 10.21**.

Table 10.21: Proposed Overlay Thickness and Composition

Component Layer	Material Type	Structural co-efficient	Thickness of Pavement Layers, mm		Remarks
			L41&L43	L42	
Surfacing Course	AC	0.425	50	50	For 10 years deign life
	DBM	0.38	-	50	
SN Provided			0.84	1.58	

Note: AC= Asphaltic Concrete, DBM= Dense Bituminous Macadam,

10.4.5 Shoulders

As per AASHTO, “a shoulder is the portion of the roadway contiguous with the travelled way for accommodation of stopped vehicles, for emergency use and for lateral support of sub-base, base and surface course. There should be continuous paved shoulder on both the right and the left side of all freeways facilities and the usable paved width of the shoulder should be between 10 ft to 12 ft”.

Keeping in view the constraint of available land width and to meet the requirement of IRC recommendations, for the project road, paved shoulder of 1.50 m width has been proposed with similar pavement composition as that of main carriageway on outer side of each carriageway. The shoulders would be useable during all seasons of the year. Besides this Earthen shoulder of width 1.00m has also been proposed on the outer side of paved shoulder on each carriageway.

Shoulder Composition

It is envisaged that the shoulders of the project road would serve as a parking bay for disabled vehicles and as a part of carriageway during any repair and maintenance works on the regular carriageway. Besides, strong shoulder is a pre-requisite to provide adequate lateral support to the edges of pavement to ensure satisfactory structural performance and improved capacity. Any joint on the edge of pavement due to difference in layer thickness and differences in composition between carriageway and shoulder may allow surface water to penetrate to the sub-grade, which would be detrimental to the structural strength of the carriageway pavement. In view of the above, paved shoulders on outer side of the carriageway have been proposed with similar layer composition as proposed for the main carriageway.

10.4.6 Service Roads

Service roads are proposed for the urban/ built-up areas for effective segregation of traffic and to enforce access control measures. Carriageway width of 3.5/5.5/7.0m is proposed with footpath of 1.50m widths depending on local traffic movement expected and availability of land. Variable separator having width of 0.60m/4.00m is proposed between Main carriageway and service road. Details of provision of service road provided are shown in **Table 10.22**.

Table 10.22: Slip/ Service Road Locations

Location		Carriageway Width (m)	Length (km)
From	To		
14.400	15.400	7.50	1.000
15.900	16.700	7.50	0.800
16.700	17.600	5.00	0.900
17.600	18.000	6.50	0.400
18.000	18.500	6.00 & 7.50	0.500

Location		Carriageway Width (m)	Length (km)
From	To		
18.500	20.500	7.50	2.000
20.500	21.400	7.50	0.900
21.400	22.230	7.50	0.830
22.230	22.400	7.50	0.170
23.000	23.550	5.00	0.550
24.000	24.850	7.50	0.850
25.680	26.380	7.50	0.700
28.300	29.100	7.50	0.800
29.720	30.250	6.00	0.530
31.250	31.90	7.50	0.700
32.580	33.600	6.00	1.020
33.600	34.450	7.50	0.850
37.000	37.600	6.00	0.600
38.750	39.400	7.50	0.650
40.850	41.000	7.50	0.150
41.000	42.750	4.50	1.750
45.300	46.155	7.50	0.855
47.960	48.760	7.50	0.800
49.900	50.640	7.50	0.740
55.100	56.050	6.00	0.950
57.150	57.800	6.00	0.650
60.150	60.850	7.50	0.700
65.200	66.000	7.50	0.800
68.100	68.900	7.50	0.800
69.730	70.630	7.50	0.900
71.570	72.140	7.50	0.570
72.200	72.700	7.50	0.500
76.370	77.270	7.50	0.900
80.380	81.180	7.50	0.800
87.100	87.900	7.50	0.800
92.600	93.800	7.50	1.200
97.900	98.700	7.50	0.800
103.870	104.700	7.50	0.830

Service Road Composition

It is proposed to provide service road along the proposed partially access controlled project road on both sides to accommodate the movement of the local traffic at selected road sections.

The proposed service road caters the traffic of urban/semi urban area and the estimated traffic is around 20% of the normal design traffic of the project road. The pavement composition has been adopted from IRC: 37-2001. The pavement composition of the existing service road comprises of 50mm BC, 65mm DBM, 250mm WMM and 200mm GSB. Moreover, at many stretches, the proposed service road is required to be widened and hence it is proposed to have same composition as existed. The pavement composition adopted for the construction of service road is presented in **Table 10.23**.

Table 10.23: Adopted Pavement Composition - Service Road

Type of Construction	Pavement Composition	
	Material Type	Thickness (mm)
New Construction	BC	50
	DBM	65
	WMM	250
	GSB	200
	Sub grade (500mm) CBR	9% soaked

However, the bituminous courses of BC and DBM have been reduced to 25mm and 50mm respectively as insisted.

10.5 Preliminary Designs for Bridges and Other Structures

General

The Improvement schemes for the bridges and other structures have been derived from the site specific project requirements and the same are discussed / detailed in Chapter-8. The following paragraphs shall deal with the structural schemes and design aspects of the structural components for the bridges, flyovers, underpasses etc.

Design Methodology and Standards for Structures

The design of new structures shall be based on the following materials and loadings-

Materials

Concrete Grade

Grade of concrete in various elements has been kept as follows for moderate conditions of exposure:

- All PSC members - M40
- All RCC members - M35 for RCC Girder/Slab Superstructures
 M30 for RCC Slab Superstructures and Approach Slabs
- M30/M35 for Substructures
- M30 for open foundations and M35 for pile foundations
- All PCC members - M25/M20

Reinforcement Steel

- Thermomechanically Treated (TMT) deformed bars shall be of grade Fe415
- Mild steel bars shall be of grade Fe240

Exposure Condition

- **Moderate exposure conditions** have been considered while designing various components of all the structures.

Concrete Clear Covers:

- For all reinforcement - As per Cl. 304.3 of IRC:21-2000

For pre-stress cable - As per clause 16 of IRC:18-2000 duct to outer most fibre of girder

Pre-stressing System

- a) System (Post tensioning) : 12T13/19K13 multipull strand system of "Freyssinet" or "ISMALCCL" or equivalent
- b) Cables (Post tensioning) : 12T13/19K13 cables with strands of 12.7mm nominal dia, area-1184.4 mm²/1875.3 mm², Ultimate strength – 224 MT/356 MT, Es = 1.95e07 T/m²
- c) High Tensile Strand :
 (for pre tensioning)
 Strands : Nominal 15.2mm dia 7 ply low relaxation strands conforming to class 2 of IS:14268-95
 Area : 140 sq.mm per strand (nominal cross sectional area)
 Ultimate load : 26.667 MT per strand
 Modulus of
 Elasticity : 1.95x10⁵MPa
- d) Sheathing (Post tensioning) : 75/90mm OD corrugated HDPE flexible sheathing for 12T13/19K13 cables respectively.
- e) Friction Coefficient (Post tensioning) 0.17/radian
- f) Wobble Coefficient (Post tensioning) 0.002/m
- g) Anchorage Slip (Post tensioning) 6mm average
- h) Loss of force due to
 relaxation : As per Clause 11.4 of IRC-18-2000.

For Post Tensioning Stressing shall be carried out simultaneously from both ends. All the strands of a cable shall be stressed in one go. Provisions for 4% emergency cables will be provided. If they are not utilised during construction, they will be pulled out and cable ducts will be grouted and plugged suitably. Access to the superstructure shall be provided to enable maintenance, inspection and future pre-stressing operations.

Structural Steel

Structural steel shall conform to IS:226 with Yield stress of 23.6 kg/mm²

Bearings

Reinforced elastomeric bearings have been proposed for short span simply supported superstructures. Elastomeric bearings shall be designed as per IRC:83 (Part II) and shall conform to Cl.2005 of MOST's Specifications for Road & Bridge Works (4th Revision).

RCC type solid slab superstructures of bridges have been proposed to rest directly on pier/abutment caps with a tar paper in between.

Pot fixed/Pot PTFE sliding bearings have been proposed for long span simply supported/continuous superstructures. These bearings shall be designed and supplied by the approved manufacturers. The loads and forces on the bearings shall be calculated to enable the manufacturer to design these bearings and these shall conform to Cl. 2006 of MOST's Specifications for Road & Bridge Works (4th Revision).

Expansion Joints

The following types of Expansion Joints shall be adopted:

- **Filler type expansion joints** have been proposed for minor bridges with solid slab superstructures having span lengths not exceeding 10 metres. These type of joints shall conform to Cl. 2605 of MOST's Specifications for Road & Bridge Works (4th Revision).

- **Single Strip seal expansion joints** has been proposed for superstructures having movements up to 80mm.(± 40 mm).

The strip seal type expansion joints shall conform to Cl. 2607 of MOST's Specifications for Road and Bridge works (4th Revision).

Miscellaneous

An asphaltic concrete wearing course has been proposed over the deck slab. It conforms Clause 2702.12 of MORTH Specifications (4th Revision).

Drainage spouts with gratings at the top shall be provided on the bridges to ensure proper drainage of surface water.

An approach slab 3.50m long and 300mm thick resting on the bracket taken out from the dirt wall shall be provided on both sides of the bridge resting on the 150mm thick leveling course. The gap between the approach slab and dirt wall shall be filled with bituminous joint filer sealing compound.

Weep holes shall be provided behind abutment and wing wall to avoid building up of hydrostatic pressure behind them. Weep holes shall be provided 150mm, above the low water level or bed level whichever is higher. In case of stone masonry weep holes of 150mm.diameter or 80X150mm. size in 1:20 slope shall be provided.

MoRTH Specifications

The specifications for Road and Bridge Works of Ministry of Road Transport & Highways published by Indian Road Congress shall be used for materials to be used for construction of bridges.

Loads and Load Combinations

Loads

Dead Loads

Following unit weights shall be assumed in the design as per IRC Codes.

Pre-stressed Concrete - 2.5 t/cu.m

Reinforced Concrete - 2.4 t/cu.m

Plain Cement Concrete - 2.2 t/cu.m

Structural steel - 7.85 t/cu.m

Dry Density of Soil - 1.80 t/cu.m

Saturated Density of Soil - 2.0 t/cu.m

Superimposed Dead Loads

Wearing Coat : 65mm thick asphaltic concrete with total weight of 0.2 t/sq.m
(including allowance for overlay)

Crash barriers : From design (i.e. 1.0 t/m per side)

Carriageway Live Load

Preliminary design of all the new cross drainage structures has been done for the following loading-

Live Loads : One/Two lanes/Three lanes of IRC Class A.

(Whichever produces worst effect) or One lane of IRC Class 70R (wheeled/tracked) + One lane of Class A.

The impact factor shall be as per Clause 211 of IRC: 6 for the relevant load combinations. For simplicity in design, the impact factor for continuous structures shall be calculated for the smallest span of each module and used for all the spans in that module.

Longitudinal Forces

The following effects have been considered for calculating the longitudinal forces in the design-

- Braking forces as per the provision of Cl. 214 of IRC:6.
- Frictional resistance offered to the movement of free bearings due to change of temperature.
- Distribution of longitudinal forces due to horizontal deformation of bearings/frictional resistance shall be carried out as per Cl. 214.5 of IRC:6 by assuming stiff supports.

