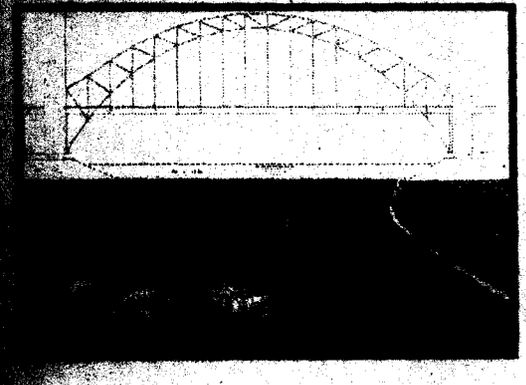
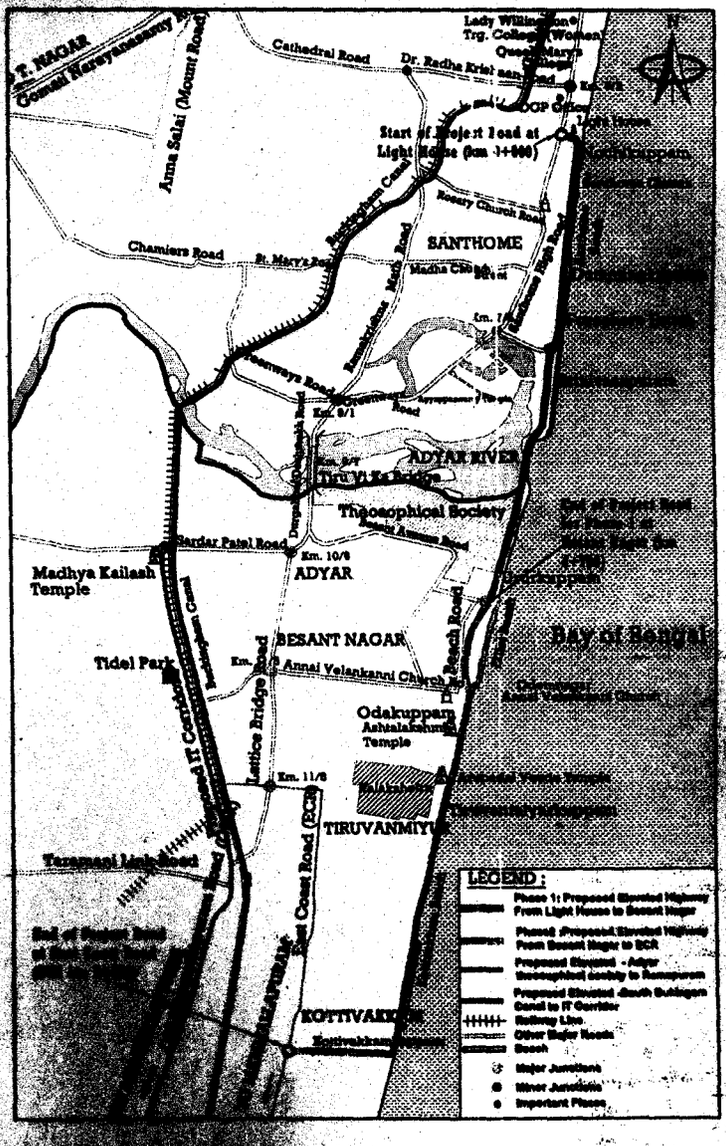
Highways Department

LINK ROAD FROM LIGHT HOUSE JUNCTION NEAR SALAI TO ECR VIA BESANT NAGAR

FEASIBILITY REPORT





Private Limited
ENGINEERS & PLANNERS

Wilbur Smith Associates

MAY 2009

Highways Department

LINK ROAD FROM LIGHT HOUSE ON KAMARAJAR SALAI TO ECR VIA BESANT NAGAR

FINAL DETAILED FEASIBILITY REPORT

Phase 1 : Light House on Kamrajar Salai to Besant Nagar

Volume I - Main Report

Wilbur Smith Associates Private Limited ENGINEERS & PLANNERS

MAY 2009

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Executive Summary

EXECUTIVE SUMMARY

1. Project Introduction

Government of Tamil Nadu (GoTN) has formed a Beach committee to improve the existing beach along the east coast by enhancing the aesthetics and other facilities also to decongest the existing traffic along the marina beach. As part of the enhancement measures, Beach committee now intends to construct a link road from Light house on Kamarajar Salai to Besant Nagar (Via) Santhome Bypass, Sreenivasapuram, and Ururkuppam including construction of a high level bridge across Adyar Estuary to join ECR.

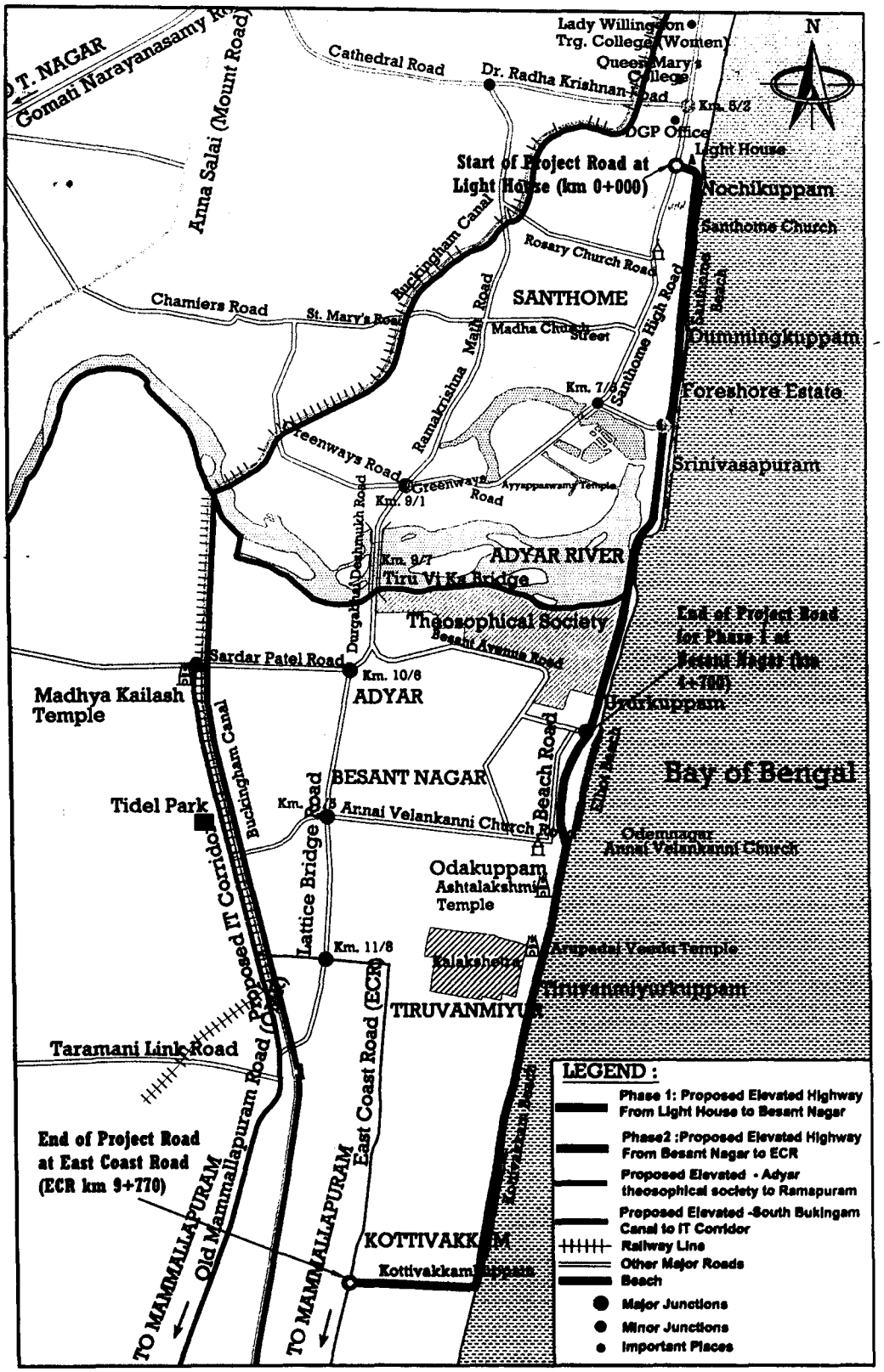
The draft feasibility report was submitted to the Highways Department during April, 2007 and further to this review meetings were conducted by the review committer on 06.08.07, 19.03.08, 16.04.08, 22.11.08, 30.01.09, 05.02.09, 09.02.09 and 09.03.09. During the above review meetings considering the availability of existing roads along the proposed alignment, it is proposed to implement the project under the following two phases:

Phase1 Reconstruction of existing road with Elevated Corridor from Light House to Besant Nagar near Ururkuppam including provision of entry & exit ramps near Foreshore estate road junction and reconstruction of existing bridge across river Adyar with "Signature bridge". (4.7km). This phase will also include necessary arrangement for linking with Phase 2 at Besant Nagar Junction in due course.

Phase 2 Construction of Elevated Corridor from Besant Nagar to East Coast Road (ECR) along the coast by making use of the existing road alignments

The Final feasibility report is also prepared for two phase's separately and this report discusses only on the Phase 1 of the project.

Key map of the project area is in shown in **Figure** below.



Key Map of the Project Area

1.1 Project Objective

The primary objectives of the study are:

- To establish the technical, economical, environmental, social and financial viability of the project
- To prepare detailed feasibility report including the Environmental and Social Management Plan (ESMP).

2. Surveys and Investigations

The various surveys and investigations, which have been carried out, cover the following

- Traffic Surveys
- Road Inventory Survey
- Pavement Condition Survey
- Topographical Survey
- Geotechnical Investigations

2.1 Traffic Surveys

The survey locations that were finalized in consultation with Highways Department are given in **Table** below.

Traffic Survey Locations and Duration

Sl No.	Location	Duration	Dates of Surveys
Link Count Surveys			
1.1	Santhome Beach Road	3 days (2 week days+ 1 weekend)	28- 12-2005 to 29-12 - 2005, 07-01-2006
1.2	Elliots Beach	3 days (2 week days+ 1 weekend)	28- 12-2005 to 29-12 - 2005, 08-01-2006
1.3	Thiru Vi Ka Bridge (Km 9/4 of Greenways Rd)	2 working days	03-01-2006 to 04-01-2006
1.4	Lattice Bridge Rd –Sardar Patel Junction (L & R turning movements only)	2 working days	05-01-2006 to 06-01-2006
O-D Surveys			
2.1	Thiru Vi Ka Bridge (Km 9/4 of Greenways Rd)	2 working days	03-01-2006 to 04-01-2006
2.2	Lattice Bridge Rd –Sardar Patel Junction (L & R turning movements only)	2 working days	05-01-2006 to 06-01-2006
Junction Count Surveys			
3.1	DGP Office Junction (Km 5/2)	2 days (1 week day+ 1 weekend) 14 hours (8 am to 10 pm)	09-12-2005, 07-01-2006
3.2	Marina Entrance Junction (Km 5/4)	1 weekend day -14 hours (8 am to 10 pm)	08-01-2006
3.3	Light House Junction (Km 5/6)	1 weekend day -14 hours (8 am to 10 pm)	09-01-2006
3.4	ECR Junction (Km 14/6 of ECR)	1 week day- 12 hours (8 am to 8 pm)	02-01-2006
Pedestrian Counts (crossing + along carriageway)			
4.1	Santhome beach	1 weekend day - 6 hours	07-01-2006

Sl No.	Location	Duration	Dates of Surveys
		(4 pm to 10 pm)	
4.2	Elliots beach	1 weekend day - 6 hours (4 pm to 10 pm)	08-01-2006
5. Parking Surveys			
5.1	Santhome beach	1 weekend day - 6 hours (4 pm to 10 pm)	07-01-2006
5.2	Elliots beach	1 weekend day - 6 hours (4 pm to 10 pm)	08-01-2006

2.2 Road Inventory Survey

The details collected are as follows:

- Project Stretch Details
- Terrain Type - Plain
- Width of Carriageway – 2.5m to 10.0m
- Earthen Shoulder – 1.0m to 2.0m
- Paved Shoulder – 1.0m to 4.0m
- Right of Way (ROW) – 7.0m to 28.0m
- Major Junction – 14
- Minor Junctions – 49
- Road Side Land Use and location of built-up sections – Residential / Sea
- Utility details
- Possible alignment options for the connecting existing alignment with ECR

2.3 Pavement Survey

The project Stretch consists of bituminous surface only on some portions. The existing pavement is of bituminous flexible type with varying compositions and characteristics. Pavement condition survey (Visual) has been carried out to assess the adequacy and effectiveness of existing pavement in serving the present traffic needs. The Following distresses were recorded as part of pavement condition survey;

- Rut depth on wheel path
- Edge break or Edge drop
- Cracking
- Pot hole & Patching areas
- Ravelling and stripping of aggregates

2.4 Geotechnical Investigations

The details of geotechnical investigation done are given in **Table** below.

Details of Geo-Technical Investigations

Sl. No.	Location	Bore Hole /Trial Pit No.	Termination Depth from GL(m)	Remarks
1	Light House	BH-1	24	N=>100
2	Adyar Bridge	BH-2	22.5	N=>100

Sl. No.	Location	Bore Hole /Trial Pit No.	Termination Depth from GL(m)	Remarks
3	Mahalakshmi Temple	BH-3	29	N=>100 Rock Encountered
4		BH-4	25	N=>100 Rock Encountered
5		BH-5	21	N=>100
6		BH-6	26.5	N=>100 Rock Encountered
7		BH-7	24	N=>100 Rock Encountered
8		BH-8	25	N=>100 Rock Encountered
9		BH-9	23	N=>100
10		BH-10	28	N=>100 Rock Encountered
11		BH-11	27	N=>100
12		BH-12	22.5	N=>100
13		BH-13	25.5	N=>100 Rock Encountered
14		BH-14	28.5	N=>100 Rock Encountered
15		BH-15	25	N=>100 Rock Encountered
16		BH-16	24.5	N=>100 Rock Encountered
17		BH-17	25.5	N=>100 Rock Encountered
18		BH-18	23	N=>100
19		BH-19	27	N=>100 Rock Encountered
20		BH-20	27	N=>100 Rock Encountered

The soil varies from fine to medium sand for shorter depths in all the bore hole locations. Hard strata or rock is encountered at about 23m in all the bore hole locations. Based on the sub soil findings, suitable foundations are proposed. The type, depth and safe bearing capacities of footings are described in the preliminary bridge design section.

3. Traffic Studies & Projections

3.1 Average Daily Traffic

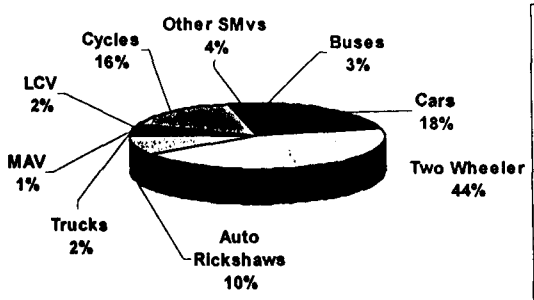
The Average Daily Traffic (ADT), Vehicle Composition and Peak Hour Traffic & Hourly variation for the following locations are as given below:

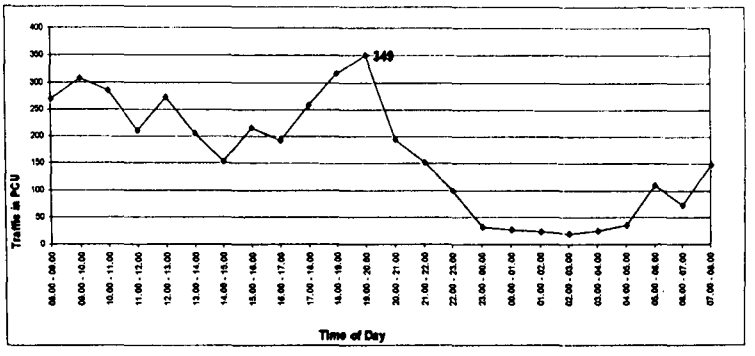
3.1.1 Santhome Beach Road

ADT on Santhome Beach Road, 2006 (No. of vehicles)*

Vehicle Type	Buses	Cars	Two Wheeler	AR	Trucks	MAV	LCV	Total FMVs	Cycles	Other SMVs	Total SMVs	Total Vehicles	Total PCU
Nos.	119	711	1715	368	66	47	85	3111	616	140	757	3868	3937

(Note *: ADT is the weighted average of 3 day count, giving a weightage of 2 for weekends and a weightage of 5 for working days)



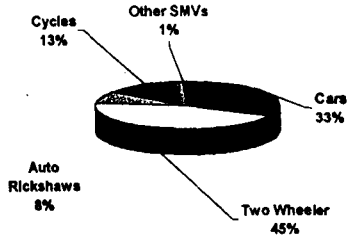


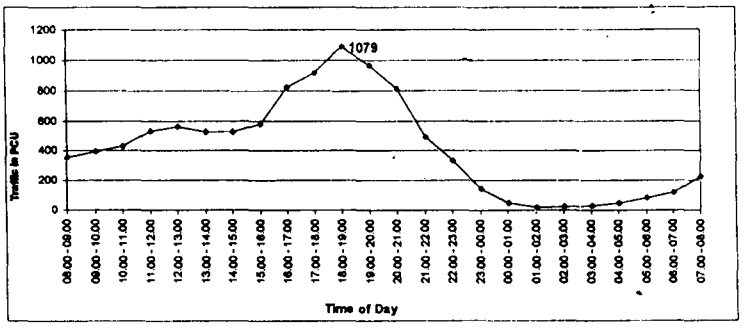
3.1.2 Elliot's Beach Road

ADT on Elliots beach Road, 2006 (No. of vehicles)*

Vehicle Type	Buses	Cars	Two Wheeler	AR	Trucks	MAV	LCV	Total FMVs	Cycles	Other SMVs	Total SMVs	Total Vehicles	Total PCU
Nos.	49	3439	4720	883	18	30	10	9148	1398	103	1501	10650	9905

(Note: ADT is the weighted average of 3 day count, giving a weightage of 2 for weekends and a weightage of 5 for working days)*

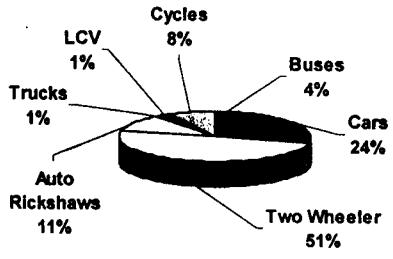


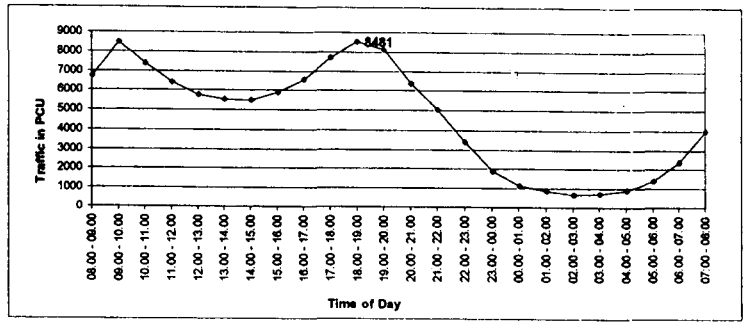


3.1.3 Thiru-Vi-Ka Bridge

ADT on Thiru- Vi- Ka Bridge, 2006 (No. of vehicles)*

Veh. Type	Bus	Cars	Two Wheeler	AR	Trucks	MAV	LCV	Total FMVs	Cycles	Other SMVs	Total SMVs	Total Vehicles	Total PCU
Nos.	4419	26762	55061	12111	1319	31	1483	101186	8929	78	9007	110193	110652





3.2 Junction Turning Counts

The peak hour traffic observed at the four junctions along the proposed elevated highway is given in **Table** below.

Peak Hour Junction Turning Volume , 2006 (No. of Vehicles)

Name of Junction	Bus	Car/ Jeep/ Van (O)	Car/ Jeep/ Van (N)	Two Wheelers	Auto	Trucks	MAV	LCV	Slow Moving Vehicles	Total Vehicles	Total PCU
DGP Office Junction	308	219	2127	3690	1481	16	1	28	297	8167	8429
Light House Junction	10	36	356	385	88	0	0	6	62	943	924
Beach Junction	3	140	320	775	73	0	0	0	36	1347	1203
Palavakkam Junction	173	76	828	1901	535	17	0	54	368	3944	3865

3.3 Speed & Delay Surveys

The speeds observed during peak hours are presented in **Table** below.

Speed – Delay Survey Results on the roads in the Available Routes

From	To	Length (Km)	Journey time(Min.)	Journey Speed (KMPH)
Dr. Radha Krishnan Road and Royapettah High road Jun	Light House Jun	1.80	5.25	20.57
Dr. Radha Krishnan Road and Royapettah High road Jun	Greenways road Junction (through Ramakrishna Math road)	3.10	11.25	16.53
Light House Jun	Santhome Church	0.60	2.50	14.40
Santhome Church	Greenways Road Jun	2.80	9.60	17.50
Greenways Road Jun	Besant Nagar road Jun	1.30	7.40	12.16
Besant Nagar road Jun	Annai Velankanni Church road	1.40	6.25	13.44
Annai Velankanni Church road	Thiruvanmiyur Jun	1.00	3.85	15.58
Thiruvanmiyur Jun	Kottivakkam Jun	2.80	6.90	24.35
Besant Avenue Road		1.8	9	20.0

3.4 Origin-Destination Surveys

Zoning system was adopted for the study in order to capture the possible movements along the proposed bypass. The study region was divided into 25 zones. The zone list and Estimated Movement wise traffic of the study area is shown in Table below. Various traffic movements are shown in Figure below.

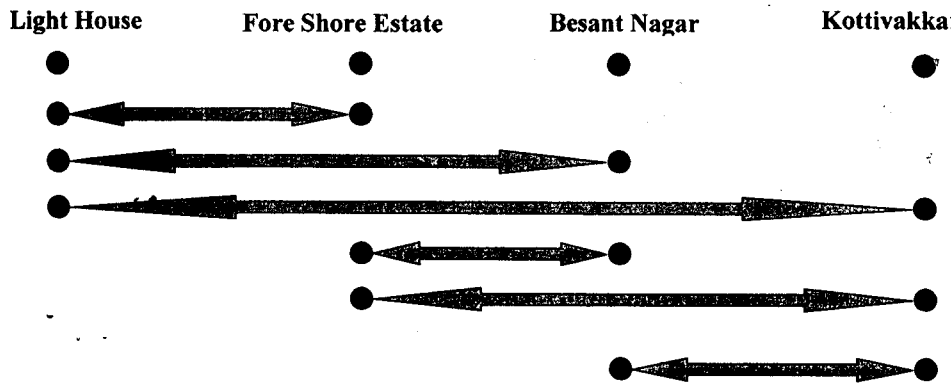
Zone List for the study area

Zone No.	Zone Description
1	Santhome
2	Santhome Beach
3	Foreshore Estate, Pattinappakkam, MRC Nagar and Srinivasapuram
4	Besant Nagar, Kalashethra colony and Shastri Nagar
5	Elliot's Beach
6	Ashtalakshmi Temple and Annai Velankanni
7	Thiruvanmiyur
8	Kottivakkam and Palavakkam
9	Adayar and Theosophical Society
10	Gandhi Nagar
11	Velachery, Tharamani, Tidal Park and Madipakkam
12	Injambakkam, Kovalam and other beach resorts along ECR and Mahabalipuram
13	Pondichery, Kanchipuram and other southern districts of Tamil Nadu
14	Nandanam, Saidapet, Kotturpuram and Guindy
15	Mylapore, Mandaveli, R.A Puram, Abhiramapuram and Music Academy
16	Alwarpet, Royapettah, Teynampet, Triplicane, Chepau k and Marina Beach
17	Parrys, George Town, Park Town, Chindadripet, Royapuram, Washermanpet and Tondiarpet
18	Purasavakkam, Egmore, Vepery, Perambur, Villivakkam, Annanagar, Aminjikarai, Chetpet, Nungambakkam, Avadi, Ambathur and Vyasarpadi
19	T.Nagar, West Mambalam, Vadapalani, Kodambakkam and nearby area
20	Other districts of Tamilnadu
21	Other States of India
22	Tambaram, Pallavaram, Chrompet and surrounding places
23	Thoraipakkam, Perungudi, Sholinganallur, Navalur and Kelambakkam

Estimated Movement wise Traffic

Movements	Origins	Destinations	Movements (No. of Trips)					
			Car	TW	Auto	LCV	MAV	Truck
Light House- Besant Nagar	16,17,18, 19	4,5,6	2674	6916	1423	91	4	139
Light House - Kottivakkam and beyond	16,17,18, 19	8,12,13	631	1929	161	91	3	239*
Fore Shore Estate to Besant Nagar	15	4,5,6	30	122	51	-	-	-
Fore Shore Estate to Kottivakkam & beyond	15	8,12,13	401	869	126	-	-	-
Besant Nagar – Kottivakkam and beyond	14,19,22	8,12,13	300	471	64	81	-	-

*(Note: *- trucks including coal carrying trucks from Chennai Port)*



Various Movements on the Proposed Elevated Road

3.5 Pedestrian count Survey

The pedestrian count was conducted at three locations. The count was taken up in the peak hours in the morning/evening. The summary of pedestrian count is given in the **Table** below. Since it is proposed to develop an elevated road for the entire length, no recommendations are made for pedestrian facilities along the road.

Peak Pedestrian counts

Sl. No	Road Stretch	Peak Hour	Pedestrians Along the Road	Pedestrians Across the Road
1	Elliots Beach Road	7pm- 8pm	3520	901
2	Santhome Beach Road	9.30 am- 10.30 am	1013	475

3.6 Parking Survey

Parking survey was conducted at three locations. The count was taken up in the peak hours. The summary of the parking survey is given in the **Table** below. Due to the same reasons listed above, no recommendations are made for parking also.

Summary of Parking Count Survey

Sl. No	Road Stretch	Peak Hour	Peak Hour Parking				
			Bus	Auto	Car	TW	Cycles
1	Elliots Beach Road (from Skating Ground to 5th Avenue)	7pm- 8pm	-	-	531	2560	177
2	Santhome Beach Road	6 pm- 7pm	9	135	152	644	117

3.7 Traffic Forecasting

3.7.1 Projection Based on Peak Hour Traffic

A peak hour factor of 8% is taken as observed on Thiru- Vi- Ka Bridge, to estimate the maximum traffic on the Section between Fore Shore Estate and Besant Nagar, as this section will carry the highest traffic. The peak hour traffic is also projected to the horizon year to verify the lane requirement based on peak traffic and is presented in **Table** below.

Projected Peak Hour Traffic on Section II

Year	Peak Hour Traffic (PCU)	Year	Peak Hour Traffic (PCU)
2006	1248	2018	2970
2007	1343	2019	3184
2008	1445	2020	3415
2009	1556	2021	3659
2010	1677	2022	3923
2011	1802	2023	4206
2012	1938	2024	4512
2013	2085	2025	4841
2014	2244	2026	5197
2015	2416	2027	5580
2016	2587	2028	5993
2017	2772	2029	6439

3.8 Recommendation

From the traffic projection and the growth potential along the corridor, it is proposed to have a six lane road from Foreshore to Besant Nagar and four lane road from Light house to Foreshore Estate and Besant Nagar to Kottivakkam with entry and exit ramps at Fore Shore Estate, and Besant Nagar.

4. Improvement Proposals

The improvement proposals are finalized based on the results of the surveys and investigations described in Chapters 2 and 3 and also based on the decisions taken during the discussions held with the client. As part of the study, the following two alignment options were studied for proposed elevated road from km 5/4 of Kamarajar Salai near Gandhi Statue to connect East Coast Road (ECR) at Km 14/6 near Kottivakkam. The proposed two alignment options are shown in **Figure 4.1**

1. **Option 1:** From Light House to ECR via Srinivasapuram, Oorur kuppam, Kottivakkam Kuppam along the Coast to Join ECR at km 14/6 (9.705 Km)

2. **Option 2:** From Light House to ECR via Srinivasapuram, Oorur Kuppam, Besant Nagar, 5th, 3rd, 4th 2nd & 7th Avenue, LB Road, along ECR via Tiruvanmiyur,terminates at km 14/6 of ECR near Kottivakkam(11.6km), along the existing road alignments for the entire length.

4.2.1 Alignment Approval

The above two alignment options were submitted to the Highways Department, GoTN during July, 2006 and approval for the section of Option 1 from Light House to Ururkuppam (5.0km) was given by Highways Department on 30.08.2006 ***(Letter No.11458/2006/D.1/dated 30.08.2006).*** Further to this, a joint site inspection was held with Superintending Engineer (H), Chennai Circle on August 16, 2006 to get the approval for the remaining sections and accordingly the stage II alignment between Ururkuppam to ECR along the coast was approved by Highways Department on 07.12.2006 ***(letter No.11458/2006/D1/dated 07.12.2006).***

Further to the getting approval for the alignment along the coast (Option 1), the draft feasibility report (DFR) was submitted on 12.04.2007 and the same was presented to the Chief Secretary on 06.08.2007 and this committee has also approved the Option 1 alignment along the costal line on 28.08.2007 ***(Letter No.14283/HW1/2007-3 dated 28.08.2007).*** The project after incorporating the suggestions

19.03.2008.

The project was also presented to the Hon'ble Chief Minister of Tamil Nadu on 16.04.2008. During the above meeting Hon'ble minister for PWD, Hon'ble minister for Highways, Chief Secretary, Finance Secretary, Highways Secretary, Chief Engineer (H), General and other officials from GoTN were also present. This committer has also decided to take up the improvement of Phase I from Light House to Besant Nagar on a priority basis. Snapshots of the presentation to the Hon'ble Chief Minister of Tamil Nadu on 15.04.2008 is shown in Plate 4.1

The comments and suggestions made during the above review meetings on the draft final report were incorporated in the final report and the same was submitted to Principal Secretary to Govt. Highways Department on 14.11.2008. Further to this there was a presentation to the Principal Secretary to Govt. Highways Department on 22.11.08. The revised final report incorporating the comments of Govt. was submitted to Chief Engineer (H), Metro on January 21, 2009.

Further to the submission of the revised final detailed feasibility report, presentation was given to the Chief Secretary, GoTN on 28.01.09. During the above review meeting Chief Secretary has requested the Housing & Urban development secretary to organize further review meetings to sort out the issue of alignment fouling with the proposed housing schemes by Tamil Nadu Slum Clearance Board under ETRP. Meeting was held in the Chamber of Principal Secretary to Government Housing Department on 30.01.09 and 09.02.09 organized by Housing Secretary. Another meeting organized by CMDA held on 05.02.09. During the above review meeting comments has been made to revise the alignment to have least disturbance to the proposed tenements by TNSCB. The revised alignment incorporating the suggestions made during the above review meetings was submitted to C.E (H), Metro on 18.02.09.

Further to this Steering Committee was held on 09.03.09 and committee suggested that the alignment may be suitably modified to shift the ramp away from the statues after taking minimum extent of land from DOP office in order to avoid shifting of statues located on the eastern side of Kamarajar Salai. The Principal Secretary, Highways and Minor Ports further asked to include the cost of land belonging to TN Slum Clearance Board in the Project cost. In the committee Deputy Commissioner of Police, (Traffic) Central District, Chennai felt that the clearance of 5.5m for the exit ramp may not be sufficient for accommodating the floats loaded with helicopters for the Republic Day Parade from Light House to Gandhi Statue. The Principal Secretary to Government, Highways and Minor Ports explained that when the floats with helicopters are transported from Tambaram and crosses the ROB at MIT Gate which has the same clearance, the Republic Day Floats can also cross the proposed elevated viaduct of obligatory span at Light House which will have a vertical clearance of 5.5m. The proposed alignment has been finalized considering all these suggestions

4.1 Design Parameters

Design Speed	Camber	Maximum Super elevation
100kmph/30kmph	2.5%	4%

4.2 Carriageway Width

Based on traffic projection, the entire stretch is divided in to the following three different homogeneous sections.

- Section I – Gandhi Statute to Fore Shore Estate
- Section II – Fore Shore Estate to Elliots Beach
- Section III – Elliots Beach to Kottivakkam

Four lane configuration is proposed for the Section I and Section III and six lane width is proposed for the Section II. Ramps with two lane configuration are provided at Foreshore estate and Eliot beach.

4.3 Horizontal Alignment

Horizontal Alignment should be fluent and blend well with the surrounding topography. The horizontal curves are designed as per IRC standards with sufficient transition lengths. The minimum curve radius adopted for ruling design speed of 100 Kmph is 360m and for design speed of 30Kmph is 40 m.

4.4 Vertical Alignment

Vertical alignment is designed based on the provision of IRC SP: 23. Details of rate of curvature and minimum curve length adopted are given in Table below. As per IRC_086-1983-Geometric Design Standards for Urban Roads 5.5m vertical clearance is ensured wherever vehicular movement needs to be permitted below the structure.

Minimum Length of Vertical Curves

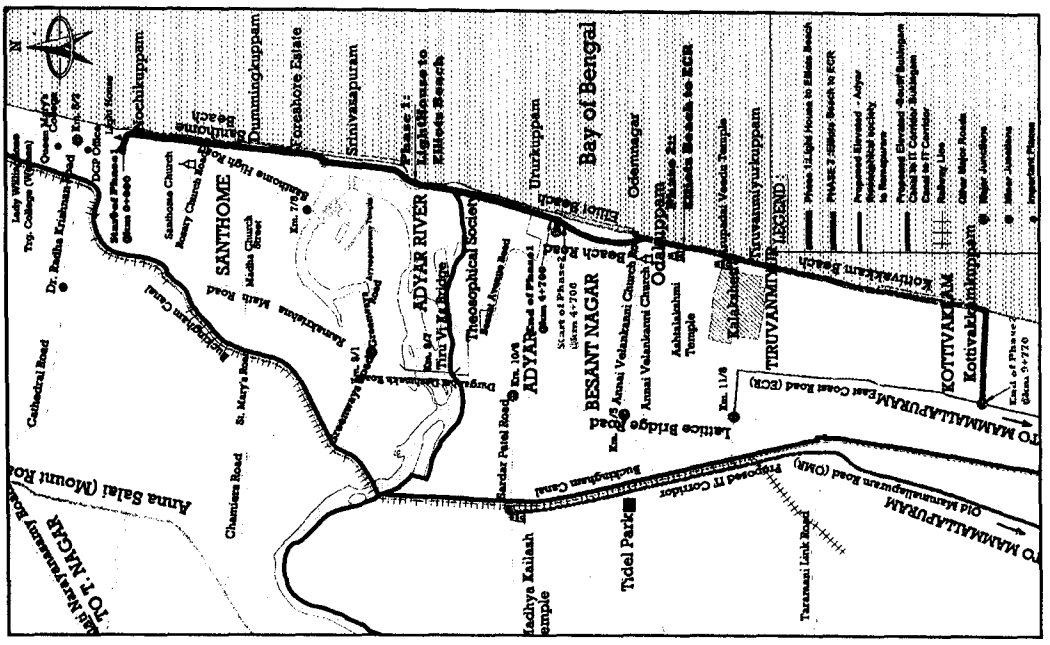
Design Speed (Km/h)	Maximum grade change (%) not requiring a vertical curve	Minimum length of vertical curve (m)	K value	
			Sag	Hog
30	1.5	15	2	3.5
65	0.8	40	19	18
100	0.5	60	64	42

4.5 Alignment Details

The alignment takes off at km 5/4 of Kamarajar Salai near Gandhi Statue.

- Entry Ramp starts about 120m to the South of Gandhi Statue and it's towards the western edge of Existing carriageway for 300m. Then Turns left to Beach road and go along its southern side and turns right to join the elevated Highway.
- The exit ramp terminates on beach road at 100m from the junction of Beach road to Kamarajar Road which is on the northern side of Road
- Then elevated section runs along the western edge of the existing Santhome loop road for a length of 1.9 km, passing through Nochikuppam, Dumming Kuppam, Bhavani Kuppam and Mulliamman Nagar, where it joins with the Fore Shore Estate road. Upto here the alignment length including the start ramps is of length 2.4km.
- The alignment further runs along settlements of Srinivasapuram along the western edge of the existing BT road upto Adyar River. Total length of this section of alignment between Santhome Loop road junction upto Adyar River is 0.7km
- The alignment crosses Adyar Estuary to the western side of the existing broken bridge, further runs along the existing single lane BT road upto Ururkuppam, where the alignment joins with the Besant Nagar 5th Avenue road near Elliot's beach. Total length of this section between Adyar Estuary and 5th Avenue road is 0.998 km.
- Total length of the alignment approved for Phase I is 4.7km of elevated structure with 5.5m vertical clearance. As the proposed alignment is entirely elevated, entry and exit ramp arrangements are provided at junction of project road with Fore shore estate road and Besant Nagar 5th Avenue Road.

Figure below will give the phasing arrangements



4.6 Right Of Way (Row)

According to lane requirement and social issues the proposed right of way required is formulated and presented in the **Table** below.

Proposed Right of Way (ROW)

Chainage (km) From	Chainage (km) To	Length (km)	ROW Width (m)	Section / Location
0+000	0+370	0+370	32.5	Approach Ramp and at grade roads in Kamarajar Salai
0+370	2+000	1+630	21.5 to 26.5	Elevated Corridor along Santhome loop road up to Foreshore Estate Road
2+000	3+055	1+055	26.5 to 40.0	Ramp location in Foreshore Estate. This is including the proposed two lane entry & exit ramp arrangements
3+055	3+240	0+185	18	After Ramp at Foreshore Estate upto to Adyar Bridge, along Srinivasapuram
3+250	3+529	0+279	20.5	Along bridge across Adyar River
3+529	3+670	0+141	18	After bridge across AdyarRiver
3+670	4+280	0+610	27 to30	From Adayar Bridge to Ramp at Orukuppam
4+280	4+640	0+360	35	Ramp Approach to Besant Nagar Junction

4.7 Pavement Design

Pavement design for at grade roads dealt as design of pavement for new construction. For the purpose of pavement design, the entire length of the service road is taken as a single homogeneous section. Details of Pavement Composition are given in **Table** below.

Proposed Pavement Layer Compositions for New Construction

Road Section		At grade roads	Service roads
Design Life		20 Years	20 Years
Design Traffic		25 MSA	05 MSA
Design CBR		8 %	8 %
Proposed Pavement Composition in mm	Wearing Course	40 BC	25 SDBC
	Binder Course	95 DBM	50 DBM
	Granular Base	250 WMM	250 WMM
	Granular Sub Base	200 GSB	150 GSB

4.8 Structural Schemes

The structural system consisting mainly of superstructure, substructure and foundation are planned based on the suitability of the same at the proposed location, constructability, degree of impact during construction on the beach goers and surrounding people, severe salinity of the atmosphere due to the proximity of sea, aesthetics, degree of hindrance to beach view etc. Accordingly, various options were planned for superstructure, substructure and foundation.

Criteria for finalization of structural type

The basic consideration in the planning and finalization of the structural scheme is to have least number of different types/arrangements to ensure speedy construction and to curb cost. Stretches with existing road at grade and the up/down ramps are also given due consideration in finalizing the structure type/locations. Suitable superstructure arrangement is proposed at the locations of entry/exit of ramps and their merging. Substructure type is mainly based on the locations of existing roads at grade and change over of stretches with and with out service roads at grade.

4.9 Design Methodology

Based on the topographical data and the data collected at site, the span requirement is studied. Span arrangement at each location is finalized for satisfying the functional requirement and also based on the subsoil characteristics at the location. Due consideration to the type of structure is given to ensure good aesthetics. General arrangement drawing is prepared after finalizing the type of structure. spans etc. Provision for up and down ramps is also provided as required.

Loading standards adopted

The structures are designed for loadings as per IRC 6: 2000. The basic loadings considered are

- Dead load constituting of self weight of structural members
- Superimposed dead load constituting of wearing coat, crash barrier, footpath and railing loads
- Live load constituting of loads due to IRC Class A vehicles or IRC 70R vehicles
- Wind load as applicable to the site based on the height
- Seismic load as per provisions in IRC code. Seismic zone II is considered for the design

Clearances adopted

Vertical clearance - 5.5m up to soffit of deck from the road at grade at locations of crossing.

5.5m up to the bottom of the pier cap where vehicles ply under the flyover at locations with restriction of available ROW.

Horizontal clearance - As per the junction requirement

Exposure Condition

Due to the proximity to the sea, severe exposure condition is adopted in the design.

Structural arrangement

Based on subsoil investigation report and site specific details, Post tensioned girders and PSC voided slabs are proposed as superstructure. Girder structure is proposed for straight stretches and voided slab structure is proposed at locations of merging of ramps with the main flyover. Hammer headed elliptical pier is proposed as substructure. Trestle pier is proposed as abutment piers on either end of the main flyover. Pile foundations with 4, 6 and 8 pile groups are proposed as per requirement.

Details of superstructure arrangements adopted is shown below in **Table** below **Superstructure Details**

Span length	Type of superstructure	Number of spans
Main Flyover		
35	Fish Belly	31
30	Fish Belly	7
25	Fish Belly	5
35	PSC I Girder	27
30	PSC I Girder	2
26.5	PSC I Girder	1
25	PSC I Girder	7
22.5	Voided Slab	2
20	Voided Slab	18
18	Voided Slab	1
17.5	Voided Slab	2
17	Voided Slab	2
15	Voided Slab	5
Ramp Section		

Span length	Type of superstructure	Number of spans
35	Fish Belly	6
35	PSC I Girder	13
30	PSC I Girder	3
25	PSC I Girder	3
22.5	Voided Slab	2
20	Voided Slab	54
19	Voided Slab	1
18	Voided Slab	4
17.5	Voided Slab	2
16	Voided Slab	1
15	Voided Slab	7

The proposed alignment passes the Adayar estuary and runs near the existing broken bridge between chainage 3+470 and 3+650. The existing bridge fouls with five pier points of the proposed elevated structure, which runs at a higher level than the existing broken bridge. Existing broken bridge at this location shall be dismantled.

5. Environmental Impact Assessment and EMP

Introduction

This section on Environmental Impact Assessment is organised in two specific components for the first phase of the project. The first component carries out the Environmental Screening of the project proposals vis-à-vis the base line environmental conditions and identifies the broad issues of environmental criticality. The second component then assesses the specific impacts of the proposed improvements and proposes mitigative measures for each of the identified impact.

The present study in this perspective looks at

- Assessing the impacts on environmental attributes due to the construction and operation of the proposed works along the phase I stretch of the proposed Santhome bypass and to prepare an Environmental Impact Assessment (EIA) Report.
- Preparation of an Environmental Mitigation Plan (EMP) recommending management measures to minimize the negative environmental impacts due to the project and to keep the unavoidable impacts to the permissible level under regulatory norms and also to outline the measures for improving the environmental quality.
- To prepare budgetary cost estimation for implementation of EMP

The EIA Report has been prepared according to the structure of the EIA Report presented in the EIA Notification, 2006 by Ministry of Environment and Forests, Government of India. The EIA is based on detailed field reconnaissance surveys, inventories and available secondary information. Based on all these activities the following conclusions are made.

The project is an elevated road network and the proposed stretches of Santhome bypass falls under CRZ II. Hence, it is required to obtain the environmental clearance from MoEF. The entire road stretch is located in Chennai along the coast of Bay of Bengal.

Baseline Environmental Profile of the Project Area

In order to assess the baseline environmental status of the project influence area, monitoring of various environmental attributes were conducted by the Consultants. In addition to the baseline environmental monitoring, field inspection at all the sensitive locations, collection of secondary information for all the environmental components and discussions with the officials, NGO's and local public were conducted by the Consultants.

Land use of the area is primarily of urban type as the study area is within the Chennai Metropolitan Development Authority (CMDA) area limits. The stretch of Santhome bypass under study in this phase is adjacent to the coast of Bay of Bengal. Some stretches of the road is very close to the sea (within 50m from the shoreline). The land use pattern was dominated by the presence of beach with some fishermen settlements.

As part of the baseline environmental monitoring, noise levels were measured at 2 locations and samples were collected from 2 locations for ambient air quality, 2 locations for ground water quality, 5 locations for surface water quality and 2 locations for soil quality along the project road. The

sampling locations were identified to capture the different land use and the sensitive receptors along the Stretch.

The ambient air quality monitoring results demonstrated mmaximum TSPM concentration as 180 $\mu g/m^3$ at Besant Nagar and also maximum concentration of SO_2 and NO_x was found as 8.6 $\mu g/m^3$ and 11.7 $\mu g/m^3$ respectively. CO was observed less than 114.5 ppm for all stations and HC less than 65 ppm for all stations.

Surface water quality at all the sampling locations showed high degree of alkalinity and also the presence of high chloride concentration represented the characteristics of typical sea water as the proposed road is very close to the sea.

High concentration of total hardness was recorded for all the stations in their ground water samples. The concentration exceeded the limitation prescribed by IS 10500 standard for drinking water. All other parameters were well within the drinking water standard.

The soil quality analysis results suggested that the soil was alkaline in nature with average electrical conductivity. Presence of organic matter was less. Considering NPK values, Nitrogen content was very less in S1 and good in S2, Phosphorus content was found to be less in all the two samples and ranged between 12 – 17 (Kg/ha) The presence of Potassium was very less in S1 and was found to be good in S2 and ranged from 90 – 247 (mg/100 gms).

Noise levels in all the locations monitored reflected the traffic noise being adjacent to the road. The observations of the noise monitoring indicated that all the values were within the standards set by the CPCB.

In order to study the aquatic ecology, surface water samples were collected from different location in the river and adjoining sea. The collected samples were preserved and analysed for the presence of the Phytoplankton and Zooplankton. From the analysis the phytoplankton population in the Adyar River showed a health environment than Adyar Creek and sea. The species like Cybbella Sp, Gyrosigma Sp, Pleurosigma Sp and Fragilaria Sp were dominant in the Estuary and the sea. Whereas the Species like Anabaena Sp, Microcyctis Sp, Oscillatoria Sp, Rivularia Sp and Ankistrodesum Sp, Euglena sp and Ceratium Sp showed their presence in the River. The common Zooplankton species like Ostracod Sp, Cyclops Sp, Vorticella Sp, Copepod Sp and Acartia Sp for the tropical water were observed in all the samples. The presence of the species network showed a healthy population in the surface water

Tree cutting is very minimal along the first bypass stretch, especially near the fishermen villages and mostly Coconut and Drumstick, Neem trees are the dominant species. No tree felling is envisaged as the trees will not fall under the carriageway; hence can be retained

The project stretches of the Santhome Bypass (Elevated Expressway) falls under the category of CRZ II as per the Department of Environment (DoE), Tamil Nadu. This is because the entire Chennai shoreline is classified under the CRZ II, due to the Urbanisation of the growing population. However no development is envisaged in the present project on the seaward side.

Assessment of Potential Environmental Impacts

The assessment of the environmental impacts has been estimated as an overall impact caused by the execution of the proposed Santhome bypass project under two phases. The specific impacts have been assessed over a 100 m wide corridor with respect to the centre line of the proposed road whereas the study area for assessing broader environmental impacts was considered to be an area within 5 km on both the sides of the centre line of the proposed road.

Positive Impacts: The potential positive environmental impacts due to project apart from its economic importance include the following.

- Reduced noise and air pollution - With the construction of proposed bypass, noise and air pollution levels are expected to go down in the urban areas where human exposure is more. Though there will be rise in pollutant levels in the proposed road alignment, the overall human exposure to noise and air pollution will be minimal due to less congestion.

- Reduced risk of accidents - The proposed alignment shall provide adequate safety measures and proper sight distances thereby resulting in reduced accidents. Moreover with expected decrease in overall traffic density due to increased road carrying capacity, the chances of accidents will reduce considerably.

- Improved accessibility and connectivity. - The accessibility and connectivity increases as it will reduce the time of travel between places in the city.

- Reduced vehicle operating and maintenance cost. - With advent of the expressway, the vehicle operating and maintenance cost is expected to go down substantially. These benefits can be attributable to smooth and even roads and low congestion.

- Savings in fuel consumption. - Savings in fuel consumption can be attributed to low congestion and relatively less travel time due to proposed improvements.

- Improved quality of life. The proposed project is expected to improve the quality of life of the people residing in the project zone in terms of their economic, social and health status. Land value in the nearby areas of the proposed alignment will increase substantially.

- Improved Aesthetics. - The overall aesthetics of the area shall improve with proposed landscaping and avenue plantation in the project stretch.

- Generation of local employment. Both skilled and unskilled labours will be employed during the construction stage of the project.

Negative Impacts: Some of the potential direct and indirect negative impacts of the project during construction phase will be the following.

- Filling in low-laying areas for embankments of the road

- Loss of topsoil due to clearing and grubbing of new alignment, borrow area and quarry operation, construction of camps and material stacking yard
- Temporary impacts on flora and fauna due to the construction activities. The proposed construction activity has significant impact on fauna. The proposed site is known for the breeding ground of Olive Ridley Turtle (Green Turtle). The construction activities will have major impact on the turtle breeding.
- The first phase of the proposed road project crosses the marine environmental sensitive place of Adyar estuary. The estuary is also name demarcated as bird sanctuary by the Tamil Nadu Forest Department. Noise generation arising during the construction activity will drive the birds away and cause an ecological imbalance to the estuary and the fish population.
- Temporary impact on the drainage pattern due to embankment, culvert and bridge constructions
- Impact on traffic management system
- Increased air pollution (including dust) due to the movement of vehicles and construction activities
- Increased noise levels due to the movement of vehicles and construction activities
- Increased soil erosion leading to loss of top soil and pollution of surface water bodies such due to run offs from construction sites
- Spillage of oils and other hazardous materials leading to pollution of surface and sub-surface waters.

Some of the potential direct and indirect negative impacts of the project during operation phase are the following.

- Increased noise pollution due to the vehicular movement
- Impact on natural drainage pattern of the project area
- Pollution of water bodies and impacts on its ecosystem due to hazardous chemical or oil spillage into the canals and streams.

Mitigation of Impacts and Environmental Management Plan (EMP)

To mitigate the impacts during construction and operation stages of the project, an Environmental Management Plan has been prepared. An Environmental Monitoring Plan has been prepared as part of the EMP to evaluate the efficiency of implementation of mitigation measures recommended in the EMP and facilitate management decisions for the first phase of the project. The EMP shall be included in the contract document of the project for implementation by the contractor under supervision of the Construction Supervision Consultant and Project Implementation Unit (PIU).

The cost of implementing above mitigation measures is established in the table below. The construction cost for the first phase of the project stretch is estimated to be Rs. 37.14 lakhs and the operational cost is estimated to be Rs. 84000.

Cost Estimates for Environmental Management Plan

Sl No	Activities	Assumption	Cost in Rupees
Construction phase			
1	Provision of Sewage and sanitation facilities for the construction camps, including maintenance for 1 year	Lump Sum	1,000,000.00
2	Provision of Water Supply Facilities for the construction camps	Lump Sum	560,000.00
3	Environmental Monitoring		
3.1.	Air Pollution Monitoring	Rs. 3000/- per location * 3 locations (based on settlement)* 1 days/ month * 4 seasons for fugitive sources.	36,000.00
3.2.	Noise Monitoring	Rs.1000/- for 24 hours * 1 day/month *3 location * 4 seasons	12,000.00
3.3.	Water Pollution Monitoring	Rs. 3000/- per sample* 3 locations/month * 4 seasons	36,000.00
3.4.	Mobilisation Charges	Rs. 45000 /- per season * 4 seasons	1,80,000.00
4	Dust Suppression at site	Rs.500/- per trip *10 trips a day/ 1 year	1,825,000.00
5	Severances and Others (Including Training)	Lump Sum	65,000.00
Total Cost during Construction Phase			**3,714,000.00**
Operation Phase			
1	Environmental Monitoring		
1.1	Air Pollution monitoring	Rs. 3000/- per location * 3 locations (based on settlement)* 1 days/ month * 4 seasons for fugitive sources.	36,000.00
1.2	Noise Monitoring	Rs.1000/- for 24 hours * 1 day/month *3 location * 4 seasons	12,000.00
1.3	Water Pollution Monitoring	Rs. 3000/- per sample* 3 locations/month * 4 seasons	36,000.00
Total Cost during Operation Phase			**84,000.00**

Environmental Clearances for Contractor

Apart from the CRZ clearance from MoEF, for overall project works, the following statutory requirements have to be complied by the contractor before and during the execution of the proposed work as presented in the table below

Environmental clearance required during construction

Sl.no	Construction activity for which clearance is required	Statutory authority	Statute under which Clearance is Required
1	Hot mix plants, Crushers and Batching plants	Tamilnadu State Pollution Control Board	Air (P & CP) Act, 1981
2	Discharges form construction activities	Tamilnadu State Pollution Control Board	Water (P&CP) Act, 1974
3	Storage, handling and transport of hazardous materials	Tamilnadu State Pollution Control Board	Hazardous Wastes (Management and Handling) Rules. 1989 Manufacturing, Storage and Import of Hazardous Chemicals Rules, 1989
4	Sand mining, quarries and borrow areas	Department of Geology and mining, Govt of Tamilnadu	Tamil Nadu Minor Mineral Concession Rules, 1959 (corrected up to 31.3.2001)
5	Disposal of bituminous wastes	Tamil Nadu State Pollution Control Board	Hazardous Wastes (Management and Handling) Rules. 1989
6	Felling of trees[#]	Department of Environment and Forest, Govt of Tamilnadu	Forest (Conservation) Act, 1980

Conclusions and Recommendations

Significant adverse impact anticipated due to the proposed project is the disturbance of breeding of Olive Ridley Turtles along the beach. However, this can be avoided by restricting the construction during the breeding season.

Temporary impacts are anticipated on air quality, noise levels, water quality, soil quality, flora & fauna and socio-economic environment of the project area. Further, an increase in ambient noise level is expected along the project road during the operation stage.

Proper mitigation measures are proposed in the EMP for mitigating the negative impacts. The environmental monitoring plan and reporting mechanism proposed as part of the EMP will ensure the proper implementation of the EMP. Thus the overall benefits of project outweigh the negative impacts of the project.

6. Social Assessment and Rehabilitation Action Plan

6.1 Introduction

This section summaries the R&R issues and the Social Cost involved in the Phase I .This phase starts from Kamaraj Salai near Light House to Oroor kuppam at Besant Nagar- Km 0/0 to Km 4/700 with the main objective of identifying the locations of social sensitivity and to assess the social feasibility of the phase-I of the project

[#] No Tree felling is envisaged as the trees are not falling along the proposed RoW; if any tree felling is to be done during implementation stage contractor should o

6.2 Project Area Profile

Administratively, this phase of the project road falls in Chennai district in the state of Tamil Nadu. The proposed alignment takes off at km 5/4 of Kamarajar Salai near the Light House, passes along the Kamarajar Salai for about 200m, joins the existing Santhome loop road passing through Nochikuppam, Dumming Kuppam, Bhavani Kuppam and Mulliamman Nagar, and joins with the Fore Shore Estate road. From this junction the alignment run along settlements of Srinivasapuram upto Adyar River crossing Adyar estuary to the distance of 600m to the western side of the existing broken bridge. And further it runs through the eastern side of the Theosophical Society campus passing through Ururkuppam and joins Elliot Beach road. Population of the project area is 1.009 lakhs, which is hardly 0.162 percent of the total state population and urbanization rate in the project area is 100%. The Project area shows higher literacy levels for general at 77.37 % and female literacy level(47%) is less as the project area is along the coast and habituated by the fishermen community.

The project area has a main workforce participation rate of 94 percent which is very higher compared to state average of 38 percent and district average of 31.78. The project area has a large proportion of (64.22 percent) of population as non workers, a value higher than that for the state at 55.33 percent.

Chainage wise Settlements & Landuse along Project Road:

From	To	Terrain	Name of Village/Town	Landuse
Phase-I				
0/000	1/500	Plain	Nochi kuppam	Residential
1/500	1/800	Plain	Dumming kuppam	Residential
1/800	2/300	Plain	Rajiv Gandhi nagar, Mullaimanagar & Nambikkai nagar	Residential
2/300	3/100	Plain	Srinivasapuram	Residential
3/100	3/600	Plain	Adyar river	Water body
3/600	4/300	Plain	Uroor kuppam	Open land
4/300	4/600	Plain	Uroor kuppam	Residential

6.3 R&R process

Principles and objectives governing resettlement:

Addressing legitimate concerns of relevant stakeholders, especially project affected persons.

Avoiding or minimizing resettlement and rehabilitation due to land acquisition and transfer of government land under different tenure system through appropriate technical and management measures.

Ensuring appropriate resettlement and rehabilitation of project affected persons irrespective of legal status with a view to provide sustainable livelihood options that at least restore, if not improve, their standard of living.

Protecting the marginalized and vulnerable groups, including economically and socially disadvantaged.

Compensation and assistance: In general terms, the PAPs under the project will be entitled to five types of compensation and assistance: (i) Compensation for loss of land, (ii) Compensation for structures (residential/commercial) and other immovable assets; (iii) Assistance for loss of

business/wage income; (iv) Assistance for shifting; and, (V) Assistance for re-building and/or restoration of community resources/facilities.

6.4 Assessment of Land Acquisition

Resettlement Action Plan (RAP) document describes the principles and approach to be followed in minimizing and mitigating negative social and economic impacts of the project.

Considering the huge traffic flow in the existing roads the proposed elevated alignment is designed with ROW of 18m and by providing entry and exit ramps at 3 locations. A signature bridge is been proposed to the western side of the broken bridge for the connectivity. Junctions at Kamarajar Salai and East Coast Road are improved. ROW details of the existing roads where the proposed alignment pass on can be ascertained by the department.

A broad landuse is already identified and based on that, total land area to be acquired is estimated. Additionally, a detailed structure count was undertaken to know the category wise number of affected structures.

. Based on the field reconnaissance and detailed walk through, the loss categories broadly identified are:

- Loss of Land
- Loss of Structures
- Loss of livelihood / trade / occupation
- Loss of Tenure

Loss of Land

As the entire Elevated alignment runs on the existing roads (owned by Highways and Chennai Corporation) only land alienation has to be carried out from the respective departments like Tamil Nadu Police Head Quarters, Tamil Nadu Slum Clearance Board apart from the government Poromboke land for this project. Land alienation has been worked out in order to provide the entry and exit ramp facilities to the proposed elevated alignment. It is estimated that 46,393 sq.m (4.64 hectares) of land to be alienated from the other departments for the Proposed elevated highway

Loss of Structures

Impact on various types of structures has been identified such as residential, commercial, community structures.

Phase-I		
	Nos	**%**
Residential	928	96.1
Commercial	19	2.0
Religious	8	0.8
Public Utility	11	1.1
Total	**966**	**100**

Impact on Livelihood/ Tenure

There are 27 commercial establishments found affected at East Coast Road where the proposed elevated alignment meets. An average of two employees per establishment would be affected due to

the proposed improvement. The exact number of employees whose livelihood would get affected is to be arrived at the time of implementation.

6.5 Public Consultation and Information Dissemination

To ensure that people's concerns are incorporated in the project design and to promote public understanding about the project and its implications, public consultation and information dissemination is treated as a two way process where the information is passed on to the public and their feed back is sought to understand their issues at the project preparatory stage itself. The major key stakeholders who participated in consultations at various stages include all Project Affected Families/Persons (PAF/Ps); elected representatives, Community leaders of PAPs, representatives of CBOs; designated staff of Project Management Unit (PIU); DC / officials from DC's office and local Revenue officials; and representatives of local NGOs.

