Government of India
Government of Tamil Nadu
Highways & Minor Ports Department (HMPD)
Tamil Nadu Infrastructure Development Board (TNIDB)

PREPARATORY STUDY FOR CHENNAI PERIPHERAL RING ROAD DEVELOPMENT IN INDIA

FINAL REPORT

VOL.1

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Japan International Cooperation Agency (JICA)

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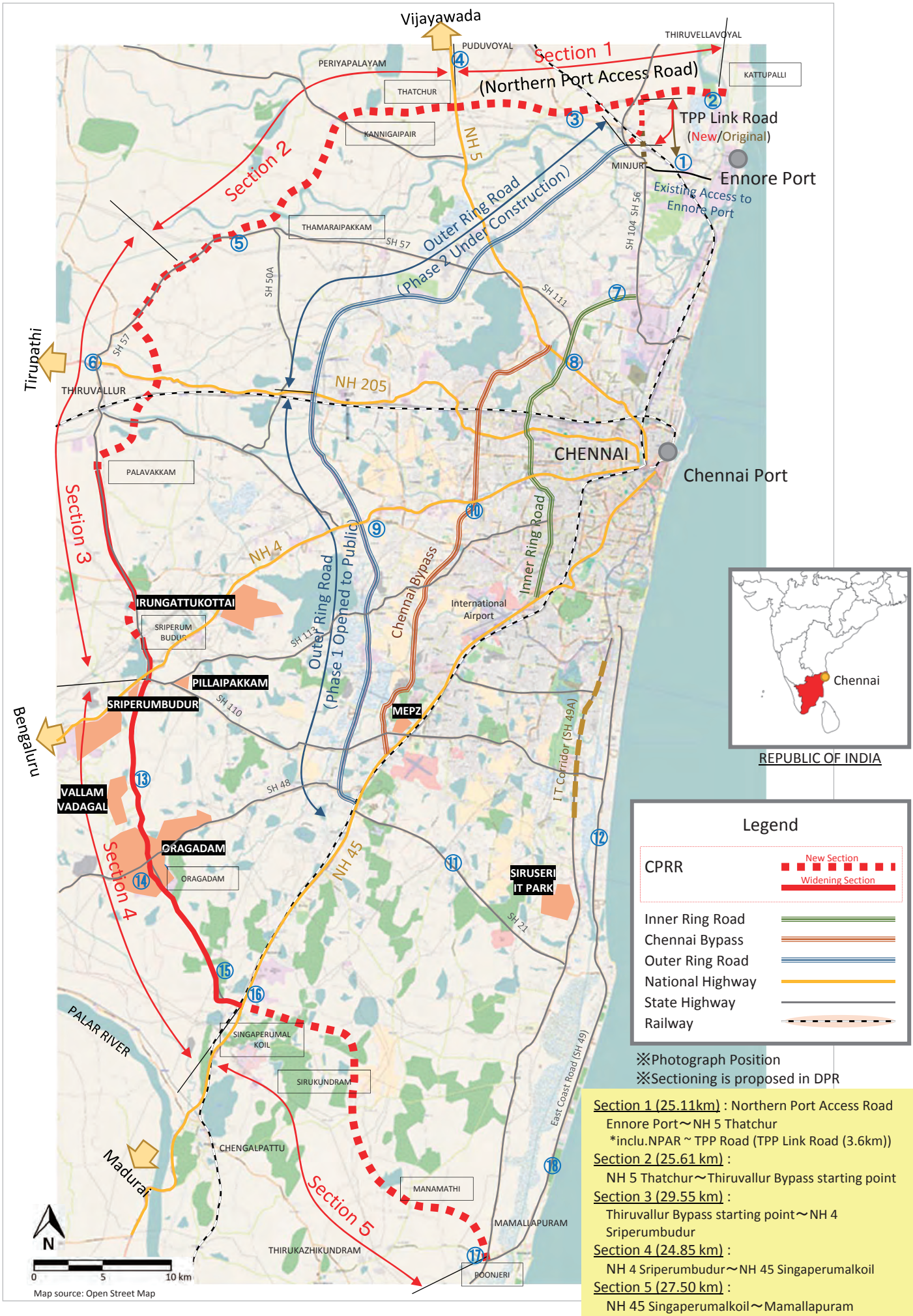

Section 1 (25.11km) : Northern Port Access Road
Ennore Port～NH 5 Thatchur
*inclu.NPAR ~ TPP Road (TPP Link Road (3.6km))

Section 2 (25.61 km) :
NH 5 Thatchur～Thiruvallur Bypass starting point

Section 3 (29.55 km) :
Thiruvallur Bypass starting point～NH 4 Sriperumbudur

Section 4 (24.85 km) :
NH 4 Sriperumbudur～NH 45 Singaperumalkoil

Section 5 (27.50 km) :
NH 45 Singaperumalkoil～Mamallapuram

LOCATION MAP OF CHENNAI PERIPHERAL RING ROAD

		
①	②	③
		
④。	⑤	⑥
		
⑦	⑧	⑨

EXISTING CONDITIONS (1/2)

		
⑩	⑪	⑫
		
⑬	⑭	⑮
		
⑯	⑰	⑱

EXISTING CONDITIONS (2/2)

PREPARATORY STUDY FOR CHENNAI PERIPHERAL RING ROAD DEVELOPMENT IN INDIA

FINAL REPORT VOL.1

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Abbreviations

ATIS	Advance Traveler Information System
ATCC	Automatic Traffic Counter cum Classifier
ATCS	Area Traffic Signal Control System
BC (B/C)	Benefit Cost Ratio
BRT	Bus Rapid Transit
BTS	Bus Tracking System
BP	Beginning Point
CE	Chief Engineer
CEO	Chief Executive Officer
CFO	Chief Financial Officer
CFS	Container Freight Station
CCTV	Closed-Circuit Television
CMA	Chennai Metropolitan Area
CMDA	Chennai Metropolitan Development Authority
CMRL	Chennai Metropolitan Rail Limited
CMWSSB	Chennai Metropolitan Water Supply and Sewerage Board
CP (C/P)	Counterpart
CPRR	Chennai Peripheral Ring Road
CRZ	Coastal Regulation Zone
C/S	Construction Supervision
CSCL	Chennai Smart City Limited
CTP	Chennai Traffic Police
CTTS	Comprehensive Traffic and Transportation Study
D/D	Detailed Design
DEA	Department of Economic Affairs
DFR (DF/R)	Draft Final Report
DOE	Department of Environment
DPR	Detailed Project Report
EC	Environmental Clearance
ECR	East Coast Road
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMP	Environmental Management Plan
EP	End Point
ETC	Electronic Toll Collection
ETMS	Electronic Ticket Management System
F/F	Fact Finding
FIDIC	Federation International des Ingenious-Conseils
FIRR	Financial Internal Rate of Return
FMB	Field Measurement Book
FR (F/R)	Final Report
GCC	Greater Chennai Corporation
GOI	the Government of India
GOJ	the Government of Japan
GoTN	the Government of Tamil Nadu
GPS	Global Positioning System
GST	Goods and Service Tax
HMPD	Highways & Minor Ports Department
HTMS	Highway Traffic Management System
IC	Interchange
ICR (IC/R)	Inception Report
IHMCL	Indian Highways Management Company Limited

IIT	Indian Institute of Technology
IPCC	Intergovernmental Panel on Climate Change
IRC	Indian Road Congress
IRR	Inner Ring Road/Internal Rate of Return
IT	Information Technology
ITMS	Integrated Traffic Management System
ITR	Interim Report
ITS	Intelligent Transport System
JCT (Jct)	Junction
JICA	Japan International Cooperation Agency
JST	JICA Study Team
LA (L/A)	Loan Agreement
LARAP	Land Acquisition & Resettlement Action Plan
LPS	Land Plan Schedule
LVUP	Light Vehicle Under Pass
MJB	Major Bridge
MM (M/M)	Man-Month
MNB	Minor Bridge
MTC	Metropolitan Transport Corporation
MORTH	Ministry of Road Transport and Highways
NEXCO	Nippon Expressway Co., Ltd.
NH	National Highway
NHAI	National Highway Authority of India
NPV	Net Present Value
NURM	National Urban Renewal Mission
NUTP	National Urban Development Plan
OD	Origin & Destination
ODA	Official Development Assistance
OM (O&M)	Operation & Maintenance
ORR	Outer Ring Road
PAF	Project Affected Family
PAH	Project Affected Household
PAP	Project Affected Person
PIS	Passenger Information System
PIT	Project Implementation Team
PMC	Project Management Consultant
PWC	Pricewaterhouse Cooper
PQ	Pre-Qualification
RAP	Resettlement Action Plan
RF	Reserved Forest
RFID	Radio Frequency IDentifier
ROB	Railway Overhead Bridge
ROW	Right of Way
SBD	(JICA) Standard Bidding Documents
SEC (Sec)	Section
SH	State Highway
SIA	Social Impact Assessment
SLA	Service Level Agreement
SPM	Suspended Particulate Matter
SS	Suspended Solids
STL	Sub Team Leader
SPV	Special Purpose Vehicle
TANGEDCO	Tamil Nadu Generation and Distribution Corporation
TEU	Twenty-foot Equivalent Unit
TIS	Traffic Information System

TL	Team Leader
TMS	Traffic Management System
TN	Tamil Nadu
TNIDB	Tamil Nadu Infrastructure Development Board
TNRDC	Tamil Nadu Road Development Company
TNRSP	Tamil Nadu Road Sector Project
TNSDC	Tamil Nadu State Data Center
TNSEAC	Tamil Nadu State Expert Appraisal Committee
TNSEIAA	Tamil Nadu State Environmental Impact Assessment Authority
TNSPCB	Tamil Nadu State Pollution Control Board
TPP	Tiruvottiyur Ponneri Pancheti
TPY	Truck Parking Yard
TUFIDCO	Tamil Nadu Finance and Infrastructure Development Corporation
UNFCCC	United Nations Framework Convention on Climate Change
VGF	Viability Gap Funding
VMS	Variable Message Signs
VUP	Vehicle Under Pass
WB	World Bank
WIM	Weigh-In-Motion

1. INTRODUCTION

1.1 Background of the Study

As in other major cities in India, traffic congestion is getting worse in Chennai Metropolitan Area (hereinafter referred to as "CMA"), which is the target area of the study, because road infrastructure improvements have not caught up with the increase in traffic demand due to population growth and economic development.

The Government of Tamil Nadu (GoTN) is promoting the development of roads and public transportation as a countermeasure to traffic congestion in CMA. The major arterial road network in CMA consists of National Highways No. 5, No. 205, No. 4, and No. 45 as major radial roads, and Inner Ring Road (IRR), Chennai Bypass, and Outer Ring Road (ORR) as ring roads. The implementation of the Chennai Peripheral Ring Road (CPRR) Project is expected to contribute to the further expansion of the Radial-Ring Road Network corresponding to the growing traffic demand.

In addition, as a countermeasure to alleviate congestion at the center of CMA where the development site for road infrastructure is limited, the improvement of Intelligent Transport System (ITS) facilities that promote efficient use of the road is an issue.

Based on this background, the Government of India (GoI) has prepared the Detailed Project Report (DPR) describing the development plan of CPRR and ITS and has requested the Government of Japan (GoJ) for loan assistance.

1.2 Objectives of the Study

The study aims to collect necessary information to appraise the Project for it to be implemented under the Official Development Assistance (ODA) scheme through the confirmation of the objectives and the outline of the Project, including project cost, implementation schedule, procurement and construction method, project organization, capability of operation and maintenance, as well as social and environmental conditions.

1.3 Target Sections of the Study

The DPR presents the implementation plan for the following:

- Construction of CPRR (widening section: 36.5 km, new section: 96.9 km, total: 133 km), and
- Development of ITS facilities for CPRR and for the CMA road network.

1.4 Components of the Final Report

The subject of this study was originally the CPRR Project and the Chennai City ITS Project; however, the procedure for environmental and social consideration of the CPRR Project was delayed. For this reason, JICA decided to separate the Chennai City ITS Project from the CPRR Project and aimed only for the Chennai City ITS project as the initial goal for the March 2018 Loan Agreement (L/A). For the CPRR project, JICA and HMPD confirmed that the section 1 will be the priority for the ODA loan.

With this, the CPRR Project is compiled as Volume 1 and the Chennai City ITS Project as Volume 2 in this report.

2. PRESENT CONDITION AND CIRCUMSTANCES OF THE PROJECT

2.1 Outline of the Chennai Peripheral Ring Road (CPRR) Development Project

Objectives of the Project

The objective of the project is to address the rapidly increasing road traffic demand in the Chennai Metropolitan Area (CMA) by constructing CPRR and developing Intelligent Transport System (ITS) facilities, thereby contributing to the sustainable economic growth in CMA. The Project is expected to improve the connectivity in and around Chennai City by:

- Formulating the Radial-Ring Road Network in CMA in collaboration with other ring roads such as the Inner Ring Road (IRR), the Chennai Bypass, and the Outer Ring Road (ORR) in order to provide alternate routes for traffic as well as to improve redundancy of the road network,

- Providing a direct access to Ennore Port and Kattupalli Port from industrial clusters located in suburban areas of CMA in order to accelerate industrial and economic growth, and
- Improving efficiency in the use of the road network by providing ITS facilities such as a traffic information system and a traffic management system for CPRR and the central area of CMA.

Past Studies on the Project

CPRR was conceptualized to provide better connectivity around the city catering to future traffic requirements, and to provide efficient commercial transportation by enhancing port connectivity. This road will facilitate container movement from the southern districts to Ennore Port and Kattupalli Port.

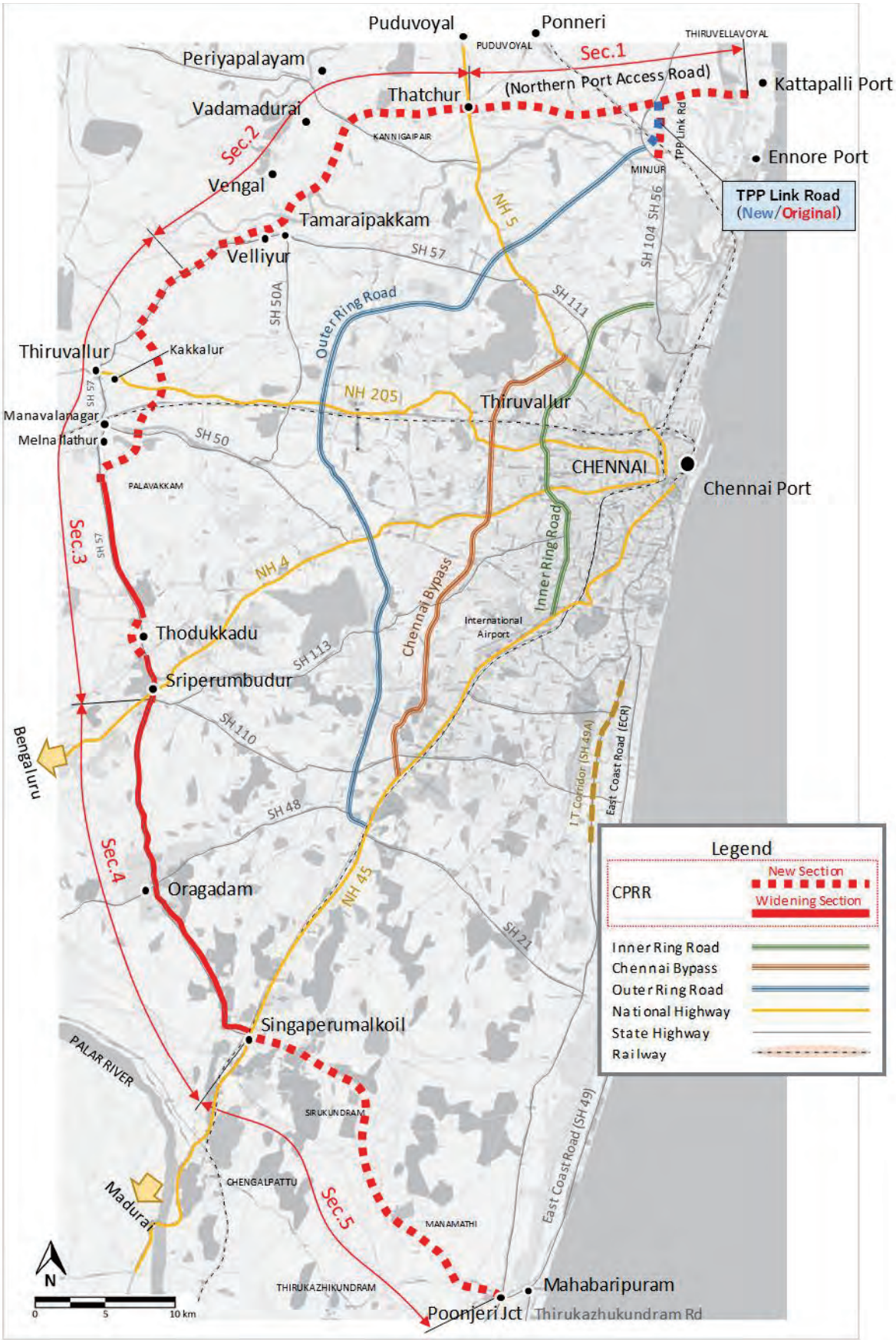
According to the DPR, the alignment of CPRR was approved by the Steering Committee and was finalized by the Principal Secretary of HMPD on 9 July 2014.

The JICA Study Team requested HMPD to provide all volumes of the DPR; however, some volumes were not available because they were under the process of obtaining concurrence from other concerned departments such as the Public Works Department (PWD) and the Water Resource Department (WRD).Although some parts of the DPR such as "Design Report (Structures)" and "Rate Analysis" were not available at the time of review, these were finally provided after February 2018. As such, the JICA Study Team obtained all documents except "Technical Specifications". However, further modification and updating by HMPD are still ongoing, even after receiving additional parts of the DPR; thus, there are inconsistencies among the series of the provided report.

2.2 Present Condition and Issues of Road Network

Roads in CMA have been developed following the pattern of the Radial-Ring Road Network as shown in Figure 2.2.1. Major radial roads which originate at the center of Chennai City are NH4 (towards Mumbai via Bengaluru), NH5 (towards Kolkata), NH45 (towards Madurai), and NH205 (towards Tirupathi). With respect to ring roads, the IRR was first proposed as a city bypass road in 1968, and construction started in the 1980s from its central arm connecting NH45 to NH5. Subsequently, the northern and southern arms were developed. Then, the second ring road, the Chennai Bypass, was opened in 2008. However, since the urbanized area of Chennai is rapidly expanding, these two ring roads were incorporated into the built-up area. Therefore, the third ring road, or the ORR, is currently being developed, and the CPRR was even proposed to enhance the road network for further expansion of the metropolitan area and increase of traffic demand.

Tamil Nadu State has highways and roads of 62,468 km in length, and a large part of National Highways (NH) and State Highways (SH) have double or more lanes (99% for NH and 97% for SH).



Source: JICA Study Team based on OpenStreetMap

Figure 2.2.1 Road Network in CMA

The issues of the road network in CMA are summarized as follows:

Concentration of Traffic in the Core Area of Chennai

The incompletion of the road network development in the pattern of the Radial-Ring Road Network in CMA (construction of ring roads has not caught up with the increase in traffic demand) is causing serious traffic congestion in major roads towards the city center. Traffic is concentrated particularly in the core area of Chennai. It was found that more than 200,000 vehicles per day are traversing NH45 and IRR, including motorbikes. On the other hand, the traffic volume on the same road but in the suburbs is less than 70,000 vehicles per day. Similar characteristics were found in other major roads. As a result, the travel speed of traffic towards Chennai City in the morning peak hour becomes less than 30 km/hr in the city center.

It is therefore required to disperse incoming traffic before it comes into the city center.

High Proportion of Large Vehicles

A high ratio of large vehicles is found in the suburban section of NH5, NH4, and NH45. This indicates that these roads are used by a large number of commercial vehicles, such as heavy lorries and trailers, to access the industrial areas and the Kattupalli/Ennore/Chennai Ports. The high proportion of slow-moving large vehicles causes a decrease in the overall travel speed of traffic.

A large number of large vehicles are frequently passing through small villages in the suburbs. Thus, there are a lot of pedestrians and motorcycles in the villages that are always facing high risks of traffic accidents.

Hence, a new link connecting industrial areas in the suburban area to ports shall be developed to ease the load of existing highways.

Expansion of Built-up Areas

Rapid economic growth and increase in the population of CMA is encouraging the urbanized built-up area to expand, thereby changing the classification of IRR and Chennai Bypass from bypass roads to urban highways. The ORR which is currently being constructed will be, once it opens, the newest ring road with the largest radius of 20 to 30 km; however, urban development is approaching such current outskirts.

The necessity of the development of further ring roads has been recognized to enhance the road network as well as improve redundancy of the network.

2.3 Present Condition and Issues of Traffic in the Study Area

Traffic Signal Shortage

There are many intersections without traffic signals in Chennai. At such intersections, barricades and roundabouts are adopted as alternative facilities. However, such facilities cause problems such as traffic congestion and increase in travel time. In addition, pedestrian safety is threatened because crossing at intersections without signals involves great danger.

In short, the lack of signals causes traffic congestion and prolonged travel time. Therefore, it is necessary to secure efficient traffic operation and pedestrian safety by installing traffic signals.

Processing Capacity and Operation at the Chennai Port

Due to the small processing capacity and the inefficient operation of the Chennai Port, large vehicles flow into community roads and form a long queue on roads.

Since improvements to the operation of Chennai Port and the utilization of Ennore Port are in progress, some developments to the situation are expected.

Issues due to the Road Structure/Operation

Although the ORR is partially open to public, there are problems of connection with the main radial roads. The junction at the connecting point with NH4 and NH45 is still under construction. Therefore, the ORR is not effectively utilized.

In Chennai, there are many sections where sidewalks and parking lots are not provided. In such sections, the risk of traffic accidents involving pedestrians is high, as parked vehicles occupy a lane, cause traffic jams, and increase travel time.

In addition, at many intersections of trunk roads, vehicles travelling on service roads cannot go straight or turn right, but must take a detour instead.

These road structure and operational problems lead to traffic congestion, increase in travel time, and fatal accidents. Therefore, it is required to improve the efficiency of traffic flow and pedestrian safety by reviewing the road structure and operations.

Deterioration of Pavement

There are sections where roads are depressed due to deterioration of pavement. Pavement deterioration lowers travel speed, making overtaking difficult. Especially in Chennai, where many industrial parks are located in suburbs, there is a large volume of heavy vehicles in the access roads, and depression of roads are also evident. Pavement deterioration also causes logistics problems such as damage in handling and transport of trucks and increase of logistics time. Therefore, it is necessary to improve road pavements to allow smooth flow of traffic.

3. TRAFFIC SURVEY, ANALYSIS, AND FORECAST

3.1 Traffic Survey

Objectives of the Project

The target of the traffic survey is the central urban area which is the introduction area for the traffic signal control system and the Chennai Peripheral Ring Road (CPRR). In the central urban area, traffic survey was carried out inside the Inner Ring Road (IRR) and the information technology (IT) corridor, in which the number of IT companies increased remarkably. In the CPRR, traffic survey was carried out at the starting point and cross section of each section.

Table 3.1.1 Outline of Traffic Survey

Survey	Objectives	Contents
Intersection Traffic Volume Survey	Indicators for measuring the effect of introducing intelligent transport system (ITS)	Inside IRR × 6 places
	Check traffic distribution	Around the IT corridor × 2 places
	Update the Origin-Destination (OD) table	CPRR × 8 places

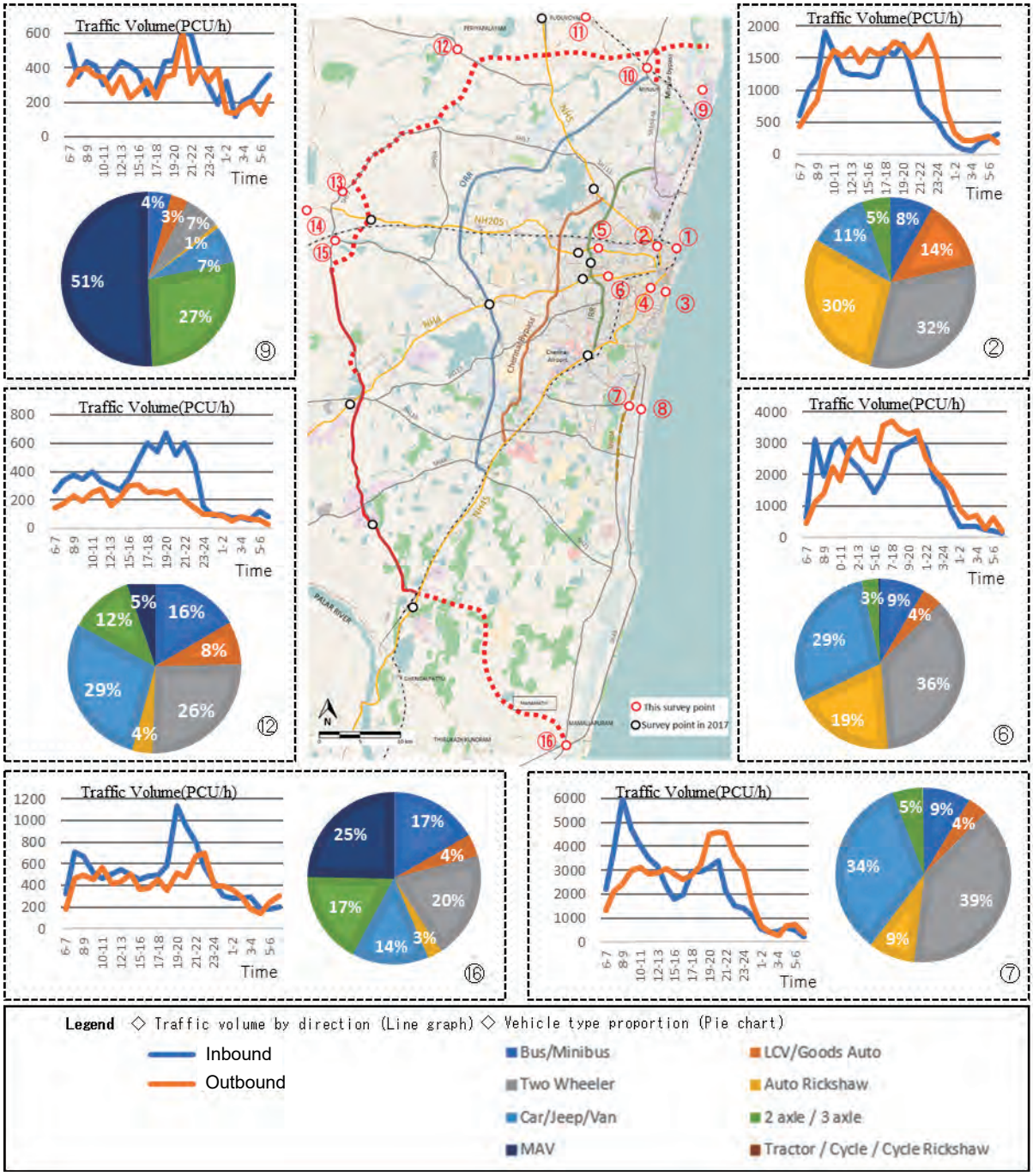
Source: JICA Study Team

Results of the Traffic Survey

The outline and the summary of the results of the traffic volume survey are shown in the figure below. In the city, inbound traffic is high in the morning, and outbound traffic increases in the evening. On the other hand, traffic tends to increase in the suburbs from evening to midnight.

The pie chart shows the ratio by type of vehicle. Gray portions indicate the proportion of two-wheeled vehicles. There are many motorcycles in the center of the Chennai, such that two-wheeled vehicles account for 39% in SH49A. On the other hand, the proportion of large vehicles is relatively higher in the suburbs than in the city.

As such, the city road is used for commuting in the morning and evening, while the suburban road is used for large vehicles such as heavy trucks from evening to midnight.



Source: JICA Study Team

Figure 3.1.1 Outline of Traffic Volume Survey Results

3.2 Hearing Survey for Related Development Plans

Traffic Demand Forecast

In this survey, traffic demand forecast was reasonably carried out using network analysis of the "Data Collection Survey for Chennai Metropolitan Region Intelligent Transport System" in 2017. Specifically, the method and year of estimation of traffic demand forecast were set to be the same as that of the survey. The following points were also considered:

- Data update using the result of traffic volume survey.
- Future traffic demand considering the development plan along CPRR and port development plan.

Future Traffic Demand Forecast

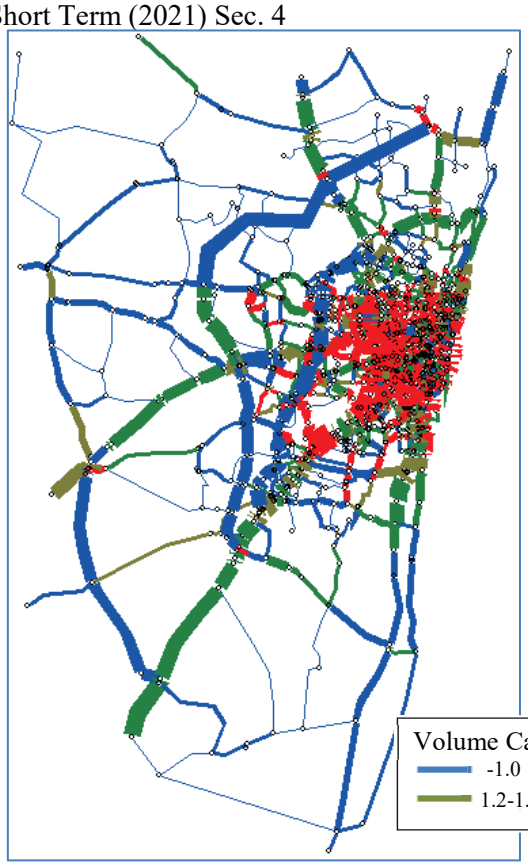
The results of the future traffic demand forecast for short term, mid-term and long term are shown in the figure below.

In the short term, the traffic capacity of the access road to the Ennore Port is expected to increase due to the increase in the cargo volume brought about by the improvement of the processing capacity at the Ennore Port. In addition, it is expected that there will be no problem in increasing the traffic volume of the ORR and the CPRR (Section 4), but it is expected that congestion will occur in the section from the ORR to the Ennore Port.

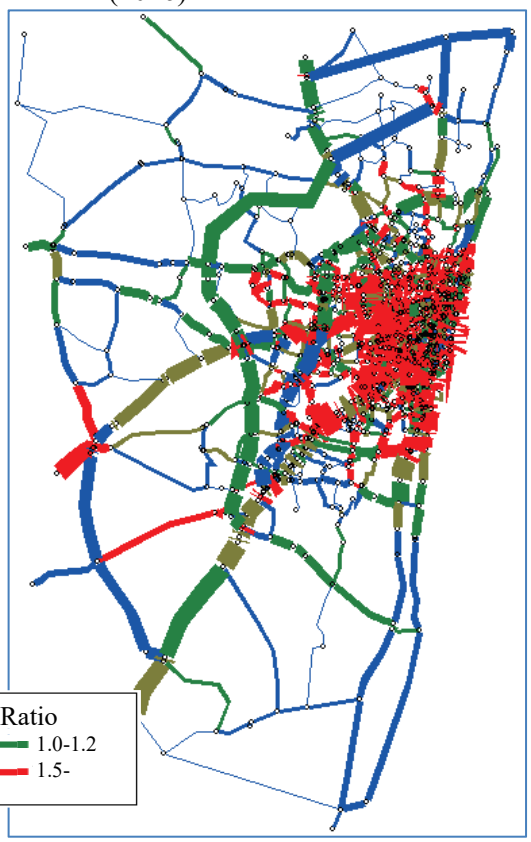
In the mid-term, it is expected that the congestion in the section from the ORR to the Ennore Port will be alleviated by constructing the CPRR (Section 1).

In the long term, traffic congestion occurrs in the city due to the increase in total traffic volume.

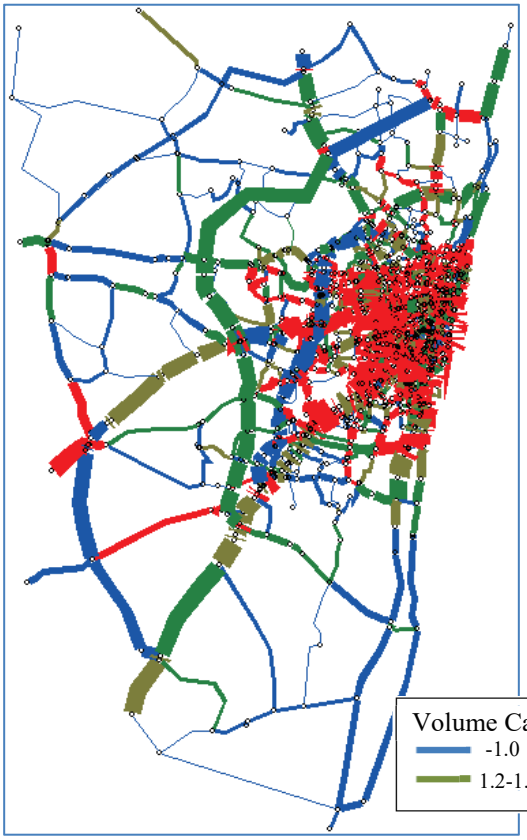
Short Term (2021) Sec. 4



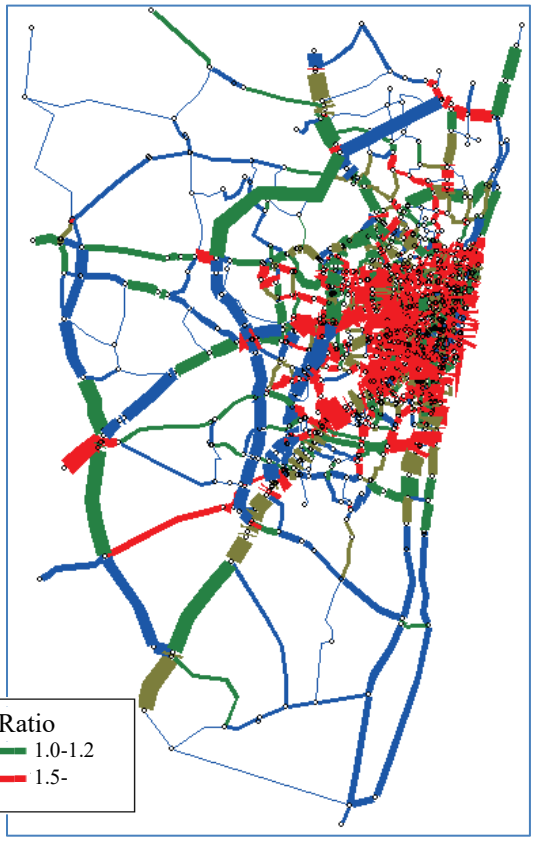
Mid Term (2026) Sec. 1 + Sec. 4

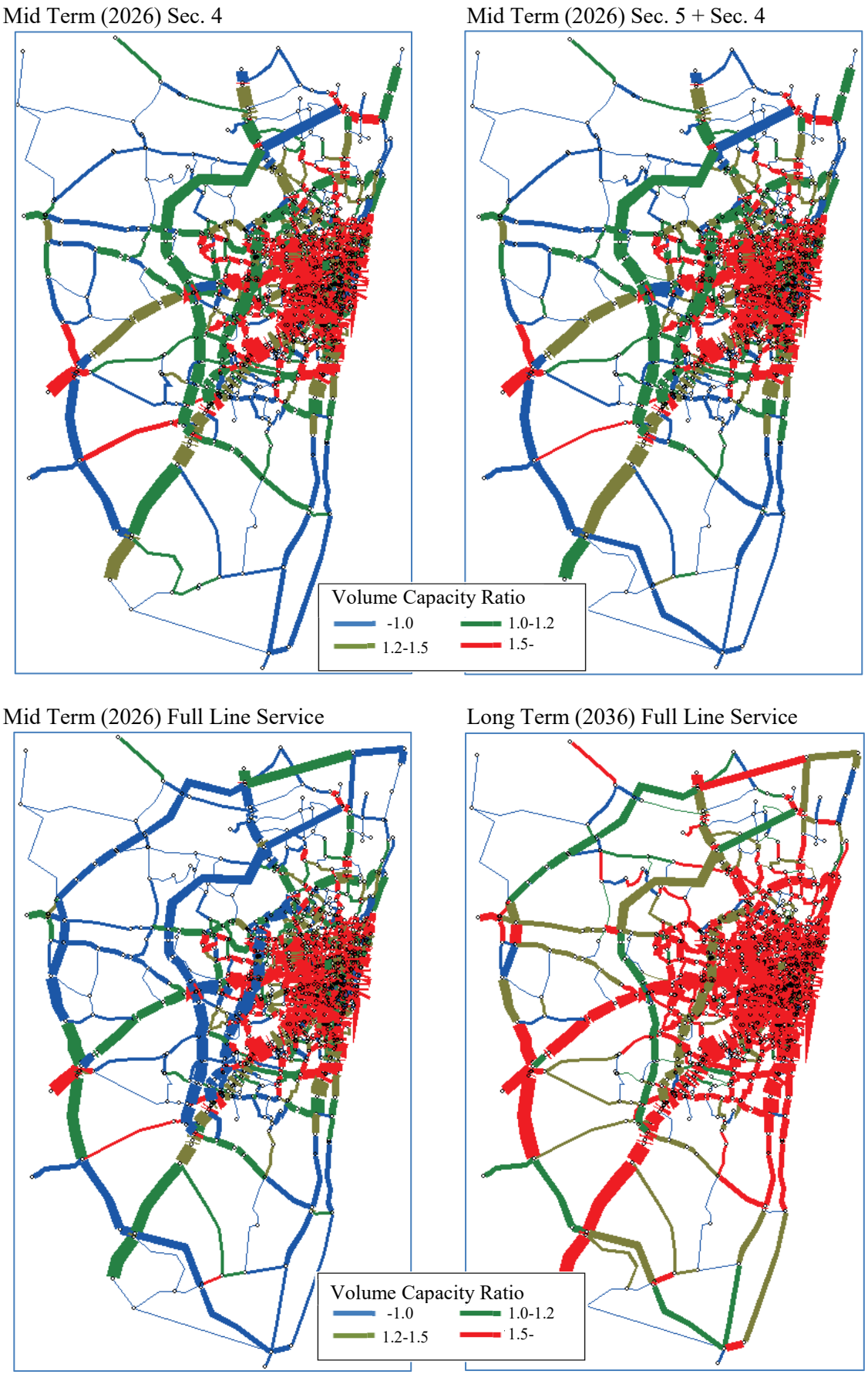


Mid Term (2026) Sec. 2 + Sec. 4



Mid Term (2026) Sec. 3 + Sec. 4





Source: JICA Study Team

Figure 3.2.1 Traffic Assignment Result

4. PRIORITIZATION AND FORMULATION OF THE PROJECT FOR JICA LOAN SCHEME

4.1 Approved Alignment and Sectioning of CPRR

According to the Detailed Project Report (DPR), the alignment for CPRR was approved by the Steering Committee and was finalized by the Principal Secretary of the Highways and Minor Ports Department (HMPD) on 9 July 2014. The CPRR starts at Ennore Port and ends at Poonjeri Junction (KM 56/800 of ECR) in Mahabalipuram. The alignment connects four national highways, namely NH5, NH205, NH4, and NH45, as well as eight state highways, namely SH51, SH50A, SH50, SH48, SH57, SH49B, SH49A (OMR), and SH49 (ECR). The length of the alignment is 133 km and is divided into five sections as follows:

- Sec. 1: Northern Port Access Road-Ennore Port to Thatchur on NH5, and

  CPRR (Ch.6+200) to Tiruvottiyur Ponneri Pancheti (TPP) Road via TPP Link Road (Connected point on TPP Road differs in original alignment and new alignment)
- Sec. 2: Thatchur on NH5 to the start of Thiruvallur Bypass
- Sec. 3: Start of Thiruvallur Bypass to Sriperumbudur on NH4
- Sec. 4: Sriperumbudur on NH4 to Singaperumalkoil on NH45
- Sec. 5: Singaperumalkoil on NH45 to Mahabalipuram

The outline of the sections is summarized in Table 4.1.1.