Centrifugal Forces

Bridges on a horizontal curve have been designed for centrifugal forces based on the following equation-

$$C = W \cdot V^2 / 127R,$$

Where C = Centrifugal force acting normal to the traffic

W = Carriageway live load

V = Design speed of the vehicles using the bridge in km per hour

R = Radius of curvature in metres

The centrifugal force has been considered to act at 1.20m above the formation level of the bridge in the transverse direction. No impact value on carriageway live load has been considered for calculating the centrifugal force.

Water Current Forces

The effect of water current forces has been calculated in accordance with clause number 213 of IRC:6-2000 on sub-structure and foundations.

Earth Pressure

Horizontal forces due to earth pressure has been calculated as per the provision of Cl. 217 of IRC:6 assuming the following soil properties :

Type of soil assumed for backfilling : Gamma = 1.80 t/cu.m

Angle of Internal Friction : $\phi = 30^\circ$

Angle of Wall Friction : $\delta = 20^\circ$

Coefficient of Friction ' μ ' at base: $\tan (2/3 \phi)$, where ϕ is the angle of internal friction of substrata immediately under the foundation

Live load surcharge has been considered as equivalent to 1.2m height of earth fill in case of abutments and equivalent to 0.6m height of earth fill in case of return/wing walls.

Wind Forces

Structures have been checked for wind effects as stipulated as Cl. 212 of the IRC:6. The wind forces has been considered in the following two ways-

- (i) Full wind forces at right angles to the superstructure
- (ii) 65% of wind force as calculated in (i) above acting perpendicular to the superstructure and 35% acting in traffic direction.

Seismic Effect

The project road falls under seismic zone II. Horizontal seismic force has been calculated using the following formula-

$$F_{eq} = A_h X (\text{Dead Load} + \text{Appropriate Live Load})$$

Where, A_h = horizontal seismic coefficient = $(Z/2) X (S_a/g) / (R/I)$

Z = Zone factor and is equal to 0.24 for seismic zone IV

I = Important factor and is taken as 1.5 for important bridges

R = Response reduction factor and is equal to 2.5

S_a/g = Average response acceleration coefficient depending upon fundamental period of vibration T

T = Fundamental period of the bridge in seconds in horizontal vibrations

Temperature Range

The bridge structure/components i.e. bearings and expansion joints, has been designed for a temperature variation of $\pm 25^\circ\text{C}$ considering extreme climate.

The super-structures have been designed for effects of distribution of temperature across the deck depth as per stipulations of BD 37/88 suitably modified for the surfacing thickness.

Differential Shrinkage Effects

A minimum reinforcement of 0.2% of cross sectional area in the longitudinal direction of the cast-in-situ slab has been provided to cater for differential shrinkage stresses in superstructures with in-situ slab over pre-cast girders as per Cl 605.2 of IRC:22-1986.

Construction Stage Loadings

A uniformly distributed load of 3.6 KN/m² of the form area has been taken into account of construction stage loadings in the design of superstructure elements, wherever applicable, as per Cl. 4.2.2.2.2 of IRC:87-1984.

Buoyancy

100% buoyancy has been considered while checking stability of foundations. Pore pressure uplift limited to 15% shall be considered while checking stresses of the substructure elements.

In the design of abutments of river bridges, the effect of buoyancy has been considered assuming the fill behind abutments has been removed by scour.

Load Combination

All members have been designed to safely sustain the most critical combination of various loads and forces that can coexist. Various load combinations as relevant with increase in permissible stresses considered in the design are as per Cl. 202 of IRC:6 and Cl. 706 of IRC:78.

Codes to be Adopted for Design

Codes

Following codes have been used for the preliminary design of the cross drainage structures-

- | | | |
|-------|------------------------|--|
| i) | IRC: 5- 1998 | Standard Specifications & Code of Practice for Road bridges, Section I – General Features of Design (Seventh Revision) |
| ii) | IRC:6- 2000 | Standard Specifications and Code of Practice for Road bridges, Section I – General Features of Design (Fourth Revision) |
| iii) | IRC:7- 1971 | Recommended Practice for Numbering Bridges and Culverts (First Revision) |
| iv) | IRC: 18-2000 | Design Criteria for Prestressed Concrete Road bridges (Post-Tensioned Concrete) (Third Revision) |
| v) | IRC: 21-2000 | Standard Specifications and Code of Practice for Road Bridges, Section II – Cement Concrete (Plain and Reinforced) (Third Revision) |
| vi) | IRC: 22-1986 | Standard Specifications and Code of Practice for Road Bridges, Section VI – Composite Construction (First Revision) |
| vii) | IRC: 24-2001 | Standard Specifications and Code of Practice for Road Bridges, Section V – Steel Road Bridges (Second Revision) |
| viii) | IRC:45-1972 | Recommendations for Estimating the Resistance of Soil Below the Maximum Scour Level in the Design of Well |
| ix) | IRC: 54-1974 | Lateral and Vertical Clearances at Underpasses for Vehicular Traffic |
| x) | IRC: 78-2000 | Standard Specifications and Code of Practice for Road Bridges, Section VII – Foundations & Substructure (Second Revision) |
| xi) | IRC: 83-1999 (Part I) | Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearing, Part I: Metallic Bearing (First Revision) |
| xii) | IRC:83-2002 (Part III) | Standard Specifications and Code of Practice for Road bridges, Section IX – Bearings, Part III: POT, POT-CUM-PTFE, PIN and Metallic Guide Bearings |

- | | | |
|--------|------------------|--|
| xiii) | IRC:89-1997 | Guidelines for Design and Construction of River Training & Control Works for Road Bridges (First Revision) |
| xvi) | IRC: SP: 13-2004 | Guidelines for the Design of Small Bridges & Culverts (First Revision) |
| xvii) | IRC: SP: 18-1978 | Manual for Highway bridge Maintenance Inspection |
| xviii) | IRC: SP: 35-1990 | Guidelines for Inspection and Maintenance of Bridges |
| xix) | IRC: SP: 40-1993 | Guidelines on Techniques for strengthening and Rehabilitation of Bridges |
| xx) | IRC:SP: 47-1998 | Guidelines on Quality Systems for Road Bridges (Plain Reinforced, Pre-stressed and Composite Concrete) |

Based on the above material specifications/ load combinations and following the stipulations of the IRC/BIS code the structural components of the bridge and other structures have been designed. Following paragraphs give an outline of the designs and provisions.

Type of Super-Structure of Proposed Bridges / Flyovers / Elevated Roads

RCC Solid Slab, RCC T-beam girders for bridges and Pre-cast post tensioned / Pre-cast pre tensioned girders have been proposed for flyovers and elevated roads.

Type of Sub-Structure and Foundations for Proposed Bridges / Flyovers / Elevated Roads

Piers shall be avoided in the mid-stream where velocity of water is high.

Circular/wall type piers shall be used after considering the aesthetics and economy.

Solid wall type abutments shall be provided.

Open Foundations / Pile Foundations are proposed for the bridges. For Flyovers and Elevated Roads, Pile Foundations have been proposed.

Vehicular/Non-Vehicular Underpasses

RCC Boxes on ground have been proposed for vehicular/non vehicular underpasses. For vehicular underpasses single cellular boxes of internal clear dimensions of 10.5m x5.5m and for non-vehicular underpasses single cellular boxes of internal clear dimension of 4.0mx3.0m have been proposed.

Retaining Walls/ Wing Walls /RE Walls

In accordance with the site specific requirements state return walls have been proposed for the bridge approaches. For vehicular and non-vehicular underpasses, flyovers and elevated roads following options have been proposed:

- Reinforced Earth (RE) walls in the approaches with no Land Acquisitions
- No RE walls with minimum land acquisitions by providing retaining walls to confine the embankment slope keeping in view the acquirable right of way. RCC retaining walls have been proposed.

Principles of Preliminary Structural Designs

For the Superstructure girder bridges (RCC/PSC) loads and forces on the individual girders have been assessed through Grillage Analysis carried out using STAAD-PRO for possible load combinations. The girders then have been designed following the

guidelines of IRC either for RCC or PSC. For pre-stressed structures the girders have been checked for both Working stress and ultimate strength.

The substructures and foundations are also designed using dedicated soft wear packages for all the probable load combinations. For foundations the recommendations of the subsoil investigation in respect of the bearing capacity, settlements, pile capacities etc. have been duly considered in deriving the proposal for foundations including the founding levels.

For RCC box structures on ground the box cells have been analysed for various load combinations as a frame using STAAD PRO and designs have been carried out as per IRC guidelines using dedicated in-house soft ware packages.

Suitable protective works have been prescribed for the bridges and the same have been designed as per the guidelines of IRC with special emphasis given to the discharge, scourability etc.

Details of the Proposed Structures

The details of the bridges, pedestrian underpasses, vehicular underpasses, and flyovers roads have been given in the **Tables 10.24, Table 10.25, Table 10.26 and Table 10.27** respectively:

Table 10.24: Details of Major and Minor Bridges

The existing bridges are all 2x3-lane for main carriageway. No bridges are envisaged to be constructed new due to discontinuity of service road.

Table 10.25: Details of Proposed Pedestrian Underpasses/Cattle Crossings

Sl. No.	Underpass location	Clear Width (m)	Total Width (m)	Clear Height (m)	Structure Type	Retaining Structures
1	17.060	4.0	31.0	3.0	RCC single cellular box on ground	RE wall
2	23.270	4.0	31.0	3.0	RCC single cellular box on ground	RE wall
3	30.020	4.0	31.0	3.0	RCC single cellular box on ground	RE wall
4	32.880	4.0	31.0	3.0	RCC single cellular box on ground	RE wall
5	37.300	4.0	31.0	3.0	RCC single cellular box on ground	RE wall
6	39.080	4.0	31.0	3.0	RCC single cellular box on ground	RE wall
7	55.650	4.0	31.0	3.0	RCC single cellular box on ground	RE wall
8	57.486	4.0	31.0	3.0	RCC single cellular box on ground	RE wall
9	63.410	4.0	31.0	3.0	RCC single cellular box on ground	RE wall
10	69.330	4.0	31.0	3.0	RCC single cellular box on ground	RE wall
11	73.800	4.0	31.0	3.0	RCC single cellular box on ground	RE wall
12	78.446	4.0	31.0	3.0	RCC single cellular box on ground	RE wall
13	79.835	4.0	31.0	3.0	RCC single cellular box on ground	RE wall
14	83.446	4.0	31.0	3.0	RCC single cellular box on ground	RE wall
15	88.699	4.0	31.0	3.0	RCC single cellular box on ground	RE wall
16	91.498	4.0	31.0	3.0	RCC single cellular box on ground	RE wall
17	94.496	4.0	31.0	3.0	RCC single cellular box on ground	RE wall
18	96.746	4.0	31.0	3.0	RCC single cellular box on ground	RE wall
19	99.196	4.0	31.0	3.0	RCC single cellular box on ground	RE wall
20	100.666	4.0	31.0	3.0	RCC single cellular box on ground	RE wall

Sl. No.	Underpass location	Clear Width (m)	Total Width (m)	Clear Height (m)	Structure Type	Retaining Structures
21	102.951	4.0	31.0	3.0	RCC single cellular box on ground	RE wall
22	105.776	4.0	31.0	3.0	RCC single cellular box on ground	RE wall