The consultative process is continuous through out the project period – design preparation, project initiation, project implementation and post implementation periods. In the project preparation stage the information gathered from field surveys are incorporated in the design phase of the project and preparation of RAP. At this stage methodologies used for public consultation and information dissemination includes reconnaissance survey; Focus Group Discussions; and public consultations.

FGDs were conducted at fishermen settlements to know about their perceptions and views about the project.

6.6 Institutional Framework

The implementing authority would have an Environmental and Social Development Unit which will undertake the revalidation of RAP before the start of RAP implementation and will engage services of Project Consultant (PC) for the same.

RAP Implementation

R&R Cell will be established as a part of PIU, and a District Resettlement and Rehabilitation Officer (DRRO), for the project district will be appointed to R&R Cell. DRRO will assist PD in all land acquisition and resettlement activities for the project implementation. Highways Department, GoTN will be the Executing Agency (EA) for project.

Implementation Schedule: Implementation of RAP will include land acquisition, and Resettlement and Rehabilitation (R&R) activities. The implementation process will cover (i) identification of cut-off date and notification; (ii) verification of properties of PAPs and estimation of their type and level of losses and distribution of identity cards; and (iii) Relocation and resettlement of the PAPs. It is assumed that implementation will take minimum 6 months to hand over land for civil works. No civil works should begin until all PAPs receive the approved compensation package.

Monitoring and Evaluation: RAP implementation will be closely monitored to provide Project Implementation Unit (PIU) with an effective basis for assessing resettlement progress and identifying potential difficulties and problems. For monitoring and evaluation (M&E), the PIU will appoint an independent agency to undertake external monitoring of the entire project.

6.7 RAP Budget

RAP budget, can be broadly subdivided into following three subsections:

(a) Assistance for Loss of Land

(b) Assistance for Loss of Structures, Assets & Developed Area within Resi/Com. Plots

(c) R&R Implementation

Final RAP Budget –Phase – I

Total budget-Phase I	**Rs.p**	**Rs.in crores**
Compensation-Land	193809690.00	19.38
Compensation-Structure	105573993.75	10.56
Compensation R&R	0.00	0.00
Total	**299383683.75**	**29.94**
Solatium 30%	89815105.13	8.98
Establishment charges 10%	29938368.38	2.99
Contingency 3%	8981510.51	0.90
Supervision 1%	2993836.84	0.30
Grand Total	**431112504.60**	**43.11**

7. Project Cost Estimate

The project cost estimate chapter deals with the derivation of cost for Phase 1 from Light house on Kamarajar Salai (Beach Road) to Besant Nagar of length 4.7km long elevated corridor road The project cost is arrived based on the on the improvement proposals and quantities thereof. The unit rates arrived for the construction of a new elevated link road is adopted for arriving at the project cost, is arrived using Standard Data book of MoSRT&H after considering Market rate of material, PWD labour rate and Lead for different material.

Basic rates for material and labour have been adopted from Tamilnadu PWD schedule of rate 2008-2009. For items not covered by PWD schedule of rate, local market rates were considered.

7.1 Total Project Cost

As discussed in Chapter 4, the project costing is given in Table 7.1.

TABLE 7.1 SUMMARY OF PROJECT COST

Tentative Project Cost for Phase I - Light House to Oorurkuppam near Elliots Beach (4.7 km)	
Item Description	**Cost (Rs. Crores)**
Elevated Corridor	377.0
Signature bridge across Adyar Estuary (250m)	32.0
Road works including junction improvements	8.0
Drainage and protective works	4.0
Road Furniture (Traffic signs, markings and other Appurtenances)	0.5
Shifting of utilities	2.0
Street Lighting & High Mast Lighting	1.5
Land Acquisition and Social cost	43.1
Environmental Mitigation Cost	0.4
Total Project Cost	**468.5**
Say, Rs. 469 Crores	
Provision of interchange to connect the proposed Adyar river bund corridor (Optional)	40.0

8. Economic Analysis

8.1 Introduction

The objective of the cost benefit economic analysis is to identify and quantify the benefits and costs associated in developing a new bypass from Light House to Kottivakkam/Palavakkam on ECR in Chennai City, in order to select the optimum solution along with the economic viability in terms of its likely investment return potential. In broad terms, the society costs pertaining to the highway development, to be considered in this analysis include (a) agency cost and (b) road user cost.

8.2 Upgradation Proposal

The analysis period of the project is taken as 35 years from the base year 2006 for different sections of the project road as follows:

- Base Year 2006
- Construction period – 2009 to 2010
- Project opening for traffic – 2011
- End of the analysis period –2040
- No. of operating years after project improvement, considered for economic analysis – 30 years

Thus, 30 years of operation, in effect, from the start of the proposed project road i.e. 2011, has been considered for economic evaluation for the project road.

8.3 Conclusions and Recommendations

Phase I for the construction of Santhome bypass is found to be economically feasible, considering its positive values of feasibility criteria (EIRR and ENPV) at normal scenario with EIRR of more than the minimum required level of 12%.. Under the worst scenario of sensitivity analysis, Phase I is found to EIRR with more than 11%.

Hence from the economy feasibility point of view, it is recommended to develop the bypass from Light House to Oorurkuppam near Besant Nagar under Phase I with the recommended lane configuration.

Chapter 1 : Project Background

Contents

Figure List

1. INTRODUCTION

1.1 Background

Chennai is one of the four major metropolitan cities in India and is the largest metropolis in South India. The total extent of Chennai Metropolitan area (CMA) is 1177 sq.km of which the main City comprises an area of about 172 sq.km. The total population of CMA was about 64 lakhs in the year 2001, and Chennai city alone accounts for 42 lakhs. The population level of CMA is expected to reach 75 lakhs by the year 2011.

Government of Tamil Nadu (GoTN) has formed a Beach committee to improve the existing beach along the east coast by enhancing the aesthetics and other facilities also to decongest the existing traffic along the marina beach. As part of the enhancement measures, Beach committee now intends to construct a link road from Light house on Kamarajar Salai to Besant Nagar (Via) Santhome Byepass, Sreenivasapuram, and Ururkuppam including reconstruction of a high level bridge across Adyar Estuary to join ECR.

1.2 Need for the Study

1.2.1 Existing Situation

Residential/ historically important places such as Adyar, Besant Nagar, Thiruvanmiyur, Kottivakkam and Palavakkam are the major traffic attracting areas on south Chennai along the east coast. The famous Marina Beach, Santhome beach and Elliot beach are located along this corridor, which attract huge traffic during weekends. Also, the famous Ashtalakshmi Temple and Shrine of Velankanni are the major religious centres along the coastal corridor.

The traffic from places such as Chennai port, Parrys corner, Secretariat and Marina Beach to reach the above mentioned places located on the southern side is at present using Kamarajar Salai, Santhome High Road, Green ways road, Durgabhai Deshmukh road and Lattice Bridge road. Total length of the present route through the above roads is 6.8 km and the traffic congestion is heavy during the peak hours. The section between DGP office Junction (Km 5/2) and Greenways Road junction (9/1) through the Santhome high road is heavily congested during peak hour as the road is of two lane configuration.

The traffic bound to Adyar and places down South from Kamarajar Salai, Rama Krishna Mutt Road and Greenways Road has to cross the Thiru- Vi-ka bridge across river Adyar, as no other alternate crossing across River Adyar is available in the near locality. Hence the bridge is heavily congested during peak hours. Also the presence of famous Santhome Church and four major schools generate more traffic and heavy pedestrian movements makes the situation worse during the peak hours on these roads. Apart from this, the traffic bound to ECR from the city also have to detour this route, adding more traffic congestion. Due to heavy traffic on this route, major junctions are signalised and road stretches are made one ways to manage traffic, increase travel time on these routes. It is observed that the journey speed along this route during the peak hour is about 20 KMPH.

Traffic bound from places in the north of Adyar River to IT firms such as Tidel Park, SIPCOT Information Technology Park and other educational institutions located in South Chennai along the "IT CORRIDOR" also use the Thiru Vi Ka Bridge to cross the Adyar River which also adds more traffic on this link.

1.2.2 Project Road- Better Link to Adyar/ Besant Nagar

As the widening of the above roads on these routes is not possible as the present route is passing through thickly populated areas and land required for upgradation is restricted. The development of a

new bypass road along the sea shore including the reconstruction of a bridge across Adyar Estuary will ease traffic congestions on the existing traffic corridor, especially on Thiru Vi Ka bridge and nearby areas. Also the proposed road will act as a bypass to the existing Santhome High Road, Greenways road and ECR from city centre.

Considering the above problems and in order to decongest traffic on Santhome high road and LB road, Beach committee has decided to form a new link road connecting Kamarajar Salai on the north and ECR on the south by making use of the existing 2.0km long Santhome Loop Road from Light house up to Foreshore estate. Key map of the project area including the proposed alignment is shown in Figure 1.1.

In this connection, Highways Department, GoTN has retained the services of M/s Wilbur Smith Associates Private Limited (WSAPL) to prepare Detailed Feasibility Study Report (DFR) for the formation of the above link road.

1.3 Objective of the Study

The primary objectives of the study are:

- To establish the technical, economical, environmental, social and financial viability of the project
- To prepare detailed feasibility report including the preliminary Environmental and Social Management Plan (ESMP).

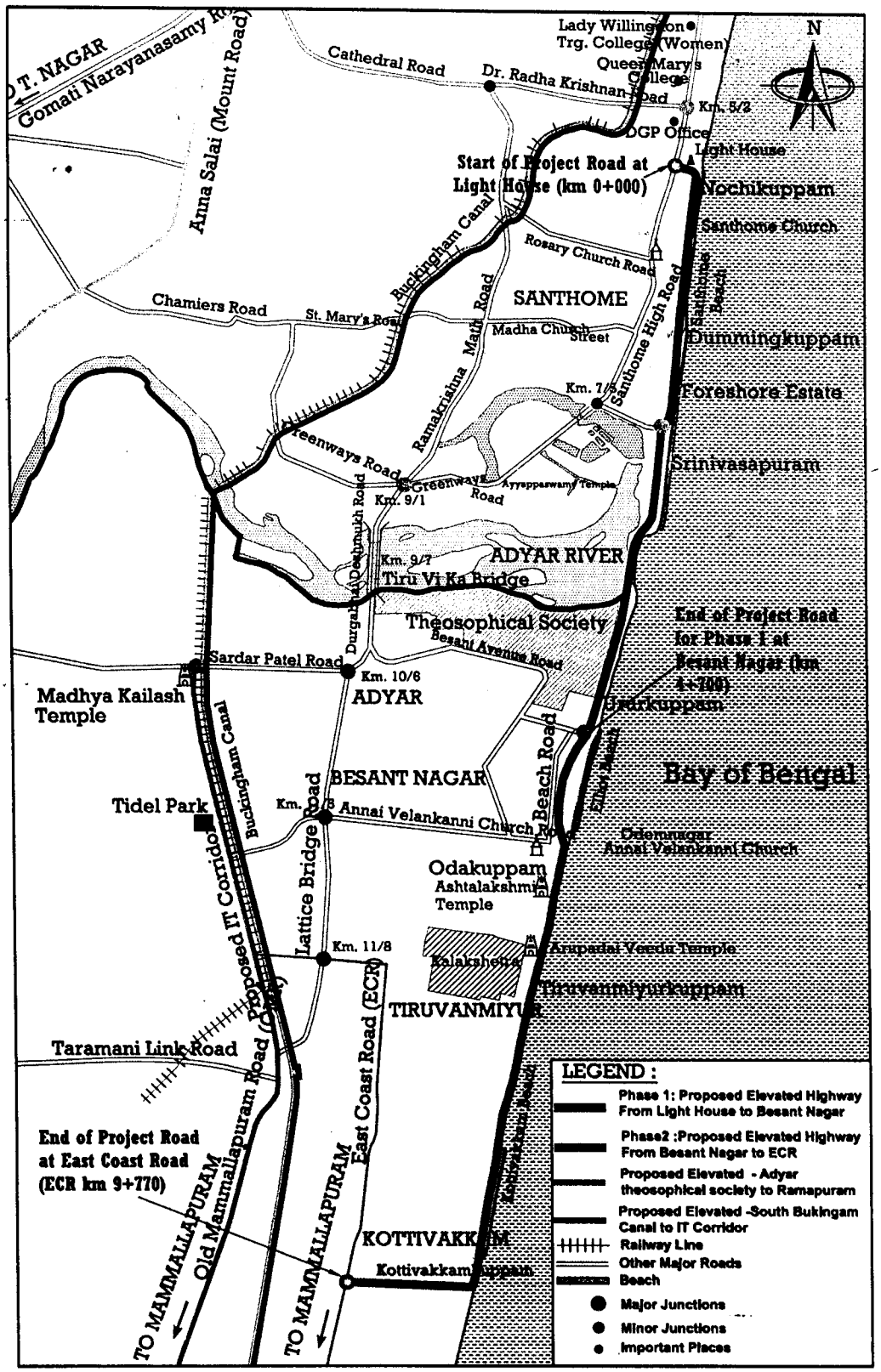


Figure 1.1: Key Map of the Project Area

1.4 Scope of the Consultancy Services

In order to achieve this objective, the feasibility study will address the following in particular.

- Collection of all Secondary Data & Review of data and documents related to the project roads and project influence area.
- Detailed reconnaissance Survey to study the existing situation in terms of engineering, environmental and social aspects
- Inventory and condition surveys for existing road, pavement, cross drainage structures and bridge
- Study of different alignment options including the Identification of possible improvement of the existing alignment
- Identification of problem areas, where formation of new link may not be possible for physical / environmental / social constraints within the parameters of ToR.
- Environmental and social screening to select the better alignment option.
- To carryout traffic volume count surveys for 7 days period on major link and 3days at other study area locations including OD surveys at two important locations at the present routes to estimate the possible diversions on the proposed link road.
- Parking surveys where predominant parking exists and pedestrian count at major built-up and busy areas
- Traffic demand forecasting for the next 20 years and Capacity Assessment based on IRC 64-1990
- Detailed Topographical Survey to collect and map the existing features along the proposed alignment
- Pavement Investigations including the necessary test to find out strength of the soil
- Geotechnical investigations for the proposed bridges at the appropriate locations
- Preliminary design of horizontal and vertical alignment including cross sections, Pavement Structure, Intersections, cross drainage structures and bridges, flyovers, interchanges, railway over bridges, user oriented facility along the road (road side amenities), road and other appurtenances.
- Preliminary design of complete drainage system and disposal point for storm water
- Traffic growth and traffic projection for next 15 years for different homogeneous sections of the project road
- Carry out preliminary design for each of the component of the road, bridges approaches, embankments, junctions etc., and prepare alignment plans, longitudinal sections and cross sections.
- Environment impact assessment, Environmental Management plan and Rehabilitation and Resettlement studies meeting the requirements of the prevailing act
- Prepare block cost estimate for the different project options incorporating the estimate for shifting of Service utilities (EB, Waterline, Drainage line etc.,) of all types involved from the concerned department.
- To carryout the social survey and analysis to assess the broad social impacts of the project, identify social issues of concern due to acquisition of land. Social Assessment study should also aims at identifying the impacts on the possible Project Affected People (PAPs).

- To identify all types of necessary clearance required for implementation of the project from the concerned agencies.
- Economical and financial viability of the project

1.5 Project Phasing

The draft feasibility report was submitted to the Highways Department during April, 2007 and further to this review meetings were conducted by the review committer on 06.08.07, 19.03.08, 16.04.08 and 22.11.08. During the above review meetings considering the availability of existing roads along the proposed alignment, it is proposed to implement the project under the following two phases:

Phase1 Reconstruction of existing road with Elevated Corridor from Light House to Besant Nagar near Ururkuppam including provision of entry & exit ramps near Foreshore estate road junction and reconstruction of existing bridge across river Adyar with "Signature bridge". (4.7km). This phase will also include necessary arrangement for linking with Phase 2 at Besant Nagar Junction in due course.

Phase 2 Construction of Elevated Corridor from Besant Nagar to East Coast Road (ECR) along the coast by making use of the existing road alignments

The Final feasibility report is also prepared for two phase's separately and this report discusses only on the Phase 1 of the project.

1.6 Report Organisation

The final feasibility report is structured into two volumes namely Volume I: Main Report, and Volume II: Drawings.

The Volume I, Main Report is presented in eight chapters and is detailed below:

- Chapter 1: **Introduction.** It describes the background of the project, need for the study objective and scope of the work, including the proposed phasing of the project.
- Chapter 2: **Surveys and Investigations.** This chapter describes the various surveys and investigations carried out by the consultants. Various surveys include topographic surveys, pavement and soil test pits and geotechnical investigations.
- Chapter 3: **Traffic Studies and Projections.** It deals with the existing traffic scenario and traffic projections. It includes various traffic surveys conducted along the project location and the analysis including the traffic forecast.
- Chapter 4: **Project Improvements Proposals.** This chapter describes various alternatives studied before finalising the proposals. The detailed analysis of pros and cons of each alternative is studied and consultants' proposal for implementation is described in this chapter.
- Chapter 5: **Preliminary Environmental Assessment and Environment management Plan.** This chapter deals environmental screening, base line environmental conditions, impact predictions and environmental management plan.
- Chapter 6: **Preliminary Social assessment and Rehabilitation Action Plan.** This chapter identifies key social issues relevant to the project, social screening, identification of stakeholders and project affected population. It also recommends specific action to be taken with regard to the Rehabilitation Action Plan.

- Chapter 7: **Project Cost Estimates**. It deals with the summary of project cost estimates for different project alternatives and proposed project scheme.
- Chapter 8: **Economic and Financial Studies**. This Chapter deals with the economic studies for different project alternatives and detailed financial analysis and for the final project proposals.

Volume II, Drawings consists of the following drawings:

- Location Map
- Plan and Profile
- Typical Cross sections
- Junction Drawings
- Road Furniture
- Structural Drawings
- Standard Drawings

Chapter 2 : Surveys & Investigations

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2. SURVEYS & INVESTIGATIONS

2.1 General

Surveys and investigation plays an important role in any project. The field surveys and Investigations aim at generating adequate database for preparing the most appropriate proposal to meet the functional and structural requirement of the project. Surveys and investigations were carried out as per the MOSRT&H / IRC / BIS codes and other relevant guidelines and specifications.

The various surveys and investigations, which have been carried out, cover the following

- Traffic Surveys
- Road Inventory Survey
- Pavement Condition Survey
- Topographical Survey
- Geotechnical Investigations

The following sections describe the conduct of the surveys.

2.2 Traffic Surveys

Various traffic surveys conducted and its analysis is described in Chapter 3: **Traffic Studies & Projections**. The assessment of base year (2005) traffic characteristics of the project road is essential for the selection of improvement Programmes on the road. It is also necessary to estimate the possible diversions from other alternate roads once the road will be improved. In this regard, the following traffic surveys were carried out:

- Parking Surveys
- Pedestrian Count Surveys
- Journey Speed and Delay Surveys
- Junction Turning Counts
- Origin Destination Surveys (OD-Surveys)
- Classified Link Traffic Counts

The traffic surveys were conducted in accordance with IRC SP19-2001.

2.3 Road Inventory Survey

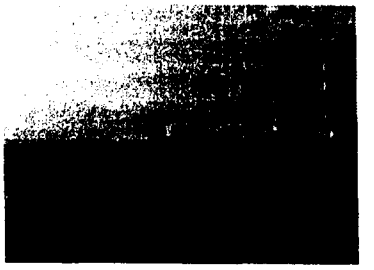
The project stretch inventory was aimed at collecting available information and recording observed data for the road and structures so as to assess the existing status viz. nature of terrain, land use, road features, their condition and visible deficiencies so as to decide the extent of improvement required for the project stretch to conform it to the formulated design standards.

An inventory of project stretch has been prepared through dimensional measurement and visual inspection. The detail collected includes the following:

- Project Stretch Details
- Terrain Type
- Width of Carriageway, Shoulder & Right of Way (ROW)
- Location and details of junction
- Road Side Land Use and location of built-up sections
- Utility details
- Possible alignment options for the connecting existing alignment with ECR

The details collected from the road inventory survey are presented in **Annexure 2.1**.

2.3.1 General



Project Stretch

The existing Santhome bypass takes of from Kamarajar Salai at Km 5/6 near Light house and passes through Nochikuppam, Dumming Kuppam, Bhavani kuppam, Mullaiamman Nagar upto Foreshore estate and then the alignment joins back with the Santhome High Road at km 7/5. Total length of this section between light house and Fore shore estate is 2.0km and generally runs through the fisherman kuppam and slum clearance board housing colonies on the RHS and beach activities on the LHS.

The section of the road between Foreshore estate junction and mouth of the Adyar River is running entirely through Srinivasapuram and at present it is under the maintenance of the Chennai Corporation. The alignment from this point is discontinuous due to the broken bridge across river Adyar. The width of river crossing is about 400m as the river joins with Bay of Bengal at this point. From this point the alignment is running through the existing single lane carriageway on the east of the Theosophical Society campus and running through Ururkuppam before it joins with Elliot Beach road. From this point the alignment is running through the existing Elliots Beach corporation road and terminates at Annai Velankanni Church near Besant Nagar and is not having a proper link to join with ECR.

Santhome Bypass (Light House to Fore Shore Estate)

The existing 2.0km long Santhome byepass between Light House and Foreshore Estate is having a uniform undivided four lane carriageway and the width of carriageway varies from 10m to 13.7m. Footpath of 2.8m wide is available on the sea side (LHS) and it is absent on the RHS. The available ROW in this section is 20m with settlements is absent on the RHS and coastal line on the LHS. The entire 2km section is running at the ground level.

Srinivasapuram Section (Fore Shore Estate upto Adyar Estuary)

This section is about 1km long and the existing road configuration is having only a two lane carriageway with 6.0m wide carriageway and 1.0m wide earthen shoulders on either side. The available ROW of this section is about 10m with pucca structures on the RHS and kutcha huts of fisherman's on the LHS.

Olcot Ururkuppam Section (Adyar Estuary upto Elliots Beach)

This section is about 1.1km long and having only a single carriageway of width 3.5m for the entire length.

Table 2.1: List of Town/Village/Tourist Spot along the Road

Sl. No	Name of the Town/Village/Tourist Spot	Location
1	Nochikuppam	Km 0/2
2	Foreshore Estate	Km 2/0
3	Srinivasapuram	Km 3/0
4	Theosophical Society	Km 4/0
5	Ururkuppam	Km 5/1

2.3.2 Terrain

The entire corridor passes through plain terrain as it is along the coastline.

2.3.3 Carriageway & Shoulder

The existing road is of bituminous type for the entire section and the width of carriageway varies from 2.5 to 10.0 m and details of the carriageway width breakup are given in **Annexure 2.1.** Earthen shoulders of 1.0 m to 2.0m wide are available on either side for small stretch; however paved shoulder of 1.0 m to 4.0 m is available for large portion. It is observed that, existing shoulder is under poor condition.

2.3.4 Right of Way (ROW)

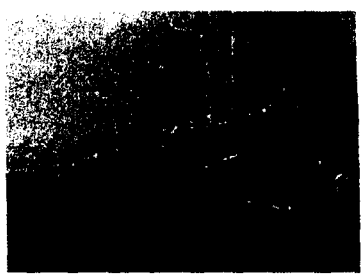
During the inventory, it was observed that the boundary stones were not available on both sides for the entire length. Hence, the distance between the permanent structures based on the measurement at field is considered as the available ROW. Based on road inventory, it is observed the Right of Way (ROW) varies from 7.0 m to 28.0 m. ROW details for the whole stretch is given in **Annexure 2.1.**

2.3.5 Junctions

The project road is having 14 important junctions and the details are given in **Annexure 2.1.** In addition to the important junctions discussed above, there are also 49 cross roads, which have direct access to the project stretch. Proper channelisation, traffic signs and road marking are absent at all the junctions.

2.3.6 Land Use along the project Corridor

As the project Stretch is generally running very close to the sea, the land use on the left hand side is beach and Kuppams of Srinivasapuram, Olcot Ururkuppam are located on the RHS. The section of the project stretch between Adyar Estuary to Ururkuppam is running very close to Theosophical society for a length of about 0.7 km.



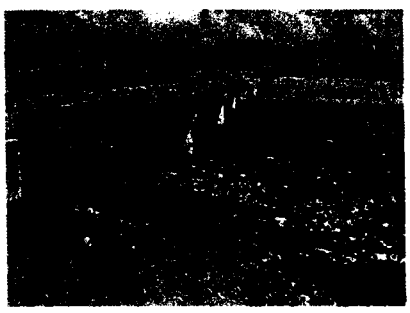
Land Use along PR

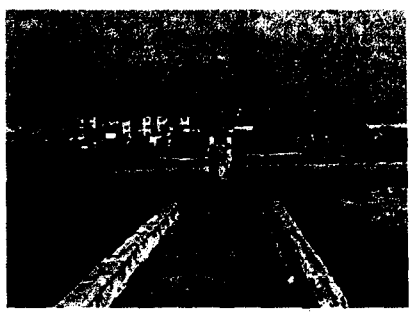
2.3.7 Alignment Details

The alignment of the Stretch (both horizontal and vertical) is generally satisfactory for the entire length.

2.3.8 Broken Bridge across River Adyar

This bridge was constructed across river Adyar during 1966 and this bridge was washed away due to the heavy floods during 1977. The section of bridge for a length of about 100m alone is left out on the Besant Nagar side. This bridge is having a width of only 3.0 m wide. The bridge is resting on circular well foundation and substructure is RCC circular column with RCC beams.





Bridge across Adyar River

2.3.9 Proposed alignment for the Project Stretch

The proposed alignment for the project stretch is shown in **Figure 2.1**

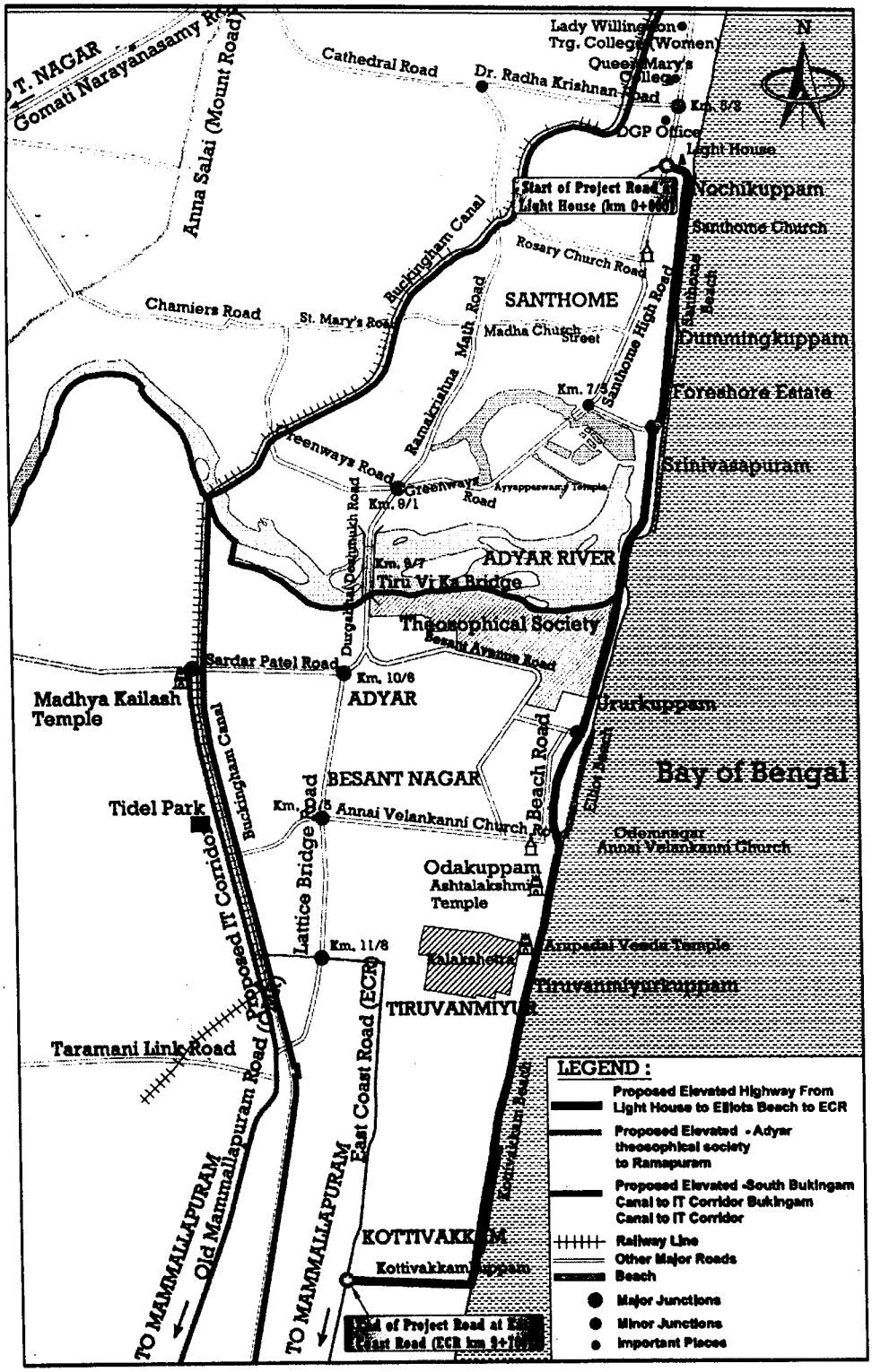


Figure 2.1: Proposed Alignment for the Project Stretch

designs;

- Prepare base plan containing all the natural and man made features like buildings, fences, walls, utilities, temples and other religious structures etc. which would govern the finalization of horizontal alignment.
- Utilize the same Terrain Model to form the basis for the estimation of engineering construction materials.

Horizontal Control Stations

As part of this survey, reference pillars with 30cm x 30cm x 45 cm concrete pillars with nail on the top have been established at 1km interval to form control stations along the Project Road. The control stations are located within the ROW and have been placed at locations where there is a clear visibility. These have been properly referenced and documented. Furthermore, secondary control stations were also located wherever the inter-visibility of adjacent control stations was not available.

Vertical Control Stations

The vertical control stations (benchmarks) along the proposed road have been established by Fly-leveling using auto levels. Control points set up for horizontal control are also used for setting up vertical as vertical control stations and RLs of these control points has been established with respect to GTS Bench mark. Besides control stations due consideration has been given to install as many additional Benchmarks as possible on culverts. Loop system has been adopted to ensure the accuracy of RLs within the permissible limits. The ultimate error was within the permissible limit of 12 $\sqrt{K}$ where K is the length in Km and error is in mm.

DTM Data Collection

After establishing horizontal and vertical control points, accurate data in digital format with respect to x, y, z co-ordinates for all breaks in terrain such as ridges and ditches has been collected perpendicular to the centre line at 25 m intervals in tangent sections and 5 m in curve sections using Total Stations. The survey extends to a minimum of 15 m beyond either side of the centerline of the existing carriageway or land boundary whichever is more. At major intersections the survey has been extended to 150 m to allow for design of intersections. All natural and man made features such as buildings, irrigation channels, drainage structures, temples, mosques, trees and utility installations etc. have been recorded in the description column. Spot leveling have been taken on the carriageway to make leveling more realistic. Large individual trees and agricultural land areas have also been surveyed.

River Bed Profiles and Cross-Sections

Where existing road cross the water courses, in accordance with the IRC recommendations for the hydraulic design of bridge and culverts, bed stream cross-sections and longitudinal sections have been taken at regular intervals on both upstream and down stream side of the structure including one at structure location. The longitudinal section to determine the bed slope has been taken at an interval of 20m following the channel course extending on both up stream and down stream side of the structure as per IRC: SP-13.

Generation of DTM

The Digital Terrain Model (DTM) is developed from the details collected through topographic survey. The DTM thus generated forms the base for the horizontal and vertical design in 'MX' software.

2.6 Geotechnical Investigations

The preliminary sub soil investigation has been carried out by Geo Global Consultants; Chennai. Subsoil condition is analyzed along with evaluation of field and laboratory data for determination of necessary physical and chemical characteristic of the in-situ soil strata.

Objective

The object of Geo-technical Investigation is to evaluate the following:

- To ascertain the sub-soil strata
- To study standing Ground Water Level
- To study the physical and engineering properties of soil strata and rock strata (if encountered).
- To evaluate allowable safe bearing capacity and settlements of soils/rock to design foundations for bridge.
- To Recommend type and depth of foundation
- To recommend improvements to the weak soil strata if any.

Scope and Methodology of the Work

The scope of work entrusted includes making twenty bore holes and five trial pits at proposed locations and conducting the following Field (in situ) investigations and Laboratory Tests.

Field (In-situ) Investigations

- Drilling bore holes of 150 mm diameter to a maximum depth of 20 to 30m or minimum of 3m in rock if rock is encountered earlier.
- Collecting disturbed and undisturbed soil samples at regular depth intervals
- Conducting field-testing such as Standard Penetration Tests as per IS 2131-1981 at every 1.5m depth intervals or wherever strata changes in Boreholes to determine N values as well as relative density and stiffness of the soil strata.
- To study and record the standing Ground Water Table Level.
- To ascertain the sub-soil strata and ground topography.

Laboratory Testing

The scope of Laboratory Testing is as follows:

- Grain Size Analysis as per IS 2720 part 4 – 1985.
- Specific Gravity as per IS 2720- part 3
- Atterberg Limits as per IS 2720 part 5 1985.
- Determination of natural moisture content as per IS 2720 part 2 - 1973.

- Determination of natural density as per IS 2720
- Determination of Strength Parameters(c & ϕ) as per IS 2720 - Part 13
- Determination of water absorption, Specific Gravity and Unit weight of rock core samples
- Modified Proctor Density on Trial Pit Sample

The details of geotechnical investigation done are given in **Table 2.3** and detailed geotechnical report is attached to this volume as separately bound document.

Table 2.3: Details of Geo-Technical Investigations

Sl. No.	Location	Bore Hole /Trial Pit No.	Termination Depth from GL(m)	Remarks
1	Light House	BH-1	24	N=>100
2	Adyar Bridge	BH-2	22.5	N=>100
3	Mahalakshmi Temple	BH-3	29	N=>100 Rock Encountered
4		BH-4	25	N=>100 Rock Encountered
5		BH-5	21	N=>100
6		BH-6	26.5	N=>100 Rock Encountered
7		BH-7	24	N=>100 Rock Encountered
8		BH-8	25	N=>100 Rock Encountered
9		BH-9	23	N=>100
10		BH-10	28	N=>100 Rock Encountered
11		BH-11	27	N=>100
12		BH-12	22.5	N=>100
13		BH-13	25.5	N=>100 Rock Encountered
14		BH-14	28.5	N=>100 Rock Encountered
15		BH-15	25	N=>100 Rock Encountered
16		BH-16	24.5	N=>100 Rock Encountered
17		BH-17	25.5	N=>100 Rock Encountered
18		BH-18	23	N=>100
19		BH-19	27	N=>100 Rock Encountered
20		BH-20	27	N=>100 Rock Encountered

Table 2.4: Sub soil Profile

Sl: No.	Location	Bore Hole No.	Depth from Ground Surface (m)	Description of Strata
1.	Light House	BH-1	5.2	Brownish fine to medium sand
			6.45	Brownish fine sand
			8.67	Brownish medium Sand and bottom of SPT greyish clay
			10.00	Brownish fine to medium sand
			13.5	Greyish soft to medium stiff silty clay
			19.5	Brownish fine to medium sand
			21	Brownish and greyish fine to medium sand
			24	Brownish and greyish soft rock es
2	Adyar Bridge	BH-2	6.5	Brownish fine to medium sand
			11.35	Brownish fine sand
			13.5	Greyish soft to medium silty clay
			22.5	Greyish clayey silty fine to medium sand with occasionally broken shells
3	Mahalakshmi Temple	BH-3	2.00	Brownish fine to medium sand
			4.5	Brownish medium to fine sand
			6.45	Brownish fine to medium sand
			20.50	Brownish silty medium to fine sand
			22.80	Greyish stiff clay
			26.5	Soft disintegrated rock
			29	Soft rock
4		BH-4	4.9	Brownish fine to medium sand
			6.5	Brownish fine sand
			7.8	Brownish medium sand

Sl. No.	Location	Bore Hole No.	Depth from Ground Surface (m)	Description of Strata
			12.6	Medium stiff silty clay
			18.6	Brownish fine to medium sand
			22.6	Brownish and grayish fine to medium sand
			25	Brownish soft rock
5			5.4	Brownish fine sand
			10.2	Brownish medium sand
			14	Soft to medium silty clay
			21	Greyish clayey silty fine to medium sand
6			3	Brownish fine to medium sand
			7	Brownish medium sand
			20	Brownish silty medium to fine sand
			23	Greyish stiff clay
			26.5	Soft disintegrated rock
7			5.2	Brownish fine to medium sand
			6.45	Brownish fine sand
			8.5	Brownish medium sand
			12	Brownish fine to medium sand
			16.5	Greyish stiff clay

Sl. No.	Location	Bore Hole No.	Depth from Ground Surface (m)	Description of Strata
			21	Soft disintegrated rock
			24	Soft rock
8			5	Brownish fine to medium sand
			8.5	Brownish medium sand and bottom of SPT grayish clay
			14	Greyish soft to medium stiff silty clay
			18.5	Brownish fine to medium sand
			21.5	Brownish and grayish fine to medium sand
			25	Brownish and grayish soft rock
9			4.8	Brownish fine to medium sand
			10.5	Brownish fine sand
			14.5	Greyish soft to medium silty clay
			23	Greyish clayey silty fine to medium sand with occasionally broken shells
10			2	Brownish fine to medium sand
			6.45	Brownish fine to medium sand
			18	Brownish silty medium to fine sand
			22	Greyish stiff clay
			25	Soft disintegrated rock
			28	Soft rock

Sl. No.	Location	Bore Hole No.	Depth from Ground Surface (m)	Description of Strata
			26.5	Soft disintegrated rock
			28.5	Soft rock
15			4.8	Brownish fine to medium sand
			6.2	Brownish fine sand
			8.5	Brownish medium sand and bottom of SPT grayish clay
			10	Brownish fine to medium sand
			14.2	Greyish soft to medium stiff silty clay
			18	Brownish fine to medium sand
			21	Brownish and greyish fine to medium sand
			25	Brownish and greyish soft rock pieces
16			5.5	Brownish fine to medium sand
			7.5	Brownish fine sand
			9.6	Brownish medium sand
			13.5	Brownish fine to medium sand
			17	Greyish stiff clay
			20	Soft disintegrated rock
			24.5	Soft rock
17			5	Brownish fine to medium sand
			8	Brownish medium sand and bottom of SPT greyish clay
			14	Greyish soft to medium stiff silty clay
			18.5	Brownish fine to medium sand
			22	Brownish and greyish fine to medium sand
			25.5	Brownish and greyish soft rock
18			6	Brownish fine to medium sand
			11.5	Brownish fine sand
			16.8	Greyish soft to medium silty clay

Sl. No.	Location	Bore Hole No.	Depth from Ground Surface (m)	Description of Strata
			23	Greyish clayey silty sand
19			3.8	Brownish fine to medium sand
			7.3	Brownish fine to medium sand
			14.5	Brownish silty medium to fine sand
			18	Greyish stiff clay
			25	Soft disintegrated rock
			27	Soft rock
20			5.3	Brownish fine to medium sand
			8	Brownish medium sand
			13.2	Greyish soft to medium silty clay
			19.5	Brownish fine to medium sand
			23.5	Brownish and greyish fine to medium sand
			27	Brownish and greyish soft rock

The soil varies from fine to medium sand for shorter depths in all the bore hole locations. Hard strata or rock is encountered at about 23m in all the bore hole locations. Based on the sub soil findings, suitable foundations are proposed. The type, depth and safe bearing capacities of footings are described in the preliminary bridge design section.

2.7 Material Investigations

Preliminary material investigations have been carried out to find out the availability of adequate good quality materials for construction. Based on reconnaissance and local inquiries, including discussions with the highway department, a list of quarries which is near to the alignment is made and presented in the following table.

Table 2.5 List of Quarries

SI No	Material	Source	Lead in Km
1	Sand for Mortar	Palar River	60
2	Metal	Pallavaram	23
3	Gravel	Perumbakkam	25
4	Sand For Filling	Karanodai	36

Chapter 3 : Traffic Studies and Projections

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3. Traffic Studies and Projections

3.1. Objective

Traffic studies have been done with a view to establish the need for the bypass, identify the locations for ingress and egress to the bypass, decide on the lane requirements and geometrics taking cognizance of the constraints and to examine the economical feasibility of the project. The traffic study encompasses various aspects and these include:

- Assessing traffic on existing route
- Estimation of divertable traffic on the proposed facility
- Growth Factor estimation for Traffic Forecasting
- Lane requirement based on traffic forecasting.
- Economical feasibility analysis.
- Environmental impact assessment

3.2. Necessity of the Bypass

River Adyar separates areas in Central Chennai such as Triplicane, Royapettah, Mylapore, Foreshore estate, Mandavelli etc; from those in the southern side that include Adyar, Basant Nagar, Thiruvanmiyur, Kottivakkam and Palavakkam. Thiru-Vi-Ka Bridge between Greenways Road and Lattice Bridge Road is the only available connecting link on Adyar River near these areas. The present road network in the project region is presented in **Figure 3.1**. The road corridor connecting the two banks of the Bridge, i.e.; Santhome high road, Green ways road and Thiru Vi Ka Bridge are carrying substantial traffic with acute traffic congestions during morning and evening peak periods.

Piling up of vehicles on Thiru Vi Ka Bridge

Widening of the above said roads are not possible as they pass through thickly populated areas and due to restricted right of way. The development of a new bypass road along the sea shore connecting Kamarajar Salai in the north and EC road in the south including the construction of a bridge across Adyar Estuary is expected to ease traffic congestion on the existing traffic corridor, provide better connectivity to ECR from city centre and significantly improve traffic mobility.

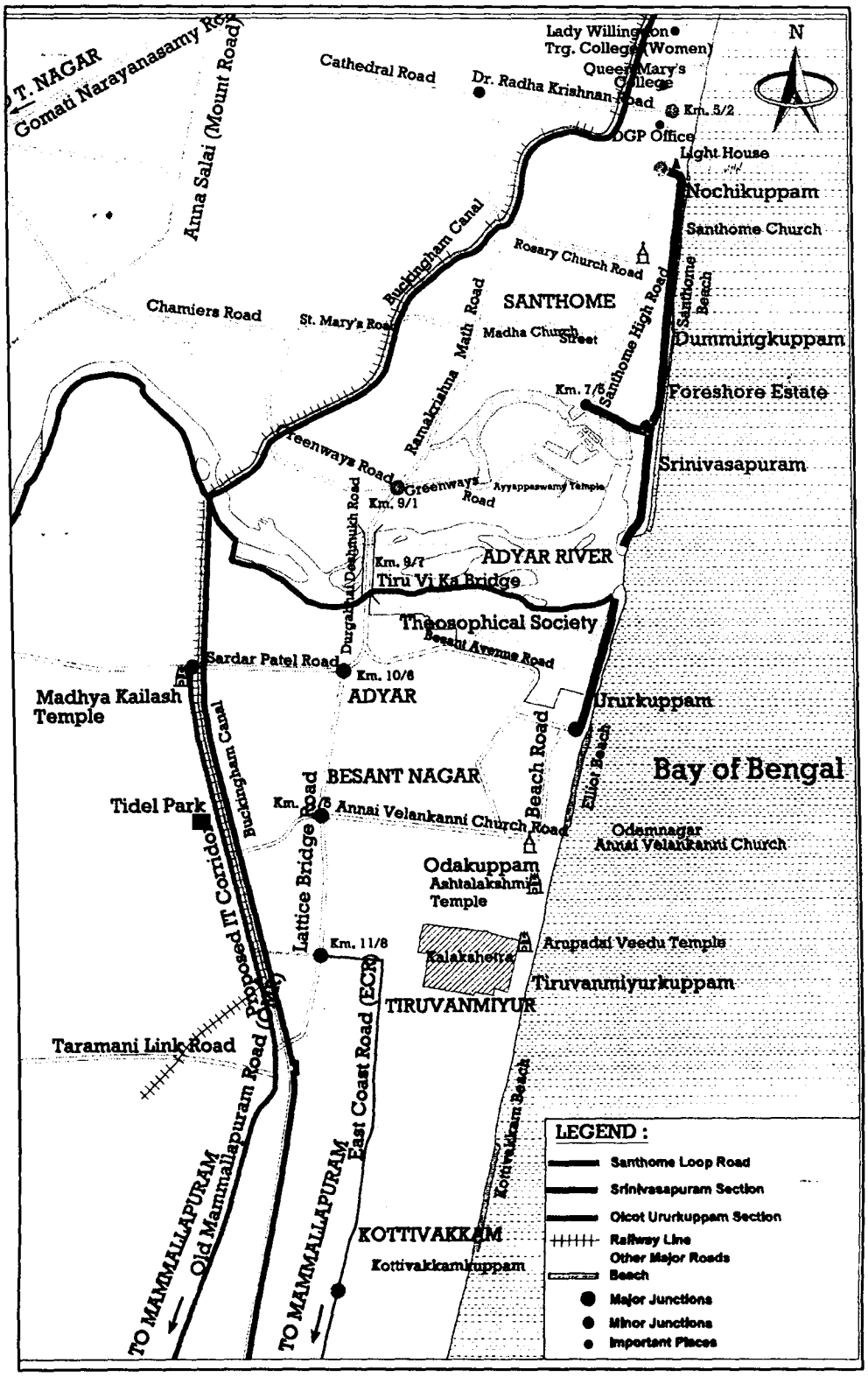


Figure 3.1: Present Road Network in the Project region

3.3. Primary Surveys

Primary surveys were conducted on the existing links of the project road and on present traffic route to assess the possible traffic on the project road in the future. The following surveys were carried out in this regard:

- Classified Volume Count Surveys at 4 locations
- Road side Interview surveys at two locations on alternate routes
- Turning Volume Counts at 4 junctions
- Speed and Delay Surveys along the alternate routes
- Parking Surveys at 2 locations
- Pedestrian Count Survey at 2 locations

The survey locations that were finalized in consultation with Highways Department are given in **Table 3.1** and in **Figure 3.2**.

Table 3.1: Traffic Survey Locations and Duration

Sl No.	Location	Duration	Dates of Surveys
1. Link Count Surveys			
1.1	Santhome Beach Road	3 days (2 week days+ 1 weekend)	28- 12-2005 to 29-12 - 2005, 07-01-2006
1.2	Elliots Beach	3 days (2 week days+ 1 weekend)	28- 12-2005 to 29-12 - 2005, 08-01-2006
1.3	Thiru Vi Ka Bridge (Km 9/4 of Greenways Rd)	2 working days	03-01-2006 to 04-01-2006
1.4	Lattice Bridge Rd –Sardar Patel Junction (L & R turning movements only)	2 working days	05-01-2006 to 06-01-2006
2. O-D Surveys			
2.1	Thiru Vi Ka Bridge (Km 9/4 of Greenways Rd)	2 working days	03-01-2006 to 04-01-2006
2.2	Lattice Bridge Rd –Sardar Patel Junction (L & R turning movements only)	2 working days	05-01-2006 to 06-01-2006
3. Junction Count Surveys			
3.1	DGP Office Junction (Km 5/2)	2 days (1 week day+ 1 weekend) 14 hours (8 am to 10 pm)	09-12-2005, 07-01-2006
3.2	Marina Entrance Junction (Km 5/4)	1 weekend day -14 hours (8 am to 10 pm)	08-01-2006
3.3	Light House Junction (Km 5/6)	1 weekend day -14 hours (8 am to 10 pm)	09-01-2006
3.4	ECR Junction (Km 14/6 of ECR)	1 week day- 12 hours (8 am to 8 pm)	02-01-2006
4. Pedestrian Counts (crossing + along carriageway)			
4.1	Santhome beach	1 weekend day - 6 hours (4 pm to 10 pm)	07-01-2006
4.2	Elliots beach	1 weekend day - 6 hours (4 pm to 10 pm)	08-01-2006

Sl No.	Location	Duration	Dates of Surveys
5. Parking Surveys			
5.1	Santhome beach	1 weekend day - 6 hours (4 pm to 10 pm)	07-01-2006
5.2	Elliots beach	1 weekend day - 6 hours (4 pm to 10 pm)	08-01-2006

3.3.1 Classified Link Volume Count Survey

The classified traffic volume counts were conducted manually by counting vehicles on both directions. The vehicles were broadly classified into various categories i.e. Cars/Jeeps/Vans, Buses, Trucks, Multi Axle Vehicles (MAVs), Light Commercial Vehicles (LCVs), Two wheelers, Auto rickshaws and slow moving vehicles which includes cycles, cycle rickshaws and carts. Buses were classified into MTC Buses, Mofussil Buses, Company buses, Institutional Buses and minibus. The format used for the survey is given in **Annexure 3.1**.

3.3.2 Turning Movement Survey

Classified turning movement counts were carried out at four intersections. The survey was conducted for 14 hours to capture the peak hour traffic in the morning/evening. Since the DGP office junction carry traffic to Marina beach and to Institutions / Offices, the survey was done for two days including a working day and a weekend day.

3.3.3 Road Side Interview Surveys (RSI)

The proposed road is a new link connecting Santhome and EC road and will give access to various places located along the corridor. Being a new road, it is necessary to estimate the likely traffic that will use it once constructed. Hence OD surveys were conducted on the available alternate routes to estimate the possible traffic on the project road. Also OD surveys are useful for estimating the traffic influence region for estimation of traffic growth rates in the absence of past traffic data.

The locations were selected so as to capture the possible movements on the proposed road. The surveys were carried out for 2 working days by stopping the vehicles randomly with the assistance of police on sample basis. The volume count surveys were combined with the roadside interview surveys to calculate the expansion factors and to ensure a good sampling rate.

The information collected includes; Vehicle type, Frequency, Occupancy, Origin, Destination and purpose of the journey in case of the passenger traffic. For goods traffic, in addition to the above information, the type of the goods transported was also collected. The format prepared for the RSI survey is given in **Annexure 3.1**.

3.3.4 Speed and Delay survey

Speed and delay survey was conducted on a normal working day along the existing corridor by moving car observer method to estimate the running speed, average journey speed and associated delays. The survey vehicle travelled in the stream of general traffic at similar speeds as of other traffic during different times of the day. The delays and corresponding contributory factors such as intersections / major activity centres, etc. was collected to identify major bottlenecks along the route. The survey format is given in **Annexure 3.1**.

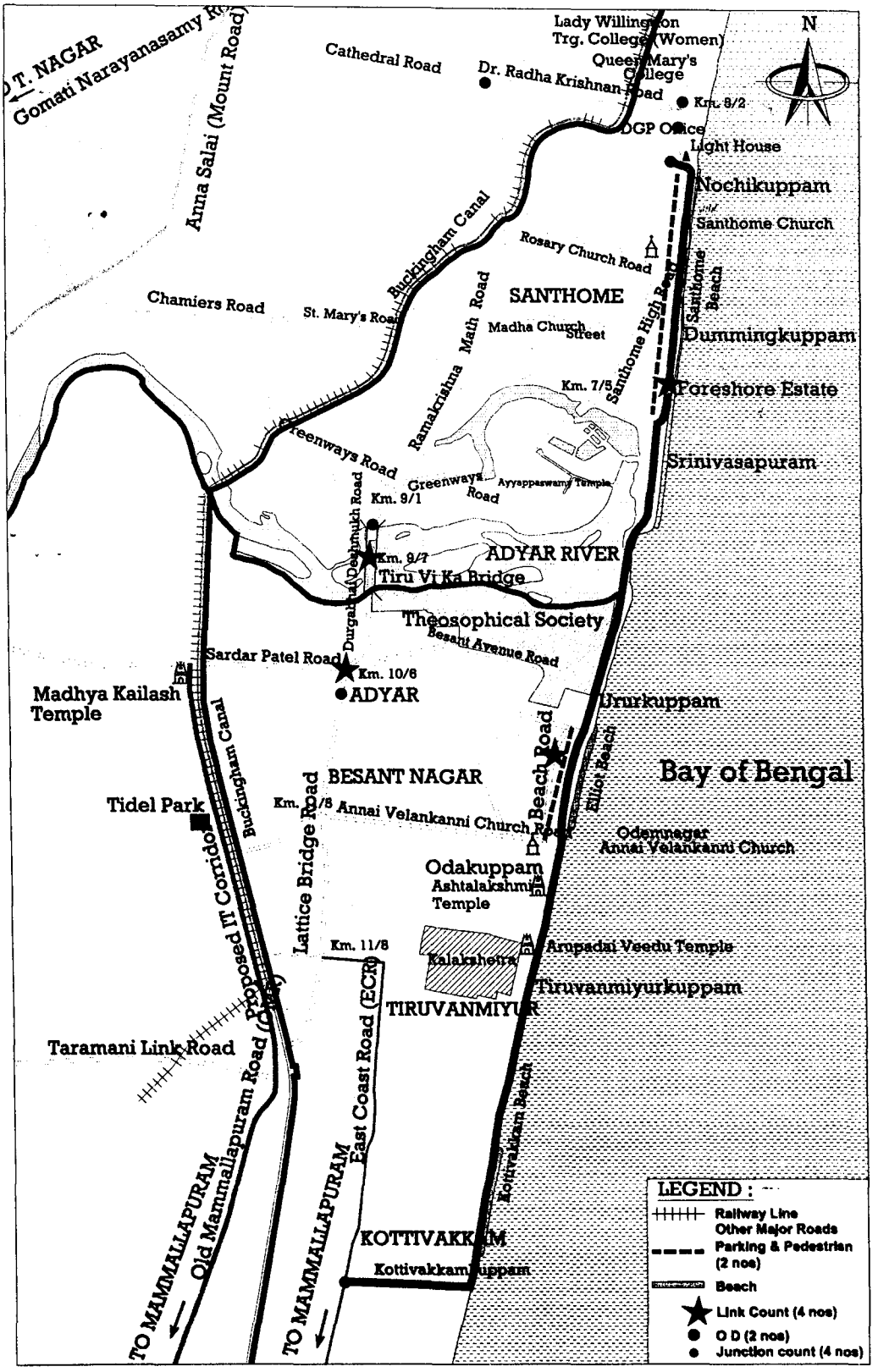


Figure 3.2: Traffic Survey Locations

3.3.5 Pedestrian count survey

Pedestrian count survey was carried out at two locations (Santhome Beach and Elliots Beach) where substantial pedestrian movement, both along the carriageway and across the road is observed. It was carried out during morning/evening peak hours on a weekend day to capture the maximum pedestrian count. Location details are given in **Table 3.2**.

3.3.6 Parking Surveys

Parking surveys were organized at Santhome beach and Elliot's beach to quantify the parking demand at these places. Since considerable parking occurs during weekends, the surveys were carried out during a weekend evening for six hours.

3.4. Homogeneous Sections

It is proposed to provide ramps at Fore Shore Estate road, Besant Avenue road, in addition to the ramps at the start and end points. Based on the expected traffic characteristics of the bypass and ramp locations, it could be divided into three homogeneous sections. They are given in **Table 3.2**.

Table 3.2: Homogeneous Sections Identified

Section No	Homogeneous Sections	Length (Km)
1	Light House – Foreshore Estate	2.1
2	Foreshore Estate- Besant Nagar	3.4
3	Besant Nagar – Kottivakkam	3.0

3.5. Findings of Primary Surveys

The findings of various traffic surveys are described in the following sections.

3.5.1 Mid Block Counts

PCU Values: As the project road falls within Chennai city limits, Passenger Car Units (PCUs) corresponding to urban roads as per IRC: 106-1990 is adopted and the values adopted is given in **Table 3.3**.

Table 3.3: Equivalency factors for Various Types of Vehicles on Urban Roads

Vehicle Type	Equivalent PCU Factors	
Vehicle Composition	**<5%**	**>10%**
Two Wheelers	0.5	0.75
Passenger Cars/ Pick Up Vans	1.0	1.0
Auto Rickshaw	1.2	2.0
Light Commercial Vehicle	1.4	2.0
Truck or Bus	2.2	3.7
MAV	4.0	5.0
Cycle	0.4	0.5
Cycle Rickshaw	0.5	2.0
Fish Cart	2.0	3.0
Hand Cart	2.0	3.0

(Source: IRC: 106-1990)

Classified link counts were conducted at two locations for two working days and one weekend day on the existing stretches of the project road, ie; at Santhome beach road and Elliot's beach road. Also a seven day count was carried out on Thiru Vi Ka Bridge, which is the available link for the project road. The results of the traffic counts at these three locations are presented in the following sections.

3.5.1.1 Santhome Beach Road

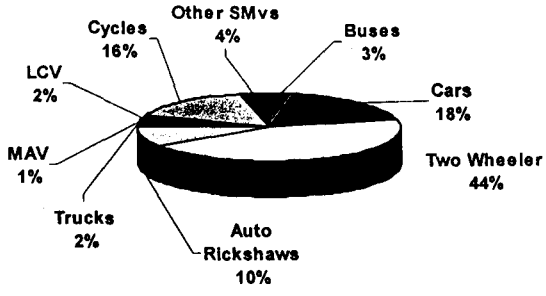
Average Daily Traffic (ADT): Average Daily Traffic observed on the road is 3937 PCU constituting 3836 vehicles. The summary of ADT, in terms of vehicles and PCU is given in **Table 3.4**. Traffic count details are given in **Annexure 3.2**.

Table 3.4: ADT on Santhome Beach Road, 2006 (No. of vehicles)*

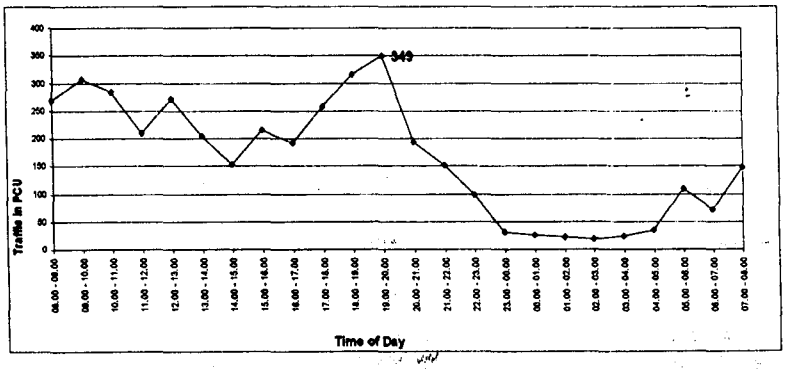
Vehicle Type	Buses	Cars	Two Wheeler	AR	Trucks	MAV	LCV	Total FMVs	Cycles	Other SMVs	Total SMVs	Total Vehicles	Total PCU
Nos.	119	711	1715	368	66	47	85	3111	616	140	757	3868	3937

*(Note *: ADT is the weighted average of 3 day count, giving a weightage of 2 for weekends and a weightage of 5 for working days)*

Vehicle Composition: Passenger vehicles form about 75% with two wheelers about 44% of the total traffic. It has been observed that institutional buses and mini buses ply on the road to park along the roadside during day time. The movement of goods vehicles is very less, forming about 5% of the total traffic, transporting fish from the beach. SMVs form a substantial share of 20% of the total traffic in which Cycles are about 85%, is due to the fishermen colonies along the stretch.