Table 4.1.1 Outline of Sections of CPRR

		Sec.1		Sec.2	Sec.3	Sec.4	Sec.5	TOTAL
		Main Road	TPP Link	Main Road	Main Road	Main Road	Main Road	
Section Length		21.51km	3.6km	25.61km	29.55km	24.85km	27.5km	132.62km
Scope of Work	New Construction	21.51km	3.6km (4.21km)	25.61km	19.95km	0km	25.5km	96.17km
	Improvement	0km	0km	0km	9.6km	24.85km	2km	36.45km
ROW		100m	45-60m	60m	60m	40-60m	60m	
Land Acquisition Area		255ha		188ha	208ha		163ha	814ha
Number of Lane	Main Line	2x2Lane	2x2Lane	2x3Lane	2x3Lane	2x3Lane	2x2Lane	
	Service Rd	2x2Lane	2x2Lane	2x2Lane	2x2Lane	2x2Lane	2x2Lane	
BP		Ch.0+000 /Ennore Port	TPP Link Ch.0+351 /CPRR (Ch.6+200)	Ch.21+506 /NH5 (29/000)	SH57 (50/500)	NH4 (42/100)	NH45 (47/400)	
EP		Ch.21+506 /NH5 (29/000)	TPP Link Ch.3+950 /TPP Rd	SH57 (50/500)	NH4 (42/100)	NH45 (47/400)	Ch.129+171 (Poonjeri)	
Structures	IC	0	0	1	2	0	1	4
	ROB	1	1	0	1	0	1	4
	MJB	1	0	2	1	0	1	5
	MNB	1	0	6	8	0	11	26
	VUP	6	0	5	6	9	6	32
	LVUP	6	0	4	2	4	7	23
	BC	39	0	0	1	0	7	47
	PC	8	0	204	107	0	132	451
	Entry/Exit Ramps	0	0	2	2	0	2	6

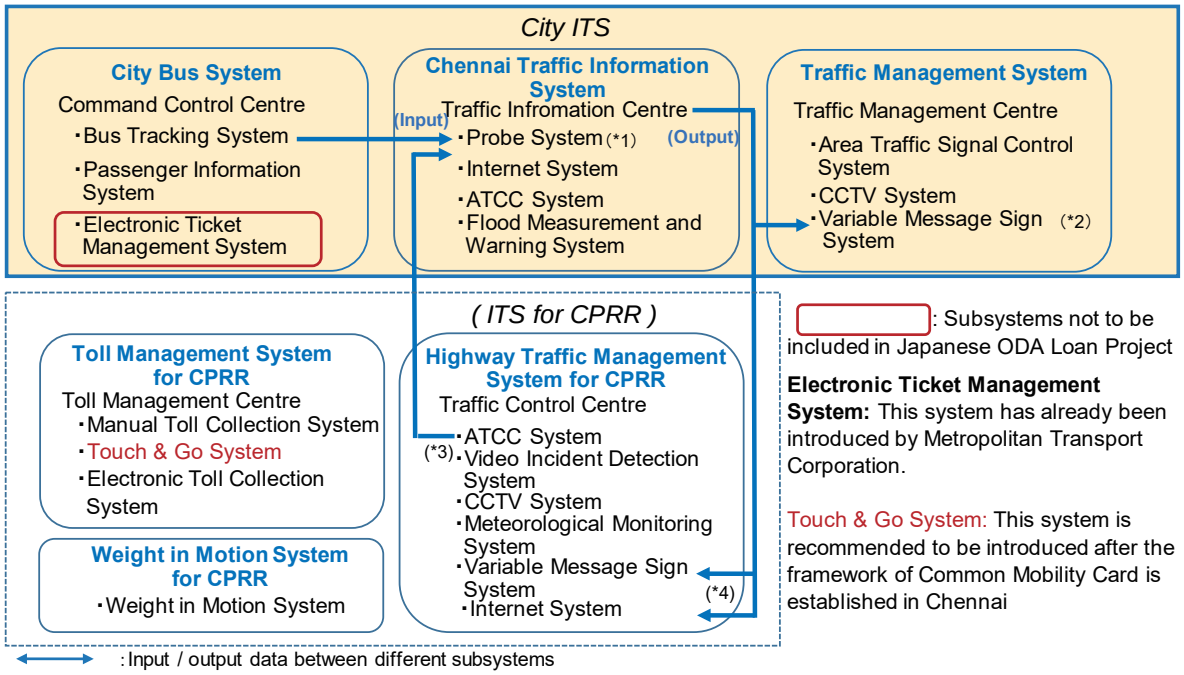
Source: Land Acquisition Area: STUP's Letter E/14518/149/NJW/GK/0132 dated 11 Aug 2017,
Chainage of BP/EP of each section: JICA Study Team estimates, Other Items: DPR Main Report, From P7-2 To P7-5

Note: 1) CPRR: Chennai Peripheral Ring Road, IC: Interchange, ROB: Railway Over Bridge, MJB: Major Bridge, MNB: Minor Bridge, VUP: Vehicular Underpass, LVUP: Light Vehicular Underpass, BC: Box Culvert, PC: Pipe Culvert
2) BC and PC are planned for irrigation and utility crossings.
3) MJB: Sec.1: Buckingham Canal, Sec.3: Kannigaipper Tank, Kosathalai River, Sec.4: Coovam River, Sec.5: Sengundram Tank
4) The alignment of TPP Link was modified and the section length was changed from 4.21km to 3.6km.

With respect to the TPP Link Road, HMPD conducted a survey on alternate alignments in May to June 2018, as the inhabitant's opposition were encountered on the original alignment. In early July, the state government decided that the new alignment would start from the TPP road around Minjur to the Northern Port Access Road (NPAR) (as a main line of Section 1), having a length of 3.6 km, Also, the new alignment connects to the Outer Ring Road (ORR) near Minjur.

4.2 ITS Components

Figure 4.2.1 shows the overall Intelligent Transport System (ITS) components which are candidates for the Japanese ODA Loan Project. As described in 1.1 in this report, the ITS for CPRR was considered separately from the City ITS. The system linkage with the City ITS, as shown in Figure 4.2.1, will be established after introducing the ITS for CPRR.



*1: To generate congestion information on the road network based on the probe data obtained from Bus Tracking System

*2: To provide congestion information on the general roads under the authority of Traffic Police

*3: To complement the Probe System to generate congestion information after completion of CPRR

*4: To provide congetion information generated by Chennai Traffic Information System. Other information will be generated by Highway Traffic Management System for CPRR and provided.

Source: JICA Study Team

Figure 4.2.1 Overall ITS Components for Japanese ODA Loan Project

Regarding the Touch & Go System, the Japan International Cooperation Agency (JICA) Study Team recommended to adopt the common mobility card which can be used for other transport modes, e.g., Chennai Metro Rail, city buses, etc. In case the common mobility card does not exist yet in Chennai, the Touch & Go System should be introduced after the framework of the common mobility card is established in Chennai.

4.3 Prioritization of CPRR Components

In this Study, the prioritization is made by setting out the evaluation criteria shown in Table 4.3.1.

As a result, it is recommended that the 1st priority be given to Section 1, the 2nd priority to Sections 2 and 3, and the 3rd priority to Section 5 considering that Sections 2 and 3 shall be developed simultaneously since they will form a united road section from the viewpoint of completeness of the CPRR.

Table 4.3.1 Evaluation Criteria for Prioritization

Criteria		Indicator	Evaluation (Score)		
			High	Middle	Low
1	Effect on Improvement of Traffic Situation	Traffic Volume (pcu/day)	**10:** 100,001- **9:** 75,001-10,000 **8:** 50,001-75,000	**7:** 40,001-50,000 **6:** 30,001-40,000 **5:** 20,001-30,000 **4:** 10,001-20,000	**3:** 7,501-10,000 **2:** 5,001-7,500 **1:** 2,501-5,000 **0:** -2,500
		Reduction in Total Travel Time (vehicle hour)	**10:** 100,001- **9:** 75,001-10,000 **8:** 50,001-75,000	**7:** 40,001-50,000 **6:** 30,001-40,000 **5:** 20,001-30,000 **4:** 10,001-20,000	**3:** 7,501-10,000 **2:** 5,001-7,500 **1:** 2,501-5,000 **0:** -2,500
		Large Vehicle Rate (%)	**10:** 41- **9:** 36-40 **8:** 31-35	**7:** 26-30 **6:** 21-25 **5:** 16-20 **4:** 10-15	**3:** 8.0-9.9 **2:** 6.0-7.9 **1:** 4.0-5.9 **0:** -3.9
2	Magnitude of Environmental and Social Impact	Impact on Reserved Forest and Coastal Regulation Zone	**5:** RF: - **5:** CRZ: -	**2:** RF: 0-4ha **2:** CRZ: III	**0:** RF: 5ha- **0:** CRZ: I, II
		Area of Land to be Acquired (ha)	**10:** -50 **9:** 51-100 **8:** 101-150	**7:** 151-200 **6:** 201-250 **5:** 251-350 **4:** 351-400	**3:** 401-600 **2:** 601-800 **1:** 801-1,000 **0:** 1,001-
3	Economic Rationality	EIRR (%)	**10:** 28.0- **9:** 24.0-27.9 **8:** 21.0-23.9	**7:** 18.0-20.9 **6:** 15.0-17.9 **5:**12.0-14.9 **4:** 9.0-11.9	**3:** 8.0-8.9 **2:** 7.0-7.9 **1:** 6.0-6.9 **0:** -5.9

Source: JICA Study Team

Table 4.3.2 Evaluation Results for Prioritization

Criteria		Indicator		Sec.1	Sec.2	Sec.3	Sec.5
1	Effect on Improvement of Traffic Situation	Traffic Volume (pcu/day)		58,324	31,184	89,528	43,282
			SCORE	**8**	**6**	**9**	**7**
		Reduction in Total Travel Time (vehicle hour)		54,871	45,192	67,494	26,239
			SCORE	**8**	**7**	**8**	**5**
		Large Vehicle Rate (%)		76	13	25	27
			SCORE	**10**	**4**	**6**	**7**
2	Magnitude of Environmental and Social Impact	Impact on Reserved Forest and Coastal Regulation Zone		RF: - CRZ: Cat..III	RF: - CRZ: -	RF: 0.28 CRZ: -	RF: 9.95 CRZ: -
			SCORE	**7**	**10**	**7**	**5**
		Area of Land to be Acquired (ha)		255	188	208	163
			SCORE	**5**	**7**	**6**	**7**
3	Economic Rationality	EIRR (%)		18.1	19.7	20.2	12.8
			SCORE	**7**	**7**	**7**	**5**
TOTAL SCORE				45	41	43	36
PRIORITY				**1**	**3**	**2**	**4**

Source: Land Acquisition Area: STUP's Letter E/14518/149/NJW/GK/0132 dated 11 Aug 2017,
Project Cost: Construction Cost shown in DPR Main Report, P9-3

1st **2nd** **3rd**

During the consultation with inhabitants around the site of the TPP Link Road (Original Alignment), it was found that it is very important to obtain social consensus for the road construction. As an alternative solution to minimize the social impact, the south end of the TPP Link Road is to be shifted approximately 1.5 km west of the original alignment. This new alternative alignment has a total length of 3.6 km from the connecting point with Northern Port Access Road to the southern end. The length of 1.65 km in the northern part is the same as the original alignment, and the remaining 1.95 km in the southern part is different from the original alignment.

4.4 Consulting Services for the Prioritized Project

4.4.1 CPRR

Mode of Contract Scheme

A model of the Engineering, Procurement, and Construction (EPC) contract mode has been published by the Planning Commission for highway projects in India based on past experiences in infrastructure development, where the conventional item-rate contract is said to be generally prone to time and cost overruns. This is particularly evident in the national highway sector, resulting in enhanced cost to the financing institutions, and also considerable delay in the completion of projects.

Most of the EPC contracts in India, except for the projects financed by the multilateral development banks World Bank and Asian Development Bank awarded since 2014, seem to have been affected by Local Competitive Bidding (LCB) in accordance with the procedures used in India. EPC has also been introduced in state highway projects, and applications of the EPC for CPRR is one of options according to HMPD.

Tender Method of Consultant Procurement

A supervising consultant selected by the executing agency through International Competitive Bidding (ICB) will discharge the functions and duties of an Authority's Engineer (AE) as per the Terms and Conditions of the EPC Agreement.

With the intention of maintaining high quality in the works executed by the contractor, the JICA Study Team recommends applying 'Procurement of Works' of the 'JICA Standard Bidding Documents Under Japanese ODA Loans (Works)' which follows the general conditions of the Federation International des Ingenious-Conseils (FIDIC MDB) Harmonized Edition. Detailed design is also recommended to supplement further design related information from the DPR to be used for bidding by the JICA SBD.

4.4.2 CPRR ITS

Mode of Contract Scheme

The 'Design Build' scheme, i.e., design, supply, and installation, wherein the employer prescribes the requirement of the systems and performance and the contractor carries out the detailed design, is best suited because ITS is a project which is mainly composed of systems and equipment.

The 'Design Build' scheme was also adopted to other public projects of ITS in India. Some major examples are the MITRA Project of the City Bus Monitoring and Passenger Information System in Mysore in Karnataka State (World Bank), the KSRTC Project of the Inter-City Bus Monitoring and Passenger Information System in Karnataka State (state budget), and the B-TRAC Project of the Traffic Management System of Bengaluru traffic police in Karnataka State (state budget).

The 'Procurement of Electrical and Mechanical Pant, and for Building and Engineering Works, Designed by the Contractor' from the 'JICA Standard Bidding Documents Under Japanese ODA Loans (SBD)' which is based on FIDIC is recommended to be used for this Japanese ODA Loan Project. This SBD has been used in the ITS project under the Japanese ODA Loan Project in other city in India.

Tender Method of Consultant Procurement

It is very important that the requirements are clearly defined/prescribed so that bidders can properly reflect the requirement on their proposals, particularly because the ITS project utilizes advanced technology. This is a different method from 'Turn Key Project' or EPC, where the contractor takes almost the entire responsibility regarding the design and construction. In particular, the Indian local contractors do not have sufficient experience on ITS projects yet. As such, ensuring the quality throughout the project, particularly the upper stage (basic design and contractor procurement), is very important because the quality of the upper

stage will affect the entire project including the stages of implementation, operation, and maintenance. Therefore, procuring the Consultant through ICB, including the stages of basic design and contractor procurement, is recommended.

(3) Selection Method of Contractor Procurement: Quality and Cost Based Selection (QCBS)

ITS facilities such as an emergency call box, traffic counter, CCTV, weather monitoring facility, VMS, and center system are all obligated to be installed on national highways under the jurisdiction of NHAI, where a certain level of traffic volume is expected (i.e., more than 40,000 daily traffic volume). However, there is currently no road where these facilities have been installed correctly, and no information is actually provided. As for the City ITS in India, Ahmadabad in Gujarat State is the only city where the dynamic traffic information has been provided in real time by an installed traffic information system. The system was introduced by a Japanese company under a support scheme of the Japanese small and medium enterprise overseas business developments by JICA.

It is considered that the above situation of ITS in India is caused by the fact that the contractors who have sufficient technical capabilities for developing and handling the advanced system are not selected, and the selection method of the contractor procurement is considered one of the predominant factors behind this. ITS consists of several subsystems wherein technical aspects are vitally important, such as software processing methods, interface between subsystems or external systems, and integration of systems. Therefore, selecting a contractor with enough technical capabilities determines the success of a project. To properly evaluate the technical capabilities of bidders and to select an appropriate contractor, adopting QCBS as an evaluation point of technical evaluation as reflected in addition to the financial evaluation is strongly recommended.

5. HIGHWAY OPERATION AND MAINTENANCE (O&M) STRUCTURE

5.1 Recommendations on the O&M Plan

Proposal on O&M Contracting

The Highways and Minor Ports Department (HMPD) of the Government of Tamil Nadu will oversee the construction and O&M of the CPRR. Most probably, the Project Wing of the Highways Department will take charge of the construction of CPRR, and the Construction and Maintenance Wing will take charge of the O&M.

During the meeting held in February 2018 between HMPD and JICA, HMPD agreed in principle to apply the Standard Bidding Documents (SBD) issued by JICA for the contract for Section 1, although HMPD and JICA are discussing which particular SBD is to be applied in the project. The JICA mission stated that the SBD for “Procurement of Works” is generally mandatory in similar types of Japanese ODA Loan Projects.

When the construction of CPRR is completed, the supervision of O&M will be shifted from the Project Wing to the Construction and Maintenance Wing.

After the completion of construction, most probably a PBMC will be used for the O&M works. Currently, the Highways Department has been switching one-by-one to PBMC from the conventional single-year maintenance contract. It is being introduced successively to one of the highway divisions in eight circles in the state, and up to date, four highway divisions are using PBMC, namely Pollachi, Krishnagiri, Ramanathapuram, and Thiruvallur. Now the PBMC scheme will be extended to the Virudhunagar Highways Division in the current financial year.

Section 1, Section 2, and a part of Section 3 of CPRR fall under the jurisdiction of the Thiruvallur Highways Division, where PBMC was introduced on 24 February 2016. The O&M of SHs and MDRs with a total length of 498 km is being carried out with the contract worth INR 630.38 crore.

PBMC includes ordinary maintenance, initial rectification works, minor improvement works, periodic maintenance works, and emergency works. The amount as stated in a contract is a provisional estimate excluding emergency works. Ordinary maintenance will be payable as a proportionate monthly lumpsum over the 60-month period of the contract. Other works will be measured and paid based on the actual work output.

Cost Estimate of O&M

1) O&M Structure

Regarding the O&M for Section 1 of CPRR, it is assumed that the execution entity TNRDC will be in charge. The maintenance work will be contracted out to private companies.

Section 2 and a part of Section 3 of the CPRR will fall under the jurisdiction of the Thiruvallur Highways Division. Regarding the remaining sections, Section 3, Section 4, and Section 5 will fall under the jurisdiction of the neighboring Chengalpattu Highways Division. The Thiruvallur Highways Division has been contracting out to private O&M contractors with PBMC and will incorporate newly completed sections into the contract. It is assumed that the PBMC will be introduced to the Chengalpattu Highways Division by the time the CPRR is completed. If the introduction is delayed, a single-year maintenance contract will be used.

The structure of the Thiruvallur Highways Division consists of one divisional engineer, six assistant divisional engineers, and eight assistant engineers. The Thiruvallur Highways Division will outsource the work of maintenance/patrol/traffic control with PBMC to an O&M contractor. There is a plan to collect toll for Section 1. When this is carried out, toll collection work will also be outsourced to a toll contractor. There is one field office for the divisional engineer and six field offices for the assistant divisional engineers taking charge of road construction other than large-scale projects and maintenance for SHs and MDRs

2) Cost Estimate of O&M

Table 5.1.1 shows the examples of O&M costs for the four highways divisions that have already introduced the PBMC and the CORR. Although the cost of CORR is about 30% higher than those of other roads, it is assumed that the higher cost comes from the road composition of CORR, which contains service roads on both sides. The road composition of CPRR is like that of CORR and INR 0.223 crore/year/km is adopted for the calculation of the O&M cost.

Table 5.1.1 Examples of O&M Costs (INR in Crore)

No.	Highways Division	Length (km)	5-year Cost	5-year/km	1-year/km
1	Pollachi	377	233.9	0.620	0.124
2	Krishnagiri	581	450.0	0.775	0.155
3	Ramanathapuram	569	460.0	0.808	0.161
4	Thiruvallur	776	630.4	0.812	0.162
5	CORR	30	33.0	1.113	0.223

Source: JICA Study Team

By using the unit rate of INR 0.223 crore/year, the 133.23-km CPRR will produce an annual O&M cost of INR 29.71 crore.

Table 5.1.2 Annual O&M Cost of CPRR (INR in Crore)

	All Sections	Section 1	Section 2	Section 3	Section 4	Section 5
Length (km)	133.23	25.72	25.61	29.55	24.85	27.50
O&M (INR lakh)	29.71	5.74	5.71	6.59	5.54	6.13

Note: Original Alignment of TPP Link Road (4.21 km) is included in length of Section 1.
Source: JICA Study Team

Proposal on Improvement in O&M Manual

Regarding O&M of CPRR, an O&M manual, which will be a guideline for the work, should be prepared. The IRC: SP: 95-2011[1] will be the basis for the preparation. The road maintenance standards stipulated in this document is also the basis for Schedule-K in the model contract agreement for PPP and Schedule-E in the standard agreement for EPC.

Although the O&M manual for CORR covers all aspects of O&M activities, there are some points that need to be improved. Especially for the methodology in preventive maintenance, the description is no more

[1] IRC: SP: 95-2011 Model Contract Document for Maintenance of Highways

than a concept. As for preventive maintenance standards, the Guidelines for Expressways[2] compiled by MORTH stipulates a detailed methodology. The O&M manual can be improved by incorporating this part. The JICA Study Team proposes that the detailed methodology in preventive maintenance should be incorporated to improve the O&M manual.

Proposal on O&M of ITS

The total length of CPRR is 133.23 km (including the original alignment of TPP Link Road), and it is divided into five sections. Section 1, or the Northern Port Access Road (NPAR), is connected to the Ennore Port. Although it has not been decided yet, the Government of Tamil Nadu is considering to make Section 1 an access-controlled toll road. Therefore, it is recommended that a toll management system (for Section 1) and a highway traffic management system (for all sections) be introduced as ITS components for the CPRR.

Proposal on Training in Japan for Technical Enhancement in O&M

It is very valuable for the staff of the Highways Department of Tamil Nadu State, who are in charge of the CPRR, to learn this example as precedent of the Metropolitan Inter-City Expressway. The JICA Study Team proposes a training in Japan for technical enhancement in O&M, where attendees can acquire wide-ranging practical knowledge including O&M structures, actual examples of O&M manuals, responses to various traffic incidents at site, information dissemination at traffic control centers, structure and management of toll collection, emergency response to disasters/accidents, and ways to enhance road functions among others.

6. DESIGN REVIEW OF CHENNAI PERIPHERAL RING ROAD (CPRR)

6.1 Objectives and Scope of Design Review of CPRR

In order to confirm the reasonability of providing the Japan International Coordination Agency (JICA) Loan to the CPRR Project, the review is undertaken on the design made in the Detailed Project Report (DPR).

Table 6.1.1 shows the volumes of DPRs with the version provided to the JICA Study Team.

Table 6.1.1 Volumes of DPR for Review

Vol.	Report Title	Version/Date	Availability
I	Main Report	Unknown	Provided by JICA
II-A	Design Report (Highways)	Ver.R0, 9 Jan. 2017	Aug. 2017
II-B	Design Report (Structures/Box Culvert)	Unknown (Cover shows Aug. 2016)	Feb. 2018
II-C	Design Report (Structures/Minor Bridge)	Unknown (Cover shows Aug. 2016)	Feb. 2018
II-D	Design Report (Structures/Major Bridge)	Unknown (Cover shows Aug. 2016)	Feb. 2018
II-E	Design Report (Structures/Underpass)	Unknown (Cover shows July. 2016)	Feb. 2018
II-F	Design Report (Structures/Interchange)	Unknown (Cover shows Nov. 2016)	Feb. 2018
II-G	Design Report (Structures/Sec-1 Link Road)	Unknown (Cover shows Sep. 2016)	Feb. 2018
II-H	Design Report (Structures/ROB)	Unknown (Cover shows Aug. 2016)	Feb. 2018
III	EIA & Management Plan	Unknown	Provided by JICA
IV	Social Impact Assessment & RAP	Unknown	Provided by JICA
V	Technical Specifications	-	Not Available
VI	Rate Analysis	Ver.R0, 9 Jan. 2017	Feb. 2018
VII	Bill of Quantities	Ver.R0, 9 Jan. 2017	Nov. 2017
VIII	Cost Estimate	Ver.R0, 9 Jan. 2017	Aug. 2017
IX-A	Drawing (Highways)	Unknown	Aug. 2017
IX-B	Drawing (Structures/ Drainage)	Unknown	Aug. 2017
IX-C	Drawing (Structures/Bridges)	Unknown	Aug. 2017
IX-D	Drawing (Structures/underpass)	Unknown	Aug. 2017
IX-E	Drawing (Structures/Interchange)	Unknown	Aug. 2017

Note: Shaded text is a report not provided at the time of review.
Source: DPR Main Report P1-6 and JICA Study Team

The scope of the design review is set out as shown in Table 6.1.2 considering the objectives of the design

[2] MORTH. 2010. Guidelines for Expressways. New Delhi. IRC

review and the provided volumes of DPR at the time of review.

Table 6.1.2 Scope of Design Review

Item	Description in Provided DPR	Scope of Design Review
Traffic Analysis	The traffic survey was carried out in 2013. Future traffic volumes of CPRR (Sec. 2-5) were estimated by the elasticity method stipulated in the Indian Road Congress (IRC).	The traffic survey is carried out in 2017. Future traffic volumes of CPRR (Sec. 1-5) are to be estimated by network analysis using the JICA STRADA software.
Natural Conditions Survey	**Topographic Survey:** Control point survey using GPS, planimetric survey, and route survey (centerline, profile, and cross section) using a total station were carried out. Details of survey methodology and results including calculations are not provided. **Geotechnical Investigation:** CBR tests for subgrade and boring survey at proposed sites for structures were carried out. Results of the boring survey, including N values, are not presented in the provided DPRs. **Hydrological Survey:** No specific surveys were carried out. Standard values recommended in IRC were applied to the rainfall intensity in drainage design.	Survey results are not clearly presented in the provided DPRs; thus, natural conditions survey is not to be reviewed. Contents of surveys to be made in the next design phase of the Project are to be suggested in this Study.
Design		
Design Conditions	Design conditions such as road classification, technical standards to be applied, design speed and design criteria are presented in the design approach of the DPR report.	Validity of descriptions and consistency within DPR reports are to be reviewed.
Highway Design	**Alignment:** Elements and applied values can be read in the drawings (plan and profile). **Pavement:** Adopted design traffic volume and design CBR as well as deign calculations are presented in the DPR report. **Drainage:** Approach to drainage facilities arrangement as well as typical drainage calculations are illustrated in the DPR report.	**Alignment:** The alignment is to be reviewed based on the applied technical standards **Pavement:** Design results are to be evaluated by comparing with the results of AASHTO and other standards. **Drainage:** Design approach and design calculations are to be reviewed.
Interchange Design	Design reports of DPR (structures/interchanges) were not provided. In the provided reports, applied design criteria and general drawings are available.	The number of lanes for the main road and service road are to be evaluated based on the directional traffic movements that are estimated in this Study. Furthermore, geometric design of interchanges is to be reviewed.
Structure Design	Design reports of DPR (structures/bridges) were not provided. Drawings of structures (General Arrangement Drawings (GADs)) were provided. N values are not presented in boring logs.	Structural design is to be reviewed based on GAD. Foundations including piles could not be reviewed.
ITS Design	Interim results of the Chennai ITS Study are presented in DPR. No original proposals are included.	Updating ITS Design is to be made.
Cost Estimate	Rate analysis was not provided. Design quantities are shown in summarized manner and calculations for quantity take-off are not presented in the DPR report.	Unit rates are to be updated for the year 2017-2018 based on the schedule of rates of Tamil Nadu District. Design quantities are to be preliminarily reviewed for the major items.

Source: JICA Study Team

6.2 Road Classification and Design Standards to be Applied

Design Standards

The road design made in the DPR was conducted in accordance with IRC standards.

Design Speed

The DPR Design Report (Vol. II, Design Report-Highways) explains that design speeds of 100 km/h (ruling) and 80 km/h (minimum) are adopted in accordance with IRC:73-1980 Geometric Design Standards for Rural Highways as shown in Table 6.2.1. Since the minimum radius of horizontal curves applied to Section 4 is R=200 m, it is desirable to improve those curves in the future to ensure the consistency of the minimum design speed of 80 km/h throughout the route.

Table 6.2.1 Design Speed

Terrain Category	Slope of Ground (%)	Design Speed (km/h)	
		Ruling	Minimum
Plain and Rolling	-25	100	80
Mountainous and Steep	25-	60	40

Source: IRC:73-1980 Geometric Design Standards for Rural Highways

Design Criteria

Table 6.2.2 shows the design criteria that is clarified in the DPR Design Report (Vol. II, Design Report-Highways).

Table 6.2.2 Design Criteria

Road Category: SH Terrain: Mostly Plain, Partially Rolling		Ruling / Desirable	Minimum
Design Speed		100 km/h	80 km/h
Cross Section	Right of Way (ROW)	100 m: Section 1 of CPRR, TPP Link Road (Original Alignment) 100 m: North half of TPP Link Road (New Alignment) 45-60 m: South half of TPP Link Road (New Alignment) 60 m: Sections 2 to 5	
	Carriageway	3.5 m Widening 0.9 m (R: 75 m-100 m) 0.6 m (R: 101 m-300 m)	
	Median	5.0 m (0.5 m+4.0 m+0.5 m) (Sec. 1, 2, 3, 5) 1.5 m (0.25 m+1.0 m+0.25 m) (Sec. 4)	
	Shoulder	Paved Shoulder 1.5 m + Earthen Shoulder 2.0 m (Section 1) Paved Shoulder 1.5 m (Sections to 5)	
	Sidewalk	3.0 m (Sections 2, 3, 5) 2.5 m (Section 4) 2.0 m (Section 1)	
Crossfall		2.5% (Earthen Shoulder 3.0%)	
Embankment Slope		2H:1V (H: -3 m) 1.5H:1V Stone Pitching (H: 3 m)	
Maximum Super-elevation		7.0% (R: -400 m) 5.0% (R: 400 m)	
Minimum Horizontal Curve Radius		400 m	250 m
Stop Sight Distance		360 m (V: 100 km/h) 260 m (V: 80 km/h)	180 m (V: 100 km/h) 130 m (V: 80 km/h)
Maximum Gradient		2.5%	3.3%
Clearance	Horizontal	Road Width	
	Vertical	5.5 m (Vehicle Underpass) 4.5 m (Light Vehicle Underpass)	

Source: DPR Vol.II, Design Report-Highways

6.2.1 Number of Lanes

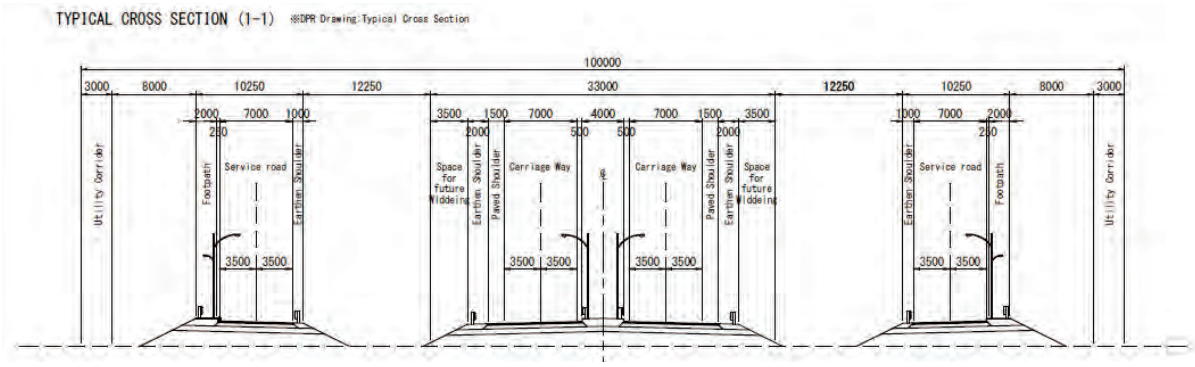
Although there is no clear clarification on the required number of lanes in the DPR, future traffic volumes of Sections 2 to 5 are presented with the limitation of Level of Service (LOS) B. According to this information, in 2028, after 10 years from 2018 as of this report, Section 2 needs 8 lanes, Sections 3 and 4 need more than 12 lanes, and Section 5 needs 6 lanes to ensure LOS B. Although the opening year that was

assumed in the DPR is not clear, there is a concern that traffic of CPRR will be unstable soon after opening, considering the numbers of lanes that were proposed in the DPR (Section 1: 4-lane, Sections 2 to 4: 6-lane, Section 5: 4-lane).

On the other hand, the LOS estimated based on future traffic volumes forecasted in this Study and the numbers of lanes proposed in the DPR (Section 1: 4-lane, Sections 2 to 4: 6-lane, Section 5: 4-lane). It is assumed that the remaining works of Section 4 will be completed in 2021, and construction of Sections 1, 2, 3, and 5 will be completed and the entire stretch will open in 2024. In 2028, after 10 years from 2018 as of this report, the LOS ranges from B to D, which is considered reasonable.

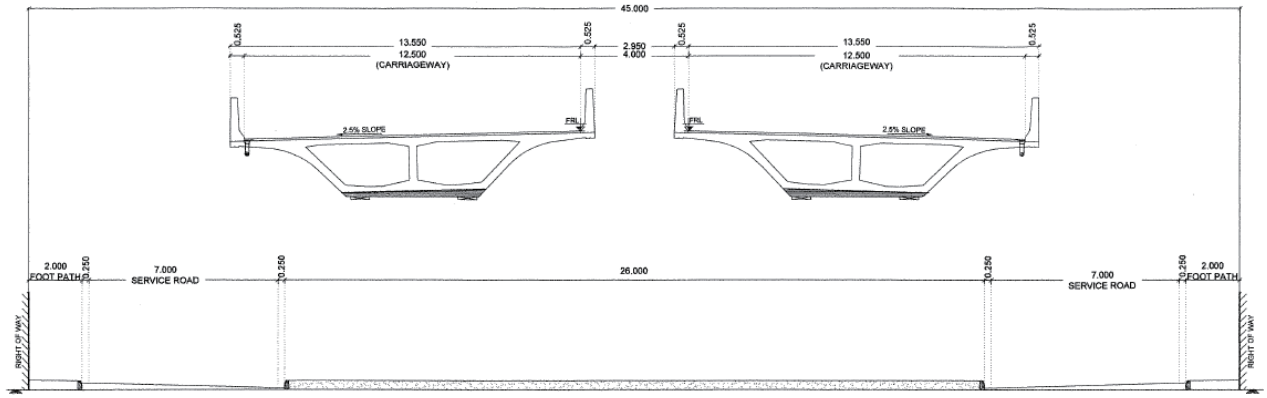
6.2.2 Typical Cross Sections

Typical cross sections proposed in the DPR were designed in accordance with the number of lanes stated above and the requirements of the applied design standards. They are shown in Figure 6.2.1 to Figure 6.2.2.