Table 10.26: Details of Vehicular Underpasses

S. No.	Underpass Location	Clear Width (m)	Clear Height (m)	Total Width (m)	Structure Type		Retaining Structures
1	16.300	1x10.5	5.5	31.0	RCC Single Cellular Box on Ground	1.50m footpath provided on both sides	RE wall
2	20.970	1x10.5	5.5	31.0	RCC Single Cellular Box on Ground	1.50m footpath provided on both sides	RE wall
3	26.030	1x10.5	5.5	31.0	RCC Single Cellular Box on Ground	1.50m footpath provided on both sides	RE wall
4	28.715	1x10.5	5.5	31.0	RCC Single Cellular Box on Ground	1.50m footpath provided on both sides	RE wall
5	31.600	1x10.5	5.5	31.0	RCC Single Cellular Box on Ground	1.50m footpath provided on both sides	RE wall
6	42.150	1x10.5	5.5	31.0	RCC Single Cellular Box on Ground	1.50m footpath provided on both sides	RE wall
7	42.250	1x10.5	5.5	31.0	RCC Single Cellular Box on Ground	1.50m footpath provided on both sides	RE wall
8	50.270	1x10.5	5.5	31.0	RCC Single Cellular Box on Ground	1.50m footpath provided on both sides	RE wall
9	60.500	1x10.5	5.5	31.0	RCC Single Cellular Box on Ground	1.50m footpath provided on both sides	RE wall
10	65.590	1x10.5	5.5	31.0	RCC Single Cellular Box on Ground	1.50m footpath provided on both sides	RE wall
11	68.500	1x10.5	5.5	31.0	RCC Single Cellular Box on Ground	1.50m footpath provided on both sides	RE wall
12	80.776	1x10.5	5.5	31.0	RCC Single Cellular Box on Ground	1.50m footpath provided on both sides	RE wall

S. No.	Underpass Location	Clear Width (m)	Clear Height (m)	Total Width (m)	Structure Type		Retaining Structures
13	87.508	1x10.5	5.5	31.0	RCC Single Cellular Box on Ground	1.50m footpath provided on both sides	RE wall
14	98.386	1x10.5	5.5	31.0	RCC Single Cellular Box on Ground	1.50m footpath provided on both sides	RE wall
15	104.271	1x10.5	5.5	31.0	RCC Single Cellular Box on Ground	1.50m footpath provided on both sides	RE wall

Table 8.27: Details of Flyovers

S. No.	Chainage	Span Arrangement	Clear Height	Total Width	Superstructures	Sub-structures	Foundations	Retaining Structures
1	14.870	3x25.0	5.2	13.5+0.5(median gap)+13.5	Precast Post Tensioned Girders(5 girders)+ RCC Slab	Wall type RCC Piers / Abutments	RCC Bored Cast-cast-in-situ 1.2m dia piles	RE wall
2	18.070	2x 20.0+1x 45.0	5.2	13.5+0.5(median gap)+13.5	PSC Box Girder (main span) + PSC Girders (end spans)+ RCC Slab	Wall type RCC Piers / Abutments	RCC Bored Cast-cast-in-situ 1.2m dia piles	RE wall
3	24.400	2x 30.0+1x 40.0	5.2	13.5+0.5(median gap)+13.5	Precast Post Tensioned Girders(6 girders)+ RCC Slab	Wall type RCC Piers / Abutments	RCC Bored Cast-cast-in-situ 1.2m dia piles	RE wall
4	34.050	2x 30.0+1x 40.0	5.2	13.5+0.5(median gap)+13.5	Precast Post Tensioned Girders(6 girders)+ RCC Slab	Wall type RCC Piers / Abutments	RCC Bored Cast-cast-in-situ 1.2m dia piles	RE wall
5	41.335	2x 30.0+ 1x 40.0	5.2	13.5+0.5(median gap)+13.5	Precast Post Tensioned Girders(6 girders)+ RCC Slab	Wall type RCC Piers / Abutments	RCC Bored Cast-cast-in-situ 1.2m dia piles	RE wall
6	45.755	2x 30.0+ 1x 40.0	5.2	13.5+0.5(median gap)+13.5	Precast Post Tensioned Girders(5 girders)+ RCC Slab	Wall type RCC Piers / Abutments	RCC Bored Cast-cast-in-situ 1.2m dia piles	RE wall
7	48.360	3x25.0	5.2	13.5+0.5(median gap)+13.5	Precast Post Tensioned Girders(5 girders)+ RCC Slab	Wall type RCC Piers / Abutments	RCC Bored Cast-cast-in-situ 1.2m dia piles	RE wall

S. No.	Chainage	Span Arrangement	Clear Height	Total Width	Superstructures	Sub-structures	Foundations	Retaining Structures
8	70.178	2x 30.0+ 1x 40.0	5.2	13.5+0.5(media n gap)+13.5	Precast Post Tensioned Girders(5 girders)+ RCC Slab	Wall type RCC Piers / Abutments	RCC Bored Cast- cast-in-situ 1.2m dia piles	RE wall
9	76.820	2x 30.0+ 1x 40.0	5.2	13.5+0.5(medi an gap)+13.5	Precast Post Tensioned Girders(5 girders)+ RCC Slab	Wall type RCC Piers / Abutments	RCC Bored Cast- cast-in-situ 1.2m dia piles	RE wall
10	93.063	3x25.0	5.2	13.5+0.5(medi an gap)+13.5	Precast Post Tensioned Girders(5 girders)+ RCC Slab	Wall type RCC Piers / Abutments	RCC Bored Cast- cast-in-situ 1.2m dia piles	RE wall

10.6 Improvement proposal for Culverts

There are 235 culverts consisting of 144 RCC pipe, 91 slab culverts. Existing Culverts are generally adequate. Detailed inventory and Condition survey is presented in Volume-II: Annexure.

Existing road is 2x2-lane, which has to be widened to 2x3-lanes carriageway configuration. The existing are in good conditions and as few of them would require minor repairs. However, the culverts, which are falling on the approaches of flyovers / underpasses, will need to be reconstructed.

Typical Pipe culvert and Slab culvert scheme is given in **Fig 10.12 to 10.17**. The list of culvert proposed to be widened is given in **Table 10.28**:

Table 10.28: Summary of Culverts

S. N.	Pipe Culvert			Slab Culvert						Total
	1 x 900 mm dia	2 x 900 mm dia	4 x 900 mm dia	1 m Span	2 m Span	3 m Span	4 m Span	5 m Span	6 m Span	
1	118	25	1	12	22	35	13	5	4	235

10.7 Traffic Control and Safety Measures

10.7.1 General

The existing two-lane road is proposed for improvement to 2x3-lane/2x4-lane carriageway system in order to provide a high-speed facility to the existing 2x2-lane national highway corridor. It is being designed, duly considering the following basic 4-laning dual carriageway parameters:

- ◇ High operating speeds of traffic
- ◇ Partially access control
- ◇ Highest standards of safety
- ◇ Highest maintenance standards and
- ◇ Systematised toll collection

The geometric characteristics of roads affect the risk and severity of the accidents. Accordingly, the project road is designed in such a way that sudden elements of surprise are avoided and that information acquisition and decision-making are facilitated. This has been achieved by providing sufficient road width, engineered alignment, access control and grade separated road crossings. The project road is proposed for extended facilities such as clearly visible delineation and road markings, traffic signs, crash barrier and right of way fencing.

10.7.2 Cross-section

The width of roadway affects the drivers' abilities to manoeuvre and to overcome potentially hazardous situation. Narrow lanes and carriageway imply restricted clearances for manoeuvring during overtaking operations. It is therefore, reasonable to deduce that increased lane; shoulder and total roadway width will reduce accidents. The project road has been provided with dual carriageway separated by wider medians to ensure segregation of directional traffic and headlight glare during night driving besides obvious risk of head-on collision from the vehicles from the opposite direction plying on the other carriageway.

10.7.3 Width of carriageway

Studies conducted on relationships between the width of carriageway/lanes and safety show that accident rates decrease with an increase in carriageway width. In fact, steep fall in accident rates is observed with increase of carriageway width from 4 m to 7 m and more. The project road has been proposed with 10.50m carriageway with 1.5m paved shoulder and 0.25m edge strips on either side separated by a 4.5/1.5m wide median. The dual carriageway would ensure unidirectional flow and further reduce the accident potential on the project road.

10.7.4 Cross Slope and Lateral Unevenness

Flat cross slopes on horizontal road section would cause accumulation of water on the road surface during heavy rains and could thereby contribute to hydroplaning accidents. The project road proposed pavement would have very high quality bituminous surfacing (Bituminous concrete) that ensures necessary friction for vehicular movements. Pavement surface would have minimum camber of 2.50% for efficient drainage of surface water and ensure safe traffic flow.

10.7.5 Alignment

Studies conducted on the relationship between horizontal alignment and accidents show that accident rate increase with reduction in curve radii and it is more so in case of sudden appearance of sharp bend after long straight sections. However, long straight sections are also prone to cause accidents out of monotony. The accidents on such alignment are caused mainly due to overtaking on curves, skidding, hazardous objects on bends, etc.

Similarly, steep grades result in higher accident rates especially for heavy vehicles on steep downgrades compared to near horizontal roads. The gradient for the project road alignment has been designed to have less than 3.0% in general. However, both the vertical gradient & horizontal curvature have been co-ordinated in design so that the driver can have better perception of the alignment.

10.7.6 Sight Distances

Inadequate sight distance reduces the driver's perception to prepare himself for, necessary manoeuvres. It is therefore, very plausible that increased sight distances would reduce accidents, unless it results in higher speeds.

Such factors have duly been considered while formulating design standards for the project road. Headlight sight distance on the valley curves has also been taken into account in alignment design for safe driving during night travel.

10.7.7 Roadside Features

The characteristics of the roadsides features affect the ability to regain control of vehicles, which have run off the roadway and the severity accidents off the roadway. It is therefore, very possible that flat side slopes and wide clear zones, free from hard objects would reduce the number of related accidents and their severity.

The rate of such accidents are influenced by

- ◇ Roadway width, and
- ◇ Roadside design

Roadway Width

It is observed that running off accidents decreases quite considerably with increase in roadway width. Studies indicate that an increase in roadway width

from 7m to 13m can cause a reduction of accidents as much as 50%. An adequate roadway width of 29.80m / 33.0m have been proposed for the project road in plain and rolling terrain respectively, which would enhance undoubtedly safety of operations.

Roadside Design

The roadside design would include side slopes in embankment, surface water drains, ditches etc. It is obvious that flatter embankment cross slopes would reduce chances & severity of run off accidents. Approximately, a distance of 6m appears to be considerably safer proposition in this regard.

The cross slopes for embankment has been proposed for the project road as 2(horizontal):1(vertical) or flatter depending on the height of embankment based on earth or rock category. Side drains would be generally quite away from the roadway and proposed after the Toe of Embankment.

In addition, there are many different types of roadside objects, which could be hit by moving vehicles. The most frequent collision objects are: trees, poles (electricity, telephone) and guardrails. The severity of the collisions depends on crash characteristics of the objects and the distance between the road and the object. Research findings indicate that a clear distance of 7-11 m would be safe for outgoing vehicles at different angles.