Peak Hour Traffic & Hourly Variation: Peak traffic of 349 PCU is observed at 7 PM to 8 PM and peak hour factor (peak hour traffic /total traffic) is 8.9%. Very less traffic is observed in the night (18% of total traffic is observed between 8PM and 6 A.M.



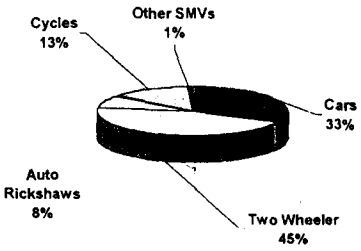
3.5.1.2 Elliot's Beach Road

Average Daily Traffic (ADT) : Average Daily Traffic observed on the road is 9905 PCU (10650 vehicles). The summary of ADT, in terms of vehicles and PCU is given in **Table 3.5**. Traffic count details are given in **Annexure 3.2**.

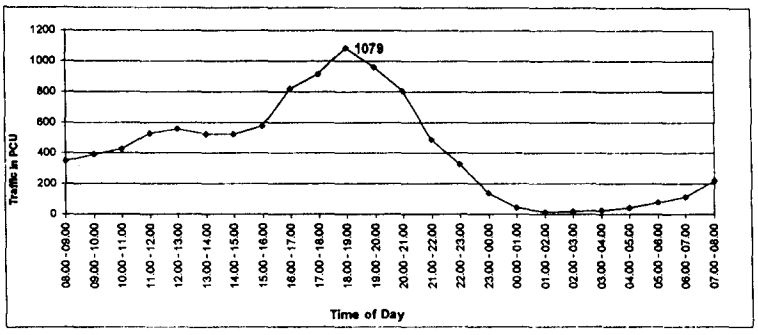
Table 3.5: ADT on Elliots beach Road, 2006 (No. of vehicles)*

Vehicle Type	Buses	Cars	Two Wheeler	AR	Trucks	MAV	LCV	Total FMVs	Cycles	Other SMVs	Total SMVs	Total Vehicles	Total PCU
Nos.	49	3439	4720	883	18	30	10	9148	1398	103	1501	10650	9905

(Note: ADT is the weighted average of 3 day count, giving a weightage of 2 for weekends and a weightage of 5 for working days)*



Vehicle Composition: Since the traffic on this road is mostly beach based, passenger vehicles and slow moving vehicles form the major share of traffic. Passenger vehicles form about 86% including two wheelers (45%) of the total traffic and the remaining slow moving vehicles.



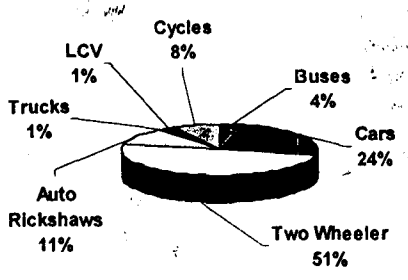
Peak Hour Traffic & Hourly Variation: High traffic is observed during evening due to the presence of beach. Peak traffic of 1079 PCU is observed at 6-7 PM and peak hour factor (peak hour traffic /total traffic) is 10.9%. Very less traffic is observed in the night (20% of total traffic is observed between 8PM and 6 AM.

3.5.1.3 Thiru- Vi-Ka Bridge

Average Daily Traffic (ADT): Very high traffic is observed on this bridge as it is the only link connecting the two sides of the river. Average Daily Traffic observed on the road is 1, 10,652 PCU (110193 vehicles). The summary of ADT, in terms of vehicles and PCU is given in **Table 3.6**. Traffic count details are given in **Annexure 3.2**.

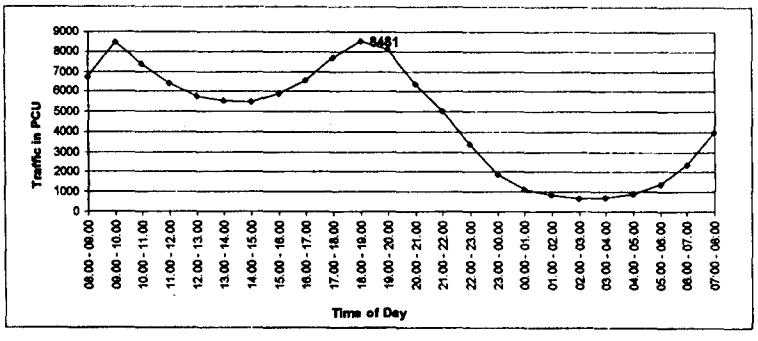
Table 3.6: ADT on Thiru- Vi- Ka Bridge, 2006 (No. of vehicles)*

Veh. Type	Bus	Cars	Two Wheeler	AR	Trucks	MAV	LCV	Total FMVs	Cycles	Other SMVs	Total SMVs	Total Vehicles	Total PCU
Nos.	4419	26762	55061	12111	1319	31	1483	101186	8929	78	9007	110193	11065



Vehicle Composition: Passenger vehicles form about 90% including two wheelers 51% and Car 24% of the total traffic. SMVs form about 8%. Trucks are merely 1% of the traffic, mostly carrying coal from Chennai Port to southern districts and Corporation garbage trucks to the Zonal office at Mylapore.

Peak Hour Traffic & Hourly Variation: Even though two peaks are observed during morning and evening, the bridge is carrying high traffic during day time. Maximum traffic is observed in the evening between 6PM and 7PM with 8481 PCU, and is about 8% of the total traffic. Very less traffic is observed in the night (20% of total traffic is observed between 9 PM and 6 AM.



The Design Service Volume (at LoS C) of a four lane divided subarterial carriageway is about 2900. But the peak hour traffic observed is about 8500 PCU, which is very much high, indicating heavy traffic congestion on the bridge. It is observed that the traffic on the bridge comes to a standstill during peak hours leading to long queues along the entire length of the bridge.

To reduce traffic congestion on this route and remove the traffic bottleneck, one option is to develop a new alternate route to bypass the congested bridge. The proposed elevated highway is seen to be a suitable measure to decongest the entire route from Santhome to Thiruvanmiyur.

3.5.2 Junction Turning Counts

The peak hour traffic observed at the four junctions along the proposed elevated highway is given in Table 3.7 and details are given in Figure 3.3. The DGP Office junction and Pallavakkam junctions have high traffic as they form junction of the project road with two major roads i.e.; Kamarajar Salai (Beach Road) and East Coast road (SH 56). Peak traffic observed at these junctions is about 8500 PCU and 3800 PCU respectively.

Table 3.7: Peak Hour Junction Turning Volume , 2006 (No. of Vehicles)

Name of Junction	Bus	Car/ Jeep/ Van (O)	Car/ Jeep/ Van (N)	Two Wheelers	Auto	Trucks	MAV	LCV	Slow Moving Vehicles	Total Vehicles	Total PCU
DGP Office Junction	308	219	2127	3690	1481	16	1	28	297	8167	8429
Light House Junction	10	36	356	385	88	0	0	6	62	943	924
Beach Junction	3	140	320	775	73	0	0	0	36	1347	1203
Palavakkam Junction	173	76	828	1901	535	17	0	54	368	3944	3865

3.5.3 Speed & Delay Surveys

It is observed that the existing roads carry heavy traffic during peak hours particularly Santhome area and at Thiru. Vi. Ka Bridge location, the journey speeds being very less, in the range of about 15 km/hour, resulting in high Vehicle Operating Cost (VoC) and extensive Travel Time. The speeds observed during peak hours are presented in **Table 3.8** and in **Figure 3.3**.

Table 3.8: Speed – Delay Survey Results on the roads in the Available Routes

From	To	Length (Km)	Journey time(Min.)	Journey Speed (KMPH)
Dr. Radha Krishnan Road and Royapettah High road Jun	Light House Jun	1.80	5.25	20.57
Dr. Radha Krishnan Road and Royapettah High road Jun	Greenways road Junction (through Ramakrishna Math road)	3.10	11.25	16.53
Light House Jun	Santhome Church	0.60	2.50	14.40
Santhome Church	Greenways Road Jun	2.80	9.60	17.50
Greenways Road Jun	Besant Nagar road Jun	1.30	7.40	12.16
Besant Nagar road Jun	Annai Velankanni Church road	1.40	6.25	13.44
Annai Velankanni Church road	Thiruvanmiyur Jun	1.00	3.85	15.58
Thiruvanmiyur Jun	Kottivakkam Jun	2.80	6.90	24.35
Besant Avenue Road		1.8	9	20.0

The data is analysed to arrive at the average speed and time for traffic from various areas of the city as there exists two alternate routes to access the Bridge from the city. Traffic from Parrys area using Kamarajar Salai- Santhome road, Greenways road, while traffic from Anna Salai using RK Mutt road or Dr. Radhakrishnan road – Santhome High road and Greenways road to access the bridge. These routes with the proposed route through the bypass are presented in Figure 3.4.

It is proposed to provide ramps at Light House Junction (Starting point), Fore Shore Estate road, Besant Avenue road and at Kottivakkam (End point). It is evident from the traffic surveys at Thiru Vi Ka bridge and speed delay surveys that the proposed bypass will benefit the following users;

- From Parrys / Alwarpet/ Chepauk and Anna Salai (can use ramp at Light House) bound either to Besant Nagar/ Elliots Beach or to Kottivakkam/EC road.
- The traffic from Mylapore/Santhome area bound to Elliots Beach, Besant Nagar and Kottivakkam/ EC road will benefit as they can access the bypass through the second ramp at Fore Shore Estate road.
- Traffic from Sardar Patel Road bound to Kottivakkam/ EC road is also expected to use the bypass through the ramp from Besant Avenue road.

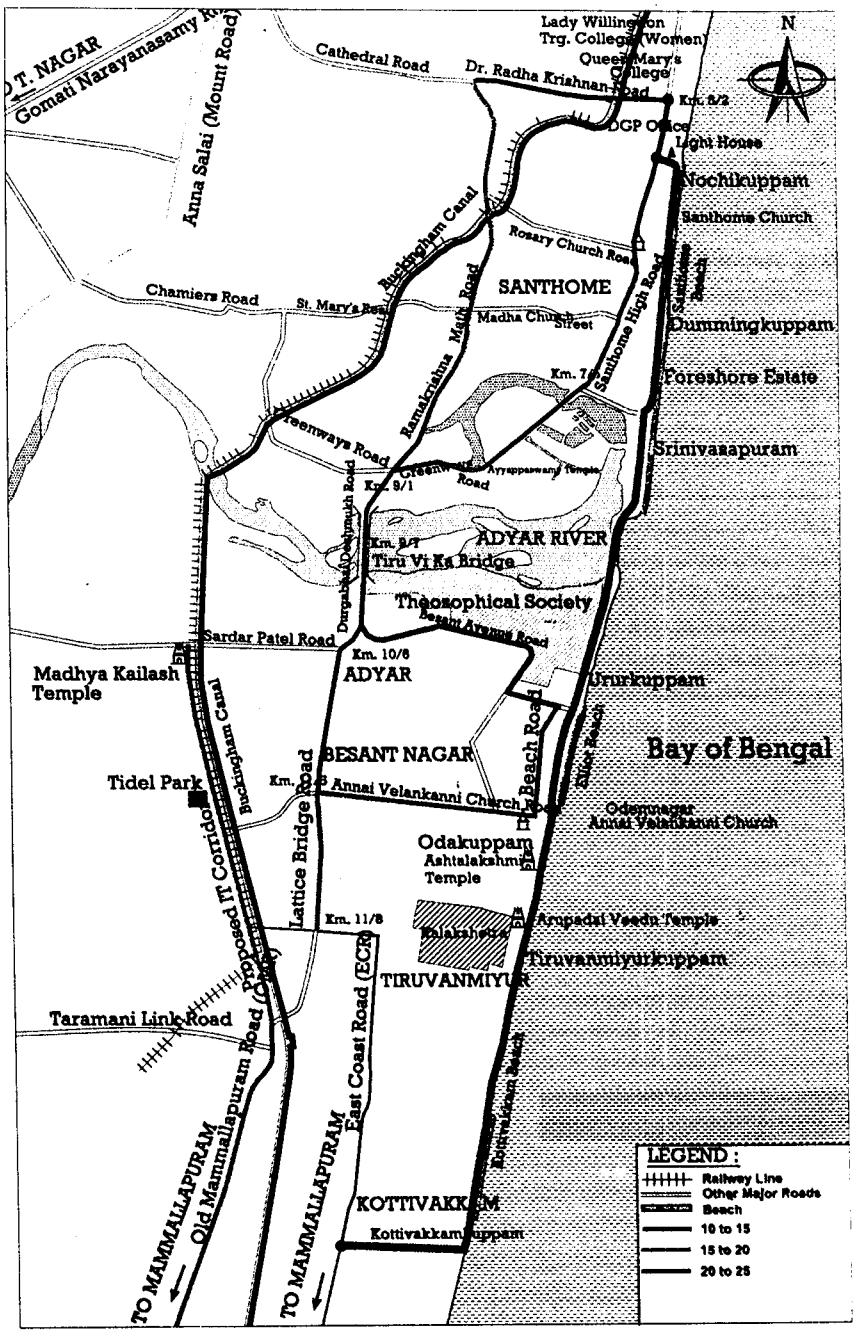


Figure 3.3: Speeds on present roads

The VoC and VoT for these traffic is estimated for using the present route and using the bypass and are compared to estimate the benefits accrued due to the development of the bypass and duly presented in Table 3.9. It is observed that though the route through the bypass will be a slightly longer one for a section of road users they will benefit due to the reduction in VoC and decrease in travel time due to higher speed (assumed 50KMPH) and relief from congestion on the bypass.

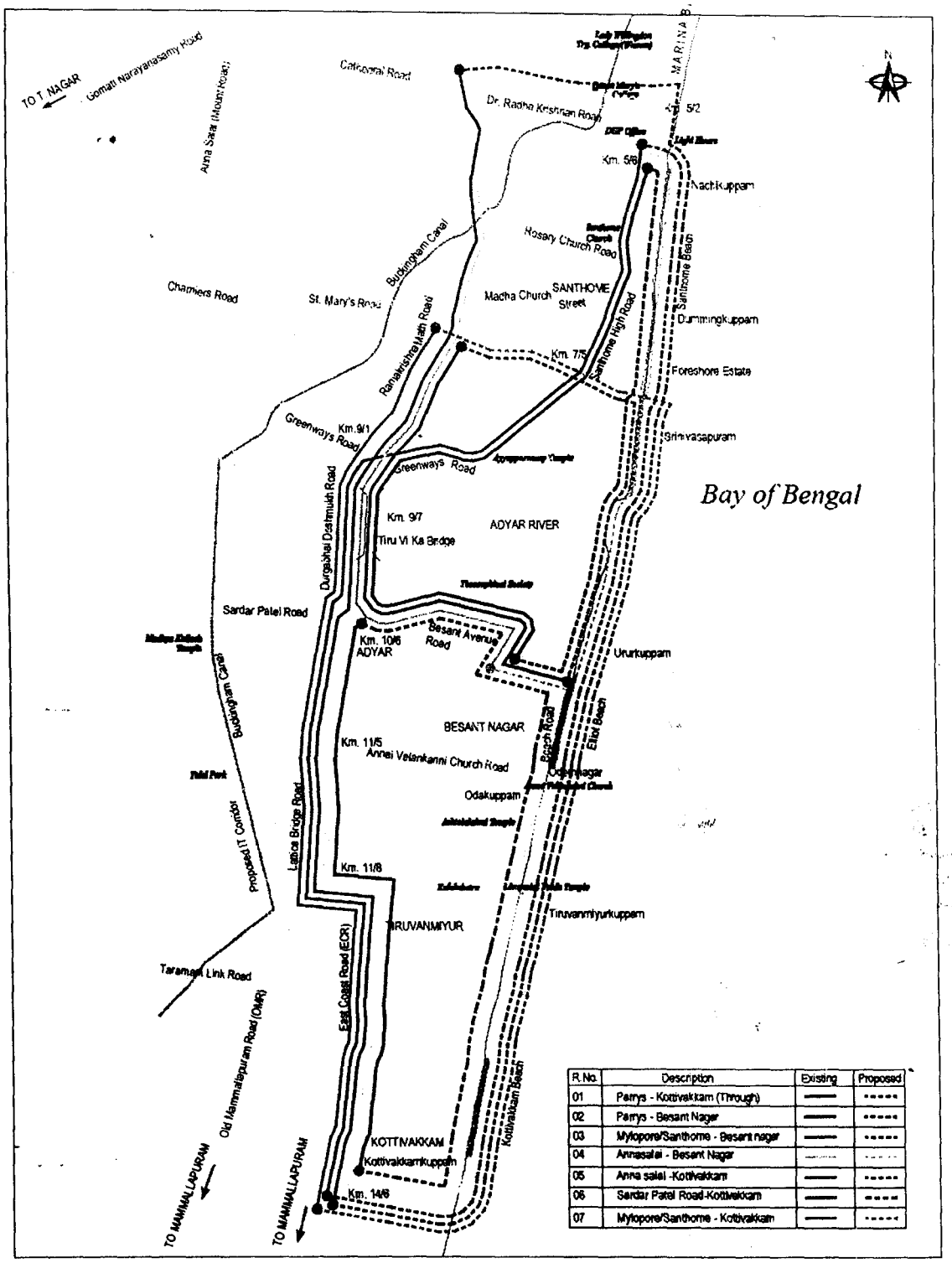


Figure 3.4: Present and proposed routes

Table 3.9: Savings Estimated due to Bypass

Movements		Distance (Km)	Time (minutes)	VoC	VoT	Total Cost (Rs/Trip)
Parrys/ Chepauk areas to Besant Nagar						
Present Route	Light House- Santhome High Road- TVK bridge- Besant Avenue road	6.3	22.50	49	13.00	62.0
Through Santhome Bypass	Light House- Santhome Bypass- Besant Avenue road	5	6.0	28	4.00	32.0
Savings		**1.3**	**16.5**	**21.00**	**9.00**	**30.00**
Anna Salai to Besant Nagar						
Present Route I	Ramakrishna Math Road- TVK Bridge- Besant Avenue Road	6	21.65	47	13.00	60.0
Through Santhome Bypass	Dr. Rathakrishnan Road- Light House- Santhome Bypass- Besant Avenue road	7	8.4	39	5.00	44.0
Savings		**-1**	**13.25**	**8.00**	**8.00**	**16.00**
Present Route II	Dr. Rathakrishnan Road- Light House- Santhome High road- TVK Bridge- Besant Avenue road	8.5	27.75	66	16.00	82.0
Through Santhome Bypass	Dr. Rathakrishnan Road- Light House- Santhome Bypass- Besant Avenue road	7	8.4	39	5.00	44.0
Savings		**1.5**	**19.35**	**27.00**	**11.00**	**38.00**
Parrys to Kottivakkam (Through Traffic)						
Present Route	Light House- Santhome High Road- TVK bridge- LB Road- EC Road- Kottivakkam	10	36.50	78	21.00	99.0
Through Santhome Bypass	Light House- Santhome Bypass- EC Road- Kottivakkam	9.6	11.5	53	7.00	60.0
Savings		**0.4**	**24.98**	**25.00**	**14.00**	**39.00**
Anna Salai to Kottivakkam (Through Traffic)						
Present Route	Ramakrishna Math Road- TVK bridge- LB Road- EC Road- Kottivakkam	9.6	35.65	75	21.00	96.0
Through Santhome Bypass	Dr. Rathakrishnan Road- Light House- Santhome Bypass- Besant Avenue road	11.1	18.6	61	11.00	72.0
Savings		**-1.5**	**17.08**	**14.00**	**10.00**	**24.00**
Mylapore/Santhome to Elliot's Beach						
Present Route	Greenways road- TVK bridge- Besant Avenue road	3.8	12.40	30	7.00	37.0
Through Santhome	Fore Shore Estate- Santhome Bypass	4	7.8	22	5.00	27.0

Movements		Distance (Km)	Time (minutes)	VoC	VoT	Total Cost (Rs/Trip)
Bypass						
Savings		**-0.2**	**4.6**	**8.00**	**2.00**	**10.00**
Mylapore to Kottivakkam						
Present Route	Greenways road- TVK bridge- LB road- EC road- Kottivakkam	7	27.40	55	16.00	71.0
Through Santhome Bypass	Fore Shore Estate- Santhome Bypass- Besant Avenue road	9.2	11.0	51	6.00	57.0
Savings		**-2.2**	**16.36**	**4.00**	**10.00**	**14.00**
Sardar Patel road to Kottivakkam						
Present Route	Greenways road- TVK bridge- Besant Avenue road- LB road- EC road- Kottivakkam	6.70	24.40	52	14.00	66.0
Through Santhome Bypass	Fore Shore Estate- Santhome Bypass- Besant Avenue road	7.5	9.0	41	5.00	46.0
Savings		**-0.8**	**15.4**	**11.00**	**9.00**	**20.00**

3.5.4 Origin - Destination Survey

OD surveys were conducted on (1) Thiru Vi Ka Bridge as this being the major alternate route for the expected traffic on Santhome bypass and at (2) Lattice Bridge Rd –Sardar Patel Junction for L & R turning movements to analyse the possible traffic on Besant Nagar –Kottivakkam stretch of the road. The analysis and results of the survey are described below.

O-D Survey

3.5.4.1 Zoning System Adopted

The zoning system adopted for the study is such as to capture the possible movements along the proposed bypass. The study region is divided into 25 zones. **Table 3.10** and **Figure 3.5** present the zoning system adopted for coding of the collected OD data.

Table 3.10: Zone List for the study area

Zone No.	Zone Description
1	Santhome
2	Santhome Beach
3	Foreshore Estate, Pattinappakkam, MRC Nagar and Srinivasapuram
4	Besant Nagar, Kalashethra colony and Shastri Nagar
5	Elliot's Beach
6	Ashtalakshmi Temple and Annai Velankanni
7	Thiruvanmiyur
8	Kottivakkam and Palavakkam
9	Adayar and Theosophical Society
10	Gandhi Nagar

Zone No.	Zone Description
11	Velachery, Tharamani, Tidal Park and Madipakkam
12	Injambakkam, Kovalam and other beach resorts along ECR and Mahabalipuram
13	Pondichery, Kanchipuram and other southern districts of Tamil Nadu
14	Nandanam, Saidapet, Kotturpuram and Guindy
15	Mylapore, Mandaveli, R.A Puram, Abhiramapuram and Music Academy
16	Alwarpet, Royapettah, Teynampet, Triplicane, Chepau k and Marina Beach
17	Parrys, George Town, Park Town, Chindadripet, Royapuram, Washermanpet and Tondiarpet
18	Purasavakkam, Egmore, Vepery, Perambur, Villivakkam, Annanagar, Aminjikarai, Chetpet, Nungambakkam, Avadi, Ambathur and Vyasarpadi
19	T.Nagar, West Mambalam, Vadapalani, Kodambakkam and nearby area
20	Other districts of Tamilnadu
21	Other States of India
22	Tambaram, Pallavaram, Chrompet and surrounding places
23	Thoraipakkam, Perungudi, Sholinganallur, Navalur and Kelambakkam

3.5.4.2 Sample Size

The collected data was coded, processed and expanded to total traffic using the expansion factors for each vehicle type, since the survey was conducted on sample basis. Average sample size obtained for various categories of vehicles for the OD survey location is given in **Table 3.11**. The matrices developed from the OD data are given in **Annexure 3.3**.

Table 3.11: Average Sample size obtained for OD Survey

Location		Car	Two Wheeler	Auto	MAV	Trucks*	LCV
Thiru Vi Ka Bridge	Sample	3211	5668	1694	14	171	254
	Volume	28535	55520	13603	34	823	1549
	%	11.3%	10.2%	12.5%	41.8%	20.8%	16.4%
LB road Junction	Sample	526	1198	265	3	14	87
	Volume	2672	7721	1176	3	14	120
	%	19.7%	15.5%	22.5%	100.0%	100.0%	72.5%

*(Note: *- excluding Garbage trucks)*

3.5.4.3 Candidate Traffic

The traffic expected to use the proposed bypass is arrived from the OD conducted at two locations. The section wise traffic is arrived by combining various movements on the stretch. Various nodes from where the movements originate from/destine to are Light House, Fore Shore Estate, Besant Nagar and Kottivakkam. Hence the entire road has been divided into three homogeneous sections. The various movements are presented in Figure 3.6. All other movements except the one between Besant Nagar and Kottivakkam are arrived at from the OD data at Thiru Vi Ka Bridge. The movements between Besant Nagar and Kottivakkam are estimated from LB road junction OD. Various zone pairs considered for analysing the candidate traffic and expected movement wise traffic is given in Table 3.10. The section wise candidate traffic for the three sections is given in Table 3.11. Due to the better east – west connectivity between Anna Salai and Kamarajar Salai, near the start of proposed bypass, (Avai Shanmugham road and Dr. Radhakrishnan Road), a part of traffic bound between Besant Nagar (and surrounding areas) and Anna Salai are assigned on the starting section of the bypass from Light House, once the bypass will be constructed.

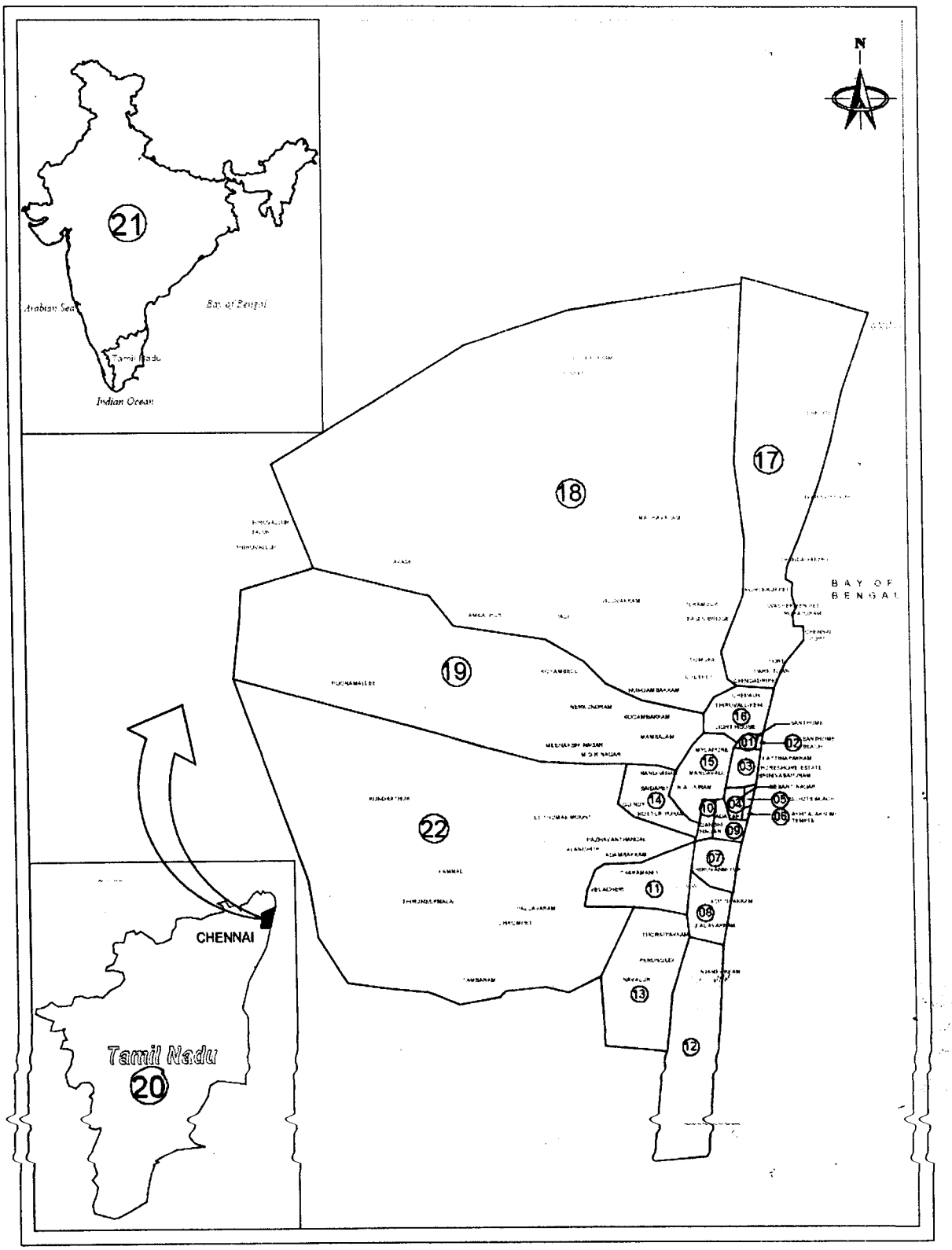


Fig 3.5: Zone Map

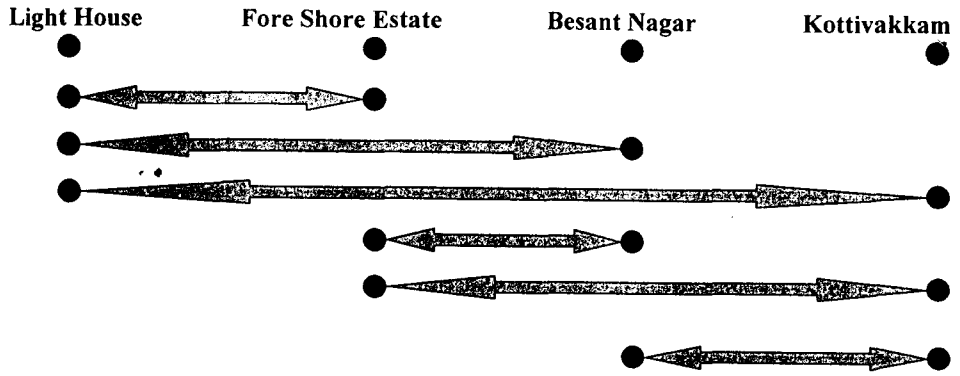


Fig 3.6 Various Movements on the Proposed Elevated Road

Table 3.12: Estimated Movement wise Traffic

Movements	Origins	Destinations	Movements (No. of Trips)					
			Car	TW	Auto	LCV	MAV	Truck
Light House-Besant Nagar	16,17,18, 19	4,5,6	2674	6916	1423	91	4	139
Light House - Kottivakkam and beyond	16,17,18, 19	8,12,13	631	1929	161	91	3	239*
Fore Shore Estate to Besant Nagar	15	4,5,6	30	122	51	-	-	-
Fore Shore Estate to Kottivakkam & beyond	15	8,12,13	401	869	126	-	-	-
Besant Nagar – Kottivakkam and beyond	14,19,22	8,12,13	300	471	64	81	-	-

*(Note: *- trucks including coal carrying trucks from Chennai Port)*

On an average, about 650 institutional/ company buses are plying through the Bridge every day. Since no OD survey is carried out for buses, a less percentage of these buses are assumed to use the proposed facility in the future. MTC buses are not expected as they have to ply along the existing route only. Lot of trucks are plying between Light House and Besant Nagar, carrying building materials and carrying fish from Eliots Beach. Corporation zonal office is located in Mylapore and due to which garbage trucks (about 450 nos.) are plying through the bridge in a day. These trucks are also not included for estimating the sectional traffic. It is also observed that about 100 trucks carrying coal from Chennai Port to southern districts of Tamil Nadu use the bridge to access EC road. This traffic is occurring during night as trucks are not allowed during day time in the city. Since Chennai Port Trust proposes to shift the coal handling facility to Ennore Port in the near future, the trucks carrying coal are not included for traffic projection

Table 3.13: Section wise Traffic

Section	Car	TW	Auto	Bus	LCV	MAV	Truck*	Total PCU
Light House-Fore Shore Estate	1685	5507	739	50	137	5	309	8266
Fore Shore Estate- Besant Nagar	3736	9836	1761	50	182	7	378	15713
Besant Nagar – Kottivakkam	1332	3269	351	50	172	3	239	5230

*(Note: *- trucks including coal carrying trucks from Chennai Port)*

3.5.5 Pedestrian count Survey

The pedestrian count was conducted at three locations. The count was taken up in the peak hours in the morning/evening. The summary of pedestrian count is given in the **Table 3.14**. Since it is proposed to develop an elevated road for the entire length, no recommendations are made for pedestrian facilities along the road.

Table 3.14: Peak Pedestrian counts

Sl. No	Road Stretch	Peak Hour	Pedestrians Along the Road	Pedestrians Across the Road
1	Elliots Beach Road	7pm- 8pm	3520	901
2	Santhome Beach Road	9.30 am- 10.30 am	1013	475

3.5.6 Parking Survey

Parking survey was conducted at three locations. The count was taken up in the peak hours. The summary of the parking survey is given in the **Table 3.15**. Due to the same reasons listed above, no recommendations are made for parking also.

Table 3.15 Summary of Parking Count Survey

Sl. No	Road Stretch	Peak Hour	Peak Hour Parking				
			Bus	Auto	Car	TW	Cycles
1	Elliots Beach Road (from Skating Ground to 5th Avenue)	7pm- 8pm	-	-	531	2560	177
2	Santhome Beach Road	6 pm- 7pm	9	135	152	644	117

3.6. Traffic Forecasting

The lane requirement of the proposed road would be decided by the expected future traffic on the road. Traffic projection is done by adopting appropriate growth rates for various vehicle types. Since the project road is a new facility, no past traffic data is present to analyse the growth of traffic in the past. Hence growth rates were estimated using Elasticity method. The details on the traffic forecasting carried out are described in the following sections.

3.6.1 Project Influencing Region

The project road is located in the city; hence the major influencing area will be Chennai city itself. It is proposed to link the road with EC road near Kottivakkam. Hence there can be traffic bound from/to southern districts of Tamil Nadu, especially Kancheepuram and Pondichery as is evident from the OD analysis.

3.6.2 Socio-Economic Profile

Socio-economic profile of Tamil Nadu is considered to derive the future growth prospects of the region and correspondingly the traffic growth in the region, as district wise data is not available for the recent past years. The performance of the economic indicators was collected for the past period with the objective of establishing elasticity of traffic demand to the different economic indicators. The economic indicators considered for the analysis include:

- Population
- Per Capita Income (PCI)

- Tourism
- NSDP

The per capita, population and tourism data is used for estimating the growth rates for passenger vehicles, while the NSDP, Secondary sector and fishing sector growth are used for commercial vehicles growth rate estimation.

3.6.3 Growth Rates for Passenger Vehicles

Growth in population, per capita income from 1998-99 to 2003-04 of Tamil Nadu and growth in tourist arrivals in Chennai are considered for the growth rate estimation. Since the road give access to Elliot's Beach and various beach resorts/ Amusement Parks on EC road, factor indicating the growth in tourism sector of Chennai is also taken into account. The indicators with weightages adopted for each sector is given in **Table 3.16**.

Table 3.16: Growth Rates for Social Indicators

Indicators	Compound Growth Rate (%)	Weightage (%)
Per Capita Income	2.98	70
Population	0.94	5
Tourism	7.05	25

(Source: Statistical Hand book, Tamil Nadu 2004-05)

The weighted growth rate of the social indicators is multiplied with elasticity factor for obtaining the final growth rate for passenger traffic. The elasticity values adopted is given in **Table 3.17**.

Table 3.17: Elasticity Values Adopted

	2006-2011	2011-2016	2016-2021
Truck/MAV	1.4	1.2	1.1
Car	1.6	1.5	1.4
Bus	1.3	1.2	1.1

(Source: Elasticity Values suggested by IRC (Road Development Vision Plan: 2021)

3.6.4 Estimation of Growth Rates for Commercial Vehicles

The growth trend for economic indicators listed above for the period 1998-99 to 2003-2004 are used for arriving growth rates for commercial vehicles. The growth in NSDP, Secondary sector and fishing sector of Tamil Nadu are taken and shown in **Table 3.17**. These combined growth rates were multiplied with the elasticity values to obtain the final growth rates. The factors and corresponding weightages adopted for the analysis are given in **Table 3.18**.

Table 3.18: Growth Rates of Economic Indicators

Indicators	Compound Growth Rate (%)	Weightage (%)
NSDP	3.95	60
Secondary	2.10	15
Fishing	1.08	25

3.6.5 Growth Rate from Vehicle Registration Data

The vehicle registration data for 2001-2002 and 2003-2004 for the district of Chennai was obtained. The same is given in **Table 3.15** for comparison of the derived growth rates.

Table 3.19 Growth Rates in Vehicle Registration

	Car	TW	Auto	LCV	Bus	Truck		Grand Total
						Lorries	MAV	
Chennai								
2001-2002	244363	1011072	43227	6254	4502	21905	2391	1333714
2003-2004	284076	1187684	42854	8837	4731	19654	2592	1550428
Growth Rate	**8%**	**8%**	**-**	**19%**	**3%**	**-**	**4%**	**8%**

(Source: Statistical Hand book, Tamil Nadu, 2004-05)

3.6.6 Recommended Growth Rates for the Project Road

It was observed that the growth rates arrived on the basis of socio economic growth of the project area gave more realistic results. As such, it is adopted for the projection of traffic for the design period. The final recommended growth rates are given in **Table 3.20**.

Table 3.20 Annual Growth Rates Adopted for the Project Road (%)

Vehicle Type	2006-2010	2011-2015	2016-2021	>2021
Car (New Tech)	6.3	7.0	6.0	5.4
Car (Old tech)	3.0	3.3	3.3	3.0
TW	7.9	7.0	6.0	5.4
Auto	3.8	4.2	3.6	3.2
Bus	3.1	3.5	3.6	3.4
Truck	4.5	4.3	3.9	3.5
MAV	5.0	4.7	4.3	4.1
LCV	5.0	4.7	4.3	4.1

3.6.7 Projected ADT

Using the above growth rates, the traffic projection is carried out for the next twenty five years (from the year 2006 to 2029) and the projected traffic for the three sections are given in **Table 3.17** to **Table 3.19.** (Note: Trucks carrying coal from Chennai Port are not included for projection). It is assumed that the bypass will be operational from 2011.

3.6.8 Generated Traffic

The road will act as a vital link between Palavakkam/ Kottivakkam/ places beyond south and Chennai city. Considering the existing land use and potential for growth of these areas, it is felt that there is better scope for new traffic generation due to the project road. But the generated traffic is not included in the traffic projection.

Table 3.21: Projected Traffic on Stretch between Light House and Fore Shore Estate

Year	Two Wheelers	Car(N)	Car(O)	Auto	Bus	MAV	LCV	Truck*	Total vehicles	Total PCU
2011	7984	2073	195	893	59	6	174	260	11646	10980
2012	8543	2218	201	931	61	7	183	271	12414	11664
2013	9140	2373	207	970	63	7	191	283	13234	12393
2014	9780	2539	213	1011	65	7	200	295	14110	13170
2015	10464	2717	220	1053	67	8	209	308	15045	13997
2016	11094	2880	226	1091	70	8	218	320	15908	14760
2017	11763	3054	233	1131	72	8	228	332	16821	15566
2018	12472	3238	240	1172	75	9	237	345	17788	16418
2019	13224	3433	247	1214	78	9	248	358	18811	17318
2020	14021	3640	255	1258	80	9	258	372	19894	18269
2021	14781	3837	263	1299	83	10	269	385	20927	19176
2022	15583	4045	270	1341	86	10	280	399	22014	20128
2023	16428	4265	279	1385	89	11	291	413	23160	21130
2024	17319	4496	287	1430	92	11	303	427	24365	22182
2025	18258	4740	295	1476	95	11	315	442	25635	23289
2026	19249	4997	304	1524	98	12	328	458	26971	24452
2027	20293	5268	313	1574	102	12	342	474	28378	25675
2028	21393	5554	323	1625	105	13	356	491	29860	26962
2029	22554	5855	333	1678	109	13	370	508	31420	28314

*(Note: *-Trucks carrying coal from Chennai Port are not included for projection)*

Table 3.22: Projected Traffic on Stretch between Fore Shore Estate and Besant Nagar

Year	Two Wheeler	Car(N)	Car(O)	Auto	Bus	MAV	LCV	Truck*	Total vehicles	Total PCU
2011	14261	4596	433	2129	59	9	232	346	22064	21187
2012	15258	4917	446	2219	61	9	242	361	23514	22500
2013	16325	5261	459	2312	63	10	254	376	25061	23898
2014	17467	5629	473	2409	65	10	266	392	26712	25386
2015	18689	6023	487	2510	67	11	278	409	28475	26971
2016	19816	6386	502	2600	70	11	290	425	30100	28432
2017	21010	6771	517	2695	72	12	302	442	31820	29974
2018	22276	7179	533	2792	75	12	315	459	33641	31604
2019	23619	7612	549	2893	78	13	329	477	35568	33325
2020	25042	8070	565	2998	80	13	343	495	37607	35143
2021	26400	8508	582	3095	83	14	357	513	39552	36874
2022	27832	8970	600	3196	86	14	372	531	41599	38694
2023	29342	9456	618	3300	89	15	387	549	43755	40607
2024	30933	9969	636	3407	92	15	403	569	46024	42617
2025	32611	10510	655	3518	95	16	419	589	48412	44730
2026	34380	11080	675	3633	98	17	436	609	50927	46951
2027	36244	11681	695	3751	102	17	454	631	53574	49286
2028	38210	12314	716	3873	105	18	472	653	56362	51740
2029	40283	12982	737	3999	109	19	492	676	59296	54320

(Note: Trucks carrying coal from Chennai Port are not included for projection)

Table 3.23: Projected Traffic on Stretch between Besant Nagar and Kottivakkam

Year	Two Wheeler	Car(N)	Car(O)	Auto	Bus	MAV	LCV	Truck*	Total vehicles	Total PCU
2011	4740	1639	154	424	59	4	219	173	7411	6984
2012	5071	1753	159	442	61	4	229	181	7900	7421
2013	5426	1876	164	461	63	4	240	188	8421	7887
2014	5805	2007	169	480	65	4	251	196	8978	8383
2015	6211	2147	174	500	67	5	263	205	9572	8912
2016	6586	2277	179	518	70	5	274	213	10121	9401
2017	6983	2414	184	537	72	5	286	221	10702	9917
2018	7403	2560	190	556	75	5	298	229	11317	10463
2019	7850	2714	196	577	78	5	311	238	11968	11039
2020	8323	2877	201	597	80	6	324	248	12657	11649
2021	8774	3033	208	617	83	6	337	256	13315	12230
2022	9250	3198	214	637	86	6	351	265	14007	12842
2023	9752	3371	220	658	89	6	366	275	14736	13485
2024	10281	3554	227	679	92	7	380	284	15504	14160
2025	10838	3747	234	701	95	7	396	294	16312	14871
2026	11426	3950	241	724	98	7	412	305	17163	15618
2027	12046	4165	248	748	102	7	429	315	18059	16404
2028	12699	4390	255	772	105	8	446	326	19002	17230
2029	13388	4629	263	797	109	8	465	338	19996	18099

(Note: Trucks carrying coal from Chennai Port are not included for projection)

3.6.9 Projection Based on Peak Hour Traffic

A peak hour factor of 8% is taken as observed on Thiru- Vi- Ka Bridge, to estimate the maximum traffic on the Section between Fore Shore Estate and Besant Nagar, as this section will carry the highest traffic. The peak hour traffic is also projected to the horizon year to verify the lane requirement based on peak traffic and is presented in **Table 3.24**.

Table 3.24 Projected Peak Hour Traffic on Section II

Year	Peak Hour Traffic (PCU)	Year	Peak Hour Traffic (PCU)
2006	1248	2018	2970
2007	1343	2019	3184
2008	1445	2020	3415
2009	1556	2021	3659
2010	1677	2022	3923
2011	1802	2023	4206
2012	1938	2024	4512
2013	2085	2025	4841
2014	2244	2026	5197
2015	2416	2027	5580
2016	2587	2028	5993
2017	2772	2029	6439

3.6.10 Lane Requirements

The lane requirement of the bypass is verified with the warrants given in "IRC 106-1990, Guidelines for Capacity of Urban Roads". The bypass is taken as sub arterial category of urban roads and as per the listed IRC, the Design Service Volume (DSV) based on ADT and peak hour traffic is given inn **Table 3.25**.

Table 3.25: Recommended Design Service Volume/ Maximum Capacity on Sub Arterial Urban Roads

Type of Carriageway	Peak Hour Traffic (PCU/ Hr)		ADT (PCU)	
	DSV (at LoS C)	Maximum Capacity (LoS E)	DSV (at LoS C)	Maximum Capacity (LoS E)
2 lane two way	1200	1700	15000	21400
4 lane Divided	2900	4100	36300	51900
6 lane Divided	4300	6100	53800	76900

It is clear from **Table 3.18** (for ADT projection) and **Table 3.20** (for peak hour traffic projection) on section II will cross the DSV (at LoS C) of 2 lane two way carriageway in the current year and the DSV of 4 lane divided carriageway in 2018. A six lane bypass is proposed for the 2nd section, while four lane is proposed for the first and third section from Besant Nagar to Kottivakkam. Though the expected traffic on the second section reach the DSV of 6-lane divided carriage way in 2024, the road will cater for another five years, but at lower LoS.

3.7. Recommendation

From the traffic projection and the growth potential along the corridor, it is proposed to have a six lane road from Foreshore to Besant Nagar and four lane road from Light house to Foreshore Estate and Besant Nagar to Kottivakkam with entry and exit ramps at Fore Shore Estate, and Besant Nagar.

Chapter 4: Improvement Proposals

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4. Improvement Proposals

4.1 General

The improvement proposals are finalized based on the results of the surveys and investigations described in Chapters 2 and 3 and also based on the decisions taken during the discussions held with the client. As part of the study, the following two alignment options were studied for proposed elevated road from km 5/4 of Kamarajar Salai near Gandhi Statue to connect East Coast Road (ECR) at Km 14/6 near Kottivakkam. The proposed two alignment options are shown in **Figure 4.1**

1. **Option 1:** From Light House to ECR via Srinivasapuram, Oorur kuppam, Kottivakkam Kuppam along the Coast to Join ECR at km 14/6 (9.705 Km)
2. **Option 2:** From Light House to ECR via Srinivasapuram, Oorur Kuppam, Besant Nagar, 5th, 3rd, 4th 2nd & 7th Avenue, LB Road, along ECR via Tiruvanmiyur,terminates at km 14/6 of ECR near Kottivakkam(11.6km), along the existing road alignments for the entire length.

4.2 Alignment Options

Option 1: As discussed above, the alignment of both the options are similar upto Ururkuppam and it continues along the existing beaches and joins ECR near Kottivakkam. Total length of this alignment option is 9.6km. At the end of the project road for about 700m, the alignment passes through residential area, and the rest of the length traverses through the coastal line along the beach.

Option 2: The initial 5km long section of alignment between Gandhi Statue and Ururkuppam is same as in the Option1. From Ururkuppam, it deviates from the line and runs along the existing Annai Velankanni road and LB road. This alignment options meet ECR at km 11/8 near Thiruvanmiyur and terminates at km 14/6 near Kottivakkam.

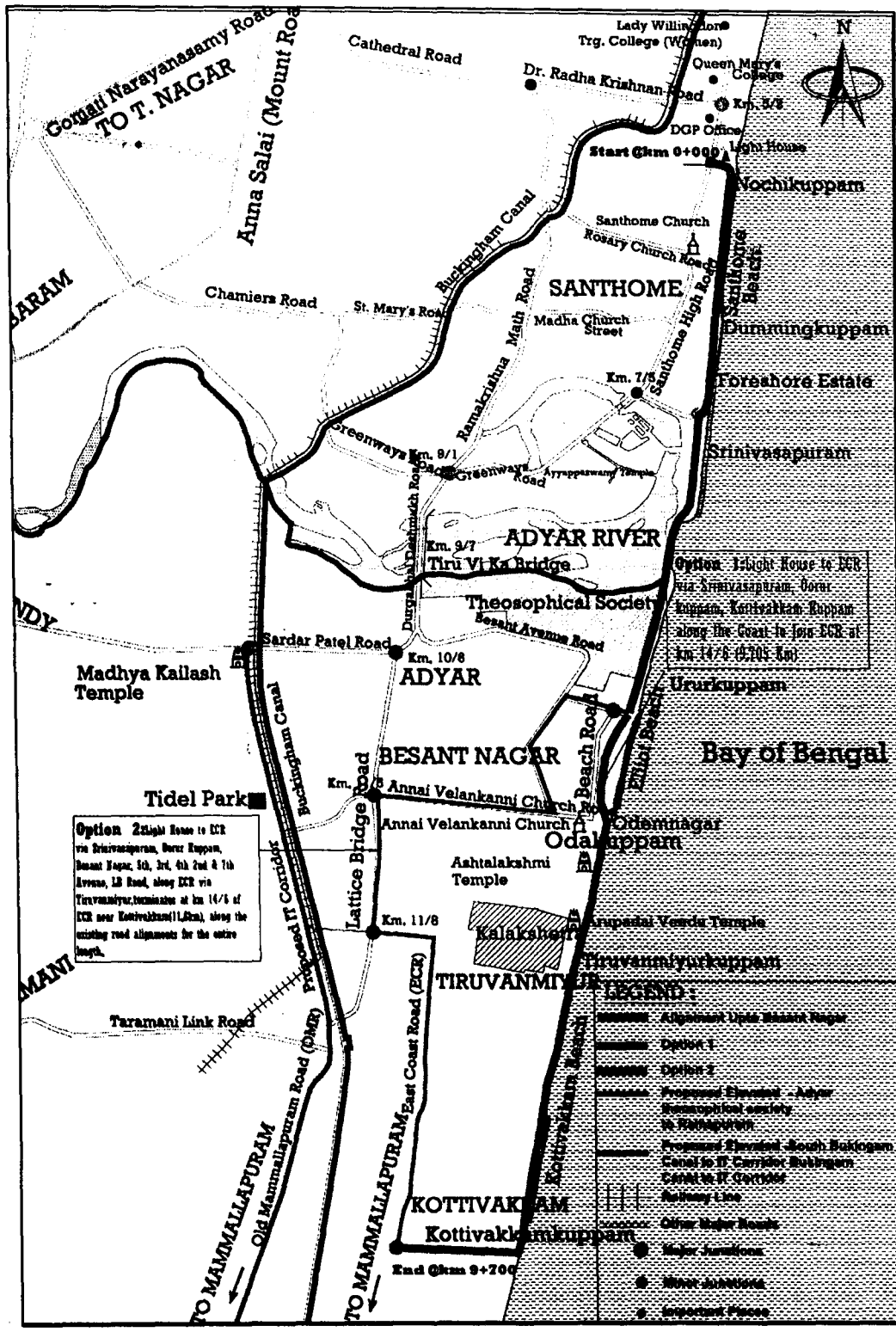


Fig 4.1 Alignment Options for Elevated Road between Light House and ECR

4.2.1 Alignment Approval

The above two alignment options were submitted to the Highways Department, GoTN during July, 2006 and approval for the section of Option 1 from Light House to Ururkuppam (5.0km) was given by Highways Department on 30.08.2006 ***(Letter No.11458/2006/D.1/dated 30.08.2006).*** Further to this, a joint site inspection was held with Superintending Engineer (H), Chennai Circle on August 16, 2006 to get the approval for the remaining sections and accordingly the stage II alignment between Ururkuppam to ECR along the coast was approved by Highways Department on 07.12.2006 ***(letter No.11458/2006/D1/dated 07.12.2006).***

Further to the getting approval for the alignment along the coast (Option 1), the draft feasibility report (DFR) was submitted on 12.04.2007 and the same was presented to the Chief Secretary on 06.08.2007 and this committee has also approved the Option 1 alignment along the costal line on 28.08.2007 ***(Letter No.14283/HW1/2007-3 dated 28.08.2007).*** The project after incorporating the suggestions made during the review meeting held on 06.08.2007 was again presented to the review committee on 19.03.2008.

The project was also presented to the Hon'ble Chief Minister of Tamil Nadu on 16.04.2008. During the above meeting Hon'ble minister for PWD, Hon'ble minister for Highways, Chief Secretary, Finance Secretary, Highways Secretary, Chief Engineer (H), General and other officials from GoTN were also present. This committer has also decided to take up the improvement of Phase I from Light House to Besant Nagar on a priority basis. Snapshots of the presentation to the Hon'ble Chief Minister of Tamil Nadu on 15.04.2008 is shown in Plate 4.1

The comments and suggestions made during the above review meetings on the draft final report were incorporated in the final report and the same was submitted to Principal Secretary to Govt. Highways Department on 14.11.2008. Further to this there was a presentation to the Principal Secretary to Govt. Highways Department on 22.11.08. The revised final report incorporating the comments of Govt. was submitted to Chief Engineer (H), Metro on January 21, 2009.

Further to the submission of the revised final detailed feasibility report, presentation was given to the Chief Secretary, GoTN on 28.01.09. During the above review meeting Chief Secretary has requested the Housing & Urban development secretary to organize further review meetings to sort out the issue of alignment fouling with the proposed housing schemes by Tamil Nadu Slum Clearance Board under ETRP. Meeting was held in the Chamber of Principal Secretary to Government Housing Department on 30.01.09 and 09.02.09 organized by Housing Secretary. Another meeting organized by CMDA held on 05.02.09. During the above review meeting comments has been made to revise the alignment to have least disturbance to the proposed tenements by TNSCB. The revised alignment incorporating the suggestions made during the above review meetings was submitted to C.E (H), Metro on 18.02.09.

Further to this Steering Committee was held on 09.03.09 and committee suggested that the alignment may be suitably modified to shift the ramp away from the statues after taking minimum extent of land from DOP office in order to avoid shifting of statues located on the eastern side of Kamarajar Salai. The Principal Secretary, Highways and Minor Ports further asked to include the cost of land belonging to TN Slum Clearance Board in the Project cost. In the committee Deputy Commissioner of Police, (Traffic) Central District, Chennai felt that the clearance of 5.5m for the exit ramp may not be sufficient for accommodating the floats loaded with helicopters for the Republic Day Parade from Light House to Gandhi Statue. The Principal Secretary to Government, Highways and Minor Ports explained that when the floats with helicopters are transported from Tambaram and crosses the ROB at MIT Gate which has the same clearance, the Republic Day Floats can also cross the proposed elevated viaduct of obligatory span at Light House which will have a vertical clearance of 5.5m.

The proposed alignment has been finalized considering all these suggestions. **The salient features of the proposed alignment of Phase I from Kamarajar Salai to Besant Nagar is discussed below:**

THE HINDU 16-04-2008

Karunanidhi meets officials

CHENNAI: Chief Minister M. Karunanidhi on Tuesday held a discussion with officials on elevated road corridors between Light House and Besant Nagar and the Chennai port and Maduravoyal.

They also discussed construction of roads on both sides of rivers in Chennai, a government press release stated.

PWD minister Durai Murugan, Highways minister M.P. Saminathan, Chief Secretary L.K. Tripathy, Finance Secretary K. Gnanadesikan, Highways secretary K. Allaudin and senior officials attended the meeting. – Special Correspondent

போக்குவரத்து நெரிசலை குறைக்க

அதிகாரிகளுடன் முதல்வர் ஆலோசனை

சென்னை, ஏப்.16: தமிழக அரசு நேற்று வெளியிட்டுள்ள செய்திக் குறிப்பு:

சென்னையில் ஏற்பட்டுள்ள போக்குவரத்து நெரிசலை குறைக்க செய்யவுள்ள திட்டங்கள் குறித்து அதிகாரிகளுடன் முதல்வர் கருணாநிதி நேற்று ஆலோசனை நடத்தினார்.

கலங்கரை விளக்கம் முதல் பெசன்ட்நகர் வரை உயர்மட்ட பாலம் கட்டுதல், மதுரவாயல் முதல் சென்னை துறைமுகம் வரை பறக்கும் சாலை திட்டம், கூவம் உள்ளிட்ட ஆறுகளின் கரையோரங்களில் சாலை அமைப்பது ஆகிய திட்டங்கள் குறித்து ஆய்வு செய்யப்பட்டது.

இந்தக் கூட்டத்தில், அமைச்சர்கள் துரைமுருகன், சாமிநாதன், தலைமைச் செயலாளர் திரிபாதி, நிதித்துறை செயலாளர் ஞானதேசிகன், நெடுஞ்சாலைத்துறை செயலாளர் அலாவுதின் உட்பட பலர் கலந்து கொண்டனர்.

Plate 4.1 View of the Review meeting held with Hon'ble Chief Minister of Tamil nadu on 15.04.2008

4.3 Salient Features of the Approved alignment for Phase 1

The alignment takes off at km 5/4 of Kamarajar Salai near Gandhi Statue.

- Entry Ramp starts about 120m to the South of Gandhi Statue and it's towards the western edge of Existing carriageway for 300m. Then Turns left to Beach road and go along its southern side and turns right to join the elevated Highway.
- The exit ramp terminates on beach road at 100m from the junction of Beach road to Kamarajar Road which is on the northern side of Road
- Then elevated section runs along the western edge of the existing Santhome loop road for a length of 1.9 km, passing through Nochikuppam, Dumming Kuppam, Bhavani Kuppam and Mulliamman Nagar, where it joins with the Fore Shore Estate road. Upto here the alignment length including the start ramps is of length 2.4km.
- The alignment further runs along settlements of Srinivasapuram along the western edge of the existing BT road upto Adyar River. Total length of this section of alignment between Santhome Loop road junction upto Adyar River is 0.7km
- The alignment crosses Adyar Estuary to the western side of the existing broken bridge, further runs along the existing single lane BT road upto Ururkuppam, where the alignment joins with the Besant Nagar 5th Avenue road near Elliot's beach. Total length of this section between Adyar Estuary and 5th Avenue road is 0.998 km.
- Total length of the alignment approved for Phase I is 4.7km of elevated structure with 5.5m vertical clearance. As the proposed alignment is entirely elevated, entry and exit ramp arrangements are provided at junction of project road with Fore shore estate road and Besant Nagar 5th Avenue Road.

Fig 4.2 will give the phasing arrangements.

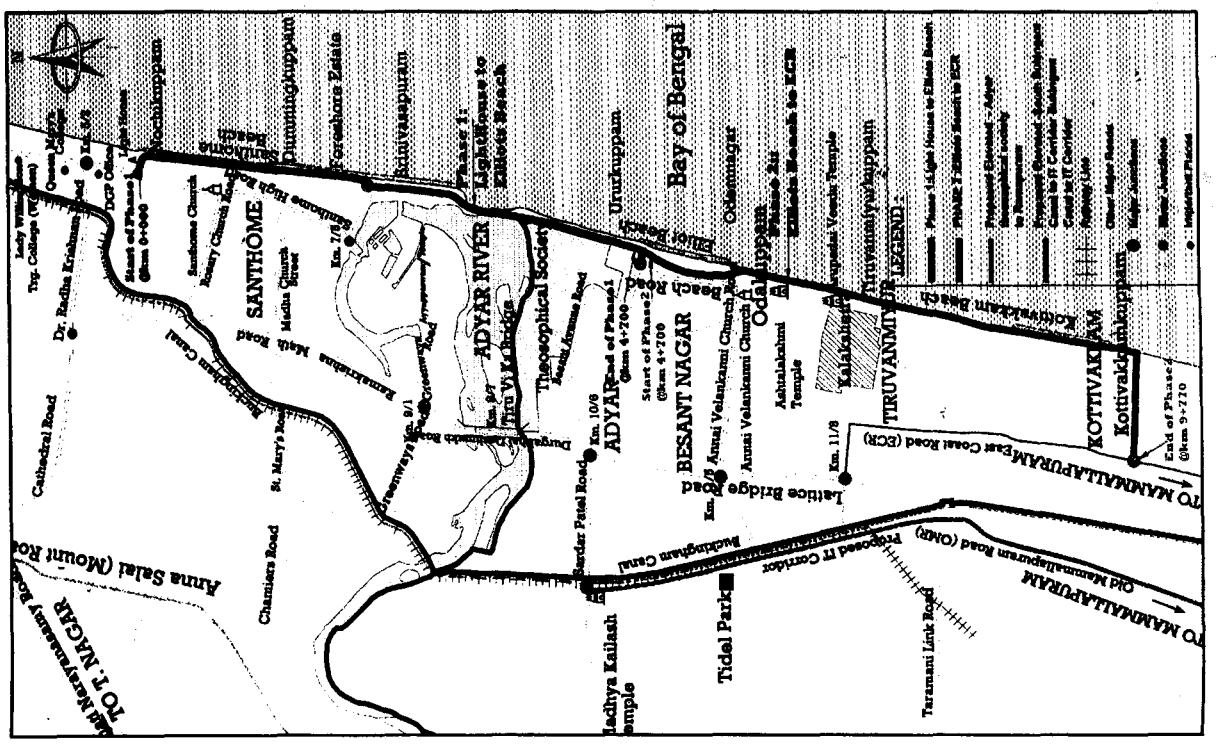


Fig 4.2 Phasing for Elevated Road between Light House and ECR

4.4 Geometric Design Standards

As this project road falls in Chennai City limits, relevant IRC design standards for urban roads with due consideration to the latest directive and guidelines of MORT&H/IRC was followed with reference to the Terms of Reference, as far as possible, while formulating the highway design standards. Other National and International standards and relevant technical papers/journals were also referred to wherever found relevant. Standards for the various components are briefed below.