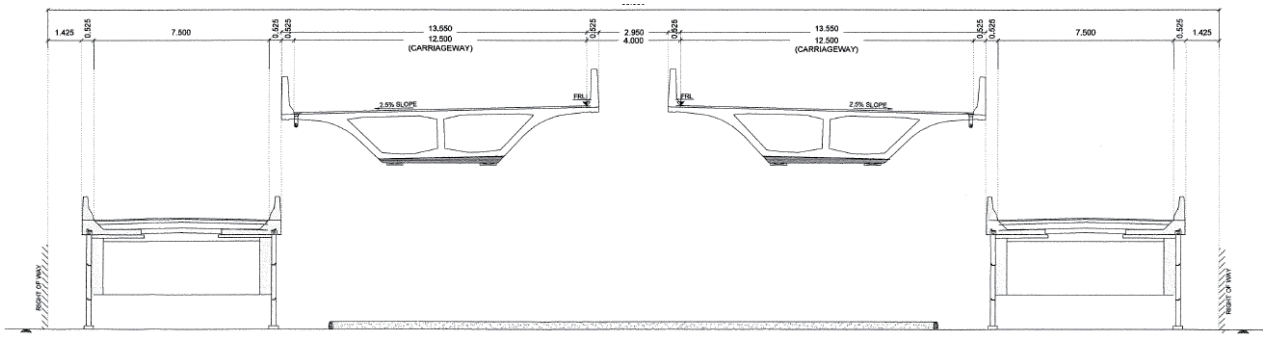


Source: JICA Study Team based on DPR

Figure 6.2.1 Typical Cross Sections (Section 1)



Flyover Section (ROW 45 m)



Approach Section (ROW 60 m)

Source: STUP

Figure 6.2.2 Typical Cross Sections TPP Link Road (New Alignment)

6.3 Design Update (Section 1)

As described earlier in this report, some missing parts of the DPR such as “Design Report (Structures)”, “Drawings”, and “Rate Analysis” were provided after the review period. Major changes in the newly provided materials are: design update by HMPD, modifications for the JICA Study Team comments at IT/R2, agreement issues in the JICA mission held in February and April 2018, and other updates. However, further modification and updating of the DPR are still ongoing by HMPD even at the time of the DFR, and this situation results in inconsistencies among the series of provided materials, such as report, drawing, and quantities.

In this section, the result of the review of the provided materials and suggestions to be considered in the further detailed design stage are described.

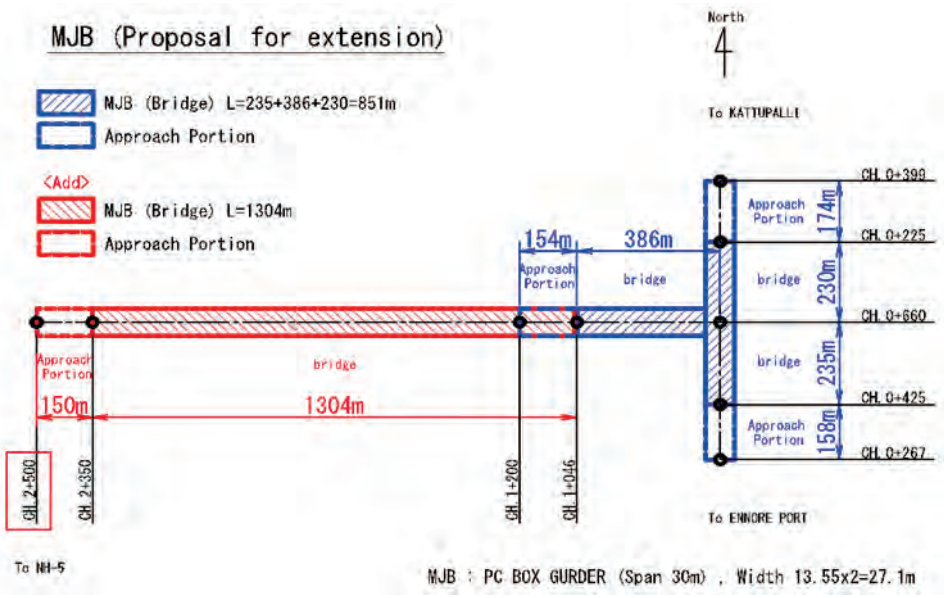
6.3.1 Main Renewed Points

Bridge Extension Near the Beginning Point (MJB101)

The end chainage of MJB101 was originally Ch.1+200 but it will be revised to approx. Ch.2+500 as per TNRDC meeting held on April 24, 2018. The JICA Study Team considered the extension but could not be reviewed since there is no detailed plan yet. Therefore, a thorough design review of the extension must be carried out during the detailed design.

The following are considered in the cost estimate of the JICA Study Team:

- Extension of MJB end chainage to Ch. 2+500 from Ch. 1+200
- The bridge type is initially set as a 30 m span PC box girder according to the DPR
- One bridge and four box culverts are removed from this section: MNB101, BC2/1～BC2/3 and BC3/1



Source: JICA Study Team

Figure 6.3.1 MJB101 Extension Plan

Changing of IC-1 (NH5) to Section 1

When the review of the DPR was executed for the whole section, IC-1 was included in Section 2. However, when the meeting with HMPD was held in February 2018, it was decided that IC-1 will be included in Section 1. Therefore, the end point of Section 1 became the edge of the retaining wall (Ch.21+506) which is connected to the interchange bridge (this position was confirmed at the TNRDC meeting on April 24, 2018). For this reason, the access to Section 2 becomes unnecessary. The study of traffic operation and the stage construction for connection with Section 1 and NH5 are required.

Installation of Toll Barrier

Partial access control of toll road was studied in which it is possible to access the service road from the entry and exit to the service road except in interchange considering the type of interchange (clover leaf is unfavorable to install toll gate) and the connection with the service road. Therefore, open system was adopted, and some toll barriers were planned in order to reduce the inequality of the toll rate. Toll barrier was planned at the location with high visibility of the toll gate at the grand horizontal and vertical alignment, avoiding the structure section, and also away from at-grade intersection. Locations of toll barriers were at Ch.15+800 and Ch.2+200 on CPRR, and at Ch.1+200 on TPP Link Road. Moreover, the toll booth and the toll office were planned within the right of way (ROW 100 m) in consideration of the installation of ETC lane and the width of the island. As a result, the service road was shifted outside at the toll barrier section. The width and the length of the island conformed to the Indian expressway design standard (IRC-SP99-2013).

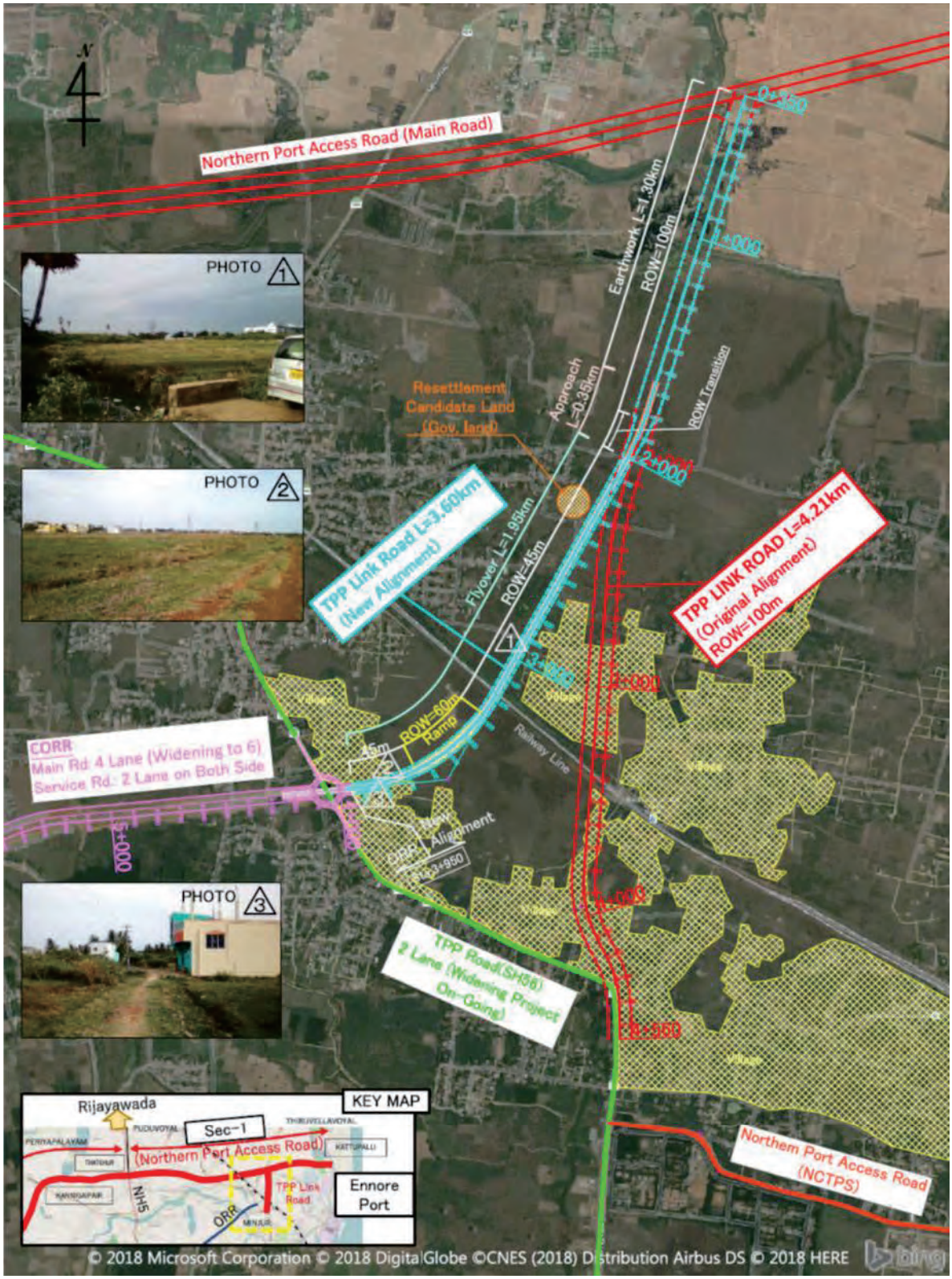
Installation of Traffic Control Center

Traffic control center (TCC) was planned in the earthwork section within Section 1 in consideration of road alignment and land area which is for office building and parking area. The location of TCC was planned at Ch.8+600 on CPRR. Acceleration lane and deceleration lane were planned in consideration of traffic safety because there are exits and entrances at the connection between the main road and TCC.

Alignment Change of TPP Link Road

The road stretch of Section 1 consists of Northern Port Access Road (NPAR) and TPP Link Road. During consultation with inhabitants around the site of TPP Link Road (original alignment), it was found that it is important to obtain social consensus for the road construction. As an alternative solution to minimize the social impact, the south end of TPP Link Road is to be shifted approximately 1.5 km west from the original alignment. This new alternative alignment has a total length of 3.6 km from the connecting point with NPAR to the southern end. The length of 1.65 km in the northern part is the same as the original alignment, and the remaining 1.95 km in the southern part is different from the original alignment.

At the southern end of TPP Link Road (new alignment), it is planned to cross overhead of the TPP Link Road near Minjur and connect directly to the ORR. In the TPP Link Road (new alignment), the section subject to ODA loan will be a stretch from Ch.0+350 (the north end) up to Ch.3 + 950, and the south is to be constructed under the ORR development project.



Source: JICA Study Team

Figure 6.3.2 Alignment Change Plan of TPP Link Road

6.3.2 Design Quantity

Since design quantities are presented in a summarized manner and detailed quantities of each structure are not available in the DPR reports, preliminary check on major items was conducted in this Study. As a result, no fatal errors were found in the design quantities of major items. Therefore, in the cost estimate in this Study, design quantities presented in the DPR are to be utilized while unit prices are to be updated.

6.3.3 Recommendation on Detailed Design of Section 1

Based on the review results above, suggestions to be noted at the detailed design stage of Section 1 are as follows. In general, further examination is recommended on the contents of the DPR which were provided after conducting the review of the JICA Study Team.

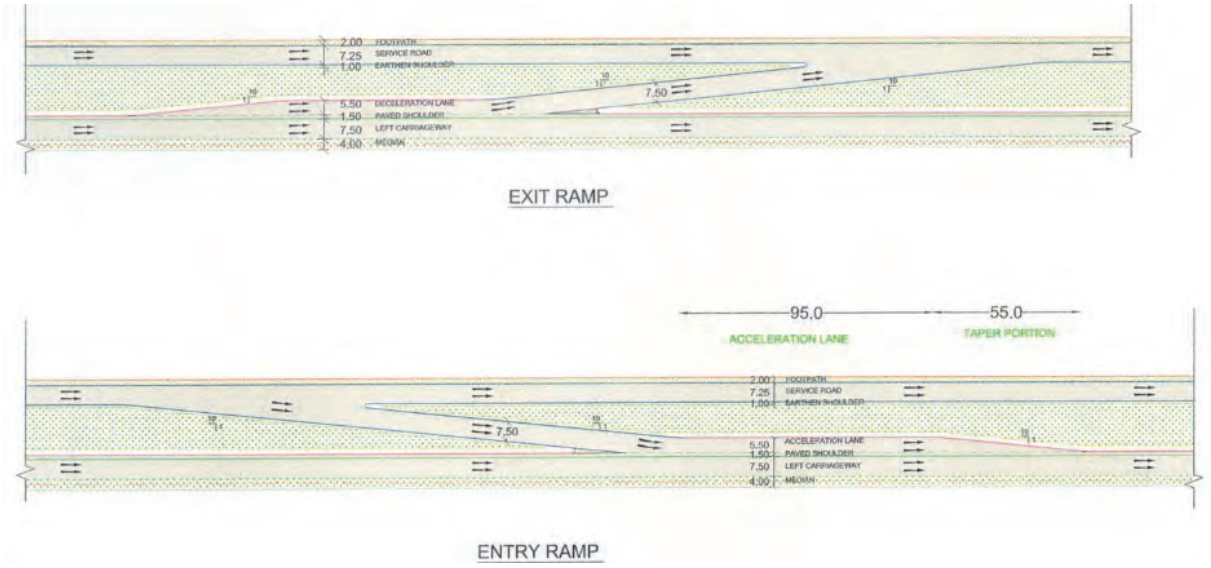
Suggestion on Road Design

1) Road Alignment

Vertical alignment was corrected by the JICA Study Team because some vertical curve length of the main road (CPRR) did not satisfy the design standard (IRC73-1980).

2) Connection of Main Road and Service Road

The connection between acceleration and deceleration lane of main road and service road with small radius curve was changed to rampway type by the JICA Study Team. Therefore, traffic safety will improve because vehicles can wait on the rampway. Moreover, it is necessary to add traffic signs in the detailed design because the visibility of connecting point becomes worse with the small intersecting angle, although the safety will increase by changing to a one-way road. Layout of entry and exit is shown in Figure 6.3.3 below.



Source: DPR

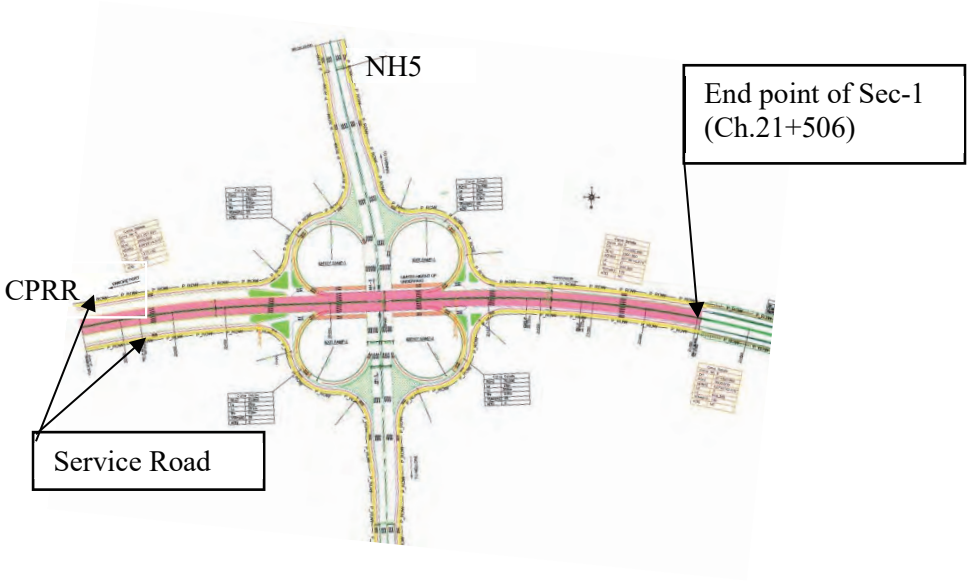
Figure 6.3.3 Layout Plan of Entrance and Exit

3) Improvement on IC-1 (NH5)

The service road was changed to one-way traffic according to the JICA Study Team. The box culverts were installed under the main road and H5 in order to connect each service road within the interchange area.

As a result of this, the connectivity was improved, but it became difficult to guide to destination.

The left-turning traffic from CPRR main road to NH5 passes through the service road (it is not direct connection ramp). Therefore, increase of travel time and decrease of traffic safety are expected because of the increase of future traffic volume. Refer to the plan of IC-1.

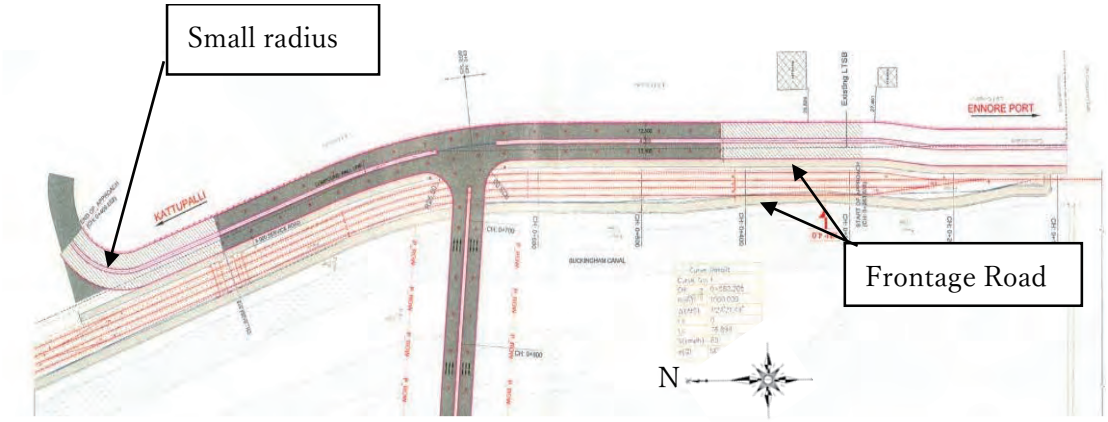


Source: JICA Study Team

Figure 6.3.4 Plan of IC-1

4) Improvement on JCT-1 (Beginning Point)

In the Interim Report, north-south direction traffic at the beginning point was suggested to pass on the ground instead of the flyover (frontage road is provided for north-south direction). However, afterwards, the direction of the alignment of the north side was changed from the north direction to the east direction. Therefore, it became dangerous because the small radius curve continues after the straight and steep alignment at the north side of the beginning point. Consequently, it is necessary to improve safety by enlarging the radius of curve and installing traffic sign in the detailed design. Plan of JCT-1 is shown in Figure 6.3.5.



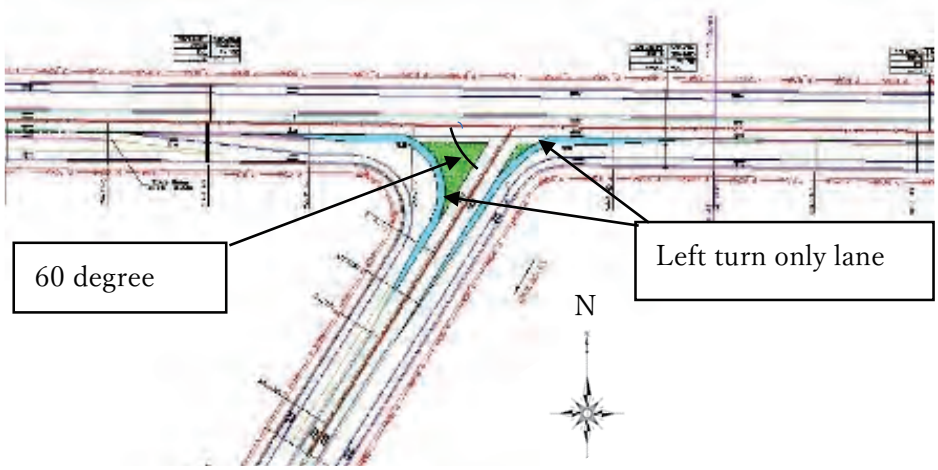
Source: JICA Study Team

Figure 6.3.5 Plan of JCT-1

5) Improvement on JCT-2 (Connect with TPP Link Road)

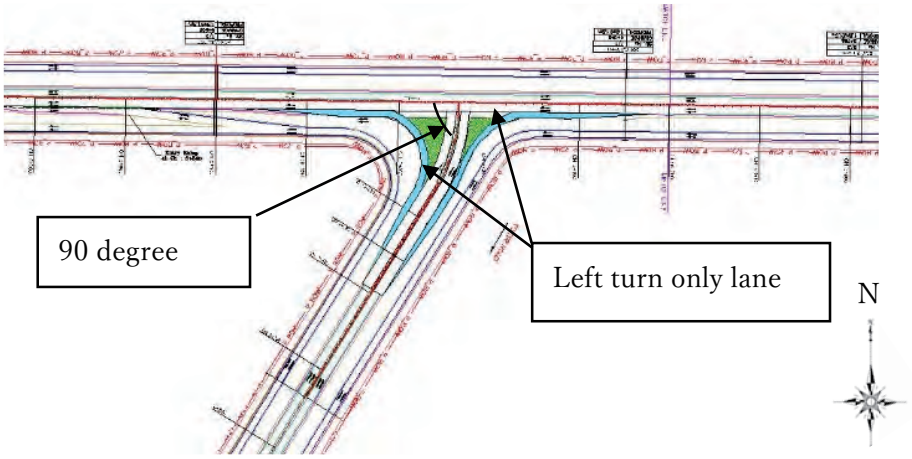
It is recommended again to add the left turn only lane in order to increase traffic safety and the traffic capacity of the left turn traffic from the main road to TPP Link Road. Plan of JCT-2 is shown in Figure 6.3.6.

It is proposed as an alternative to change the intersection angle from 60 degrees to 90 degrees between the main road and the TPP Link Road. It can increase the capacity by reducing the intersection area and increase the safety by improving the visibility. Alternative plan of JCT-2 is shown in Figure 6.3.7.



Source: JICA Study Team

Figure 6.3.6 Plan of JCT-2



Source: JICA Study Team

Figure 6.3.7 Traffic Control Center on CPRR Ch.8+600

Suggestion on Structure Design

6) Inclusion of the Railway Plan (MJB101)

HMPD states that MJB101 is planned to be connected by railroad in the north and south. Details of MJB101 railroad plan such as clearances, determination of bridge type based on construction limits, span arrangement and others must be reflected in the detailed design.

7) River Conditions (MJB, MNB)

Although the cross section and water level (FWL) are shown in the final DPR (drawing), it could not be verified on site. Verification of the cross section and water level by means of tests must be done prior to the detailed design. The water level during construction must be checked as well.

8) Abutment Type (MJB101, 202, 301)

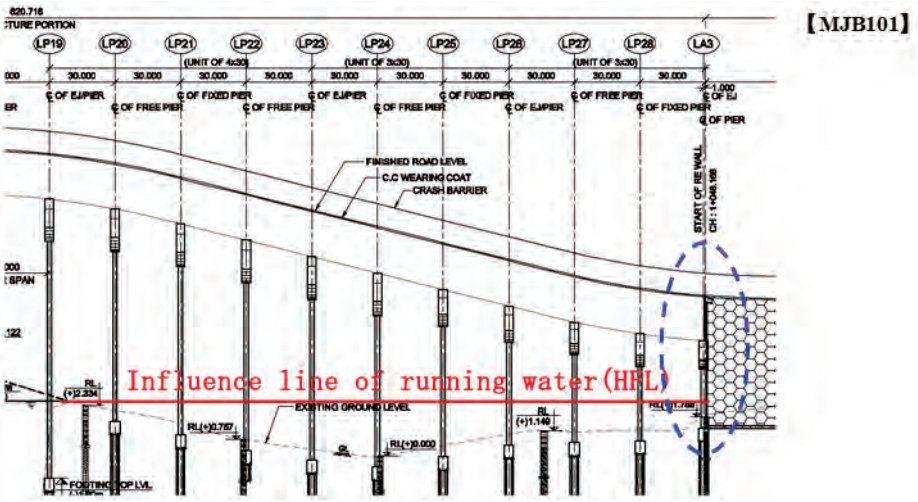
The structure of some river bridge abutments is not found to be a common abutment structure but a combined structure of reinforced earth wall and pier.

Although HMPD stated that these structures are not affected by the water current, it would be better to adopt the abutment structure and hydraulic force countermeasures because the common reinforced earth wall is weak against hydraulic force. During the detailed design, it is necessary to review and study the abutment structures upon conducting hydrologic surveys and upon checking the water level.

Table 6.3.1 Suggestion on the Abutment Type (MJB101)

Sec.	No.	STRUCTURE CODE	Location	Revision Suggestion			
				Plan of DPR	Affected by running water		Suggestion
Sec.1	1	MJB101-1 Str.No.1/1	A1(Start point)	Pier + RE Wall	No (land)	→	No change
			A3 End point	Pier + RE Wall	Yes	→	Change from pier to Abutment
		MJB101-2 Str.No.1/1	A2(End point)	Pier + RE Wall	No (land)	→	No change

Source: JICA Study Team



Source: JICA Study Team based on DPR (Drawing)

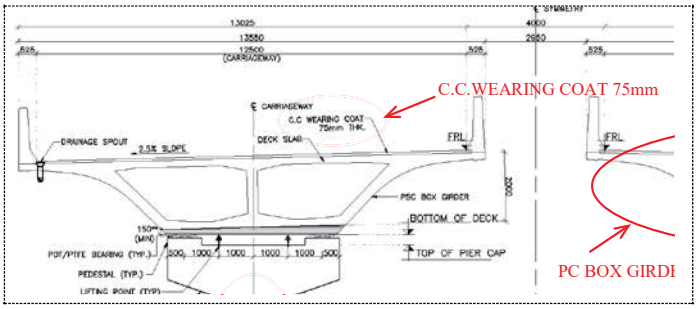
Figure 6.3.8 Abutment of MJB101

9) Reduction of Substructures on River (MJB, MNB)

The bridge plan in the final DPR is based on the minimum span of concrete bridges excluding ROBs. Although the ease of superstructure construction could be the major consideration in the plan, constructability becomes inferior by placing several piers due to the increase of path obstruction rate and cost of temporary construction equipment particularly in MNBs on narrow rivers. The current plan is considered economical by HMPD as opposed to the opinion of the JICA Study Team. This is an important matter that must be reviewed in the detailed design.

10) Type of Pavement (All Bridges)

In the final DPR, the planned bridge pavement material is concrete. However, asphalt pavement is used in the vicinity of earthworks section as well as ORR, while concrete asphalt is used in the already constructed bridge at the end of Section 4. Although material procurement could be the main consideration, others such as consistency must also be considered in the determination of pavement material during the detailed design.



Source: JICA Study Team based on DPR (Drawing)

Source: JICA Study Team

Figure 6.3.9 Cross Section of MJB101 and Constructed Bridge in Section 4 (Concrete Pavement)

11) Consultation with the Railway Company (ROB)

The ROBs design condition, construction limits, and bridge plan must be confirmed during the consultation with the railway company. Since there is no record of consultation in the DFR, the railway company must be consulted to confirm details such as the sequence and the bridge plan and to obtain approval.

12) Further Investigation About Superstructure and Substructure Type (VUP)

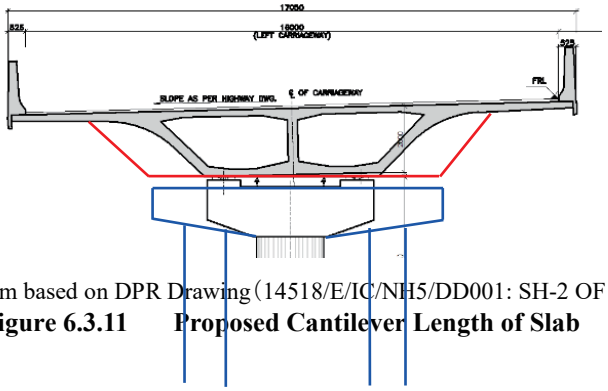
In the final DPR, the adopted structure is a reinforced concrete girder with minimum span while in ORR, a simply supported box girder bridge is adopted. The type of structure must be finalized in the detailed design considering economy and constructability. In addition, by adopting a box girder bridge, expansion joint and bearing may be omitted resulting to ease of maintenance.

Source: JICA Study Team

Figure 6.3.10 VUP in the Outer Ring Road（Box, Block Wall）

13) Slab Cantilever Length (IC/NH5)

The deck cantilever is about 4.5 m. Although this design is valid in HMPD, it is preferable not to set the length to maximum considering deterioration and unexpected loadings. Adjustment of edge curvature or box girder width in order to attain the preferable length is advised.

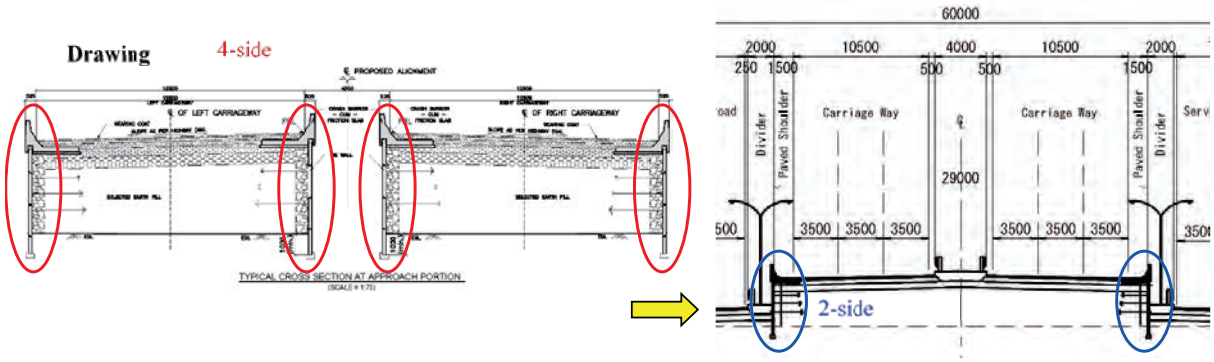


Source: JICA Study Team based on DPR Drawing（14518/E/IC/NH5/DD001: SH-2 OF 3）

Figure 6.3.11 Proposed Cantilever Length of Slab

14) Number of Face of Reinforced Earth Walls (IC)

Reinforced earth walls are placed between each gap of the upper and lower lanes of IC. The total number of faces is four. The said gap is about 3 m high if it is filled with soil. There will be two installation faces of reinforced earth wall which in turn will be economical. For bridges other than IC, there are two faces, but this should be reviewed in the detailed design.

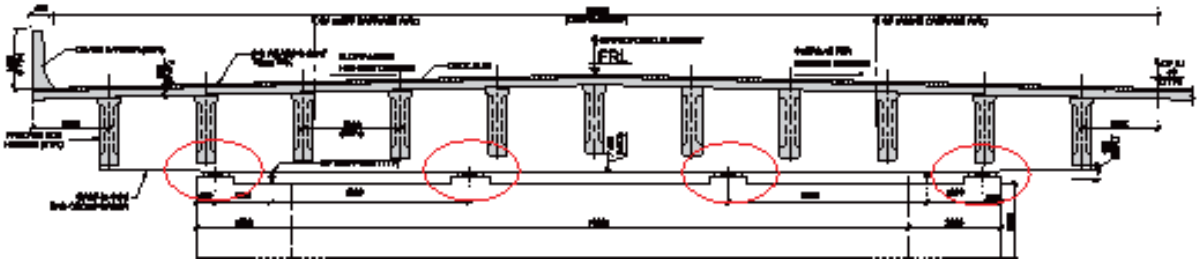


Source: JICA Study Team based on DPR Drawing（14518/E/IC/NH5/DD001: SH-2 OF 3）

Figure 6.3.12 Cross Section of Reinforced Earth Wall (IC)

15) Bearing Position and Width of Substructure (All Bridges)

The bearings are located under the end cross beams and as compared with the superstructure width, the coping width of some substructures is found to be extremely small. It is advised that the bearing position and the coping width be reviewed in order to be certain of the vertical support load and to ensure bridge fall prevention in case unexpected forces occur.



Source: JICA Study Team based on DPR Drawing

Figure 6.3.13 Proposed Bearing Position (MJB101)

Suggestion on Possible Adoption Measures Against Climate Change

16) Influence of Climate Change on Roads

In recent years, disasters caused by extreme meteorological phenomena such as strong typhoon, hurricane, local heavy rain, drought and heat wave have occurred and caused enormous damage all over the world. To address the influence of global climate change, adaptation measures against already surfaced impact and unavoidable effect in the medium to long term are required as well as mitigation measures, including reduction of greenhouse gas emissions.

Table 6.3.2 shows major influence of climate change on roads.

Table 6.3.2 Major Influence of Climate Change on Roads

Cause	Influence
Increase in Rainfall and Rainfall Intensity	・ Flood on roads ・ Inundation and wash away of roads ・ Destabilization of road structure and collapse of road embankment ・ Reduction in drainage capacity due to sediment runoff
Rise in Temperature	・ Deterioration and damage of pavement
Increase in Wind Force	・ Reduction of stability of bridges

Source: JICA Study Team

17) Possible Adaptation Measures in the Project

The CPRR, forming arterial road network in Chennai, is expected to play important roles such as emergency transport route, route for police and fire fighting, and others. To develop a safe and reliable road, it is desirable to undertake adaptation measures against climate change as shown in Table 6.3.3 during the detailed design and/or construction supervision stages.

Table 6.3.3 Adaptation Measures against Climate Change in the Project

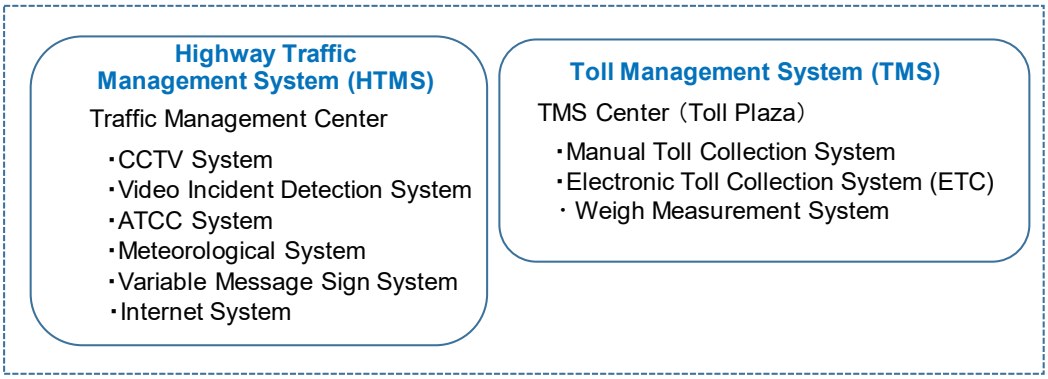
Item	Adaptation Measures against Climate Change
Road Embankment	・ Setting out of the proposed elevation based on recent rainfall trend ・ Proper design of slope protection in inundation-prone areas ・ Design of embankment and soft ground treatment considering lowering of groundwater level
Drainage	・ Design of drainage facilities considering lowering of capacity due to sediment runoff
Pavement	・ Application of superelevation for drainage ・ Use of sound material for pavement
Bridge	・ Design of bridges based on recent rainfall trend and appropriate design discharge ・ Consideration of appropriate wind load

Source: JICA Study Team

7. PRELIMINARY DESIGN OF CHENNAI PERIPHERAL RING ROAD INTELLIGENT TRANSPORT SYSTEM (CPRR ITS)

7.1 Scope and Objectives of Preliminary Design of the Chennai Peripheral Ring Road Intelligent Transport System (CPRR ITS)

The scope of the CPRR ITS Project, which will be introduced to CPRR by Japanese official development assistance (ODA) loan, was determined based on the studies carried out so far and discussions with Tamil Nadu State as shown in Figure 7.1.1. There are two components, i.e., Highway Traffic Management System (HTMS) and Toll Management System (TMS), and each is composed of some subsystems. The preliminary design of these components, including identifying the quantity of equipment and cost estimation, was carried out for the formulation of this Japanese ODA Loan Project.



Source: JICA Study Team

Figure 7.1.1 Scope of CPRR ITS for the Project

7.2 Highway Traffic Management System (HTMS)

The design concept of HTMS is shown in Table 7.2.1.