The roadway for the project road would be clear of such roadside objects and the entry/exits being controlled, precautionary measures has been taken up at such locations by providing channelization, acceleration lanes/ deceleration lanes, weaving sections etc.

10.7.8 Crash Barrier

In addition to the adequate provisions of roadway width and roadside design, crash barrier/guard rails have been proposed to be installed all along the roadway edge on either side

10.7.9 Road Signs and Markings

Adequate road signs and markings have been proposed for the proposed project road in order to provide advance information to regulate/control traffic flow and ensure safety of operations. The criteria and other details have already been discussed in preceding paragraphs.

10.9.10 Rest Areas

Rest areas are proposed for the convenience and to ensure certain essential facilities to the project road user. These are provided for the motorist to stop and rest for short periods. It is general practice to provide minimum of one rest area at every 50km of travelling distance. The length of proposed project road is around 93km; hence rest area has been proposed at Km 38.000 and Km 104.000 which will be finalised in consultation with Client NHA and local bodies.

These rest areas would provide for adequate recreation facilities, fuel refilling station, service station, restaurant, first aid medical assistance, telephone and other public amenities. Further emergency accident relief and vehicle breakdown facilities are also to be planned. The location, detailed layout along with provision of various facilities shall be worked out at the detailed engineering stage.

Chapter - 11

Environmental Impact and Assessment

CHAPTER – 11

Environmental Impact Assessment

11.1 General

The Environmental Examination for the proposed project has been undertaken as a parallel exercise with the Engineering Analysis, so as to bring out the environmental concerns in planning and the proposed design. The basic aim of the present study is to assess the magnitude of actual and potential environmental concerns due to conversion of the existing 4 lane National Highways into 6-lane. This is also to ensure that the environmental considerations are given due weightage, in the design of proposed highway improvements being studied. Basic idea is to minimize adverse environmental and social impacts with best possible engineering solutions at the optimal cost to make development environmentally sound and sustainable.

Environmental Screening of the study area has the following major objectives:

- To classify the type of environmental assessment required,
- To delineate the major environmental issues and identify the potential hotspots, which requires further study i.e. scope for EA,
- To recognize the potential environmental concerns,
- To determine the magnitude of potential impacts and ensure that environmental considerations are given due weightage while selecting and designing proposed highway improvements,

11.2 Defining Boundaries for Environmental Assessment

The project consists of Consultancy Services for feasibility study of retrofitting from its existing situation i.e. a 4 lane highway of about 92 km in length to a 6-lane highway of NH-4 section from Poonamallee to Walajapet in the State of Tamil Nadu.

The total length of the existing road under consideration is 92 km, which starts from Poonamallee and traverses through towns/built up area of Varadrajpuram, Sriperumbudur, Baluchetti Chatram and Walajapet. The project road passes through two districts i.e. Kanchipuram, and Vellore of Tamil Nadu State. The area of **direct influence** will be confined in a linear fashion along the corridor where the construction activities take place. The road is proposed to be retrofitted into six-lane for which ROW, supposedly, is available and only at places a ROW of 5 meters may be required for acquisition. Therefore, the area of direct influence of 10 meters on either side has been considered.

However, for various other Environmental Components, which are likely to have a broader area of influence, a distance of 10 Km. on either side of the road (as per the MOEF Notification of Environmental Impact assessment, Government of India, 2006) has been used to define the **indirect area of Influence**. Thus, the term project influence area referred in this chapter therefore, covers both direct and indirect area of influence.

The Environmental feasibility Report is based on field surveys and investigations made during site visit, and include information depicting the existing environment characteristics as well as an assessment of potential impact on the physical and natural environment of the area.

11.3 Inventory of Environmental Features

11.3.1 Secondary Data

Secondary information on various environmental components such as physiography, soil, geology, drainage, forest, ambient air quality, land-use, demography etc. have been collected from old reports & various published sources to examine the baseline status of the environmental features in the project influence area.

11.3.2 Local Concerns

In addition to the secondary data collected and the inventory information obtained, discussions with the stakeholders including the local people and government officials have been held so as to provide a realistic assessment of any significant/specific socio-environmental concerns due to proposed project. These discussions helped in incorporating the views of the stakeholders.

11.4 Preliminary Environmental Assessment

11.4.1 Baseline Environmental Setup¹

The baseline environmental status of the project influence area is based on the field survey within proposed ROW and within the Col, i.e., a radius of 10 km from the centreline of the road by environmental team, as well as data collected from various secondary sources. It will help in assessing the magnitude of potential impacts both beneficial as well as adverse due to the proposed project activities on the environment.

Physical Resources

Topography

The configuration of the project area is more or less plain crisscrossed by network of water channels/irrigation canal.

Situation

This section of project road passes through districts of Kanchipuram and Vellore in the State of Tamil Nadu. The highway generally traverses through the agricultural zones, except at km 18-21, 21-25, 72-73, 74-75, 81-83, where it comes close to Reserve forest. The existing four lane development itself is not witnessing designed traffic growths owing to the project highway, as per discussions with stakeholders and the Engineering team, lying in agricultural hinterland with no major commercial activity beyond the agricultural. This results in good environmental condition with air, water & noise levels lying generally within limits. But, the situation may change with time necessitating regular monitoring of the environmental parameters along the highway and especially the towns by NHAI/Concessionaire, so that mitigation measures could be enforced in the event of air, water, noise levels cross permissible levels.

There are schools, colleges, substations and religious shrines along the, ROW, entire stretch of NH-4 section.

¹ Source: Baseline Environmental status, - EIA for upgrading NH-4 in Tamilnadu State; Package I & II, Field Survey



Electricity Power Distribution station along the existing Highway (NH-4)

Geology, Soils

The vast stretch of the area is represented by Archaean. The major geological formation in the area is presented in **Table 11.1**:

Table 11.1: Geology

Formation	Age
Alluvium soils,	Recent
Conjeevaram Gravels	Mioplocene
Upper Gondwana super group (clays, shales, and sand stones)	Mid Triassic to Lower Cretaceous
Dharwar super group(Quartzite)	Lower Precambrian
Charnockite, Pyroxene-granulite and norite Magnetite-quartzite, crystalline Lime Stone, Quartzite, Unclassified Gneisses(Peninsular Gneiss, Biotite Gneiss) Hornblende-granite gneiss, Pink gneiss and Composite gneiss gornetiferous biotite gneiss	Archeans

Soils

The soil in the stretch is mainly red soil with texture sandy, Laterite soils and alluvial soil. The red soils are mostly derived from granite gneisses and crystalline schists. The red colour is due to wide diffusion rather than high proportion of Iron content. The soils are well drained. The soils in general are fertile.

Climate

Rainfall – The climate of the study area is sub-tropical humid with annual precipitation ranging from 800 - 1200 mm. The rainfall in the area is brought in two spells i.e. mainly by North- East monsoon (October to December) and very light occasional thunder showers during South-West monsoon (March-June)

Temperature – The temperature of the region varies between 43° C to 18 ° C. It is very warm in May & June with a mean maximum temperature touching to 39 ° C.

Humidity

The climate in the region is generally sub-humid. The humidity is slightly less than the adjacent coastal areas. The relative humidity ranges, generally, at 85 in December and 55 in the month of February.

Wind Speed

Winds are light to moderates in speed.

Land Use Pattern

Endowed with a rich variety of soils the two districts occupy an important place in States agriculture, which is the most important occupation. The major agricultural produce is banana, turmeric, carrot, paddy, black gram, green gram, groundnut, jowar, bajra, maize, ragi and maize. The main cash crops are sugarcane, chillies, cotton, coconut, tobacco etc.

Water Resources

The entire stretch along the project Highway is well drained with water channels. Apart from these, many small ponds and lakes also exist within 10 Kms corridor from the road. The ground water table varies from 3 m to 15 m in the project area. Wells and handpumps are the main sources of the drinking water whereas water from irrigation canals/water channels is used for agricultural purpose.

Water Quality

Water quality along the road is good as reported by the local communities. There are no major pollution sources in the area. However, the water sources, where construction activity is proposed, should be monitored after the detail designing is done, during construction and operation, to contain/mitigate any probable pollution.

Air Quality

Ambient air quality of the area lies within permissible limits except SPM as per the discussion with the State Pollution Control Board personnel's owing to the highway passing through agricultural hinterland and the traffic volumes being lesser than the designed. The concessionaire should monitor the air quality in consultation with the, Regional office of the State Pollution Control Board, so that appropriate mitigation measures may be adopted if the air quality exceeds the permissible limits of CPCB (**Table 11.2**) ,to minimize the adverse effects on the environment.

Table 11.2: National Ambient Air Quality Standards

<i>Pollutant</i>	Time weighte d Average	Sensitive Area	Industri al Area	Residenti al, Rural & Other Areas	Method of Measurem ent
Sulphur Dioxide SO ₂	Annual *	15 µg/m ³	80 µg/m ³	60 µg/m ³	Improved West and Gaeke Method
	24 hours**	30 µg/m ³	120 µg/m ³	80 µg/m ³	Ultraviolet Fluorescenc e
Oixde of Nitrogen as NO ₂	Annual *	15 µg/m ³	80 µg/m ³	60 µg/m ³	Jacob & Hochheiser Modified (Na- Arsenite) method
	24 hours**	30 µg/m ³	120 µg/m ³	80 µg/m ³	Gas phase Chemilumin escence
Suspended participate Matter (SPM)	Annual *	70 µg/m ³	360 µg/m ³	140 µg/m ³	High Volume Sampling
	24 hours**	100 µg/m ³	500 µg/m ³	200 µg/m ³	(Average flow rate not less than 1.1 m ³ / minute)
Respirable Particulate Matter (RPM) size less than 10 µm	Annual *	50 µg/m ³	120 µg/m ³	60 µg/m ³	Respirable particulate
	24 hours**	75 µg/m ³	150 µg/m ³	100 µg/m ³	Matter sampler
Lead (Pb)	Annual *	0.50 µg/m ³	1.0 µg/m ³	0.75 µg/m ³	AAS Method after sampling using
	24 hours**	0.75 µg/m ³	1.5 µg/m ³	1.00 µg/m ³	EPM 2000 or equivalent filter paper
Carbon Monoxide (CO)	8 hours**	1.0 mg/m ³	5.0 mg/m ³	2.0 mg/m ³	Non- dispersive infrared
	1 hour	2.0 mg/m ³	10.0 mg/m ³	4.0 mg/m ³	Spectrosc opy

* Average of annual sampling ** 8 hour monitoring results

Source: CPCB guidelines

Noise Level

Since the traffic volume on the project road is not much and the highway is generally passing through open and agricultural fields, noise is not a major problem at present. But, it may be an irritant in city areas, in future, with the growth in traffic. Noise level monitoring should be carried out, by the concessionaire during construction and operation, in city/built up areas so that proper mitigation could be developed as and when the noise level exceeds the standards.

Industries

The sections of NH-4 passes, primarily, through agricultural area but there are also some medium and small size industries..

Thermal Power Plant at Chennai is situated close to the project area.

Mines and Quarries

The project study area has identified locations of lime stone, Bauxite, Magnesite and Lignite.

11.4.2 Ecological Resources

Trees /Vegetation within corridor of impact

The road alignment passes primarily through agricultural fields. Number of trees / plants of various species planted along the avenue and median exist within and outside the ROW. The **Photo** shows the typical plantation along the project road.