Design Speed

The ruling design speed of 100 Kmph is adopted for the elevated road corridor portion, 30 kmph is adopted for the design of junction and approach curves at the start and end of the flyover. Entry and exit ramps are designed for 65kmph.

Carriageway Width

Based on traffic projection, the entire stretch is divided in to the following three different homogeneous sections.

- Section I – Gandhi Statue to Fore Shore Estate
- Section II – Fore Shore Estate to Elliots Beach
- Section III – Elliots Beach to Kottivakkam

Based on the traffic requirement as per the projections, four lane configurations is proposed for the Section I and Section III and six lane width is proposed for the Section II. Ramps with two lane configuration are provided at Foreshore estate and Eliot beach. ***However, during the presentation held with Government on 06.08.07, the committee has recommended to have only uniform four lane carriageway width for the entire length of the corridor and accordingly the present proposal is finalized with four lane configuration.***

Camber

Camber of 2.5% is proposed for carriageway. On super-elevated sections, the maximum super elevation is restricted to 4% as per urban standards.

Horizontal Alignment

Horizontal Alignment should be fluent and blend well with the surrounding topography. The horizontal curves are designed as per IRC standards with sufficient transition lengths. The minimum curve radius adopted for ruling design speed of 100 Kmph is 360m and for design speed of 30Kmph, it is 40m.

Vertical Alignment

Vertical alignment is designed based on the provision of IRC SP: 23. Details of rate of curvature (K Value) and minimum curve length adopted are given in **Table 4.1**.

Table 4.1: Minimum Length of Vertical Curves

Design Speed (Km/h)	Maximum grade change (%) not requiring a vertical curve	Minimum length of vertical curve (m)	K value	
			Hog	Sag
30	1.5	15	2	3.5
65	0.8	40	19	18
80	0.6	50	33	26
100	0.5	60	74	42

While proposing the at grade features, high and low tide levels have been analyzed and minimum datum level kept around 2m above the high tide levels. As per IRC_086-1983-Geometric Design Standards for Urban Roads 5.5m vertical clearance is ensured wherever vehicular movement needs to be permitted below the structure.

Road Signage and Markings

Proper signage and delineators are critical for safety and guidance of a driver. Signage drawings will show guide signs and regulating signs at appropriate locations. The signs will be of reflector type to be easily visible in the dark.

All road signs are designed in conformity with the provision of IRC SP 32 – 1992 New Traffic Signs and IRC 67 – 2001 Code of Practice for Road Signs. The signs are Mandatory / Regulatory, Cautionary / Warning and Informatory. Roadside lighting is provided in the median or in the absence of median it is proposed on the crash barrier. The road markings are also designed in conformity with the IRC Standards (latest versions):

- IRC 35-1997 : Code of Practice for Road Markings with Paint;
- IRC 30-1968 : Standard Letters and Numerals of Different Heights Use in Highway Signs and
- IRC 31-1969 : Route Marker Signs for State Roads

Hot applied thermoplastic paints are proposed for better visibility and longer service life (Clause 803-MOST Specifications).

4.5 Improvement Proposals

4.5.1 Junction Improvement Arrangement on Kamarajar Salai

Alignment takes off at km 5/4 on Kamarajar Salai near Gandhi Statue. Considering the land availability and to make use of existing carriage ways at the starting location, up ramp and down ramp are provided. The entry ramp starts at 120 m to south of Gandhi Statue to the western side of Kamrajar Salai Road. It runs for a 300m along the western side of existing carriageway and then turns left crossing the Kamarajar Salai Road towards Santhome Beach runs along the Santhome Beach Road to join the elevated Highway. The exit ramp starts at 90m from the junction of Kamrajar Salai Road and Beach Road and joins the elevated highway. The start point of the project road near light house is ideal for the commuters who are traveling from places such as Chennai port, Parrys corner, Secretariat and Marina Beach. Fig 4.3 gives the plan and proposed view of the arrangement at starting point of the project road on Kamarajar Salai.

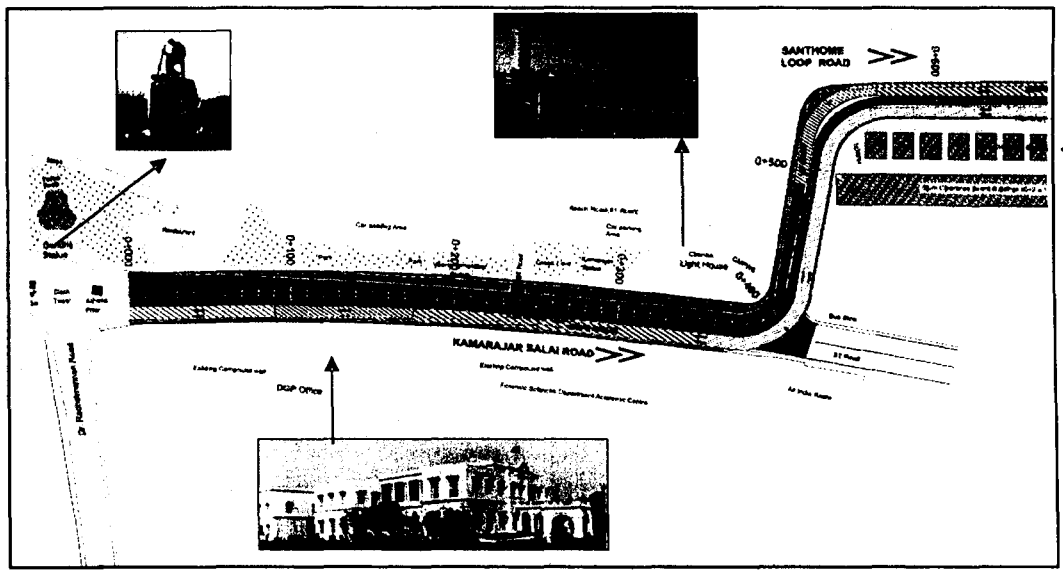


Fig 4.3 Proposed View of Improvements at Kamarajar Salai

4.5.2 Entry Exit Arrangement at Fore Shore Estate Junction

The alignment crosses the Fore shore estate junction at km 2/4, where provision for entry and exit arrangements are made. These ramps are provided in order to give access for the traffic from Santhome high road, Green ways road, Durgabhai Deshmukh road and Lattice Bridge road to use the elevated corridor. The proposed entry and exit arrangement at this location is given in Figure 4.4.

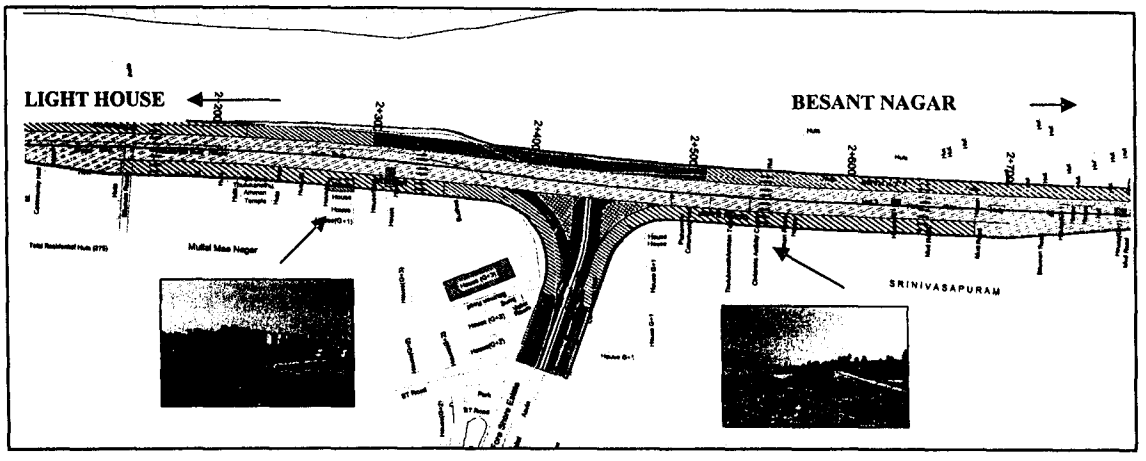


Fig 4.4 Proposed Entry and Exit Ramp Arrangements at Fore Shore Estate junction

4.5.3 Signature Bridge across Adyar River

The alignment crosses Adyar River near the existing broken bridge from km 3/230 to km 3/555. Hence it was decided to reconstruct the existing bridge as part of this project. The option of designing a "Signature bridge" was discussed with the committee during the meeting held on 06.08.07 and committee has welcomed the above idea and approved the design of Signature bridge across Adyar River. The following two options are studied for the reconstruction of the existing bridge:

I. Extradosed cable stayed bridge of length 220m. Approximate cost Rs.29 Crores
II. Steel arched bridge of length250m. Approximate cost Rs.32 Crores

View of alignment along Adyar estuary is shown in figure 4.4 and view of the proposed signature bridge is shown in figure 4.5.

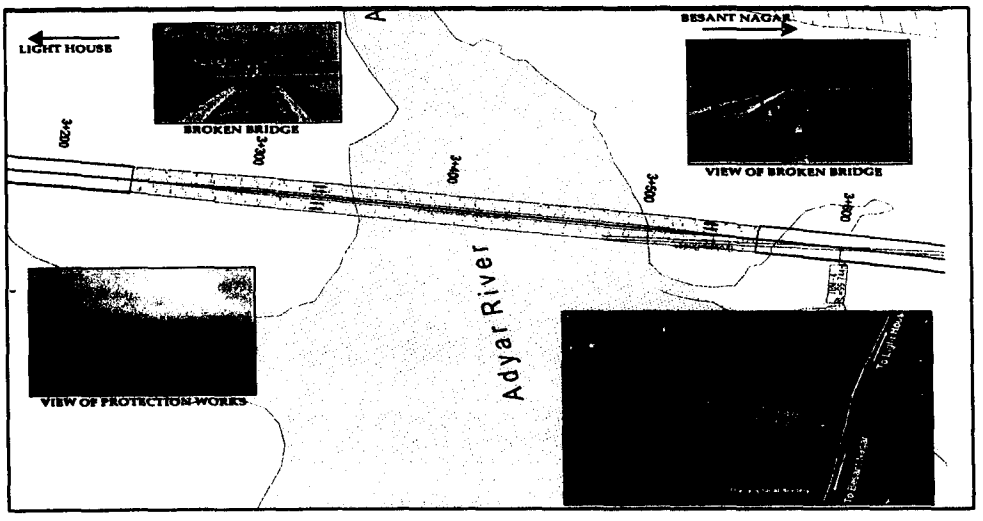
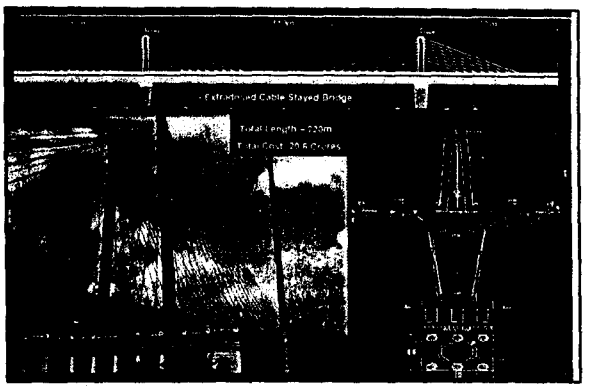
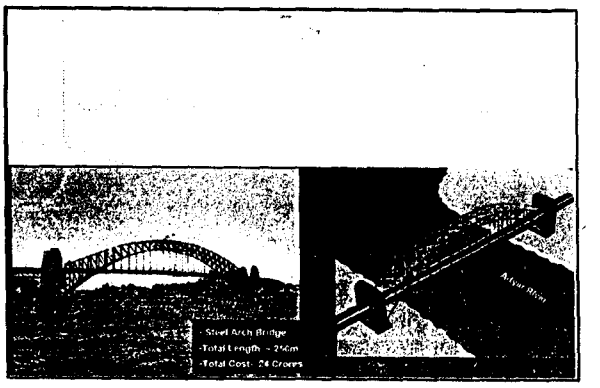


Figure 4.5 View of Alignment along Adyar Estuary





Signature Bridge - Extradosed cable stayed **Signature Bridge – Steel Arched**

Figure 4.6 View of proposed Signature Bridge across Adyar River

The committee has approved the option II with steel arched bridge during its meeting held under the Chairmanship of Chief Secretary on 01.03.2008.

4.5.4 Entry and Exit Arrangement at Besant Nagar

Exit ramp to the Besant Nagar starts at km 4/226 and entry ramp at km 4/263 to cater the needs of traffic from Besant Nagar and Adyar and the phase 1 terminates at km 4/700 and the proposed arrangements at this location are shown in figure 4.7. By terminating the main structure at km 4/318 and extending ramps up to Besant Nagar will help for linking the phase-1 with phase-2 with out much hassle. The arrangements are presented in fig 4.7 and detailed in drawing No SE-1-23-RAMP-001of drawing volume.

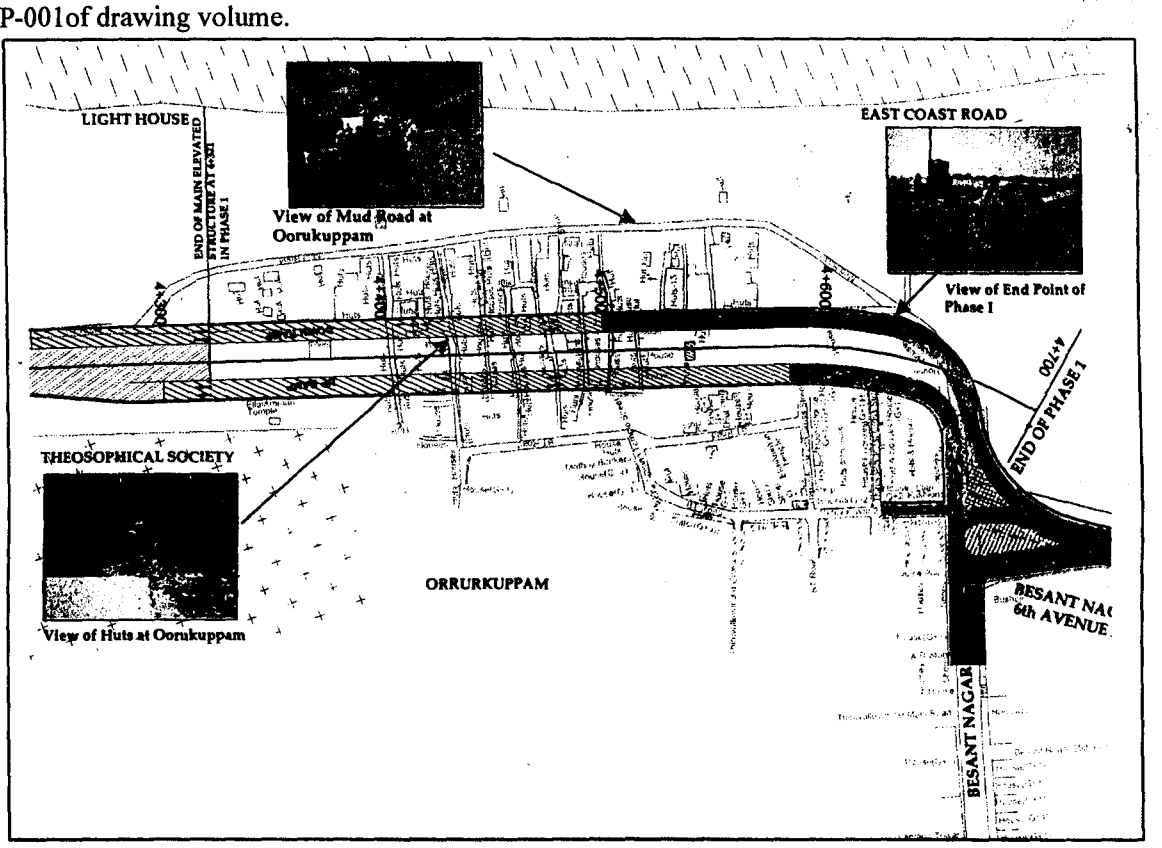


Figure 4.7 Entry and Exit Ramp with provision for Phase 2 arrangement at Besant Nagar

4.6 Connectivity for Proposed Southern Bund Road along Adyar River

In order to reduce congestion and delay at key intersections and other main roads, GoTN has decided to create additional road space along the existing waterways laying emphasis on connectivity to road network within city and the outskirts ensuring mobility to road user. In this connection, GoTN has entrusted the preparation of DFR work to Adyar Poonga Trust (APT). The proposed beltway includes development of a elevated corridor along the southern bund of Adyar River from Adyar esturary to Ramapuram for a length of 11.8km. As the proposed elevated corridor under the present study from Light house to Besant Nagar crosses the Adyar Estuary at km 3/0, the review committee during the meeting held on 19.03.2008 has decided to link this elevated corridor with the proposed southern bund road of Adyar River as shown in Figure 4.8. As both the proposed alignments are elevated, it is proposed to have three tier interchange at this location for the uninterrupted traffic flow. The proposed interchange arrangements at this location is shown in Figure 4.8.

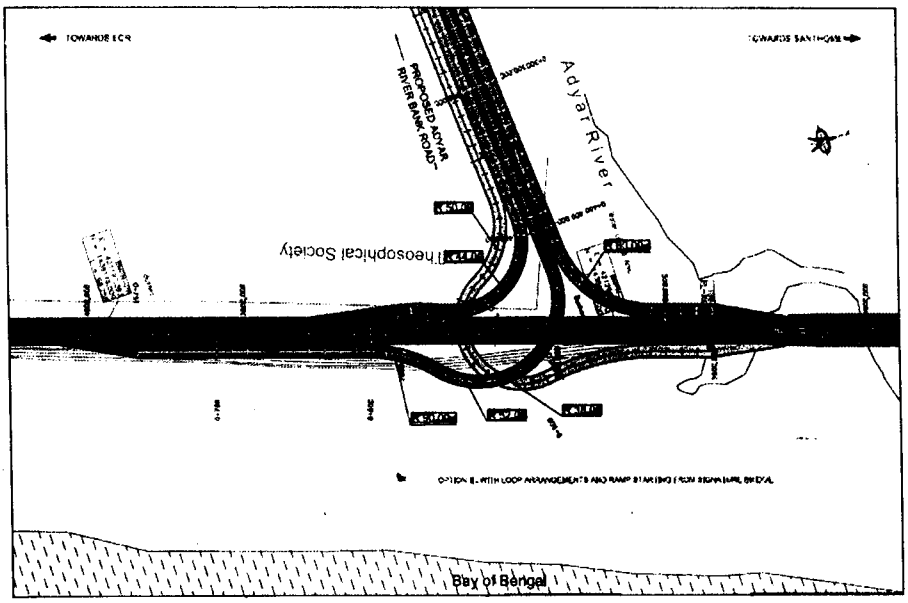


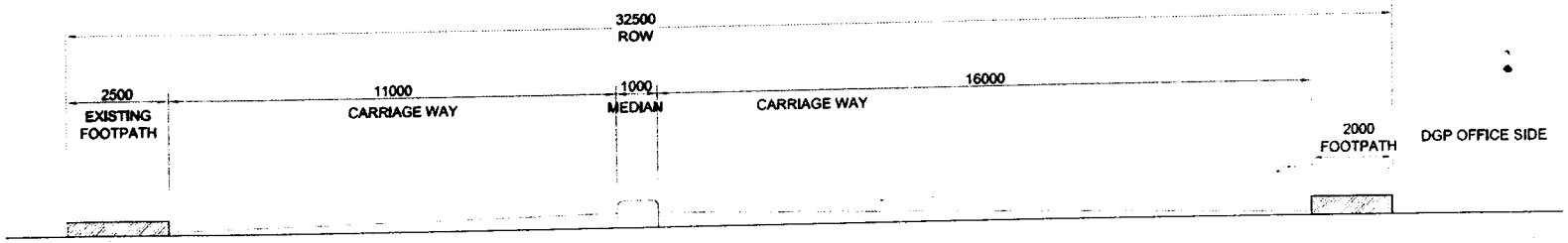
Figure 4.8 Proposed Interchange Arrangement

The main traffic (up and down traffic on the main corridor) between Light house and Besant Nagar will move in the central portion of the elevated corridor. The left turn traffic from Besant Nagar side towards Adyar Bund road will move on the free left arm at "+1 level", also the left turning traffic from Adyar bund road towards Light House will move in the free left at "+1 level". The right turning traffic from Light House side towards Adyar bund road will move at "+0 level" below the elevated corridor. The other right turning traffic of this junction from Adyar bund side towards Besant Nagar will move at "+2 level, over the elevated corridor.

However, the provision of this interchange to be decided during the preparation of the detailed project report (DPR) based on the outcome of the proposed elevated road along the southern bund of the Adyar river.

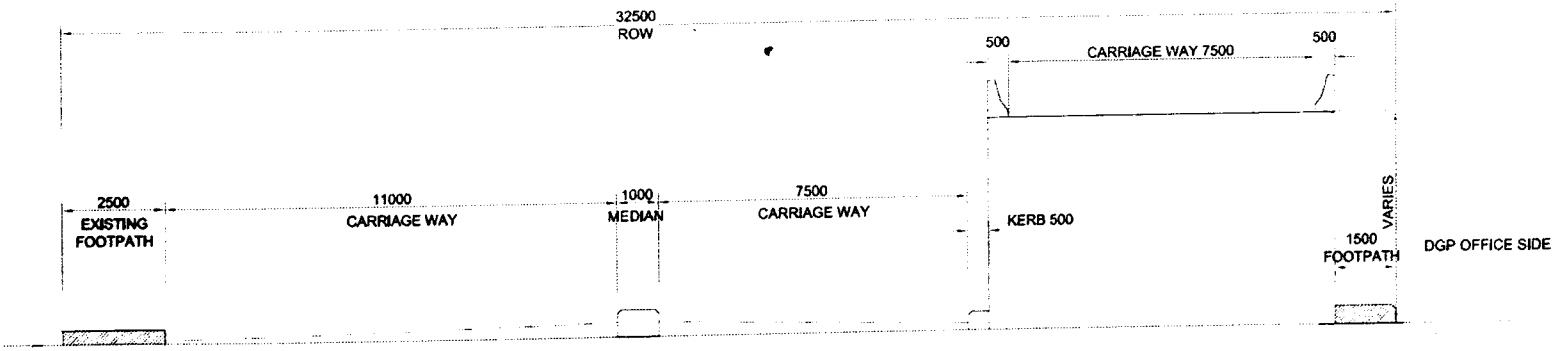
4.7 Typical Cross Section

Single Pier with fish belly superstructure is provided at locations where the elevated road passes along the Santhome loop road for a length of 2.2 km at other locations two piers are provided for a length of 2.5 km. The proposed cross section at different locations are shown in figure 4.9.



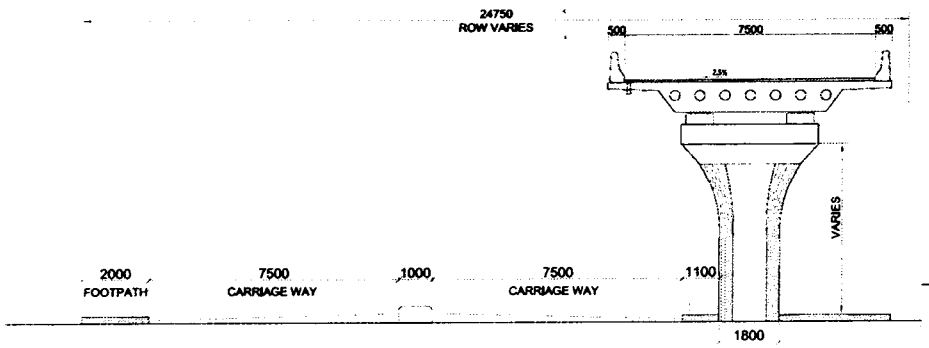
TYPICAL CROSS SECTION AT GRADE ROAD (FROM KM 0+000 TO KM 0+090)

DETAILS OF A-A



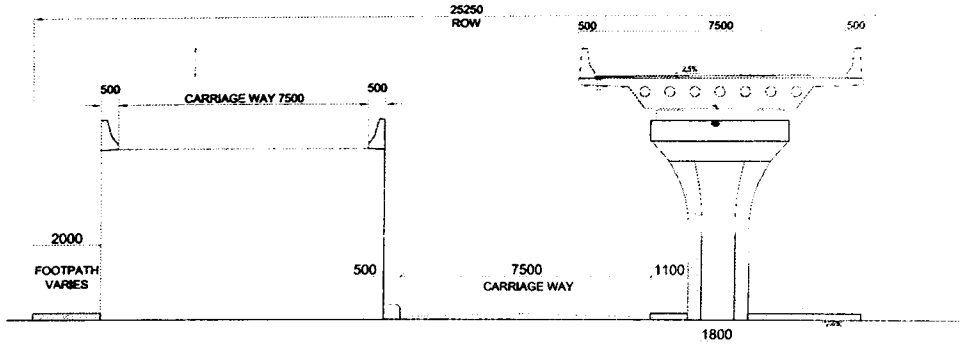
TYPICAL CROSS SECTION FOR STARTING RAMP FROM KM 0+090 TO KM 0+175

DETAILS OF B-B



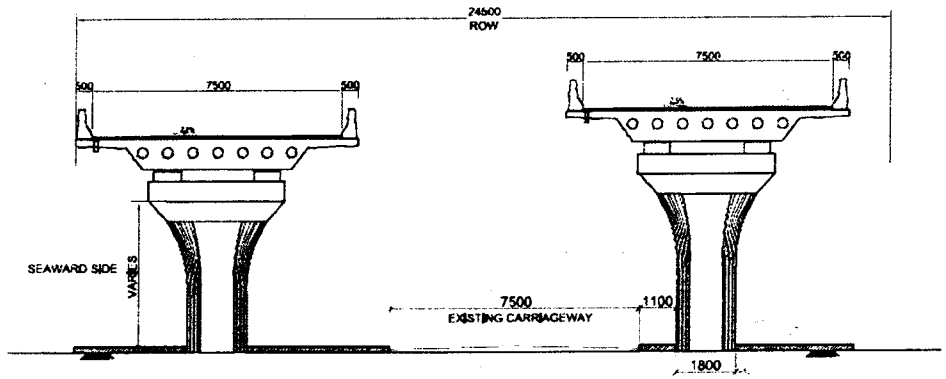
TYPICAL CROSS SECTION FOR SINGLE PIER AT RAMP APPROACH FROM KM 0+175 TO KM 0+490

DETAILS OF C-C



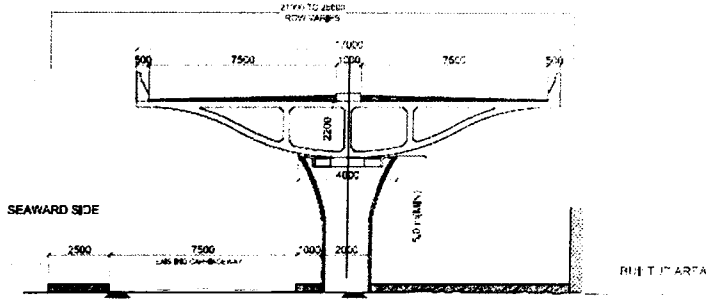
TYPICAL CROSS SECTION AT RAMP APPROACH FROM KM 0+490 TO KM 0+585

DETAILS OF D-D



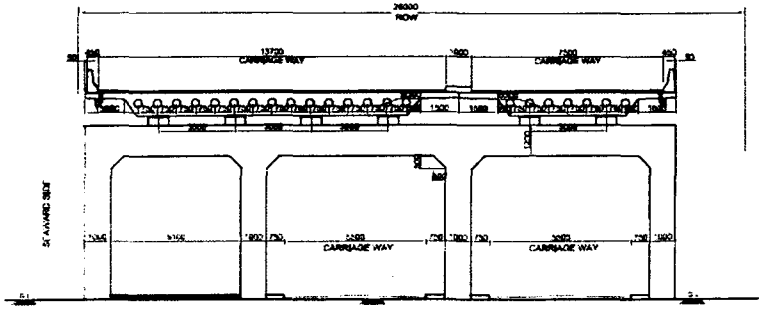
TYPICAL CROSS SECTION AT ELEVATED PORTION FROM KM 0+585 TO KM 0+860

DETAILS OF E-E

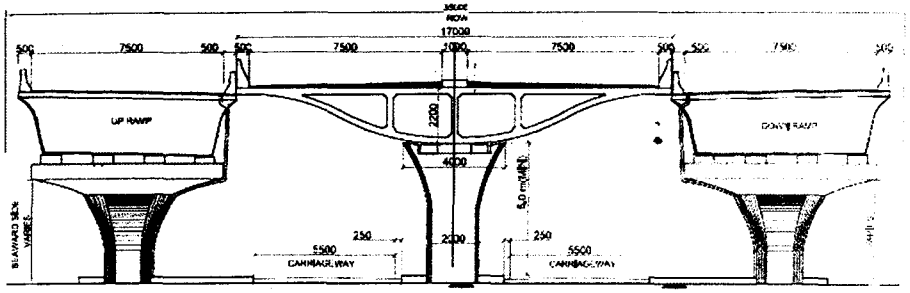


TYPICAL CROSS SECTION FOR SINGLE PIER AT ELEVATED PORTION (FROM KM 0+860 TO KM 1+935),(KM 3+660 TO 4+150)

DETAILS OF F-F

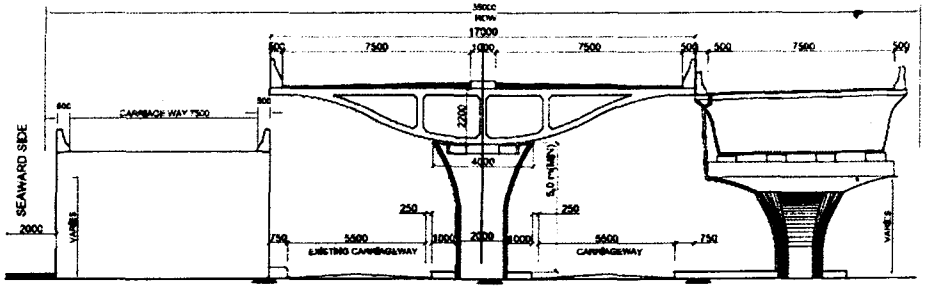


* TYPICAL CROSS SECTION FOR SINGLE PIER AT RAMP APPROACH FROM KM 1+935 TO KM 2+136



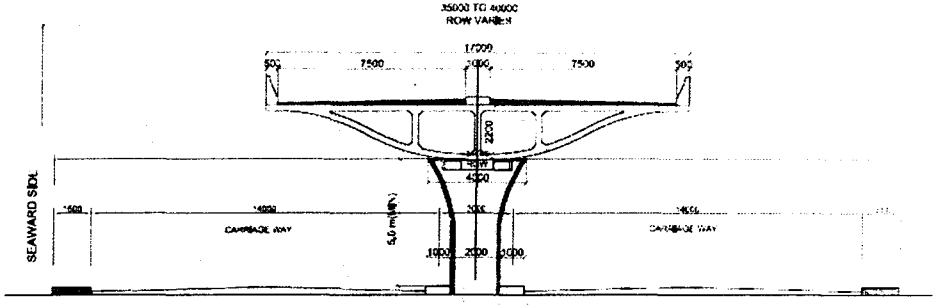
TYPICAL CROSS SECTION FOR SINGLE PIER AT RAMP APPROACH
(FROM KM 2+136 TO KM 2+220),(FROM KM 4+300 TO KM 4+415)

DETAILS OF J-J



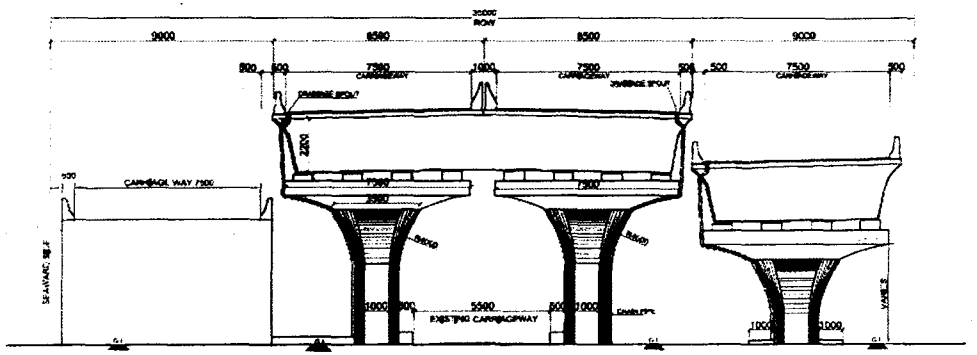
TYPICAL CROSS SECTION FOR SINGLE PIER AT RAMP APPROACH FROM KM 2+220 TO KM 2+300

DETAILS OF G-G



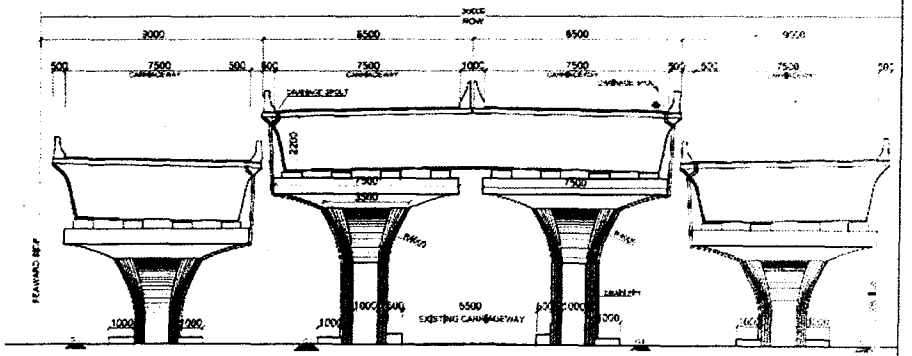
TYPICAL CROSS SECTION AT GRADE ROAD FROM KM 2+300 TO KM 2+510

DETAILS OF H-H

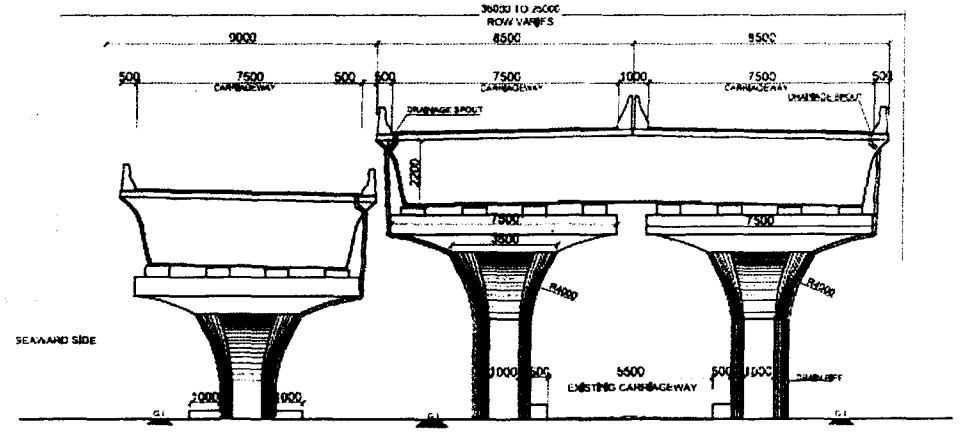


TYPICAL CROSS SECTION FOR SINGLE PIER AT RAMP APPROACH FROM KM 2+510 TO KM 2+585

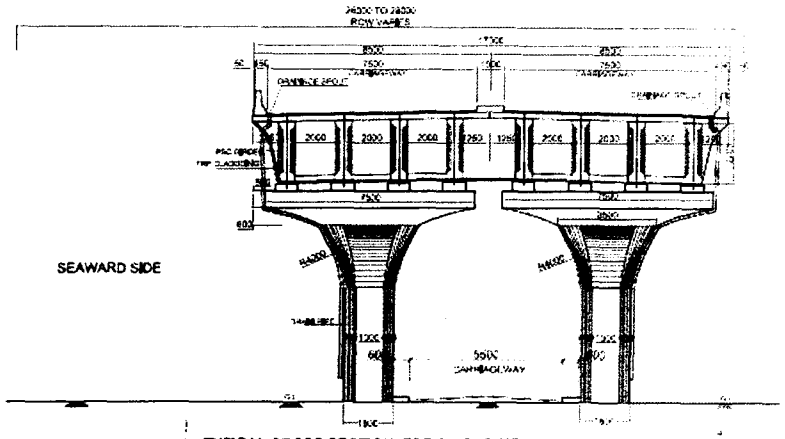
DETAILS OF H



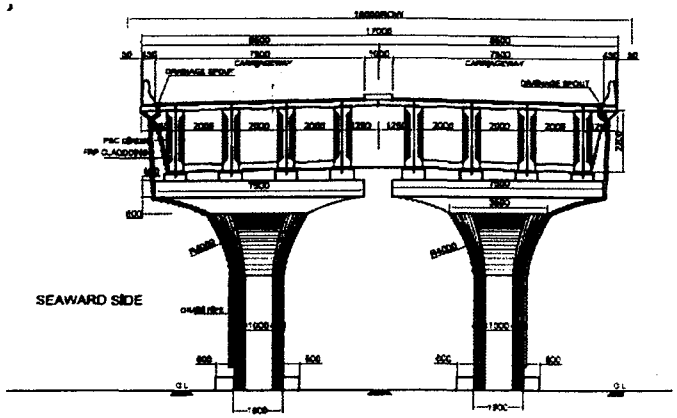
TYPICAL CROSS SECTION FOR SINGLE PIER AT RAMP APPROACH FROM KM 2+585 TO KM 2+700



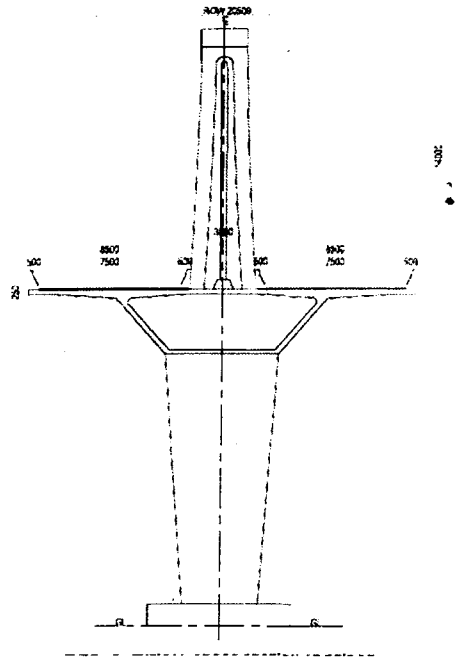
TYPICAL CROSS SECTION FOR SINGLE PIER AT RAMP APPROACH FROM KM 2+700 TO KM 2+885
FROM KM 4+150 TO KM 4+320

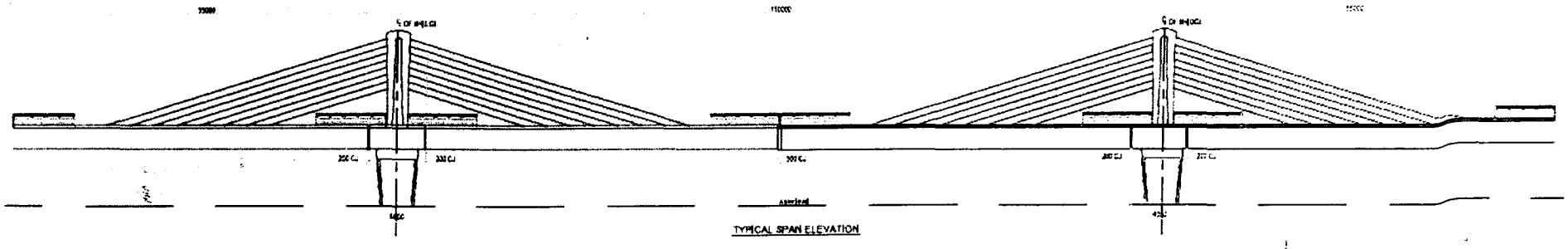


TYPICAL CROSS SECTION FOR SINGLE PIER AT RAMP APPROACH FROM KM 2+885 TO KM 3+060
FROM KM 3+650 TO KM 4+150



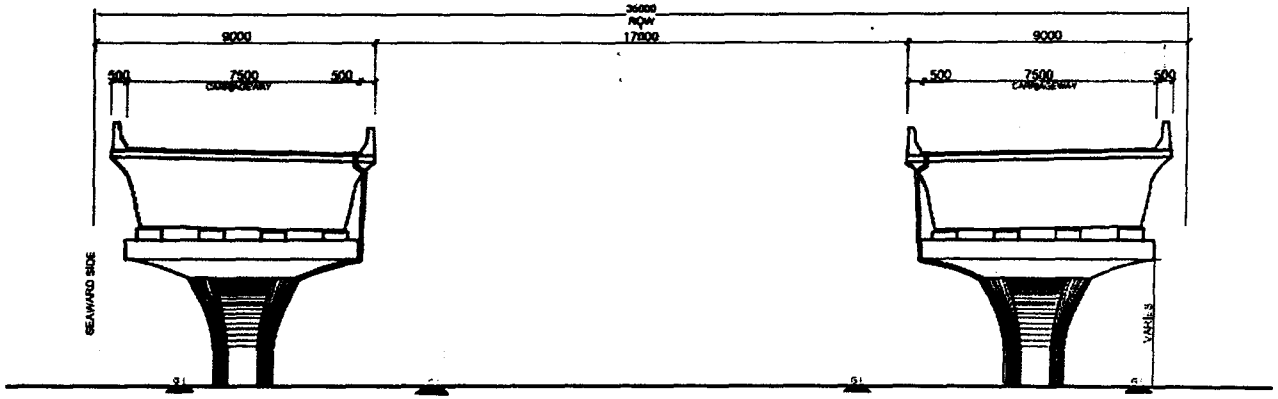
TYPICAL CROSS SECTION FOR SINGLE PIER AT RAMP APPROACH (FROM KM 3+060 TO KM 3+260)
(FROM KM 3+540 TO KM 3+650)



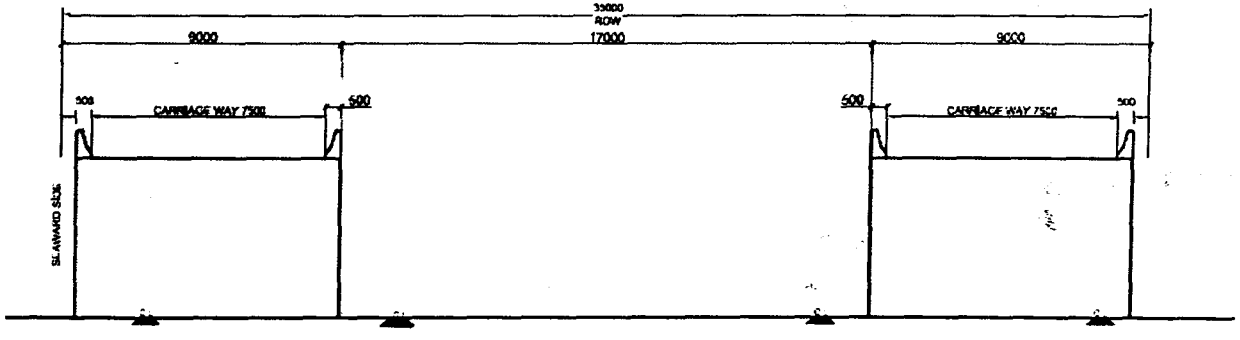


TYPICAL SPAN ELEVATION

Signature Bridge



TYPICAL CROSS SECTION FOR RAMP APPROACH FROM KM 4+320 TO KM 4+440



TYPICAL CROSS SECTION FOR RAMP APPROACH FROM KM 4+440 TO KM 4+580

Figure 4.9: Proposed Typical Cross section for Phase I

4.8 Right Of Way (Row)

According to lane requirement and social issues the proposed right of way is formulated and presented in the **Table 4.2.**

Table 4.2: Proposed Right of Way (ROW)

Design Chainage (Km)		Length (km)	ROW Width (m)	Section / Location
From	To			
0+000	0+370	0.370	32.5	Approach Ramp and at grade roads in Kamarajar Salai
0+370	2+000	1.630	21.5 to 26.5	Elevated Corridor along Santhome loop road up to Foreshore Estate Road
2+000	3+055	1.055	26.5 to 40.0	Ramp location in Foreshore Estate. This is including the proposed two lane entry & exit ramp arrangements
3+055	3+240	0.185	18	After Ramp at Foreshore Estate upto to Adyar Bridge, along Srinivasapuram
3+250	3+529	0.279	20.5	Along bridge across Adyar River
3+529	3+670	0.141	18	After bridge across AdyarRiver
3+670	4+280	0.610	27 to30	From Adayar Bridge to Ramp at Orukuppam
4+280	4+640	0.360	35	Ramp Approach to Besant Nagar Junction

4.9 Pavement Design

Pavement design is carried out for the at grade road below the proposed elevated corridor and at the approach ramps. The pavement design is carried out based on IRC-37 2002 guidelines. The various design parameters considered for the pavement design is discussed below.

Design Life Period

A design life period of 20 years is adopted for the flexible pavement design.

Vehicle Damage Factor (VDF)

National average vehicle damage factor (number of standard axles per commercial vehicle) of 3.5 is adopted for the design as per IRC 37.

Design Traffic

Results of traffic survey and the projected traffic data given in Chapter 3 are made use for the pavement design. The design traffic is considered in terms of the cumulative number of standard axles to be carried by the pavement during the design life of the road and is derived from the initial volume of commercial vehicles per day after accounting for lateral distribution of traffic, growth rate, design life in years and the vehicle damage factor (number of standard axle per commercial vehicle) to convert commercial vehicles to standard axles. CSA for service roads are arrived with 10% of generated traffic.

A design CSA 25 MSA for at grade roads are adopted for the pavement design and to arrive at the pavement layer composition.

Design of Flexible Pavement for New construction

The thickness and the composition of the pavement layers were determined using pavement design thickness tables and charts as given in IRC: 37-2001. Proposed pavement compositions are given in **Table 4.3** and the typical pavement Cross Section details are shown in **Figure 4.10.**

Table 4.3: Proposed Pavement Layer Compositions for New Construction

Road Section		At grade roads
Design Life		20 Years
Design Traffic		25 MSA
Design CBR		8 %
Proposed Pavement Composition in mm	**Wearing Course**	40 BC
	Binder Course	95 DBM
	Granular Base	250 WMM
	Granular Sub Base	200 GSB

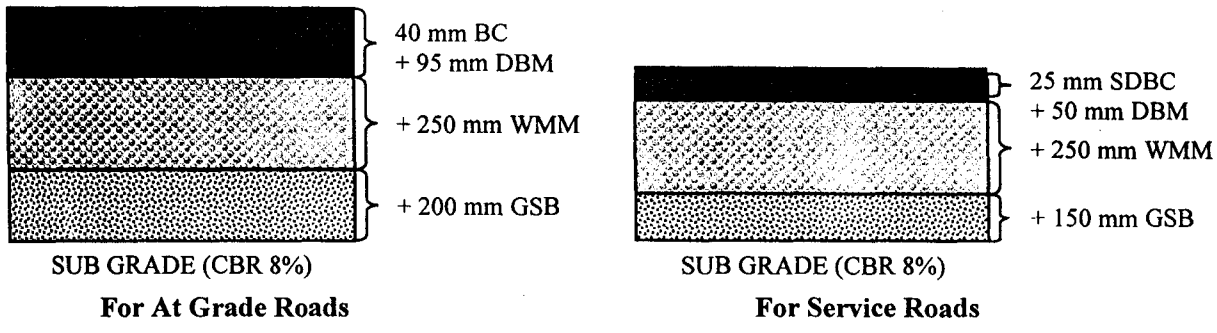


Figure 4.10: Typical Pavement Composition

Also Improvement for the pavement in the form strengthening/ widening has been considered for Kamarajar Salai, Nochikkuppam Road, Santhome link road and the road leads from Foreshore estate road to Adayar river northern bank.

4.10 Structural Schemes

The structural system consisting mainly of superstructure, substructure and foundation are planned based on the suitability of the same at the proposed location, constructability, degree of impact during construction on the beach goers and surrounding people, severe salinity of the atmosphere due to the proximity of sea, aesthetics, degree of hindrance to beach view etc. Accordingly, various options were planned for superstructure, substructure and foundation.

Criteria for finalization of structural type

The basic consideration in the planning and finalization of the structural scheme is to have least number of different types/arrangements to ensure speedy construction and to curb cost. Stretches with existing road at grade and the up/down ramps are also given due consideration in finalizing the structure type/locations. Suitable superstructure arrangement is proposed at the locations of entry/exit of ramps and their merging. Substructure type is mainly based on the locations of existing roads at grade and change over of stretches with and with out service roads at grade.

Numbering and identification of structures

The following numbering/naming system is adopted

The main flyover substructure starts from P1 to P248 and finally Abutment A2. The ramps are numbered separately. The up ramp substructures at the project start are numbered as R1P1 to R1P18 and that for down ramp, it is numbered as R2P1 to R2P20. The abutments at the project start are numbered as R1A1 and R2 A2 for up and down ramp respectively.

Ramps before Foreshore estate junction:

The down ramp has substructures numbered as R3P1 to R3P9 and abutment as R3A1. The up ramp substructures are numbered as R4P1 to R4P9 and abutment as R4A1.

Ramps after Foreshore estate junction:

The up ramp has substructures numbered as R5P1 to R5P10 and abutment as R5A1. The down ramp substructures are numbered as R6P1 to R6P9 and abutment as R6A1.

Ramps before Besant Nagar junction:

The down ramp has substructures numbered as R7P1 to R7P11 and abutment as R7A1. The up ramp substructures are numbered as R8P1 to R8P9 and abutment as R8A1.

Ramps after Besant Nagar junction:

The up ramp has substructures numbered as R9P1 to R9P12 and abutment as R9A1. The down ramp substructures are numbered as R10P1 to R10P12 and abutment as R10A1.

Two phases are considered for the project. Phase I shall end at CH 4+208 of Main flyover. Phase II shall start from CH 4+208. The pier at CH 4+208 shall become the connection point for both the phases. The substructure, including pedestals for Phase II and foundation at CH 4+208 shall be completed in full respect in Phase I, but shall be loaded only on one side. The loading on other side shall be affected in Phase II.

Out of the 10 ramps provided, Ramps 1 to 8 shall be constructed in Phase I. Ramps 9 and 10 shall be constructed in Phase II

The details of structural arrangement for phase I are given in Table 4.4 and 4.5.

Foundation

The type of foundation to be adopted mainly depends on the sub-soil condition at the proposed location. Total 20 numbers of bore holes were taken to get a good idea of the composition of the sub soil at the location and to gather information regarding probable founding strata. Various tests to identify the composition of the soil strata at different levels and also to find out various parameters of the soil composition were also carried out at field and at the laboratory. These tests and test results suggest requirement of deep foundations. Pile foundations are proposed at an average founding level of 24m from the ground level.

Substructure

Substructure type is finalized considering the aesthetics, visibility for at grade facilities, superstructure type, spacing, other functional requirements etc

Substructure types proposed are:

- Hammer headed type with elliptical section
- Portal pier
- Trestle pier

Hammer headed pier: The basic type of substructure proposed is hammer headed type with Elliptical section for the shaft of the substructure. A wide flare upper portion above the pier shaft is proposed to reduce the cantilever portion of pier cap beyond the pier. At locations, with no built up are and no service roads at grade, having PSC I-girders and cast in place deck slab superstructure, two separate piers are

proposed for each direction of traffic. Each pier shall support two lane carriageway. At built up locations with at grade service roads, single pier for four lane carriageway is proposed. Only a mild flare and no distinct hammer head is proposed at top of pier shaft as the superstructure is fish belly type box and the bearings are placed closer. Height of the substructure is fixed based on the clearance requirement. 5.5m vertical clearance is ensured wherever vehicular movement needs to be permitted below the structure. Typical section of substructure and foundation is given in **Figure 4.11.**

The dimension of the pier at the base is kept as 1.8m x 1.3m. The top of flare is proposed as 3.5m and the length of pier cap is kept as 7.5m. The pier cap is given a root depth of 1.2m above the flared portion.

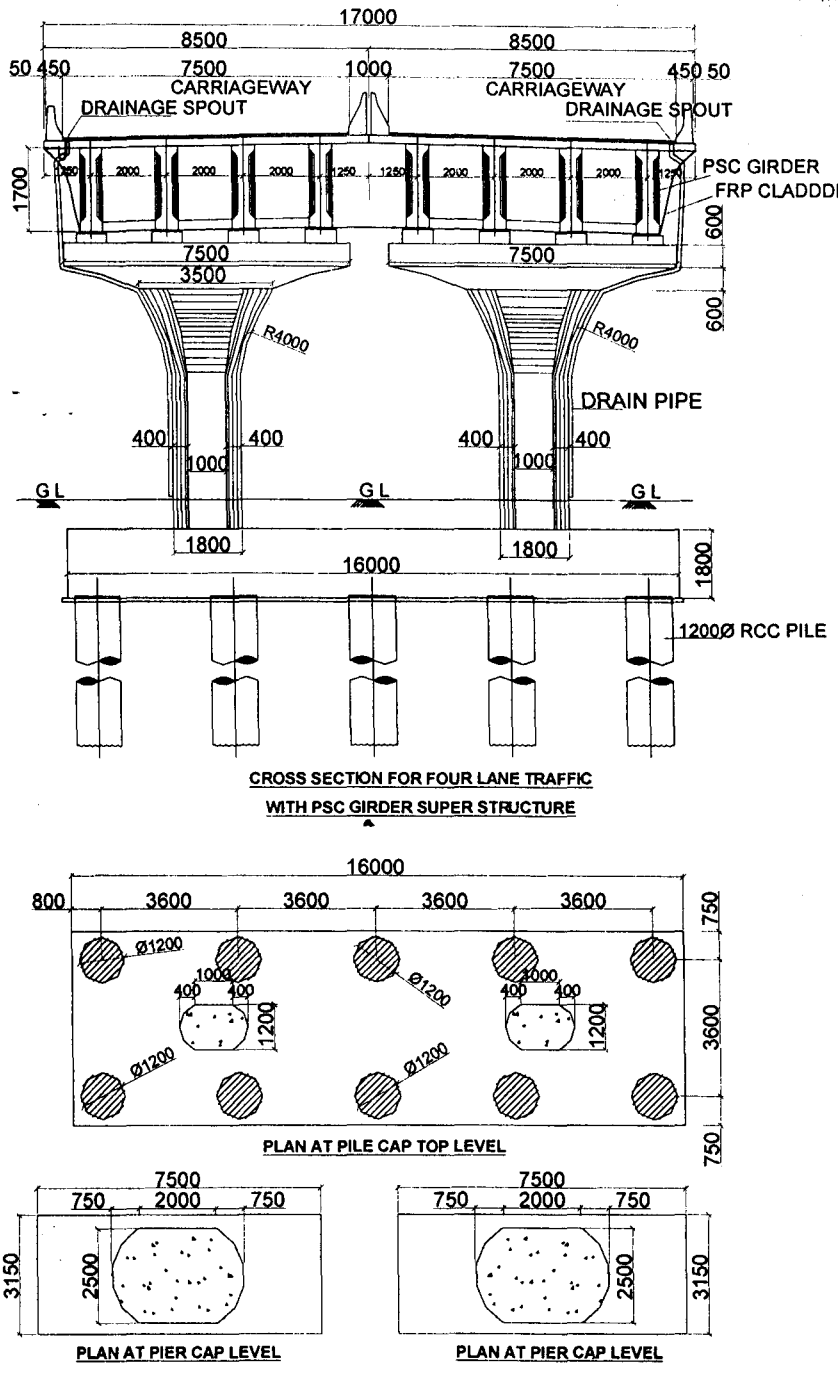


Figure 4.11a: Typical cross section of elliptical pier (double) and pile foundation

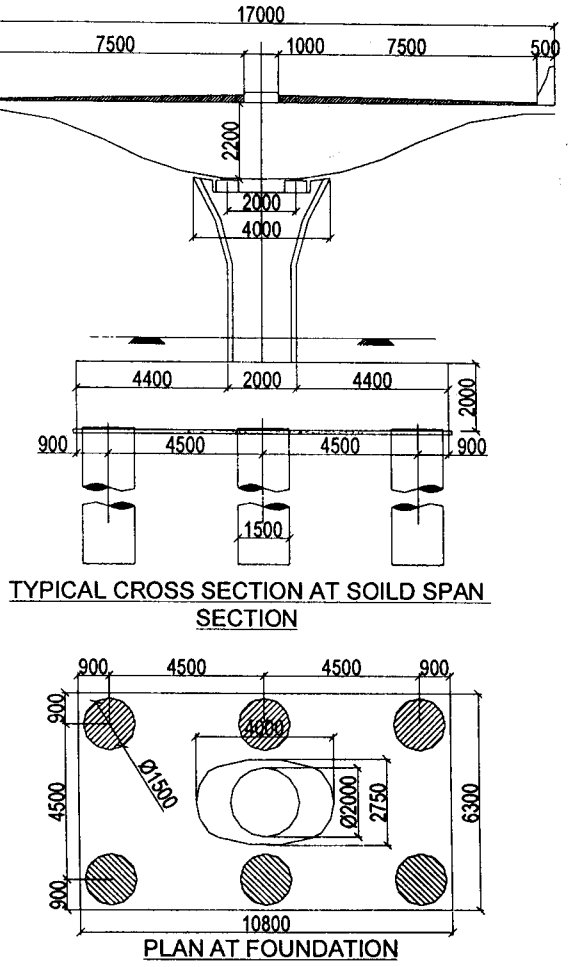


Figure 4.11b: Typical cross section of elliptical pier (single) and pile foundation

Portal pier: Portal piers are provided for transition between stretches with single pier arrangement to twin pier arrangement or vice versa (Piers P37, P43, P60, P119, P145 and P218). Typical section is given if **Figure 4.12**. Portal pier is also proposed at the location where the up and down ramp at the Project start comes closer forming the standard 17.0m cross section (Pier P1).