Table 7.2.1 Design Concept of HTMS

Subsystem	Design Concept
CCTV System (CCTV)	・It monitors the traffic situation on CPRR from the center. ・The details of the traffic event detected by VIDS are confirmed from the center using the PTZ function (*); accordingly, the necessary actions are to be taken, e.g., dispatching the patrol cars, and informing the relevant organizations. ・The film footages taken are kept in the server for a certain period and are shared to the relevant organizations upon request, e.g., traffic police. ・The operation status of the facilities and system are monitored, and the maintenance team is dispatched in case of failure.
Video Incident Detection System (VIDS)	・It detects incidents occurred on CPRR, and an alarm is automatically issued. ・The video is automatically taken when detected and kept in the server for a certain period. ・The number/frequency of occasion of the incident is summarised and reported to TNRDC in such format as weekly, monthly, and yearly report. ・The operation status of the facilities and system are monitored, and the maintenance team is dispatched in case of failure.
Automatic Traffic Counter Cum System (ATCC)	・It counts traffic volume by vehicle type. ・The measured data is kept in the server for a certain period and summarised by time and day. ・The result is reported to TNRDC in such format as weekly, monthly, and yearly report. ・The operation status of the facilities and system are monitored, and the maintenance team is dispatched in case of failure.
Meteorological System (MET)	・It measures precipitation, wind velocity, and visibility, and the alarm is automatically issued when the measured results reach the threshold value. ・The alarm messages are provided to road users through VMS and internet in case the threshold value is reached. ・The measured data which reached the threshold value is kept in the server for a certain period, and the number/frequency of occurrence of reaching the threshold value is summarised. ・The operation status of the facilities and system are monitored, and the maintenance team is dispatched in case of failure.
Variable Message Sign Board System (VMS)	・Information, such as accidents, road work, lane restrictions, and actions that need to be taken by the road users, is provided. ・The provided information is updated every five minutes as necessary. ・Information to be provided is made by combining the preset messages that are prepared by the operators in advance. Free messaging can also be provided. ・The languages to be used are selected from English, Hindu or Tamil, or automatically switched. ・The operation status of the facilities and system are monitored, and the maintenance team is dispatched in case of failure.
Internet System	・Information, such as accidents, road work, lane restrictions, and actions that need to be taken by the road users, is provided. ・The provided information is updated every five minutes as necessary. ・The languages to be used are selected from English, Hindu or Tamil by the internet users. ・The operation status of the facilities and system are monitored, and the maintenance team is dispatched in case of failure.

(*) PTZ Function: PTZ is an abbreviation of 'Pan' which means moving the camera lens to the direction of right or left, 'Tilt' which means moving the camera lens to the direction of up and down and 'Zoom' which means zooming. PTZ Function refers to those functions of CCTV.

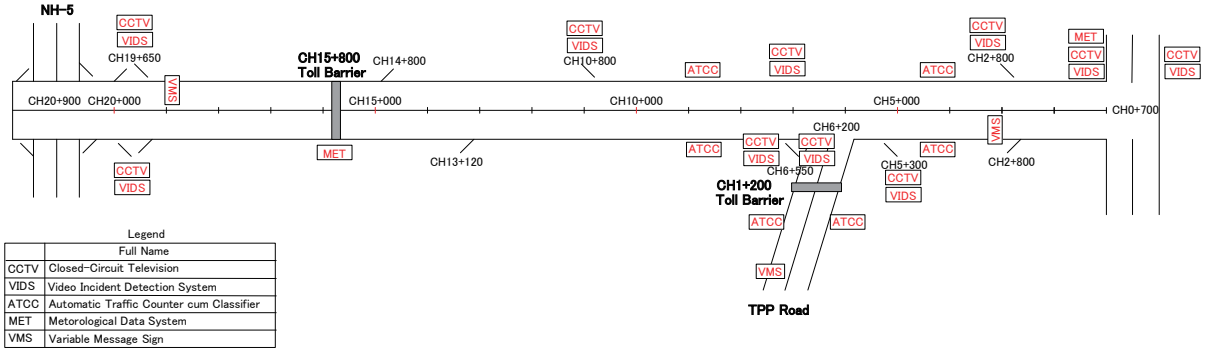
Source: JICA Study Team

(1) Location Plan and Quantity of Roadside Equipment of HTMS

CCTV and VIDS are proposed to be installed at the merging point of on/off ramps to/from the carriage way of CPRR and the merging point between CPRR and Tiruvottiyur Ponneri Pancheti (TPP) Link Road. The measurement equipment of the meteorological system is proposed to be installed on both ends of CPRR. The sensors of the Automatic Traffic Counter cum Classifier (ATCC) are proposed to be installed between (i) the toll barrier of CPRR (Ch.15+800) and the junction of TPP Link Road (Ch.6+200), (ii) the junction of TPP Link Road (Ch.6+200) and the end point of CPRR near the port (Ch.0+700), and (iii) the junction of

TPP Link Road (Ch.6+200) and the start point of TPP Link Road, for a total of three locations. VMS boards are proposed to be installed between (i) NH5 and the toll barrier of CPRR (Ch.15+800), (ii) the end point of CPRR near the port (Ch.0+700) and the junction of TPP Link Road (Ch.6+200), and (iii) the start point of TPP Link Road and the toll barrier on TPP Link Road (Ch.1+200), for a total of three locations.

The locations of roadside equipment of the HTMS and the location plan concept and quantity of equipment are shown in Figure 7.2.1 and Table 7.2.2, respectively.



Source: JICA Study Team

Figure 7.2.1 Location Plan of Roadside Equipment of HTMS

Table 7.2.2 Location Plan Concept and Quantity of Roadside Equipment of HTMS

Facilities	Location Plan Concept	Quantity
CCTV System (CCTV)	It will be installed to confirm the situation, e.g., accident at site detected by VIDS, equipped with PTZ function.	10
Video Incident Detection System (VIDS)	It will be installed at black-spot locations, i.e., merging points of service roads entering CPRR and around the junction of CPRR and TPP Link Road.	10
Automatic Traffic Counter Cum System (ATCC)	It will be installed to measure the traffic volume by section. The proposed locations are between (i) the end point of CPRR near the port and TPP Link Road junction, (ii) the TPP Link Road junction and CPRR toward NH5, and (iii) the TPP-link junction and start point of TPP Link Road. The sensors are proposed to be installed at one location in both directions at those places.	6
Meteorological System (MET)	It will be installed to measure the precipitation, wind direction/velocity, and visibility at two locations, i.e., both ends of CPRR. The alarm messages will be issued in case the measured data reaches the threshold value.	2
Variable Message Sign System (VMS)	It will be installed to provide information on the traffic situation ahead of the vehicles entering CPRR and TPP Link Road. The information to be provided are accident, congestion, road work, lane restrictions, etc.	3

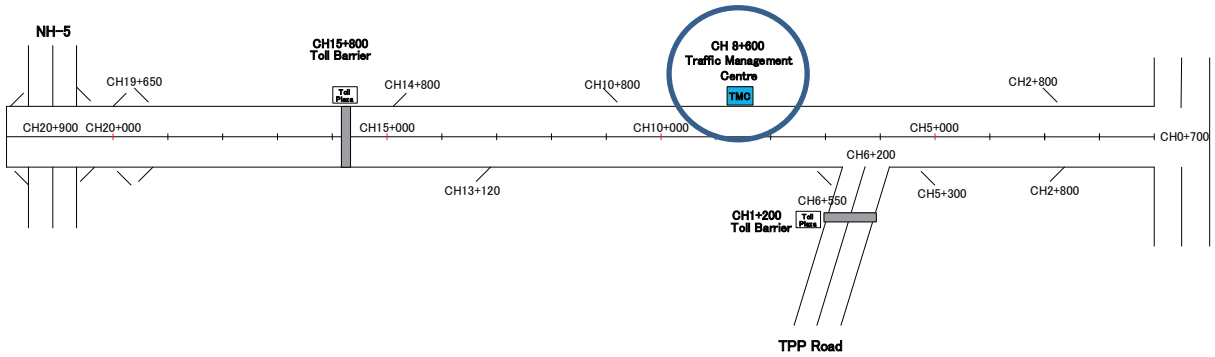
Source: JICA Study Team

Fiber optic cables will be laid on the shoulders on both sides of the CPRR, and the roadside equipment will be connected by this communication network exclusive for CPRR.

Center for HTMS: Traffic Management Center

The Center for HTMS: Traffic Management Center, is proposed to be located at a different location from the toll plaza because of the different natures of work. The Traffic Management Center will be for highway management, whereas the toll plaza will be engaged in handling the toll. It is proposed that the Traffic Management Center will be constructed at Ch.8+600, which satisfies the conditions that (i) it is almost at the mid-point of Section 1 from a viewpoint of operation and management for the target section, (ii) there is sufficient space for the Center in terms of right of way (ROW), and (iii) it does not affect the parking area for the large vehicles planned nearby.

Figure 7.2.2 shows the location plan for the Traffic Management Center.



Source: JICA Study Team

Figure 7.2.2 Location Plan for Traffic Management Center (HTMS)

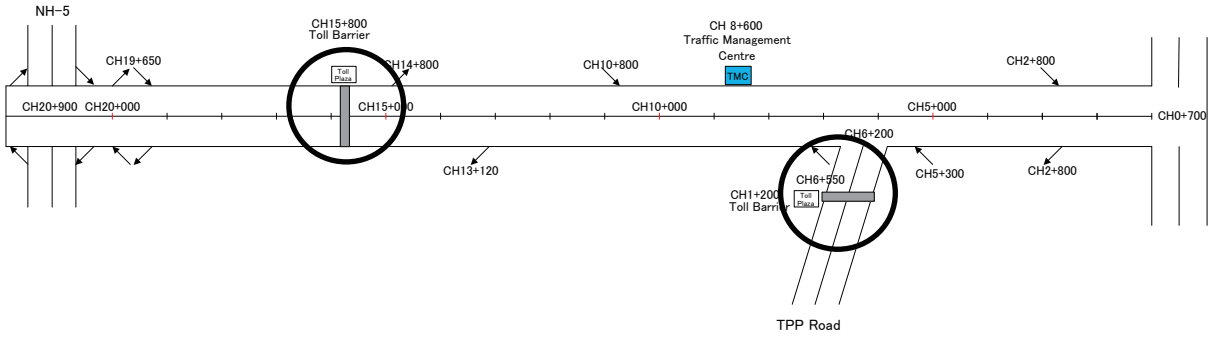
7.3 Toll Management System (TMS)

(1) Toll Collection Method

Manual toll collection and electronic toll collection (ETC) (RFID method: FASTag) will be adopted. The Touch-and-Go system using an interchange (IC) card will not be adopted because the plan towards realizing the common mobility card or electronic settlement, which can be used across different transport modes, is still under discussion in Chennai, and it is not clear when such payment method will become available in Chennai. Thus, it is anticipated that sufficient increase of Touch-and-Go usage cannot be expected and that the convenience for road users are limited by the IC card, which can be used only for Section 1 of CPRR. Regarding the tariff system, the distance-based system will be adopted. (More details are given in Chapter 8.)

Locations of Toll Plazas

According to discussions with Tamil Nadu Road Development Company (TNRDC), it has been determined that toll plazas will be constructed in two locations as shown in Figure 7.3.1. As shown below, the toll barriers will be located on the main carriageway of CPRR (Ch.15+800) and TPP Link Road (Ch.1+200). (The reasons of determining those locations are given in Chapter 8)



Source: JICA Study Team

Figure 7.3.1 Locations of Toll Plazas

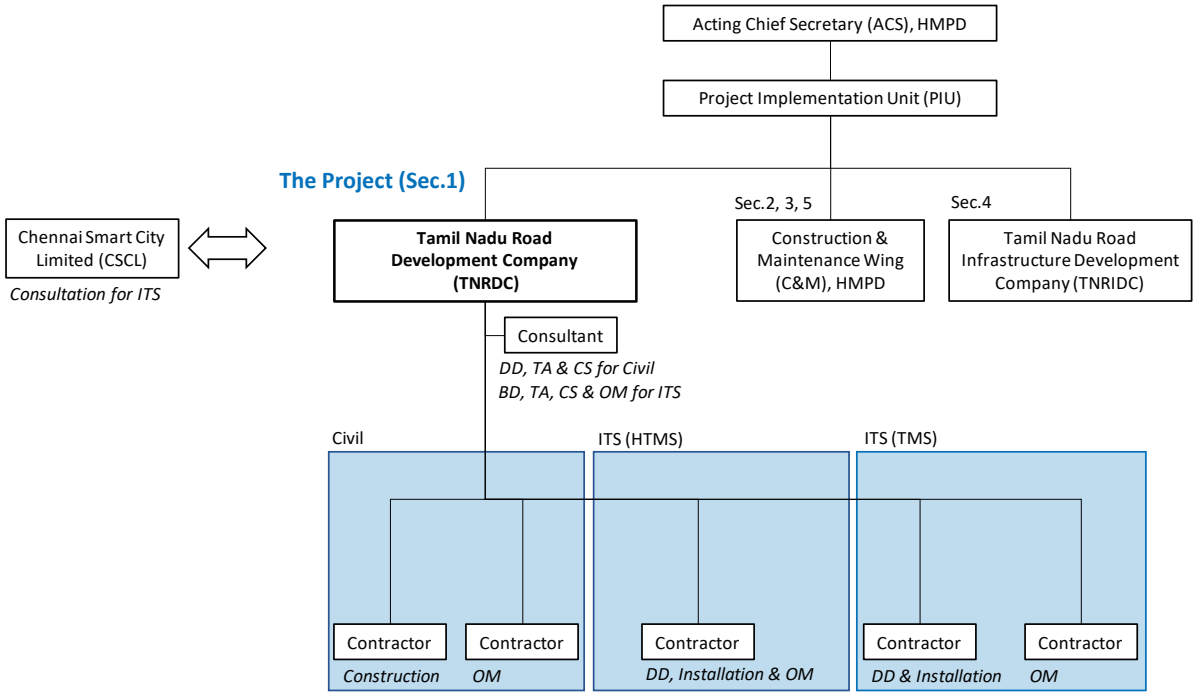
8. IMPLEMENTATION ORGANIZATION FOR CPRR ITS

8.1 Organizational Framework of Project

The following figure shows the organizational framework of the Intelligent Transport System (ITS) Project for Chennai Peripheral Ring Road (CPRR). The Tamil Nadu Road Development Company (TNRDC) will be responsible for the implementation of Section 1 of the Project as shown in the figure below. Under TNRDC, the Consultants for civil construction and ITS will be procured. The Consultant for ITS will be in-charge of basic design, tender assistance, and supervision of construction and operation and maintenance (O&M).

The O&M for the Highway Traffic Management System (HTMS) will be carried out by the supplier of the system who is in-charge of the detailed design and installation. As for the Toll Management System (TMS), the detailed design and installation will be completed by the supplier of the system, but the O&M contractor will be procured separately.

The Chennai Smart City Limited (CSCL) will engage in the Project, taking an advisory role and assisting as necessary.



(BD: Basic Design, DD: Detailed Design, TA: Tender Assistance, CS: Construction Supervision, OM: Operation and Maintenance)

Source: JICA Study Team

Figure 8.1.1 Organizational Framework of ITS Project for CPRR

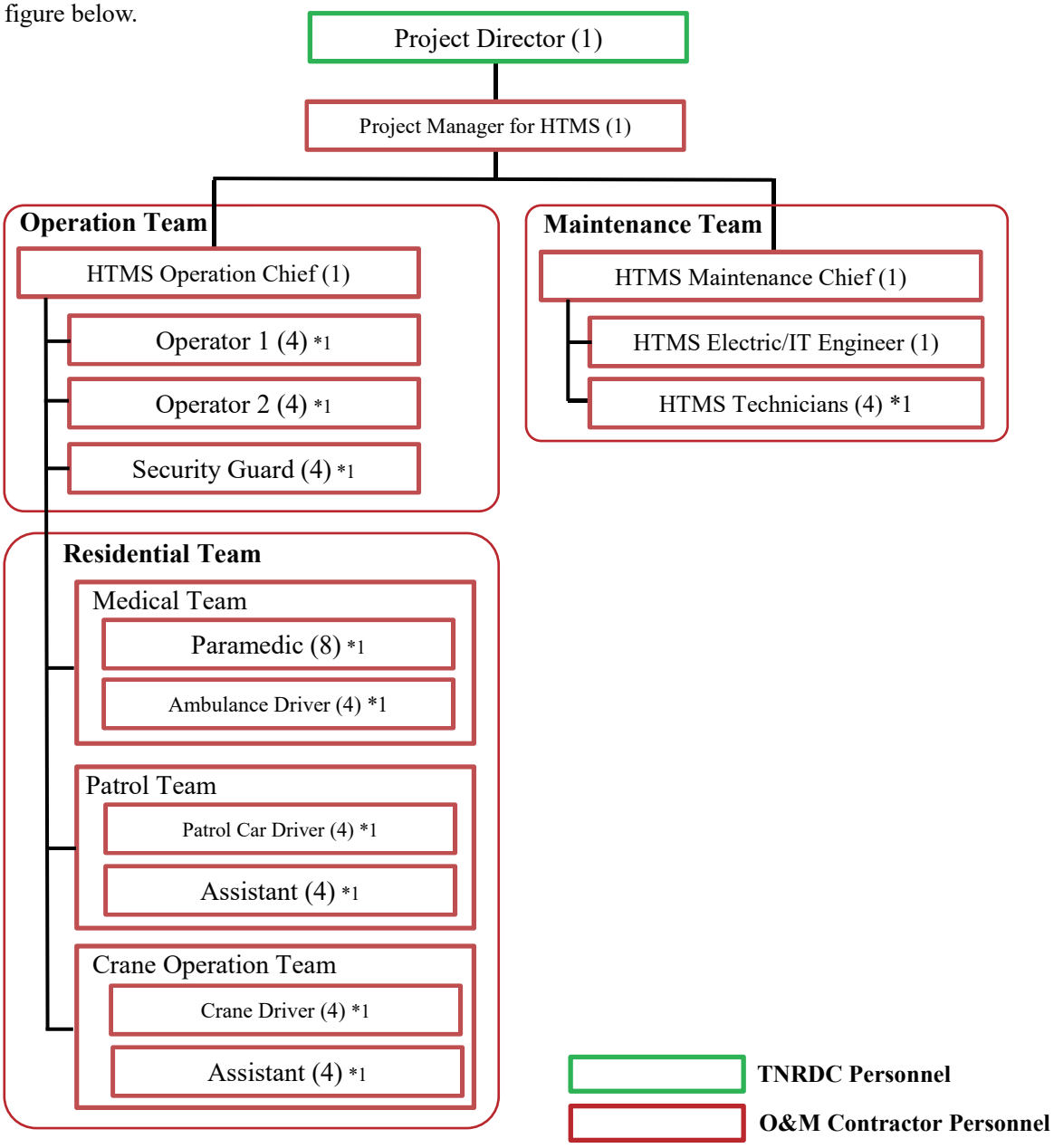
8.2 Operation and Maintenance (O&M) Plan for Chennai Peripheral Ring Road Intelligent Transport System (CPRR ITS)

CPRR ITS has two ITS components, i.e., HTMS and TMS. This clause describes the required ITS O&M structure, roles, number of staff, and their shift arrangement. TNRDC, which is the responsible organization for tender and O&M, intends to hire two different O&M companies for HTMS and TMS, respectively. Therefore, the O&M plans for HTMS and TMS were considered separately.

8.2.1 Highway Traffic Management System (HTMS)

Organizational Structure for O&M of HTMS

The organizational structure for O&M of the HTMS and the required number of staff are shown in the figure below.



*1: The number of staff in the figure above indicates the total number including shifts. The shift plans are described in the subsequent clauses.

Source: JICA Study Team

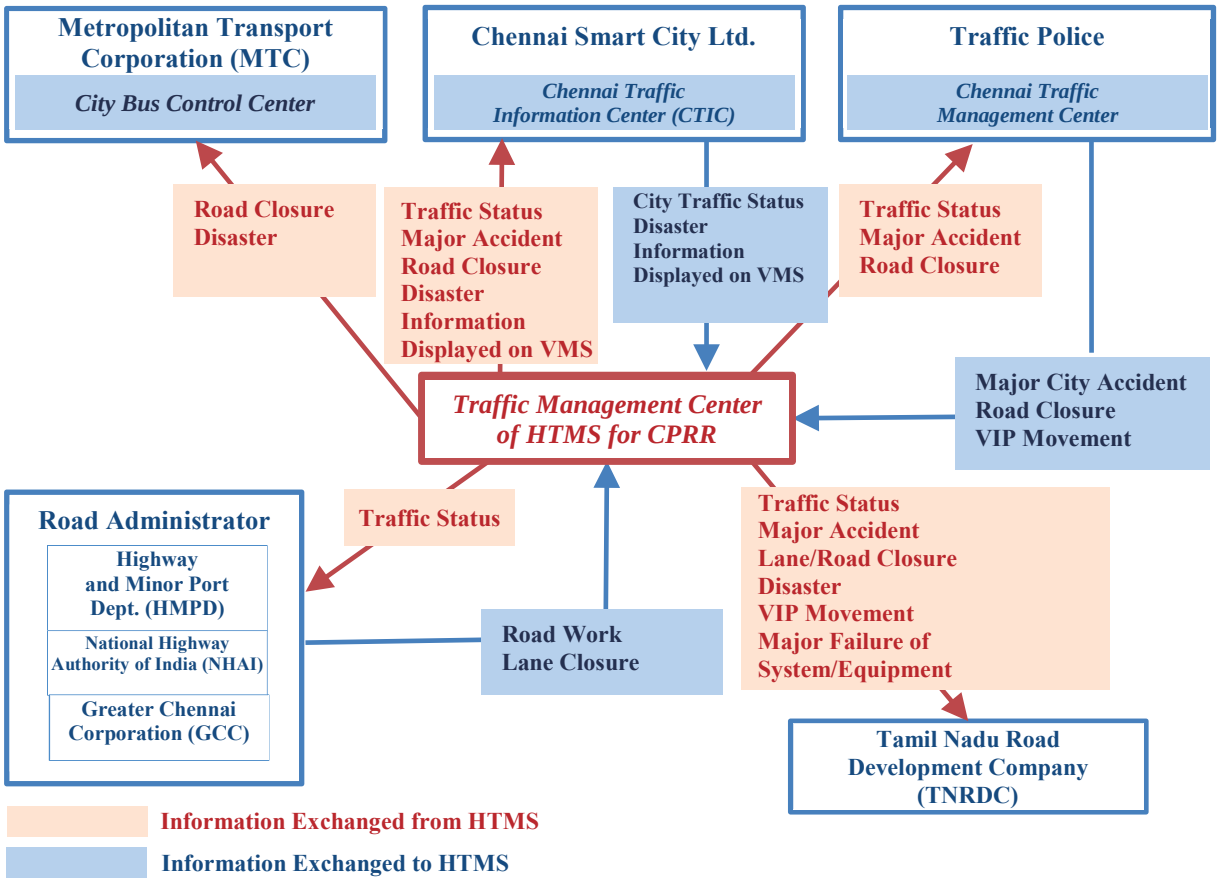
Figure 8.2.1 Organizational Structure and Number of Staff for O&M of HTMS

The HTMS O&M Team consists of the staff of the O&M contractor which will be formed under the Project Director of TNRDC. All staff of the HTMS O&M Team will work in the Traffic Management Center building.

Collaboration with Other Related Organizations in the Transport Sector in Chennai

The planned route of CPRR will connect industrial parks in the suburbs, such as Oragadam and Mahindra World City, and the ports, such as Ennore Port and Kattupalli Port, and will contribute to the mitigation of the incoming flow of large vehicles into the city. The coordination of traffic information between CPRR ITS

and City ITS and the collaboration with related organisations are vitally important to control the traffic flow, maximizing the efficient use of the road network in Chennai. The figure below shows the examples of information exchange between CPRR ITS, i.e., Traffic Management Center of HTMS, and the related organisations. The collaboration shall be executed among the related organisations and centers in Chennai as shown below.



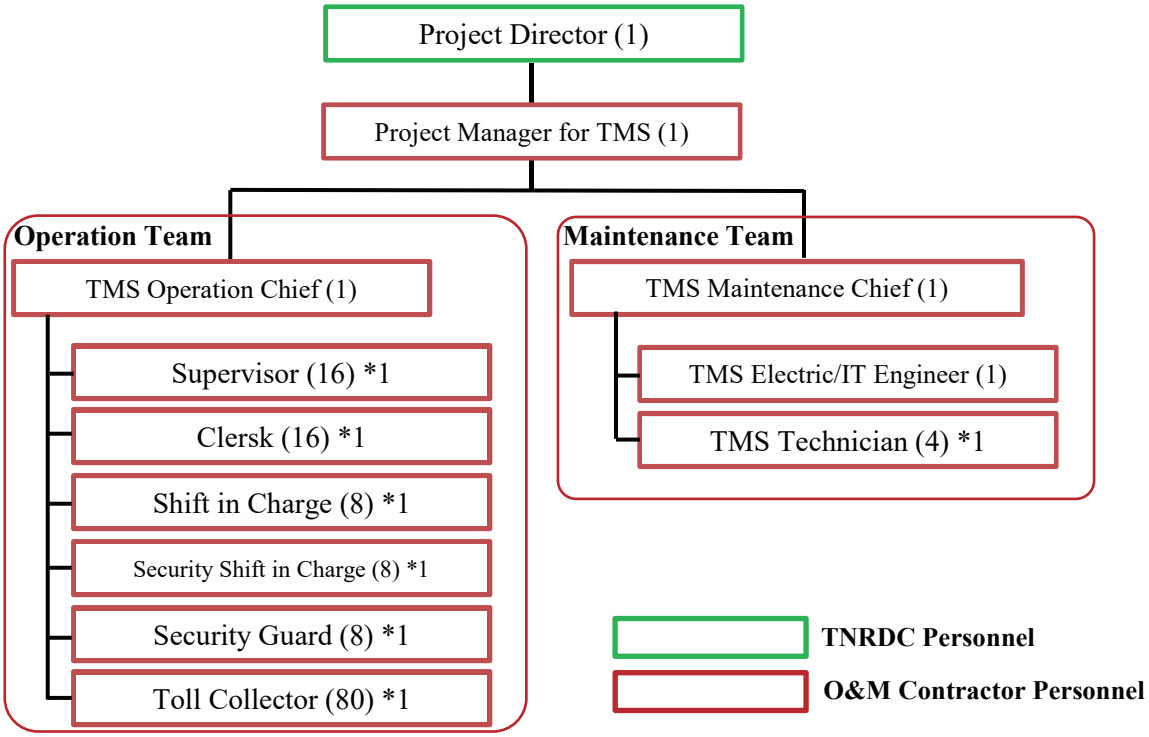
Source: JICA Study Team

Figure 8.2.2 Examples of Information Exchange between Traffic Management Center of HTMS for CPRR and Related Organizations

8.2.2 Toll Management System (TMS)

Organizational Structure for O&M of TMS

The organisational structure for the O&M of TMS and the required number of staff are shown below.



*1: The number of staff in the figure above indicates the total number including the shifts. The shift plans are described in the subsequent clauses.

Source: JICA Study Team

Figure 8.2.3 Organization Structure and Number of Staff for O&M of TMS

The TMS O&M Team consists of the staff of the O&M contractor, which will be formed under the project director of TNRDC. All the staff of the TMS O&M will work in the two toll plazas.

Toll Fare System (Distance Based Toll Collection) and Toll Collection Method

As a result of discussions with TNRDC, it was decided to adopt Distance Based Toll Collection as the toll fare system based on the TNRDC policy for the target section of the Project. It was also agreed with TNRDC that toll barriers will be installed at two locations, i.e., on the west side of CPRR main carriageway and on TPP Link Road, with consideration of the following matters:

- A part of the toll plaza to be constructed should be on the embankment.
- Sufficient space should be secured next to a toll plaza for the toll plaza building and parking.
- Enough space for the toll plaza square should be secured.
- The longitudinal gradient should be less than 3%.
- A certain distance should be secured from the edge of the toll plaza square to the entrance/exit ramp.
- The distance between the grade junction point and the taper end of toll plaza square should be more than 600 m (by IRC).

The Distance Based Toll Collection method was considered for cash and ETC payments, on the condition that two toll barriers will be constructed. The explanatory image for consideration is shown in Figure 8.2.4, where the letters A, B, C, and D are given to explain the relation between the traveling section of vehicles and the toll fare for each case where E and F represent Toll Barriers on CPRR and TPP Link Road,

respectively. There are many entrance/exit ramps where the vehicles can enter the target section for free from the parallel service roads.

Source: JICA Study Team

Figure 8.2.4 Explanatory Figure for Toll Collection Method and Location of Toll Plazas

9. PROCUREMENT PLAN, CONSTRUCTION PLAN, AND COST ESTIMATE

9.1 Review of DPR Cost Estimate (All Sections)

Rationale for Setting Unit Prices

Among major work items, which has high sharing of cost estimate in DPR, the "Tamil Nadu Highways Dept. SOR 2016-2017" is mainly applied for roadwork and the "Tamil Nadu PWD SOR 2016-2017" is for construction works. Work items not described in the schedule of rates (SOR) is said to be based on the market price. The basis of unit prices in the DPR is shown in the table below.

Table 9.1.1 Basis of Base Cost of DPR

Item		Basis
Material	Sand, gravel, stone aggregate, cement, steel, brick	Highway Department SOR 2016-2017 Tamil Nadu PWD SOR 2016-2017
	Bitumen, emulsion	Indian Oil Corporation Ltd. (IOCL) latest rates of Chennai refinery
Labor		Tamil Nadu PWD SOR 2016-2017
Machinery	Typical machines	MORTH design data book including escalation of 5%/year calculated from 2001-2002 up to 2016-2017
	Non-listed machines	Market rates

Source: JICA Study Team

However, DPR Volume VI [Rate Analysis] has not been provided to the Japan International Cooperation Agency (JICA) Study Team and the basis for setting each unit price was unknown as of December 2017. For this reason, the unit price review of this survey was conducted to refer to the material above and to check whether there is any obvious mistake in the unit price setting.

Table 9.1.2 Basis of Base Cost of DPR

Item	Total Cost Share	Unit	Unit Price		
			(1) DPR	(2) Rebuild for Review	Ratio (1) / (2)
Filling with approved earth from borrow areas	14.1%	cum	514	594	87%
Providing and laying bituminous concrete	2.4%	cum	6,878	7,555	91%
Providing and laying dense graded	5.7%	cum	6,305	6,661	95%

Item	Total Cost Share	Unit	Unit Price		
			(1) DPR	(2) Rebuild for Review	Ratio (1) / (2)
bituminous macadam					
W-shaped metal beam crash barrier	5.4%	m	4,581	4,686	98%
HYSD Reinforced steel	14.2%	ton	65,122	74,649	87%
Reinforced Earth Facia wall in approached	3.9%	sqm	5,150	5,066	102%

Source: JICA Study Team

Updated DPR Unit Prices

As a result of comparing FY2016/17 and FY2017/18 of the PWD SOR where updated versions are issued annually, prices are rising at the following rates.

Table 9.1.3 Ratio of Unit Price Inflation

Rate Item	Description	(FY2017/18) / (FY2016/17)
Labour	-	110 %
Material	Brick and Tiles	104 %
	Stone and Road Materials	105 %
	Lime, Timber, and Roofing Materials	100 %
	Metal and Iron Items	105%
Work	Clearing the Site, Dismantling, Quarrying and Blasting, Earthwork, Concrete, Brick or Stone Masonry, Concrete Vibrators, Miscellaneous, Cutting and Threading of GI Pipe	110%

Source: JICA Study Team based on PWD SOR

Renewal of the Project Cost Estimate

Based on SOR's inflation rate, the JICA Study Team updated the cost estimate base year from 2016 to 2017, the surveyed year.

9.2 General Procurement Situation in Tamil Nadu

Outline of Procurement Situation

Procurement of typical construction materials in Tamil Nadu is simple. Majority of equipment such as trucks, tippers, loaders, hot mix plants, paver finishers, rollers, pile boring machines, prestressing equipment, and cranes are readily available.

For construction of roads and bridges, the main materials, like aggregate, sand, cement, steel, brick, and lime, are easily available within the state. However, among these, the procurement of sand remains difficult. The growth of unrestricted sand mining has affected water bodies. Therefore, the government imposed a partial ban on sand mining in some important water bodies. Illegal sand mining is rampant. The ban has reduced the supply. Sand price increases enormously as the demand keeps increasing. The Government of India (GOI) is importing sand to ease the scarcity. The increase in the price of sand had shot up the cost of all projects involving sand. There are agencies that can obtain permission from government departments to import the required items. There is also a choice for the contractor to import directly. In such case, the actual user needs to get prior permit to import an item. For this also, there are agencies who can act on behalf of the company. Some unusual equipment such as sensors for ITS, machines to work in marshy areas, and surveillance equipment may have to be imported.

Influence of Procurement Circumstances on the Project

Generally, the civil works planned for the Chennai Peripheral Ring Road (CPRR) are composed of construction of a similar level of primal roads such as Outer Ring Road (ORR) and Chennai Bypass. Therefore, difficulty is not expected for the implementing organization and local contractors. On the other hand, regarding the introduction of ITS in CPRR and Chennai City, there is no similar case and most contractors are not familiar with the installation and effective operation of equipment. Therefore, project management and technical support through official development assistance (ODA) loan project are considered indispensable.

9.3 Cost Estimate for CPRR (Sec-1)

Section 1 is evaluated to be a top priority among the entire CPRR and the most appropriate for a Japanese ODA Loan Project.

Cost Estimate Condition

Basic conditions of cost estimate are summarised below.

Table 9.3.1 Pre-condition of Cost Estimate for CPRR

Item	Condition
Currency	USD = JPY 106.0
	USD = INR 65.6
	INR = JPY 1.62
Price escalation	FC (JPY) : 1.83%
	LC (INR) : 4.13%
Physical contingency	Construction : 5.0%
	Consultant : 5.0%
Base year and month	March 2018
Consultant billing rate	Pro-(A) : JPY 3,246,000
	Pro-(B) : INR 389,259
	Supporting staff : INR 50,000
Project administrative expense	3.0%
Interest during construction	Construction: 1.50%
	Consultant: 0.01%
Front end fee	0.2%
Tax	GST 18.0%
	Import tax 0.0%

Source: JICA Study Team

Summary of Cost Estimate

The above-mentioned overall project cost is reorganised into the JICA appraisal form, which was arranged in JPY. Project cost is summarised in the tables below.

Table 9.3.2 Construction Cost Summary of CPRR (Civil Works)

Civil (Section-1) Loan Coverage Ratio 100

item	Cost		Total
	Foreign	Local	
	JPY	INR	JPY
I. ROAD WORKS	2,151,783,902	7,515,594,320	14,327,046,701
1. Site Clearance	2,184,045	7,628,272	14,541,846
2. Earth Work Excavation, Embankment Construction and Ground Improvement	840,745,112	2,936,493,382	5,597,864,392
3. Sub-base and base courses	150,085,853	524,208,951	999,304,353
4. Bituminous bases and surface courses	230,027,028	803,421,673	1,531,570,138
5. Drainage works	101,639,031	354,997,415	676,734,844
6. Protection works	209,058,742	730,185,170	1,391,958,717
7. Traffic signs, Markings and other road appurtenances	285,617,051	997,582,465	1,901,700,644
8. Road side amenities	53,256,705	186,011,147	354,594,764
9. Junctions & Intersections	109,587,472	382,759,153	729,657,300
10. Landscaping and Arboriculture	2,491,507	8,702,156	16,588,999
11. Highways Lighting	51,928,936	181,373,610	345,754,184
12. Temporary Diversion during construction	9,941,580	34,723,226	66,193,205
13. Toll Plaza including Fastag equipments	105,220,841	367,507,700	700,583,315
II. STRUCTURES	2,255,972,115	7,879,495,331	15,020,754,551
14. Major bridges	582,509,578	2,034,547,091	3,878,475,866
. Elevated Road	742,061,947	2,591,820,000	4,940,810,347
15. Minor bridges	74,436,123	259,985,077	495,611,947
16. Interchanges (NH5)	234,440,678	818,837,348	1,560,957,182
17. Road over bridges	265,961,177	928,929,858	1,770,827,547
18. Vechicular Underpasses	274,109,229	957,388,778	1,825,079,049
19. Culverts	82,453,383	287,987,179	548,992,613
III. EMP	0	30,642,727	49,641,218
20. Cost for EMP implementation	0	30,642,727	49,641,218
V. UTILITY SHIFTING	0	317,627,987	514,557,339
29. TANGEDCO Cost	0	255,261,552	413,523,714
30. TWAD Cost	0	33,690,636	54,578,830
31. BSNL Cost	0	28,675,799	46,454,794
Total	4,407,756,017	15,743,360,365	29,911,999,809

Source: JICA Study Team

1) ITS Cost

The cost of ITS installation works is summarised below.

Table 9.3.3 Cost Summary of CPRR (ITS for CPRR)

ITS (Section-1) Loan Coverage Ratio 100

item	unit	Quantity	Unit Price		Cost		Total
			Foreign	Local	Foreign	Local	
			JPY	INR	JPY	INR	JPY
Highway Traffic Management Sytem (HTMS)	LS	1	221,977,949	310,199,296	221,977,949	310,199,296	724,500,808
Toll Management System (TMS)	LS	1		226,095,881	0	226,095,881	366,275,327
Toll Plaza Building	LS	1		118,588,434	0	118,588,434	192,113,264
					0	0	0
Total					221,977,949	654,883,611	1,282,889,399

Source: JICA Study Team

2) Operation and Maintenance Cost (ITS for CPRR)

As a part of technical transfer, operation and maintenance (O&M) activities for three years will be commenced after ITS installation. The summarised cost is shown below.