Wildlife

The project highway does not pass through any ecologically sensitive area.

Social Forestry

The avenue and median plantations have been done under social forestry scheme along the highway at various locations. Divisional Forest Office Kanchipuram and Vellore have the responsibility of maintenance of this plantation.

11.4.3 People's Perception on Project

Major perception on environmental issues rose during the discussions with local peoples and stakeholders are summarized as follows:

- Protection of water bodies, which are very close to the project road,
- Minimum loss to the properties,
- Minimum loss to agricultural land
- Protection of trees and plants which are beyond the formation width, but very close to the project road,
- Protection of cultural properties, archaeological sites,
- Provision of Road safety
- The rainfall in the area is brought in two spells i.e. mainly by North- East monsoon (October to December) and very light occasional thunder showers during South-West monsoon (March-June)

11.4.4 The Critical Issues

The critical issues in the study area and the main findings of the initial environmental survey are summarized herewith. These issues are detailed out in this report.

- The project area generally has a flat plain terrain.
- The climate of the study area is tropical subhumid with annual precipitation ranging from 800 - 1200 mm. The rainfall in the area is brought by two spells i.e. mainly North- East monsoon (October to December) and very light South-West monsoon (March-June)
- The major land use pattern along the project road is agricultural, interspersed with small and medium size industries.
- The quality of environmental parameters i.e. Air Quality, Water Quality and Noise levels is good.
- The noise level is expected to be high at town junctions during peak traffic.
- North Chennai Thermal Power Plant is situated in the vicinity of project area.
- Number of saplings which have been planted on the avenue of various species exists, which are likely to be impacted due to proposed expansion of the project highway. The proposed development will result in removal of some of these saplings/plants.
- Town areas along the highway e.g. Sriperumbadur at Km. 17/18, from Poonamallee, a national monument, poses a practical challenge for improvement of Geometrics and fitting in the extra lanes.
- There are a number of religious structures, falling within the corridor of impact.
- The project road passes through many towns/built up areas viz. Varadrajpuram, Sriperumbedur, Baluchetti Chatram and Walajapet raising safety concern



Existing situation in towns along NH-4

11.4.5 Potential Impacts

The main environmental impacts have been analyzed covering Environmental Resources, Human Use Values and Ecological Resources. A brief description of these impacts is given herewith.

Impact on Water Environment

River Cooum and a network of water channels/irrigation canals and a few ponds exist along the project road. Construction activities may lead to degradation of water quality in terms of increased suspended solids as well as oil / grease concentration. However, during operation the overall impact on water resources will be positive except oil and grease content. Adequate precautionary / mitigation measures will be exercised to control these effects during construction and operation

Impact on Land Environment

Alteration of Agricultural land to non-agricultural land is a major impact on land, as some land needs to be acquired for the proposed project.

Impact on Air Environment

Adverse impacts on air quality due to the movement of construction machinery as well as haulage of construction material, site clearance, earth filling etc in construction stage.

Impact on Noise Environment

Movement of construction vehicles, operation of construction machinery and congestion due to construction activities result in increase in increased noise level in the project area. However during operation phase, smooth traffic flow will minimize the noise level.

Impact of Human Use Values

There are numbers of Temples, and a large number of shrines within the corridor of impact and the widening activity will result in the negative impacts in terms of religious sentiments.



Temple near the ROW along the existing Highway

Impact on Ecological Resources

Due to the proposed retrofitting of additional lane and service road, some of the recently planted trees within the corridor of impact are likely to be affected, which will result in ecological degradation. However, transplanting, of the younger plants, and compensatory afforestation will compensate these losses.

11.4.6 Mitigation Measures

On the basis of information collected during Environment Feasibility Survey, the following mitigation measures as given in the **Table 11.3** have been proposed.

Table 11.3: Impact Potential Evaluation

Environmental Parameters	Mitigation Measures	Locations
Air and Noise Quality – Improvements	(i) By improving intersections; (ii) By removing traffic bottlenecks; (iii) By maintaining a steady stream flow of traffic and by segregating slow and fast moving traffic. (ii) Noise barriers, if a section regularly, has parameters above permissible levels and plantation at sensitive areas	At all towns e.g. Poonamallee, Baluchetti Chatram & Walajapet Various town areas/Educational institutions/Hospitals falling on the project highway
Drainage and Run off of Water	(i). Provision of adequate size and number of cross-drainage structures to ensure efficient cross-	All along the project road

Environmental Parameters	Mitigation Measures	Locations
	drainage	
Contamination of water quality	(i) Construction work near water bodies will be avoided especially during monsoon periods (ii) All waste arising due to project activities will be disposed off, as per State Pollution Control Board norms	At all water bodies
Loss of Trees	(i) Through proper design to minimize cutting of trees. (ii) Compensatory Afforestation @ rate decided by the forest department of the trees which are going to be cut.	Trees which are going to be felled.
Road Safety – Improvement	(i) Design improvement at crossings and where traffic is mixing (ii) Segregation of slow traffic in congested areas by providing service roads (iii) Provision of proper signage & proper lighting arrangement to avoid accidents. (iv) Traffic management plans will be prepared for congested locations	At congested locations.

11.4.7 Recommendations

On the basis of the field study conducted and data analysis from environmental point of view, following points should be considered while finalizing the alignment / engineering design.

- There does not seem to be any major environmental issue along NH-4
- The traffic volumes are not high apparently bringing environmental parameters like air and noise within permissible limits. But, with the proposed development it may become a cause of concern in future. Thus, it is recommended that these parameters be monitored during construction and operation so that a suitable mitigation be designed, if they rise beyond permissible limits especially in towns.
- The traffic junctions, along the highway, itself are having free access and is cause of concern for the current traffic. Thus it is recommended to have suitable designs to improve safety.

- The existing highway is passing through cities and towns with undersigned intersections creating a hazardous situation in present low volume of traffic. Even in town/ villages/countryside there is a tendency to move in wrong lane which necessitates controlled access and designed intersections for smooth and unhindered traffic movement.
- There are number of shrines along the highway which pose a problem for the proposed expansion. This makes it pertinent to take up the project in phases removing such bottlenecks, while the work is carried out on easier sections.

11.4.8 Clearance Requirements

- The project can be undertaken, as per the Environmental Notification of 14th September 2006 ,after taking Prior Environmental Clearance from the concerned regulatory authority, in the Ministry of Environment and Forests for matters falling under Category 'A' in the Schedule and at State level the State Environment Impact Assessment Authority (SEIAA) for matters falling under Category 'B' in the Schedule, before any construction work, or preparation of land by the project management except for securing the land, is started on the project or activity.
- The existence of Chennai Thermal power Plant requires that use of fly ash in construction in the radius of 100 Km (from the thermal power plant)
- The proposed development along the existing highway with avenue plantation, all along, warrants obtaining a clearance as per Tamil Nadu (Protection of Trees and Timbers in Public Premises) Rules.
- The NOC/ Certificate to erect & operate for siting labour camps, construction machinery will be required from the State/Central Pollution Control Board.

Chapter - 12

Social Impact Assessment

CHAPTER – 12

Social Impact Assessment

12.1 General

Road projects are normally undertaken with a view to promote accessibility to transport movements so that trade, business, local economy and other social activities can be enhanced. With rapid increase of population, growth of industries and vehicular movements the need of new and new roads are also emerging, widening of the existing roads are becoming unavoidable requirements with a view to minimize accidents, provide better and smooth vehicular accessibility and for better connectivity so far it is practicable. This is the basic reason that two lanes are now attempted to widen to four lanes and four lanes to six lanes, it is demand of the rapid growth of urbanization

12.2 Description of the Project

The proposed road stretch comes under Tamil Nadu State covering a distance of 93 km. It is a National Highway No.4 and part of the Golden Quadrilateral Corridor. Though, it is already a 4-lane highway, but considering day to day increasing needs of the transport and increasing traffic congestion, the proposed 6-lanning of the road is justified. Some of the clusters of the said road project are highly accident prone, particularly where the business communities are carrying out their business. The details have been already discussed in the Public Consultation. Most of them are not in favour of 6-lane but of a flyover as an alternative will be acceptable to them. But, considering higher public interests and to speed up the traffic movement without any accidents the 6-lanning of the road seems to be a practical requirement.

The key benefits envisaged out of this road project mainly comprise of improved connectivity and accessibility of the people.

12.2 Social Impact Assessment

The social impact assessment and resettlement planning has following aspects:

- Census and base line Socio-economic survey of the potentially affected structures/households
- Public consultation at various places, particularly market places, temples, churches and other C. P. Rs
- Minimize accidents, access to better connectivity and smooth vehicular movement.

The survey as well as public consultations were organized with a view to finding out:

- The negative impacts on the persons affected by the project would be avoided or minimized.
- Affected persons and the beneficiary population/ communities will be informed and consulted about the project and its design where the negative impacts are unavoidable.
- People's participation will be undertaken in planning and implementation of the project.
- All information related to resettlement plan and implementation will be disclosed to the project affected persons/ communities. Base line data was collected within a strip of 30 m to either sides in rural areas and 30 m to either side in urban areas to get information about the proposed corridor of impact.

12.3 Land Acquisition and Project Impact

The impacts of the present project includes loss of structures (residential and commercial, residential-cum-commercial), C. P. Rs and community places. The details of the losses have been incorporated. A resettlement plan will be now required to arrive at compensation and replacement costs as described in NHA Entitlement Matrix. RP (Resettlement Plan) will be based on Socio-economic assessment of the potentially affected structures (both commercial and residential), land and livelihoods due to widening of the existing road namely NH-4 from Poonamallee to Walajapet (Km 13.80 to Km 106.80).

12.4 R & R Principles and Assistance

In accordance with the resettlement and rehabilitation (R&R) policy of the project, all affected households/ SBEs will be entitled to a combination of compensation measures and resettlement assistance, depending on the nature of ownership rights of lost assets and scope of the impact, including social and economic vulnerability of the affected persons. In general terms, the affected persons in the project will be entitled to four types of compensation and assistance: (i) compensation for loss of land, crops/trees; (ii) compensation for structures (residential/commercial) and other immovable assets; (iii) assistance for loss of business/wage income; and (iv) re-building and/or restoration of community resources/facilities. Revenue verification may ascertain the status of the occupants. The project may have adverse impacts on 929 structures of various categories.

12.5 Methodology Adopted

Following tools have been adopted to find out the ground reality. The techniques which have been administered are-Census survey of the total road stretch (km 13.80 to km 106.80). Besides, public consultations at the important road junctures and business centres have been conducted, interviews of the people were taken, meeting with the religious heads and the Panchayat committee members (where applicable) were organized. The outcomes of the same have been incorporated.

12.6 Findings from Census Survey

The project may have adverse impacts on 1380 structures of various categories. A census survey conducted in April-June, 2008 revealed that the resettlement impacts in this project area are 'significant'. The project is likely to entail adverse impacts on 1380 structures comprising 2041 families. Further, a huge numbers of local people will also be affected as many of the structures are of commercial nature and service providers.

12.7 Findings of Public Consultations

Detailed public consultations were organized with the people who are either carrying out business on the ROW /proposed ROW or, have constructed residential houses, Temples or church which will be affected for proposed 6-lanning of NH-4. Different views of the people have been collected, which are incorporated below. Besides, interview has been taken with the church authority and local Panchayat officials, whose land will be adversely affected. Both, positive and negative views have been observed.