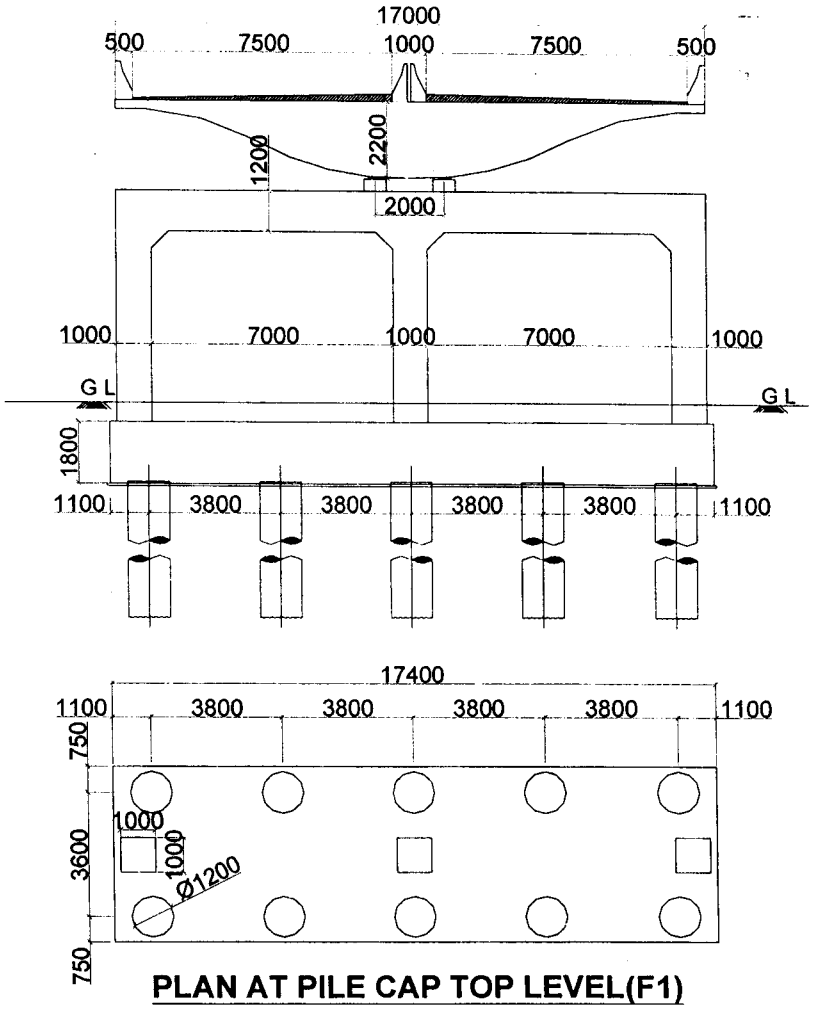


Figure 4.12: Typical cross section of portal pier and pile foundation

Trestle type pier is proposed at the abutment locations, near the earth filled approach. The cap of the trestle pier also have dirt wall to hold the approach slabs over the total width. Circular trestles are proposed on pile foundation. Typical section is given in **Figure 4.13**

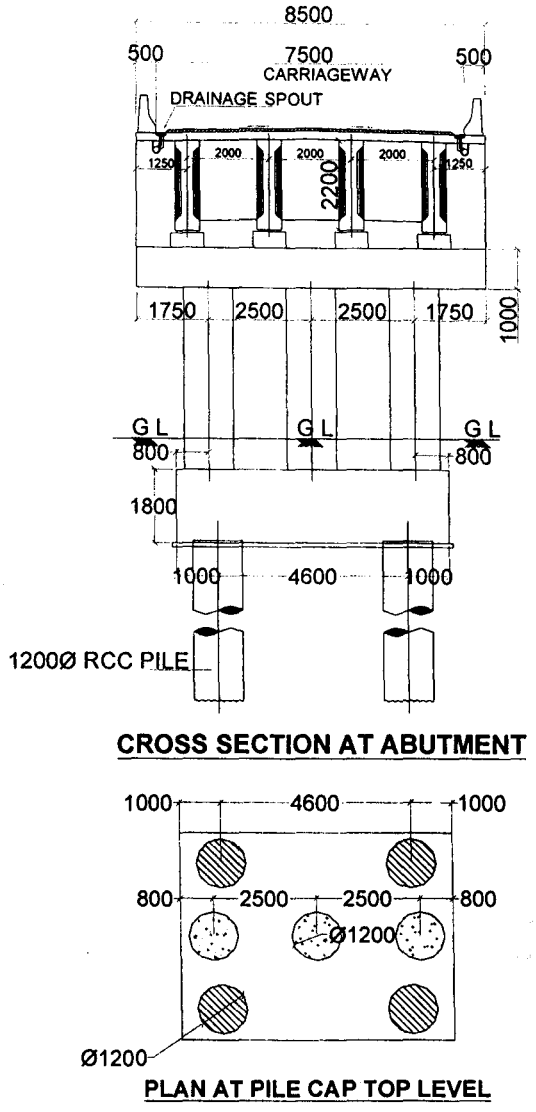


Figure 4.13: Typical Cross section of trestle pier and pile foundation (R5A1, R6A1, R7A1 & R8A1)

Superstructure systems considered are:

- Pre-stressed, voided slab
- Pre-stressed Post tensioned girders
- PSC Fish belly type box

Pre-stressed voided slab superstructure is proposed at locations where the alignment is at sharp curves or where the width of the roadway is varying. The purpose of adopting voided slab structure is to adjust the geometry as per the alignment. Further, voided slab structures need lesser depth and hence suitable for locations with depth restriction. In the proposed road, voided slab is provided at the start of the structural portion near light house where the alignment shifts towards the beach from the existing road. Depth of superstructure is restricted and profile of superstructure fitting to the horizontal curve is achieved by provision of voided slab superstructure. PSC voided slabs are also proposed at the ramp entry/exit points and locations where the ramps merge with the main carriageway and further tapers down to the standard cross section. Maximum span length proposed is 24m. Typical cross for voided slab superstructure for 4 lane deck is given in **Figure 4.14**.

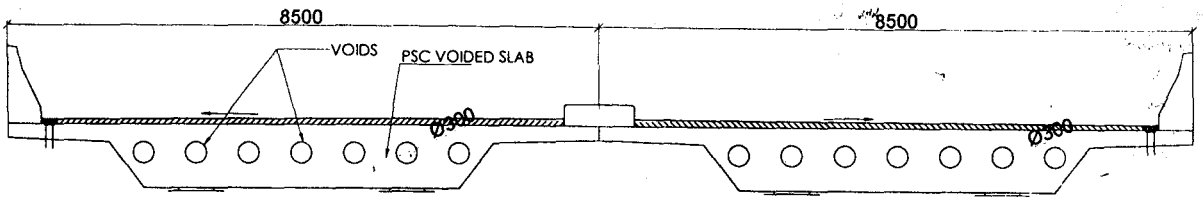


Figure 4.14: Typical cross section with PSC Voided slab for 4-lane deck

Post tensioned girders are proposed for straight spans where service roads are not provided at grade. Based on the sub-soil report and preliminary design, it is estimated that a span length of about 35.0m will be economical. Accordingly, Post tensioned I-girders with cast in place deck slab are proposed. Girders are spaced at 2m in the transverse direction. Typical cross sections for four lane arrangement are given in **Figure 4.15.**Though span length is kept as 35 m as standard, smaller spans are proposed near the merging point to adjust the span lengths between the stretches with fixed cross section and variable cross sectional width. Cross diaphragms are proposed at both the support locations.

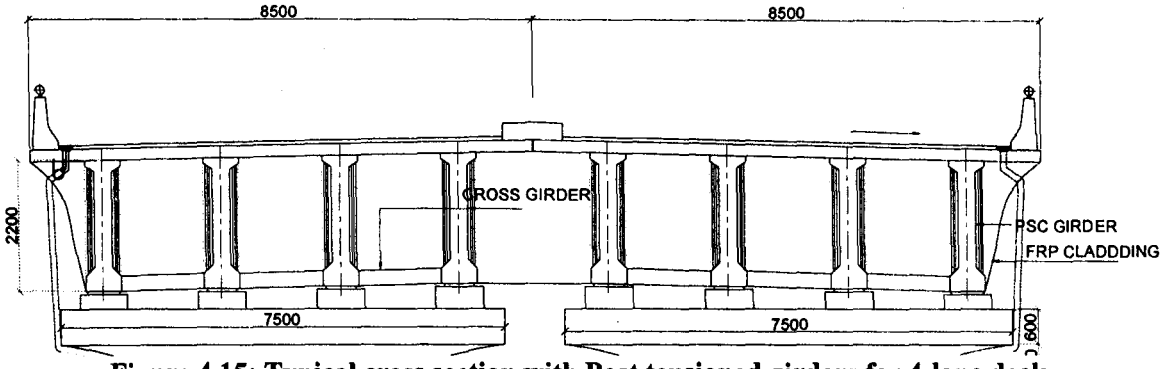


Figure 4.15: Typical cross section with Post tensioned girders for 4-lane deck

Fish belly type structure is provided as the superstructure where service roads are provided. Maximum individual span length proposed is 35m. Pre-stressed structure is proposed. This type of superstructure is fit for segmental construction. Also, this super structure will give good aesthetic appearance. Five span continuous and three span continuous spans are given depending on the span arrangement. Typical cross sections for four lane arrangement is given in **Figure 4.16**

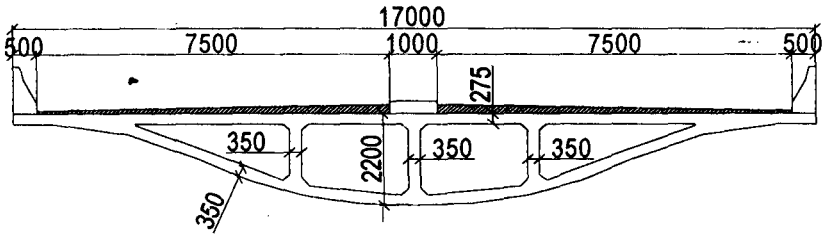


Figure 4.16: Typical cross section with Fish belly for 4-lane deck

Bridge Across Adayar Estuary

At the location where the alignment crosses Adayar Estuary, a steel Arch bridge is proposed. Single span 250m long arch bridge is proposed. The proposed bridge architecture is similar to the Sydney Harbour bridge. Two RCC pylons are proposed at each end of the Arch. RCC deck is proposed over steel beams connecting the arches on either side. The Arch structure consists of three dimensional trusses. View of the bridge is given in Figure **4.17**

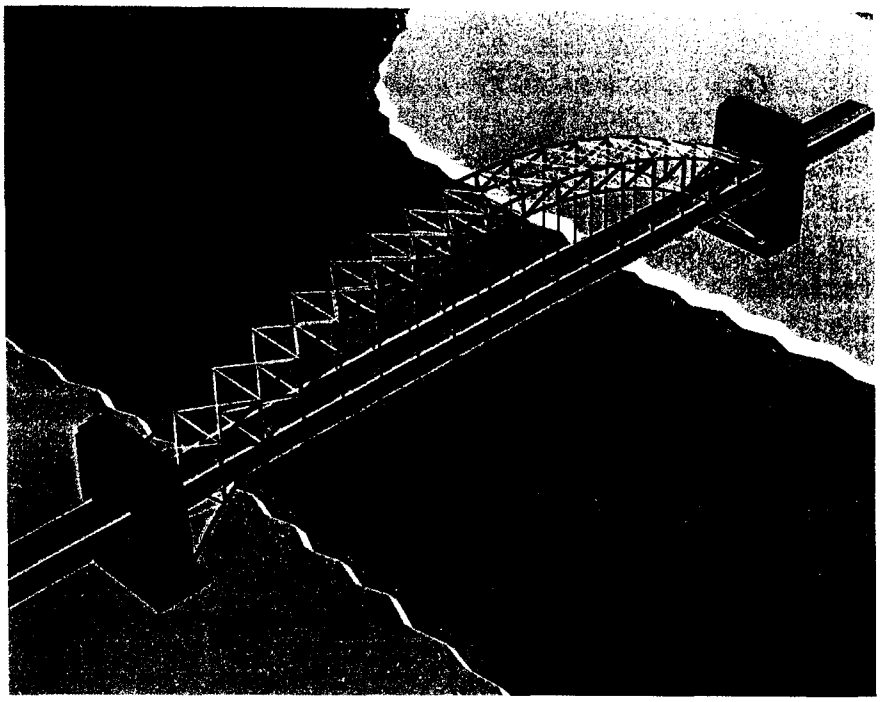


Figure 4.17: Steel arch bridge across Adayar River

Miscellaneous features:

Expansion joints

Strip seal expansion joints are proposed. To reduce the riding discomfort over expansion joints, it is proposed to keep three consecutive spans continuous. The continuity shall be achieved through deck slab continuity. Special flexible joints with asphalt rich wearing coat, MS "T" sections, PVC sealant etc should be used. Details of the joint are given in **Figure 4.18** below.

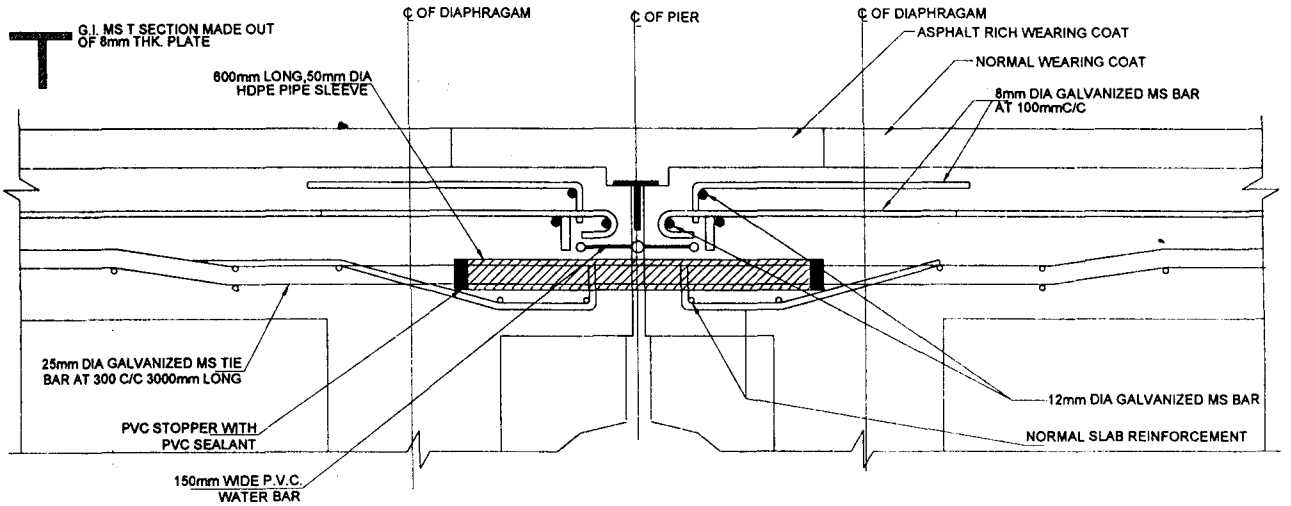


Figure 4.18: Details of Deck slab continuity

Bearings

Two types of bearings are proposed, viz, elastomeric and POT PTFE. Elastomeric bearings are proposed at locations where I girders are proposed. Bearings are proposed under each girder. POT-PTFE bearings are proposed at the locations where voided slab and Fish belly box superstructures are proposed.

Storm water drains

Drainage spouts connected by longitudinal pipes under the deck and further connected to vertical down take pipes at pier locations for discharging storm water on to the drains at grade. Drainage spouts are proposed at regular intervals.

Cladding

To enhance the aesthetics of the elevated roadway, it is proposed to provide FRP cladding to cover the soffit of the superstructure extending up to the bottom of the cantilever slab on both sides.

Corrosion protection

To the severe corrosive environment of the location, it is proposed to adopt corrosion protection coating for reinforcement and also to paint all the exposed surfaces with anti-corrosive paint.

Connection arrangement for Phase I and II

Phase I shall end at Ch 4+318.110. However, the pedestals for the Phase II on the common substructure at CH4+318.110 shall be constructed in Phase I only. The arrangement on substructure at Ch 4+318.110 is given in Fig 4.19.

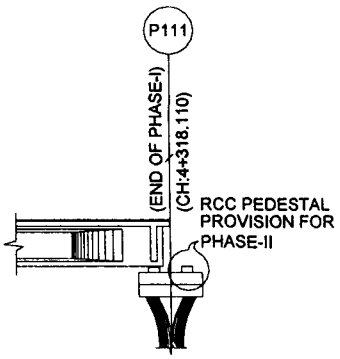


Figure 4.19: The arrangement of pedestal on substructure at Ch 4+318.110

4.11 Structural Design Standards

The basic design standards adopted for the structural designs are as per the requirements laid down in the latest editions of IRC codes of practices & standards specifications, and guidelines of Ministry of Road Transport & Highways. Additional technical references are used wherever the provisions of IRC/IS codes are found inadequate.

Following IRC/IS Codes are used in the design

IRC:5 -1998	Standard Specifications & code of Practice for Road Bridges Section -I. General Features of Design
IRC:6-2000	Standard Specifications & code of Practice for Road Bridges, Section -II. Loads and Stresses
IRC:18-2000	Design Criteria for Prestressed Concrete Road Bridges (Post-Tensioned Concrete) (Third Revision)
IRC:21-2000	Standard Specifications & code of Practice for Road Bridges, Section -III. Cement concrete (Plain and reinforced)
IRC:22-1986	Standard Specifications and Code of Practice for Road Bridges, Section VI - Composite Construction (First Revision)
IRC:78-2000	Standard Specifications & code of Practice for Road Bridges, -Foundations & Substructure.
IRC:69-2005	Guidelines and Specifications of Expansion joint
IRC:83(Part-I)-	Standard Specifications and codes of Practices for Road Bridges, Section IX –

1989	Bearing , Part II: Elastomeric Bearing
IRC:83(Part-III)-2002	Standard Specifications and codes of Practices for Road Bridges, Section IX – Bearing , Part II: POT Bearings
IS 6403 -1981	Code of Practice for determination of Bearing Capacity of Shallow Foundations
IS 2911-1979	Code of practice for design and construction of pile foundations

For the items not covered in the above specifications, provisions of following standards are followed in the given order of priority:

- Provisions of IS codes of Practices:
- Relevant Provisions of BS coded of practice
- Sound Engineering Practices, technical Literature/ Papers & Provisions of relevant codes of advanced and developing countries.

The grades of concrete for various structural components are adopted based on the guidelines in IRC codes of practices. Fe415 grade is used as steel reinforcement for all the structural members. The design life of all the structures is 100 years.

4.12 Design Methodology

Based on the topographical data and the data collected at site, the span requirement is finalised. Span arrangement at each location is finalized for satisfying the functional requirement and also based on the subsoil characteristics at the location. Due consideration to the type of structure is given to ensure good aesthetics. General arrangement drawing is prepared after finalizing the type of structure, span arrangements etc.

Loading standards adopted

The structural systems are designed for loadings as per IRC 6: 2000. The basic loadings considered are

Dead load constituting of self weight of structural members

Superimposed dead load constituting of wearing coat, crash barrier, footpath and railing loads

Live load constituting of loads due to IRC Class A vehicles or IRC 70R vehicles

Wind load as applicable to the site based on the height

Seismic load as per provisions in IRC code relevant for Seismic zone II is considered for the design

Clearances adopted

Vertical clearance - 5.5m up to soffit of deck from the road at grade at locations of crossing.

5.5m up to the bottom of the pier cap where vehicles ply under the flyover at locations with restriction of available ROW.

Horizontal clearance - As per the junction requirement

Exposure Condition

Due to the proximity to sea, severe exposure condition is considered in the design.

Span arrangement details

Based on subsoil investigation results, it is estimated that span length of 35.0m will be optimum for the proposed flyover. Span arrangement is carried out in such a way that to keep the span length as 35.0m as far as possible. Where the existing site conditions like presence of cross roads or other constraints like entry/ exit of ramps, location of merging lanes etc occur, the span lengths are adjusted to suit the specific requirements. Accordingly, two basic types of superstructure is proposed, viz., Post tensioned girders and PSC voided slabs. Post tensioned girder are provided for span lengths of 27m, 30m, 31m, 33m and 35m. Same cross section is proposed for the girders. Adjustments in the amount of pre-stressing shall be done

based on requirement. Voided slab structures are proposed for smaller spans, adopted at location with constraints and at locations where the tapering in the superstructure is required for accommodating merging lanes. PSC voided slabs are provided for span lengths 15, 16m, 18m, 19m, 20m, 22m, 23m, 24m and 25.0m. 15.0m long voided slabs are provided where the alignment is along acute curves. All the other PSC voided slab spans are provided at locations of merging of ramp with the main flyover.

Details of superstructure arrangements adopted is shown below in **Table 4.4**

Table 4.4: Superstructure Details (Phase I)

Span length	Type of superstructure	Number of spans
Main Flyover		
35	Fish Belly	31
30	Fish Belly	7
25	Fish Belly	5
35	PSC I Girder	27
30	PSC I Girder	2
26.5	PSC I Girder	1
25	PSC I Girder	7
22.5	Voided Slab	2
20	Voided Slab	18
18	Voided Slab	1
17.5	Voided Slab	2
17	Voided Slab	2
15	Voided Slab	5
Ramp Section		
35	Fish Belly	6
35	PSC I Girder	13
30	PSC I Girder	3
25	PSC I Girder	3
22.5	Voided Slab	2
20	Voided Slab	54
19	Voided Slab	1
18	Voided Slab	4
17.5	Voided Slab	2
16	Voided Slab	1
15	Voided Slab	7

4.13 Detailed layout presentation for Phase1

Table 4.5: Layout details along the Proposed Road for Phase 1

Stretch		Location	Distance (m)	Description	Superstructure	Substructure	Foundation
Start	End						
0+860.61	0+895.61	Dumminig kuppam	35	4-lane road way on structure portion with single span of 35.0m. Isolated pile caps provided for piers supporting the superstructure.+	PSC Fish Belly type box	Elliptical hammer headed pier and Portal pier at Ch:1+860.61	Pile foundation with 1.5m dia piles at single pier location, and 1.2m dia piles at portal pier location
0+895.61	0+925.61	Dumminig kuppam	30	4-lane road way on structure portion with single span of 30.0m. Isolated pile caps provided for piers supporting the superstructure.	PSC Fish Belly type box	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles
0+925.61	1+000.61	Dumminig kuppam	75	4-lane road way on structure portion with 3 spans of 25.0m. Isolated pile caps provided for piers supporting the superstructure.	PSC Fish Belly type box	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles
1+000.61	1+385.61	Dumminig kuppam	385	4-lane road way on structure portion with 11 spans of 35.0m. Isolated pile caps provided for piers supporting the superstructure.	PSC Fish Belly type box	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles
1+385.61	1+435.61	Dumminig kuppam	50	4-lane road way on structure portion with 2 spans of 25.0m. Isolated pile caps provided for piers supporting the superstructure.	PSC Fish Belly type box	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles
1+435.61	1+495.61	Dumminig kuppam	60	4-lane road way on structure portion with 2 spans of 30.0m. Isolated pile caps provided for piers supporting the superstructure.	PSC Fish Belly type box	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles

Stretch		Location	Distance (m)	Description	Superstructure	Substructure	Foundation
Start	End						
1+495.61	1+740.61	Dumminig kuppam	245	4-lane road way on structure portion with 7 spans of 35.0m. Isolated pile caps provided for piers supporting the superstructure.	PSC Fish Belly type box	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles
1+740.61	1+830.61	Dumminig kuppam	90	4-lane road way on structure portion with 3 spans of 30.0m. Isolated pile caps provided for piers supporting the superstructure.	PSC Fish Belly type box	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles
1+830.61	1+935.61	Dumminig kuppam	105	4-lane road way on structure portion with 3 spans of 35.0m. Isolated pile caps provided for piers supporting the superstructure.	PSC Fish Belly type box	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles
1+935.61	1+950.61	Corporation Play Ground	15	Single span of 15.0m is proposed. The carriage way width varies from 15.0m to 16.82m for accommodating the ramp. Single pile cap provided for the portal piers supporting superstructure.	PSC Voided slab	Portal pier with three columns	Pile foundation with 1.20m dia piles
1+950.61	2+010.61		60	Three spans of 20.0m is proposed. The carriage way width varies from 16.82 (7.5m + 9.32m) to 18.65 (7.5m + 11.15m) for accommodating the ramp. Portal piers provided as substructure on pile foundation. The carriageway beneath is maintained.	PSC Voided slab	Portal pier with three columns at 1+950.61 and with four columns at 1+970.61 and 1+990.61	Pile foundation with 1.20m dia piles

Stretch		Location	Distance (m)	Description	Superstructure	Substructure	Foundation
Start	End						
2+010.61	2+055.61	Corporation Play Ground	45	Two spans of 22.50m is proposed. The carriage way width varies from 18.65 (7.5m + 11.15m) to 23.51 (9.9m + 13.61m) for accommodating the ramp. At 11.15m and 13.61m carriage way location combined pile cap is proposed for piers supporting superstructure. 7.5m and 9.9m carriageway locations isolated pile cap is proposed for piers supporting superstructure.	PSC Voided slab	Elliptical hammer headed pier	Pile foundation with 1.20m dia piles
2+055.61	2+070.61		15	Single span of 15.0m is proposed. The carriage way width varies from to 23.51m (9.9m + 13.61m) to 28.60m (12.44m + 16.16m) for accommodating the ramp. At 13.61m and 12.44m carriage way location combined pile cap is proposed for piers supporting superstructure in each direction. 9.9m and 16.16m carriageway locations isolated pile cap is proposed for piers supporting superstructure.	PSC Voided slab	Elliptical hammer headed pier	Pile foundation with 1.20m dia piles
2+070.61	2+170.61		100	Five spans of 20.0m is proposed. The carriage way width varies from 28.60m (12.44m + 16.16m) to 30.23m (14.13m + 16.10m) for accommodating the ramp portion. At 12.44m and 14.13m carriage way location combined pile cap is proposed for piers supporting superstructure. 16.16m and 16.10m carriageway locations isolated pile cap is proposed for piers supporting superstructure	PSC Voided slab	Elliptical hammer headed pier	Pile foundation with 1.20m dia piles

Stretch		Location	Distance (m)	Description	Superstructure	Substructure	Foundation
Start	End						
2+170.61	2+345.61		175	4-lane road way on structure portion with five spans of 35.0m each. Isolated pile caps provided for piers supporting superstructure.	PSC Fish Belly type box type box	Elliptical hammer headed pier, At Ch:1+910 Portal pier	Pile foundation with 1.20m dia piles
2+345.61	2+375.61	Mullimanagar	30	4-lane road way on structure portion with singl span of 30.0m each. Isolated pile caps provided for piers supporting superstructure.	PSC Fish Belly type box type box	Elliptical hammer headed pier, At Ch: 1+910 and Ch: 2+505 Portal pier	Pile foundation with 1.5m dia piles at single pier location, and 1.2m dia piles at portal pier location
2+375.61	2+515.61	Srinivasa Puram	140	4-lane road way on structure portion with four spans of 35.0m each. Combined pile cap for piers supporting superstructure in each direction.	PSC Fish Belly type box type box	Elliptical Hammer headed pier, At Ch: 2+505 Portal pier	Pile foundation with 1.2m dia piles
2+515.61	2+550.61	Srinivasa Puram	35	4-lane road way on structure portion with single span of 35.0m. Combined pile cap for piers supporting superstructure in each direction.	PSC I Girder	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles
2+550.61	2+600.61	Srinivasa Puram	50	4-lane road way on structure portion with two spans of 25.0m. Combined pile cap for piers supporting superstructure in each direction.	PSC I Girder	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles

Stretch		Location	Distance (m)	Description	Superstructure	Substructure	Foundation
Start	End						
2+600.61	2+670.61	Srinivasa Puram	70	4-lane road way on structure portion with two spans of 35.0m. Combined pile cap for piers supporting superstructure in each direction.	PSC I Girder	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles
2+670.61	2+700.61	Srinivasa Puram	30	4-lane road way on structure portion with single span of 30.0m. Combined pile cap for piers supporting superstructure in each direction.	PSC I Girder	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles
2+700.61	2+760.61		60	three spans of 20.0m is proposed. The carriage way width varies from 31.99 to 30.42m (14.42m + 16.0m) for accommodating the ramp portion. At 14.42m carriage way location combined pile cap is proposed for piers supporting superstructure in each direction. 16.0m carriageway location isolated pile caps are proposed for piers supporting superstructure.	PSC Voided Slab	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles

Stretch		Location	Distance (m)	Description	Superstructure	Substructure	Foundation
Start	End						
2+760.61	2+775.61		15	Single span of 15.0m is proposed. The carriage way width varies from 30.42m (14.42m + 16.0m) to 28.82m (12.84m + 15.98m) for accommodating the ramp portion. At 14.42m and 12.84m carriage way locations combined pile cap is proposed for piers supporting superstructure in each direction. 16.0m and 15.98m carriageway locations isolated pile caps are proposed for piers supporting superstructure.	PSC Voided Slab	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles
2+775.61	2+810.61	Srinivasa Puram	45	Two spans of 17.50m is proposed. The carriage way width varies from 28.82m (12.84m + 15.98m) to 25.16m (11.05m + 14.11m) for accommodating the ramp portion. At 12.84m, 11.05m and 14.11m carriage way locations combined pile cap is proposed for piers supporting superstructure in each direction. 15.98m carriageway location isolated pile caps are proposed for piers supporting superstructure.	PSC Voided Slab	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles

Stretch		Location	Distance (m)	Description	Superstructure	Substructure	Foundation
Start	End						
2+810.61	2+870.61		60	Three spans of 20.0m is proposed. The carriage way width varies from 25.16m (11.05m + 14.11m) to 21.24m (9.19m + 12.05m) for accommodating the ramp portion. At 12.05m, 11.05m and 14.11m carriage way locations combined pile cap is proposed for piers supporting superstructure in each direction. 9.19m carriageway location isolated pile cap is proposed for pier supporting superstructure.	PSC Voided Slab	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles
2+870.61	2+885.61	Srinivasa Puram	15	Single span of 15.0m is proposed. The carriage way width varies from 21.24m (9.19m + 12.05m) to 17.66 (7.5m + 10.16m) for accommodating the ramp portion. At 12.05m carriage way location combined pile cap is proposed for piers supporting superstructure in each direction. 9.19m, 7.5m and 10.16m carriageway locations isolated pile caps are proposed for piers supporting superstructure.	PSC Voided Slab	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles
2+885.61	3+200.610	Orur Kuppam	315	4-lane road way on structure portion with nine spans of 35.0m each. Combined pile cap for piers supporting superstructure in each direction.	PSC I Girder	Elliptical Hammer headed pier,	Pile foundation with 1.2m dia piles

Stretch		Location	Distance (m)	Description	Superstructure	Substructure	Foundation
Start	End						
3+200.61	3+250.61	Orur Kuppam	50	4-lane road way on structure portion with two spans of 25.0m each. Combined pile cap for piers supporting superstructure in each direction.	PSC I Girder	Elliptical Hammer headed pier, At Ch:3+245 Pylon	Pile foundation with 1.2m dia piles
3+250.61	3+529.61	Orur Kuppam	279	4-lane road way on structure portion with single span of 279.0m.	Steel Arch bridge	Pylon	Pile foundation
3+529.61	3+559.61		30	4-lane road way on structure portion with single span of 30.0m each. Combined pile cap for piers supporting superstructure in each direction.	PSC I Girder	At Ch: 3+524 Pylon, Elliptical Hammer headed pier.	Pile foundation with 1.2m dia piles.
3+559.61	3+699.61		140	4-lane road way on structure portion with four spans of 35.0m each. Combined pile cap for piers supporting superstructure in each direction.	PSC I Girder	Elliptical Hammer headed pier.	Pile foundation with 1.2m dia piles.
3+699.61	3+749.61		50	4-lane road way on structure portion with two spans of 25.0m each. Combined pile cap for piers supporting superstructure in each direction.	PSC I Girder	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles

Stretch		Location	Distance (m)	Description	Superstructure	Substructure	Foundation
Start	End						
3+749.61	4+099.61		350	4-lane road way on structure portion with ten spans of 35.0m each. Combined pile cap for piers supporting superstructure in each direction.	PSC I Girder	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles
4+099.61	4+124.61		25	4-lane road way on structure portion with single span of 25.0m each. Combined pile cap for piers supporting superstructure in each direction.	PSC I Girder	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles
4+124.61	4+151.11		26.5	4-lane road way on structure portion with single span of 26.5m each. Combined pile cap for piers supporting superstructure in each direction.	PSC I Girder	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles
4+151.11	4+168.11		17	Single span of 17.0m is proposed. The carriage way width varies from 15.0m (7.5m + 7.5m) to 17.12m for accommodating the ramp portion. At 15m carriage way location combined pile cap is proposed for piers supporting superstructure in each direction. 17.12m carriageway locations isolated pile caps are proposed for piers supporting superstructure.	PSC Voided Slab	Elliptical Hammer headed pier.	Pile foundation with 1.2m dia piles.

Stretch		Location	Distance (m)	Description	Superstructure	Substructure	Foundation
Start	End						
4+168.11	4+208.11	Orur Kuppam	40	Two spans of 20.0m is proposed. The carriage way width varies from 17.12m (7.5m + 9.62m) to 19.23m (7.5m + 11.73m) for accommodating the ramp portion. At 11.73m carriage way location combined pile cap is proposed for piers supporting superstructure in each direction. 7.5m, 9.62m carriageway locations isolated pile caps are proposed for piers supporting superstructure.	PSC Voided Slab	Elliptical Hammer headed pier.	Pile foundation with 1.2m dia piles.
4+208.11	4+226.11	Orur Kuppam	18	Single span of 18.0m is proposed. The carriage way width varies from 17.12m (7.5m + 9.62m) to 19.23m (7.5m + 11.73m) for accommodating the ramp portion. At 11.73m carriage way location combined pile cap is proposed for piers supporting superstructure in each direction. 7.5m, 9.62m carriageway locations isolated pile caps are proposed for piers supporting superstructure.	PSC Voided Slab	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles
4+226.11	4+243.11	Orur Kuppam	17	Single span of 17.0m is proposed. The carriage way width varies from 17.12m (7.5m + 9.62m) to 19.23m (7.5m + 11.73m) for accommodating the ramp portion. At 11.73m carriage way location combined pile cap is proposed for piers supporting superstructure in each direction. 7.5m, 9.62m carriageway locations isolated pile caps are proposed for piers supporting superstructure.	PSC Voided Slab	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles

Stretch		Location	Distance (m)	Description	Superstructure	Substructure	Foundation
Start	**End**						
4+243.11	4+283.11	Orur Kuppam	40	Two spans of 20.0m is proposed. The carriage way width varies from 17.12m (7.5m + 9.62m) to 19.23m (7.5m + 11.73m) for accommodating the ramp portion. At 11.73m carriage way location combined pile cap is proposed for piers supporting superstructure in each direction. 7.5m, 9.62m carriageway locations isolated pile caps are proposed for piers supporting superstructure.	PSC Voided Slab	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles
4+283.11	4+318.11 (end of phase-I)		35	4-lane road way on structure portion with one span of 35.0m. Combined pile cap for piers supporting superstructure in each direction.	PSC I Girder	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles
RAMP1							
0+181.61	0+301.610	Light House	120	2-lane road way on structure portion with six spans of 20.0m each. Isolated pile caps provided for piers supporting superstructure.	PSC Voided Slab	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles
0+301.61	0+316.610		15	2-lane road way on structure portion with single span of 15.0m. Isolated pile caps provided for piers supporting superstructure.	PSC Voided Slab	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles

Stretch		Location	Distance (m)	Description	Superstructure	Substructure	Foundation
Start	End						
0+316.61	0+334.610		18	2-lane road way on structure portion with single span of 18.0m. Isolated pile caps provided for piers supporting superstructure.	PSC Voided Slab	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles
0+334.61	0+349.61	Light House	15	2-lane road way on structure portion with single span of 15.0m. Isolated pile caps provided for piers supporting superstructure.	PSC Voided Slab	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles
0+349.61	0+365.610		16	2-lane road way on structure portion with single span of 16.0m. Isolated pile caps provided for piers supporting superstructure. The horizontal profile is in curve.	PSC Voided Slab	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles
0+365.61	0+380.61		15	2-lane road way on structure portion with three spans of 15.0m each. Isolated pile caps provided for piers supporting superstructure. The horizontal profile is in curve.	PSC Voided Slab	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles
0+380.610	0+520.610		140	2-lane road way on structure portion with seven spans of 20.0m each. Isolated pile caps provided for piers supporting superstructure.	PSC Voided Slab	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles

Stretch		Location	Distance (m)	Description	Superstructure	Substructure	Foundation
Start	End						
0+520.610	0+574.610		54	2-lane road way on structure portion with three spans of 18.0m each. Isolated pile caps provided for piers supporting superstructure.	PSC Voided Slab	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles
0+574.610	0+814.610		240	2-lane road way on structure portion with twelve spans of 20.0m each. Isolated pile caps provided for piers supporting superstructure.	PSC Voided Slab	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles
0+814.610	0+833.610		19	2-lane road way on structure portion with single span of 19.0m. Isolated pile caps provided for piers supporting superstructure.	PSC Voided Slab	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles
0+833.61	0+866.610	Light House	30	2-lane road way on structure portion with two spans of 15.0m. Isolated pile caps provided for piers supporting superstructure.	PSC Voided Slab	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles
RAMP-2							
0+579.14	0+879.140	Light House	300	2-lane road way on structure portion with fifteen spans of 20.0m. Isolated pile cap provided for piers supporting superstructure.	PSC Voided Slab	Elliptical hammer headed	Pile foundation with 1.2m dia
RAMP-3							
2+055.85	2+010.850	Mullimaa Nagar	45	2-lane road way on structure portion with two spans of 22.50m. Isolated pile caps provided for piers supporting superstructure	PSC Voided Slab	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles

Stretch		Location	Distance (m)	Description	Superstructure	Substructure	Foundation
Start	End						
2+010.85	1+995.850	Mullimaa Nagar	15	2-lane road way on structure portion with single span of 15.0m. Isolated pile caps provided for piers supporting superstructure	PSC Voided Slab	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles
1+995.85	1+895.850		100	2-lane road way on structure portion with five spans of 20.0m. Isolated pile caps provided for piers supporting superstructure	PSC Voided Slab	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles
1+895.85	1+860.850		35	2-lane road way on structure portion with single span of 35.0m. Isolated pile caps provided for piers supporting superstructure	PSC Fish Belly type box type box	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles
RAMP-4							
2+131.05	2+171.05	Mullimaa Nagar	40	2-lane road way on structure portion with two spans of 20.0m. Isolated pile caps provided for piers supporting superstructure	PSC Voided Slab	At Ch: 1+9+10 Trestle abutment, Elliptical hammer headed pier	Pile foundation with 1.2m dia piles

Stretch		Location	Distance (m)	Description	Superstructure	Substructure	Foundation
Start	End						
2+171.05	2+346.050	Mullimaa Nagar	175	2-lane road way on structure portion with five spans of 35.0m. Isolated pile caps provided for piers supporting superstructure	PSC Fish Belly type box	Elliptical Hammer headed pier	Pile foundation with 1.2m dia piles
RAMP-5							
2+576.13	2+601.130	Srinivasa Puram	25	2-lane road way on structure portion with single span of 25.0m. Isolated pile caps provided for piers supporting superstructure	PSC I Girder	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles
2+601.13	2+671.130		70	2-lane road way on structure portion with two spans of 35.0m. Isolated pile caps provided for piers supporting superstructure	PSC I Girder	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles
2+671.13	2+701.130		30	2-lane road way on structure portion with single span of 30.0m. Isolated pile caps provided for piers supporting superstructure	PSC I Girder	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles

Stretch		Location	Distance (m)	Description	Superstructure	Substructure	Foundation
Start	End						
2+701.13	2+761.130		60	2-lane road way on structure portion with three spans of 20.0m each. Isolated pile caps provided for piers supporting superstructure	PSC Voided Slab	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles
2+761.13	2+776.130		15	2-lane road way on structure portion with single span of 15.0m. Isolated pile caps provided for piers supporting superstructure	PSC Voided Slab	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles
2+776.13	2+811.130		35	2-lane road way on structure portion with stwo spans of 17.50m. Isolated pile caps provided for piers supporting superstructure	PSC Voided Slab	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles
RAMP-6							
2+491.115	2+516.115	Srinivasa Puram	25	2-lane road way on structure portion with single span of 25.0m. Isolated pile caps provided for piers supporting superstructure	PSC I Girder	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles
2+516.115	2+551.115		35	2-lane road way on structure portion with single span of 35.0m. Isolated pile caps provided for piers supporting superstructure	PSC I Girder	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles

Stretch		Location	Distance (m)	Description	Superstructure	Substructure	Foundation
Start	End						
2+551.115	2+601.115		50	2-lane road way on structure portion with two spans of 25.0m. Isolated pile caps provided for piers supporting superstructure	PSC I Girder	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles
2+601.115	2+671.115		70	2-lane road way on structure portion with two spans of 35.0m. Isolated pile caps provided for piers supporting superstructure	PSC I Girder	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles
2+671.115	2+701.115		30	2-lane road way on structure portion with single span of 30.0m each. Isolated pile caps provided for piers supporting superstructure	PSC I Girder	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles
RAMP-7							
4+225.95	4+242.985	Besant Nagar	17	2-lane road way on structure portion with single span of 17.0m. Isolated pile caps provided for piers supporting superstructure	PSC Voided Slab	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles
4+242.985	4+282.985	Besant Nagar	40	2-lane road way on structure portion with two spans of 20.0m. Isolated pile caps provided for piers supporting superstructure	PSC Voided Slab	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles

Stretch		Location	Distance (m)	Description	Superstructure	Substructure	Foundation
Start	End						
4+282.985	4+387.985	Besant Nagar	105	2-lane road way on structure portion with three spans of 35.0m. Isolated pile caps provided for piers supporting superstructure	PSC I Girder	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles
4+387.985	4+412.985	Besant Nagar	25	2-lane road way on structure portion with single span of 25.0m. Isolated pile caps provided for piers supporting superstructure	PSC I Girder	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles
RAMP-8							
4+283	4+423	Besant Nagar	140	2-lane road way on structure portion with four spans of 35.0m. Isolated pile caps provided for piers supporting superstructure	PSC I Girder	Elliptical hammer headed pier	Pile foundation with 1.2m dia piles

Preliminary foundation design is attached as Annexure 4.1 in this report.

4.14 Drawings

A separate drawing volume consist of following sets of drawings are given as Volume II Drawings are presented in drawing volume which is subdivided in to highways and structure. Detailed Plan and profile which shows proposed alignment along with existing details, proposed levels and geometric details are presented in drawing volume. Typical cross section, lane markings and sign boards, electrical arrangements, strip plan showing important features and land use along the alignment and junction drawings are also included in the drawing volume.

List of Drawings

Sl. No.	Drawing Number	Drawing Title
1	SE-1-00-001	LIST OF DRAWINGS
2	SE-1-00-002	KEY PLAN
		PLAN AND PROFILE
3	SE-1-23-001	PLAN AND PROFILE KM 0+000 - KM 1+000
4	SE-1-23-001	PLAN AND PROFILE KM 1+000 - KM 2+000
5	SE-1-23-001	PLAN AND PROFILE KM 2+000 - KM 3+000
6	SE-1-23-001	PLAN AND PROFILE KM 3+000 - KM 4+000
7	SE-1-23-001	PLAN AND PROFILE KM 4+000 - KM 4+7000
8	SE-1-23-RAMP-001	PLAN AND PROFILE – STARTING UP RAMP KM 0+400 TO KM 0+875
9	SE-1-23-RAMP-001	PLAN AND PROFILE – STARTING DOWN RAMP KM 0+000 TO KM 0+863
10	SE-1-23-RAMP-001	PLAN AND PROFILE – FORESHORE ESTATE DOWN & UP RAMP DOWN RAMP KM 2+011 TO KM 2+400 & UP RAMP KM 2+400 TO KM 2+862
11	SE-1-23-RAMP-001	PLAN AND PROFILE – FORESHORE ESTATE DOWN & UP RAMP DOWN RAMP KM 2+351 TO KM 2+755 & UP RAMP KM 2+131 TO KM 2+500
10	SE-1-23-RAMP-001	PLAN AND PROFILE –BESANT NAGAR DOWN & UP RAMP DOWN RAMP KM 4+226 TO KM 2+583 & UP RAMP KM 4+283 TO KM 4+648
		TYPICAL CROSS SECTIONS
14	SE-1-30-001	TYPICAL CROSS SECTIONS
		JUNCTION IMPROVEMENTS
15	SE-1-40-001	PROPOSED JUNCTION IMPROVEMENT AT FORESHORE ESTATE (KM 2+400)
16	SE-1-40-002	PROPOSED JUNCTION IMPROVEMENT BESANT NAGAR JUNCTION(KM 4+650)
		INTERCHANGE DRAWINGS
16	SE-1-40-003	INTERCHANGE ARRANGEMENTS OVER ADYAR ESTURARY CONNECTING BESANT NAGAR JUNCTION
		STANDARD DRAWINGS
17	SE - 1-90-001	KERB AND DRAIN NEW JERCEY BARRIER
18	SE - 1-90-002	ROAD MARKING AND KERB PAINTING
19	SE - 1-90-003	TRAFFIC SIGNS
20	SE - 1-90-003	TRAFFIC SIGNS
21	SE - 1-90-004	DETAILS OF LIGHT POLE
22	SE - 1-90-004	DETAILS OF LIGHT POLE
23	SE - 1-90-005	STREET LIGHT ARRANGEMENT DRAWING

4.15 CONCLUSION

The Consultants have proposed a link road from Light house to Kottivakkam to cater the hassle free traffic, bypassing busy lattice bridge road, Santhome high road and Kamaraj Road. Special care has been taken in to account for not disturbing the beach scenery and activities of people residing in kuppams. Entry and exit ramps are provided at Foreshore estate link road, Besant Nagar and Elliot's Beach near Ashtalakshmi Temple. It is proposed to implement the project into two phases with Phase I from Light House to Besant Nagar.

Chapter 5: Environmental Impact Assessment & Environmental Management Plan.

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5 ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL MANAGEMENT PLAN

5.1. Introduction

This section on Environmental Impact Assessment is organised in two specific components for the first phase of the project. The first component carries out the Environmental Screening of the project proposals vis-à-vis the base line environmental conditions and identifies the broad issues of environmental criticality. The second component then assesses the specific impacts of the proposed improvements and proposes mitigaitive measures for each of the identified impact.

The screening exercise thus broadly, involves the preparation of environmental profile of the project area through detailed field inventories and investigations and evaluation of the project proposals. These reconnaissance surveys and field investigations were aimed at determining the environmental and social features such as meteorology, geology, hydrology, ecology, soil characteristics, land use and other demographic features of the project area. In addition to the above, a detailed inventory of the population, built up areas, sensitive features specific to the area on both sides of the project road, was also recorded.

Based on the primary and secondary data generated in the screening phase of the study, various impacts on the environmental components of the project area were identified in the assessment phase of the study and appropriate mitigitive measures were proposed.

5.2. Objectives of the Study

The phase -1 starts from Kamrajar Salai and Ends at Besant Nagar at km 4+700 and the main elevated structure terminates at km 4+318. The stretch falls within the CRZ II regulation zone and hence it is required to obtain the environmental clearance from MoEF. The alignment of this stretch is presented in **Figure 5.1**. The present study in this perspective looks at

- Assessing the impacts on environmental attributes due to the construction and operation of the proposed works along the phase I stretch of the proposed Santhome bypass and to prepare an Environmental Impact Assessment (EIA) Report.
- Preparation of an Environmental Mitigation Plan (EMP) recommending management measures to minimize the negative environmental impacts due to the project and to keep the unavoidable impacts to the permissible level under regulatory norms and also to outline the measures for improving the environmental quality.
- To prepare budgetary cost estimation for implementation of EMP

5.3. Scope of Environmental Impact Assessment

Environmental Impact Assessment would address the impact due to the project on either side of the Phase I stretch of the Santhome bypass and impacts assessed for a 100 m corridor.

The broad scope of the study include:

- To conduct a literature review and to collect additional data relevant to the study area;
- To undertake environmental monitoring so as to establish the baseline environmental status of the study area;
- To assess the impacts on environmental attributes due to the construction and operation of the proposed work.
- To prepare an Environmental Management Plan (EMP) outlining the measures for improving the environmental quality and budgetary cost estimation for implementation;
- To identify critical environmental attributes required to be monitored subsequent to the implementation of the proposed project

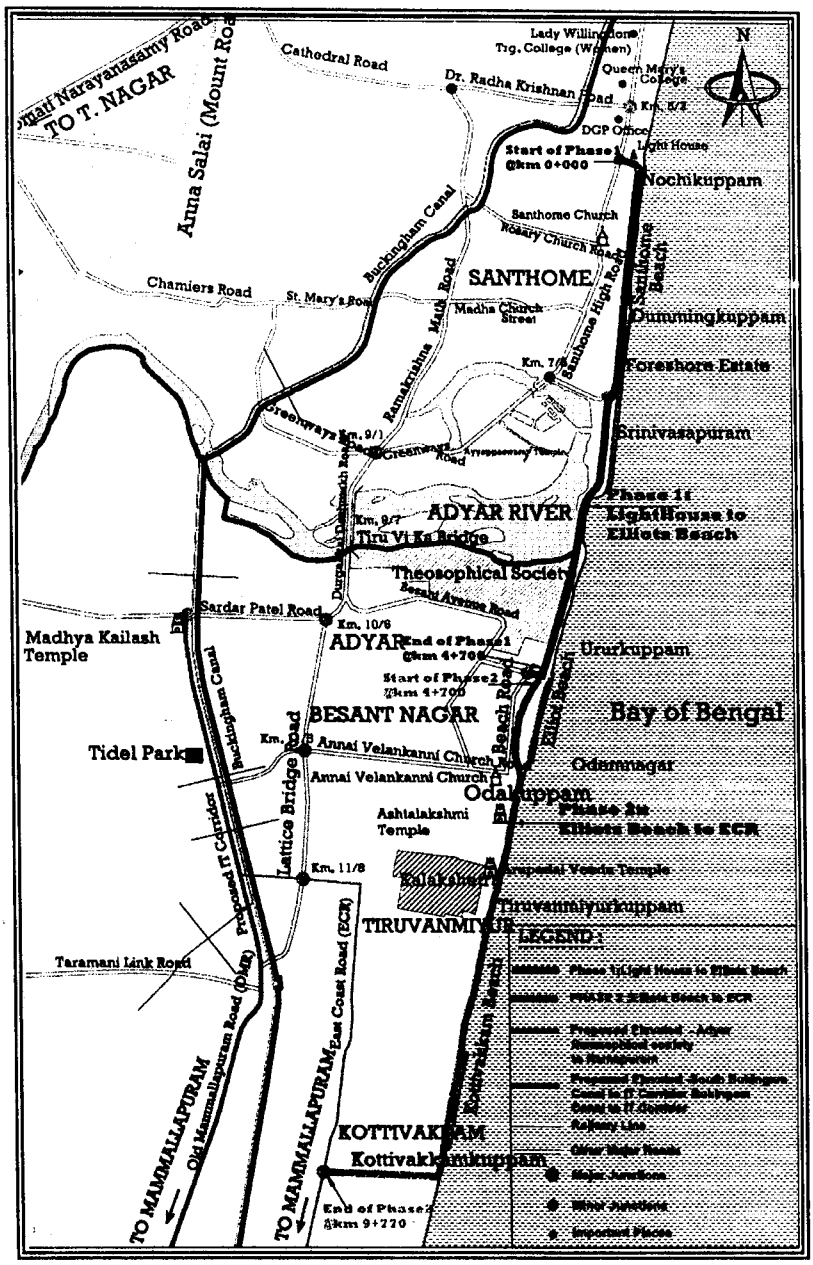

Figure 5.1. Proposed Bypass Alignment along the Coast under Phase I and Phase II

5.4. Study Approach

In order to accomplish the above objectives, studies were organised in line with the guidelines stipulated by the Ministry of Environment and Forests (MoEF), Government of India, for environmental impact assessment of highway projects.

Task 1 Field Reconnaissance Survey and Review of Earlier Studies

The approach to the entire study was formulated based on a detailed field reconnaissance survey and thorough understanding of the proposed project. The reconnaissance survey was carried out for the project road to understand the salient environmental features of the project area, sensitive areas with regards to the proposed project activities, and general understanding of the proposed project. Reports of previous studies were studied to obtain a clear understanding of the project activities.

Based on the above an environmental profile of the project area, primary and secondary data requirements for carrying out further activities of the study, environmental surveys necessary for assessing the project impacts, and the project influence area were identified.

Task 2 Review and Assessment of Applicable Environmental Regulations

Discussions with the pollution control board authorities and review of the various regulations and guidelines for EIA were conducted to assess the sampling and analysis requirements for the project and the procedural requirements for conducting an EIA. This primarily comprised of reviewing all relevant documents and studies available for the project area.

Task 3 Delineation of Study Area for Assessment

The above tasks identified the survey and analysis requirements for assessing the impacts of the proposed project activities. Based on which, the study area that is critical for assessing the project impacts was identified and delineated. While the influence area varies for each of the environmental component, the study area was considered as 100 m wide corridor (50 m either side of the centre line of the road).The project influence area also considered those areas that are directly or indirectly influenced by the project activities during construction or operation of the proposed road work.

Task 4 Assessment of Base Line Environmental Conditions

This task comprised of field surveys for assessing the baseline environmental conditions and collecting secondary information regarding physical, biological and socio-economic conditions of the study area. In addition, existing environmental quality of the study area was assessed based on the field environmental monitoring surveys. For monitoring the air, noise, surface and ground water, and soil quality, monitoring stations were set up and samples were collected and analyzed for relevant parameters.

Task 5 Prediction of Impacts

This task identified the likely future impacts through changes in the physical, biological or socio-economic environment based on the analysis of the base line environmental data collected in the earlier tasks. The assessment considered both positive and negative impacts due to the project and also due to the construction, and operation and maintenance of the road.

Task 6 Environment Management and Monitoring Plan

The major components of the environment management plan comprised preparation of mitigation plan for all the negative impacts identified in the earlier tasks to avoid, minimise or compensate the impacts, and the post-project monitoring plan for the measures suggested in the management plan to ensure that the impacts of the project are within the regulatory standards.

5.5. Baseline Environmental Status

An Environment Impact Assessment (EIA) study includes identification, prediction and evaluation of the potential impacts of a proposed project on the environmental quality within the study area. For the proposed road works, the following environmental components are identified as the major receptors of the project impacts, although not in the same order.

- Surface and ground water
- Ambient air
- Noise environment
- Land environment
- Terrestrial ecology
- Aquatic ecology
- Local socio-economy

The specific impacts have been assessed over a 100 m wide corridor with respect to the centreline of the proposed road whereas the study area for assessing broader environmental impacts is considered to be an area within 5 km on both the sides of the centre line of the proposed road. The baseline setting for the above-mentioned environmental components is documented and presented summarily. As mentioned earlier in the report initial environmental assessment suggests that Santhome bypass stretch falls under CRZ - II.

5.5.1 Data Collection

The present study being a Rapid EIA (REIA) study, the baseline data was collected for one season. Following tasks were undertaken by the Consultant for development of the baseline environmental scenario.

- Reconnaissance survey of the study area
- Field environmental monitoring for primary data generation
- Collection of available secondary data from government agencies and research institutes
- Review of reports of previous feasibility studies, Social assessment studies and Environmental assessment.
- Discussions with officials of State highways and officials of the concerned state departments

Primary data was collected during the study period to establish baseline scenario for micrometeorology, ambient air quality, noise levels, soil quality and water quality, in the month of April, 2006. In addition, the Consultant also collected data on the terrestrial ecology and socio-economy through secondary data. Moreover, the available secondary data on these environmental components and the socio-economic factors has been used to understand the baseline environmental status of the impact zone. The secondary data was collected from available literature including various technical reports, research papers, census data and discussions with the concerned government officials and local people.

5.5.2 Environmental Attributes Covered under the Study

The environmental parameters expected to be most significantly impaired by the project activities needs to be identified together with determining their existing status by direct observation and/or available records. Data on land use, meteorological conditions, sources of pollutants and local environmental conditions that influence the magnitude of the impacts primarily on sensitive receptors is obtained. This further delineates baseline status of the project area.

Table 5.1. Environmental Attributes Covered Under Field Studies

Attribute	Frequency / Coverage
Land Use Pattern	Keeping the Project area as core zone, a 100m wide corridor along the project road and a secondary impact area of 5 Km buffer zone was also taken for studying land use pattern
Meteorology	Wind speed and direction at one location continuously for one month using automatic Met station with monitoring frequency of 30 min.
Ambient air Quality SPM, RPM, SO_2, NO_X, CO and HC	24 hourly samples for SPM and RPM and 8 Hourly Samples for SO_2, NO_X, CO and HC for two days a week and for four weeks including a Sunday at two locations. The locations are selected to cover the project area characteristics
Noise levels	Continuous noise level monitoring was done at two locations for a period of 24 hours to determine L_{eq} values during day and night time.
Water quality	Samples were collected from surface and ground water at two locations and analysed for Physical, Chemical and Bacteriological parameters to provide the baseline status and assess impacts due to project on the water quality.
Ecology	Existing terrestrial and aquatic flora, fauna and endangered species along the stretch were listed.
Soil Quality	Two samples were collected along the proposed project road and analysed for various parameters to establish the baseline conditions.

In addition, secondary data was also collected to supplement the field data, as mentioned in **Table 5.2.**

Table 5.2. Environmental Attributes Covered under Secondary Data

Attribute	Coverage
Land use	Landuse pattern information are collected from Statistical and District Information Centre
Meteorology	Published meteorological data for a period of 10 years is obtained form IMD (Indian Meteorology Department), Chennai

Attribute	Coverage
Water quality	Secondary data on ground water quality was collected from office of Central Ground Water Board.
Ecology	Listing of species for flora and fauna in the general study area was done based on the published secondary data from Department of Environment and Forest, Saidapet.
Socio-economic aspects.	Socio-economic aspects and general demographic characteristics were compiled from secondary data.
Geology	Geology profile for the project area is collected from the secondary data obtained from CGWB, PWD and published literatures.
Hydrology	Groundwater and surface water details are collected from Institute for water studies, Chennai
Industrial Data	Field observation was used to Identify the existing industries along the project corridor

5.5.3 Land Environment

5.5.3.1 Land use

Land use of the area is primarily of urban type as the study area is within the Chennai Metropolitan Development Authority (CMDA) area limits. The stretch of Santhome bypass under study in this phase is adjacent to the coast of Bay of Bengal. Some stretches of the road is very close to the sea (within 50m from the shoreline). The land use pattern was dominated by the presence of beach with some fishermen settlements.

5.5.3.2 Soil Quality

Soil characteristics depend on the geo-morphology and climatology of the area as well characteristices of the parent material, relief and time. Soil analysis is required to assess the plantation and afforestation potential of the soil. The study area is covered by soil made up of clay brought by rivers and mixed with shale and fine sand with grey and dark grey in colour.