Table 9.3.4 Cost Summary of Operation and Maintenance of ITS for CPRR

ITS OM (Section-1) Loan Coverage Ratio 0

item	unit	Quantity	Unit Price		Cost		Total
			Foreign	Local	Foreign	Local	
			JPY	INR	JPY	INR	JPY
Toll Management System (TMS)	Year	3		122,100,429	0	366,301,287	593,408,085
Highway Traffic Management Sytem (HTMS)	Year	3		73,920,429	0	221,761,287	359,253,285
Cars of O&M	LS	1		8,831,500	0	8,831,500	14,307,030
Total					0	596,894,074	966,968,400

Source: JICA Study Team

10. IMPLEMENTATION SCHEDULE OF SECTION 1

10.1 General

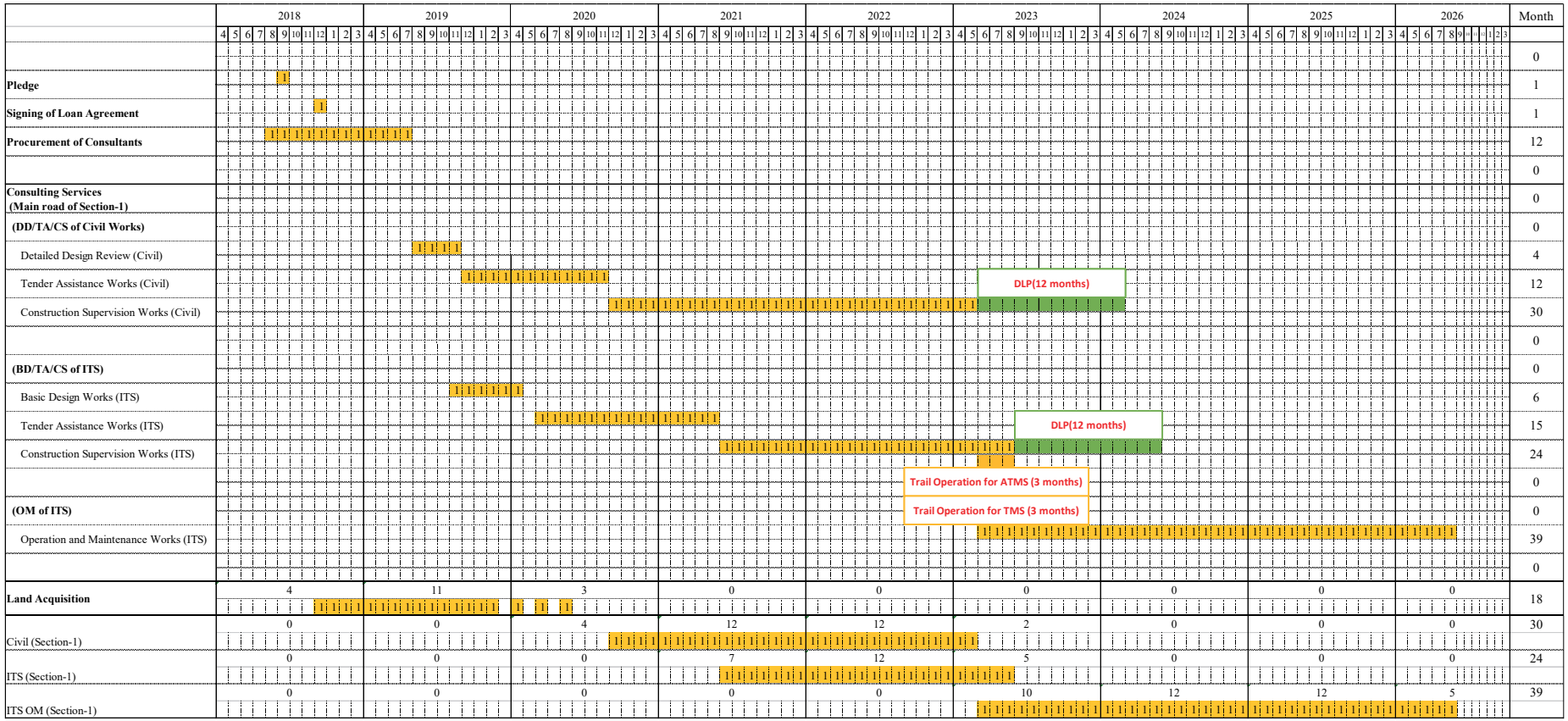
The subject of this study was originally the Chennai Peripheral Ring Road (CPRR) Project and the Chennai City Intelligent Transport System (ITS) Project. However, the procedure for environmental social consideration of CPRR was delayed. For this reason, JICA decided to separate the Chennai City ITS Project from the CPRR Project and aimed only for the Chennai City ITS Project as the initial goal of the March 2018 loan agreement (L/A). The Tamil Nadu Infrastructure Development Board (TNIDB) applied to the DEA to list Chennai City ITS Project separately from CPRR Project and to list it in the rolling plan independently. Based on the above, the project implementation schedule of the CPRR Project and the Chennai City ITS Project was independently examined. Regarding the Chennai City ITS project, the study results are compiled in Vol. 2 of this report.

10.2 Tentative Implementation Schedule for CPRR

Between consultation with Japan International Cooperation Agency (JICA), it had high economic validity, most advanced land acquisition progress, and highest priority among sections. During consultation with inhabitants around the site of the Tiruvottiyur Ponneri Pancheti (TPP) Link Road (Original Alignment), it was found that it is important to obtain social consensus for the road construction. As an alternative solution to minimise the social impact, the south end of TPP Link Road is to be shifted approximately 1.5 km west

from the original alignment. This new alternative alignment totals 3.6 km from the connecting point with Northern Port Access Road (NPAR) to the southern end. The 1.65-km section in the northern part is the same as the original alignment, and the remaining 1.95 km in the southern part is different from the original alignment. Through an additional survey at the alternate site, social consensus was confirmed for the new alignment. Therefore, it is expected that NPAR and TPP Link Road (New Alignment) will become the object of the Japanese official development assistance (ODA) loan project as Section 1. Sections 2, 3, and 4 are also confirmed for economic validity of the project in "4.3 Prioritization of Components for Implementation ".

Figure 10.2.1 shows the proposed project schedule of CPRR Section 1.



Source: JICA Study Team

Figure 10.2.1 Project Schedule of CPRR Section 1

11. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

The Chennai Peripheral Ring Road (CPRR) Project is divided into five sections. The first stage of this study reviewed all the sections and finally selected Section 1 as priority section. After the selection of the priority section, Section 1 was examined in detail. Therefore, the main scope of the Project is Section 1.

Section 1 consists of the Northern Port Access Road (NPAR) and the TPP Link Road. After the detailed survey and consultation with local residents, it was concluded that social consensus was not yet formed on the TPP Link Road. The Highways and Minor Ports Department (HMPD) moved the southern end of the TPP Link Road about 1.5 km west of the original alignment. The length of the new alignment is 3.6 km, with the original 1.65 km in the north and the new 1.95 km in the south. Social consensus on TPP Link Road (new alignment) was confirmed. It is expected, therefore, that Section 1 (main road (Northern Port Access Road) and TPP Link Road (new alignment)) will be the target of the Japanese ODA Loan Project.

The objective of this study is for the JICA Study Team 1) to review the environmental impact assessment (EIA) and resettlement action plan (RAP) reports prepared by HMPD, 2) to study the gaps between the above reports and the requirements of the JICA guidelines, and 3) to conduct additional studies to fill in the gap if there is any.

11.1 Review of the DPR EIA/SIA/RAP for All Sections

11.1.1 Screening

The Project is categorized A according to the JICA Environmental and Social Guidelines 2010 because the road sector is likely to have significant adverse impacts on the environment, and its components are likely to have significant adverse impacts on the society regarding large-scale involuntary resettlement.

Environmental Notification 2006, with its amendment in 2009, 2011, and 2013, stipulates the conduction of EIA, Environmental Clearance (EC), and their procedures according to the type, size, and location of the proposed project. The proposed project can start only after the EC is granted. For a State Highway (SH) project, acquiring an EC is stipulated. The proposed project includes new construction highway intervals; therefore, the Project is categorized B in 7(f) (i) wherein an EC is required.

The HMPD (Chengalpattu Divisional Engineer (H)) has applied for EIA TOR for the CPRR Project on 26 October 2017. The Tamil Nadu State Environmental Impact Assessment Authority (TNSEIAA) issued the EIA TOR on 5 March 2018 to HMPD. HMPD submitted the draft EIA report to Tamil Nadu State Pollution Control Board (TNSPCB) on 11 April 2018. TNSPCB called for public comments, then, conducted public consultation meetings in Kancheepuram District on 10 July 2018 and in Thiruvallur District on 12 July 2018. The collected comments/opinions and records of the meeting were reflected on the final EIA report, and the report was submitted to TNSEIAA on 20 July 2018.

11.1.2 Review of the DPR EIA and SIA/RAP

Initial environmental evaluation and public consultations were also implemented to disseminate the Project, the survey results on environmental and social impacts, plan and policy on land acquisition, and framework of compensation and other assistances.

The environmental impacts expected to be caused by the CPRR are the same as those caused by the ordinal road construction works and existence of artery roads. In this sense, the prediction of impacts described in the DPR EIA was agreed in principle by the JICA Study Team.

11.2 Environmental and Social Considerations in Section 1

11.2.1 General Condition of the Project Area

The alignment of the link road is not significantly changed. The general condition of the Project area applies also to TPP Link Road (New Alignment).

The study area is located on the east coastal plain of India. The topography of the area is almost flat. The Thiruvallur District is located in Section 1, the share of wasted land and unculturable land is 46.1%, and the other 34% is agriculture and pasture land. Land use of Section 1 ROW shows the same components with that of the district in general.

		
Power plant and industry near the start point	Wet land and abandoned land	Farming land (rice) and hamlet
		
Pasture land, fallow land	Waste land	Area near the planned NH5 Interchange

Source: JICA Study Team

Figure 11.2.1 Images of the Land Use on ROW of Section 1 and Nearby Area

The ROW of Section 1 is not located in or near any protected areas designated by Tamil Nadu or Indian governments. Section 1 is located in the Coastal Regulation Zone.

In India, national parks and wildlife sanctuaries are designated for the areas where there are certain necessities for natural environment protection under the Wildlife Protection Act 1972. The CRZ within the project area is not designated as such and is not classified as 'Protected Area' according to the definition of the JICA Guidelines.

11.2.2 Impact Assessment

Based on the survey results, final impact assessment in the planning, construction, and operation phases are described in and Table 11.2.1. The table explains the impact assessment for Section 1, together with specific considerations necessary for other sections.

Table 11.2.1 Impact Assessment and Evaluation

	Impacts	Scoping of Potential Impacts		Main Road & TPP Link Road (Original Alignment)		Main Road & TPP Link Road (New Alignment)	
		Planning & Construction	Operation	Planning & Construction	Operation	Planning & Construction	Operation
	Pollution Control						
1	Air Pollution	B-	B±	B-	B±	B-	B±
2	Water Pollution	B-	B-	B-	B-	B-	B-
3	Waste	B-	D	B-	D	B-	D
4	Soil Contamination	B-	D	B-	D	B-	D
5	Noise and Vibration	B-	B±	B-	B±	B-	B±
6	Ground Subsidence	C	C	D	D	D	D
7	Offensive Odor	D	D	D	D	D	D
8	Bottom Sediment	D	D	D	D	D	D
	Natural Environment						
9	Sanctuary	D	D	D	D	D	D
10	Ecosystem	B-	B-	B-	B-	B-	B-
11	Hydrological Situation	B-	B-	B-	B-	B-	B-
12	Topography and Geographical Features	B-	D	D	D	D	D
13	Involuntary Resettlement, Loss of	A-	D	A-	D	A-	D

	Impacts	Scoping of Potential Impacts		Main Road & TPP Link Road (Original Alignment)		Main Road & TPP Link Road (New Alignment)	
		Planning & Construction	Operation	Planning & Construction	Operation	Planning & Construction	Operation
	Land and Asset, Business Relocation						
14	The Poor	B-	D	B-	D	B-	D
15	Ethnic Minorities, Indigenous Peoples	D	D	D	D	D	D
16	Local Economy, Employment and Living, Livelihood	B±	B+	Section 1 B+ Section2 B+ Section3, Section5 B±	B+	Section 1 B+	Section 1 B+
17	Land Use, Local Resource Use	D	D	D	D	D	D
18	Water Use, Water Rights	B-	B-	B-	B-	B-	B-
19	Existing Public Facilities, Road and Transportation Facilities, Social Infrastructure, Social Services	B-	B±	B-	B±	B-	B±
20	Social Capitals, Local Decision-making Systems, Social Organizations	D	D	D	D	D	D
21	Uneven Distribution of Project Impact and Benefit	D	D	D	D	D	D
22	Local Conflicts of Interest	D	D	D	D	D	D
23	Split of Community	B-	C	B-	Section 1 D Section2 D Section3 Section5 B-	B-	Section 1 D
24	Historical Heritage, Cultural Resources	D	D	D	D	D	D
25	Landscape	D	D	D	D	D	D
26	Gender	D	D	D	D	D	D
27	Children's Rights	B-	B-	B-	B-	B-	B-
28	Sanitation, Public Health, Transmittable Diseases including HIV/AIDS	B-	D	B-	D	B-	D
29	Work Environment, Occupational Safety and Health	B-	B-	B-	B-	B-	B-
30	Accidents, Crime	B-	B±	B-	B±	B-	B±
31	Climate Change, Cross-border Impacts	B-	B±	B-	B±	B-	B±

A+/-: Remarkably positive/serious negative impact is predicted.
B+/-: Positive/negative impact is expected to some extent.
C: Extent of impact is unknown. (Further study is necessary.)
D: Impact is very small or nil, and further survey is not required.

Source：JICA Study Team

11.3 Land Acquisition and Resettlement of Section 1

11.3.1 Project Affected Structures, Households and Businesses in Section 1 (Main Road and TPP Link Road (Original Alignment))

Project affected households and businesses in Section 1 are shown in Table 11.3.1. In total, 206 structures and households, 24 businesses, and 16 public facilities are to be displaced. The Census Survey by HMPD in 2017 recorded the number of households and businesses within the ROW. The size of a household was asked in the Socio-economic Survey which resulted to an average household size of 4.1 persons. The number of persons to be displaced was estimated at 845 persons by multiplying the number of PAH by 4.1 (206 x 4.1 = 844.6).

Table 11.3.1 Project Affected Assets in Section 1 (Main Road and TPP Link Road (Original Alignment))

			Displaced			Non-displaced		
Ownership	Category		Main Road	TPP Link Road (Original Alignment)	Total	Main Road	TPP Link Road (Original Alignment)	Total
Owner	Residential	a	15	135	150	0	0	0
	Commercial	b	4	9	13	0	0	0
	Residential and Commercial	c	2	7	9	0	0	0
	Others	d	-	-	-	9	2	11
	Abandoned	e	-	-	-	8	2	10
	Under construction	f	0	5	5	0	0	0
	Structures to be affected with minor impact (less than 1/3)	g	-	-	-	0	4	4
	Subtotal		21	156	177	17	4	21
Squatters	Residential	h	17	2	19	0	0	0
	Commercial	i	1	0	1	0	0	0
	Residential and Commercial	j	0	0	0	0	0	0
	Others	k	-	-	-	0	0	0
	Abandoned	l	-	-	-	0	0	0
	Subtotal		18	2	20	0	0	0
Tenants	Residential	m	0	8	8	-	-	-
	Commercial	n	1	0	1	-	-	-
	Residential and Commercial	o	0	0	0	-	-	-
	Subtotal		1	8	9	-	-	-
Total Structures and Households		p	40	166	206	17	4	21
Business Total b+c+i+j+n+o		q	8	16	24	0	0	0
Public Facilities		r	11	5	16	0	0	0
Non-residential Land Owners		s	-	-	-	448	549	997
Workers		t	-	-	-	5	6	11

Squatter: Illegal occupants of private and public land
Source：DPR RAP July 2018 Table 5.40, Table 5.41

11.3.2 Project Affected Structures, Households and Businesses in Section 1 (Main Road and TPP Link Road (New Alignment))

Project affected households and businesses in Section 1 (Main Road and TPP Link Road (New Alignment)) are shown in Table 11.3.2. In total, 60 structures and households, 8 businesses, and 11 public facilities are to be displaced. The census conducted by HMPD in 2017 recorded the number of households and businesses within the ROW. The size of a household was asked in the Socio-Economic Survey, and the average household size was determined to be 4.1 persons. The number of persons to be displaced was

estimated by multiplying the number of PAH by 4.1, thus arriving at 246 persons (60 x 4.1 = 246).

Among the 60 structures to be displaced, 40 structures are located on the ROW of the Main Road and 20 structures are located on the ROW of TPP Link Road (New Alignment).

Table 11.3.2 Project Affected Assets in Section 1 (Main Road and TPP Link Road (New Alignment))

			Displaced			Non-Displaced		
Ownership		Category	Main Road	TPP Link Road (New Alignment)	Total	Main Road	TPP Link Road (New Alignment)	Total
Owner	a	Residential	15	12	27	0	0	0
	b	Commercial	4	0	4	0	0	0
	c	Residential and Commercial	2	0	2	0	0	0
	d	Others (i.e. wells)	-	-	-	9	0	9
	e	Abandoned	-	-	-	8	0	8
		Subtotal	21	12	33	17	0	17
Squatters	f	Residential	17	0	17	0	0	0
	g	Commercial	1	0	1	0	0	0
	h	Residential and Commercial	0	0	0	0	0	0
	i	Others	-	-	-	0	0	0
	j	Abandoned	-	-	-	0	0	0
		Subtotal	18	0	18	0	0	0
Tenants	k	Residential	0	8	8	-	-	-
	l	Commercial	1	0	1	-	-	-
	m	Residential and Commercial	0	0	0	-	-	-
		Subtotal	1	8	9	-	-	-
Structures and Households Total	n		40	20	60	17	0	17
Business Total b+c+g+h+l+m	o		8	0	8	0	0	0
Public facilities	p		11	0	11	0	0	0
Non-residential land Owners	q		-	-	-	448	296	744
Workers	r		-	-	-	5	0	5

Squatter: Illegal occupants of private and public land
Source: DPR RAP 2018 p.iv, Table 5.43

11.3.3 Project Affected Structures, Households and Businesses in Section 1 (Main Road and TPP Link Road (New Alignment))

The land area necessary for land acquisition for Section 1 (Main Road and TPP Link Road（New Alignment）) is 250.81 ha, as shown in Table 11.3.3.

Table 11.3.3 Land Area for Acquisition

	Private Land (ha)	Public Land (ha)	Total (ha)
Main Road	152.42	73.89	226.31
TPP Link Road （New Alignment）	18.84	5.66	24.50
Total	171.26	79.55	250.81

Source: 31 July 2018 HMPD

11.4 Stakeholder Meetings

Public consultations following JICA guidelines are held twice.

Besides the above consultations, TNSPCB held public consultations on the draft EIA report submitted by HMPD for all sections in Chengalpattu, Kancheepuram District on 10 July 2018, and at Thamaraipakkam in Thiruvallur District on 12 July 2018.

During the census for the PAHs of the TPP Link Road (New Alignment) in July 2018, consultation at each house was conducted for all the 20 PAHs. Out of all the PAHs, three HHs were absent during the visit. There were four HHs represented by women during the meetings. The consultation included information dissemination about the project, free queries and answers, and question on willingness to relocate to the proposed relocation site. The stakeholder meeting and site visit for the PAHs of the TPP Link Road (New Alignment), including ROW title holders, absentee land owners, local residents, road users of TPP Road, and general public, was organized at the project area, or Bharathi Nagar, on 12 July 2018 from 2:00 pm to 4:00 pm. Bharathi Nagar is the residential area located at the southern end of the TPP Link Road (New Alignment).

Table 11.4.1 Summary of the First Meetings

Sl. No.	Description	Minjur	Panchetti
1	Date	11:00 to 14:00, Monday, 9 April 2018	11:00 to 14:00, Tuesday, 10 April 2018
2	Venue	Block Development Office, Minjur	Village Panchayat Office, Panchetti
3	Officials Present	● HMPD Assistant Divisional Engineer, Ponneri and Thiruvallur ● TNRDC, SM ● HMPD Consultant (STUP)	● HMPD Assistant Divisional Engineer, Ponneri and Thiruvallur ● TNRDC, SM ● HMPD Consultant (STUP)
4	No. of Participants	More than 250 including NGOs (lady participants: 45)	More than 90 including NGOs (lady participants: 4)
5	Attendance Signed	145	47

Source: HMPD

Table 11.4.2 Summary of the Second Meetings

No.	Description	Minjur	Panchetti
1	Date	11:00 to 14:00, Friday, 11 May 2018	11:00 to 14:00, Saturday, 12 May 2018
2	Venue	Block Development Office, Minjur	Village Panchayat Office, Panchetti
3	Officials Present	● HMPD Assistant Divisional Engineer, Ponneri and Thiruvallur ● TNRDC, SM ● HMPD Consultant (STUP)	● HMPD Assistant Divisional Engineer, Ponneri and Thiruvallur ● TNRDC, SM ● HMPD Consultant (STUP)
4	No. of Participants	More than 200 including NGOs (lady participants: 22)	More than 75 including NGOs (lady participants: 1)
5	Attendance Signed	63	22

Source: HMPD

Table 11.4.3 TNSPCB Consultations

Dates	Locations
10 July 2018	Divisional Engineers Office, Chengalpattu, Kancheepuram District
12 July 2018	S.V. Rajammal Marriage Hall, Thamaraipakkam, Thiruvallur District

Source: http://www.environmentclearance.nic.in/writereaddata/FormB/EC/Public_Hearing/20072018CDTZ15DIAnnexure-DocumentofPublicHearing.pdf

12. PROJECT EVALUATION

12.1 Economic Analysis

The main objective of this economic analysis is to examine the investment efficiency of the project from the viewpoint of the national economy using cost-benefit analysis in the case where it can be applied. Market prices are converted to economic costs where the influence of market distortion is removed (so-called shadow prices). Opportunity costs are used for the costs of goods and services if their markets do not exist. Economic Internal Rate of Return (EIRR) is used as an indicator of the efficiency of a project investment.

A main objective of this financial analysis is to examine the efficiency of a project investment from the viewpoint of the project implementation body using cost-benefit analysis. Market prices are used. An Internal Rate of Return (IRR) is used as the indicator of the efficiency of a project investment. IRR used in financial evaluation is called the Financial Internal Rate of Return (FIRR).

12.2 Project Evaluation on CPRR (All Sections)

By using the project cost in economic price and benefit mentioned so far, cash flow tables are constructed, and EIRRs are calculated. The EIRR for each case is shown below.

Table 12.2.1 EIRR for Each Case

Case No.	Case	EIRR
1	Section 4 and 1 are constructed.	18.1%
2	Section 4 and 2 are constructed.	19.7%
3	Section 4 and 3 are constructed.	20.2%
4	Section 4 and 5 are constructed.	12.8%

Source: JICA Study Team

Since the JICA Study Team sets the social discount rate at 12%, it is therefore concluded that all cases are feasible.

EIRR Calculation

EIRR for Section 1 after the alignment change is 15.6%. As the JICA Study Team sets the social discount rate at 12%, Section 1 is deemed feasible.

There are such bad environmental influences that come about even if planned environmental mitigation measures are taken. As it is difficult to quantify them, they are not included in the EIRR calculation. Such bad influences, however, will be minimized due to the environmental mitigation measures including noise control. Thus, EIRR calculation result would not change so much as to alter the feasibility of the project even if they were included in the calculation.

FIRR Calculation

FIRR was calculated with market price of cost and toll revenue. As FIRR is negative, -6.5%, Section 1 is not feasible enough financially, that is, from the viewpoint of a private project or an independent one. On the other hand, it is socially significant from the viewpoint of public works conducted by a public organization since EIRR is more than the social discount rate set by the JICA Study Team.

13. CONCLUSIONS AND RECOMMENDATIONS

13.1 Necessity and Effect of the Chennai Peripheral Ring Road (CPRR) Project

With regard to the necessity and development effect of Chennai Peripheral Ring Road (CPRR) Project, the effects of traffic congestion mitigation and economic validity were examined and evaluated taking into account the traffic situation as of 2017. As a result, this project diverts through traffic as a peripheral ring road forming a ring and radial road network constituting the Chennai Metropolitan Area (CMA), and by provision of access between industrial area and regional transportation facilities, and improvement of the urban environment in CMA. It was confirmed that this project greatly contributes to economic development of CMA.

As a result of economic analysis based on the future traffic demand and project cost of each sections, the

Economic Internal Rate of Return (EIRR) of this project was calculated as follows: Section 1: 18.1%, Section 2: 19.7%, Section 3: 20.2%, and Section 5: 12.8%. Regarding Section 4, development was implemented by the state government's own funds, and as a subject for loan project, a comprehensive evaluation including the degree of environmental and social impact is added to the economic analysis, resulting in the table below.

Table 13.1.1 Result of Prioritization

Criteria		Indicator		Sec.1	Sec.2	Sec.3	Sec.5
1	Effect on Improvement of Traffic Situation	Traffic Volume (pcu/day)		58,324	31,184	89,528	43,282
			SCORE	**8**	**6**	**9**	**7**
		Reduction in Total Travel Time (vehicle hour)		54,871	45,192	67,494	26,239
			SCORE	**8**	**7**	**8**	**5**
		Large Vehicle Rate (%)		76	13	25	27
			SCORE	**10**	**4**	**6**	**7**
2	Magnitude of Environmental and Social Impact	Impact on Reserved Forest and Coastal Regulation Zone		RF: - CRZ: Cat..III	RF: - CRZ: -	RF: 0.28 CRZ: -	RF: 9.95 CRZ: -
			SCORE	**7**	**10**	**7**	**5**
		Area of Land to be Acquired (ha)		255	188	208	163
			SCORE	**5**	**7**	**6**	**7**
3	Economic Rationality	EIRR (%)		18.1	19.7	20.2	12.8
			SCORE	**7**	**7**	**7**	**5**
TOTAL SCORE				45	41	43	36
PRIORITY				**1**	**3**	**2**	**4**

Source: Land Acquisition Area: STUP's Letter E/14518/149/NJW/GK/0132 dated 11 Aug 2017,
Project Cost: Construction Cost shown in DPR Main Report, P9-3

1st **2nd** **3rd**

Source: JICA Study Team

With respect to Tiruvottiyur Ponneri Pancheti (TPP) Link Road, Highways and Minor Ports Department (HMPD) conducted a survey on the alternate alignment from May to June of 2018, as inhabitants' opposition was given to the original alignment. In early July, the government decided a new alignment of 3.6 km from the TPP Link Road around Minjur to Northern Port Access Road (NPAR) (as a main line of Section 1). Also, the new alignment connects to the Outer Ring Road (ORR) near Minjur.

13.2 Confirmation of Appropriateness of the Project Components

As a result of the review on the Detailed Project Report (DPR) and social environmental-related reports of CPRR, some issues were found. To be appropriate project under the official development assistance (ODA) scheme, the DPR of CPRR needs to consider the following:

Horizontal Alignment

Significant issues are not found for the horizontal curve radius. However, the spiral length is not sufficient in some sections. Thus, it is desirable to improve those sections.

Vertical Alignment

There is no issue with the gradient since all the applied values meet the Indian Road Congress (IRC) requirement throughout the route. However, the vertical curve length is not sufficient in some sections. Thus, it is desirable to improve those sections.

Entry/Exit and Service Road

Two-lane service roads that are to be operated as two-way roads are proposed on both sides of the main road. This system requires crossing at entries to enter the main road, and there is a concern of incursions and collisions at exits. Therefore, it is recommended to have a one-way operation on the service road at least in the vicinity of entries and exits.

Junctions

Traffic jam is expected at the at-grade intersection because of the increase in future traffic volume (large vehicles such as trailers) at the beginning point. It is proposed to have a separation of road for the through traffic (south to north) and left turn (south to west and west to north) and right turn (west to south and north to west).

Traffic jam is expected at the at-grade intersection between the main line and the TPP Link Road because of increase in future traffic volume (large vehicles such as trailers). To increase the capacity of the intersection, an exclusive lane for left turn (free left turn) is proposed instead of a left turn (east to south).

Traffic flow at the intersection of the ending point is complicated due to a roundabout. The installation of traffic signals is proposed at the crossing point to improve safety at the intersection.

Interchanges

Four interchanges are planned to connect the project road and the national roads.

As for interchanges (IC) 1, 2, and 3, left-turning traffic on the project road exit to the service road before the interchange. Vehicles enter the project road from the service road. Therefore, it takes a longer time and causes congestion on the service road. Additional direct ramps for left-turning traffic and a service road located outside of the ramps are proposed.

As for IC-1, 2, 3, the curve radius of the loop rampway is 70 m. However, the transition curve is not inserted between the straight line and curve. Therefore, the horizontal alignment and transition of super-elevation is not smooth. It is desirable to insert the transition curve between straight line and curve (R=70 m, e=5%).

As for IC-1, 2, 3, the weaving is occurred between the merging point and the diverging point at the connected section of the main road and the rampway. There are four lanes in this section (W=16 m), including the rampway (one lane). The distance between the merging point and the diverging point is 240 m. It is expected that congestion is caused by the decrease of running speed considering the future traffic volume (weaving traffic and non-weaving traffic). It is recommended to increase the rampway width (one more lane) outside of the main road. The total width becomes 19.5 m (five lanes).

As for IC-2, the curve radius of the ramp terminal of the beginning side of the project road is 525 m. It has a small and steep super-elevation (5%). It is dangerous for cars passing with high speed, even with the installation of speed limitation signs (80 km/h). To improve safety, it is recommended to apply a radius bigger than 700 m, which is prescribed in the Road Structure Ordinance Standards of Japan. The curve radius of the ramp terminal of the main road follows a design speed of 80 km/h.

As for IC-3, the shape of this interchange is not symmetrical, avoiding the Hinduism Temple. Therefore, the distance between the merging nose and the diverging nose is short, and the weaving becomes difficult. Also, it is difficult to guide and safety is low. It is recommended to provide the distributing lane (design speed 40 km/h), which is parallel to NH5 at the end point side, and to connect the distributing lane and rampway. Moreover, the weaving distance becomes longer because the rampway alignment is changed.

As for IC-4, the elevated roundabout type is adopted, and the shape of the roundabout is an ellipse. The small radius is 35 m and big radius is 100 m. The distance between the merging nose and the diverging nose is longer, and the on-ramp and off-ramp are separated in order to decrease the influence of weaving. However, it is expected that congestion is caused by weaving, considering the future traffic volume. It is recommended to add the separated left-turn rampway outside of the roundabout in order to increase the capacity of the roundabout.

Major Bridge Design

There are piers planned as hybrid structures (bridge piers + reinforced earth walls) and piers planned as abutments (from Plan & Profile, Drawing). Hybrid structures are being constructed in many places in India. However, in areas affected by running water, maintenance and management will be a concern from the viewpoint of anti-erosion and protection from running water. The substructure at the ends of the bridge subject to the impact of flowing water is proposed to be constructed as an abutment type for the purpose of protecting from erosion and protecting the back soil from the reinforced earth wall.

Also, about bridge piers in the DPR drawing, there is no width allowance for the superstructure's bearing in the substructure's coping. It is preferable to provide an allowance in case unexpectedly large forces, such as earthquakes, occur. The width of the substructure, bearing width allowance, and other details must be reconsidered in the detailed design.

Minor Bridge Design

The minimum span of several minor bridges (MNBs) is set as 10 m. The DPR considers improving the accuracy of the bridge plan, including structural investigation at the time of the detailed design by setting

the short span and economical reinforced concrete slab bridge as the design standard. Investigation to increase economic efficiency by lengthening the span and reducing the number of piers, study to improve the river flow and constructability by reducing pier on the river, and confirmation of bridge plan details by consultation with environmental authorities should be examined and confirmed at the time of detailed design.

Interchange Bridge

The sectional view of a reinforced earth wall is in the drawing, and "Terre Armee" is placed between the northbound and southbound lanes. The total count is four planes. However, for bridges other than ICs, there is no cross-section drawing, but the number is counted in two-surface construction where no reinforced earth wall is placed between the northbound and southbound lanes.

The distance between the northbound and southbound lanes is about 4 m. If the reinforcing earth wall is arranged at the back of the bridge end, two sides can be constructed, and the structure is economical. Therefore, a plan for the reinforced earth wall of the IC with two-side construction is proposed.

There is a concern that the cantilever length of the slab is large and does not have sufficient reaction against the assumed dead load and live load. (The cantilever slab length is about 4 m based on the scale of the drawing.)

It is generally preferable that the cantilever length of the PC slab is within 3 m, and a review of the structure of the PC box girder for the purpose of reducing the cantilever length is proposed. It is better to plan a three-box girder because the space is wide. In addition, concerning the width of the beam of piers, it is necessary to revise the structure as well as review the box girder. The position of the bearing that supports the superstructure is based on the cross beams, and the spacing of the outer main girders is greater than the width of the beam of the pier.

To ensure that the vertical load is supported and to preserve the rigidity of the main girder, it is proposed that the beam width be larger than the outer main girder spacing and that the bearing be placed under the main girders.

Box Culvert

There is a part where the connection between the box culvert and the retaining wall structure on the box is simplified and integrated. Since the collision load of the guardrail vehicle may act on the top of the retaining wall. Attention should be focused on the following:

In order to ensure the rigidity of the end of the retaining wall, it is preferable to separate the box and retaining walls at the ends of the foundation.

The base of the retaining wall should be a spread foundation after carrying out the member calculation and stability calculation as a protective fence foundation.

Cost Estimate

The main report of DPR and Volume VIII [Cost Estimate] is not consistent with the contents and the results of the cost estimate. Therefore, Volume VIII, which was published in a new period, is regarded as a review subject in this study. It is noted that the ITS component is not included in the breakdown of Volume VIII.

DPR Volume VI [Rate Analysis] has not been provided to the Japan International Cooperation Agency (JICA) Study Team, and the basis for setting each unit price was unknown as of December 2017. For this reason, the unit price review of this survey was conducted to refer to the material above and to check whether there is any obvious mistake in the unit price setting. The JICA Study Team rebuilt unit prices based on the estimate materials of the Ministry of Road Transport and Highways (MORTH) Standard DATA Book for major work items with a high proportion of overall project cost such as borrow material and rebars. Because of evaluating the appropriateness of the DPR's unit price setting by comparing the unit price of each, it was considered that there is no obvious error in DPR because none of them have large deviations.

ITS for CPRR

As the ITS component for CPRR is not included in the cost breakdown of Volume VIII. The ITS component for CPRR should be examined and included in the DPR.

Project Scheme

HMPD expressed that the project scheme of CPRR is not PPP, and HMPD will prepare and implement

the project, complying with JICA procurement guidelines, namely the "Guidelines for the Employment of Consultants under Japanese ODA Loans" dated April 2012 and the "Guidelines for Procurement under Japanese ODA Loans" dated April 2012.

HMPD agreed in principle to apply Standard Bidding Documents (SBD) issued by JICA for the contract for Section 1 though HMPD, and JICA is discussing which particular SBD is to be applied for the project.

Project Implementation Schedule

The road stretch of Section 1 consists of Northern Port Access Road (NPAR) and TPP Link Road. During consultation with inhabitants around the site of the TPP Link Road (Original Alignment), it was found that it is important to obtain social consensus for the road construction. As an alternative solution to minimise the social impact, the south end of the TPP Link Road is to be shifted approximately 1.5 km west from the original alignment. This new alternative alignment has a total length of 3.6 km from the connecting point with the NPAR to the southern end. The 1.65 km stretch in the northern part is the same as the original alignment, and the remaining 1.95 km in the southern part is different from the original alignment. Through an additional survey at the alternate site, social consensus was confirmed for the new alignment. Therefore, it is expected that NPAR and TPP Link Road (New Alignment) will become the Section 1 of the Japanese ODA Loan Project. The proposed implementation schedule of Section 1 of the project is shown in Figure 10.2.1.

O&M

The Highways Division of the Construction and Maintenance Wing responsible for each area of CPRR will take over the O&M.

Section 1, Section 2, and a part of Section 3 of the CPRR will fall under the jurisdiction of Thiruvallur Highways Division. The remaining portions of Section 3, Section 4, and Section 5 will fall under the jurisdiction of the neighbouring Chengalpattu Highways Division. It is assumed that Performance Based Maintenance Contract (PBMC) will be introduced to the Chengalpattu Highways Division by the time the CPRR is completed. If the introduction should be delayed, the single-year maintenance contract will be used.

The structure of the Thiruvallur Highways Division consists of one divisional engineer, six assistant divisional engineers, and eight assistant engineers. This Highways Division will outsource the work of maintenance/patrol/traffic control with PBMC to an O&M contractor. There is a plan to collect toll for Section 1, and when it is carried out, toll collection will also be outsourced to a contractor. There is one field office for the divisional engineer and six field offices for the assistant divisional engineers taking charge of road construction other than large-scale projects and maintenance for state highways and major district roads.

Environmental and Social Considerations

HMPD agreed to implement land acquisition and resettlement process, complying with the "JICA Guidelines for Environmental and Social Considerations" dated April 2010.

CHAPTER 1 INTRODUCTION

1.1 Outline of the Study

1.1.1 Background of the Study

As in other major cities in India, traffic congestion is getting worse in Chennai Metropolitan Area (hereinafter referred to as "CMA"), which is the target area of the study, because road infrastructure improvements have not caught up with the increase in traffic demand due to population growth and economic development.