12.8 Scope of Land Acquisition and Project Impact

The project as per the Technical design may have to acquire land (land under structures and open land) for proposed ROW as well as lands of those who have been carrying out business / using the land by constructing structures for residential purpose or for religious purpose. Revenue verification may ascertain the status of the occupants. The project may have adverse impacts on 1380 structures of various categories. A Resettlement Plan has to be prepared following the objectives Land Acquisition Act of Government of India (with amendment of section 6 in 2002), National Resettlement Policy of 2006 and, NHAI Entitlement Policy for compensation payment to mitigate the adverse impacts. It should be also attempted to minimize land acquisition so far it is practicable.

12.9 Mitigative Measures

The primary objective of this plan is to identify impacts and to plan measures to mitigate various losses due to the implementation of the project. Needs to be prepared based on general findings of the census survey, field visits and meetings with various project-affected persons in the project area. Taking into account the various losses, the Entitlement Matrix of NHAI, which provides for compensation and resettlement assistance to all affected persons including the non-titleholders in the subproject area, will be consulted.

12.10 Land Acquisition Plan

Land survey for the payment for the payment of compensation will be done on the basis of updated official records and ground facts. The land acquisition plan (LA) will be prepared. The land for 6-lanning shall be acquired under the NHAI Land Acquisition Act of 1998. This is applicable for acquisition of land needed for public purpose.

The land records will be updated containing information relating to title, land classification, and current use of land. According to NHAI Act where the Central Government is satisfied that for a public purpose any land is required for the building, maintenance, management or operation of a national highway or part there of, it may , by notification in the Official Gazette, declare its intention to acquire such land.

12.11 R & R Principles, Policy Frame Work

12.11.1 The Policy

This plan describes the principles and approaches to be followed in minimizing and mitigating negative social and economic impacts by the project road.

12.11.2 The objectives of Resettlement Plan

- The Resettlement Plan will be prepared keeping the following broad objectives:
- The negative impact on project affected by the project will be avoided or minimized.
- Affected people and the beneficiary population will be informed and consulted about the project and its design.
- Where negative impacts are unavoidable, the project affected persons will be assisted in improving or regaining their standard of living.
- People's participation will be undertaken in planning and implementation of the project.

- All information related to resettlement plan and implementation will be disclosed to the affected persons.

12.11.3 R & R Benefit

The Government of India has brought forward a National Policy of “Resettlement and Rehabilitation for project affected families” through the Ministry of Rural Development (Department of Land Resources) during 2004. The policy essentially addresses the need to provide support to the asset less rural poor, support the rehabilitation efforts of the poor sections, namely, small and marginal farmers, SCs/ STs and women who have been displaced.

12.11.4 NHAI Entitlement Matrix

NHAI Entitlement Matrix will be described in details in the main text.

12.11.5 Implementation Arrangement & Grievance Reddressal

The Project Implementation Unit (PIU) with assistance of implanting agency will have the primary responsibility of the RP preparation and implementation. The PIU would ensure monitoring if any changes occur to the road project design which may require re-evaluation of the need for and adequacy of the RP. The PIU will ensure resettlement budgets are delivered on time to the APs for timely RP implementation.

A Grievance Reddressal Committee (GRC) will be established at the project level with the primary objective of providing a mechanism to mediate conflict and disputes concerning compensation payments and cut down on lengthy litigation. All compensation and other assistances will be paid to the APs prior to commencement of civil works.

This shall comprise thermocouple/pyrometer, humidity meter, anemometer, visibility meter and sensor for pavement temperature shall be modular sign panels.

Chapter - 13

Cost Estimate

CHAPTER - 13

Preliminary Project Costs

13.1 General

The cost estimation have been prepared for the project corridor, for widening of the existing 4-lane divided carriageway to 6-lane divided carriageway including dismantling, site clearance, strengthening the existing pavement of main carriageway and service roads, new construction for widening of pavement, construction/ widening of cross drainage structures, Provision of new underpasses, retaining structures, covered RCC longitudinal drains, utility chambers, road furniture, street lighting, bus bays etc. The cost for land acquisition, rehabilitation and environmental costs and Independent Consultant's fees have also been considered.

13.2 Existing Cross Section

The entire project road between km 13.80 and km 106.80 is four lane divided carriageway except some urban areas with six lanes. Service roads on either side of highway exist only in urban areas. Based on an existing cross section elements and composition of pavement, the details of entire length are described in the following paragraphs:

Widening of this section from existing 2-lane single carriageways to 4 lane divided carriageway was completed in the year 2006. The existing cross section in this stretch comprises of

- The width of the central median is highly varied and ranges between 5.0m to 1.8m including kerb shyness of 0.25m.
- The carriageway width in 4-lane sections is 7.0m with shyness of 250 mm. Paved shoulder of 1.5m and earthen shoulder of 2.0m are provided on both sides. Wherever service roads are provided the earthen shoulder is replaced by separators of 1.0/ 0.6m width.
- In 6-lane sections, the carriageway width is 10.5m with shyness of 250 mm. At the immediate approach of the structures, paved shoulder of 1.5m and earthen shoulder of 2.0m are provided on both sides. At locations of structures (Underpass/ROBs), paved shoulder is missing.
- Service roads wherever provided are either 4.0m/ 6.0m/ 7.5m width with or without covered drains.
- The pavement of the main carriageway including paved shoulder consists of 50mm Bituminous Concrete (BC), 130mm Dense Bituminous Macadam (DBM), 250 mm Wet Mix Macadam (WMM) and 200mm Granular Sub Base (GSB). For service roads, the pavement composition is 50mm Bituminous Concrete (BC), 65mm Dense Bituminous Macadam (DBM), 250 mm Wet Mix Macadam (WMM) and 200mm Granular Sub Base (GSB)
- 2.2m wide RCC covered drains cum utility chamber are provided in urban stretches at the outer edge of service roads.
- Anti Glare railings are provided in the central median and separators. Where the width of the central median is large hedges are planted and no railings are provided. RCC crash barriers are provided at locations of bridges, underpasses and ROBs. W-Beam crash barriers are also provided at some locations.
- At bus-bay locations raised separators are provided.

13.3 QUANTIFICATION

The quantification of proposed 6-laning scheme is based on the following provisions/recommendations:

- Existing central median is retained without any modifications.
- Existing carriageways and paved shoulders are retained and strengthened with required bituminous overlay.
- Existing earthen shoulders are dismantled upto granular sub-base (GSB) top level.
- Proper benching i.e. steps are made in embankment, sub-grade and granular sub base for proper bond with new construction.
- Open lined (Stone pitched) drains are provided after at the edge of Right of Way in rural areas.
- In Urban areas, RCC covered drains are provided at the edge of service road, where Right of Way is less than 50m. These drains have been raised which will also act as a footpath. RCC open drains are provided where Right of Way is 60metre between main carriageway and service road. Street lightings have been provided where footpaths are proposed. Existing drains are dismantled wherever necessary.
- Service roads of various widths (4m, 6m and 7.5m) are provided based on the availability of existing Right of Way. Existing service roads are widened to 7.5m, wherever the existing pavement could be utilized. Where the usable width of the service road is less, the pavement is dismantled upto GSB top and is rebuilt.
- In order to optimize construction cost, the existing 6-lane configuration was kept untouched even if it does not fully satisfy the NHA Manual.
- Culverts are widened as per the proposed sections. In case of bridges, which are mostly 6-lane new structures are being retained.
- RCC crash barriers are proposed at the edges of structures and Metal beam (Double W-Beam) barriers are proposed for separators and median width having less than 4.5m.
- Turfing and Stone pitching have been adopted in high embankment areas as erosion preventive measures.
- The reinforced earth structures have been provided at all underpass approaches to minimise the land acquisition.
- At some locations RCC retaining walls have also been provided.
- Reconstruction of major and minor access roads and bus-bays has also been taken into consideration.

The existing toll plazas at km. 37.800 and km. 104.900 are retained with five additional lanes at 37.800 and three additional lanes at 104.900 are proposed on either side.

13.4 Item of Works

For estimation of quantities and costs, various work items have been grouped under the following heads:

Site Clearance	Clearing and Grubbing Dismantling of Structures, Pavement Scarifying of Bituminous Surface
Earthwork	Earth excavation Rock Excavation Fill by excavated earth Fill by borrowed earth Sub-grade

	<i>Turfing</i>
Sub-base & Base Courses	<i>Earthen Shoulder Granular Sub-base Wet Mix Macadam Cement Stabilisation at Earthen Shoulders</i>
Bituminous Courses	<i>Prime coat Tack Coat Bituminous Macadam Dense bituminous Macadam Bituminous Concrete</i>
Bridges & Structures	<i>Minor Bridges Major Bridges ROBs Vehicular Underpasses Non-vehicular Underpasses Grade Separators Rehabilitation of Existing Bridges</i>
Cross Drainage Structures	<i>Pipe Culverts RCC Slab Culverts</i>
Slip/ Service Roads	<i>Earth Work Sub-base & Base Courses Bituminous Courses</i>
Drainage & Protective Works	<i>Unlined drain Open lined drain Covered drain Median drain Toe Wall RCC Retaining Wall</i>
Improvement of Junctions (excluding structures)	<i>Non-vehicular At Grade Grade Separator Vehicular Underpass</i>
Appurtenances	<i>Crash Barrier (New Jersey Type) Guard Rail Fencing Kerbs Footpath Gantry Signs & Pavement Markings Colour Pigment Delineators etc.</i>
Road Side Amenities	<i>Bus bays Truck Park/Rest Area</i>
Toll Plaza	<i>Addition of extra lanes</i>
Land Acquisition	
Lighting for Urban Area & Intersections	<i>High Mast Street Lighting</i>
OFC conduit at Median	
Relocation of Utilities	<i>Telephone Lines Electric Lines HT/LT Lines Water/Gas Pipe Lines Other Utility services</i>
Initial Environmental Examination	
Rehabilitation, Resettlement and Social	

13.5 Estimation of Quantities

The estimation of bill of quantities is carried out on the basis of available as built drawings of sections of highway and inventory data collected during the validation of these drawings. It should be noted that the works are mostly limited to strengthening of existing carriageway, addition of lanes to carriageway, new underpasses, roadside drains and new service road. The quantities were worked for the highway from km.13.80 to km 106.80:

The estimation of quantities has been made for various items of works identified in para 13.4 above.

- ◇ Land acquisition
- ◇ Site Clearance
- ◇ Earthwork
- ◇ Shoulder, Sub base and base courses
- ◇ Bituminous Courses
- ◇ Bridges & Structures
- ◇ Cross Drainage Structures
- ◇ Slip/ Service Road
- ◇ Drainage and Protective Works
- ◇ Improvement of Junctions
- ◇ Appurtenance: Crash Barrier, 200 m/km. Stone, Traffic Sign boards, Pavement markings
- ◇ Road Side Amenities: Truck/ Bus/ Lay-bye, Truck/ Bus parks, Rest Area
- ◇ Toll Plaza
- ◇ Lighting for Urban Area & Intersections
- ◇ OFC Duct at Median
- ◇ Relocation of Services
- ◇ Initial Environmental Examination
- ◇ Rehabilitation, Resettlement and Social

13.6 Specifications

For arriving at unit rates for major items of works the specifications for the works shall generally conform to the stipulations made in “**Specifications for Road and Bridge Works (IVth Edition – August 2001)**” of MORT&H.