In order to assess the soil quality of the study area, soil sampling and analysis were carried out at two locations **(Figure 5.2)** along the stretch. The details of the sampling locations are given in **Table 5.3.** At each location, soil samples were collected from three different depths viz. 30 cm, 60 cm and 100 cm below the surface and were mixed to prepare composite sample. The soil samples were then analysed for the parameters responsible for the fertility of the soil. The results of soil analysis are given in **Table 5.4.** The results are compared with standard classification given in **Table 5.5.**

Table 5.3. Details of Soil Sampling Locations

Location Code*	Description
S 1	Light House – Opposite To Commissioner Office
S 2	Besant Nagar – Near the Besant Nagar Church

The collected soil samples were analysed and the results are presented in **Table 5.4**

Table 5.4. Soil Sampling Results

Parameters	S1	S2
Texture	Sandy loam	Sand Clay Loam
pH	8.22	8.62
Moisture content (%)	3.11	5.10
Organic Carbon (%)	0.321	0.463
Chlorides (Kg/ha)	48.3	62.1
Nitrogen (Kg/ha)	48	112
Phosphorous (Kg/ha)	12.0	17.0
Potassium (mg/100 gms)	90	247
Electrical Conductivity (m-mhos/cm)	0.085	0.113
Sodium Adsorption Ratio	1.12	0.79

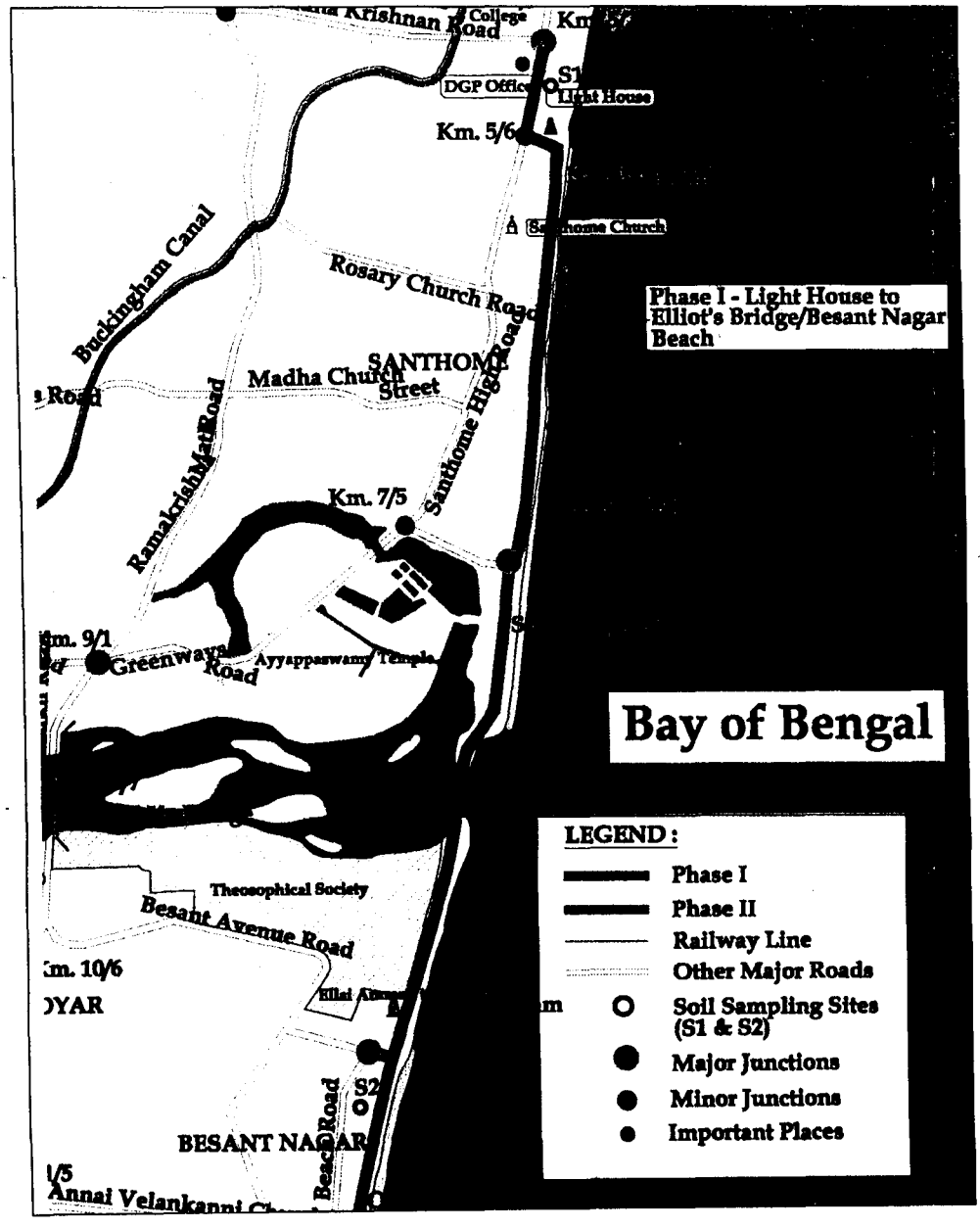

Figure 5.2. Soil Sampling Sites along the Proposed Alignment in Phase I

Table 5.5. Standard Soil Classification

Sl No.	Soil Test	Classification
1	pH	<4.5 Extremely acidic 4.51- 5.00 Very strongly acidic 5.51-6.0 moderately acidic 6.01-6.50 slightly acidic 6.51-7.30 Neutral 7.31-7.80 slightly alkaline 7.81-8.50 moderately alkaline 8.51-9.0 strongly alkaline 9.01 very strongly alkaline
2	Salinity Electrical Conductivity (mmhos/cm) (1mmho/cm = 640 ppm)	Upto 1.00 Average 1.01-2.00 harmful to germination 2.01-3.00 harmful to crops
3	Organic Carbon	Upto 0.2: very less 0.21-0.4: less 0.41-0.5 medium, 0.51-0.8: on an average sufficient 0.81-1.00: sufficient >1.0 more than sufficient
4	Nitrogen (Kg/ha)	Upto 50 very less 51-100 less 101-150 good 151-300 better >300 sufficient
5	Phosphorus (Kg/ha)	Upto 15 very less 16-30 less 31-50 medium, 51-65 on an average sufficient 66-80 sufficient >80 more than sufficient
6	Potassium (Kg/ha)	0 -120 very less 120-180 less 181-240 medium 241-300 average 301-360 better >360 more than sufficient

The soil analysis results suggest that soil is alkaline in nature with average electrical conductivity. Presence of organic matter is less. Considering NPK values, Nitrogen content is very less in S1 and good in S2, Phosphorus content is found to be less in the two samples and ranges between 12 – 17 (Kg/ha) and the presence of Potassium is very less in S1 and is found to be good in S2 and ranges from 90 – 247 (mg/100 gms).

5.5.3.3. Geology, Hydrogeology and Hydrology

Study of Geology, Hydrogeology and Hydrology of the project area was through the data collected from the secondary sources such as Central Ground Water Board (CGWB) and Geological Survey of India. No primary survey was carried out. The information collected is presented in the following sections

Geology

The study area is predominantly covered by thick soil alluvium followed by Gondwana sediments viz. sand stone, shale and silt stone for which, the Archaean crystalline formation charnockite and granitic gneisses are basements. These litho units are dipping towards east and the thickness of formation varies from place to place.

The litho units, which persist in and around the study area, belong to Archaean to Recent geological system. No crystalline exposure is seen in and around the study area since it is covered by thick soil alluvium. The crystalline rocks which are in deeper levels are moderately weathered and fractured.

The presence of bedding joints, shears and micro folding are indicative of the extensive tectonic disturbance in the post Gondwana period. There is an erratic thickness of sand and silt layer, which could be fluvial in origin. The coastal areas have sand dunes and beach ridges resulting from the recent marine and fluvial interaction. The presence of shell bed at shallow depth is also an indication of old lagoon and marine regression activity

Hydrogeology

Ground water in study area occurs in almost all the geological formations and is extracted by means of ring wells, filter point wells and tube wells. Ground water potential of the area varies from place to place. The soil alluvium which is predominantly covered in the study area is highly porous and, forms a potential ground water zone. The discharge of the tube well and ring wells, which are sunk in this zone, is about 2 to 6 litres per second and 1 to 3 litres per second respectively.

Ground water occurs in water table and semi-confined to confined conditions in the porous alluvial formations. Gravels, coarse to fine sands, clay and silty clay constitute the alluvial material, and of these, the gravels and sands form potential aquifers. The moderate ground water yielding zones occurs under semiconfined condition in tertiary sandstones and shales, which are less weathered and fractured. Ground water occurs in water table condition and confined condition in Gondwana sand stones. The shales and clays are highly consolidated and fractured and act like weathered crystallines. Moderate yield is obtained by tapping this zone.

In deeper zones i.e. in crystalline formations, which are heterogeneous in nature and forms semi confined aquifer, ground water is available. The average yield of the bore wells which are sunk in this zone is 1 to 3 liters per second. Different hydrogeological studies were made by CGWB and the brief information is given below. Rainfall is the major source of recharge to the phreatic aquifer and the water level fluctuations are in response to recharge and draft. The study indicates that generally the water table is shallow in November-January period and is deeper in May-August period.

The depth to water level varies from season to season. The depth to water level in pre-monsoon period ranges between 1.15 and 7.93 m below ground level, where as it is shallow in the range of 0.15 and 5.63 m below ground level in post monsoon period. The over development of beach aquifer had led to lowering of the water table below mean sea level, which may possibly lead to the inland

movement of the fresh water –sea water interface. The water table elevation varies from 3.49 m above MSL to 2.2 m below MSL.

5.5.4 Water Environment

This section describes the hydrology and baseline quality of the surface and ground water bodies of the study area.

Hydrology

The study area is influenced by coastal hydrodynamics of river -sea interface. Adyar is a short and Non-perennial River of about 42 km length, originating near the Chemberambakkam tank, flows through the industrial and residential areas of the city and confluences with the Bay of Bengal at Foreshore Estate. This river is rain fed, flows only for about two to three months in a year during northeast monsoon season. The flow in this river mainly includes discharge of domestic wastewater and effluent through several outfalls during rest of the year, leaving the waterway as a storage basin for wastewater. Industries such as Indian Drug and pharmaceuticals, Guindy Industrial Estate, Hindustan Tele printers, Standard Battery and hospitals, release their waste into the river. Untreated or partially treated hospital wastes contribute most, to the entry of certain pathogenic organisms into the river. This poses major health hazards to the coastal population and the aquatic organisms. Continuous deposition of sediments at the mouth of the river leads to stagnation of water body, thus converting the river into a mosquito breeding ground. The river and canal is influenced by tidal action and backwater enters upto 3 to 4 km during high tide.

Water Quality

Understanding the water quality of the project area is an integral part of Environmental Impact Assessment to identify critical issues with a view to suggest appropriate mitigation measures for implementation. Water samples were collected from the project area to represent the baseline condition. Water samples from Adyar Estuary and Adyar creek are collected and analysed for the surface water quality. Details of surface water sampling locations are given in **Table 5.6**. Even though impact on ground water is not envisaged in the proposed road work, two groundwater samples were collected from bore wells to get the existing status of ground water quality. Details of water sampling locations are given in **Table 5.7**. In the study area ground water is tapped at different places. Ground water quality of the area is influenced by a complex system of marine water, pollutants and over exploitation of ground water. The surface water and ground water sampling locations are presented in **Figure 5.3** respectively.

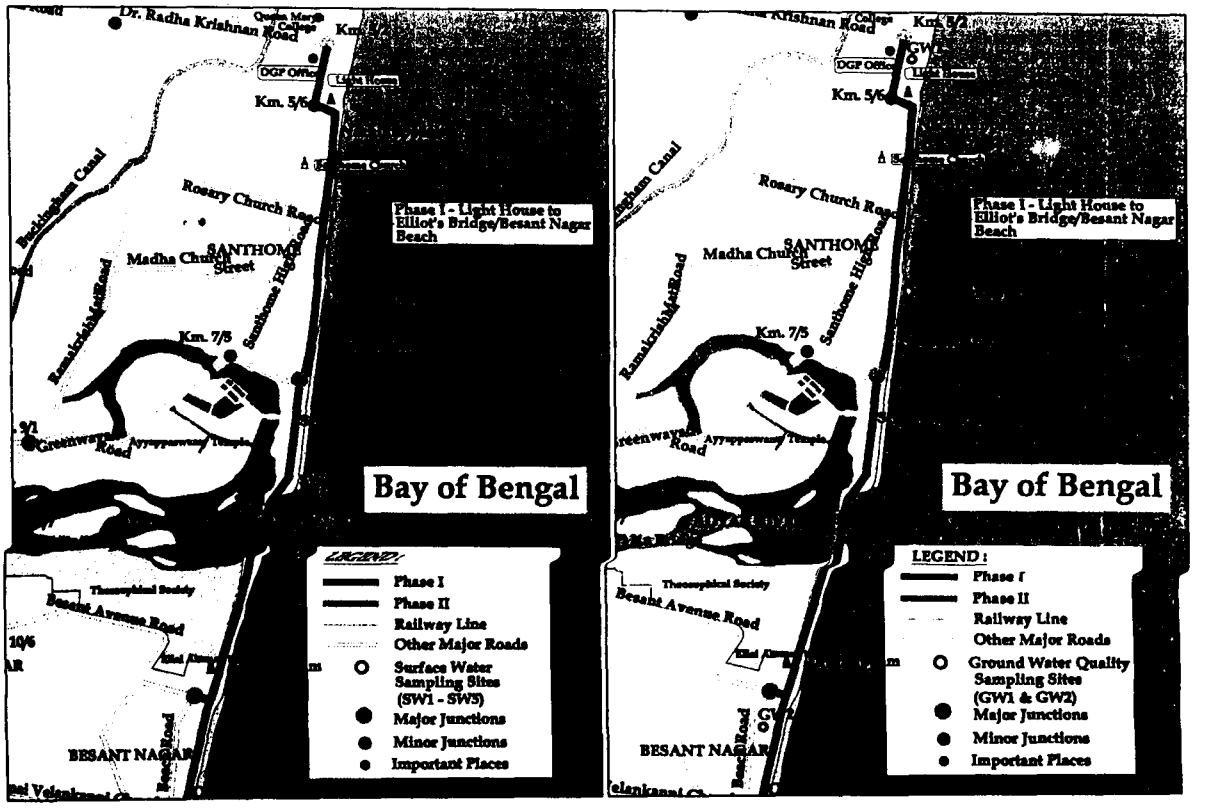

Figure 5.3. Surface Water and Ground Water Sampling Sites

As part of this study, the following assessments were done:

- Assessment of the existing water quality characteristics for critical parameters;
- Evaluation of the impacts on habitat conditions, recreational resources and aesthetics in the vicinity; and
- Assessment of the impact on water quality by the construction of road and related activities.

Table 5.6. Details of Surface Water Sampling Locations

Location Code*	Description/Observations
SW1	0.5 km from the river mouth (in the river).
SW2	In the mouth of the river.
SW3	0.5 km from the river mouth (in the sea).
SW4	0.5 km north of SW3 (in the sea).
SW5	0.5 km south of SW3 (in the sea).

* SW – Surface water

Table 5.7. Details of Ground Water Sampling Locations

Location Code*	Description/Observations
GW 1	Bore well water near the Light House was collected which is used for Drinking purpose
GW 2	Open well water was collected near the Besant Nagar residential place

* GW – Ground water

The collected samples have been analysed as per the procedure specified in "Standards Methods for the Examination of Water and Wastewater" published by American Public Health Association (APHA).The ground water quality has been compared with the Indian Drinking Water Quality Standards IS:10500 given in **Table 5.8**

Table 5.8. Standard Drinking Water - Specification (BIS 10500: 1991)

Sl No.	Substance or Characteristic	Unit	Requirement (Desirable Limit)	Permissible Limit in the Absence of Alternate Source
1	Colour, Max	Hazen units	5	25
2	Odour		Unobjectionable	Unobjectionable
3	Taste		Agreeable	Agreeable
4	Turbidity, Max	NTU	5	10
5	pH Value		6.5 to 8.5	No Relaxation
6	Total Hardness (as CaCo3) Max	mg/l	300	600
7	Iron (as Fe) Max	mg/l	0.3	1.0
8	Chlorides (as Cl) Max.	mg/l	250	1000
9	Residual, free chlorine, Min	mg/l	0.2	--
10	Desirable Characteristics			
11	Dissolved solids, Max	mg/l	500	2000
12	Calcium (as Ca), Max	mg/l	75	200
13	Copper (as Cu), Max	mg/l	0.05	1.5
14	Manganese (as Mn), Max	mg/l	0.10	0.3
15	Sulfate (as SO4), Max	mg/l	200	400
16	Nitrate (as NO3), Max	mg/l	45	100
17	Fluoride (as F), Max	mg/l	1.9	1.5
18	Phenolic Compounds (as C6H5OH), Max.	mg/l	0.001	0.002
19	Mercury (as Hg), Max	mg/l	0.001	No relaxation
20	Cadmiun (as Cd), Max	mg/l	0.01	No relaxation
21	Selenium (as Se), Max	mg/l	0.01	No relaxation
22	Arsenic (as As), Max	mg/l	0.05	No relaxation
23	Cyanide (as CN), Max	mg/l	0.05	No relaxation
24	Lead (as Pb), Max	mg/l	0.05	No relaxation
25	Zinc (as Zn), Max	mg/l	5	15
26	Anionic detergents (as MBAS), Max	mg/l	0.2	1.0
27	Chromium (as Cr6+), Max	mg/l	0.05	No relaxation
28	Polynuclear aromatic hydro carbons (as PAH), Max	g/l	--	--
29	Mineral Oil, Max	mg/l	0.01	0.03
30	Pesticides, Max	mg/l	Absent	0.001
31	Radioactive Materials			
32	i. Alpha emitters, Max	Bq/l	--	0.1
33	ii. Beta emitters, Max	pci/l	--	1.0
34	Alkalinity. Max	mg/l	200	600
35	Aluminium (as Al), Max	mg/l	0.03	0.2
36	Boron, Max	mg/l	1	5

Table 5.9. Surface water Analysis Results

Sl. No.	Parameters	Unit	SW 1	SW 2	SW 3	SW 4	SW 5
1	pH		8.38	8.3	8.27	8.36	8.35
2	Temp	°C	26.9	26.6	26.5	26.6	26.7
3	D.O	mg/L	5.17	5.2	6.01	6.54	6.15
4	salinity	mg/L	27.2	28.9	30.4	29.8	30.1
5	turbidity	NTU	1.85	2	4.13	4.56	4.62
6	chloride	mg/L	13342.2	13668.9	14836.71	14751	15506.3
7	phosphate	mg/L	93	84	77	78	75
8	nitrate	mg/L	77	58	35	32	37
9	BOD	mg/L	63	52	30	35	35

From the analysis of the surface water, it is evident that the water is alkaline and presence of high chloride concentration represents the characteristics of typical sea water. The DO concentration is low in the SW 1 and SW 2; this is due to the presence of the organic pollution in the river water. BOD concentration is found to be high in the Adyar River at SW 1 and SW 2; due to the high pollution concentration.

Table 5.10. Ground Water Analysis Results

Sl. No.	Parameters	Unit	GW 1	GW 2
1	pH	Mg/L	7.35	7.80
2	Colour	NTU	5	<5
3	Total Dissolved Solids	Mg/L	1922	1025
4	Total Suspended Solids	Mg/L	11	10
5	Oil & Grease	Mg/L	-Nil-	-Nil-
6	BOD (3 days at 270C	Mg/L	3	2
7	COD	Mg/L	39	30
8	Dissolved Oxygen	Mg/L	3.4	3.3
9	Total Hardness as CaCO3	Mg/L	1030	434
10	Chlorides as Cl	Mg/L	810	294
11	Sulphates as SO4	Mg/L	112	83
12	Fluorides as F	Mg/L	0.18	0.17
13	Sodium as Na	Mg/L	196	141
14	Potassium as K	Mg/L	23	16
15	Iron as Fe	Mg/L	0.33	0.27
16	Manganese as Mn	Mg/L	0.01	<0.01
17	Total Coliform	MPN/ 100ml	-Nil-	-Nil-
18	Faecal Coliform	MPN/ 100 ml	-Nil-	-Nil-

High concentration of total hardness is recorded for the two stations, the concentration exceed the limitation prescribed by IS 10500 standard for drinking water. All other parameters are well within the drinking water standard.

5.5.5 Air Environment

This section documents the baseline scenario of the ambient air environment in the study area. The baseline scenario is established based on the micrometeorology and ambient air quality monitoring carried out in the study area.

5.5.5.1. Climate and Rainfall

The project area has a hot and humid climate, which can be termed as tropical maritime monsoon type. The temperature is always on the higher side and it is being compensated to a considerable degree due to the proximity to the coast.

The winter season sets in during the month of December and continues till end of February. Winter is followed by the summer season which starts from February and continues till May. Temperature is very hot and humid during this period. Occasional summer showers with gusty wind and lightning are a characteristic of this season. The North-East Monsoon commences in October, dry weather setting in by the end of December.

The area receives the maximum rainfall from the North East Monsoon. The minimum rainfall ranges from 6mm - 10mm in the month of February and Maximum rainfall of around 320mm is recorded in the month of November with an annual average of 1215 mm.

The minimum temperature ranges from 21^0C to 24^0C in the month of December to February and maximum temperature recorded 37^0C in the month of May. Mean relative humidity is high through out the year, and varies from 65% in May-July to 80% in October – December.

5.5.5.2. Micrometeorology

Micro-meteorological data for the study area was collected from the India Meteorological Department (IMD). In addition to the secondary data, the field monitoring data collected in the month of April and May 2006 was used for assessing the baseline meteorological conditions in the study area. For this purpose, one meteorological monitoring station was fixed in the project area so as to get representative data. Hourly maximum, minimum and average values of wind speed, wind direction, relative humidity, temperature and solar radiation, cloud cover were recorded continuously at the site. The summarised daily results of the micrometeorological monitoring are given in **Table 5.11**

Table 5.11. Meteorology observation along the project corridor

Sl.no	Date of Sampling	Wind velocity (Km/Hr)		Wind Direction (Km/Hr)	Temp °C		Relative Humidity (%)		Cloud Cover (Oktas)	Rainfall (mm)
		Min	Max		Min	Max	Min	Max		
1	15/04/05	3.2	16.8	SW	27.50	39.00	46.0	82.0	clear	0
2	16/04/05	1.9	12.8	SW	28.00	38.50	41.0	83.0	clear	0
3	17/04/05	2.5	13.8	SW	29.00	38.50	41.0	82.0	clear	0
4	18/04/06	2.9	15.5	SW	29.00	39.00	42.0	82.0	clear	0
5	19/04/06	3.9	10.3	SW	29.00	38.50	40.0	79.0	clear	0
6	20/04/06	3.8	11.4	SW	29.00	39.00	41.0	81.0	clear	0
7	21/04/06	3.6	13.1	SW	29.00	38.50	40.0	80.0	clear	0
8	22/04/06	2.9	11.2	SW	28.50	38.50	42.0	80.0	clear	0
9	23/04/06	3.1	13.2	SW	28.50	38.00	41.0	80.0	clear	0
10	24/04/06	3.0	12.6	SW	26.5	36.5	41.0	81.0	clear	0
11	25/04/06	3.1	12.5	SW	28.5	38.5	41.0	82.0	clear	0
12	26/04/06	1.9	8.4	SW	28.0	38.5	43.0	80.0	clear	0
13	27/04/06	3.0	11.1	S	28.5	37.5	40.0	80.0	clear	0

Sl.no	Date of Sampling	Wind velocity (Km/Hr)		Wind Direction (Km/Hr)	Temp °C		Relative Humidity (%)		Cloud Cover (Oktas)	Rainfall (mm)
		Min	Max		Min	Max	Min	Max		
14	28/04/06	3.6	11.8	SW	28.0	38.0	44.0	79.0	clear	0
15	29/04/06	2.4	10.1	SW	28.5	39.0	41.0	79.0	clear	0
16	30/04/06	2.4	8.4	SW	28.5	38.0	40.0	79.0	clear	0
17	01/05/06	2.5	8.1	SW	28.5	38.5	40.0	78.0	clear	0
18	02/05/06	2.1	15.1	SW	29.0	38.5	39.0	79.0	clear	0
19	03/05/06	2.1	7.8	SW	27.0	38.0	40.0	78.0	clear	0
20	04/05/06	2.2	10.3	SW	27.5	38.5	46.0	80.0	clear	0
21	05/05/06	2.4	8.3	W	27.0	38.0	38.0	81.0	clear	0
22	06/05/06	2.2	8.0	SSW	27.0	37.5	40.0	82.0	clear	0
23	07/05/06	3.1	14.5	SW	27.5	37.0	42.0	80.0	clear	0
24	08/05/06	2.0	13.3	W	27.0	38.0	38.0	77.0	clear	0
25	09/05/06	2.8	12.3	WSW	27.0	38.0	37.0	77.0	clear	0
26	10/05/06	2.0	12.2	SSW	27.5	38.0	40.0	75.0	clear	0
27	11/05/06	2.3	12.5	S	27.0	38.5	38.0	78.0	clear	0
28	12/05/06	3.5	11.3	SW	27.0	39.0	36.0	79.0	clear	0
29	13/05/06	2.1	10.3	SW	28.0	39.0	40.0	78.0	clear	0
30	14/05/06	2.2	12.4	SSW	27.5	39.0	36.0	76.0	clear	0

From the results obtained, the minimum wind velocity ranges from 1.9 to 3.9 Km/Hr and maximum ranges from 7.8 to 16.8 Km/Hr. The minimum temperature ranges from 26.5°C to 29°C and maximum ranges form 36.5°C to 39°C respectively. Relative humidity shows a minimum range between 36 (%) to 46 (%) and a maximum of 75 (%) to 83 (%).

5.5.5.3. Ambient Air Quality (AAQ)

Major sources of air pollution in the study area are emissions from vehicular traffic, dust arising from the roads due to vehicular movement. A baseline air quality survey was carried out to assess the air quality of the area. Air quality of the study area is assessed by a network of Ambient Air Quality Monitoring (AAQM) stations. AAQM is also useful in assessing conformity to the standards of the ambient air quality during the operation of the road. The study zone for air quality includes regions up to approximately 500 meters from the project road.

The design of monitoring network in the air quality surveillance program has been based on the following considerations:

- Network of project roads
- Meteorological conditions
- Topography of the study area
- Likely impact areas

Location of AAQM stations was selected along the proposed stretch to represent the impact due to the road traffic. Accordingly the stations were selected considering residential, commercial and mixed development areas.

The AAQ was monitored for the following parameters.

- Suspended Particulate Matter (SPM)
- Respirable Particulate Matter (RPM)
- Sulphur di-oxide (SO_2)
- Oxides of Nitrogen (NO_x)
- Carbon monoxide (CO) and
- Hydrocarbons (HC)

List of the AAQM locations is given in **Table 5.12**. The monitoring locations are also shown in **Figure 5.4**. Summary of the baseline ambient air quality data in the study area is given in **Table 5.13**. The National Ambient Air Quality Standards (NAAQS) prescribed by CPCB are given in **Table 5.14**. The relevant standard values are also given in ambient air quality tables for easy reference

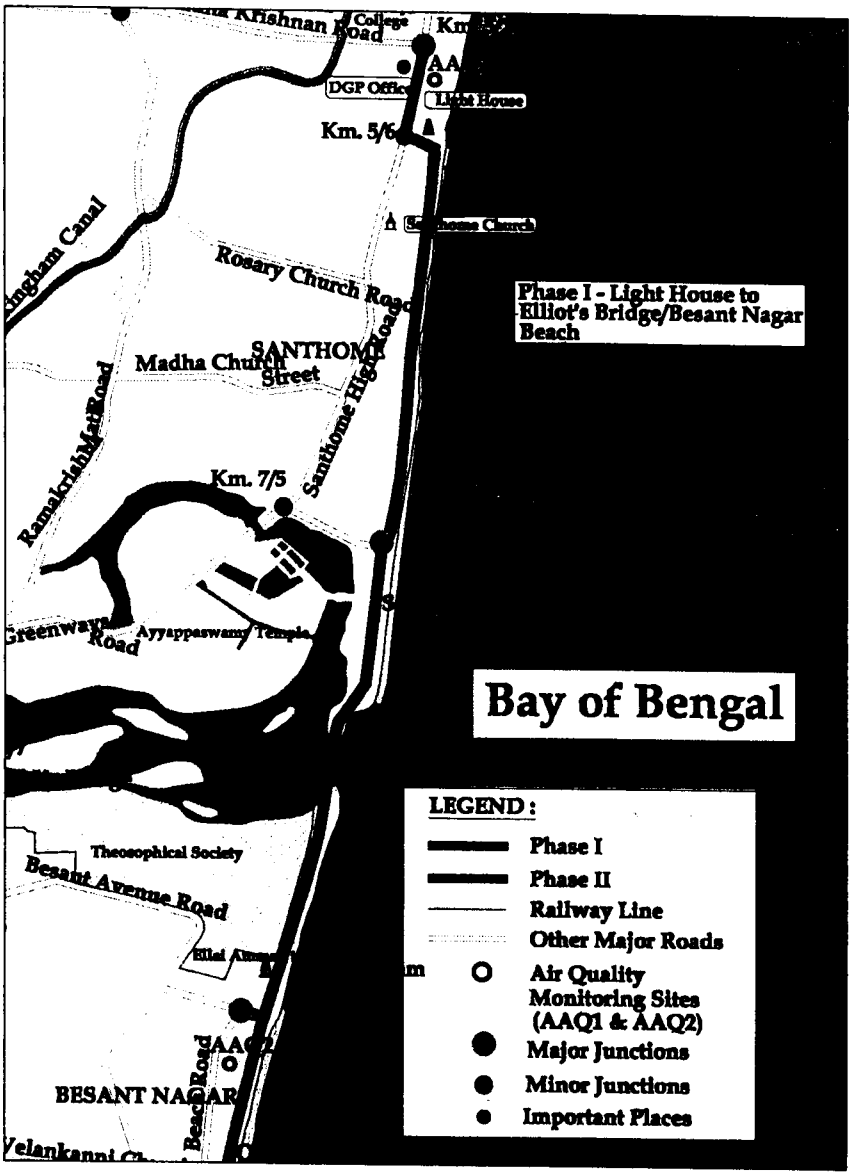

Figure 5.4. Ambient Air Quality Monitoring Sites

Table 5.12. Ambient Air Quality Monitoring (AAQM) Locations

Station Code	Location	Environmental setting
AQ -1	Light House (Santhome)	Residential / Commercial
AQ-2	Besant Nagar – Near the Besant Nagar Church	Residential / Commercial

Table 5.13. Summary of AAQM Results (Average Values)

Location	SPM	NOx	SO2	CO	HC
	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	ppm	ppm
Light House (Santhome)	155	10.78	7.9	<114.5	<65
Besant Nagar – Near the Besant Nagar Church	180	11.70	8.6	<114.5	<65

Table 5.14. National Ambient Air Quality Standards (CPCB, New Delhi, India)

Pollutant	Time weighted Average	Concentration in ambient air (µg/m3) unless otherwise specified			Measurement method
		Industrial area	Residential, Rural and Other areas	Sensitive area	
Suspended Particulate Matter (SPM)	Annual Average 1	360	140	70	High Volume Sampler,(average flow rate not less than 1.1 m3/min)
	24 hours 2	500	200	100	
Respirable Particulate Matter (RPM)	Annual Average	120	60	50	Respirable Particulate Matter Sampler
	24 hours	150	100	75	
Sulfur Dioxide (SO2)	Annual Average	80	60	15	Improved West and Gaeke method Ultraviolet fluorescence
	24 hours	120	80	30	
Oxides of Nitrogen (as NO2)	Annual Average	80	60	15	Jacob & Hochheiser modified (Na-Arsenite) method Gas phase chemiluminescenc
	24 hours	120	80	30	
Lead (Pb)	Annual Average	1	0.75	0.5	AAS Method after sampling using EPM 20006Y equivalent filter paper
	24 hours	1.5	1	0.75	
Carbon Monoxide (CO)	8 hours	5000	2000	1000	Non-dispersive Infrared technique
	1 hour	10000	4000	2000	

[1] Annual arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.
[2] 24 hourly/8 hourly values should be met 98% of the time in a year. However, 2% of the time it may exceed, but not on two consecutive days.

From the AAQ observation, it is inferred that Maximum TSPM concentration was recorded as 180 $\mu g/m^3$ at AQ2 (Besant nagar) and also maximum concentration of SO_2 and NOx is found as 8.6 $\mu g/m^3$ and 11.7 $\mu g/m^3$ respectively. CO is observed as less than 114.5 ppm for the two stations and HC as less than 65 ppm for the stations.

5.5.6 Noise

The main objective of noise monitoring in the study area is to establish the baseline noise levels in the different zones and assess the impact of the total noise expected to be generated by the proposed project in the surrounding community. Noise level monitoring has been conducted in the study area while considering that locations represent, commercial and residential zones. Noise monitoring was undertaken for 24 hours for three days at each location. The instrument used was an integrated sound level meter with attached out put device.

This section documents the baseline noise levels in the study area. In order to establish the baseline noise scenario, results of noise level monitoring carried out during the study period at 2 locations in the study area have been considered. These locations are given in **Table 5.15** and are also shown in **Figure 5.5.** The monitored noise level data is given in **Table 5.16**. Similarly, the ambient noise standards prescribed by the CPCB are given in **Table 5.17.**

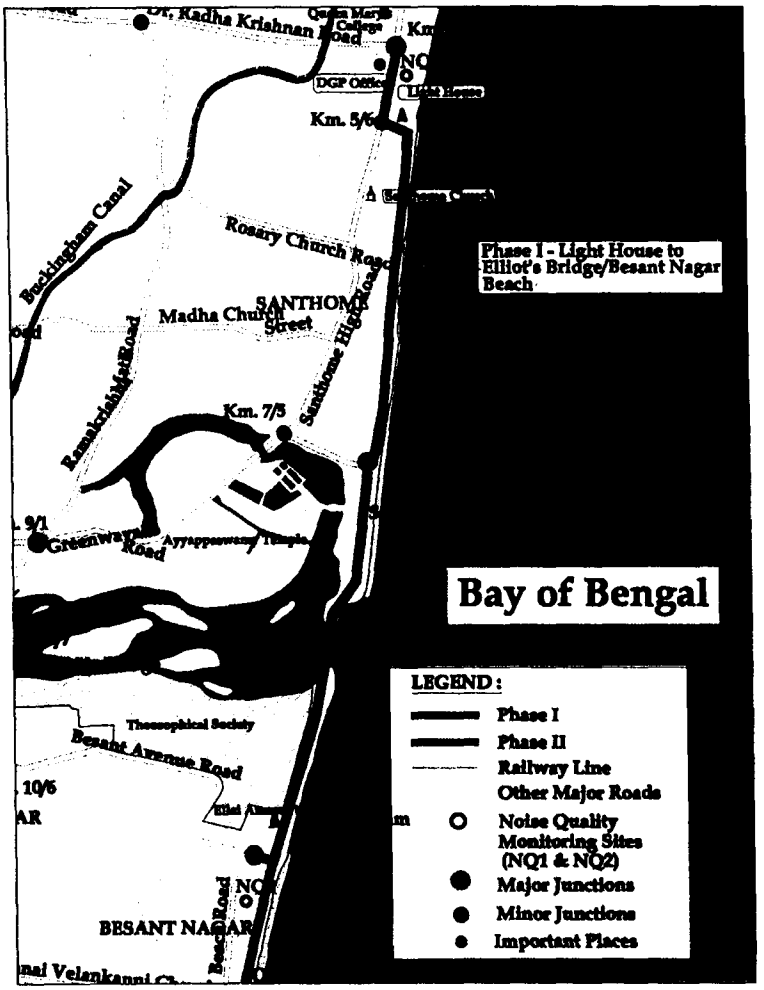

Figure 5.5. Noise Monitoring Sampling Sites

Table 5.15. Details of Noise Monitoring Locations

Sl.no	Location (Location Code)	Description
1	Light House (Santhome)	Residential / Commercial
2	Besant Nagar – Near the Besant Nagar Church	Residential / Commercial

Instrument for Noise monitoring was programmed to monitor noise levels in terms of Sound Pressure Levels. Hourly readings of L 90, L 50, L 10, L eq and further 3 days (6 am to 9 pm) and 3 days (9 pm to 6 am), L dn were monitored and recorded.

- L10 is the noise level exceeded 10 per cent of the time;
- L50 is the noise level exceeded 50 per cent of the time; and
- L90 is the noise level exceeded 90 per cent of the time.

Using L90, L50, and L10 equivalent sound pressure levels (L eq) can be calculated. The L eq is the equivalent continuous sound level that is equivalent to the same sound energy as the actual fluctuating sound measured in the same period. This is necessary because sound from noise source often fluctuates widely during a given period of time. Each hour L eq is monitored by setting the instrument in the slow pulse mode, i.e. the recording interval and response time is set to 1 second. After 3600 recording (since the time interval set is one hour) the instrument calculates L eq, L 90, L 50 and L10 using standard integration technique.

- L day is defined as the equivalent noise level measured over a period of time during day (6 am to 9 pm).
- L night is defined as the equivalent noise level measured over a period of time during night (9 pm to 6 am).
- 24 hours L eq is calculated by logarithmically averaging the 24 values of hourly L eq.

Table 5.16. Noise Monitoring Observations

Location	Time	L eq	L 10	L 50	L 90	L max
Light House	Day	55.5	58.2	54.8	49.2	60.1
	Night	42.2	44.2	42.2	39.2	45.2
Besant Nagar	Day	48.6	52.3	47.2	45.2	54.6
	Night	41.2	43.6	41.2	38.2	45.1

The monitored noise levels are compared with the CPCB ambient noise standards presented in **Table 5.16.** All the locations monitored are reflecting the traffic noise being adjacent to the road. In such case the distance between road (noise source) and monitoring location is also a determining factor for ambient noise levels.

Monitored noise levels are presented in **Table 5.15.** The Leq in the range of 48.6 – 55.5 dB (A) in day time and 41.2 – 42.9 dB (A) in night time. The observations of the noise monitoring indicate that all the values are within the standards set by the CPCB.

Table 5.17. CPCB Ambient Noise Standards

Area Code	Category of Area	Limits in dB(A)	
		Day Time	Night-Time
(A)	Industrial area	75	70
(B)	Commercial area (C)	65	55
(C)	Residential area (R)	55	45
(D)	Silence zone	50	40

Note: Daytime is reckoned between 6 a.m. to 9 p.m and Night-time is reckoned between 9 p.m. to 6 a.m.

5.5.7 Aquatic Ecology

In order to study the aquatic ecology, surface water samples are collected from different location in the river and adjoining sea. The collected samples are preserved and analysed for the presence of the Phytoplankton and Zooplankton. The analysed results are shown in the **Tables 5.18 and 5.19**.

Table 5.18. Details of Phytoplankton Species in the surface water

Phytoplankton	River	River Mouth	Sea
Anabaena sp.	S	A	A
Microcystis sp.	D	R	A
Oscillatoria sp.	S	A	R
Rivularia sp.	R	A	A
Ankistrodesmus sp.	D	R	R
Chlorella sp.	S	A	A
Pandorina sp.	S	R	A
Scenedesmus sp.	S	R	A
Ulothrix sp.	R	A	A
Volvox sp.	R	A	A
Cymbella sp.	S	D	S
Gyrosigma sp.	S	D	D
Pleurosigma sp.	S	D	D
Fragilaria sp.	R	D	S
Amphora sp.	R	S	S
Navicula sp.	D	D	D
Nitzschia sp.	D	D	D
Pinnularia sp.	D	S	S
Synedra sp.	S	S	S
Chaetoceros sp.	R	R	A
Pandorina sp.	R	A	A
Ceratium sp.	R	A	A
Euglena sp.	R	A	A

* D- Dominant, S- Subdominant, R- Rare and A - Absent

From the analysis the phytoplankton population in the Adyar River shows a health environment than Adyar Creek and sea. The species like Cybbella Sp, Gyrosigma Sp, Pleurosigma Sp and Fragilaria Sp are dominant in the Estuary and the sea. Whereas the Species like Anabaena Sp, Microcyctis Sp,

Oscillatoria Sp, Rivularia Sp and Ankistrodesum Sp, Euglena sp and Ceratium Sp shows their presence in the River.

Table 5.19. Details of Zooplankton Species in the surface water

Zooplankton	River	River Mouth	Sea
Cyclops Sp.	D	S	R
Keratella Sp.	S	S	D
Vorticella Sp.	S	R	R
Nauplius Larva	S	D	D
Ostracod Sp.	R	R	S
Tintinopsis Sp.	S	R	R
Copepod Sp.	D	D	D
Nebaliad Sp.	S	D	D
Philodina Sp.	R	S	R
Favella Sp.	S	S	A
Evadne Sp	R	R	R
Acartia Sp.	S	S	R

* D- Dominant, S- Subdominant, R- Rare and A - Absent

The common Zooplankton species like Ostracod Sp, Cyclops Sp, Vorticella Sp, Copepod Sp and Acartia Sp for the tropical water are observed in all the samples. The presence of the species network shows a health population in the surface water

5.5.8 Area under Coastal Regulation Zone (CRZ)

Under the Environment Protection Act, 1986 a notification was issued in February, 1991, for regulation of activities in the coastal area by the Ministry of Environment and Forests (MoEF). As per the notification, the coastal land up to 500 m from the High Tide Line (HTL) is designated as area under Coastal Regualtion Zone. The distance from the High Tide Line shall apply to both sides in the case of rivers, creeks and backwaters and may be modified on a case to case basis for reasons to be recorded in writing while preparing the Coastal Zone Management Plans provided that this distance shall not be less than 100 meters or the width of the creek, river or backwaters, which ever is less. The distance up to which development along rivers, creeks and backwaters is to be regulated shall be governed by the distance up to which the tidal effects are experienced which shall be determined based on salinity concentration of 5 parts per thousand (ppt). For the purpose of this notification, the salinity measurements shall be made during the driest period of the year and the distance upto which tidal effects are experienced shall be clearly identified and demarcated accordingly in the Coastal Zone Management Plan. The above notification includes only the inter-tidal zone and land part of the coastal area and does not include the ocean part. The notification imposed restriction on the setting up and expansion of industries or processing plants etc. in the said CRZ. CRZ along the country has been placed in four categories as described in **Table 5.20**.

Table 5.20. Classification of Costal Regulation Zone

Sl No	Category	Criteria
1	CRZ-I	Ecologically sensitive and important areas, such as national parks/marine parks, sanctuaries, reserved forests, wild habitats, mangroves, corals/coral reefs, area close to breeding and spawning grounds of fish and other marine life, areas of outstanding natural beauty, historical and heritage areas, areas rich in genetic biodiversity, areas likely to be inundated due to rise in sea level consequent upon global warming and such areas as may be declared by the authorities. Areas between LTL and HTL
2	CRZ-II	Areas that have already been developed up to the shoreline For this purpose, 'Developed Area' is referred to as that area within the municipal limits or in other legally designated urban areas which is already substantially built up and which has been provided with drainage and approach roads and other infrastructural facilities, such as water supply and sewerage mains.
3	CRZ-III	Areas that are relatively undisturbed and those which do not belong to either category I or II. These will include coastal zone in the areas (developed and undeveloped) and also areas within Municipal limits or in other legally designated urban areas which are not substantially built up.
4	CRZ-IV	Coastal stretches in Andaman and Nicobar islands, Lakshadweep and small islands, except those designated as CRZ-I, CRZ-II and CRZ-III.

The first phase of the project area comprising of the Santhome Bypass (Elevated Expreassway) falls under the category of CRZ II as per the Department of Environment (DoE), Tamilnadu. This is because the entire Chennai shoreline is classified under the CRZ II, due to the Urbainisation of the growing population. However no development is envisaged in the present project on the seaward side.

5.6. Environmental Impact Assessment

The assessment of the environmental impacts and their mitigation measures have been estimated as an overall impact caused by the execution of the proposed Santhome bypass project under two phases. The proposed road along the sea coast is expected to have varying degree of impacts on the following environmental components in its different stages of development.

1 Land
2 Ambient air
3 Water
4 Noise
5 Local socio-economy

In this chapter, the potential impacts of the proposed project on these environmental components are predicted and evaluated. The baseline environmental data collected, the various project activities and their extent along with the impact mitigation measures, form the basis for impact evaluation. The environmental impacts due to proposed road works can be categorised as direct or primary impacts and indirect or secondary impacts. Primary impacts are attributed directly by the project whereas secondary impacts are indirectly induced and typically include the associated investment and changing patterns of social and economical activities due to proposed action.

For the purpose of impact evaluation, the project activities are assessed in two phases such as Construction Phase including project planning and Operation Phase.

Construction Phase Activities

The major activities during the construction phase of the proposed project will be

1 Clearing of encroachments
2 Land clearing, levelling etc.
3 Excavation of land
4 Disposal of excavated material
5 Construction of Resettlement colony
6 Other developmental works

Operation Phase Activities

1. Vehicular Movement along the road

The impacts due to project activities during construction and operation phases are different. The potential environmental impacts due to the project activities are studied for the two phases of the project viz. construction phase and operation phase. The potential environmental impacts due to project activities considered are presented in **Table 5.21**.

Table 5.21. Potential Environmental Impacts due to Proposed Project Activities

Project Activities	Environmental Impacts
Construction Phase	
Site clearance	Loss of vegetation Change in land use
Production of construction material	Dust emission/air pollution Loss of vegetation
Transportation of construction material	Air and noise pollution
Construction of labour camps	Sewage and solid waste generation
Road construction operation	Air and noise pollution
Operation Phase	
Vehicular traffic	Air and noise pollution
Landscape development	Improved aesthetics Reduction in noise levels Improved air quality
Infrastructure development	Improved road facility

5.6.1. Construction Phase Impacts

5.6.1.1. Impact On Topography / Land Use

Construction phase starts from taking possession of the site. The work in this phase comprises of site clearance, land development, building of infrastructural facilities and all construction work till commissioning. Duration of this phase is dependent on many factors such as finance, size of the project, location and infrastructural support, etc.

Land acquisition of private land is not envisaged in the current project; however removal of the fisherman villages on a temporary basis is required. The proposed project stretch has a monument in

the Besant Nagar beach alias Elliots beach, but the monument is not recognised by Archaeological Survey of India (ASI) except this there are no archaeological monuments. Depending on the RoW requirement obstruction, relocation and protection measures along these places shall be suggested. Since the project involves only elevated structure, changes in existing topography are not expected and the construction phase impact is negligible.

The project implementation involves construction of office buildings, labour camps, mixing plants etc during construction period. This may result in a change in the local landuse. How ever, these impacts are marginal and exist only during the construction phase. Similarly the construction of the resettlement site for rehabilitating the project affected families will cause local land use changes in the identified location.

It is estimated that the first phase of the project would generate around 35,500 cum of excavated waste. Disposal of the construction waste can also affect the local topography of the area if accumulated or indiscriminately dumped in the project area. However these excavated waste will be tested for their CBR values and if found suitable will be used for subgrade or else will be used for filling in Resettlement sites or disposed off in identified designated dumping site and low lying areas to avoid major impacts.

The material required for the road construction would include around 66000 cum of aggregates and 5000 cum of sand to be acquired from the identified stone quarries, which operate under lease agreements with the Department of Mining and Geology. The lease agreement will stipulate implementation of Environmental Management Plan incorporated in the mining plan during and at the closure of mining operations. In the case of the present works, no hot mix plant or quarry or borrow areas are planned along the project road stretch and will be planned outside the project area. Necessary clearance for such operations shall be responsibility of the contractor and suitable clauses for such clearances will be provided in the contract conditions. Hence impacts on the local environment due to the quarrying operation are not envisaged for the project.

5.6.1.2. Impact on Water Quality

Even though the proposed works do not have any direct impact on the water quality, use of water for construction purposes and disposal of construction waste into the water bodies may affect the quality of water in the project area. It is expected that around 17500 Kilo litre of water is required for the construction purpose. In the absence of any surface water bodies along the project road the only alternative will be ground water. However the results of the water quality monitoring indicate that the ground water along the project stretch is high in TDS and it is not suitable for the construction purposes. For the construction purpose the water can be purchased (or) outsourced from government bodies like Metro water or private water supplying agencies. Being close to the sea dumping of construction and bitumen waste in to the coastal waters will have an impact on the quality of the coastal waters along this stretch.

5.6.1.3. Impact on Air Quality

Impact on air quality during construction phase is due to

- Material transport

- Operation of construction yard
- Fugitive emissions

The vehicular movement due to project is not expected to cause a significant rise in existing traffic and it is distributed over time (of the day) and span (the entire project road). The fugitive dust emission due to loading and unloading of construction material (stone aggregate and sand) will be minimum and much localised due to the size and rapid settling. Cement will be transported in bags. Mitigative measures are suggested for further reduction of impact due to material transport.

Use of equipments and machinery using diesel as fuel will contribute to air pollution. The air pollution due to operation of construction yard will be mainly ground based with localised effect for the construction period.

5.6.1.4. Impact on Noise Levels

The noise levels are expected to increase during the construction phase of the project due to the movement of vehicles transporting the construction material to the construction yard and the noise generating activities at the yard itself. Cement concrete mixers; hot mix plants, crushers etc are the other sources of noise. Operation of Earthmovers, Pavers, Rollers, Generators, and activities like concreting, mixing, casting and material movement are primary noise generating activities in the yard and will be distributed over the entire construction period.

Construction activities are expected to produce noise levels in the range of 80 - 95 dB (A). The major work will be carried out during the daytime. Considering the drop-off rate of 6 dB (A) with the doubling of receptor distance from the point source the noise produced will not exceed 55 dB (A) beyond a distance of 250 meters from the boundary of the construction yard. This suggests the noise produced during the construction phase will not have a significant impact on the existing ambient noise levels if the construction yard is located 500 m away from the sensitive receptors.

The construction equipment will have high noise levels that can affect the personnel operating the machines. Use of proper personal protective equipment like ear muffs (or) ear plugs will mitigate any adverse impact of the noise generated by such equipment. The noise levels in the working environment are compared with the standards prescribed by Occupational Safety and Health Administration (OSHA - USA) which in-turn are being enforced by Government of India through Model rules framed under the Factories Act. The acceptable limits for each shift being of 8 hour duration, the equivalent noise level exposure during the shift is 90 dB (A). Hence noise generated due to various activities in the construction camps may affect workers, if equivalent 8-hour exposure is more than the safety limit.

The noise likely to be generated during excavation, loading and transportation of material will be in the range of 90 to 105 dB (A) and this will occur only when all the equipments operate together and simultaneously. This will be a remote possibility. The workers in general are likely to be exposed to an equivalent noise level of 80-90 dB(A) in an 8 hour shift for which all statutory precautions should be taken into consideration. The personnel protective devices such as earplug / muff should be provided to the workers working in the vicinity of the high noise generating machine. Careful planning of machinery operations and scheduling of operations can reduce these levels.

5.6.1.5. Impact on Ecology

Impact on Flora

The proposed project site doesn't have endangered Flora. Very few common trees like drumstick, Neem and coconut trees are observed in some fishermen settlements. Due to the proposed construction activity the loss of trees are not envisaged.

Impact on Fauna

The proposed construction activity has significant impact on fauna. The proposed site is known for the breeding ground of Olive Ridley Turtle (Green Turtle). The construction activities will have major impact on the turtle breeding.

Moreover, the first phase of the proposed road project crosses the marine environmental sensitive place of Adyar estuary. The estuary is also name demarcated as bird sanctuary by the Tamil Nadu Forest Department. Noise generation arising during the construction activity will drive the birds away and cause an ecological imbalance to the estuary and the fish population.

5.6.1.6. Other Impacts

The construction phase covers the arrangement for housing and living requirements for the construction workers. Most of the work in construction phase is moderately labour intensive. In fact, the site will be having more workers during construction phase than operating phase. As most of the construction job will be done by contractors, workers will be provided with proper shelter facilities. The workers will be provided with safe drinking water and proper sanitation facilities. The workers will be provided with fuel in order to avoid cutting of any near by wood for fuel purpose at the construction site.

During construction phase a good number of workers will be working on the site. There is a possibility that some of them will be coming from beyond immediate neighbourhood. Unless steps are taken in advance to meet the construction stage demand, short term immigration may have some impact on the local housing, civic facilities, health and culture. To avoid this problem, contractors will be asked to provide suitable camps for their work force

5.6.2. Operation Phase Impacts

In the operation phase of the project, the impact is mainly due to the vehicular movement resulting in air and noise pollution and the functioning of the resettlement site. After commissioning of the project there are benefits associated like economic upliftment, reduction in traffic congestion etc

5.6.2.1. Impact on Topography/ Landuse

During the operation phase of the road, the impact on the topography and the change in the land use pattern is negligible. Due to these changes minor land use variations are expected. However the project road falling under CRZ and with the restriction on the development within CRZ the impact is considered to be very minimum.

Similarly the development of the resettlement colony is expected to induce ancillary development around the proposed site resulting in the localised land use changes. However this is expected to improve the local economy of the area.

5.6.2.2. Impact on Water Quality

Vehicular movements are not expected to cause any impacts on the water quality of the project area.

5.6.2.3. Impact on Air Quality

During operation phase of the project it is expected that the improved road network will ensure smooth flow of traffic by reducing congestion, delay and fuel consumption and thereby reducing the vehicular emissions. However, the new road alignment would attract more traffic over a period of time there by increasing the overall mass emissions. As a result the air quality along the narrow corridor of the roadway is likely to be lower.

5.6.2.4. Impact on Noise Level

The Sound Pressure Level (SPL) generated by noise sources decreases with increasing distance from the source due to wave divergence. An additional decrease in SPL with distance from the source is expected due to atmospheric effect or its interaction with objects in the transmission path.

Unlike the construction phase, the noise level generated during the operation phase is very minimal. During the commissioning of the project the increase in traffic load along the first phase stretch of the Santhome bypass is expected to be very minimal, due to this scenario the chances of increasing noise level will be under controlled condition and it won't be a threat to the local communities. This activity will add a positive impact during the operation phase due to the free flow of traffic.

5.6.2.5. Other Impacts

Reduction in Travel Time and Traffic Congestion

The overall proposed project ensures smooth traffic flow between Lighthouse (Marina beach), Besant Nagar Beach to the ECR - Kottivakkam. This will reduce traffic congestion on the Adyar, Kamarajar Salai, Rama Krishna Mutt Road and Greenways Road. For all the categories of vehicle rise in the travel speed will reduce the travel time and fuel consumption thereby reducing idling of engines and the associated vehicular emissions.

Impact on Ecological Resources

The project stretch of the Santhome Bypass is within the Coastal Regulation Zone (CRZ-II). This ensures restricted development along the coast and that will help in preserving the flora and fauna in the project area. In the operation phase no adverse impact on the aquatic ecology is expected.

5.6.3. Summary of Impacts

A summary of significant project impacts is presented in **Table 5.22**. Details of mitigation measure are covered in Environmental Mitigation Plan.

Table 5.22. Summary of Potential Environmental Impacts of the overall Santhome Bypass

Sl No.	Project Activities	Environmental Components										
		Topography	Water Resource	Soil	Geology	Air	Noise	Sensitive Receptors	Land use	Vegetation	Aesthetics	Infrastructure/ Community
I	**Construction Phase**											
1	Site clearance	-ve/t	-ve/t	-ve/p		-ve/t	-ve/t	-ve/t	-ve/t	-ve/p	-ve/t •	
2	Mobilisation of construction equipment	-ve/t	-ve/t	-ve/t		-ve/t	-ve/t	-ve/t				
3	Setting up of construction camps		-ve/t	-ve/t				-ve/t	-ve/t	-ve/t	-ve/t	
4	Use of construction camps		-ve/t	-ve/t		-ve/t	-ve/t	-ve/t		-ve/t		
5	Quarrying	-ve/p		-ve/p	-ve/p	-ve/t	-ve/t		-ve/p		-ve/p	
6	Transportation of materials		-ve/p			-ve/t	-ve/t	-ve/t		-ve/t		
7	Materials storage					-ve/t						
8	Construction activities		-ve/t	-ve/t		-ve/t	-ve/t	-ve/t				
9	Employment											+ve/p
II	**Operational Phase**											
1	Improved transport corridor					-ve/p	-ve/p	-ve/p	+ve/p			+ve/p
2	Vehicular traffic movement		-ve/t	-ve/t		-ve/p	-ve/p	-ve/p			+ve/p	+ve/p

Legend: t – Temporary, p – Permanent

5.7. Environmental Mitigation Plan

The Environmental Mitigation Plan (EMP) is designed to address the requirement of successfully mitigating the likely adverse impacts of the proposed project. It also identifies the post project monitoring requirements needed for the successful implementation of the suggested mitigation measures. The institutional arrangements needed for implementing the mitigation measures and conducting post project monitoring are also been identified.

5.7.1. EMP for Construction Phase Impacts

5.7.1.1. Impacts on Vegetation

Tree cutting is very minimal along the first phase stretch of the bypass, especially near the fishermen villages and mostly Coconut and Drumstick, Neem trees are the dominant species. Actual number of trees that would require felling will be less as the trees which do not fall under the carriageway can be retained.

5.7.1.2. Impacts on Air Quality

The impacts on air quality during construction are mainly due to the material movement and the actual construction activities. By material movement air quality over a large area is affected due to emissions and increase in the dust levels though, not in significant levels.

The emissions from the construction machinery are the major source of ambient air pollution during the actual construction. The fugitive dust emissions will be mainly from quarrying, crushing, blasting, hot mix plants, machinery equipment and access roads. Continuous use of construction machinery and generator sets may cause rise in ambient air pollution levels. The degree of impact may be higher during winter season and in the early morning hours and night time.

Mitigation measures

- In order to curb the increased fugitive dust emissions in the area due to vehicular movement and raw material transport, provisions should be made for sprinkling of water on the entire haul roads in the area. Sprinkling of water should be carried out at least twice a day on a regular basis during the entire construction period.
- Weekly inspection of haul roads and the construction site should be carried out to ensure removal of construction debris to the land fill sites.
- Dust covers should be used over the beds of trucks that will be used for the transportation of materials prone to fugitive dust emissions. Additionally any of these materials which may collect on the horizontal surfaces of these trucks during loading should be removed before transportation.
- Construction requiring road closings in heavy traffic areas should be performed during off-peak hours.
- Idling of delivery trucks or other equipments should not be permitted during periods when they are being unloaded or are not in active use.

5.7.1.5. Impact on Flora and Fauna

The construction activity doesn't have impact on the flora of the project site but it has significant impact on the existing fauna. As discussed earlier in this chapter, the site is known for Olive Ridley Turtles breeding ground. In order to preserve the endangered turtle the construction activities shall be hold for the month of December to March. The construction of the Bridge across the Adyar Estuary also has significant impact on the birds. It is suggested that proper preplanning is required for any construction activity across the estuary. Noise control measures shall be strictly followed to avoid inconvenience to the birds and the construction activity shall be hold for during the monsoon seasons, due to the flooding in the river and fish breeding season.

5.7.2. EMP for Operation Phase Impacts

5.7.2.1. Impacts on Air Quality

After the project implementation the ambient air quality levels in future years will be better due to increased level of service for the project roads. However, as the traffic increases, the ambient air quality levels will decrease marginally. The effect will be more pronounced during winter season when night time/early morning ground level inversion is observed.