The Government of Tamil Nadu (GoTN) is promoting the development of roads and public transportation as a countermeasure to traffic congestion in CMA. The major arterial road network in CMA consists of National Highways No. 5, No. 205, No. 4, and No. 45 as major radial roads, and Inner Ring Road (IRR), Chennai Bypass, and Outer Ring Road (ORR) as ring roads. The implementation of the Chennai Peripheral Ring Road (CPRR) Project is expected to contribute to the further expansion of the Radial-Ring Road Network corresponding to the growing traffic demand.

In addition, as a countermeasure to alleviate congestion at the center of CMA where the development site for road infrastructure is limited, the improvement of Intelligent Transport System (ITS) facilities that promote efficient use of the road is an issue.

Based on this background, the Government of India (GoI) has prepared the Detailed Project Report (DPR) describing the development plan of CPRR and ITS and has requested the Government of Japan (GoJ) for loan assistance.

1.1.2 Objectives of the Study

The DPR presents the implementation plan for the following:

- Construction of CPRR (widening section: 36.5 km, new section: 96.9 km, total: 133 km), and
- Development of ITS facilities for CPRR and for the CMA road network.

The study aims to collect necessary information to appraise the Project for it to be implemented under the Official Development Assistance (ODA) scheme through the confirmation of the objectives and the outline of the Project, including project cost, implementation schedule, procurement and construction method, project organization, capability of operation and maintenance, as well as social and environmental conditions.

1.1.3 Target Sections of the Study

As shown in the location map of Chennai, CPRR is classified into Sections 1 to 5. In this study, preliminary investigation for the whole section was carried out as a first step of the project, and the result is that the priority is Section 1. After deciding the priority ranking, the JICA Study Team conducted a detailed investigation of Section 1. The road stretch of Section 1 consists of the Northern Port Access Road and the Tiruvottiyur Ponneri Pancheti (TPP) Link Road.

During the consultation with inhabitants around the site of the TPP Link Road (Original Alignment), it was found that it is very important to obtain social consensus for the road construction. As an alternative solution to minimizing the social impact, the south end of TPP Link Road is to be shifted approximately 1.5 km to the west of the original alignment. This alternative alignment has a total length of 3.6 km from the connecting point with Northern Port Access Road to the south end. The length of 1.65 km in the northern part is the same as the original alignment, and the remaining 1.95 km in the southern part is different from the original alignment. Through an additional survey at the alternative site, social consensus was confirmed for the new alignment. Therefore, it is expected that Northern Port Access Road and TPP Link Road (New Alignment) will become the Section 1 of the Japanese ODA Loan Project.

1.1.4 Scope of the Study

In accordance with the agreement between JICA and the Consultant, the following work items are carried out in the study:

[1] Preparation and Discussion of Inception Report (IC/R)

[2] Review of the Background of the Project

[3] Survey on the Current Situation and Issues of Chennai Peripheral Ring Road (CPRR)

[4] Traffic Survey and Traffic Demand Forecast

[5] Formulation of the Project

[6] Prioritization of Project Components

[7] Preliminary Design

[8] Construction Planning

[9] Study on the Procurement Method

[10] Formulation of Project Implementation Schedule

[11] Confirmation of Project Implementation Structure

[12] Confirmation of Operation and Maintenance (O&M) Structure

[13] Environmental and Social Considerations

[14] Study on Countermeasures against Climate Change

[15] Project Cost Estimate

[16] Study on Points to Consider for Project Implementation

[17] Project Evaluation

[18] Preparation of Basis of ITS Technical Specifications

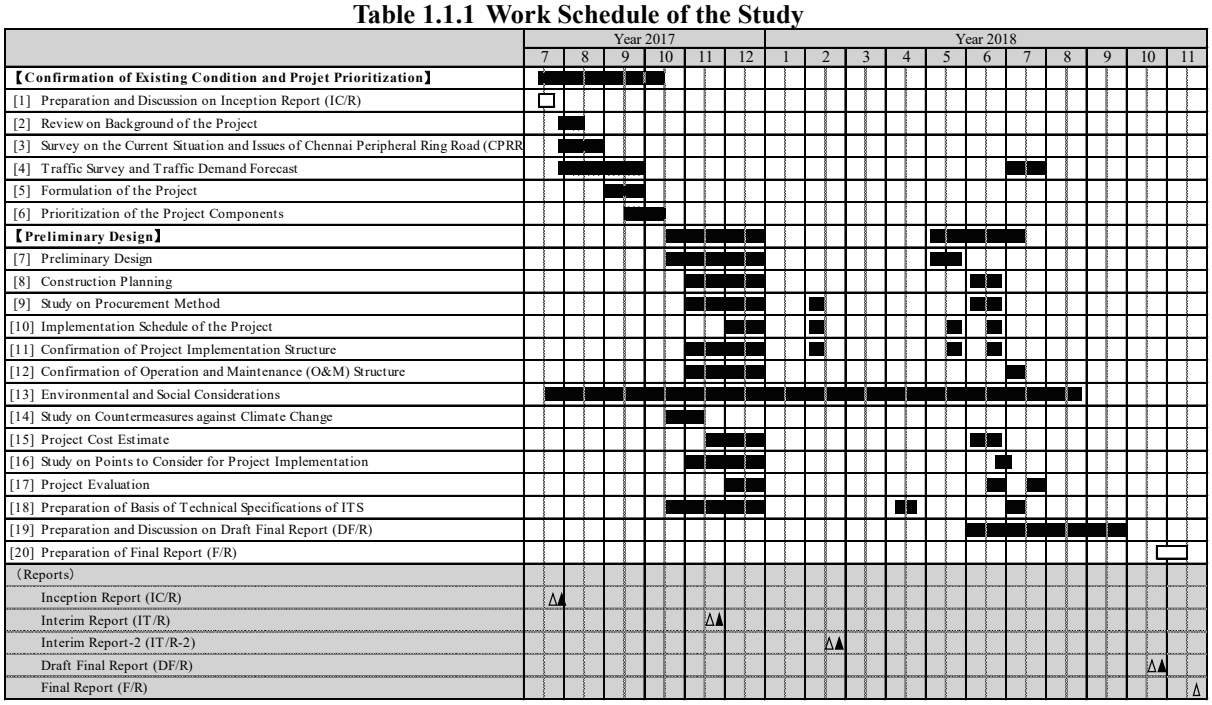
[19] Preparation and Discussion on Draft Final Report (DF/R)

[20] Preparation of Final Report (F/R)

1.1.5 Work Schedule of the Study

The study was started in the middle of July 2017, and the F/R will be submitted in November 2018. Table 1.1.1 shows the work schedule of the study.

Table 1.1.1 Work Schedule of the Study



Source: JICA Study Team

1.1.6 Objectives of the Final Report

The objectives of Final Report (F/R) are:

- To compile the results of the preliminary design of the Chennai City ITS Project and the design review of the CPRR Project into the report, and
- To update environmental and social consideration procedures for early project implementation.

1.1.7 Components of the Final Report

The subject of this study was originally the CPRR Project and the Chennai City ITS Project; however, the procedure for environmental and social consideration of the CPRR Project was delayed. For this reason, JICA decided to separate the Chennai City ITS Project from the CPRR Project and aimed only for the Chennai City ITS project as the initial goal for the March 2018 Loan Agreement (L/A). For the CPRR project, JICA and HMPD confirmed that the section 1 will be the priority for the ODA loan.

With this, the CPRR Project is compiled as Volume 1 and the Chennai City ITS Project as Volume 2 in this report.

1.1.8 Organization of the Study

JICA entrusted the study to the Consultant, and the Consultant dispatched the JICA Study Team to India, comprised the following 16 members:

JICA Study Team

1)	Mr. Takayasu Nagai	Team Leader/Road Planning
2)	Mr. Ippei Iwamoto	Deputy Team Leader/Road Planning 2/Road Design
3)	Mr. Hiroya Totani	ITS Planning/Design 1
4)	Mr. Noboru Kondo	ITS Planning/Design 2
5)	Mr. Akira Magario	Road Structure Design 1 (Geometric, Interchange (IC))
6)	Mr. Seiya Hikino	Road Structure Design 2 (Viaduct, Bridge, Road Structures)
7)	Mr. Eiji Wakatsuki	ITS Operation
8)	Mr. Hisanari Ushirooka	Traffic Demand Forecast 1
9)	Mr. Yuki Sugiyama	Traffic Demand Forecast 2
10)	Mr. Makoto Yajima	Economic and Financial Analysis
11)	Mr. Kiyoshi Dachiku	Road Operation and Maintenance Planning
12)	Mr. Kenichi Moritani	Natural Condition Survey
13)	Mr. Daisaku Kiyota	Social Environmental Consideration
14)	Ms. Natsumi Hara	Environmental Consideration
15)	Ms. Kakiko Ide	Social Consideration
16)	Mr. Motoki Iwamaru	Construction Planning (Procurement/Cost Estimate)

The following two agencies are designated to be the counterparts (C/P) in the Government of Tamil Nadu.

C/P Agencies

1) Highways and Minor Ports Department (HMPD)
2) Tamil Nadu Infrastructure Development Board (TNIDB)

1.2 Record of Meetings

The JICA Study Team had several meetings with various stakeholder organizations of the CPRR Project and the Chennai City ITS Project to carry out confirmation of the current situation and proposal on the prioritized section for the Japanese ODA Loan Project.

HMPD is a C/P agency for the CPRR Project, and TNIDB is a C/P agency for the Chennai City ITS Project.

Kick-off meetings with HMPD and TNIDB are held individually, and the JICA Study Team explained the procedure of the Japanese ODA Loan Projects from the preparatory survey to the signing of L/A, as well as the position of the preparation survey and the Japanese ODA Loan Projects to C/Ps.

1.2.1 Meetings with Concerned Agencies of CPRR

HMPD is conducting the preparation of a DPR of CPRR through STUP Consultants Pvt. Ltd. (hereinafter "STUP"), who is an assignee of HMPD.

A list of the meetings with HMPD and relevant agencies which presents the main agenda and the results of the meetings is shown in Table 1.2.1.

Table 1.2.1 Meeting List with Concerned Agencies of CPRR

Date	Agency	Major Agenda	Results
19 Jul. 2017	HMPD Headquarters (HQ)	Kick-off Meeting a) Explanation of Inception Report b) Proposal of Steering Committee c) Request for DPR d) Organizational Framework e) Progress of Social and Environmental Works and Land Acquisition f) Mode of Implementation g) Request Coordination with the Enivronmental Impact Assessment (EIA) Expert h) Section Prioritization	・DPRs were not provided.
27 Jul. 2017	HMPD HQ	a) Request for DPR	・DPRs were not provided.
28 Jul. 2017	HMPD HQ	a) Request for DPR	・DPRs were not provided.
2 Aug. 2017	HMPD HQ	a) Request for DPR b) Request for clarification of the environmental clearance (EC) process	・DPRs were not provided.
4 Aug. 2017	HMPD Division Office STUP Consultants	a) Request for DPR b) Request for clarification of the EC process	・Some DPR volumes were provided.
10 Aug. 2017	HMPD HQ STUP Consultants	a) Request for clarification of the EC process	・HMPD commented that EC is not necessary before declaration of state highway (SH). Environmental Impact Assessment (EIA)/ Resettlement Action Plan (RAP) reports were prepared, and public consultations were held in 2014.
22 Aug. 2017	STUP Consultants	a) Request for clarification of the EC process	・STUP commented that EC is not necessary before declaration of SH.
29 Aug. 2017	HMPD HQ	a) Request for clarification of the EC process	
31	Department of	a) Request for clarification of the	・DoE commented that the State Expert

Date	Agency	Major Agenda	Results
Aug. 2017	Environment (DoE), Tamil Nadu	EC process b) Request for clarification of the necessity of EC for CPRR	Appraisal Committee (SEAC) would answer after receipt of the EC application.
6 Sep. 2017	HMPD HQ	a) Request for application of EC for JICA Loan	・HMPD commented that EC application was submitted and that HMPD would find the application. The L/A Act of 2013 can be applied to CPRR. Public consultations were held in 2014.
7 Sep. 2017	Tamil Nadu State Pollution Control Board (TNSPCB)	a) Request for clarification of the necessity of EC for CPRR	・TNSPCB commented that CPRR should submit the EC application for the judgement of SEAC.
12 Sep. 2017	Tamil Nadu Road Development Company (TNRDC)	a) Request for clarification of the environmental procedure	・TNRDC commented that the clearance of the Coastal Regulation Zone (CRZ) has not yet started; that the notice as per Highways Act 15(2) would be completed by March 2018 for Section 1; and that the L/A Act of 2013 for non-title holders would not be applied.
14 Sep. 2017	HMPD Division Office STUP Consultants	a) Request for clarification of Land Acquisition of Section 1 b) Request for confirmation of Land Plan Schedule (LPS) and Field Measurement Book (FMB) of Sections 2,3, and 5.	・LPS and FMB were shown to the JICA Study Team.
15 Sep. 2017	HMPD Division Office STUP Consultants	a) Request for clarification of the EC process b) Explanation of the social and environmental survey conducted by the JICA Study Team c) Request for the cooperation in the social and environmental survey d) Request for the clarification of the clearance of the Reserved Forest (RF) e) Request for application of the L/A Act of 2013 to Sections 2,3, and 5	・Application of the EC was provided. ・A letter related to the RF clearance was provided.
20 Oct. 2017	HMPD HQ	Request for clarification of the EC process	HMPD reported that the application of the EC is about to be submitted.
23 Oct. 2017	State Secretariat (HMPD)	JICA Fact Finding (F/F)（Kick-off Meeting） a) Applicable Law for RAP b) Implementation of Public Consultation c) Environmental Clearance, Disclosure of EIA d) Clearance of RF, CRZ e) Nodal Ministry of the Project Compensation Policy for the Ministry of Road Transport and Highways (MoRTH)	JICA requested HMPD to clarify the discussion agenda in a wrap-up meeting.
24 Oct. 2017	TNRDC STUP Consultants	a) Request for clarification of the EC process b) RAP and Land Acquisition Project Financial Scheme of Section 1	・The status of RF and CRZ clearance related to environmental clearance was reported by the STUP Consultant. ・TNRDC agreed to introduce the same procedure with Tamil Nadu Road Sector Project (TNRSP) into the RAP

Date	Agency	Major Agenda	Results
			of Section 1. TNRDC is considering a project financial scheme based on JICA assistance.
	DoE, Tamil Nadu	Request for clarification of the EC process	JICA Study Team confirmed a detailed procedure for EC to DoE.
25 Oct. 2017	HMPD HQ	a) Applicable Law for RAP b) Implementation of Public Consultation c) EC, Disclosure of EIA d) Clearance of RF, CRZ e) Nodal Ministry of the Project f) Compensation Policy for MoRTH g) Detailed Procedure for EC Detailed Procedure for RAP	A detailed discussion regarding the agenda of the kick-off meeting was made between JICA and HMPD.
26 Oct. 2017	HMPD Nodal Officer	a) Detailed Procedure for EC Detailed Procedure for RAP	HMPD agreed on the proposed detailed procedure for EC and RAP by JICA.
27 Oct. 2017	State Secretariat (HMPD)	JICA F/F（Wrap-up meeting） a) EC b) RAP and Land Acquisition c) Line Ministry of the Project d) Compensation Policy for MoRTH e) Implementation Structure in Section 1 Others	・HMPD stated that the target time to obtain an EC should be March 2018. ・HMPD agreed that the procedures required by the JICA Guidelines for Environmental and Social Considerations should be added to the standard flow of land acquisition as stipulated in the Tamil Nadu Highways Act of 2001. ・HMPD will confirm the nodal ministry of the project. ・JICA explained that it is not able to provide a loan to a Project implemented under Public-Private Partnership (PPP) mode. HMPD will answer questions about the project financial scheme. ・A superintendent engineer is assigned as the nodal person of the project. HMPD agreed that the ITS portion would be implemented ahead by separating loan packages.
7 Nov. 2017	HMPD HQ	a) EC Implementation Structure in Section 1	・HMPD informed that EC application was uploaded to the online site. HMPD informed that the implementation structure in Section 1 is not yet decided in HMPD.
17 Nov. 2017	HMPD HQ	a) Line Ministry and Agreement with the National Highway Authority of India (NHAI) b) Implementation Structure in Section 1 c) EC, CRZ, RF d) RAP and Land Acquisition Provision of Data for DPR Review Works by JICA	・Chief Engineer (CE) will confirm the line ministry and the agreement with NHAI to the secretary by 21 November 2017. ・HMPD informed that the implementation structure in Section 1 is not yet decided in HMPD. ・HMPD informed that presentation to the State Environmental Impact Assessment Authority (SEIAA) about the EC application is scheduled in December. ・HMPD agreed on the proposed detailed

Date	Agency	Major Agenda	Results
			procedure for EC and RAP based on TNRSP by JICA. HMPD agreed to provide the requested DPR data to the JICA Study Team.
8 Dec. 2017	HMPD HQ	a) Line Ministry and Agreement with NHAI b) Implementation Structure in Section 1 c) EC, CRZ, RF d) RAP and Land Acquisition Provision of Data for DPR Review Works by JICA	・HMPD will visit MoRTH on 27 December 2017 for follow-up on the issue. ・HMPD informed that the implementation structure in Section 1 is not yet decided in HMPD. CE will confirm with the secretary. ・HMPD informed that the presentation to SEIAA about EC application is scheduled in February. ・HMPD informed that the special team for RAP will be formulated by January. HMPD agreed to provide the requested DPR data to the JICA Study Team.
21 Dec. 2017	HMPD HQ	a) Line Ministry and Agreement with NHAI b) Implementation Structure in Section 1 c) EC, CRZ, RF d) RAP and Land Acquisition Provision of Data for DPR Review Works by JICA	・HMPD will visit MoRTH on 27 December 2017 for follow-up on the issue. ・HMPD informed that the implementation structure in Section 1 is not yet decided in HMPD. CE will confirm with the secretary. ・HMPD informed that the presentation to SEIAA about EC application is scheduled in February. ・HMPD informed that the special team for RAP will be formulated by January. HMPD informed that the rate analysis, geological survey report, hydrological report, and river cross sections will not be shared considering the fact that the reports and designs have not yet been approved.
7 Feb. 2018	DOE, HMPD	a) Importance of CPRR b) EIA Schedule for the Implementation of the Project of Section 1 as a Japanese ODA Loan Project c) Progress of each Procedure - CRZ Clearance - Forest Clearance - Environmental Clearance	JICA explained the following: ・The purpose and importance of the CPRR construction project. ・Section 1 will be selected as the priority for the Japanese ODA Loan project. ・EC must be approved by May 2018 because the disclosure of the EIA report that acquired EC is required 120 days before L/A.
23 Apr. 2018	HMPD	JICA F/F-2 (Kick-Off Meeting) a) Schedule and Procedure for the Signing of L/A b) Schedule and Procedure of FF-2 Agenda c) Financial Procedure for the Japanese ODA Loan Project d) Aid Memoire and Minutes	・JICA explained the schedule and the outline of the loan financing examination.
24 Apr.	HMPD, TNRDC	a) Implementation Schedule	・JICA explained the implementation

Date	Agency	Major Agenda	Results
2018		b) Cost Estimate	schedule and the cost estimate of the project. ・HMPD informed that the following updates for the current DPR is still on-going: a) Extension of a major bridge (MJB) up to Ch.2+500 b) Shifting the end point of Section-1 from Ch. 20+900 to Ch. 21+506 (The whole NH5 IC will be included in Section 1) c) Introduce toll gates in two locations d) Introduce a traffic control center
25 Apr. 2018	HMPD	a) EIA/RAP	・HMPD shared the progress of the EIA and RAP preparation.
26 Apr. 2018	TNRDC	a) Implementation Organization b) Project Evaluation Criteria	・TNRDC shared the organizational chart of the TNRDC Project Implementation Team. ・TNRDC suggested to apply the following in the Project Evaluation Criteria: - Annual average daily traffic (AADT) (vehicle/day, passenger car unit (PCU)/day) - Freight flow (ton/year) - Required driving time through the typical route in CMA (minute) ・To consider each road leading to the Ennore Port as a toll road in the condition of the Traffic Demand Forecast. - ORR (under TNRDC): scheduled to be charged in half a year - Chennai Bypass (under NHAI) to be run as a toll road - Port access section in Kattupalli Road (under Ennore Port) scheduled to be charged after 2 years - IRR scheduled to be charged ・To consider 25 years after completion as a project evaluation period in the economic internal rate of return (EIRR) calculation.
26 Apr. 2018	HMPD, TNRDC	JICA F/F-2 (Wrap-up Meeting) a) FF-2 Overview b) Aid Memoire	・Discussed issues in F/F-2 are confirmed. ・HMPD suggested to study the possibility of shortening the project implementation process.
21 May 2018	TNRDC	JICA F/F-3 (Kick-OffMeeting) a) Implementaion Schedule, Cost	・JICA explained revised implementation schedule, cost

Date	Agency	Major Agenda	Results
		Estimate, IRR, Project Effectiveness Index b) Issue on social environment consideration of TPP Link Road	estimate, IRR, and project effectiveness index. ・It was discussed how to respond to the strong opposition from southern part of TPP Link Road.
22 May 2018	HMPD, TNRDC	a) Issue on social environment consideration of TPP Link Road b) Draft agreement on the document on environmental and social considerations (EIA, RAP)	・It was discussed how to respond to the strong opposition from southern part of TPP Link Road. ・It was confirmed the contents pertaining to the draft agreement on environmental and social considerations (EIA, RAP).
23 May 2018	HMPD, TNRDC	Issue on social environment consideration of TPP Link Road	・It was discussed how to respond to the strong opposition from southern part of TPP Link Road.
24 May 2018	HMPD, TNRDC	JICA F/F-3（Wrap-Up Meeting） a) Time Bound Action Plan c) Implementaion Schedule, Cost Estimate, IRR, Project Effectiveness Index b) Issue on social environment consideration of TPP Link Road	・It was confirmed status of Time Bound Action Plan（NHAI agreement for the revenue loss, updated RAP, etc.）. ・Shortening of implementation schedule, revised cost estimate・IRR・Project Effectiveness Index are explained and agreed by HMPD. ・Measures for improving strong opposition from southern part of TPP Link Road was discussed and agreed.
9 July 2018	HMPD, TNRDC	JICA F/F-4（Kick-Off Meeting） a) Time Bound Action Plan b) Schedule for L/A c) Implementation schedule d) Realignment of TPP Link Road	・It was confirmed status of Time Bound Action Plan（Official request, EC, updated RAP, etc.）. ・It was explaned signing of loan agreement is scheduled after predge and 120 days of EIA disclosure. ・Revised implementation schedule is explained. ・HMPD made explanation of design matters and environmental and social considerations concerning the realignment of TPP Link Road.
11 July 2018	HMPD, TNRDC	a) Cost estimate b) Realignment of TPP Link Road	・Detaile of the revised cost estimate was explained. ・JICA explained HMPD that the necessary matters concerning design and environmental and social considerations for inclusion of the realignment of TPP Link Road in Phase-1.
12 July 2018	TNRDC	a) Realignment of TPP Link Road	・TNRDC made a detailed explanation of design matters concerning the realignment of TPP Link Road including question and answer session with JST. JST discussed about scope of the realignment of TPP Link Road with TNRDC.
13 July	HMPD	JICA F/F-4（Wrap-Up Meeting）	・JICA informed HMPD that the

Date	Agency	Major Agenda	Results
2018		a) Realignment of TPP Link Road b) Time Bound Action Plan	necessary matters concerning design and environmental and social considerations for inclusion of the realignment of TPP Link Road in Phase-1 is generally satisfied. However, there are partial insufficiency and JICA explained to carry forward the judgment to their headquarter. ・ JICA reminded HMPD to take prompt action for Time Bound Action Plan（Official request, Clarification of Nodal Ministry, EC, updated RAP, etc.）.

Source: JICA Study Team

1.2.2 Meetings with Concerned Agencies of CPRR ITS

'Data Collection Survey for Chennai Metropolitan Region ITS' which was completed in March 2017 proposed two ITS components for CPRR, i.e., (i) Highway Traffic Management System (HTMS) and (ii) Toll Management System (TMS).

The meetings for the Japanese ODA Loan Project were held with the following agencies related to these ITS components. The major agenda and results of each meeting are shown below. The minutes of the meetings are presented in Appendix 1.

Table 1.2.2 Meeting List with Concerned Agencies of CPRR ITS

Date	Agency	Major Agenda	Results
18 Apr. 2018	HMPD	a) Request for clarification of the Project Implementation Unit (PIU) establishment b) Request for clarification of the implementation structure for the Japanese ODA Loan Project	・ It was confirmed that the establishment of PIU had already been requested to the Governemnt of Tamil Nadu and that it will be approved soon. ・ It was confirmed that PIU will be established under HMPD and its key role is to coordinate organizations below. ・ Responsible organization for each section of CPRR was confirmed as follows: Section 1: TNRDC Section 2, 3, and 5: HMPD Section 4: TNRIDC ・ As shown above, TNRDC will implement Section 1 of the project with responsibility for procurement, installation, construction, and O&M. ・ It was confirmed that the Chennai Smart City Limited (CSCL) will be involved in the implementation of the project, and will be taking advisory roles.
24 Apr. 2018	TNRDC	a) Request for clarification of the basic matters for toll road section b) Request for clarification of the basic matters for O&M	The following basic matters for the toll road section (Section 1) were confirmed by mutual agreement: ・ Toll tariff rules: distance-based ・ Toll plaza: two toll plazas ・ Toll plaza lane: 5x5 lanes ・ Lane designation: one electronic toll

Date	Agency	Major Agenda	Results
			collection (ETC) dedicated lane, three lanes for both manual collection and ETC, and one free lane for emergency vehicles, motorcycles, and auto-rickshaws. ・ ETC: FASTag by NHAI ・ Toll area crossing facility for toll collectors: bridge type The following matters for O&M were confirmed by mutual agreement: ・ TMS O&M Contractor: TNRDC will procure. ・ HTMS O&M Contractor: system integrator will be in charge of O&M after the development of the system. ・ O&M period: 3 years ・ Defects liability period: 1 year
25 Apr. 2018	TNRDC	a) Concept of toll fare table b) Request for clarification of the O&M structure	・ It was agreed that the concept of the toll fare table based on the rules of toll tariff for Section 1 will be calculated by distance. ・ O&M structures for HTMS and TMS were confirmed by mutual agreement.
25 Apr. 2018	HMPD, TNRDC, CSCL	a) ITS components b) O&M organization	・ It takes time until the final decision of the toll system adopted for CPRR. Facility planning is subject to introduce distance-based charges. ・ Two toll gates (main line barrier type) are introduced, one on the main line (west side) and another on TPP Link Road. ・・ Not to introduce a toll gate between the main road and service roads (free entry/exit). ・・ The level of toll is to follow the Toll Act.
2 May 2018	TNRDC	a) Section 1: Request for clarification of cooperation with external organizations related to O&M b) Request for clarification of toll plazas on ORR	・ Cooperation with traffic police, fire authorities, and medical institutions (including response to natural disasters) for road operation after opening of Section 1 was confirmed. ・ A condition of the site for toll plazas to be constructed on ORR was confirmed.

Source: JICA Study Team

1.2.3 Meetings with Other Organizations

A meeting with Japan External Trade Organization (JETRO) was held on 26 July 2017 to make an interview about the requested and desired road projects by Japanese-related organizations in Tamil Nadu State.

CHAPTER 2 PRESENT CONDITION AND CIRCUMSTANCES OF THE PROJECT

2.1 Outline of the Chennai Peripheral Ring Road (CPRR) Development Project

2.1.1 Objectives of the Project

The objective of the project is to address the rapidly increasing road traffic demand in the Chennai Metropolitan Area (CMA) by constructing CPRR and developing Intelligent Transport System (ITS) facilities, thereby contributing to the sustainable economic growth in CMA. The Project is expected to improve the connectivity in and around Chennai City by:

- Formulating the Radial-Ring Road Network in CMA in collaboration with other ring roads such as the Inner Ring Road (IRR), the Chennai Bypass, and the Outer Ring Road (ORR) in order to provide alternate routes for traffic as well as to improve redundancy of the road network,
- Providing a direct access to Ennore Port and Kattupalli Port from industrial clusters located in suburban areas of CMA in order to accelerate industrial and economic growth, and
- Improving efficiency in the use of the road network by providing ITS facilities such as a traffic information system and a traffic management system for CPRR and the central area of CMA.

2.1.2 Past Studies on the Project

CPRR was conceptualized to provide better connectivity around the city catering to future traffic requirements, and to provide efficient commercial transportation by enhancing port connectivity. This road will facilitate container movement from the southern districts to Ennore Port and Kattupalli Port.

Section 1 of CPRR, the section from Ennore to Thatchur, used to be recognized as Northern Port Access Road (NPAR). The Feasibility Study Report for NPAR was originally prepared by the National Highways Authority of India (NHAI) in 2008, and NHAI handed over the NPAR project to the Government of Tamil Nadu (GoTN). Then, according to Government Order (Ms) No. 94, dated 23 April 2012 and concerning the Industries Department, Tamil Nadu Road Development Company (TNRDC) is appointed as the Managing Associate and the Highways and Minor Ports Department (HMPD) is appointed as the Monitoring Department for the NPAR Project. Subsequently, the land alignment details were prepared by TNRDC and were handed over to the State Industries Promotion Corporation of Tamil Nadu (SIPCOT) to undertake the development. Furthermore, according to Government Order (Ms) No. 69, dated 18 April 2013 and concerning HMPD, M/s. CDM Smith is entrusted the work of updating the Detailed Feasibility Report.

Subsequently, NPAR was taken as Section 1 of CPRR, and the Detailed Project Report (DPR) for CPRR was prepared by HMPD entrusting the work to M/s. STUP Consultants together with other sections (i.e., Sections 2 to 5). The concept of CPRR is to form a new ring road with a radius of 40 to 60 km in the outskirts of Chennai City, connecting Mahabalipuram to Ennore Port.

According to the DPR, the alignment of CPRR was approved by the Steering Committee and was finalized by the Principal Secretary of HMPD on 9 July 2014.

The DPR consists of the various volumes listed in Table 2.1.1. The JICA Study Team requested HMPD to provide all volumes of the DPR; however, some volumes were not available because they were under the process of obtaining concurrence from other concerned departments such as the Public Works Department (PWD) and the Water Resource Department (WRD).

Although some parts of the DPR such as “Design Report (Structures)” and “Rate Analysis” were not available at the time of review, these were finally provided after February 2018. As such, the JICA Study Team obtained all documents except “Technical Specifications”. However, further modification and updating by HMPD are still ongoing, even after receiving additional parts of the DPR; thus, there are inconsistencies among the series of the provided report.

Table 2.1.1 Composition of DPR

Vol.	Report Title	Version/Date	Availability
I	Main Report	Unknown	Provided by JICA
II-A	Design Report (Highways)	Ver.R0, 9 Jan. 2017	Aug. 2017
II-B	Design Report (Structures/Box Culvert)	Unknown (cover shows Aug. 2016)	Feb. 2018
II-C	Design Report (Structures/Minor Bridge)	Unknown (cover shows Aug. 2016)	Feb. 2018
II-D	Design Report (Structures/Major Bridge)	Unknown (cover shows Aug. 2016)	Feb. 2018
II-E	Design Report (Structures/Underpass)	Unknown (cover shows Jul. 2016)	Feb. 2018
II-F	Design Report (Structures/Interchange)	Unknown (cover shows Nov. 2016)	Feb. 2018
II-G	Design Report (Structures/Sec-1 Link Road)	Unknown (cover shows Sep. 2016)	Feb. 2018
II-H	Design Report (Structures/ROB)	Unknown (cover shows Aug. 2016)	Feb. 2018
III	EIA & Management Plan	Unknown	Provided by JICA
IV	Social Impact Assessment & RAP	Unknown	Provided by JICA
V	Technical Specifications	-	Not Available
VI	Rate Analysis	Ver.R0, 9 Jan. 2017	Feb. 2018
VII	Bill of Quantities	Ver.R0, 9 Jan. 2017	Nov. 2017
VIII	Cost Estimate	Ver.R0, 9 Jan. 2017	Aug. 2017
IX-A	Drawing (Highways)	Unknown	Aug. 2017
IX-B	Drawing (Structures/ Drainage)	Unknown	Aug. 2017
IX-C	Drawing (Structures/Bridges)	Unknown	Aug. 2017
IX-D	Drawing (Structures/underpass)	Unknown	Aug. 2017
IX-E	Drawing (Structures/Interchange)	Unknown	Aug. 2017

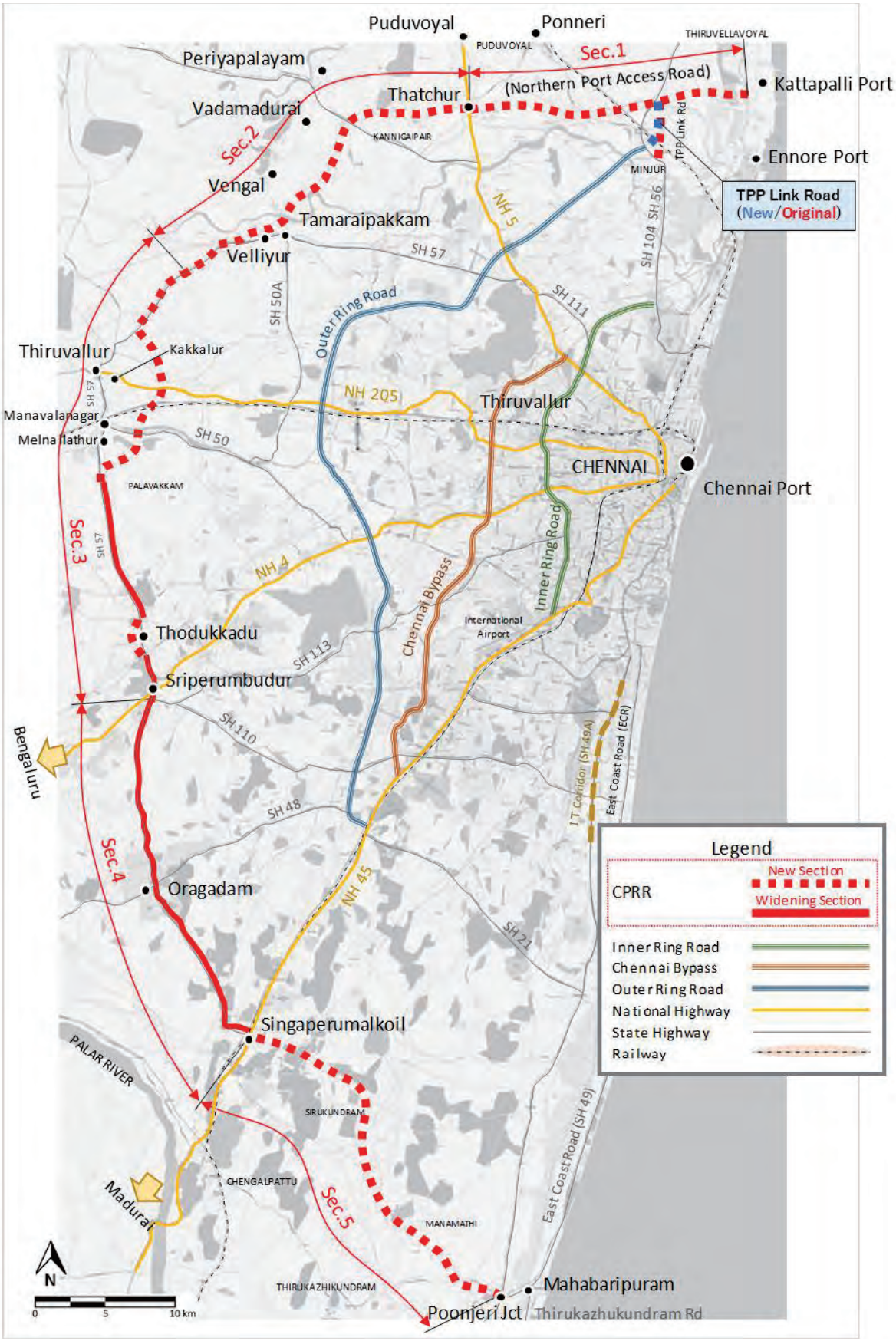
Source: DPR Main Report P1-6 and the JICA Study Team

2.2 Present Condition and Identified Issues of Roads and Traffic in the Study Area

2.2.1 Present Condition and Issues of Road Network

Roads in CMA have been developed following the pattern of the Radial-Ring Road Network as shown in Figure 2.2.1. Major radial roads which originate at the center of Chennai City are NH4 (towards Mumbai via Bengaluru), NH5 (towards Kolkata), NH45 (towards Madurai), and NH205 (towards Tirupathi). With respect to ring roads, the IRR was first proposed as a city bypass road in 1968, and construction started in the 1980s from its central arm connecting NH45 to NH5. Subsequently, the northern and southern arms were developed. Then, the second ring road, the Chennai Bypass, was opened in 2008. However, since the urbanized area of Chennai is rapidly expanding, these two ring roads were incorporated into the built-up area. Therefore, the third ring road, or the ORR, is currently being developed, and the CPRR was even proposed to enhance the road network for further expansion of the metropolitan area and increase of traffic demand.

Table 2.2.1 and Table 2.2.2 show the statistics on the road network in Tamil Nadu State. There are highways and roads of 62,468 km in length, and a large part of National Highways (NH) and State Highways (SH) have double or more lanes (99% for NH and 97% for SH).