Surfacing (Bituminous Concrete) has been considered with Modified bitumen binder.

13.7 Unit Rates

13.7.1 General Approach

Unit rates of major items of works have been worked out based on the detailed study of available latest schedule of rates of National Highways Circle, PWD, Government of Tamil Nadu for the year 2010-2011. Prevailing market rates have been adopted for items not covered by the Schedule of Rates, wherever considered appropriate.

Consistent with the high qualitative standard of the facility, the consultants have considered mechanised construction methods for the analysis of unit rates. The “Standard Data Book for Analysis of Rates (First Revision-2003)” published by Ministry of Surface Transport, had been followed by the consultants.

C) Quarry Chart and Lead

The cost of materials like gravel, aggregates and sand includes the basic cost at source, transportation charges to work site and loading and unloading charges. While estimating lead of materials, the consultants assumed that:

- ◇ borrow earth, gravel and stone aggregates for granular sub-base would be directly transported to the construction site, and
- ◇ crushed stone aggregate, bitumen, cement etc would be transported to the Hot Mix Batching Plant site and mixed material then be carried to the work site.

Depending on the location of the quarries, the following average lead of materials for the project road were worked out and considered in the rate analysis:

Materials	Average Lead (km)
Bitumen	60
Borrow Earth	11

Sand	46
Granular materials	35
Stone Aggregates	46
Stone Boulders	35

A quarry chart and diagram showing the location of quarries with their approximate distance from the project road alignment is shown in figure-13.1.

The abstract of unit rates adopted for various major items are tabulated below:

Item No.	Description	Unit	Rate (Rs.)
1	Clearing and Grubbing of road land	Hect.	42591
2	Dismantling of Plain Cement Concrete	m ³	338
	Dismantling of Reinforced Cement Concrete	m ³	516
	Dismantling of flexible Pavement	m ³	209
3	Roadway Excavation in all types of soil	m ³	41
4	Construction of Embankment using borrow materials	m ³	188
5	Construction of Embankment using approved material obtained from roadway excavation	m ³	97
6	Construction of Sub-grade with selected material	m ³	228
7	Granular Sub-base	m ³	1007
8	Wet Mix Macadam	m ³	1370
9	Prime Coat	m ²	24
10	Tack Coat	m ²	11
11	Profile corrective course with Dense Bituminous Macadam (DBM)	m ³	6290
12	Dense Bituminous Macadam (DBM)	m ³	6290
13	Bituminous Concrete (BC) with PMB	m ³	7856
14	Structural Excavation in all types of soil	m ³	36
15	Structural Excavation in rock	m ³	163
16	PCC Grade M15	m ³	3252
17	PCC Grade M20	m ³	3680
18	RCC Grade M25	m ³	4205
19	RCC Grade M30	m ³	4642
20	RCC Grade M35	m ³	4735
21	Pre-cast Post-tensioned girders with cast-in-situ deck slab in Grade M45	m ³	6092
22	HYSD /TMT steel	t	49689

13.8 Project Cost

The cost of various components of proposed road widening between km 13.80 and km 106.80 are calculated separately and presented in the table below:

Bill No.	Item of Works	Cost in Rupees
A	Civil Works	
1	Site Clearance and Dismantling	28,424,937
2	Earthwork	563,049,986
3	Sub-base and Base Courses	441,891,340
4	Bituminous Courses	1,714,106,568
5	Bridges and Structures	2,899,652,479
6	Cross Drainage Structures	223,905,500
7	Service Roads	535,305,029
8	Drainage and Protective Works	616,315,620
9	Improvement of Junctions	236,996,341
10	Road Appurtenances	190,822,964
11	Road Side Amenities	83,500,000
12	Toll Plaza	80,000,000
13	Lighting for urban area and intersections etc.	59,946,900
	Sub-total for Civil Works (A)	7,673,917,664
	<i>Cost per km for Civil Works</i>	<i>82,515,244</i>
B	Non-civil Works	
14	Land Acquisition	894,529,071
15	Relocation of Utilities	118,800,000
16	Environmental Improvement	49,223,750
17	Rehabilitation and Social	57,610,000
	Sub-total for Non-civil Works (B)	1,120,162,821
	<i>Cost per km for Non-civil Works</i>	<i>12,044,762</i>
	Total Cost (A+B)	8,794,080,485
	<i>Cost per km</i>	<i>94,560,005</i>
C	Independent Consultant's Fee @0.5 % on Total Cost (A+B)	43,970,402
	Grand Total (A+B+C)	8,838,050,887
	<i>Cost per km</i>	<i>95,032,805</i>

Cost of Road and Bridge works (including Underpasses) i.e. cost of main carriageway, service road, road side drainage, traffic signs and marking, earth retaining structures, road safety works, toll plaza etc. including costs of construction of service road bridges, overpass, underpasses and culverts worked out to be Rs. **767.39 Crores** after restructuring.

The total project cost (Civil Works and Non-civil Works) including Land acquisition, Environment improvement and Rehabilitation works out to be Rs. **883.80 Crores**.

Chapter - 14

Traffic Management During Construction

CHAPTER 14

Traffic Management during Construction

14.1 Importance of Traffic Management

During construction, traffic management is an essential part of any transportation project to ensure safe and efficient construction.

Before the start of construction, Traffic Management Plans shall be prepared which will provide more details of the division of the project into contract areas, the likely construction programme and the general strategy for traffic management. Once contractors have been appointed, regular traffic liaison meetings should be arranged with highway authorities and the Police, bus operators (taxi trade representation as appropriate) and other emergency services as appropriate. These meetings will provide an opportunity for contractors to present proposals for future works affecting the highway including methods of construction and proposed programme and for a review of the associated traffic management requirements. The objective will be to achieve concurrence on a scheme prior to a formal submission to the relevant highway authority.

The planning of the works will include consideration of the access and servicing requirements of affected residential and commercial premises. The contractor will work together with the nominated undertaker to ensure regular communication with parties affected by the works. Local residents and businesses should be informed in advance of the dates and durations of closures and should be provided with details of diversion routes at least two weeks in advance or when final details are available. Access and servicing will be maintained as far as reasonably possible, within the constraints of the works and the need to ensure the safety of the public.

Some traffic management proposals may require Traffic Regulation Orders to cover measures such as the closure of one lane, banned turns, temporary speed limits and the suspension of parking places. These will be discussed at the liaison meetings and applications for these orders should be made to the relevant traffic authority.

In general, the guidelines on safety in road construction zones “IRC: SP: 55:2001” should be followed for maintaining the safety during construction and to keep the traffic flowing with minimum disruptions.

14.2 Construction Sequencing

The proposed widening to 6 lanes also includes the construction of service road, various underpasses, widening of bridges and pedestrian crossings/subways. Proper synchronization among the construction activities of these structures will be required to provide smooth flow of traffic during the construction period. The project road caters to the traffic volume between approximately 38829 PCU to 51971 PCU per day, thus even during the construction phase it is essential to make available minimum two lane paved carriageway to each direction of traffic and also to maintain the connectivity with the cross roads. Following paragraphs explain the likely construction sequencing to be followed during construction for various components of project. Each typical component of project is discussed separately.

14.2.1 Vehicular Underpass

During stage-1: Traffic will use the existing roads i.e. main carriageway and cross roads. Construction of Service roads shall be taken up.

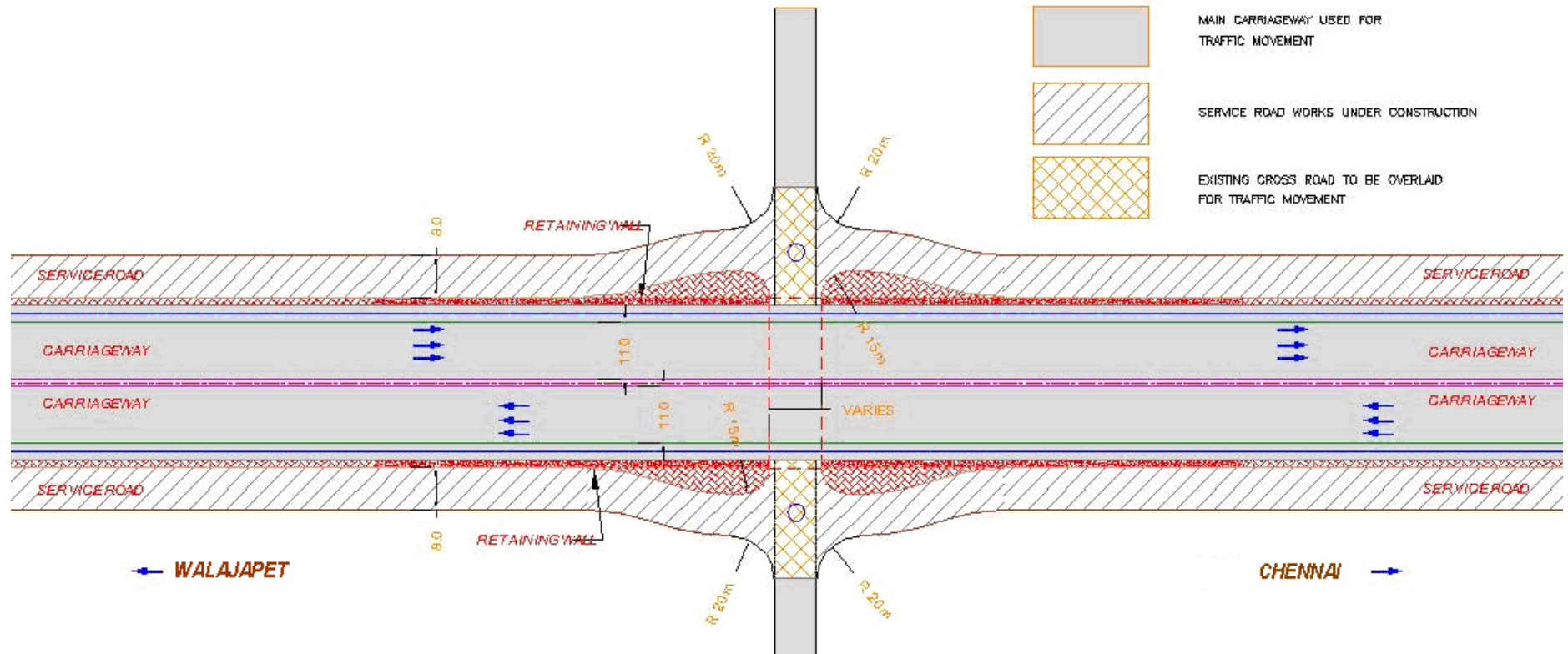


Fig. 14.1

During stage-2: Traffic will be diverted to newly constructed service roads and construction of main carriageway and underpass structure shall be taken up.