Mitigation Measures

- The most effective control methods of air pollution due to vehicular emissions is to use fuel efficient engines, introduction of catalytic converters for petrol vehicles and use of smoke traps for diesel vehicles.
- It should be made compulsory for all vehicles to adhere to the engine maintenance schedules and CPCB standards to reduce air pollution due to vehicular emissions.
- Development of landscape along the road can bring about 30% reduction of concentration of pollutants at the ground level. It is therefore recommended that the area available in the median shall be used for growing small plants and grasses to minimise the air pollution impacts. Such development will also improve the general aesthetics in the region.

5.7.2.2. Impacts on Noise Levels

An increase in the ambient noise levels of the region along the proposed project is expected due to continuous traffic movement at higher speeds. Ambient night time noise levels would experience high levels due to movement of heavy traffic. The sensitive receptors along the proposed alignment can be protected by landscaping within their compound. Further noise barriers are proposed at sensitive receptors along the project road on elvated stretch itself. Since the road is completely elevated there is no scope for avenue plantation and in the present project, noise pollution control can be imposed through enforcement of rules and regulations such as regulation is use of air horns, compliance for regular maintance of vehicles so as to reduce the noise emissions etc.

Mitigation Measures

- Minimisation of use of horns near sensitive locations and air horn should be restricted along the Santhome bypass. This can be achieved through the use of sign boards in

proper positions.

- Noise barrier of 1.85 m height on either side of the sensitive receptors.

Summary of the detailed environmental impacts and the mitigations measures are presented in **Table 5.23.**

Table 5.23. Summary of Environmental Impacts and Mitigation Measures – Light House to Besant Nagar Beach (0+000 km - 4+700 km) of Santhome bypass

Environmental Component	Environmental Impact	Mitigation Measures
CONSTRUCTION PHASE		
1. Soil		
Soil Erosion	Although no burrow pits are planned along the project road, excavations of borrow pits at approved locations for the present project will increase soil erosion	In borrow pits, the depth of the pit should be regulated so that the sides of the excavation will have a slope not steeper than 1 vertical to 4 horizontal from the edge of the final section of bank The device for checking soil erosion include the formulation of sediment basins, slope drains etc. Such works and maintenance thereof will be deemed as incidental to the earthwork
Loss of topsoil	Loss of productive soil during the leasing of land to contractors for storing, stock yards and workers camp Borrowing pits during project construction	The top soil will be stripped and stored The stored topsoil will be spread back to maintain the physico-chemical and biological activity of the soil The borrow pit areas could be developed into ponds for fisheries Land taken for borrow areas should be infertile
Compaction of soil	The excavations in borrow areas may lead to marginal loosening of soil The compaction of soil may not be affected largely	It should be ensured that the stability of excavation of fills is maintained Construction vehicles, machinery and equipment shall move, or be stationed in the designated areas If operating from temporarily hired land, it will be ensured that the topsoil for agriculture remains preserved & not destroyed by storage, material handling or any other construction related activities Earth, if required, should be dumped in areas selected & approved by the authorized representatives of the project implementing agency.
Borrowing of earth	Earth is needed for raising the level of the widening portion of the road which will be sourced from approved borrow areas.	If new borrow areas are selected, there should be no loss of productive soil, and environmental considerations are met with If vehicles are passing through some villages, the excavation and carrying of earth will be done during day time only The borrow areas should not be dug continuously, and the size and shape of borrow pits to be decided by the authorized representatives of the project implementing agency Borrow pits should be redeveloped by dumping of spoils; by creating a pond for fisheries, etc. or by leveling an elevated, raised earth mounds

Environmental Component	Environmental Impact	Mitigation Measures
Contamination of soil from fuel and lubricants	The impact will be negligible since the chemical nature of the soil will not change much. Negligible impact on the growth of vegetation	Vehicles and machines are maintained and refilled in such a fashion that old diesel spillage does not contaminate the soil Fuel storage and refilling sites should be kept away from cross drainage structures and important water bodies All spoils shall be disposed off as desired and the site shall be fully cleaned before handing over
Contamination of soil from construction wastes	The impact will be marginal on the soil quality The growth of vegetation will be partially disturbed	The construction wastes should be dumped in selected pits, developed on infertile land Follow the norms of TNPCB Borrow pits to be filled by such wastes
2 Water		
Water bodies	Water quality may be deteriorated due to surface runoff from the construction site, dumping of construction debris etc. Community water sources may be affected	Plantation along these water bodies may be undertaken. No labour camps, stone crushers, hot mix plants and other heavy machinery should be located near water bodies. Debris dumping to be strictly avoided Any source of water for the community such as ponds, wells, tube-wells etc. lost incidentally shall be replaced immediately All desired measures will be taken to prevent temporary or permanent flooding
Other water sources	Dumping of construction waste into the coastal waters due to its proximity to the coast will have an impact on the near shore environment.	Sites for the Disposal of construction and related wastes should be identified and approved by the authorized representatives of the project implementing agency before the start of construction work.
Drainage and run-off water	The flow of run off water will not be affected largely, except at certain stretches where the drainage problem already exists	At cross drainage channels, etc. the earth, stone or any other construction material should be properly disposed of so as not to block the flow of water
Contamination of water from fuel and lubricants	The fuel and lubricants may affect water bodies especially the coastal water due to its proximity to the project site.	To avoid contamination from fuel and lubricants, the vehicles and equipment shall be properly maintained and repaired.
Sanitation and waste disposal in construction camps	Absence of proper sanitation may lead to many human diseases which are mostly water-borne	The construction labourers` camp shall be located away from the habitation and from major water bodies The sewage system for such camps shall be properly designed and built so that no water pollution takes place to any water-body or water course
Use of water for	The use of water from sources, already in use.	Arrangement for supply and storage of water will be made by the contractor in such a

Environmental Component	Environmental Impact	Mitigation Measures
construction	by local community may cause scarcity of water for community	way so that the water availability and supply to nearby communities remain unaffected. If a new tube-well is to be bored, proper sanction and approval by Underground Water Department is needed The wastage of water during the construction should be minimised
3 Air		
Emission from construction vehicles and machinery	Effect on human health Dust settled on leaves may reduce growth rate of the plants	All vehicles, equipment and machinery used for construction shall be regularly maintained to ensure that the pollution emission levels are as per norms of TNPCB Monitoring of suspended particulate matter to be conducted at least once a month at the sites where crushers are used The human settlements should be at least 500 m down windward direction of Hot (asphalt) mix plant
Dust and its treatment	The impact of dust at construction sites is rather adverse, but localized in nature No serious health problem is likely to be caused	All precautions to reduce the level of dust emissions from the hot mix plants shall be taken The hot-mix plants are sited at least 500 m from the nearest habitation and from major water bodies. They should be fitted with dust extraction units Water should be sprayed on the earth mixing sites, asphalt mixing site and service roads. During sub grade construction, water spraying is needed to compact the soil properly. After the compaction, water should be sprayed regularly to prevent dust Vehicles delivering material should be covered
4 Noise Levels		
Noise from construction vehicles, asphalt plants and equipment	The activities using heavy machinery and equipment are localized and intermittent No serious impact on human health like loss of hearing ability though some sleep disorders may result	The plants and equipment used in construction shall strictly conform to CPCB noise standards Vehicles and equipment used should be fitted with silencers Noise standards will be strictly enforced to save construction workers from damage At construction sites within 150 m of human settlements, noisy construction should be stopped between 10:00 pm and 8:00 am Noise to be monitored at construction sites
5. Fauna		
Olive Ridley Turtles, birds and fish species	Construction activites will affect the breeding phases of the endangered Green Turtle, the birds in the Bird Sanctuary and fish species in the Adyar River.	Construction activities shall be hold for the month of December to March. The construction of the Bridge across the Adyar Estuary also has significant impact on the birds. It is suggested that proper preplanning is required for any construction activity across the estuary. Noise control measures shall be strictly followed to avoid

Environmental Component	Environmental Impact	Mitigation Measures
		inconvenience to the birds and the construction activity shall be hold for during the monsoon seasons, due to the flooding in the river and fish breeding season
6 Safety and Accidental Risk		
Accident risk from construction activities	The type of accidental risks may be due to ill-maintains machines and vehicles, due to poor light conditions at the work place, or due to carelessness and poor management of the work involved	To ensure safe construction in the temporary accesses during construction, lighting devices and safety signal devices shall be installed. Traffic rules and regulations to be strictly followed Safety of workers undertaking various operations during construction should be ensured by providing them helmets, masks, safety goggles etc The electrical equipment should be checked regularly to avoid risks to workers At every work place, a readily available first aid unit including an adequate supply of dressing materials, a mode of transport (ambulance), nursing staff and an attending doctor to be provided Lighting device and signals at workplace to be installed
Health issues	The prevalence of unhygienic conditions at work place of construction workers The non-availability of good drinking water	At every workplace, good and sufficient water supply shall be maintained to avoid waterborne diseases and securing the health of workers. Adequate drainage, sanitation and waste disposal to be provided at workplaces Medical care to be provided to workers if falling ill
OPERATION PHASE		
Contamination from spills due to traffic and accidents	The chances of accidents are likely to be reduced with improved width and quality of the road. The contamination of soil and water due to spills will be minor	Cleaning of the spills at the accidental site and the left over spill may be scrapped to a small nearby pit within RoW
Air pollution	The degree of air pollution is likely to be on a lower scale with improvement in road surface and with better maintenance	SPM, RSPM, CO, SO_2, NO_x to be monitored monitoring plan The vehicles using elevated corridor should strictly comply with air emission norms. Public awareness programmes to be launched
Accidents involving hazardous materials	The chances of such accidents will be minimum, yet not unavoidable	The rules as defined in Environmental (Protection) Act, 1986 should be complied For delivery of hazardous substances, three certificates namely permit license, driving license and guarding license issued by transportation department are required Vehicles delivering hazardous substances will be printed with unified signs Public security transportation and the fire fighting departments will designate a special route for these vehicles

Environmental Component	Environmental Impact	Mitigation Measures
		The project hazardous substances will be administrated by highway management department registration system In case of spillage, the report to relevant department is made and instructions followed
Safety measures	The chances of accidents would be reduced in view of improved road conditions	Traffic management plan to be developed, especially in congested locations Traffic control measures including speed limits to be enforced strictly Further growth of encroachment and squatting on RoW to be discouraged Widening of the existing carriageway will reduce accidents Strengthening the pavement Improving upon the curves in road geometrics Proposing service lanes for local approaches Providing proper median. Improving upon road crossings. Putting warning signals and signboards

5.7.3. Environmental Clearances for Contractor

Apart from the clearance for overall project works, the following statutory requirements have to be complied by the contractor before and during the execution of the proposed work as presented in **Table 5.24**

Table 5.24. Environmental clearance required during construction

Sl.no	Construction activity for which clearance is required	Statutory authority	Statute under which Clearance is Required
1	Hot mix plants, Crushers and Batching plants	Tamilnadu State Pollution Control Board	Air (P & CP) Act, 1981
2	Discharges form construction activities	Tamilnadu State Pollution Control Board	Water (P&CP) Act, 1974
3	Storage, handling and transport of hazardous materials	Tamilnadu State Pollution Control Board	Hazardous Wastes (Management and Handling) Rules. 1989 Manufacturing, Storage and Import of Hazardous Chemicals Rules, 1989
4	Sand mining, quarries and borrow areas	Department of Geology and mining, Govt of Tamilnadu	Tamil Nadu Minor Mineral Concession Rules, 1959 (corrected up to 31.3.2001)
5	Disposal of bituminous wastes	Tamilnadu State Pollution Control Board	Hazardous Wastes (Management and Handling) Rules. 1989
6	Felling of trees (If any)#	Department of Environment and Forest, Govt of Tamilnadu	Forest (Conservation) Act, 1980

5.7.4. Cost Estimation of EMP

The cost of implementing above mitigation measures is established in the **Table 5.25**. The construction cost for the first phase of the project stretch is estimated to be Rs. 37.14 lakhs and the operational cost is estimated to be Rs. 84000.

Table 5.25. Cost Estimation of Implementing EMP

Sl No	Activities	Assumption	Cost in Rupees
Construction phase			
1	Provision of Sewage and sanitation facilities for the	Lump Sum	1,000,000.00

As such no felling of trees is envisaged for the project. During project implementation stage if any tree felling is required the contractor has to obtain required permission from Department of Environment andForest, Govt. of Tamil Nadu.

Sl No	Activities	Assumption	Cost in Rupees
	construction camps, including maintenance for 1 year		
2	Provision of Water Supply Facilities for the construction camps	Lump Sum	560,000.00
3	Environmental Monitoring		
3.1.	Air Pollution Monitoring	Rs. 3000/- per location * 3 locations (based on settlement)* 1 days/ month * 4 seasons for fugitive sources.	36,000.00
3.2.	Noise Monitoring	Rs.1000/- for 24 hours * 1 day/month *3 location * 4 seasons	12,000.00
3.3.	Water Pollution Monitoring	Rs. 3000/- per sample* 3 locations/month * 4 seasons	36,000.00
3.4.	Mobilisation Charges	Rs. 45000 /- per season * 4 seasons	1,80,000.00
4	Dust Suppression at site	Rs.500/- per trip *10 trips a day/ 1 year	1,825,000.00
5	Severances and Others (Including Training)	Lump Sum	65,000.00
Total Cost during Construction Phase			**3,714,000.00**
Operation Phase			
1	Environmental Monitoring		
1.1	Air Pollution monitoring	Rs. 3000/- per location * 3 locations (based on settlement)* 1 days/ month * 4 seasons for fugitive sources.	36,000.00
1.2	Noise Monitoring	Rs.1000/- for 24 hours * 1 day/month *3 location * 4 seasons	12,000.00
1.3	Water Pollution Monitoring	Rs. 3000/- per sample* 3 locations/month * 4 seasons	36,000.00
Total Cost during Operation Phase			**84,000.00**

Chapter 6: Social assessment & Rehabilitation Action Plan

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6. Social Impact Assessment and RAP Budget

6.1 Introduction

Government of Tamil Nadu (GoTN) has formed a Beach committee to improve the existing beach along the East coast by enhancing the aesthetics and other facilities and also to decongest the existing traffic that creates chaos and time spillage for the vehicles plying along the roads that lead to the east coast from the world fame marina beach and other tourist spots around it. As part of the enhancement measures, Beach committee now intends to construct a link road from Lighthouse on Kamarajar Salai to Besant Nagar (Via) Santhome Bypass, Sreenivasapuram, and Ururkuppam including construction of a high level bridge across Adyar Estuary to join ECR.

This report illustrates the proposed improvements, R&R issues and the Social Cost involved in the Phase I .This phase starts from Kamaraj Salai near Light House to Oroor kuppam at Besant Nagar- Km 0/0 to Km 4/700

6.1.1 Objectives of Social Assessment Exercise

A Rapid Social Assessment was conducted with the main objective of identifying the locations of social sensitivity to assess the social feasibility of the project. The objectives also include the following:

Providing inputs to the project design team about the social concerns

- Understanding the type of social impacts
- Quantifying the extent of social impact
- Estimating the land acquisition cost and
- Volume of R&R issues

Considering the above and the Terms of Reference (ToR) of the study, the following methodology has been adopted to carry out the social assessment.

6.1.2 Approach and Methodology

Task 1: Collection and Analysis of Secondary Data

Secondary data pertaining to various socio-economic parameters was collected from government departments like Census of India, Department of Industries, Department of Economics and Statistics, Directorate of Settlements and Land Records etc. This helped to

understand the socio-economic profile of the project area with respect to indicators like population growth rate, literacy rate, work force participation rate (WFPR) etc. in comparison with the project districts and Tamil Nadu state.

Task 2: Initial Field Reconnaissance

Initial field reconnaissance was conducted in the beginning of the study to gather a preliminary understanding of the project location with respect to following features:

- Social and physical features like settlement pattern, density, typology of buildings, especially presence of religious buildings, Institutional and commercial building, land use etc.
- Topography of the land,

Task 3: Detailed Field reconnaissance

Further to initial reconnaissance, a detailed reconnaissance was undertaken to record and document the above socio-environmental features in detail.

Sub-task 3.1: Preparation of strip plans

The land use on either side of the proposed alignment was mapped at every 20metres for indicating the distance of private property line from the proposed centerline, the location of buildings within 20m ROW, type of building, number of floors, use of buildings etc.

Sub-task 3.2: Counting of structures within 20m. ROW

This task was undertaken to quantify the impact on structures that would be affected by the proposed construction of the road. The number of residences, commercial buildings, public utility buildings and religious structures were counted along the stretch separately and an inventory of the count was prepared for every 20m length of the road.

Sub-task 3.3: Detailed study of socially sensitive features

Along with sub-task 3.2, detailed study of socially sensitive features like mosques, churches and temples were studied with respect to their location, distance from the edge of the carriageway, type of building, ownership, historical importance etc. This task helped to document these features and identify the critical stretches from a social perspective.

Sub-task 3.4: Focused Group Discussions (FGD)

Focus Group Discussions were conducted at project location to understand the people's perception about the project as well as their issues and concerns. The willingness of the people to part with their land for the project and the compensation anticipated.

Sub-task 3.5: Collection of Land Value

The market values of land at various locations were collected from the people, in addition to the guideline values fixed by the government of Tamil Nadu to facilitate calculation of land acquisition cost.

Task 4: Social Impact Assessment

Based on the data collected from detailed field reconnaissance the social impact assessment of the project was carried out with the objective of identifying socially sensitive areas along the project stretch. The critical issues pertaining to social sensitivities were analyzed and potential hotspots where social impact could be more were identified. Based on this, inputs were given to the project design team so that social concerns are incorporated in the design of the junction from the very beginning and any adverse social impacts are minimized to the extent possible.

6.1.3 Report Structure

Section – 6.1 of the report gives an introduction about the project, the objectives of Resettlement Action Plan (RAP), methodology of the study and the organisation of this chapter.

Section – 6.2 gives the Socio economic profile of the project area in terms of the administrative units along the project road, demographic and socio-economic profile, rapid social assessment of the project road, based on which critical stretches are identified. The summary of the proposed highway design is also given in this chapter.

Section – 6.3 discusses the legal framework applicable for the project and includes the review of guidelines which provides basic parameters for preparation of compensation and resettlement benefits.

Section – 6.4 identifies major loss categories and quantifies them based on the data from census surveys. The total area of land to be acquired, the number of affected structures, number and type of common properties affected etc. will be provided here.

Section – 6.5 discusses the different stages of public consultations, different methods adopted etc.

Section – 6.6 discusses the institutional framework for implementation of the project, implementation schedule, monitoring and evaluation framework and mechanisms envisaged for grievance redress.

Section – 6.7 gives the RAP budget.

6.2 SOCIO ECONOMIC PROFILE

6.2.1 Profile of the Project Area

Following analytical section presents the profile of the project area in terms of its geography, administrative units and socio-economic features. It uses various socio-economic parameters like literacy, work force participation etc. and draws a picture of development status of the project area in comparison with state and project district.

6.2.2 Geographical Profile

Chennai District: Chennai is situated on the north-east end of Tamil Nadu on the coast of Bay of Bengal. It lies between 12* 9' and 13* 9' of the northern latitude and 80* 12' and 80* 19' of the southern longitude on a `sandy shelving breaker swept beach'. It stretches nearly 25.60 kms. Along the Bay coast from Thiruvanmiyur in the south to Thiruvottriyur in the north and runs inland in a rugged semi-circular fashion. It is bounded on the east by the Bay of Bengal and on the remaining three sides by Kancheepuram and Thiruvallur Districts.

Chennai is one of the leading cities in India today from the point of view of trade and commerce, with the fourth largest port in the country and the first to have developed a full-fledged container terminal to international standards. The port is providing trade links with Japan, Singapore, Malaysia, Burma, Bangladesh, Ceylon and other far eastern countries. Chennai is also one of the most important IT Hubs of the sub-continent.

6.2.3 Administrative Profile

Administratively, this phase of the project road falls in Chennai district in the state of Tamil Nadu. A stretch of 4.7 Kms. starts at Km 5/600 of Kamarajar Salai and ends at 5th avenue road of Besant Nagar. Administrative profile of the project area is given in **Table 6.1**.

Table 6.1: Administrative Profile of the Project Area

District	Taluk	Revenue Villages	Zone/Wards
Chennai	Mylapore-Triplicane	Mylapore Urur	Chennai corporation zone – X Wards - 145,146, 150, 152,

6.2.4 Demographic and Socio-economic Profile

(i) Chennai District.

Chennai is situated on the north-east end of Tamil Nadu on the coast of Bay of Bengal. It lies between 12* 9' and 13* 9' of the northern latitude and 80* 12' and 80* 19' of the southern longitude on a `sandy shelving breaker swept beach'. It stretches nearly 25.60 kms. along the Bay coast from Thiruvanmiyur in the south to Thiruvottiyur in the north and runs inland

in a rugged semi-circular fashion. It is bounded on the east by the Bay of Bengal and on the remaining three sides by Kancheepuram and Thiruvallur Districts.

A large number of institutions which are known in India and abroad are found located in the city, of which mention may be made of the Theosophical Society, the Kalakshetra and colleges of Arts and Crafts. Chennai is one of the leading cities in India today from the point of view of trade and commerce, with the fourth largest port in the country and the first to have developed a full-fledged container terminal to international standards.

The Chennai district is under the Chennai corporation, the second oldest corporation in the country next to Kolkatta corporation. For administrative reason it has been divided into 10 zones which is further divided into 155 wards. The Project area comes under Chennai corporation zone X and the wards are 145, 146, 150, and 152. In revenue administration, the project area comes under Mylapore-Triplicane Taluk.

Table 6.2: Demographic and Socio-economic Profile of the Project Area

Demographic Indicators	**Tamil Nadu**	**Chennai District**	**Project Area**
Population 2001	62,405,679	4,343,645	100984
Urbanization Rate (%)	44.04	100.00	100.00
Area (Sq. km.)	1,30,267	178.20	6.05
Density	479	24,963	16,691
No. of households	14,665,983	962213	23630
Average Household Size	4.26	4.51	4.27
Sex Ratio - Females per 1000 males	987	957	994.11
Sex Ratio - Females per 1000 males (Below 6 years)	942	972	1015.09
SC Population – % of total population)	19.00	13.76	9.82
ST Population - % total population	1.04	0.15	0.06
Literacy Rate (percent)	64.94	85.33	77.37
Female Literacy Rate (percent)	28.39	80.44	47.08
Work Participation Rate (percent)	44.67	34.27	35.78
Female Work Participation Rate (WFPR) (percent)	31.54	13.52	24.23

Source: Census of India, 2001

6.2.5 Project Area

Population and Urbanization Rate. Population of the project area is 1.009 lakhs, which is hardly 0.162 percent of the total state population. Urbanization rate in the project area is

100% since the project alignment falls in the Chennai city. Population density of project area is less (16,691)when compared with chennai district(24,963) the state. As per census details 9.82 percent of the project area population belongs to Schedule Caste (SC) while a small percentage (0.06%) belongs to Schedule Tribe (ST). Both the values are lower than that for the state.

Sex Ratio and Literacy. Adult sex ratio of the project area at 994 is comparable with state figure at 987, while child sex ratio shows a comparatively higher value (1015) than state. The Project area shows higher literacy levels for general at 77.37 % and female literacy level(47%) is less as the project area is along the coast and habituated by the fishermen community as given in **Figure 6.1**.

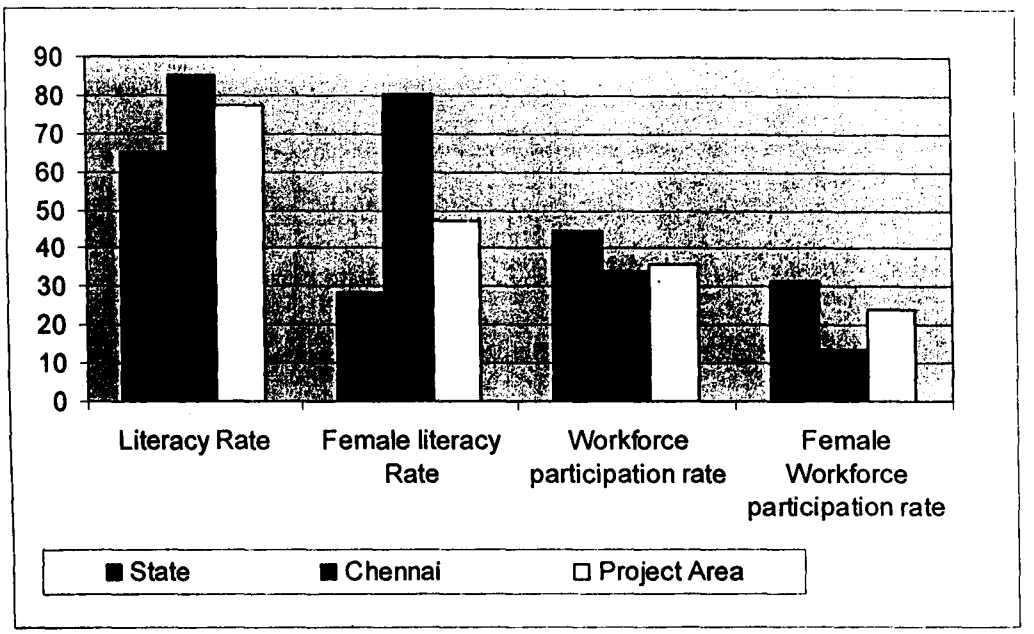

Figure 6.1 Literacy level and work force participation

Workforce Participation. Higher literacy levels of project area are not commensurate with employment opportunities. Total and female workforce participation rate indicates lower values at 36 and 23 percent respectively than that for the state at 35 and 28 percent respectively. The project district show lower values of total and female workforce participation rates than that for the state. The project area shows 100% urbanization rate as it is inside the Chennai district. The details are given in the following **Table 6.3**

Table 6.3: Worker Participation in the State, Project Districts and Project Area

Category	Tamilnadu State	Chennai District	Project Area
Total workers	2,78,78,282	14,88,364	36135
	44.67%	34.27%	35.78%
Total main workers	2,37,57,783	5,523,028	34,190
	38.07%	31.78%	94.62%
Marginal workers	41,20,499	4,30,428	1,945
	6.60%	2.47%	5.38%
Non-workers	3,45,27,397	11,421,124	64,849
	55.33%	65.73%	64.22%

Source: Census, 2001

The project area has a main workforce participation rate of 94 percent which is very higher compared to state average of 38 percent and district average of 31.78. The project area has a large proportion of (64.22 percent) of population as non workers, a value higher than that for the state at 55.33 percent.

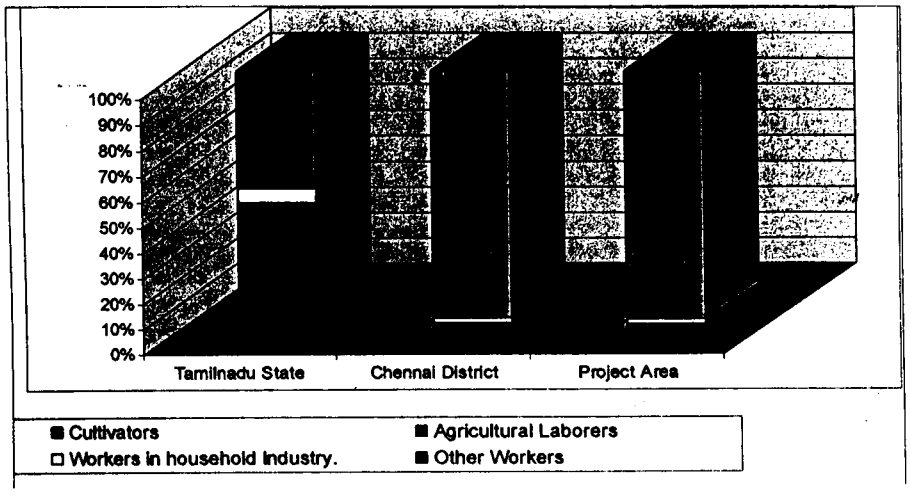

Figure 6.2 Composition of workforce among the state, project districts and project area

Table **6.4 & Figure 2.2** shows composition of work force in state, districts and project stretch. Classification of workers in the four categories – cultivators, agricultural laborers, workers in household industry and other workers. Since the project area is totally a urban area only one percent of workforce in project area are cultivators and agricultural laburers are still less with 0.3%. But ratio of agricultural laboureres are comparitively high in Kancheepuram district(17.10) than chennai district(0.42%). The ratio of other workers is also less in

kancheepuram district when compared with chennai district. A large proportion of the project area workforce (97 percent) are other workers, which is reflection of high urbanisation rate.

Table 6.4: Workforce Composition in the State and Project Districts

Category	Tamilnadu State	Chennai District	Project Area
Cultivators	5,116,039 18.35%	17,175 1.15%	495 1.01%
Agricultural Laborers	8,637,630 30.98%	7,082 0.48%	203 0.30%
Workers in household Industry.	1,499,761 5.38%	30,992 2.08%	768 1.73%
Other Workers	12,624,852 45.29%	1,433,115 96.29%	34,669 96.94%

Source: Census, 2001

Health. The project district registers less birth rate as that of the state and it is good indication that the project district shows much lower value of IMR than the state value.

Table 6.5: Health Status in the State and Project District

Health Indicators	Tamil Nadu State	Chennai District
	(%)	*(%)*
Birth Rate	19.2	16.2
Death Rate	7.9	3.0
Infant Mortality Rate (IMR)	51	15

Source: District Statistical Handbooks, 2004-05.

Human Development Index (HDI). The HDI measures the average achievements in three basic dimensions of human development – i) A long and healthy life, as measured by life expectancy at birth; ii) Knowledge, as measured by the adult literacy rate (with two-thirds weight) and the combined primary, secondary, and tertiary gross enrolment ratio (with one-third weight); iii) A decent standard of living, as measured by gross domestic product (GDP) per capita at purchasing power parity (PPP) in USD. HDI is used mainly to distinguish whether the country/state/district is a developed, developing, or under developed. HDI value for India (Year 2003, UNDP report 2005) is 0.602, which ranks country at 127th position in the list of 177th countries all over the world. Tamilnadu state shows a higher value of HDI at 0.657 than that of country, while Chennai district shows HDI values at 0.757.

6.2.6 Summary of Project Area Profile

The Phase-I of the project highway comprises of 4.7 kms along the coast of Bay of Bengal. The project area falls in urban area and the project road starts near Light house on Kamarajar

Salai passing along the coast and ends at 5th avenue road of Besant Nagar. Socio-economic indicators for the project area show a satisfactory picture, with higher literacy rate and comparable adult sex ratio as that of state.

The proposed project once completed will provide the traffic free connectivity between the Santhome and Besant Nagar without entering the existing congested road networks thereby giving increased access to urban facilities and reducing the travel time and a marine drive experience. The development is likely to have both direct and indirect benefits due to improved connectivity for the Chennai city to the southern part of the state and has no major Impact on the population of the project area.

6.2.7 Land use along Project Road

To know the landuse along project road, a detailed walk through was conducted. Since the proposed elevated alignment passes along the shore line the land use along the project corridor is primarily residential. The fisherman huts and Tamil Nadu slum clearance board colonies are found along the project road. Very few kutcha commercial structures(house hold shops) and few community structures are found in that area.. The Chainage wise broad landuse is given in **Table 6.6**

(i) **Description of alignment**.

The project stretch commences from Kamarjar salai near Light House and crosses fisherman settlements like Nochikuppam, Dumming kuppam, Foreshore estate, Srinivasapuram, and Oroor kuppam in Besant nagar.

The initial section of road is from Kamarajar Salai near Light house junction (Km. 0/000 to 2/400) to Foreshore estate junction runs through the existing alignment. At the start (Km 0/0) of the alignment, Office of the Directorate General of Police and Forensic Department are located on the RHS of the Kamarajar Salai. After that Tamil Nadu slum clearance Board Multi storied(G+2) tenements are located on the RHS at Nochikuppam and Dumming kuppam.and shore activities are there on the LHS. In the section Km 0/500 to 0/800 fishermen and women sell their daily catchments on the foot path on the LHS of the road. And apart from the TNSCB tenements there are numerous encroachments on the RHS abutting these structures which are kutcha in nature. There are very few kutcha house hold shops in between these settlements. Other than this, there are no commercial activities. Open vacant lands and corporation play ground are also available in between these settlements on RHS.

The stretch between Foreshore estate (Km 2/400 to 3/200) and the Adyar river end is Srinivasapuram which is also residential. There is a fisherman community hall, a temple and a child welfare centre at the RHS of this stretch.

The stretch from the other side of the Adyar river to Besant Nagar (Km 3/600 to 4/650) runs on the open land on the shore at rear side of the Theosophical Society. After that, a fishermen settlement called Oroor Kuppam is located on the RHS of the proposed alignment.

Table 6.6: Chainage wise Settlements & Landuse along Project Road:

From	To	Terrain	Name of Village/Town	Landuse
Phase-I				
0/000	1/500	Plain	Nochi kuppam	Residential
1/500	1/800	Plain	Dumming kuppam	Residential
1/800	2/300	Plain	Rajiv Gandhi nagar, Mullaimanagar & Nambikkai nagar	Residential
2/300	3/100	Plain	Srinivasapuram	Residential
3/100	3/600	Plain	Adyar river	Water body
3/600	4/300	Plain	Uroor kuppam	Open land
4/300	4/600	Plain	Uroor kuppam	Residential

6.2.8 Analysis of landuse along the project road highlights following key issues:

(i) Impact on densely populated settlements of Nochi kuppam, Dumming kuppam, Bhavani kuppam, Srinivasapuram, Uroor Kuppam,

(ii) Major bridge across Adyar River

(iii) Socially and historically important/sensitive features (temple, theosophical society etc.) along the road,

6.2.9 Socially Sensitive Stretches And Critical Issues for Road Design

Based on the detailed study of socially sensitive features, certain critical sections have been identified, which are considered at various stages of preparing the highway design. A summary of the same is given in **Table 6.7.**

Table 6.7: Preliminary Critical Stretches Identified

Area Name	Type of criticality	Design proposals from WSAPL (LHS and RHS are given with reference from the junction)
Kamarajar salai	Presence of Light House, Government buildings, TNSCB tenements,	Proposed centre line is taken on the existing road
Santhome	Presence of existing road	Exit ramp is proposed

Area Name	Type of criticality	Design proposals from WSAPL (LHS and RHS are given with reference from the junction)
	junction and bus terminus	
Adyar river crossing	Absence of bridge connectivity	A new signature bridge is proposed
Besant Nagar	Presence of famous temples and church	Phase-I of the proposed alignment terminates before the shrines

***Source**: Social Assessment undertaken by WSAPL*

6.2.10 Proposed Project Design

Considering the social sensitive features and to avoid serious R& R issues, the proposed C/L is taken according to the availability of the land and presence of multi storied structures.

6.3 R&R POLICIES AND ENTITLEMENT FRAMEWORK

6.3.1 Introduction

This Resettlement Action Plan (RAP) document describes the principles and approach to be followed in mitigating negative social and economic impacts of the project. The guidelines prepared for addressing the issues is limited to study for design of proposed elevated alignment. The RAP has been developed based on the prevailing guidelines. This Resettlement Action Plan (RAP) document describes the principles and approach to be followed in mitigating negative social and economic impacts of the project. The guidelines prepared for addressing the issues is limited to the construction of elevated santhome bypass. Resettlement policy for this project has been prepared in accordance with the Policies for Involuntary Resettlement and the GoI/GoTN legislation pertaining to land acquisition and resettlement. This chapter details the legal provisions involved in the implementation of the R&R provisions in the project. The highlights, principles and provisions of the R&R policy are also detailed.

6.3.2 Legal Frame work for Land Acquisition

The Land Acquisition Act of 1894, amended by GoTN in 1996, guides all land acquisition in the state. As per the LA act, the District Collector will function as the Land Acquisition Officer on behalf of the Government. As has been the experience with similar development projects within the state and elsewhere, the LA process is time consuming and contributes to delays in the projects. A major cause of the delays in LA has been regarding the amount of compensation for the land and structures lost leading to legal proceedings. To overcome these difficulties during the implementation of TNRSP, the HD, GoTN vide G.O. Ms. No. 174 dated 25.09.2001 has empowered the District Collectors to acquire land through private negotiations with the PAPs. Only in cases where the mutual agreement cannot be reached about the purchase price, the provisions of the LA Act, 1894 will be invoked. The relevant provisions of the LA Act (applicable only for cases where the land is acquired as per the LA act) are summarized below.

- **Section 4(1)** provides for notification to landowners about the interest of the Government to acquire the notified land;
- **Section 5(a)** permits landowners to express their objections against such land acquisition;
- **Section 11** empowers the Collector to award all compensations;

- **Section 18** allows the land owner who has not accepted the award by the collector to approach the court (sub-court) to seek enhanced compensation;
- **Sections 23** provides matters apart from the market value, to be considered for the determination of compensation;
- **Section 24** provides for matters which are to be neglected in determining compensation;
- In addition to the market value, a solatium of 30% on market value is allowed to be paid under **section 23 (2);**
- Under **section 25** of LA Act the compensation amount fixed by the court should not be lesser than the compensation awarded by the District Collector under **section 11;**
- **Section 28** empowers the court to order the District Collector to pay interest at 9% on the amount awarded by the court in excess of the compensation granted by the Collector;
- **Section 30** allows the District Collector to refer the case to the court in case of any disputes as to apportionment of the compensation, ownership etc;
- **Section 49** permits acquisition of part of house or building in the desire of the land/building owner; and,
- **Section 51** of Land Acquisition Act exempts the lands or the buildings acquired under this act from stamp duty and registration fees.

6.3.3 TamilNadu Encroachment Act,1905

The Tamil Nadu Encroachment Act provides for both an assessment and a penalty to be levied against illegal occupiers of publicly owned land, as well as the forcible eviction of such occupiers and forfeiture of their property, if any, subject only to service of a notice. This Act, framed in 1905 has not recognized the provision of any compensation for shifting squatters or encroachers. However, the R&R policy for the project provides for both resettlement assistance and compensation for the benefit of squatters and encroachers. As the present R&R provision envisages the betterment of the existing provisions, the PIU does not envisage any difficulties in implementing the R&R policy provisions for squatters and encroachers. To ensure that the provisions of the R&R policy shall be followed as against the provisions of TN Encroachments Act, guidelines for implementing R&R provisions will be issued to District Collectors and revenue authorities.

6.3.4 TamilNadu Highways Act, 2001

In relation to land and other property under the control of the highway authority, the Tamil Nadu Highways Act, 2000 has superseded the Tamil Nadu Encroachments Act 1905. The TN Highways Act differs from the TN Encroachments Act in:

- The Highways Act recognizes the right of the illegal occupiers to their property unlike the Encroachment Act, and,
- The Highways Act empowers the Government to exempt any land or other property under the control of highways authority from the exemption of the Act.

The following provisions of the Tamil Nadu Highways Act empower the highway authority to take up measures to prevent any further encroachments onto the RoW:

- **Section 26** of the Highway Act of Tamil Nadu, 2001 provides for the prevention of unauthorized occupation of, and encroachment onto the highway and removal of encroachments.
- **Section 28 (1)** of the Act empowers the highways authority to conduct checks and periodical inspection of highway boundaries with a view to ensure the prevention of unauthorized encroachments and the removal of such encroachments.
- **Section 28 (2)** of the Act empowers the highway authority to remove without any notice, any structure encroaching the highway or in any area where the construction or development of a highway is undertaken or proposed to be undertaken.
- **Sections 47 and 48** of the Highway Act authorize the Highways Department to penalize the encroachments or illegal occupation of the highway land.

6.3.5 Governing Acts and Policies

In India, compensation for land acquisition is governed by the Land Acquisition Act, 1894. In addition, National Policy on Resettlement and Rehabilitation (NPRR), 2007 formulated by Ministry of Rural Development (MoRD) gives the guidelines for resettlement and rehabilitation of project affected families (PAFs), if the affected families are 500 or more in plain area and 250 or more in hilly area. However, for the purpose of maintenance, sustenance and management of State Highways, The Tamil Nadu State Highways 2001 has been promulgated. Hence, Land acquisition in this project will be carried out under this Act.

Key points in the policy:

- Ensures that all PAPs will be resettled and rehabilitated with the aim of improving their livelihoods and standards of living or at least restored to earlier levels and in such a manner that PAPs have a share in project benefits
- When PAPs lose land/structures and will be displaced and/or economically affected

adversely, detailed planning will be made along with implementation arrangements in an operational Resettlement Plan

- Defines PAPs, lists entitlements, details peoples' participation, supervision by NGOs and supervision and monitoring
- Mentions an implementation schedule that would be broken up into specific activities and coordinated with the chronogram of construction
- The cost would be part of the overall project budget and adequate provision would be made for contingencies and inflation

Relevant provisions in this policy prepared by GoTN have been incorporated into procedures keeping in view the practical issues related to urban infrastructure projects.

Compensation under Land Acquisition Act 1894: Compensation to land will be paid at replacement cost to all titleholders, by the state government, from whom land will be acquired for the project.

i Where possible and permitted by regulations, the required land will be acquired by implementing agencies through direct purchase based on 'willing buyer willing seller' principle, as the first option. Negotiations for direct purchase would be carried in a public place and in transparent manner. All proceedings will be documented and final agreement would be signed by the negotiating parties.

ii Where direct purchase by implementing agencies is not materialized, negotiated settlement can be reached through the provisions of the TN Highway Act 2001, Clause 19(2), i.e. through the GoTN designated authorities (district collectors or specific authority to be authorized for the sub project) for that purpose, in respect of sub projects for Transportation Component.

iii Where negotiated settlement under the procedures specified under (ii) above is not possible, and for other urban projects, required land for the sub-projects would be acquired following the provisions of the LA Act (Emergency clause will not be applied) and the ESF.

iv The negotiated amount will be paid within three months from the date of final agreement of the negotiated settlement by the negotiating parties. Interest @12% p.a. will be added for any delay exceeding three months in payment of compensation.

v. In case of payment of compensation under the TN Highway Act or Land Acquisition Act, all other additional assistance will be as per the entitlement matrix.

Compensation for Land: Compensation to land will be paid by the state government at replacement cost to all titleholders from whom land will be acquired for the project as per the below procedures.

6.3.6 Entitlements for PAPs

The entitlement for different category of impacts is explained in the entitlement matrix. The principles of the entitlement matrix are in accordance with the National Policy on R & R, 2007.

Estimate of Affected Persons: A full survey will be undertaken to register and document the socio –economic status of the affected population in the project area.

The start date of the census survey will be the cut –off date for entitlements under the project, to determine who all will be entitled for resettlement and rehabilitation.

Consultative process for developing a Rehabilitation Action Plan (RAP): GoTN will adopt a consultative process for developing a Rehabilitation Action Plan and monitor the implementation. The people will be informed and consulted about the project, its impacts, their entitlements and the options.

Redress Mechanism for Grievances: Initially any aggrieved PAP will be directed to approach the appropriate Commissioner of ULB and subsequently if not satisfied to District Collector during the Collectors weekly grievance redress day. The third level for grievance redress will be the high level committee which would respond within 30 days from the date of receiving the petition. The action taken on the grievance will be communicated to the aggrieved PAP through registered letter within 45 days from the date of receipt of the petition. The project affected person can go through these three grievance redress forum and if not satisfied can appeal in the court of law.

Step-by step process for registering and redressing of grievance, response time communication modes, mechanism for appeal and the provisions to approach civil courts in case of other provision fail will be disseminated. These will be prepared in the local language and distributed to all the PAPs.

Institutional Arrangements for Monitoring and Evaluation: At PIU, the social Assessment report will be reviewed and the Resettlement Action Plan will be prepared. Based on the outcome of the RAP, the R & R will be monitored by a social safeguard manager who would be totally responsible for social safeguards related issues. And in case of complicated R & R, the R & R will be monitored with the help of the external consultants.

6.4 ASSESSMENT OF LAND ACQUISITION

6.4.1 Implementation of the projects

Due to the practical difficulties in implementing the recommended alignment(Option-I) at a single phase, it was decided to implement the project in two phases.

Phase I –This phase starts from Kamaraj Salai near Light House to Oroor kuppam

Phase II – This phase starts from Oroor Kuppam and Joins ECR at Palavakkam

6.4.2 Identification of Impact-

A broad landuse is already identified and based on that, total land area to be acquired is estimated. Additionally, a detailed structure count was undertaken to know the category wise number of affected structures.

6.4.3 Impact Categories

The impact of the proposed project has been identified, inclusive of both title and non-title holders. Since the Proposed alignment is an elevated highway the major Impact to the fishermen settlements are not expected. Based on the field reconnaissance and detailed walk through, the loss categories broadly identified are:

- Loss of Land
- Loss of Structures
    a) Residential
    b) Commercial
    c) Religious
    d) Public utility
    e) Community structures like religious structures, schools, public Structures / institutions, hospitals, bus stands, community taps, public toilets, etc
- Loss of livelihood / trade / occupation
- Loss of Tenure

Since the proposed road is an elevated alignment and runs on the existing alignment, only the outer edge of the kutcha structures are affected. The field reconnaissance revealed that there are encroachments/squatters found along the alignment. However, it is not possible to precisely identify the encroachments at this stage. Structure impact is given here in terms of number of structures affected.

This number does not reflect number of project affected families, as one structure may accommodate one or more number of families.

6.4.4 Loss of Land

As the entire Elevated alignment runs on the existing roads (owned by Highways and Chennai Corporation) only land alienation has to be carried out from the respective departments like Tamil Nadu Police Head Quarters, Tamil Nadu Slum Clearance Board apart from the government Poromboke land for this project. Land alienation has been worked out in order to provide the entry and exit ramp facilities to the proposed elevated alignment. It is estimated that 46,393 sq.m (4.64 hectares) of land to be alienated from the other departments for the Proposed elevated highway as given in **Table 6.8**

Table 6.8: Summary of land area to be alienated

Sl.No.	Location	area in sq.m	area in hectares	area in acres
1	DGP office	366.00	0.04	0.09
2	TNSCB Land	20001.00	2.00	4.94
3	Govt Land (Urur)	26026.00	2.60	6.43
	Total	**46393.00**	**4.64**	**11.46**

6.4.5 Loss of Structures

Impact on various types of structures have been identified such as residential, commercial, community structures (religious, educational institutions, government structures, health-related, theatres), and public utilities (public toilets, drinking water sources, bus stands, community halls etc.) and presented in **Table 6.9**. The residential structures have major impact due to the proposed elevated highway.

Table 6.9: Summary of Affected Structures

	Phase-I	
	Nos	**%**
Residential	928	96.1
Commercial	19	2.0
Religious	8	0.8
Public Utility	11	1.1
Total	**966**	**100**

(i) Residential Structures.

Entire phase-I of the proposed alignment envisage impact on around 928 residential structures. Of the total residential structures affected 50.4 % of them are kutcha structures, 37.5% semi pucca structures and remaining 12.1% are pucca structures as given in **Table 6.10**

Table 6.10. Impact on Residential Structures

Residential structures		
	Phase-I	
	Nos	%
Kutcha	468	50.4
Semi pucca	348	37.5
Pucca	19	2.0
G+1	89	9.6
G+2	4	0.4
Total	928	100

(ii) Commercial Structures.

Entire project road envisage Impact on around 19 commercial structures.

Of the 19 structures, 21.0% are kutcha, 47.4% are Semi pucca shops and rest 31.6% are pucca structures found along the alignment as given in **Table 6.11**

Table 6.11. Impact on Commercial Structures

Residential structures		
Commercial	Phase-I	
	Nos	%
kutcha	4	21.0
Semi pucca	9	47.4
Pucca	6	31.6
Total	19	100.0

(iii) Religious Structures.

The phase-I of the project road envisage Impact on 8 religious structures of which 7 are pucca and one kutcha found on the fishermen settlements along the project corridor. The legal status of the land should be ascertained by the revenue authorities at the time of implementation.

The details are given in **Table 6.12.** The R&R cost for the temples which will have minor / major Impact are included in the project cost.

Table 6.12 Details of affected Religious Structures

Sl.No	Name	Village
1	Om sakthi Bathrakali temple	Nochikuppam
2	Amman temple	Dumming kuppam
3	Sri devi Thulukkanathamman temple	Dumming kuppam
4	Sri Devi Karumari Amman temple	Srinivasapuram
5	Thulukkanathamman temple	Srinivasapuram

6	Janmagini church	Srinivasapuram
7	Miracle Prayer Hall	Srinivasapuram

(iv) Public Utility and Community Structures. Public utility and community structures are generally owned either by the government or by local authorities. However, structures owned by communities were also found in between Nochikuppam and Sreenivasapuram stretch which are to be constructed by implementing authorities. Structures owned by private/govt entities with public usage such as various educational and other institutes, health facilities, Public conveniences, play grounds etc. are also considered under this category.

6.4.6 Loss of Livelihood / Trade / Occupation

Owners whose lands / structures are fully or partially affected are likely to incur economic losses and loss of tenure due to the project. Additionally, tenants/ leaseholders will also envisage loss of livelihood/ tenure.

Though the proposed alignment does not have any major direct Impact on the fishermen settlements, it may cause some indirect Impact during construction period since the alignment is along the coast and fishermen settlements. Construction activities may have a hindrance on the fishermen's business as these people are solely depending on the sea shore for landing their catamarans, distributing and retail sales of their catchments and drying the fishes. Hence, an appropriate place had to be identified for them to carry out their routine works during the construction period.

Amongst the affected persons, most vulnerable groups are women–headed households and below poverty line households. Special attention need to be given in terms of skill up gradation and income restoration programs as they are most likely to face impoverishment. All such affected households shall be identified subsequent to census and detailed socio-economic surveys and appropriate measures to address their requirements shall be proposed as part of the compensation packages developed for the project.

6.4.7 Summary of Impact

Proposed Elevated Highway involves 4.64 Hectares (46,393 sq.m) of land alienation and Impact on 966 structures. There is no land acquisition involved in this Phase-I of the elevated alignment. This elevated alignment is proposed to run on wherever existing roads are available and also on the seashore and open land to minimize Impact on congested fisherman settlements. This has reduced impact considerably.

6.4.8 Impact on Livelihood/ Tenure

When the loss is more than 20% of the structure, it is considered to be fully affected and entitlements are calculated accordingly. Hence it has been taken into account that commercial establishments which have major impact are considered for lively hood assistance. The details on the rent loss and loss of employment can be ascertained only at the time of project implementation.

6.4.9 Conclusion

This chapter has described the project area situation with regard to the human settlements and the acquisition of land for the implementation of the project.

6.5 PUBLIC CONSULTATIONS AND INFORMATION DISSEMINATION

6.5.1 Introduction

To ensure that people's concerns are incorporated in the project design and to promote public understanding about the project and its implications public consultation and information dissemination is treated as a two way process where the information is passed on to public and their feed back is sought to understand their issues. The consultative process is continued through out the project period – design preparation, implementation and post implementation periods. The preparatory stage consultation helps to explore alternative design options, to avoid very adverse social impacts and to reduce the magnitude of the impacts of the project, while consultations during implementation stage helps to facilitate a smooth resettlement of the PAFs thereby enabling speedy implementation of the project.

6.5.2 Objectives of Stakeholder Consultations

The overall goal of the consultation programme is to disseminate project information and to incorporate PAFs views in the Resettlement Action Plan. The specific objectives of the consultations are to:

(i) Improve project design and lead to fewer conflicts and delays in implementation;

(ii) Facilitate development of appropriate and acceptable entitlement options;

(iii) Increase long-term project sustainability and ownership;

(iv) Reduce problems of institutional coordination;

(v) Make the resettlement process transparent; and

(vi) Increase effectiveness of sustainability of income restoration strategies and improve coping mechanisms.

6.5.3 Identification of Stakeholders

Stakeholders are those who have a direct interest in project development and whose participation needs to be ensured in consultations at various stages. For consultation and participation primary and secondary stakeholders are to be identified. The following are the major stakeholders:

(i) All Project Affected Persons (PAPs) and Households, Beneficiaries of the Project, including representatives of Vulnerable Households;

(ii) Host population at planned resettlement site(s);

(iii) Elected representatives, Community leaders of PAPs, representatives of CBOs;

(iv) Designated staff of Project Implementation Unit (PIU)

(v) DG / officials from DC's office and local Revenue officials; and

(vi) Representatives of local NGOs

6.5.4 Stages of Consultations and Information Dissemination

The consultation process formulated for the project employs a range of formal and informal consultative methods including in-depth interviews with key informants, focus group discussions, meetings, and workshops. The consultation programmes are scheduled at several stages of the project, which can be broadly classified as:

- Project preparation phase
- Project initiation phase
- Project implementation phase
- Post implementation phase

Project preparation phase: The current phase is the project preparation stage where in the information gathered from field surveys are incorporated in the design phase of the project and preparation of RAP. At this stage following methodologies were used by the consultants for public consultation and information dissemination.

(i) Reconnaissance survey

(ii) Focus Group Discussions

Project initiation phase: In project initiation phase, the ULB will be responsible for issue of notification, under sub-section LA Act, to inform potential PAPs about proposed acquisition along with project details. The notice will be published in two local newspapers, one of which will be in local/native language. In addition to this, PIU staff will inform potential PAPs about proposed acquisition with the help of village/ULB and revenue officials. With this, PAPs will be given opportunity to be heard in person or through legal practitioner within 21 days and can register any complaint related to proposed acquisition with Competent Authority (CA)1. The CA will satisfactorily disallow the complaints registered by PAPs in consultations with them. After disallowing complaints registered by PAPs, notification will be issued confirming the land acquisition. This notice will also be issued in two local newspapers, one of which will be in local/native language.

Project implementation phase: Consultations conducted during RAP implementation will help to identify help required by PAPs during rehabilitation. Further, an intensive information dissemination campaign for PAPs will be conducted at the outset of RAP implementation. This campaign will be designed by the PIU and executed by the implementing NGO. The objectives of the campaign are:

(i) To help counter rumours and prevent distress;

[1] District Commissioner (DC) will be the Competent Authority (CA)

(ii) To assist in preparation for relocation to new sites; and

(iii) Ensure all questions of the PAPs are answered to the best ability; print and audio-visual materials will be of secondary use in such areas.

All the comments made by the PAPs will be documented and summarized in project monitoring reports. Copies of approved Entitlement Matrix along with RAP implementation procedures and arrangements will be made available with CA/DC and PIU for reference and study by the public.

Implementing NGOs will ensure that any views of the PAPs, particularly BPL households, related to the resettlement process are looked into and addressed and that groups and individuals consulted are informed about the outcome of the decision-making process, and confirm how their views were incorporated. Since resettlement and rehabilitation is a continuous process and a baseline data/information is available, the implementing NGO will update the baseline information as and when required.

Post implementation phase: In this phase an evaluation of the project will be conducted to estimate whether the intended benefits have reached the people. All monitoring and evaluation reports of the R & R components of the project will be disclosed to the public.

6.5.5 Reconnaissance Survey

Social Assessment for the project began with reconnaissance surveys using social/ environment mapping format for collecting primary data on various categories/ typology of structures, natural and anthropogenic features and other important land uses like cultivable land, forest areas etc. As part of this a detailed socio-environmental mapping was undertaken for the entire project area for 20 m on either side from the existing edge of the carriage way. This exercise enabled social team to develop initial perceptions about the potential loss and benefits of the project on the Project Affected Families (PAFs). This exercise was also useful to interact with the public and pass on information about the project and get their feed back and viewpoints about it.

6.5.6 Consultation with Potentially Affected Households

The effectiveness of resettlement and rehabilitation process is directly related to the degree of continuing involvement of those affected by the project. In order to document the issues raised by PAPs, public consultations should be conducted.

6.5.7 Focus Group Discussions (FGD)

FGDs were conducted to assess the perception of the people about the proposed project. The stakeholders selected included mainly fishermen communities, local residents, owners/ workers of local commercial establishments etc. Issues and concerns of the people pertaining to the proposed elevated road had been discussed including their perception on the project. These discussions should be conducted to assess the perception of the people towards the project.

As the entire alignment runs along the coast, focused group discussions were conducted at various places(fishermen settlements) to make the people aware of the proposed elevated alignment and and to solicit their co-operation towards the project.

The Focussed group discussions were conducted at the following places

Table 6.13 Details of focused group discussion

Sl.No	Date	Venue	Name of the community head
1	03.01.07	Srinivasapuram	Mr.Selvamani and others
2	08.01.07	Oroor kuppam	Mr.Kasinathan and other villagers

Issues discussed

At the outset, all the heads and fishermen community people expressed their happiness and welcomed the initiative of the consultants to meet them to know their perception and views. Generally all of them pointed out the following issues.

1. Their settlements should not be disturbed.
2. Their fishing and allied activity on the sea shore should not be disturbed during the construction activities.
3. They also accepted to move from the coast if there is any unavoidable requirement provided the government assures them a reasonable rehabilitation packages.

As the consultants have assured that since the proposed road is an elevated alignment there won't be any major impact on the settlements and the affected PAPs would be suitable compensated, the people expressed their co-operation for the proposed project.

Land Acquisition: In all the places, the extent of ownership of land should be ascertained by the revenue people, as there is a chance of encroachment into government land and wherever it is needed, PAFs will be approached for their willingness to part their land for the project with comparitive market rates.

6.6 INSTITUTIONAL FRAMEWORK

6.6.1 Institutional Framework

The implementing authority should have an Environmental and Social Development Unit which will undertake the revalidation of RAP before the start of RAP implementation and will engage services of Project Consultant (PC) for the same.

RAP Implementation

R&R Cell will be established as a part of PIU, and a District Resettlement and Rehabilitation Officer (DRRO), for the project district will be appointed to R&R Cell. DRRO will assist PD in all land acquisition and resettlement activities for the project implementation. Chennai Corporation will be the Executing Agency (EA) for project. GoTN will oversee all RAP implementation activities, and will engage services of Non-Governmental Organization (NGO) for RAP implementation and an independent agency for external monitoring. Networking with Central/State/Town Departments will also be established (i) so as to link

proposed income restoration packages with government schemes, if any; (ii) for restoration/replacement of community infrastructure such as water supply, sewerage, electricity/telephone network, irrigation canals etc.; and (iii) for restoration/replacement of CPR's/public amenities such as shrines, schools etc.

Implementation Schedule: Implementation of RAP will include land acquisition, and Resettlement and Rehabilitation (R&R) activities. The implementation process will cover (i) identification of cut-off date and notification; (ii) verification of properties of PAPs and estimation of their type and level of losses and distribution of identity cards; (iii) preparation of PAPs for relocation through consultation, however, the process of consultation will continue throughout the RAP implementation and (iv) Relocation and resettlement of the PAPs. It is assumed that implementation will take minimum 3 months to hand over land for civil works. No civil works should begin until all PAPs receive the approved compensation package. Civil works should therefore be linked with the completion of land acquisition.

Monitoring and Evaluation: RAP implementation will be closely monitored to provide Project Implementation Unit (PIU) with an effective basis for assessing resettlement progress and identifying potential difficulties and problems. For monitoring and evaluation (M&E), PIU will appoint an independent agency to undertake external monitoring of the entire project. The independent agency will monitor the project on a half-yearly basis and submit its reports directly to the PIU. This monitoring will include, administrative monitoring, socio-economic monitoring and impact evaluation.

Internal monitoring will track indicators such as the number of families affected, resettled, assistance extended, infrastructure facilities provided, financial aspects, such as compensation paid, grant extended etc. R&R Cell at PIU will carry out internal monitoring, who will report to the Project Director on a monthly basis in prescribed monitoring formats. These formats, to be filled by District Resettlement and Rehabilitation Officers (DRRO) at R&R Cell, will indicate actual achievements against the targets fixed, and reasons for shortfall, if any. Based on the reports, the PIU will monitor and evaluate in every three (3) months the overall progress on each R&R component within the project and determine actions to be taken by the PIU in situations where the set objectives are not being met.