Source: JICA Study Team based on OpenStreetMap

Figure 2.2.1 Road Network in CMA

Table 2.2.1 Existing Roads in Tamil Nadu State

Classification of Road	Length (km)
National Highways (NH wing-1985 & NHAI-3009)	4,994
State Highways	12,095
Major District Roads	11,628
Other District Roads & Sugarcane Roads	33,751
Total	**62,468**

Source Highway Department

Table 2.2.2 Details of Roads in Tamil Nadu State

Unit: km

No.	Category wise	Single Lane	Intermediate Lane	Double Lane	Multi Lane	Total
1	National Highways	12	26	2,731	2,225	**4,994**
2	State Highways	56	350	9,795	1,894	**12,095**
3	Major District Roads	422	7,663	3,367	176	**11,628**
4	Other District Roads	29,287	3,507	893	64	**33,751**
Total		**29,777**	**11,546**	**16,786**	**4,359**	**62,468**

Source Highway Department

The issues of the road network in CMA are summarized as follows:

(1) Concentration of Traffic in the Core Area of Chennai

The incompletion of the road network development in the pattern of the Radial-Ring Road Network in CMA (construction of ring roads has not caught up with the increase in traffic demand) is causing serious traffic congestion in major roads towards the city center. Traffic is concentrated particularly in the core area of Chennai. It was found that more than 200,000 vehicles per day are traversing NH45 and IRR, including motorbikes. On the other hand, the traffic volume on the same road but in the suburbs is less than 70,000 vehicles per day. Similar characteristics were found in other major roads. As a result, the travel speed of traffic towards Chennai City in the morning peak hour becomes less than 30 km/hr in the city center.

It is therefore required to disperse incoming traffic before it comes into the city center.

(2) High Proportion of Large Vehicles

A high ratio of large vehicles is found in the suburban section of NH5, NH4, and NH45. This indicates that these roads are used by a large number of commercial vehicles, such as heavy lorries and trailers, to access the industrial areas and the Kattupalli/Ennore/Chennai Ports. The high proportion of slow-moving large vehicles causes a decrease in the overall travel speed of traffic.

A large number of large vehicles are frequently passing through small villages in the suburbs. Thus, there are a lot of pedestrians and motorcycles in the villages that are always facing high risks of traffic accidents.

Hence, a new link connecting industrial areas in the suburban area to ports shall be developed to ease the load of existing highways.

(3) Expansion of Built-up Areas

Rapid economic growth and increase in the population of CMA is encouraging the urbanized built-up area to expand, thereby changing the classification of IRR and Chennai Bypass from bypass roads to urban highways. The ORR which is currently being constructed will be, once it opens, the newest ring road with

the largest radius of 20 to 30 km; however, urban development is approaching such current outskirts.

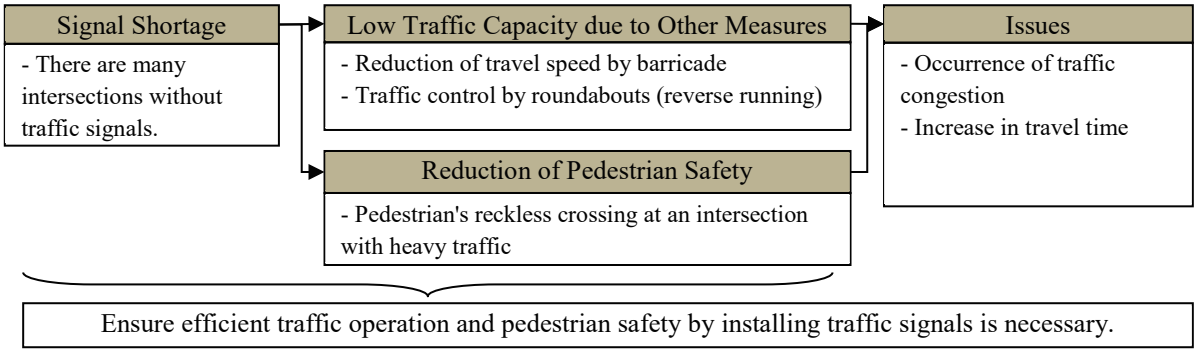
The necessity of the development of further ring roads has been recognized to enhance the road network as well as improve redundancy of the network.

2.2.2 Present Condition and Issues of Traffic in the Study Area

(1) Traffic Signal Shortage

There are many intersections without traffic signals in Chennai. At such intersections, barricades and roundabouts are adopted as alternative facilities. However, such facilities cause problems such as traffic congestion and increase in travel time. In addition, pedestrian safety is threatened because crossing at intersections without signals involves great danger.

In short, the lack of signals causes traffic congestion and prolonged travel time. Therefore, it is necessary to secure efficient traffic operation and pedestrian safety by installing traffic signals.



Source: JICA Study Team

Figure 2.2.2 Issues due to Traffic Signal Shortage

1) Reduction of Travel Speed by Barricades

Barricades are installed to reduce the travel speed of vehicles at some crosswalks and intersections. They are installed even in trunk roads with three lanes per direction. However, high speed vehicles suddenly need to change lanes to avoid barricades. Thus, it is assumed that barricades lower travel speeds but also induce accidents by sudden lane changing.

Source: JICA Study Team

Figure 2.2.3 Installation of Barricades

2) Crossing Pedestrian

There are crosswalks on trunk roads with over six lanes, but no signals are installed in most cases. Therefore, pedestrians are forced to cross the road amidst heavy traffic which causes accidents.

There are some sections where barricades are installed in front of crosswalks to decrease the speeds of vehicles and to shorten the crossing distance. Regardless, pedestrians are still in danger.

In cases where a school is located along a trunk road, a large number of students cross the road in the morning and evening as many of them use public transport. Even when a pedestrian bridge is installed near the school, students still tend to cross the road. It is assumed that the reason for this is the long distance between the pedestrian bridge and the bus stop.

For these reasons, it is said that there is a high risk of traffic accidents around schools.

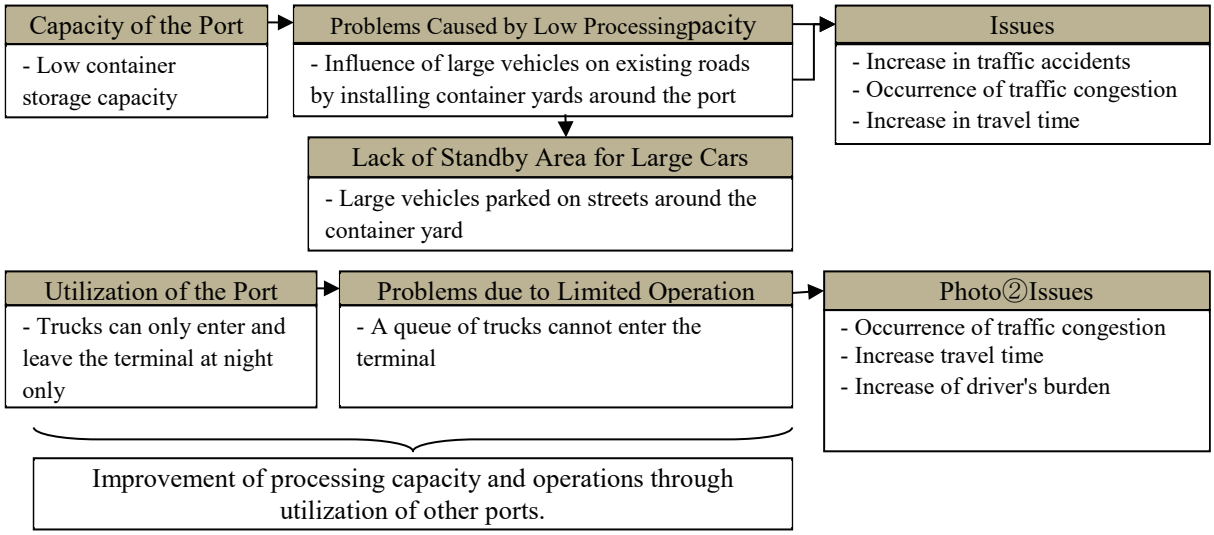
Source: JICA Study Team

Figure 2.2.4 Crossing Pedestrians

(2) Processing Capacity and Operation at the Chennai Port

As shown in Figure 2.2.5, due to the small processing capacity and the inefficient operation of the Chennai Port, large vehicles flow into community roads and form a long queue on roads.

Since improvements to the operation of Chennai Port and the utilization of Ennore Port are in progress, some developments to the situation are expected.



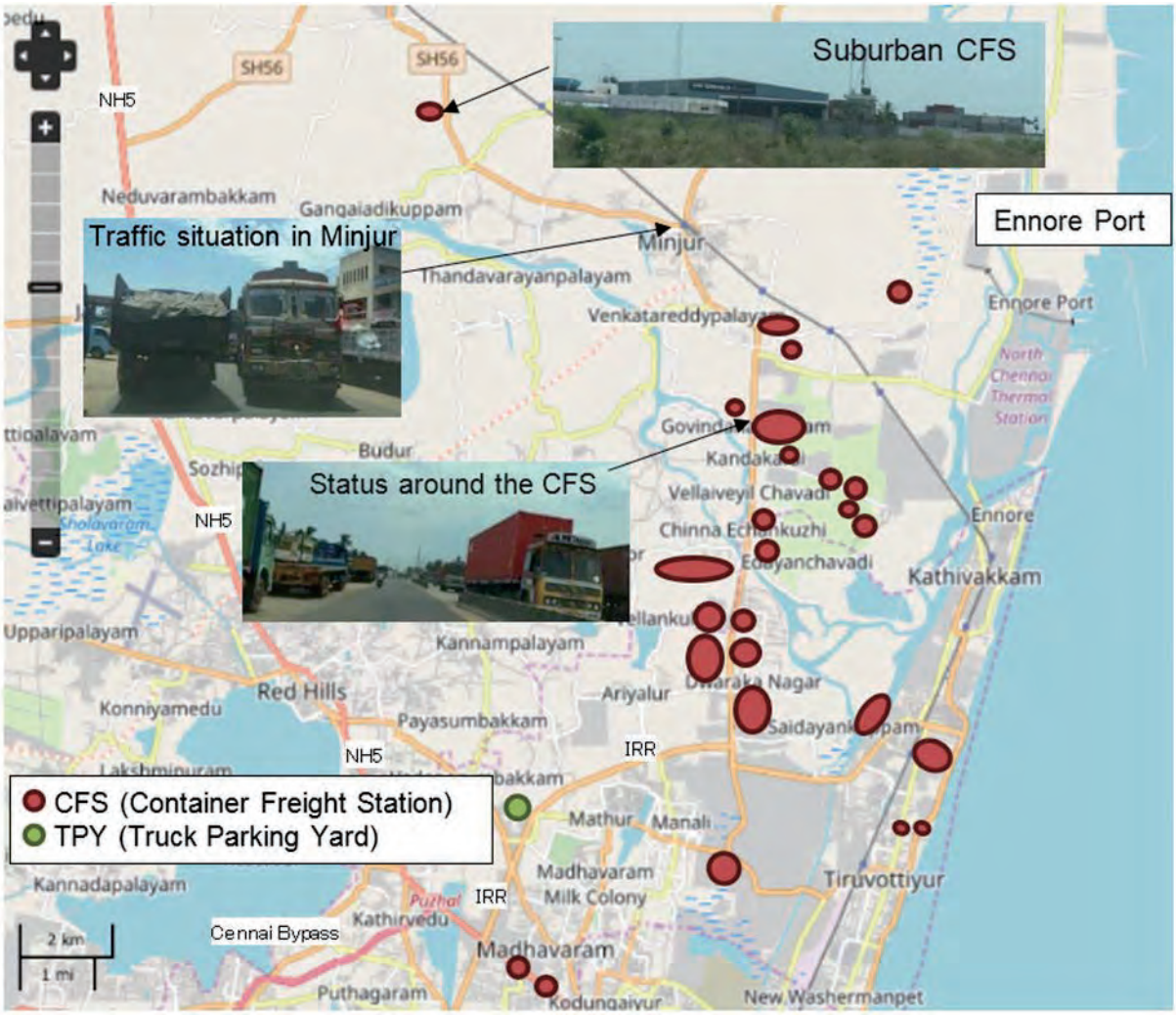
Source: JICA Study Team

Figure 2.2.5 Issues due to Small Processing Capacity and Inefficient Operation at the Chennai Port

1) Influence of Large Vehicles on Community Roads

The yard of Chennai Port is narrow, and the capacity to handle containers is limited. Container cargo landing from a ship must be immediately taken out of the yard. Therefore, there are container freight stations around the port to compensate for the shortage of port capacity (Figure 2.2.6).

However, there are cases wherein container freight stations are located in the suburbs, where trunk roads are not constructed, so there are sections where large vehicles pass through community roads (Figure 2.2.7).



Source: JICA Study Team

Figure 2.2.6 Location of Container Freight Stations

Source: JICA Study Team

Figure 2.2.7 Traffic around Chennai Port

2) On-Street Parking due to Lack of Standby Space for Large Vehicles

On the road around the container freight station, large vehicles are waiting for loading and unloading on the service road and the main road as shown in Figure 2.2.8. These vehicles cause a decrease in traffic capacity and worsened traffic congestion.

Source: JICA Study Team

Figure 2.2.8 Street Parking of the Large Vehicles around the Container Freight Station

3) Track Queue

There are 3,000 to 4,000 container vehicles that enter and exit the port each day. The entry and exit of trucks to Chennai Port is limited to nighttime only, and there is only one entrance on the north side of the port. Therefore, trucks that cannot enter the terminal form a long queue on the access road to the port. These vehicles occupy a lane, cause traffic congestion, and increase travel time.

In addition, according to the interview survey conducted by the JICA Study Team, the average waiting time of these large vehicles is 30 to 40 hours, and the burden on the truck driver is also high.

Source: JICA Study Team

Figure 2.2.9 Waiting Queue of Large Vehicles

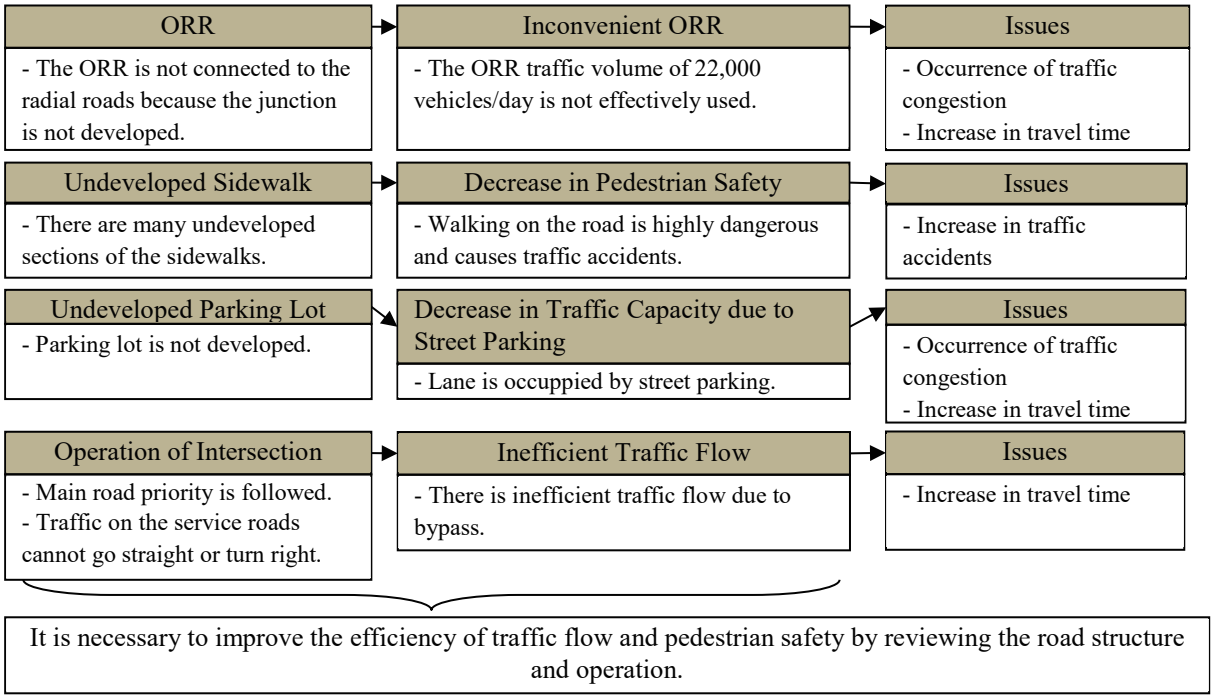
(3) Issues due to the Road Structure/Operation

Although the ORR is partially open to public, there are problems of connection with the main radial roads. The junction at the connecting point with NH4 and NH45 is still under construction. Therefore, the ORR is not effectively utilized.

In Chennai, there are many sections where sidewalks and parking lots are not provided. In such sections, the risk of traffic accidents involving pedestrians is high, as parked vehicles occupy a lane, cause traffic jams, and increase travel time.

In addition, at many intersections of trunk roads, vehicles travelling on service roads cannot go straight or turn right, but must take a detour instead.

These road structure and operational problems lead to traffic congestion, increase in travel time, and fatal accidents. Therefore, it is required to improve the efficiency of traffic flow and pedestrian safety by reviewing the road structure and operations.



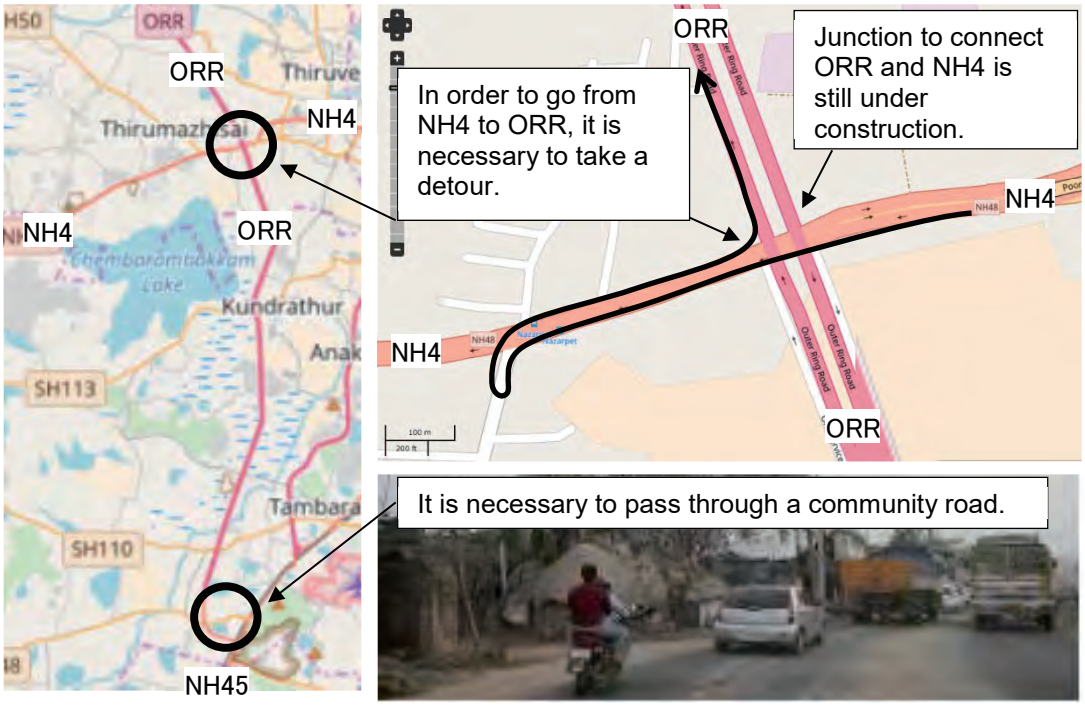
Source: JICA Study Team

Figure 2.2.10 Issues due to Road Structure and Operation

1) Undeveloped Junction of ORR

Although the ORR is partially open to public, it is not effectively used because the traffic volume of ORR is only 10% of the IRR. The reasons are as follows:

- The connection between NH4 and ORR is still under construction, and vehicles are forced to take a detour.
- The connection between NH45 and ORR is under construction, and vehicles are forced to pass through a narrow community road.



Source: JICA Study Team

Figure 2.2.11 Undeveloped Junction in ORR

2) Undeveloped Sidewalk

There are many sections where sidewalks are not provided, and pedestrians are forced to walk on the carriageway. Also, pedestrians precariously walk on the inner side of the road to avoid parked vehicles and stalls that are on the road.

It is necessary to construct sidewalks to separate pedestrians and vehicles and to secure a safe walking space.

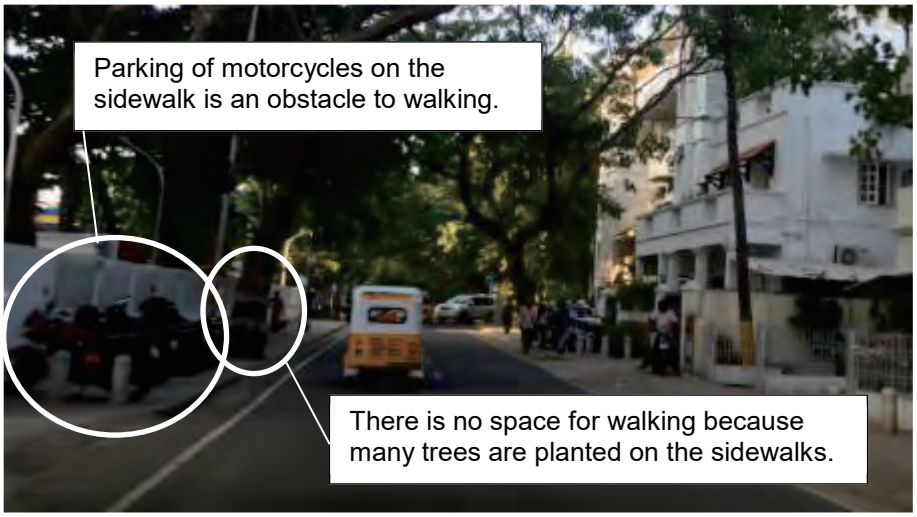
Source: JICA Study Team

Figure 2.2.12 Undeveloped Sidewalk

3) Misuse of Sidewalks

As shown in Figure 2.2.13, there are many areas where sidewalks are occupied by parked vehicles or are obstructed by trees. In such situations, pedestrians are forced to walk on the carriageway.

In order for sidewalks to serve their proper function, it is necessary to install motorcycle parking lots and to prohibit planting of trees on sidewalks.



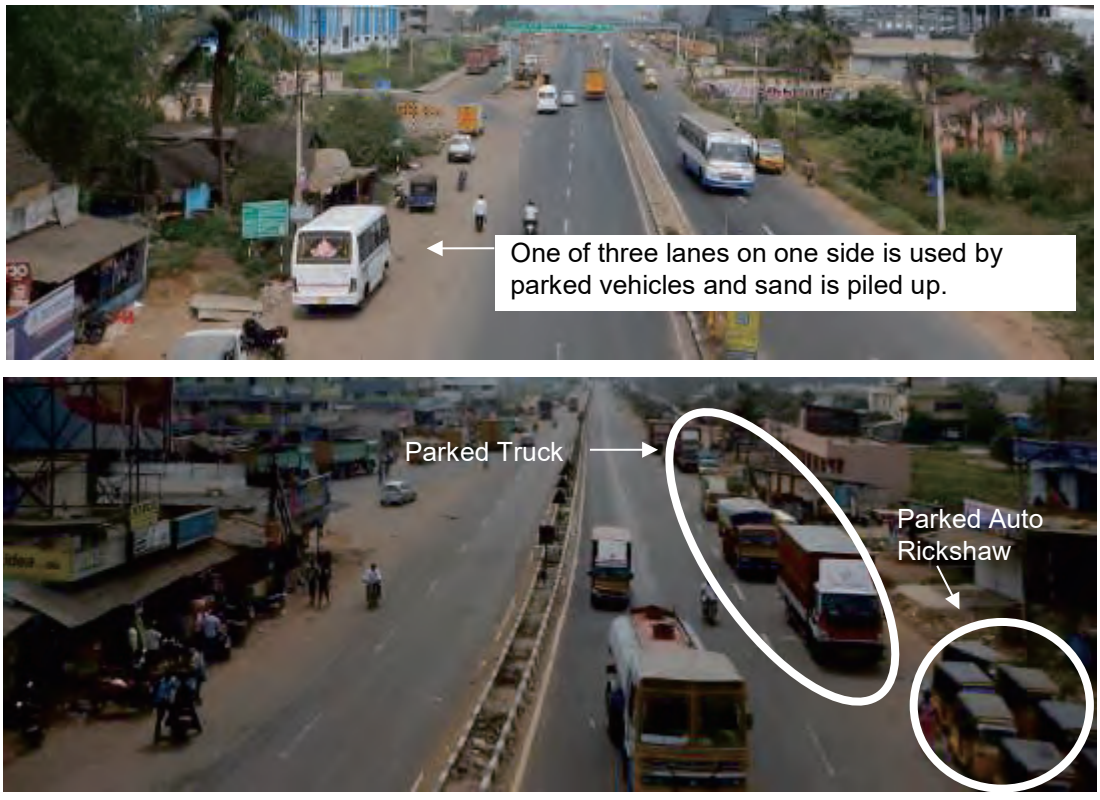
Source: JICA Study Team

Figure 2.2.13 Misuse of Sidewalks

4) Lanes Occupied by Parked Vehicles

As parking lots are not installed, many vehicles park on carriageways. There are some sections where one lane is covered by sand and cannot be recognized as a lane because it is not used for traffic as shown in Figure 2.2.14. Also, trucks occupy roads near the port and the industrial parks.

It is necessary to install parking lots in order to accommodate the parked and waiting vehicles on the road and maximize the road capacity.

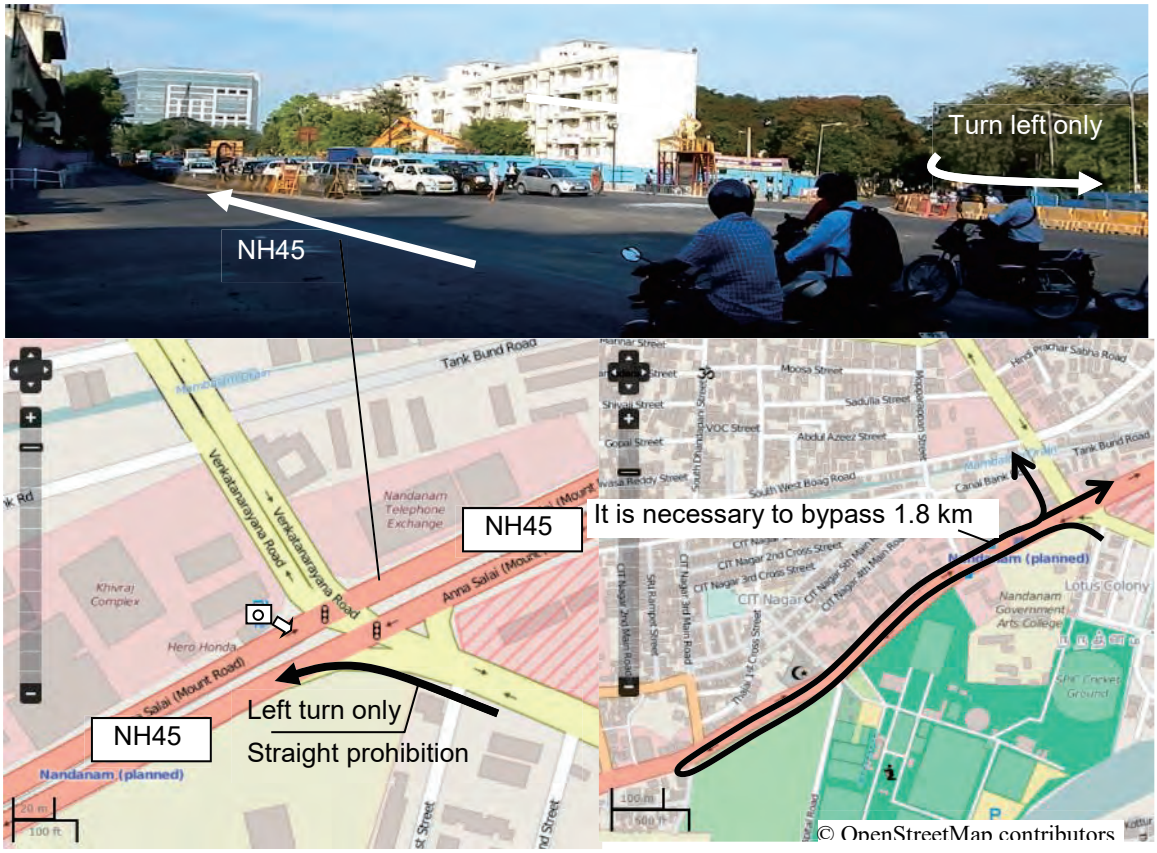


Source: JICA Study Team

Figure 2.2.14 Lanes Occupied by Parked Vehicles

5) Inefficient Operations of Intersection

At signal intersections on arterial roads such as NH 45, as shown in the figure below, the traffic on the intersecting road cannot cross the arterial road. In this case, traffic flow is inefficient because vehicles on the service road are forced to make a detour.



Source: JICA Study Team

Figure 2.2.15 Inefficient Operation of Intersection

If straight and right turns are prohibited, vehicles are forced to make a U-turn then occupy one lane, which also reduces traffic capacity and decreases travel speed.

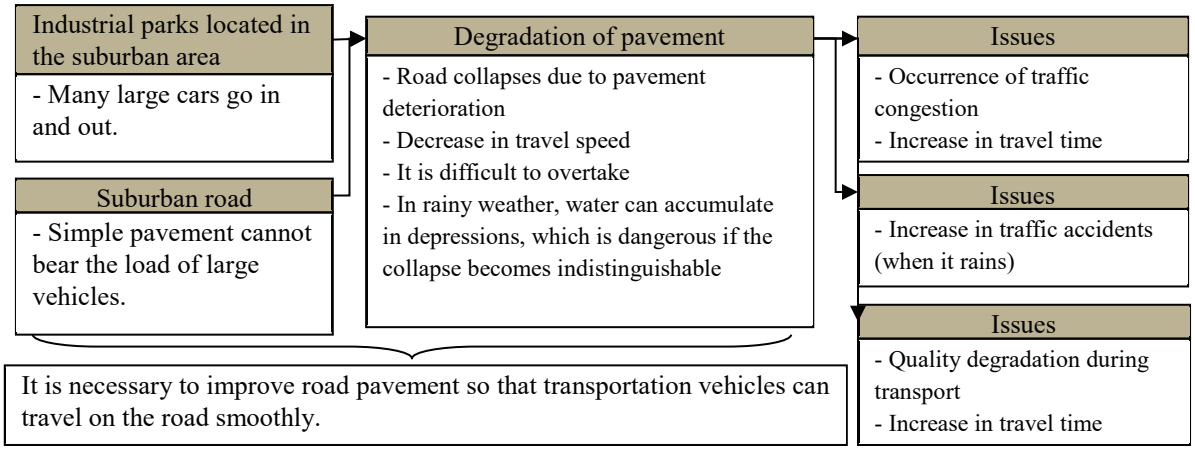
Source: JICA Study Team

Figure 2.2.16 U-Turn Point

(4) Deterioration of Pavement

There are sections where roads are depressed due to deterioration of pavement. Pavement deterioration lowers travel speed, making overtaking difficult. Especially in Chennai, where many industrial parks are located in suburbs, there is a large volume of heavy vehicles in the access roads, and depression of roads are

also evident. Pavement deterioration also causes logistics problems such as damage in handling and transport of trucks and increase of logistics time. Therefore, it is necessary to improve road pavements to allow smooth flow of traffic.



Source: JICA Study Team

Figure 2.2.17 Problems due to Deterioration of Pavement

Source: JICA Study Team

Figure 2.2.18 Road Collapse due to Deterioration of Pavement

(5) Other Issues

1) Street Parking of Large Vehicles around the Industrial Park

At the CPRR (Section 4) around the Oragadam Industrial Park, there are situations where large vehicles and corporate buses occupy the road as shown in Figure 2.2.19.

In the future, if the connecting point between the CPRR (Section 4) and the arterial road (NH4, NH45) is improved, traffic volume is expected to increase. Reduction of traffic capacity caused by on-street parking of large vehicles may cause traffic congestion.

Source: JICA Study Team

Figure 2.2.19 Large Vehicles around the Industrial Park

2) Buses Occupying the Road

Covered bus stops are installed around the railway station in Chennai. Many buses stop at designated locations, but there are also some that stop and load and unload passengers along carriageways. This becomes a factor of the decline in traffic capacity. If there is no designated stop, some buses occupy one lane, which also causes traffic congestion near the railway stations.

Even if bus bays are installed at the bus stops along the main roads, passengers wait for buses on the bus bay itself. It is assumed that passengers take such action to ensure that they get on the bus. Because passengers occupy the bus bay, the bus is forced to stop in the carriageway.

Source: JICA Study Team

Figure 2.2.20 Buses Occupying the Road

3) Unloading on Roads

Because there is no parking lot for freight cars, loading and unloading on roads become an obstacle to other vehicles.

Source: JICA Study Team

Figure 2.2.21 Occupation of Roads by Loading and Unloading on Roads

4) Decrease in Travel Speed due to Wildlife Crossing

On suburban roads, there are many instances where vehicles wait for animals to cross, causing traffic slowdown.

Source: JICA Study Team

Figure 2.2.22 Animal Crossing the Road

5) Reduction of Lane due to Sidewalk Stalls

There are many areas where one lane is occupied by people and vehicles that stop by sidewalk stalls. As a result, traffic capacity decreases and traffic congestion occurs. Also, since pedestrians cannot pass on the sidewalk, they are forced to walk on the roadway, which increases the risk of meeting traffic accidents.

Source: JICA Study Team

Figure 2.2.23 Reduction of Lane due to Sidewalk Stalls

6) Reduction of Lane due to Parked Auto-Rickshaw

Many auto-rickshaws are on standby in busy areas such as hotels and shopping malls. A lane is occupied by auto-rickshaws on standby which decreases traffic capacity and speed.

Source: JICA Study Team

Figure 2.2.24 Standby Auto-Rickshaw

7) Congestion due to Wedding Ceremonies and Other Events

When there are events such as wedding ceremonies, many vehicles of guests gather and queue at the event venue, thus disrupting the flow of traffic.

2.2.3 Present Condition and Issues of Intelligent Transport System (ITS) Facilities in the Study Area

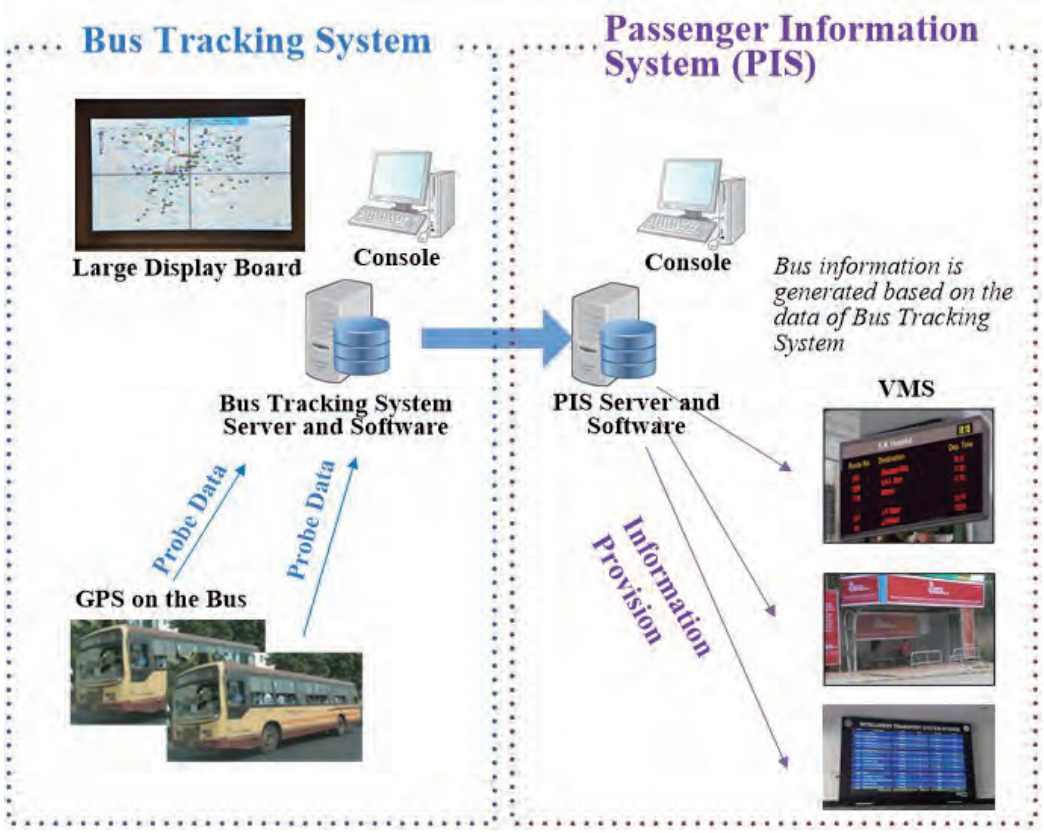
The present condition of the entire ITS in Chennai is described in the Final Report of the Data Collection Survey for Chennai Metropolitan Region ITS which was completed in March 2017. This clause reports the latest conditions of ITS updated in this study, which are directly related to the ITS components of the Japanese ODA Loan Project.