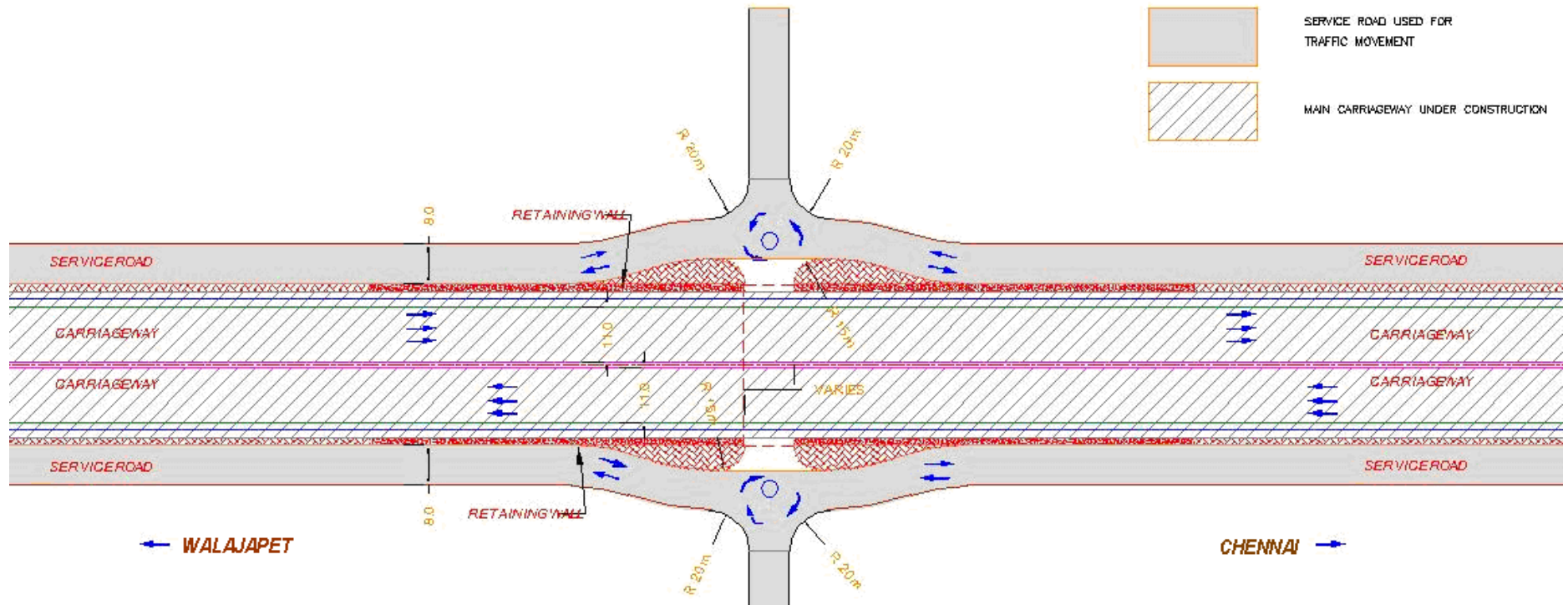


Fig 14.2

14.2.2 Major Bridges

The project road has only 1 major bridge which is already 3-lane. At these locations till new three Lane Bridge constructed existing two Lane Bridge may be utilized for movement of traffic.

12.2.3 Main Carriageway with Service Road

Apart from the locations discussed above, at other sections of highway, service roads on either side will be constructed first; during this period traffic will ply on existing carriageways. Then main carriageway will be widened if required by diverting the traffic on newly constructed service roads.

Chapter - 15

Highway Safety Appurtenances

CHAPTER – 15

Highway Safety Appurtenances

15.1 General

15.2 TRAFFIC SIGNS

Road sign shall be provided in accordance with IRC:67. There shall be marking with stop sign, give way sign, merging or diverging traffic sign, lanes closed sign, narrow and slip road, diversion, keep left sign and keep right sign. Sign not covered in IRC: 67 will be followed as per international practices. Kerb mounted sign shall be supported on GI pipe and overhead sign shall be structurally supported gantry or cantilever. Each exit ramp shall indicate the name of place and important road as well as approximate distance of next exit. For entry ramp, entry sign shall be provided on service road and U Turn prohibited sign shall be placed on main highway. Entry sign may also be provided on cross road.

Advanced directional sign shall be installed at 1 km and 0.5 km ahead of toll plaza. Toll road ahead, toll road start and toll road end signs shall be provided to caution road user before using it. Toll rate (vehicle mode wise rate) sign shall be installed at the start point of tapered section of toll plaza.

15.2 PAVEMENT MARKING

All Pavement markings on highway shall be in accordance with IRC: 35. Centre line, edge line, stop line, give way line, diagonal/ chevron markings, parking etc shall be painted with hot applied thermoplastic paints with reflectorized glass beads as per MoRTHS specification. At toll plaza, transverse bar lines with 300mm wide and spacing of 15-20m centre-to-centre shall be provided across the flare approach to toll plaza to reduce the speed of vehicles.

15.3 REST AREA

Rest areas are spaced at the interval of 60 to 90 minutes journey time between important cities. Rest areas are proposed at the locations, near Vehicular under passes. All the facilities as mentioned in the manual shall be provided.

15.4 BUS STOP

Bus stop with bus shelter shall be provided. Bus stop shall be precast concrete block (M40) pavement and design shall be as per relevant IRC Code.

15.5 PEDESTRIAN AND VEHICLE CROSSING FACILITY

Underpasses shall be provided as per manual of 6-laning. Pedestrian under pass shall be 2.5m high and 4m wide.

15.6 HIGHWAY LANDSCAPING

Tree plantations shall be carried out as per IRC: SP-21:1979, IRC: 66 and specifications mentioned in the 6-laning manual.

15.7 ADVERTISEMENT/HOARDING AND EMERGENCY OPENING

No Advertisement/Hoarding shall be allowed on the project road.

No median opening shall be provided except emergency median opening for maintenance works and emergency purpose.

15.8 ADVANCE TRAFFIC MANAGEMENT SYSTEMS

This system consists of:

- Acquisition of data from various sources such as the road user, maintenance and operation patrol unit;
- Three way of communication between the data source and central control room, display unit, maintenance and operation system
- A central control room to process all data and control highway operation

15.8.1 Data Acquisition

This system shall consist of the followings:

- Automatic Traffic Counter and Classifier;
- Video camera installed on road to cover a length of 2 km;
- Emergency call box shall be installed @ 2 km centre-to-centre;
- Metrological sensors;
- Mobile radio for patrol vehicle and ambulance.

15.8.2 Variable Message Sign

Variable message sign shall be modular sign panels. The sign should be placed such that the display is legible from a distance of 200 m.

15.8.3 Metrological Sensors

This shall comprise thermocouple/pyrometer, humidity meter, anemometer, visibility meter and sensor for pavement temperature shall be modular sign panels.

15.8.4 Emergency Call Boxes

This shall consist of loud speaker, micro phone, activation bottom with LED indicating conversion, shall be housed in a vandal proof casing and operate in full to play mode in noise level of 95 decibel.

15.8.5 Automatic Traffic Counter cum Classifier

This shall be capable of detecting and recording all categories of vehicle plying on the project road based on length and number of axle.

15.8.6 Closed Circuit Television

This shall comprise video camera, its housing and pan, and tilted head. The video camera shall be mounted at a height so to cover the target length of highway and housing shall be able to withstand adverse weather condition

15.8.7 Main Control Centre

This shall be designed for round the clock operations of monitoring, on line information acquisition and processing for decision making. This shall consist of central computer, call centre, terminal junction, UPS, etc.

15.8.8 Central Control Room

This shall be the repository of all the data acquired from the field and their processing, sorting and archiving. All information will be generated at the control room.

15.8.9 Highway Patrol

One Highway patrol unit shall consist of two persons excluding driver of the vehicle for a distance of 50 km or for a package which is less. This team shall be always in contact with the control room.

15.8.10 Ambulance

Ambulance manned shall be with at least two trained paramedics available on the project road to ensure that the response time is not more than 10 minutes of call. At least one ambulance shall be provided for 25 km length of road.

15.8.11 Lighting System

- All light posts erected on railing of bridge, structure shall have adequate height such that a uniform illumination of 40 lux shall be available.
- All high mast lights in the interchange area shall be illuminated with 40 lux
- All entry and exit ramps shall be illuminated with 40 lux.
- All underpasses shall be illuminated with 30 lux.

15.8.12 Operation and Maintenance Centre

There shall be operation and maintenance centre near or at toll plaza or any suitable location. Minimum requirement as mentioned in the 6-laning manual shall be followed.

Chapter - 16

Conclusions and Recommendations

CHAPTER – 16

Conclusions and Recommendations

16.1 Technical viability

The conclusion and recommendations of the Feasibility Study are as follows:

- ✚ Based on the feasibility study carried out for the project road section from km 13.80 to km 106.8 of existing NH-4 between Poonamallee and Walajapet in the state of Tamil Nadu, it is recommended that:
 - o rest of the project road be widened to dual 3-lane carriageway;
 - o with provision 10 numbers of flyovers, 15 numbers of vehicular and 22 number of pedestrian underpasses/ cattle crossings at the locations already described in the previous chapters. In addition to 60 numbers of exit and entry access have also been provided.
- ✚ The urban/ built-area of the project road is facilitated with flyovers/ VUP/PUP for safe crossing of local traffic as well as VRUs. In addition, slip/ service road of length about 30.305 km x 2 (both sides) also provided for smooth entry and exit of traffic. Though, the consultant did propose service road on all the urban/ built-up stretches of the project road, but due restructuring of the project the service roads have been shelved.
- ✚ The salient features of the project are:
 - o Total length of the project road is 93 km.
 - o Total length of the slip/ service road of 30.305 x 2 km is proposed for safe easy entry & exit of traffic
 - o Flexible pavement option with 20 years design period is recommended for additional lanes
 - o Flexible Overlay is recommended on existing pavement
 - o 15 number vehicular underpasses are proposed for cross road traffic and to facilitate the users for U turn and move in other direction
 - o 22 number underpass for pedestrian/ cattle crossing is provided for safe crossing of pedestrians as well as cattle
 - o 60 numbers of Exit access and 60 numbers Entry access are proposed to exit and enter from and to main highway.
 - o 10 Flyovers is proposed at major junctions.
- ✚ Other existing structures are kept unchanged, since they are already 6-lane capacity structures. Though they are not to the standard as per cross section provided in the manual but to avoid the complicity in the widening of the highway and cost implication, the consultants recommend to keep them unchanged and these issues were already discussed with the client. They also endorsed the consultants' recommendation
- ✚ No vented causeway is proposed since this is a high speed corridor and tolled highway. The consultant explored the possibility of construction of causeways on the service road. The study reveals that inclusion of vented causeway would disturb the smooth traffic flow during flood on the main highway and main highway would be overloaded and traffic hazardous during the submergence period. To avoid the traffic congestion and enhance the safety the consultant recommended no causeway for this kind of high speed corridor.

- ✚ Covered lined drain has been proposed in urban and semi urban areas and open stone pitched drain has been proposed in rural stretches. Covered drain would be utilised as footpath for the pedestrian
- ✚ Two Toll plazas have been suggested as existing at following locations considering the project road length and tollable traffic. Currently there are 5 toll lanes in each direction at each location
 - o at km 37.80
 - o at km 104.90
- ✚ From the analysis of traffic, the consultant worked out 2x10 toll lanes at Toll Plaza at km 37.80 and 2x8 toll lanes at Toll Plaza at km 104.90, if semi automatic toll collection system is in operation as existing.
- ✚ Currently 3 rest areas/truck lay-byes are proposed by the consultant.