6.7 RAP BUDGET

6.7.1 Introduction

This chapter outlines the methodology of RAP cost estimation and RAP cost in terms of Land Acquisition (LA), assistance for structure and asset loss and various other kinds of assistance that is eligible under the framework of entitlement.

6.7.2 Proposed Approach for Estimating the Compensation

In acquiring the land for the proposed road improvement, Land Acquisition Officer normally follows guidance values for fixing the compensation to PAFs. In the State of Tamil Nadu, modified guide line values(07-08) published by the government and these are base values for property transaction. The available guide line value has been taken from the official Website of Tamil Nadu Registration Department for the areas falling along the project stretch and used for calculation of compensation for land acquisition. However, current rate published in the official website will vary with the market value of the land at the time of project implementation considerably.

In case of loss of structures and assets, a technical valuation team of PWD inspects the site and advises LA Officer to fix individual award based on approved prevailing PWD Schedule of Rates for the concerned district. The LA Officer is the final discretionary authority to fix individual awards. However, the awards can be challenged in the Court of Law.

6.7.3 Per Unit Rate of Land, Structure & Other Assets

Guide Line values taken from Official website of Tamil Nadu Registration Department for the year 2007-2008 is considered for preparation of RAP budget. As there is no acquisition of private land is involved in the Phase-I, there is not land cost arrived.

For calculation of loss of structures and other household assets, following standardized rates have been used, which have been worked out using 'Schedule of Rates" for Chennai district published by PWD, Govt. of Tamil Nadu.

(a) For Pucca Structure – Rs.4304/ sq.m. of plinth area.
(b) For Semi-Pucca Structure – Rs.2421/ sq.m. of plinth area.
(c) For Kutcha Structure – Rs.1775/ sq.m. of plinth area.
(d) For Boundary Wall – Rs.1000/ running metre of 1.5m high and 1 foot wide plastered wall.

The above mentioned rates are applied to the plinth area of the above category of structures to get the total cost. Based on the extent of impact upon the structures if the remaining part is found unviable then full structure is considered as fully affected and entire area is taken for cost estimation. Where ever the remaining portion is found to be viable, it is considered as partial impact and only the affected area is considered for valuation of the structures. The minor assets like open wells, compound walls etc. has been valued separately. However, detailed item wise valuation based on PWD schedule of rates needs to be undertaken at the time of implementation.

6.7.4 RAP Budget

RAP budget, can be broadly subdivided into following three subsections:

(a) Assistance for Loss of Land

(b) Assistance for Loss of Structures, Assets & Developed Area within Resi/Com. Plots

(c) R&R Implementation

6.7.4.1 Assistance for Loss of Land

Though the land belong TNSCB has to be alienated, as per the decision taken during the steering committee meeting held on 09/03/2009, the cost of the land is included in the project cost, arrived as per the guide line value taken from the official web site of Registration Department, Government of TamilNadu. The cost arrived for the land area individually is given in the **Table 6.14**

Table.6.14 Cost of Land

Sl.No.	Location	Area to be alienated in sq.m	Rate/sq.m	Total Cost in Rs.	Cost in Crores
1	TNSCB	20001.00	9690.00	193809690.00	19.38
	Total			**193809690.00**	**19.38**

6.7.4.2 Cost of Structures

Cost of affected property adds upto Rs. 7.75 crores, of these 4.51 crores for pucca buildings. (Construction material used for constructing roof, floor and walls of a property is the major criteria to differentiate the likely affected structure into pucca, and kutcha). Remaining amount is for Semi pucca, Kutcha buildings, religious buildings and compound wall.

Table.6.15 Cost of Structures

Sl.No.	Type of Structure	Area of Structure (Sqm)	Unit cost(Rs)/Sq.m	Total Amount(Rs)	Total Amount
Phase - I					
1	Kutcha	6580	1775	11682000.00	1.17
2	S.pucca	5972	2421	14458500.00	1.45
3	Pucca	10483	4304	45120000.00	4.51
4	Public	767	5380	4125000.00	0.41
5	Religious	260	8070	2100000.00	0.21
			Total	**77485500.00**	**7.75**
			25% building allowance	19371375.00	1.94
			Sub Total	**96856875.00**	**9.69**
			9% Registration and stamp duty charges	8717118.75	0.87
			Grand Total	**105573993.75**	**10.56**

6.7.4.3 R&R Assistance

Generally, R&R assistance include livelihood allowance, rental allowance, one time shifting allowance which are given for the major impact category. As the residential and few

commercial structures that have major impact are found to be on the government land, R& R assistance is not given. Hence there is no R&R assistance arrived for Phase-I.

6.7.5 Final RAP Budget

The final RAP budget for the Phase-I works out to 43.11 crores which includes land, structure and other charges as given in **Table 6.16**

Table.6.16: Final RAP Budget –Phase – I

Total budget-Phase I	**Rs.p**	**Rs.in crores**
Compensation-Land	193809690.00	19.38
Compensation-Structure	105573993.75	10.56
Compensation R&R	0.00	0.00
Total	**299383683.75**	**29.94**
Solatium 30%	89815105.13	8.98
Establishment charges 10%	29938368.38	2.99
Contingency 3%	8981510.51	0.90
Supervision 1%	2993836.84	0.30
Grand Total	**431112504.60**	**43.11**

Chapter 7: Project Cost Estimates

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7 PROJECT COST ESTIMATES

7.1 General

This chapter deals with derivation of preliminary cost for Phase 1 from Light house on Kamarajar Salai (Beach Road) to Besant Nagar of length 4.7km long elevated corridor road. The estimate quantities were derived based on the improvement proposal discussed in Chapter 4.

7.2 Costing Methodology

The project cost is arrived based on the improvement proposals and quantities thereof. The unit rate arrived for construction of new elevated corridor. The project cost was worked out using schedule of rates of PWD Tamilnadu 2008-09 to MoRT&H standards. The quantities were worked out by taking into account for 1 km length corridor.

7.3 Cost Components

The cost for the road and structural components has been worked out under the following sub heads

- Site clearance
- Road works including earth work
- Drainage and protective works
- Road furniture (Traffic signs, markings and other appurtenances)
- Shifting of utilities
- Electrical works
- Land acquisition and social cost
- Foundation, structure and superstructure cost for elevated corridor including ramps
- Environmental mitigation cost

7.4 Land/Environmental/Social Costs

The project corridor passes through mostly on the existing road along beach and in some portions on the shore land. Acquisition cost has been calculated as given in social screening report. Environmental cost includes monitoring and mitigation measures.

7.5 Up gradation Rates

Tender premium in this project is to be higher as compared to locally bid contract due to large spread project area, CRZ zone and also along the coastal line. While working out actual cost additional percentage is to be added. However this additional percentage is not included in the present study and has to be considered at DPR stage during detailed designs and estimation.

7.6 Contingency and Centage Charges

The base costs are added with following components to get the project cost

Contingencies	3% of base cost
Petty supervision	2% of base cost
Quality control charges	1% of base cost
Design and other charges	2.0% of base cost

7.7 Basic Rates

Basic rates for material and labour have been adopted from Tamilnadu PWD schedule of rate 2008-2009. For items not covered by PWD schedule of rate, local market rates were considered. The rates for main items are as follows.

Table 7.1 Rates of Major items

Sl no	Description	Unit	Rate
1	Construction of granular sub-base	cum	1,139.00
2	Profile corrective course in Wet Mix Macadam	cum	1,214.00
3	Wet Mix Macadam	cum	1,214.00
4	Primer coat	sqm	32.00
5	Tack coat with 0.25kg/ sqm over primed surface	sqm	10.00
6	Tack coat with 0.20kg/ sqm over bituminous surface	sqm	8.00
7	Dense Graded Bituminous Macadam	cum	5,239.00
8	Bituminous Concrete	cum	5,907.00
9	Semi Dense Bituminous Concrete	cum	5,372.00
10	Earth work in excavation for foundation (ordinary soil)	cum	41.00
11	PCC Grade M15 for foundation	cum	3,856.00
12	RCC Grade M35 for foundation	cum	4,914.00
13	RCC Grade M35 for substructure	cum	5,492.00
14	RCC Grade M45 for voided slab superstructure	cum	7,347.00
15	RCC Grade M45 for T-beam & slab superstructure	cum	6,999.00
16	RCC Grade M45 for box girder superstructure	cum	7,801.00

7.8 Total Project Cost

As discussed in Chapter 4, the project costing is given in Table 7.2.

Table 7.2 Summary of Project Cost

Tentative Project Cost for Phase I - Light House to Oorurkuppam near Elliots Beach (4.7 km)

Item Description	**Cost (Rs. Crores)**
Elevated Corridor	377
Signature bridge across Adyar Estuary (250m)	32.0
Road works including junction improvements	8.0
Drainage and protective works	4.0
Road Furniture (Traffic signs, markings and other Appurtenances)	0.5
Shifting of utilities	2.0
Street Lighting & High Mast Lighting	1.5
Land Acquisition and Social cost	43.1
Environmental Mitigation Cost	0.4
Total Project Cost	**468.5**
Say, Rs. 469 Crores	
Provision of interchange to connect the proposed Adyar river bund corridor (Optional)	40.0

Chapter 8: Economic Analysis

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8. ECONOMIC ANALYSIS

8.1 Introduction

The objective of the cost benefit economic analysis is to identify and quantify the benefits and costs associated in developing a new bypass from Light House to Kottivakkam / Palavakkam on ECR in Chennai City, in order to select the optimum solution along with the economic viability in terms of its likely investment return potential.

This cost benefit economic feasibility study is carried out using the overall guidelines stipulated by the Indian Roads Congress (IRC) and the World Bank in their manuals like Economic Evaluation of Highway Projects in India (SP – 30, 1993) and, Manual for Road Investment Decision Model' (SP – 38, February 1992) and Manual for HDM - 4 Version 1.3 (World Bank, 2000), as these are accepted by the World Bank, Ministry of Road Transport & Highways (MORT&H), National Highways Authority of India (NHAI) and State Highway Departments for highway projects in India.

The cost – benefit analysis is carried out by using the discounted cash flow (DCF) technique to obtain the economic internal rate of return (EIRR) and economic net present value (ENPV) for the proposed investments linked with the project. This is followed by a 'sensitivity analysis' carried out by increasing or decreasing the critical factors affecting the cost and benefit streams of the proposed project, in order to ascertain their effect on the economic feasibility indicators i.e. ENPV, EIRR.

In broad terms, the society costs pertaining to the highway development, to be considered in this analysis include (a) agency cost and (b) road user cost. Components of these costs are discussed subsequently.

8.1.1. Agency costs

- Capital cost
- Recurrent cost for maintenance (annual & periodical)
- Residual value at the end of analysis period

8.1.2. Road user costs

- Vehicle operating cost
- Travel time cost

8.1.3. Upgradation Proposal

The analysis period of the project is taken as 35 years from the base year 2006 for different sections of the project road as follows:

- Base Year 2006
- Construction period – 2009 to 2010
- Project opening for traffic – 2011
- End of the analysis period –2040
- No. of operating years after project improvement, considered for economic analysis – 30 years

Thus, 30 years of operation, in effect, from the start of the proposed project road i.e. 2011, has been considered for economic evaluation for the project road.

8.2 Alternatives

Following alternatives are considered for the economic analysis.

Without Project Situation: The first is a 'without project' (do minimum) where the existing road network (the impact roads- the roads in the vicinity that will have an impact due to the proposed bypass) is considered as such in its present condition and without improvement. Such roads with major impact are:

- Kamarajar road from Light House to Santhome Basalica, Santhome High road, Greenways road, Dr. Durgabai Deshmukh road, Lattice Bridge road, EC road upto Palvakkam.
- Also the other impact roads that have connections with entry/exit ramps proposed on the bypass such as;
  - Fore Shore Estate road,
  - Besant Avenue road,
  - Beach road and
  - the road connecting EC road with the bypass at Palavakkam

In this case the future traffic volume is assumed to continue to flow along the existing roads only. In the HDM model analysis, this 'do minimum' alternative will form the first / base strategy against which all other strategies will be compared.

With Project Situation: Construction of a new elevated bypass from Light House to Kottivakkam/Palavakkam. The proposed bypass consists of;

- four lane road from Light House to Foreshore Estate road,
- six lane road from Fore shore Estate road to Arupadaiveedu temple; and
- four lane from Arupadaiveedu temple to Kottivakkam/Palavakkam.

The later comprises of the strategy of the 'with project' situation in the HDM model. In order to arrive at the net benefits associated with this strategy, these are compared to the 'do minimum' / 'without project' alternative separately. By comparing the above alternatives, the net agency costs and net user costs and finally net project benefits associated with the project during its analysis period are calculated for the proposed improvement options separately, in order to arrive at their economic internal rate of return (EIRR) and economic net present value (ENPV). Details of the Project Road Sections in two Phases, considered for the analysis along are detailed below in Table 8.1.

For analysis purpose, the following sections/options are considered separately:

- Phase I (Light House- Oorurkuppam near Besant Nagar)
- Phase II (Oorurkuppam near Besant Nagar – ECR) with Flyover at ECR Junction
- Phase II (Oorurkuppam near Besant Nagar – ECR) without Flyover at ECR Junction

Present Report consider only Phase I of the Project Road.

Table 8.1 Project Road Details

Section	Homogeneous Sections	Elevated/At Grade	Proposed Width	Length (km)
Phase I	Light House-Oorurkuppam near Besant Nagar	Elevated	4 lane/6 Lane	4.7
Phase II	Oorurkuppam near Besant Nagar - ECR	Elevated	6 Lane	5.0

8.3 Analysis Model

HDM model (HDM III. Manager, Version 3.0, 1995) has been further improved by the World Bank in their recently released HDM – 4 (Version 1.3). Considering the improved advantages, HDM – 4 (Version 1.3) is used for the present economic analysis, which also calculates vehicle user costs based on the pavement deterioration models. However, as there is no provision available for sensitivity analysis in the HDM – 4, computer spreadsheets developed for this purpose are used as inputs.

The World Bank initiated a Highway Design and Maintenance study in 1969 using leading research institutions and road agencies during which empirical relationships between road roughness, maintenance and vehicle operating costs were derived. These were incorporated in the HDM III in 1987, which was the result of 18 years research in Australia, Brazil, France, India, Kenya, Sweden, UK and USA. Between 1971 and 1982, four major empirical studies were carried out which included the Road User Cost Study (RUCS) carried of by MOST, Govt. of India (Dr. LR Kadiyali) the results of this study and those of Kenya, Brazil and the Caribbean were the basis of the relationships developed for HDM III model released in 1987 and further improved on in its HDM Manager Version 3.0. This version released in June 1995, was tested in more than 20 countries prior to its release and because of its strong development background in India, considered most appropriate for the analysis of this project. ***The latest version HDM – 4(Version 1.3) released in 2000 by the World Bank, is the further improvement over their HDM Manager Version 3.0, supported with adequate test applications in different situations, including the***

Indian highway projects. This justifies the relevance of HDM – 4 for Indian highway projects and use for the present study.

8.4 Input Data

8.4.1 Capital cost

The capital cost of construction of the proposed improvements including the phasing of investment during the construction period has been calculated. Construction is assumed to commence at the beginning of 2009 and be complete by the end of 2010. The new bypass will be opened to traffic by 2011.

Components considered for the calculation of construction cost include:

- All highway construction components including survey, design etc.
- Social displacement costs
- Land acquisition
- Costs of environmental protection measures
- Contingencies
- Quality control, agency charges and supervision during construction period

The pavement option considered for the economic analysis is rigid option for elevated portion and flexible for at-grade portion.
The capital cost and the construction programme are summarized below in Table 8.2 & Table 8.3. All the financial costs pertaining to construction and maintenance (Agency Cost) were converted into economic costs by using the conversion factor of 0.9 and the same were used in the economic feasibility analysis. This is as per the guidelines of International funding institutions for highway projects in India, though IRC suggests a conversion factor to be in the range of 0.80 – 0.85 (IRC: SP - 30, 1993).

Table 8.2: Construction Programme for the proposed bypass

Details	Project Road
Construction Period (Years)	2
Construction Start Year	2009
Construction End Year	2010
Year of opening for traffic	2011
Phasing of construction cost (in percentage)	
Year 1-%	40
Year 2-%	60
Total-%	**100**

Table 8.3: Details of the Construction Cost (Rs in Millions) – 2008 Price

Details	Phase I (Rs Million)
Total Financial Cost	4685.1
Total Economic Cost *	4216.6

*(Note: *- conversion factor of 0.9 is applied)*

8.4.2 Maintenance Cost (Recurrent Cost)

Details of the maintenance programme followed for the project road and the impact roads under different situations along with their unit rates, followed in the analysis, are summed up below in Tables 8.4 (a) and 8.4 (b).

The scenario for rigid pavement of the bypass is as follows;

- Slab Replacement
- Full Depth Repair
- Partial Depth Repair
- Joint Sealing

Table 8.4 (a) Annual / Periodical Maintenance Programme for the Project Road Sections – Rigid Pavement

S. No.	Maintenance Type	Starting year	Interval /Intervention	Quantity	Unit Rate (Rs) – Financial Cost
1	Slab Replacement	2015	Scheduled (every 5 years)	Based on the requirement	Rs 1262 / Sq.m
2	Full Depth Repair	2015	Scheduled (every 5 years)	Based on the requirement	Rs 200 / Sq.m
3	Joint Sealing	2015	Scheduled (every 5 years)	Based on the requirement	Rs 20 /m
4	Partial Depth Repair	2011	Annual	Based on the requirement	Rs 100 / Sq.m

Table 8.4 (b) Annual / Periodical Maintenance Programme for the impact roads – Flexible Pavement

S. No.	Maintenance Type	Starting year	Interval /Intervention	Overlay Thickness (mm)
1	Resealing	2011	Scheduled (every 5 years)	25 SDBC
2	Overlay	2007	Responsive (When Roughness > 4.0 IRI & cumulative ESAL > 150 MSA)	50 BC
3	Patching	2007	Annual (Repairing all potholes)	100%

8.4.3 The Residual Value

Considering the remaining life of the construction items the Residual value (salvage value) has been assessed at the end of the analysis period. For structures, the life is assumed to be 50 years and as such the remaining life is taken from 2040.

Values of the selected construction items such as LA, structures, sub-base, social displacement cost etc. are included in the economic analysis as residual values at the end of the analysis periods. These residual values are considered, as benefits to the project in the analysis. In order to maintain uniformity among studies, National Highway Authority of India (NHAI) has suggested

that 20% of the project cost shall be considered as salvage value at the end of the analysis period for economic evaluation studies for BOT highway projects in India. The same has been adopted for present study.

8.4.4 Road User Costs

The economic cost inputs that are required for estimating Road user costs are:

- Price of selected (popular) models, by vehicle type
- Tyre prices
- Fuel cost including oil price
- Crew cost (wages of Drivers / Assistants)
- Time costs for:
- Passenger
- Freight (holding cost)

The cost of vehicles and tyre were collected from the dealers located in the influence area of the project road. All the transfer payments such as sales tax, excise duty, road tax octroi etc. are deducted from the financial cost to arrive at the resource cost.

A vehicle operator's survey has been conducted to estimate the wages of drivers and their assistants. Finally, the crew cost is estimated with appropriate hours of work time per annum for different vehicle types.

With respect to maintenance labor costs, local workshops have been contacted to assess the vehicle type wise wage bill for repairs and amount of labor time spent on them. Based on these labor costs have been calculated per hour, for each vehicle category.

Time costs: Passengers

The average income of full-time employed people in Tamil Nadu was computed from published macroeconomic and demographic data for the year 2001-2002[1], with a premium of 33% to allow for business overheads. This value (24.84/hour at 2008 price) was applied to passenger-hours in work time.

Journeys in non-work time were valued at 30% of the average income of full-time employed people (Rs 7.45/hour). These values pertaining to 2006 and so without further updating these values are used for the model. This procedure is in keeping with the guidelines contained in the World Bank's Infrastructure Note No.OT-52.

1 Published by the Directorate of Economics and Statistics in 'Statistical Hand Book of Tamil Nadu-2002'.

2 Kenneth M Gwilliam, 'The Value of Time in Economic Evaluation of Transport Projects: Lessons from recent Research'.

Particularly in the case of subsistence workers and self-employed workers in the informal sector, the concept of 'work time' is questionable, but we have adhered to the principle that a distinction should be made between time that is lost to productive effort and time that is not.

We feel that above values estimated at macro level can represent bus passengers. Hence a step-up approach is followed to estimate the passenger time value by other better modes. Accordingly a notional increase is followed to estimate the time value for passengers by minibus, two wheelers and cars, as given in Table 8.5(a) and 8.5(b).

Table 8.5(a) Time Value Adopted for Passenger Vehicles, 2008

Vehicle Type	Time value (Rs / Hour), 2008	
	Work	Non work
Bus	24.84	7.45
Mini Bus	29.80	8.94
TW	34.77	10.43
Car	52.16	15.64

Table 8.5(b): Derivation of the Value of Passenger Time - 2006

Details		Unit	Value	Datum yr	Annual Growth (%)	2006
Input...						
Gross State Domestic Product (NSDP)	A	Rs million	1,309,175	2001-2002	6.5	1,684,210
Population	B	million	62.11	2001	1.5	65.92
Working population: main	C	%	38.13	2001*	1.5	40.47
Working population: marginal	D	%	6.64	2001*	1.5	7.05
Working population: FTE**	E=C+D/2	%	41.45			44.00
Computed...						
Assumed NSDP (70%) to households	F=A×0.70	Rs million				1,178,947
Average income per FTE worker	G=(F/B)/E	Rs/year				40,647
Average income per FTE worker***	H=G/2400	Rs/hour				16.94
Work time value, with 33% overheads	I=H×1.33	Rs/hour				22.53
Non-work time value at 30%	J=H×0.30	Rs/hour				6.76
Work time value, with 33% overheads – 2008 Price	@ 5% annual increase	Rs/hour				24.84
Non-work time value at 30% – 2008 Price	@ 5% annual increase	Rs/hour				7.45

(Note: Census; in the absence of evidence to the contrary it is assumed that average household size and the proportion of people in the working population have remained constant.*

*** Full-time equivalent workers, assuming marginal workers are employed half-time.*

**** Assuming 2,400 worked hours per year.*

Source: Statistical Hand Book of Tamil Nadu-2002, Department of Economics and Statistics, GoTN)

Time costs: Freight

From the discussions with the vehicle operators in the region and axle load surveys in the region, an estimate was made of the average load carried by each category of truck, and its economic value on state level. This was then used as the basis for computing an hourly inventory cost (or freight holding cost), using the social discount rate as the cost of working capital locked up in goods in transit and assuming an effective 2,400-hour working year.

Table 8.6 presents our derivation of the values used in the model for the three classes of freight vehicle. All three values were rounded to the nearest rupee per vehicle-hour.

Table 8.6: Derivation of the Time Value of Freight in Transit

Details	LCV	2- axle truck	3-axle truck	Multi-axle truck*
Average value of load (Rs.)	199,500	288,750	724,500	761,250
∴ interest cost for a year (× 12%)	23,940	34,650	86,940	91,350
∴ interest cost per working hour (÷ 2,400) at 2006 price	*9.975*	*14.4375*	*36.225*	*38.06*
∴ interest cost per working hour (÷ 2,400) at 2008 price	*11.00*	*15.92*	*39.94*	*41.96*

(Note: Average value of load is arrived from the discussion with the vehicle users in the study region.)

For uniformity, National Highways Authority (NHAI) had suggested economic road user costs in November 2000, in consultations with the Design Consultants, to be used as HDM Model inputs for carrying out economic analysis for BOT highway projects in India. After a careful comparison of the road user costs collected from the field and other secondary sources, it was decided to adopt data collected from the field for the present analysis. Wherever necessary, the NHAI suggested road user costs are supplemented.

Based on the above considerations, the economic costs estimated for different VOC components are presented in Table 8.7 below:

Table 8. 7: Economic Road User Cost inputs

Vehicle type	Model	New vehicle* Economic price (Rs.)	New tyre* Economic price (Rs.)	Maint.** Labour (Rs./hour)	Crew cost ** (Rs./crew hour)
Car (NT)	Maruti, CS E1 (M)	140113	947	22	27
Car (OT)	Ambassador, 1.5DL	291648	1431	19	27
Auto rickshaw		58985	555	19	27
Bus	LP1512TC/52	878439	5670	38	98
Mini Bus	Mahindra Mini Bus	444500	2396	30	46
TW	Hero Honda – Splendor	36121	436	19	-
LCV	LPT407 LB	436440	3144	31	46
2-Axle Truck	LPT1613TC/48	869483	5670	33	68
3-Axle Truck	LPT2515TC	1084629	5670	39	99
MAV	LPS4021TC	1661611	5670	47	101

*(Note: * - collected from the Dealers at Chennai in May 2005*
***- based on the information collected from the vehicle operators / workshops during traffic surveys.)*

The economic cost of petrol, diesel, oils and lubricant adopted for the present analysis are given in Table 8.8 below.

Table 8.8 Fuel Costs (Economic)

Item	Market Price	Economic cost	Factor to arrive Economic Cost*
	Rs/litre	Rs/litre	
Petrol	48.0	27.20	0.5666
Diesel	36.4	29.01	0.7971
Engine Oil	90	67.56	0.7507
Lubricants	95	71.32	0.7507
Grease	110	82.58	0.7507

*(Note *Based on Rural Road Sector Development in Madhya Pradesh and Chhattisgarh, India, Asian Development Bank, Economics PPTA Final Report, July, 2003,)*

The vehicle characteristics of representative vehicles used as input for HDM – 4 are given in Table 8.9.

Table 8.9 Vehicle characteristics (HDM input data)

Vehicle type	Gross Vehicle Weight (Tonnes)	No. of Axles	No. of Tyres	No. of passengers	Service life (Years)	Hours driven/ Year	Kms. driven/ Year	Annual interest rate (%)
Car (NT)	1.4	2	4	5	10	1950	32000	12
Car (OT)	2	2	4	4.6	10	1950	32000	12
Auto rickshaw	0.5	2	3	3.3	8	2000	30000	12
Bus	14.9	2	6	39.5	10	2000	66000	12
Mini Bus	2.5	2	4	21.8	8	1500	60000	12
TW	0.2	2	2	1.6	10	700	21000	12
LCV	5.3	2	4	-	12	1500	60000	12
2-Axle Truck	15.7	2	6	-	10	2100	85000	12
3-Axle Truck	25	3	10	-	10	2100	85000	12
MAV	40.2	5	12	-	12	2400	120000	12

8.5 Road Characteristics

The road characteristics required as input to the HDM model were collected during the road and pavement investigations and subsequent pavement design and analysis. The road characteristics for the existing roads are assessed during data collection and those proposed for the new project road is adopted from the design.

8.6 Traffic

Normal Traffic: The estimated traffic on the bypass for the year 2011 and the growth rates are adopted from the traffic section of the report. The traffic on the impact roads are assessed by conducting traffic surveys and are used to estimate the future traffic on them, after eliminating the diversion to the bypass in the 'with project' scenario.

Additional and Generated Traffic: Considering the growth potential along ECR and for the interaction with the city centers and CBD, on conservative approach, 10% generated traffic is considered for the analysis in 'one stroke' during the base year itself.

In order to suit the vehicle categories available in HDM - 4, the vehicles observed in the traffic survey have been grouped as shown in Table 8.10 below:

Table 8.10 Vehicle Classification

HDM - 4 Group	Traffic Survey Vehicles
Motorised Vehicles	
Car	Car (New technology)
Pickup	Car (Old technology),
Bus	Bus
Minibus	Minibus, Maxi cab/ Pick up Van
LCV	LCV, tractor and tractor trailer
Truck	2 Axle truck
HCV	3 Axle truck
MAV	Multi Axle truck
Two Wheelers	Scooters, Motorbikes
Auto rickshaw	Auto rickshaw
Non - Motorised Vehicles	
Animal Drawn	Bullock / Horse Drawn Carts
Cycle	Pedal Cycle
Cycle rickshaw	Cycle rickshaw

8.7 Economic Evaluation of the Project Road

In the analysis, the 'with project' alternatives of traffic using the new bypass along with its impact roads, is compared with the base option of 'without project' alternative of traffic continuing along existing impact road network, discussed earlier. This is to arrive the net the economic benefits, which consist of reduction in vehicle operation cost, and reduction in travel time.

Results of the analysis, carried out through HDM – 4 (Version 1.3), are summarized below in Table 8.11:

Table 8.11 Results of the Economic Analysis – Santhome Bypass -Phase I

Project	Economic Internal Rate of Return in %(EIRR)		Economic Net Present Value of Net Benefits at 12 % Discount Rate (Rs in Millions)	
	VOC Savings only as Project Benefit	All Savings together as Project Benefit	VOC Savings only as Project Benefit	All Savings together as Project Benefit
Santhome bypass **(PHASE I**-Light House-Oorurkuppam near Besant Nagar)	5.8%	14.3%	-1,515.11	725.25

The development of the proposed bypass in two phase and three options as indicated in the above Table 8.11 are found to be economically feasible with positive EIRR(14.3% for Phase I,) and

economic net present value (ENPV) of Rs. 725 Million, , when consider all savings as project benefit..

8.8 Sensitivity Analysis

For the full Project Road, sensitivity analysis was carried for the following scenarios:

- 15% increase to Agency cost only
- 15% decrease to Project Benefits only
- 15% increase to Agency cost and 15% decrease to Project Benefits simultaneously

Sensitivity analysis to the economic evaluation criteria (EIRR and ENPV) were also carried out for the following situations:

- Reduction in VOC only is considered as project benefit
- Reduction in VOC, and Time cost together are considered as project benefit

Results of the sensitivity analysis for the different phases and improvement options under different scenarios are summarized below in Tables 8.12. The cash flow details for economic feasibility and sensitivity analysis are given in **Annexure 8.1.**

Table 8.12: Results of the Sensitivity Analysis – Santhome Bypass –Phase I

Sl. No	Sensitivity Scenario	EIRR (%)		ENPV at 12 % Discount (Rs. Millions)	
		VOC Savings only as Project Benefit	VOC & Time Cost Savings together as Project Benefit	VOC Savings only as Project Benefit	VOC & Time Cost Savings together as Project Benefit
PHASE I-Light House- Oorurkuppam near Besant Nagar					
1.1	***Normal Scenario***	**5.8%**	**14.3%**	**-1,515.11**	**725.25**
1.2	15% increase in Agency cost Scenario	4.9%	12.9%	-1,936.33	304.03
1.3	15% decrease to Project Benefits	4.7%	12.6%	-1,709.06	195.24
1.4	***Worst scenario*** (15% increase to Agency cost and 15% decrease to Project benefits simultaneously Scenario)	3.8%	11.3%	-2,130.28	-225.98

8.9 Conclusions and Recommendations

Phase I for the construction of Santhome bypass is found to be economically feasible, considering its positive values of feasibility criteria (EIRR and ENPV) at normal scenario with EIRR of more than the minimum required level of 12%.. Under the worst scenario of sensitivity analysis, Phase I is found to EIRR with more than 11%.

Hence from the economy feasibility point of view, it is recommended to develop the bypass from Light House to Oorurkuppam near Besant Nagar under Phase I with the recommended lane configuration.

Annexure

Annexure 2.1 Road Inventory

Section		Land Use (Res / Com)		Cross Section Details											ROW (m)	Remarks
				LHS					Median	RHS						
From	To	LHS	RHS	Distance of boundary	Foot Path	Earthen Shoulder	Paved Shoulder	Carriage way		Carriage way	Paved Shoulder	Earthen Shoulder	Foot Path	Distance of boundary		
4+600	4+630	Res	Res			1		2.5		2.5		1			7	1) 1 Electric Pole on LHS
4+630	4+700	Res	Res			1		3.5		3.5			2		10	2) 2 Electric Poles on RHS
4+700	4+800	Res	Res		1.5			6.5		6.5			1.5		16	1) Besent Nagar Beach Road Junction @4+700 on LHS
																2) Cross Road of 3.5m wide @4+790 on RHS
																3) Cross road of 3.5m wide @ 4+800 on LHS
																4) water tank @4+750 on LHS
																5) Two Telephone Boxes @ 4+800 on RHS
																6) Two electric poles @30m c/c on RHS
4+800	4+900	Res	Res			1		7		7		1			16	1) Cross road of 3.5m wide @ 4+900 on LHS (Besent Nagar 32nd Cross Road)
																2) 4 Electric Poles @ 25m c/c on RHS
4+900	5+000	Govt	Res			1		7		7		1			16	1) LHS Rajaji Bhavan Compound wall
																2) Cross Road of 6m wide @4+990 on RHS
																3)Electric Transformer @ 4+950 on LHS (Inside the Rajaji Bhavan Compound wall)
5+000	5+070	Govt	Res			1		7		7		1			16	1) Junction @ 5+070 (Besent Nagar 3rd Avenue)
																2) BSNL Telephone Box on RHS @5+070
																3) 3 Electric Poles @ 20m c/c on RHS pavement edge
5+070	5+100	Govt	School		1.5		4	7		7	4		1.5		25	1) LHS Rajaji Bhavan Compund wall
																2) OLCOTT Memorial High school
																3) Olcott Bus stand on Foot path opposite to Junction @5+070 on RHS
																4) Electric Poles on Both sides @ 20 m interwell
5+100	5+200	Govt	School		1.5		4	7		7	4		1.5		25	1) RHS Olcott Scholl compound wall
																2) Rajaji Bhavan Gate on LHS at 5+195
																3) Olcott School Bus stand on LHS paved Shoulder @ 5+110
																4) 0.5m divider from 5+100 to 5+160
																5) Electric Poles on Both sides @ 20m c/c
5+200	5+300	Res	Res		1.5		4	7		7	4		1.5		25	1) BSNL telephone Box on LHS Foot Path @ 5+230
																2) BSNL telephone Box on LHS Foot Path @ 5+300
																3) Cross Road of 14m wide on RHS @ 5+265
																4) Electric Transformer & Two Electric Boxes on LHS pavement edge @5+295

Annexure 2.1 Road Inventory

Section		Land Use (Res / Com)		Cross Section Details											ROW (m)	Remarks
				LHS						RHS						
From	To	LHS	RHS	Distance of boundary	Foot Path	Earthen Shoulder	Paved Shoulder	Carriage way	Median	Carriage way	Paved Shoulder	Earthen Shoulder	Foot Path	Distance of boundary		
																5) Telephone Box on RHS of Cross Road @ 5+265
5+300	5+400	Res	Res	1	1	1	2	7		7	2	1	1	1	24	1) Besent Nagar Club @ 5+345
																2) Cross Road of 12m wide on LHS @ 5+330
																3) Telephone Box on RHS Foot Path @ 5+345
																4) Trees on RHS @ 2m Offset from the Pavement edge on the Road
5+400	5+500	R/C	Com	1.5			3	7		7	3			1.5	23	1) Bus stops on Both sides @5+400
																2) Cross Road of 3.5m wide on LHS @5+425
																3) Temple on LHS @5+445 (Photo No: 11)
																4) Besent Nagar Bus Stand on RHS @ 5+500 (Photo No: 12 & 13)
5+500	5+600	Res	Res		2		3	7		7	3		2		24	1) Metro Water Gate on LHS @ 5+510
																2) Electric Transformer on LHS @ 5+570
																3) CPWD Quarters Gate on LHS @ 5+600
																4) BSNL Telephone Box on LHS foot path @ 5+590
5+600	5+700	Res	Res		2		3	7		7	3		2		24	1) cross road of 3.5 m wide on RHS @ 5+605
																2) Cross Road of 9m wide on LHS @ 5+675 (Photo No: 14)
																3) CPWD compund wall is upto 5+675 on LHS
5+700	5+800	Com	Res		1.5		3	7		7	4		1.5		24	1) Besent Nagar 13 th cross road on RHS @ 5+710
																2) cross road of 3.5 m wide on LHS @5+775
																3) cross road of 6.0 m wide on RHS @5+775
																4) Two electric Boxes on LHS pavement edge @ 5+760
5+800	5+900	Com	R/C		2		3	7		7	4		1		24	1) ICICI Bank Bus Stop on LHS @5+815
																2) Besent Nagar 4th cross road on RHS @ 5+835
																3) BSNL Telephone Box on LHS Foot path is @
5+900	6+000				1	3		7		7	3		2		23	1) Besent Nagar 16th cross road on LHS @ 5+950
																2) Bus stop on RHS Foot Path @ 5+950
																3) cross road Junction on RHS @ 6+000 (Photo No: 15 & 16)
6+000	6+100				2	1.5	2	7		7	2		2		23.5	1) Three Bus shulters on LHS paved Shoulder from 6+015 to 6+030
																2) Besent Nagar 6th cross road of 6m wide on RHS @6+100

Annexure 2.1 Road Inventory

Section		Land Use (Res / Com)		Cross Section Details											ROW (m)	Remarks
				LHS					Median	RHS						
From	To	LHS	RHS	Distance of boundary	Foot Path	Earthen Shoulder	Paved Shoulder	Carriage way		Carriage way	Paved Shoulder	Earthen Shoulder	Foot Path	Distance of boundary		
																3) Telephone Box on RHS foot path before the cross road Junction @ 6+100
																4) Two electric boxes on LHS earthen shoulder @ 6+100
6+100	6+200				2		3	7		7	3		2		24	1) Cross road of 3.5m wide on LHS @6+175
6+200	6+300				2		3	7		7	3		2		24	1) Reserve Bank staff Quarter Gate on RHS @ 6+230
																2) Bus Stand on RHS Foot path @ 6+260
6+300	6+400				2		3	7		7	3		2		24	1) BSNL Telephone box on LHS foot path @ 6+315
																2) 4 Road Junction @ 6+330, LHS towards Anna Colony and RHS Besent Nagar 1st Main raoad
																3) Electric Transformer on LHS paved shoulder @ 6+350
6+400	6+500	com	com		2		3	7		7	3		2		24	1) Electric transformer on LHS paved shoulder @ 6+475 (Photo No: 19)
																2) Fish Market on LHS from 6+420 to 6+470 (Photo No: 17)
																3) cross road of 3.5m wide on RHS @ 6+475
6+500	6+600	com	com		2	2.5	3	7		7			2		23.5	1) Temple on LHS @6+510 (Photo No: 18)
																2) Bus stop on LHS foot path @ 6+520
																3) Bus stop on LHS earthen shoulder @ 6+550
																4) Hand pump on LHS shoulder @ 6+590
																5) Bus stop on RHS foot path @6+600
6+600	6+640	com	com		2		3	7		7	3		2		24	1) 4 Road Junction @6+640 (3.5m width roads)
6+640	6+700	com	com		2			7		7			2		18	2) cross road on LHS @ 6+700
6+700	6+800	com	com		2	1		7.5		7.5		1	2		21	1) cross road of 3.5m wide on RHS at 6+730
																2) electric box before the cross road on RHS @ 6+730
																3) electric box on LHS earthen shoulder @ 6+790
6+800	6+900				2	1.5		7.5		7.5		1.5	2		22	1) electric box on RHS earthen shoulder @ 6+950
																2) Bus stop on LHS pavement edge @ 6+900

Annexure 2.1 Road Inventory

Section		Land Use (Res / Com)		Cross Section Details											ROW (m)	Remarks
				LHS					Median	RHS						
From	To	LHS	RHS	Distance of boundary	Foot Path	Earthen Shoulder	Paved Shoulder	Carriage way		Carriage way	Paved Shoulder	Earthen Shoulder	Foot Path	Distance of boundary		
6+900	7+000				2		1	7		7	1		2		20	1) Shastri Nagar 1st Main Road of 7m wide on RHS @ 6+925
																2) Two electric boxes are after the cross road on RHS @ 6+925
																3) BSNL telephone box on LHS foot path @ 6+980
																4) cross road of 3.5m wide on LHS @ 7+000
																5)electric box on RHS foot path @7+000
																6) Electric transformer and 3 electric Boxes after the cross road on LHS @7+000
7+000	7+060				2		1	7		7	1		2		20	1) cross road of 3m wide on LHS @ 7+045
7+060	7+100				2		2	7		7	1		2		21	2) St.Marry's Teacher training school on RHS @ 7+045 (Photo No: 20)
																3) Electric Box on RHS foot path @ 7+100
7+100	7+200	com	com		2		1.5	7		7	1.5		2		21	1) BSNL telephone box on Both sides pavement shoulder edge @ 7+130
																2) Bus stop on RHS foot path @7+160
7+200	7+245				2		1.5	7		7	1.5		2		21	1) From 7+245 Meet stalls wall is at carriage way edge on RHS up to the 7+300 Junction
7+245	7+300				2		1.5	7		7					17.5	2) Lattice Bridge Road Junction @7+300 (Photo No: 21 & 22)
7+300	7+400	com	com		2			7		7			2		18	1) water tank on LHS pavement edge @ 7+340
																2) electric boxes on both sides @ 7+340
																3) cross road of 3.5m wide on RHS at 7+340
																4) water tank on LHS @ 7+370
																5) Temple on RHS @ 7+370 Photo NO:(23)
																6) cross road of 3.5m wide on LHS @ 7+400
																7) Electric box on both sides @ 7+400 (after the LHS Cross road)
7+400	7+475	com	com		2			7		7			2		18	1) electric box on RHS foot path @7+430
7+475	7+500	com	com		2			5.5		5.5		1.5	2		16.5	2) cross road of 2m wide on LHS @ 7/490
7+500	7+530				2			5.5		5.5		1.5	1.5		16	1) Two water tanks on LHS Pavement edge @ 7+540
7+530	7+570				2			5.5		5.5			1		14	2) Photo No: 24 shows the Bottle Neck portion
7+570	7+600				2			5.5		5.5		1.5	1.5		16	
7+600	7+640				4			6		6			2		18	1) 12/0 km stone @ 7+640
7+640	7+700				4			6		6			2	6	24	

Annexure 2.1 Road Inventory

Section		Land Use (Res / Com)		Cross Section Details											ROW (m)	Remarks
				LHS						RHS						
From	To	LHS	RHS	Distance of boundary	Foot Path	Earthen Shoulder	Paved Shoulder	Carriage way	Median	Carriage way	Paved Shoulder	Earthen Shoulder	Foot Path	Distance of boundary		
7+700	7+800				4			6		6			2	6	24	1) Electric Box on LHS foot path @7+770
7+800	7+900				3			8		8			2	5	26	1) Electric pole onLHS pavement edge @7+815
																2) 12/2 Stone @ 7+840
																3) BSNL telephone box on LHS pavement edge @ 7+890
7+900	8+000				2			7		7			2	6	24	1) Electric transformer on LHS Foot Path @ 7+910
																2) 12/3 stone @7+950
																3) Indira Nagar Cross road Juntion on RHS @ 7+975 (Photo No: 25 & 26)
																4) Electric Box on LHS foot path @7+975
8+000	8+100				3			7		7			3		20	1) BSNL telephone box on LHS foot path @8+020
																2) 4 Road Junction @ 8+010 (LHS is Kalachetra Road)
																3)Theygaraja Cinema Hall on LHS @ 8+100 (Photo No: 28)
																4) Sri vidya Kalyana Mahal on RHS @ 8+100 (Photo No: 27)
8+100	8+200				3			7		7			3		20	1) Bus stop on RHS foot path @8+125
																2) Electric box on both sides on foot path @ 8+150
																3) Transformer & Two electric boxes on LHS foot path @ 8+180
8+200	8+300				2		3	7		7		2	2		23	1) Jayanthi Cinema hall on RHS @ 8+220 (Photo No: 29)
																2) cross road of 3.5 m wide on RHS @ 8+250
																3) EC Road Junction@ 8+300 (Photo No: 30, 31 & 32)
8+300	8+370	com	ocm		2		4	10	1	10			2		29	1) High Mask Light on the Median at Junction 8+300
8+370	8+400	com	ocm	5	2		2	7	1	7	2		2		28	2) Electric poles are 25m c/c on the median Continuously
																3) BSNL telephone box on RHS foot path @ 8+315
																4) 11/9 km Stone on median @ 8+335
																5) Advertisement Boadrs on Median at 25m c/c continuous

Annexure 2.1 Road Inventory

Section		Land Use (Res Com)		Cross Section Details											ROW (m)	Remarks
				LHS						RHS						
From	To	LHS	RHS	Distance of boundary	Foot Path	Earthen Shoulder	Paved Shoulder	Carriage way	Median	Carriage way	Paved Shoulder	Earthen Shoulder	Foot Path	Distance of boundary		
																6) BSNL telephone box on LHS paved shoulder @ 8+360
																7) Cross road of 3.5m wide on LHS @ 8+365
																8) Electric transformer on LHS foot path @ 8+370
8+400	8+500	com	ocm	5	2		2	7	1	7	2		2		28	1) 12/0 km Stone on Median @ 8+435
																2) cross road of 3.5 m wide on RHS @ 8+460
																3) Electric box on LHS foot path @ 8+500
8+500	8+550	com	ocm	2	2		3	7	1	7	2		2	2	28	1) 12/1 km stone on median @ 8+535
8+550	8+600	com	ocm	1	2		3	7	1	7	1		1		23	2) 4 road juction @ 8+550 (LHS 3.5 m wide road an RHS 6m wide Road)
																3) electric box on both sides on foot path @8+570
																4) electric transformer on RHS foot path @ 8+570
																5) Tirvanmayur Bus Depo on RHS Photo No: 37 &
8+600	8+700	com	ocm	1	2		3	7	1	7	2			3	26	1) 12/2 km stone on median at 8+635
																2) temple on RHS @8+640
																3) Post box on RHS @ 8+645
																4) Tiruvanmyur Bus stand on RHS @ 8+660 (photo No: 39)
																5) Ambethkar statue on RHS paved shoulder @ 8+670
																6) cross road of 3.5m wide on LHS @ 8+690
																7) Telephone box on LHS paved shoulder @8+700
8+700	8+740	com	ocm		2		2	7	0.5	7					18.5	1) This section is on 90degrees curved portion
8+740	8+770	com	ocm		2		2	7	2	7	3		2		25	2) Cross road on LHS @ 8+740
8+770	8+825	com	ocm		2		2	7	6	3.5	1		1		22.5	3) temple just after the cross roan on LHS @ 8+740
8+825	8+855	com	ocm		2		2	7	1	7	2		2		23	4) Temple on Median @ 8.825 (Photo No: 40, 41 & 42)
8+855	8+900	com	ocm		2		2	7	1	7	2		2		23	5) cross road of 3.5m wide on LHS @ 8+835
																6) Electric Poles and Advertisement Boars are continuous except in curve portion)
																7) Bus stop on LHS foot path @ 8+885
8+900	9+000	com	ocm	3		2	1	7	1	7	2		2		25	1) Temple on LHS @ 8+980 (Photo No: 46)
																2) Two bus stops on LHS foot path @ 8+960
9+000	9+100						4	7	1	7	2		2		23	1) Cross road of 3.5 m wide on LHS @ 9+030
																2) 12/5 km stone on median @ 9+035

Annexure 2.1 Road Inventory

Section		Land Use (Res Com)		Cross Section Details											ROW (m)	Remarks
				LHS						RHS						
From	To	LHS	RHS	Distance of boundary	Foot Path	Earthen Shoulder	Paved Shoulder	Carriage way	Median	Carriage way	Paved Shoulder	Earthen Shoulder	Foot Path	Distance of boundary		
																3) Thiygaraja swamy Marriage Hall on RHS @ 9+040
																4) cross road on RHS @ 9+095
																5) Electric transformer and electric box on RHS foot path @ 9+090
																6) Electric box on LHS paved shoulder @9+100
9+100	9+200						2	7	1	7	2		2		21	1) 12/6 km stone on median @9+135
																2) cross road of 5m wide on LHS @ 9+200 (Signalized Junction)
																3) Temple on RHS @ 9+200 (Photo No 47)
																4) Electric box just after the cross road on LHS @ 9+200
9+200	9+300						1	7	0.5	7	1.5		2		19	1) Water ford appartments on RHS @ 9+300 (Photo No: 48)
9+300	9+400					2	2	7	0.5	7	1			2	21.5	1) BSNL telephone box on LHS @ 9+350
																2) 12/8 km stone @9+340
																3) Electric Box on LHS @ 9+400
9+400	9+480					2	2	7	0.5	7	1			1	20.5	1) Temple Under Construction on RHS @ 9+460 (Photo No: 49)
9+480	9+500					1	1	7	0.5	7	1	1			18.5	
9+500	9+600						1	7	0.5	7	1				16.5	1) 13/0 km stone @9+535
																2) Nathans Comples on RHS @ 9+540 (Photo NO: 50)
																3)Twin Roses appartments on RHS @ 9+560 and compound wall upto 9+600
9+600	9+700						1	7	0.5	7	1				16.5	1) Cross road of 3.5m wide on RHS @ 9+670
																2) 13/1 km stone @9+635
																3) open land on RHS from 9+600 to 9+670 (belongs to Krishna Builders)
9+700	9+740						1	7	0.5	7	1				16.5	1) 13/2 km stone @9+735
9+740	9+770							6.5	0.5	6.5					13.5	2) cross road of 3.5m wide on RHS @ 9+740
9+770	9+800							7	0.5	7					14.5	3) Temple on paved shoulder on LHS @ 9+740
																4) Photo No: 51 shows th Bottle neck @ 9+740
																5) Cross road of 7m wide on LHS @ 9+800 (Signalized Junction) Photo No: 52

Annexure 2.1 Road Inventory

Section		Land Use (Res / Com)		Cross Section Details											ROW (m)	Remarks
				LHS						RHS						
From	To	LHS	RHS	Distance of boundary	Foot Path	Earthen Shoulder	Paved Shoulder	Carriage way	Median	Carriage way	Paved Shoulder	Earthen Shoulder	Foot Path	Distance of boundary		
9+800	9+900					1	1.5	7	0.5	7					17	1) RTO office on LHS (Photo No: 53)
																2) Advent Christian Church on RHS @ 9+850 (Photo No: 54)
																3) Sai soubodhaya appartment on RHS @ 9+900 (Photo No: 55)
9+900	10+000					1.5	2	7	1	7	1			2	21.5	1) Electric Transformer on RHS @ 9+910
																2) Two bus stops on LHS paved shoulders @9+920
																3) RTO office Boudary end on LHS at 9+920
																4) 13/4 km stone @ 9+935
																5) Cross road of3.5 m wide on LHS @ 9+995
10+000	10+100					1		7	1	7	1	0.5			17.5	1) Mosque on RHS @ 10+062 (Photo No: 56)
																2) electric box on LHS earthen shoulder @ 10+080
																3) 13/5 km stone @ 10+035
10+100	10+200	R/C	R/C			1	2	7	1	7	2	1	2		23	1)Bus stop @10+155 on LHS
																2)Ganesh temple@10+150 on LHS (Photo No57)
																3)Cross Road of 3.5m wide@10+150 on RHS
																4)Cross Road of 3.0mwide@10+160 on LHS
																5)Cross Road of 3.5m wide@10+210 on RHS
10+200	10+300	R/C	R/C				2	7	1	7	1	2			20	1) Post Box and Earthen Shoulder @ 10+230 on RHS
																2)Bus stop and Earthen Shoulder@ 10+250 on RHS
																3)Cross Road of 3.5m wide @ 10+260 on LHS
																4)Electric Box @ 10+260 on LHS of Cross Road
																5)Telephone Box @10=300 on LHS
10+300	10+320	R/C	B U			1		7	1	3.5					12.5	1)Cross Road of 3.5m wide @ 10+320 on LHS
10+320	10+400	R/C	R/C		2		2	7	1	7	1		2		22	1)Cross Road of 5m wide @ 10+330 on RHS
																2)13+800 K M Stone is @ 10+335 and median lighting ends
																3)Cross Road of 3.5m wide @10+370 on RHS
10+400	10+500	R/C	R/C			2	2	7	1	7	2	2			23	1)13+900 K M Stone is @ 10+435
																2)A Junction @ 10+445 on RHS
																3)Cross Road of 3.5m wide @ 10+445 on LHS
																4)No F P & P S @ 10+445 Junction

Annexure 2.1 Road Inventory

Section		Land Use (Res / Com)		Cross Section Details												ROW (m)	Remarks
				LHS						RHS							
From	To	LHS	RHS	Distance of boundary	Foot Path	Earthen Shoulder	Paved Shoulder	Carriage way	Median	Carriage way	Paved Shoulder	Earthen Shoulder	Foot Path	Distance of boundary			
10+500	10+600	R/C	R/C			1	2	7	1	7		1				19	1)Cross Road of 3.5m wide @ 10+580 on LHS
																	2)Road width decreased to 5.5m from 10+580 to 10+600
10+600	10+700	R/C	R/C			1	2	7	1	7	1		2			21	1) A Temple @10+670 on RHS (Photo No 60)
																	2)Cross Road of 3m wide @10+660 on LHS
																	3)Fish Market & Water tank @10+700 on RHS (Photo No 61&62)
																	4)Cross Road of 3m wide @10=700 on LHS
10+700	10+800	R/C	R/C				2	7	1	7	2		2			21	
10+800	10+900	R/C	R/C			2		7	1	7		2					1)Cross Road of 2m wide @10+820 on LHS
																	2)Petrol Bunk (B P) @ 10+830 on RHS (Photo No 64)
																	3)Cross Road of 3m wide @ 10+840 on RHS
																	4)Cross Road of 3.5m wide @ 10+890 on LHS
10+900	11+000	R/C	R/C				2	7	1	7	2		2				1)Petrol Bunk (Indian Oil) @ 10+925 on LHS (Photo No 65)
																	2)14+400 K M Stone is @10+935
																	3)Hyundai Kun shop @10+960 on RHS (Photo No 66)
																	4)Petrol Bunk (B P) @10+990 on LHS
11+000	11+100	R/C	R/C				2	7	1	7	2		2			21	1)Four Road Junction @ 11+060
																	2)Ganesh Temple @ 11+040 on RHS (Photo No 67,68)
																	3)Palavakkam Corporation Primary School @11+090 on RHS (Photo No 70,71)
																	4)Road width reduced to 5.5m from 11+040 to 11+060 on LHS
11+100	11+200	R/C	R/C			2	2	7	1	7	1		2			22	1)End Point of option 1@11+110 (photo no 72,73)
																	2)14+600 K M Stone is @ 11+135
																	3)Transformer & Electricity Box @ 11+115
11+200	11+300	R/C	R/C				1	7	1	7	1					17	1)14+700 K M Stone is @ 11+235
																	2)Cross Road 2m wide @11+250 on LHS
																	3)Palavakkam C S I Church @ 11+270 on LHS (Photo No,74)

Annexure 2.1 Road Inventory

Section		Land Use (Res Com)		Cross Section Details											ROW (m)	Remarks
				LHS					Median	RHS						
From	To	LHS	RHS	Distance of boundary	Foot Path	Earthen Shoulder	Paved Shoulder	Carriage way		Carriage way	Paved Shoulder	Earthen Shoulder	Foot Path	Distance of boundary		
11+300	11+400	R/C	R/C				1	7	1	7	1				17	1)14+800 K M Stone is @ 11+335
																2)Cross Road 3.5m wide is @ 11+390 on RHS
11+400	11+500	R/C	R/C				1	7	1	7	1				17	1)Cross Road of3.5m wide @ 11+480 on LHS
11+500	11+635	R/C	R/C			2	2	7	1	7	1				20	1)15+000 K M Stone is @ 11+535
																2)Cross Road of 3.5m wide @11+620 on LHS
																3)Temple &Transformer @ 11+620 on RHS (Photo No 75)
																4)15+100 K M Stone is @ 11+635

(Via) Santhome Bypass, Sreenivasapuram, Uoorurkuppam including construction of a high level Bridge across Adyar Estuary to join ECR

CLASSIFIED VOLUME COUNT SURVEY

Station : **Shift : Day/ Night** **Date :**

Direction : **Weather : Sunny/Cloudy/Rainy** **Enumerator :**

Time 24:00 Hours Format	Bus					Private Vehicles & IPT						Goods Vehicles			Slow Moving Vehicles			
	MTC	Mofussil Bus	Company Bus	Other Bus	Mini Bus/ van	Old Car/Jeep	New Car/Jeep	Two Wheelers	Pass. Auto	Share Auto	Goods Auto	Trucks	MAV	LCV	Cycles	Hand Carts	Fish Carts	Cycle Rickshaw
Total (Hourly)																		

Traffic Study for Preparation of Detailed Feasibility Report for Construction of a link road from Light House on Kamarajar Salai to Besant Nagar (Via) Santhome Bypass, Sreenivasapuram, Uoorurkuppam including construction of a high level Bridge across Adyar Estuary to join ECR

ROAD SIDE INTERVIEW SURVEY

Name of the Road : **Interviewer :**

Location : **Date :** **Day:**

Direction : **Time (24:00 Hours Format) :** **Sheet No:**

Vehicle Type	Trip Frequency	Occupancy	Origin of the Trip Origin of the Trip	Destination of the Trip	Purpose of Journey	Goods Vehicle Only		Willingness to use the new road
						Goods Type	Loading in Tonnes	
1. Truck 2. MAV 3. LCV 4. Car/Jeep/van 5. Auto 6. Two Wheeler	1. 1/Day 2. 2/ Day 3. 3/Day 4. >3/Day 5. 1/Week 6. 2/Week		**City:** **Area Name :** **Street Name :**	**City :** **Area Name :** **Street Name:**	1. Work 2. Business 3. Education 4. Social & Recreation 5. Tourism 6. Others	1. Foodgrains, Cereals 2. Perishables Goods (Vegetables, Eggs etc) 3. Petroleum Products 4. Building Materials 5. Industrial Materials 6. Garments 7. Parcel Lorries 8. Empty 9. Others (Specify)		1. Yes 2. No
1. Truck 2. MAV 3. LCV 4. Car/Jeep/van 5. Auto 6. Two Wheeler	1. 1/Day 2. 2/ Day 3. 3/Day 4. >3/Day 5. 1/Week 6. 2/Week		**City :** **Area Name :** **Street Name :**	**City :** **Area Name :** **Street Name :**	1. Work 2. Business 3. Education. 4. Social & Recreation 5. Tourism 6. Others	1. Foodgrains, Cereals 2. Perishables Goods (Vegetables, Eggs etc) 3. Petroleum Products 4. Building Materials 5. Industrial Materials 6. Garments 7. Parcel Lorries 8. Empty 9. Others (Specify)		1. Yes 2. No
1. Truck 2. MAV 3. LCV 4. Car/Jeep/van 5. Auto 6. Two Wheeler	1. 1/Day 2. 2/ Day 3. 3/Day 4. >3/Day 5. 1/Week 6. 2/Week		**City:** **Area Name :** **Street Name :**	**City :** **Area Name :** **Street Name :**	1. Work 2. Business 3 .Education 4. Social & Recreation 5. Tourism 6. Others	1. Foodgrains, Cereals 2. Perishables Goods (Vegetables, Eggs etc) 3. Petroleum Products 4. Building Materials 5. Industrial Materials 6. Garments 7. Parcel Lorries 8. Empty 9. Others (Specify)		1. Yes 2. No

Sl.No	Junction / Turning Point	*QJT*			*JLT*			Time taken to travel (in sec) excluding delay	Delay in sec	Length of Jn (in Km)	Speed in Km/sec	Speed in Kmph
		min	sec	tot tim (sec)	min	sec	tot tim (sec)					