(1) City Bus System of Metropolitan Transport Corporation (MTC)

The City Bus System is composed of the following components:

- Bus Tracking System
- Passenger Information System
- Electronic Ticket Management System

The Bus Tracking System and Passenger Information System are systematically linked to function (the Electronic Ticket Management System functions independently). Both systems are shown in Figure 2.2.25.



Source: JICA Study Team

Figure 2.2.25 Images of Bus Tracking System and Passenger Information System

1) Bus Tracking System

This system is used for bus management, showing the current locations of city buses on the video wall at the command control center of the bus operator. The bus location information is collected from the GPS device installed on the bus. It was found that the Bus Tracking System has not yet been introduced.

2) Passenger Information System

This system provides information on bus operations (e.g., arrival/departure time) through Variable Message Sign Boards (VMS) at bus stops, websites, mobile applications, etc. The information is generated based on the bus location data obtained by the Bus Tracking System. It was found that this system has not yet been introduced.

3) Electronic Ticket Management System

This system is used for the collection of fare payment made by passengers and for management of revenue. It was found that this system has already been introduced. Approximately 8,000 handy ticketing devices were procured. The device is currently used only for ticket issuing, not for IC card usage. The hardware is compatible with both Type A and Felica. When the software is installed, this device can be used for both types of IC cards.

(2) Traffic Management System of Chennai Traffic Police (CTP)

The current Traffic Management System of CTP was confirmed as follows:

1) Command Control Center

The Command Control Center has been established in the CTP building, and limited functions are in operation.

2) Call Center in Command Control Center

Approximately 20 operators are stationed in the Command Control Center for 24 hours a day, handling emergency calls, inquiries, claims, etc.

3) Traffic Signal System and CCTV Camera

Traffic signals have been installed at 385 junctions in the city. The current signals are of the fixed pattern type, not the signal coordination type. The signal patterns are adjusted or changed by the police officers as necessary. There are many signals that are not working or are turned off. CCTV cameras have also been installed at the junctions. A typical image of the existing traffic signal together with a CCTV is shown in Figure 2.2.26.

Source: JICA Study Team

Figure 2.2.26 Existing Traffic Signal and CCTV Camera at Junction

4) Variable Message Sign Board (VMS)

VMS have been installed at 53 junctions in the city. The existing VMS provides static messages such as warnings on traffic rules, not dynamic traffic information. Two different languages, i.e. English and Tamil, are shown. A typical image of the VMS is shown in Figure 2.2.27.

Source: JICA Study Team

Figure 2.2.27 VMS and Displayed Message

5) E-Challan System

E-Challan System is used for traffic violation enforcement. The handy terminals deployed to the police officers issue the enforcement ticket for the fine imposed on the traffic violation at the site. The data inputted on the handy terminal is collected at the Command Control Center, and the system manages the traffic violation record. E-Challan System has already been introduced to the CTP, and approximately 400 handy terminals are in use as of now.

6) Advance Traveler Information System (ATIS)

The ATIS provides traffic information to road users as pre-trip information. A prototype system was developed by the Indian Institute of Technology (IIT)-Madras, and the pilot was carried out in a relatively

limited area, i.e., on the roads surrounding the campus of IIT Madras. The project is funded by the Government of India, and related government organizations such as CTP are aimed to utilize the system.

(3) Chennai Metro Rail Limited (CMRL)

Smart cards which can be used only for Chennai Metro have been introduced. There are two card types, i.e., Type-A (Mifare) and Felica. Multi-type card readers which can read and write both types of cards have been introduced at the gates of Chennai Metro stations. The ticketing and recharging terminals for both types of cards are also available in these stations.

The clearinghouse has already been developed in Chennai Metro and was designed to handle a maximum of 32 operators, taking into consideration the introduction of a common mobility card in Chennai in the future. It functions as a management system of the cards as well. The memory of both types of the cards has also been designed to accommodate the same number of operators. A card initializing process is required upon issuance. Simple card issuance terminals for the initialization, which are processed by manual operation not automatic, are used because there are still a relatively small number of cards used for the metro.

2.3 Organizations Related to Road and ITS Development

Organizations related to road and ITS development are described in this section. The correlation of the organizations is presented in Appendix-2.

2.3.1 Highways and Minor Ports Department (HMPD)

HMPD manages SHs and minor ports in Tamil Nadu State. CPRR is supposed to be an SH once it opens, but it is not declared at this moment; thus, the implementation agency for the construction of CPRR will be HMPD. Even NHs inside Chennai City are under the jurisdiction of HMPD. Details of HMPD are described in Section 6.2 of this report.

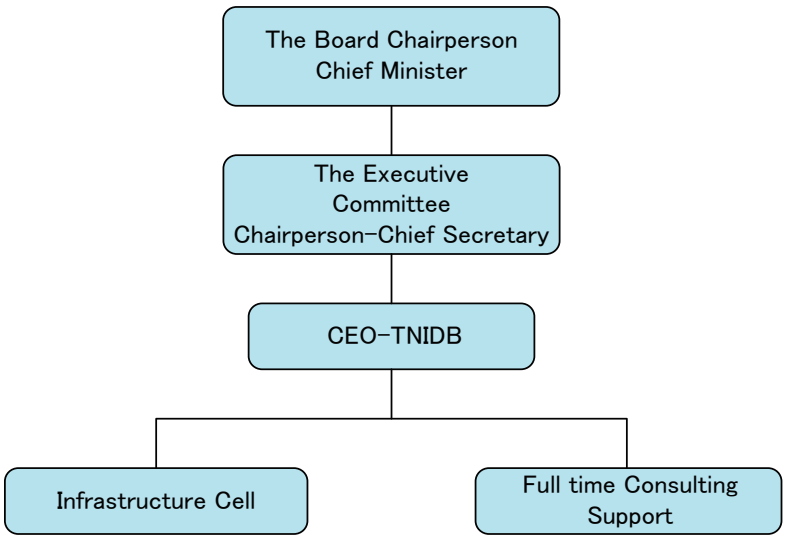
2.3.2 Tamil Nadu Infrastructure Development Board (TNIDB)

TNIDB is a nodal agency for planning and coordination of infrastructure development in Tamil Nadu State. It was established to facilitate the infrastructure development projects under the Ministry of Finance according to the Tamil Nadu Infrastructure Development Act 2012. It formulates, prioritizes, and evaluates the projects and coordinates with the related departments to acquire the state budgets and financial support from the central government. It also prepares feasibility study reports and detailed project reports and monitors the projects.

TNIDB is involved in the projects undertaken by the government (public project) and through Public Private Partnership (PPP project). The act stipulates that TNIDB is involved in the public project with more than INR 500 crores of the project cost and the PPP project with more than INR 10 crores.

The chair person is the Chief Minister and the vice-chair person is the Finance Minister. Under the chair person, the executive committee is formed. The executive committee is chaired by Chief Secretary. It consists of 10 concerned departments with officials and experts. The chief executive officer (CEO) under the executive committee deals with the day-to-day duties of TNIDB. Under the CEO, there are a core in-house team, external consultants and experts.

The organization structure is shown below.



Source: Edited by JICA Study Team based on TNIDB's website

Figure 2.3.1 Organization Structure of Tamil Nadu Infrastructure Development Board

2.3.3 Chennai Metropolitan Development Authority (CMDA)

CMDA is a planning agency for Chennai Metropolitan Area including Chennai District, part of Kanchipuram District and part of Thiruvallur District. CMDA prepares plans such as master plan and new town development plan. The plan is implemented by the individual government agencies in charge. Minister of Housing and Urban Development represents CMDA and there are following members for decision making.

Table 2.3.1 Members of Chennai Metropolitan Development Authority

Honorable Minister for Housing and Urban Development	Chairman
Vice- Chairman, CMDA	Vice Chairman
Member-Secretary, CMDA	Member
Secretary to Government H&UD, Finance, Industries, Transport	Member
Commissioner, Corporation of Chennai	Member
Managing Director CMWSS Board	Member
Director, Town & Country Planning	Member
Chief Urban Planner, CMDA	Member
Chief Engineer, Highways & Rural Works Department	Member
Chief Architect to Government	Member
Joint Director, Town & Country Planning	Member
Chairman, Tamil Nadu Housing Board	Member
Chairman Tamil Nadu Slum Clearance Board	Member
Member of the State Legislative Assembly	Member

Source: Summarized by JICA Study Team based on the Information on Website of CMDA

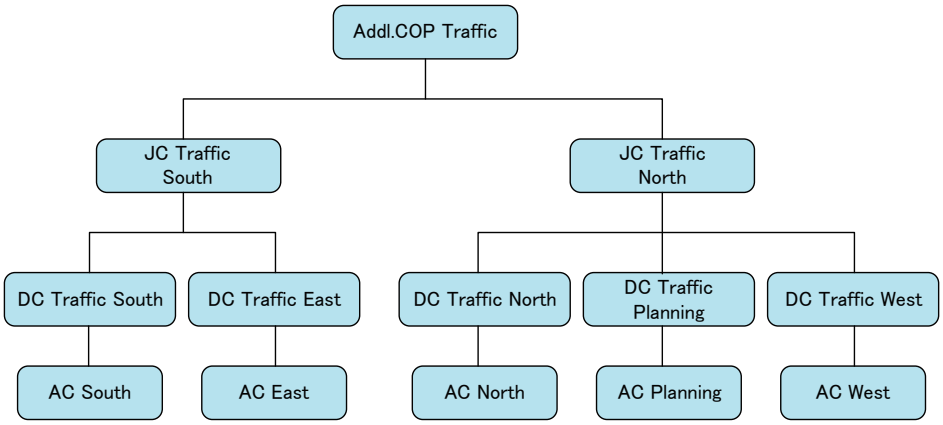
There are following units under the members

- Area Plans Unit
- Area Development Unit
- Master Plan Unit
- Road and Rail Unit
- Enforcement Cell (dealing with permission and authorization such as issuance of completion certificate of project, etc.)
- Construction Wing and General Unit.

2.3.4 Chennai Traffic Police (CTP)

CTP under Chennai Police manages traffic. They are responsible for regulating traffic and enforcing traffic rules in Chennai District. The Chennai Police is under the Ministry of Home, Prohibition and Excise and is headed by the Commissioner of Police. The Chennai Traffic Police is headed by the Additional Commissioner of Police. The jurisdiction area is divided into four (4) regions; North, South, East and West and each region is represented by Deputy Commissioner. There are also a Planning Division of Traffic Management under Chennai Traffic Police.

The organization structure is shown below.



* Addl.COP: Additional Commissioner of Police, JC: Joint Commissioner, DC: Deputy Commissioner, AC: Additional Commissioner

Source: Edited by JICA Study Team based on Website of Tamil Nadu Police Department

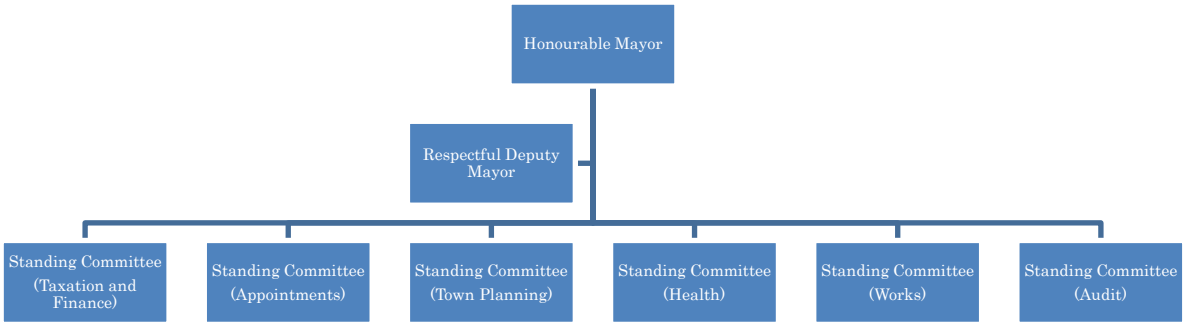
Figure 2.3.2 Organization Structure of Chennai Traffic Police

2.3.5 Greater Chennai Corporation (GCC)

GCC is an autonomous body of Chennai, a designated city by the Government Ordinance in Tamil Nadu State. GCC consists of administrative agencies with 200 members headed by the mayor and the City Council. The mayor and each City Council member are chosen by direct election, and the deputy mayor is elected among the City Council members by votation. The mayor and the deputy mayor preside over several Standing Committees. The Commissioner represents the administrative agency and controls each administrative service department such as Education, Insurance, and Health.

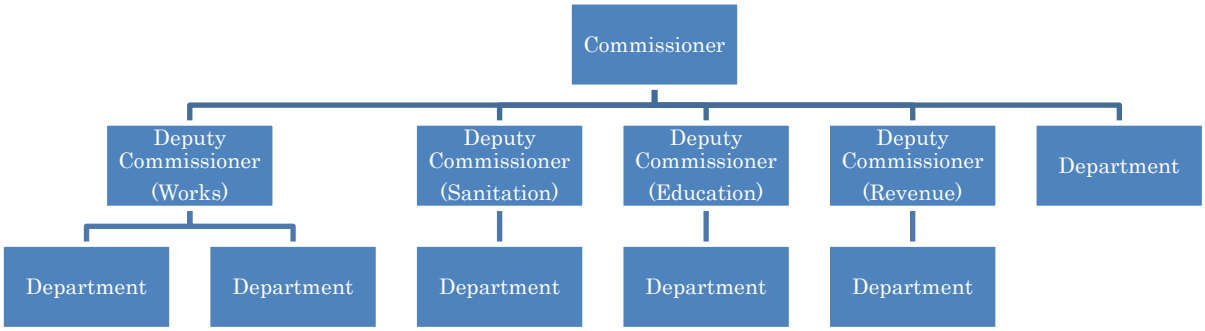
GCC has jurisdiction over the development and maintenance of city roads with a total length of approximately 5,560 km, excluding NH and SH in Chennai and roadside facilities such as bus stops, street lights, road signs, markings, drainage, sidewalks, and skywalks. The ownership of these facilities belongs to GCC. As for traffic signals, CTP carries out the maintenance, and the ownership belongs to them.

The organization structure is shown below.



Source: Edited by the JICA Study Team based on website of Greater Corporation of Chennai

Figure 2.3.3 Organizational Structure of the Executive Committee of Greater Corporation of Chennai



Source: Edited by the JICA Study Team based on website on Greater Corporation of Chennai

Figure 2.3.4 Organizational Structure of the Administrative Body of Greater Corporation of Chennai

2.3.6 Chennai Smart City Limited (CSCL)

CSCL is a Special Purpose Vehicle (SPV) for the Smart City Mission in Chennai. The roles of CSCL are planning, implementing, and managing the projects of Smart City Mission, as well as operating and maintaining the introduced facilities and systems.

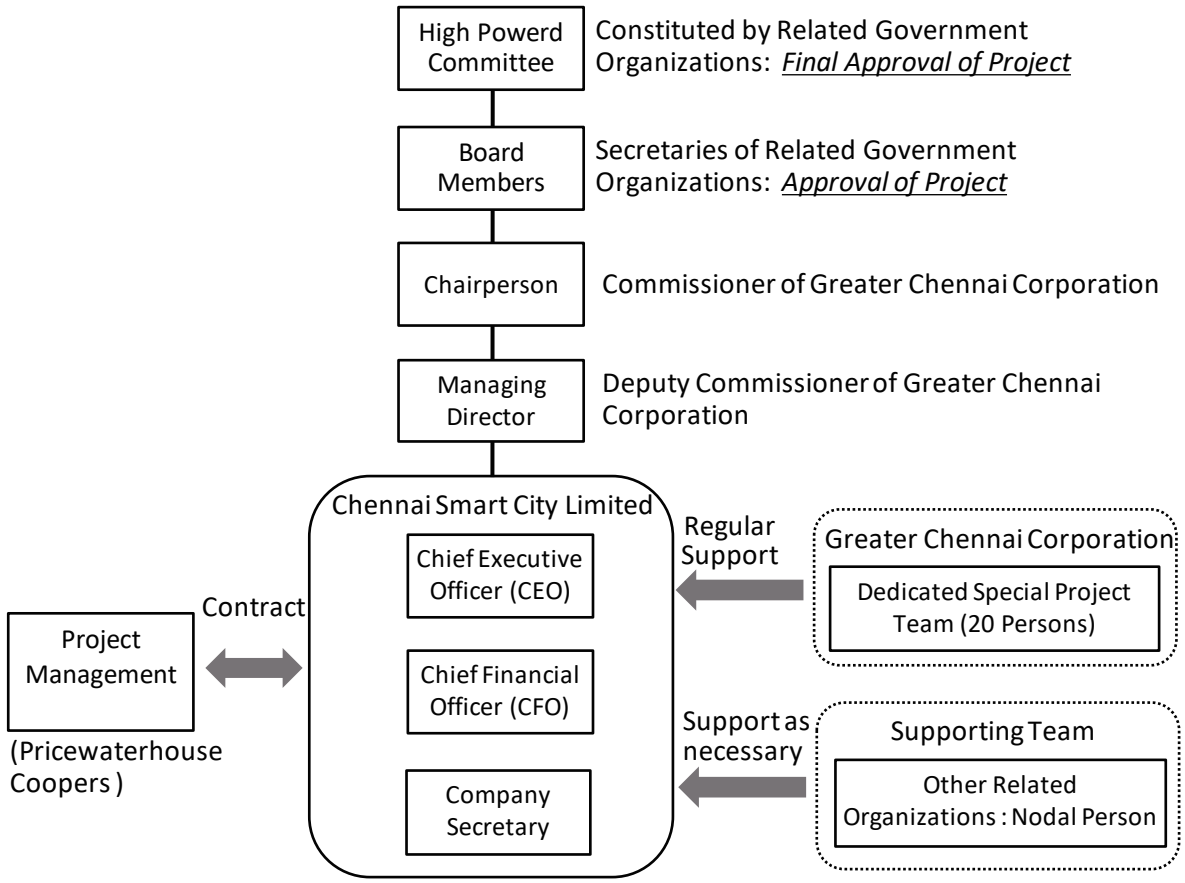
It was established in 2016 according to the Smart City Guidelines issued by the Government of India in June 2015. The coverage domain of CSCL includes several sectors as follows:

(The following are the descriptions of the objectives under the Smart City Mission which are extracted from the Smart City Guidelines.)

- *Adequate water supply,*
- *Assuring electricity supply,*
- *Sanitation including solid waste management,*
- *Efficient urban mobility and public transport,*
- *Affordable housing, especially for poor,*
- *Robust IT connectivity and digitalization,*
- *Good governance, especially e-Governance and citizen participation,*
- *Sustainable environment,*
- *Safety and security of citizens, particularly women, children and the elderly, and*
- *Health and education.*

Source: Smart City Guideline 2015, Government of India

Figure 2.3.5 shows the organization structure of CSCL.



Source: Edited by the JICA Study Team based on interviews with CSCL and related materials

Figure 2.3.5 Organization Structure of Chennai Smart City Limited

CSCL was established under the GCC. The Commissioner of GCC serves as the Chairperson, the Deputy Commissioner of GCC serves as the Managing Director, the CEO represents the CSCL, and the Chief Financial Officer (CFO) and Company Secretary constitute the CSCL as members.

For decision making, there are Board Members above the Chairperson who are in charge of the approval of projects. The Board Members are the secretaries of the related government organizations such as GCC, Tamil Nadu Finance and Infrastructure Development Corporation (TUFIDCO), etc. There is a High-powered Committee above the Board Members for the final approval of the project. It is constituted by the related government organizations.

For the implementation of the project, GCC established a Dedicated Special Project Team which consists of 20 persons. They provide support on a regular basis for CSCL. Other related organizations such as Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB), Tamil Nadu Generation and Distribution Corporation (TANGEDCO), etc. are nominated nodal persons as supporting team. The Project Management Consultant (PMC) takes management roles for the projects of the Smart City Mission such as preparing the Detailed Project Report (DPR) and overseeing the consultants hired for the individual projects. The current PMC is Pricewaterhouse Coopers Limited.

There are 20 cities in India that were selected for the first round of the Smart City Mission. The Government of India created the Smart City Fund and INR 200 crores were delivered to the individual cities. The Smart City Fund Account was opened for the states included in the Smart City Mission.

2.3.7 Tamil Nadu Road Development Company (TNRDC)

TNRDC is a government company responsible for the implementation of tolled SHs which have been established under the HMPD. It raises funds, constructs, operates, and maintains. It is a joint venture corporation of Tamil Nadu Industrial Development Corporation Ltd (TIDCO) and Tidel Park Ltd. (TIDEL). TIDCO and TIDEL are 100% government-owned companies and have equal share of TNRDC.

TNRDC was appointed by Government Order No. 94, Industries Department, dated 23 April 2012 as Managing Associate for the Northern Port Access Road Project which is currently recognized as Section 1 of CPRR. In this connection, TNRDC is currently on preparation work for the project including land acquisition and resettlement procedure for Section 1.

Details of TNRDC are described in Section 5.2.4 of this report.

2.3.8 Tamil Nadu Road Infrastructure Development Corporation (TNRIDC)

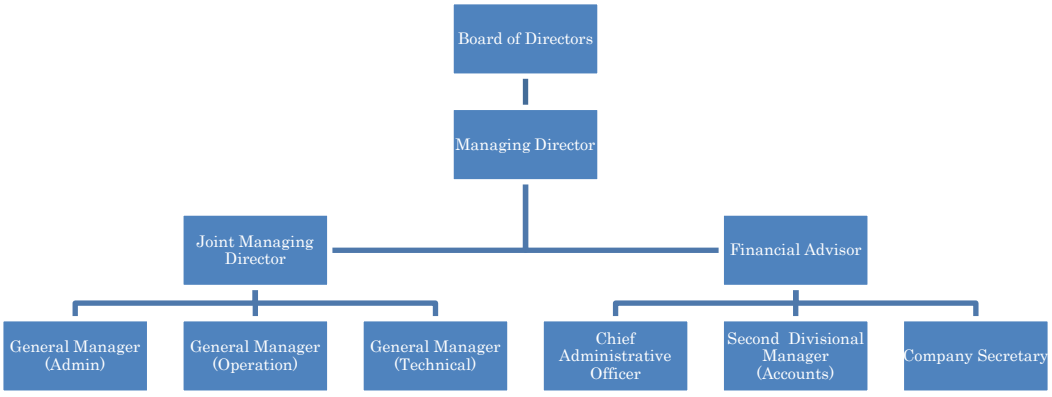
TNRIDC was established in 2005 as a non-profitable organization to implement, upgrade, and maintain road infrastructure in the State of Tamil Nadu. The Oragadam Industrial Corridor Project and the four-laning project of the Madurai Ring Road are being implemented by TNRIDC.

Details of TNRIDC are described in Section 5.2.5 of this report.

2.3.9 Metropolitan Transport Corporation (MTC)

MTC is a public city bus operator in CMA. It is a government agency under the Ministry of Transport. Metropolitan Transport Corporation offers almost 48,000 daily bus services on 842 bus routes. They own approximately 4,000 buses, and approximately 3,700 buses are operated. There are 32 bus depots, 71 bus terminals, and 151 major bus stops. There are also a number of small bus stops across Chennai. They carry approximately 4.5 million daily passengers. They operate several different types of buses with different fare categories such as ordinary, express deluxe, express, and Volvo AC services.

Metropolitan Transport Corporation is headed by the Board of Director. There are several departments and wings, such as Administration and Operation, and there are about 24,480 employees. The organizational structure is shown below.



Source: Edited by the JICA Study Team based on the website of GCC

Figure 2.3.6 Organization Structure of Metropolitan Transport Corporation

2.3.10 Tamil Nadu State Data Center

Tamil Nadu State Data Center is an ISO-certified data center of GoTN. It has been established under the National e-Governance Initiative of GoI. It offers single-point services for e-governance of Tamil Nadu State such as providing server rooms equipped with a cooling system, electric supply system by UPS, generators, data communication network, operation/maintenance of servers, user applications, etc. for computer services of various departments of the state government.

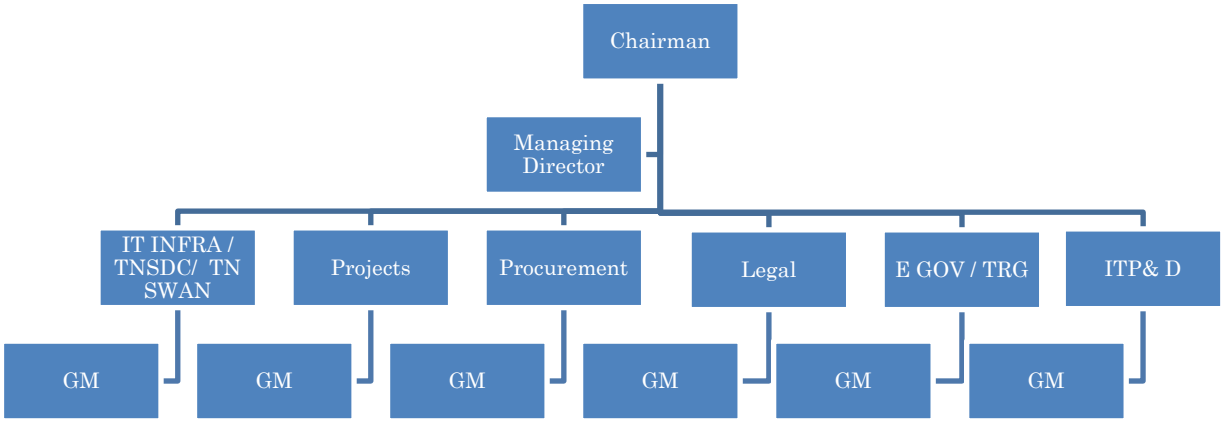
Tamil Nadu State Wide Area Network is established in Tamil Nadu State and is a major backbone network used for Tamil Nadu State Data Center. Bharat Sanchar Nigam Limited communication network is also used. A security policy for data protection is applied such as a firewall. Under the security policy, two backup data centers have been prepared, one in Bharat Sanchar Nigam Limited data center in Chennai and the other in Pune for disaster measure. Another backup center is planned in Tirchy in Tamil Nadu State.

The basic services offered by Tamil Nadu State Data Center are to provide the server spaces in the protected environment as above and operation/maintenance of servers for each department. In some cases, depending on the service agreement with the department, user applications are also prepared/procured, hosted on the server, and maintained by Tamil Nadu State Data Center. The examples of the applications

hosted include the services for tax collection/management, government's revenue management, land registrations, medical records of public hospital, etc. The servers of the Chennai Metro System are also located in Tamil Nadu State Data Center.

The Electronics Corporation of Tamil Nadu, established under the Government of Tamil Nadu, is an implementing agency that manages Tamil Nadu State Data Center and offers these services.

The figure below shows the organization structure of Electronic Corporation of Tamil Nadu and Tamil Nadu State Data Center.



*TRG: Technical Resource Group, ITP&D: Information Technology Promotion and Development,

GM: General Manager, TNSDC: Tamil Nadu State Data Center, TNSWAN: Tamil Nadu State Wide Area Network

Source: Edited by the JICA Study Team based on details of ELCOT website

Figure 2.3.7 Organization Structure of Electronic Corporation of Tamil Nadu and Tamil Nadu State Data Center

2.3.11 Chennai Metro Rail

Chennai Metro Rail Limited is an SPV for the construction and operation of the Chennai Metro. It was formed in March 2007 by the Government of India and the Government of Tamil Nadu with equal equity.

The Chennai Metro Rail is a rapid transit system in Chennai. The project is divided into two phases. Phase 1 is under construction and partially in operation. There are two corridors in Phase 1, totaling 45 km in length. About 55% of the Phase 1 corridor is underground and the rest of the structures are elevated. The following corridors are located along the arterial roads in the core area of Chennai City: Anna Salai (Mount Road or NH45), E.V. R Periyar Salai (P.H Road or NH4), and Nehru Salai (100 Ft Road or Inner Ring Road). The first stretch began its operation in June 2015. It is along Nehru Salai from Koyambedu to Alandur with 10 stations of approximately 10 km in length.

2.4 Development Plans and Projects Related to CPRR

2.4.1 Superior Development Plans

(1) National Urban Transport Policy (NUTP)

NUTP is a high-level urban transport policy in India. It was formulated by the Government of India, specifically the Ministry of Road Transport and Highways in 2006. The urban transport planning and implementation which are under the jurisdiction of the state government are to be carried out under the NUTP. The prime focuses are given to the following policies:

- To develop urban mass transport systems in the metropolises in India
- To develop urban transport infrastructure harmonized with urban development plans
- To implement various measures to shift the demand to the public transport
- To utilize ITS to solve issues of urban transport
- To develop road spaces for pedestrian and parking space
- To develop the bicycle pass
- To set Unified Metropolitan Transport Authority (UMTA) for cities with more than 40 lakhs (4 million) population.

(2) Comprehensive Traffic and Transportation Study

The Comprehensive Traffic and Transportation Study has been prepared by Chennai Metropolitan Development Authority in 2010. It envisages the vision and sets out the target and strategies for the target year of 2026 as follows:

1) Vision Envisaged by the Comprehensive Traffic and Transportation Study

The Comprehensive Traffic and Transportation Study states the vision under the framework of the second Chennai Master Plan and Vision Tamil Nadu 2026 as shown below:

"Provide safe, efficient, affordable and modern transport choices to people and businesses integrating economic, land use and transport concerns of Chennai Metropolitan Area to be fully prepared to take on the transport challenges of Chennai - the Megapolis."

2) Goals

The following indicators of modal share for the target year of 2026 are set as goals of the Comprehensive Traffic and Transportation Study.

Table 2.4.1 Target Figure of Modal Share in 2026 against 2008

Index	2008	Goal (2026)
Public Transport	41%	70%
IPT (auto, taxi, etc.)	11%	8%
Private Transport	48%	22%

Source: Summarized by the JICA Study Team based on CTTS, Chennai
Note1: The above table excludes non-motorized transport.
Note2: Construction of Mass Rail Transit, Metro Rail, Mono Rail, Light Rail Transit, Bus Rapid Transit based on plan is required, so that the public transport share rises to 70%. In addition, it is also important that parking lots, transfer stations, traffic information systems, etc. adjacent to the transport hub such as a bus stop or a railroad station is constructed. Besides, as measures of the policies, improvement of user convenience by introducing the common card and securing a regular schedule of trains are required. Most city buses, which are citizen's main transportation, are time-worn vehicles having low comfort. Thus, it is recommended that new vehicles are introduced to improve the comfort of the user. It is necessary for these measures to be carried out totally so that public transport share rises to 70%.

3) Strategy

To realize the vision and to achieve the goals stated above, the infrastructure development plan in phases (short, mid, and long term) is proposed as shown in the table below:

Table 2.4.2 Proposed Infrastructure Development: Short, Mid and Long Term

Term	Proposed Development
Short Term (2010-2015)	Pedestrian facilities (footpaths), bicycle network, traffic management, parking regulation, signal improvement, junction improvements, road markings, and signage
Medium Term (2016-2021)	Pedestrian subways, multi-level parking facilities, grade separators, flyover and underpass, traffic management centers, and skywalks
Long Term (2022-2026)	MRTS, Metro, monorail, LRT, suburban rail and BRT, intermodal stations, truck terminals, intercity bus terminals, elevated roads, freight corridors, missing roadway links, and major road widening

Source: Summarized by the JICA Study Team based on CTTS, Chennai

The cost estimates for the proposed developments are shown in the table below:

Table 2.4.3 Estimated Investment Cost

Term	Estimated Investment Cost
Short Term (2010-2015)	INR 52,689 crores
Medium Term (2016-2021)	INR 21,899 crores
Long Term (2022-2026)	INR 7,532 crores
Total	INR 82,120 crores

Source: Summarized by the JICA Study Team based on CTTS, Chennai

2.4.2 Urban Development Plans and Projects

(1) Development Plan for Chennai Metropolitan Area, 2006

Outline

The plan was issued in 2006 by Jawaharlal Nehru National Urban Renewal Mission (JNNURM), a massive city modernization scheme launched by the Government of India under the Ministry of Urban Development. The plan consists of 1) Introduction, 2) Demography, 3) Economy, 4) Land Use and Structure of Chennai, 5) Municipal Infrastructure, 6) Environment and Disaster Management, 7) Traffic and Transportation, 8) Urban Basic Services for the Poor, 9) Social Facilities, 10) Municipal Finances, 11) Vision and Goals and Strategies, and 12) Capital Investment Plan and Financing Strategy.

Objectives

The main objectives of the development plan are to have a strategy for the sustainable and planned growth of the city with appropriate policy and strategic interventions. The plan outlines the strategic policy and investment interventions to achieve the formulated vision for Chennai and comprised the following:

- Assessment of the existing situation with regard to demographic and economic growth, infrastructure services, municipal finances, etc.;
- Identification of gaps in service delivery including the issues faced by the urban poor;
- Vision and goal formulation for each sector to achieve the objectives enunciated above; and
- Formulation of a city investment plan with appropriate financing strategies for the identified interventions.

In addition, the plan also focuses on the reforms to be carried out at the state and local level in consonance with the vision and strategic plan outlined to sustain the planned interventions.

Population Projection

Population projections were carried out for the CMA based on the past trends. It is estimated that the CMA would increase to 12.6 million by 2026, of which Chennai City alone would account for 5.8 million.

Table 2.4.4 Population Projection

Unit: million

Description	Actual	Projection				
	2001	2006	2011	2016	2021	2026
CMA	7.041	7.896	8.871	9.966	11.197	12.582
Chennai City	4.343	4.628	4.950	5.239	5.540	5.856

Source: Development Plan for Chennai Metropolitan Area, 2006

Economic Growth

The plan did not make explicit projections of the Gross Regional Domestic Products (GRDP). Instead, the plan made the employment projection in CMA. It was worked out based on the existing and envisaged economic developments and past trends.

Table 2.4.5 Employment Projection in CMA

Unit: million

Description	Year			
	2011	2016	2021	2026
Male Willing to Work	2.791	3.225	3.725	4.298
Female Willing to Work	0.837	1.064	1.341	1.719
Total	3.628	4.289	5.065	6.017
Additional Jobs to Be Created	1.009	1.670	2.447	3.399

Source: Development Plan for Chennai Metropolitan Area, 2006

Water Demand

The plan projected the water demand in CMA for the future development of a water supply system.

Table 2.4.6 Total Water Demand in CMA

Unit: million liters per day

Description	Year			
	2011	2016	2021	2026
Resident Population	1,165	1,284	1,431	1,606
Office and Commercial	349	385	429	482
Industry	116	128	143	160
Total	1,630	1,797	2,003	2,248

Source: Development Plan for Chennai Metropolitan Area, 2006

The goals of the water supply sytem in the Chennai City area are as follows:

Table 2.4.7 Goals of Water Supply System in Chennai City Area

Description	Year		
	2011	2016	2021
Network Coverage for General Households	100%	100%	100%
Network Coverage for Urban Slum Households	100%	100%	100%
Per capita Supply	150 lpcd	150 lpcd	150 lpcd
Hours of Supply	6 hours/day	18 hours/day	24 hours/day
24 Hours and 7 Days' Supply	4 zones	8 zones	All 16 zones
Quality of Water	Safe and good	Safe and good	Safe and good
Non-Revenue Water	20%	15%	12%
O&M Cost Recovery	100%	100%	100%
Collection Efficiency	100%	100%	100%
Customer Satisfaction	Good	Good	Good

lpcd: liter per capita per day

Source: Development Plan for Chennai Metropolitan Area, 2006

Goals of Sewerage

The goals of the sewerage system in the Chennai City area are as follows:

Table 2.4.8 Goals of Sewerage System in Chennai City Area

Description	Year		
	2011	2016	2021
Coverage (Access)	100%	100%	100%
Treatment and Disposal	100%	100%	100%
Recycle and Reuse	25%	40%	50%
Customer Satisfaction	Good	Good	Good

Source: Development Plan for Chennai Metropolitan Area, 2006

Goals of Solid Waste Management

The goals of the solid waste management system in CMA are as follows:

Table 2.4.9 Goals of Solid Waste Management System in CMA

Description	Year		
	2011	2016	2021
Collection within the City	100%	100%	100%
Collection within the Urban Local Bodies	75%	100%	100%
Collection in Other Urban Agglomeration Areas	50%	100%	100%
Door to Door Collection	50%	75%	100%
Source Segregation	50%	75%	100%
Scientific Disposal	80%	100%	100%
Waste to Energy Generation	40%	70%	100%
Cost Recovery of O&M	50%	75%	100%

Source: Development Plan for Chennai Metropolitan Area, 2006

Transport

The plan projected the daily trips by public transport in CMA.

Table 2.4.10 Daily Trip Projection in CMA

Unit: million

Description		Actual	Projection				
		2001	2006	2011	2016	2021	2026
Population		7.041	7.896	8.871	9.966	11.197	12.582
Daily Per Capita Trips		1.30	1.34	1.50	1.60	1.60	1.65
Total Daily Person Trips		9.153	10.581	13.307	15.939	17.917	20.760
Modal Split (%)	Private	60.00	55.00	45.00	40.00	35.00	30.00
	Public	40.00	45.00	55.00	60.00	65.00	70.00
Total Daily Person Trips by Public Transport		3.661	4.761	7.319	9.564	11.646	14.532
By Rail (%)		12.00	16.00	25.00	30.00	35.00	40.00
By Road (%)		88.00	84.00	75.00	70.00	65.00	60.00
Daily Trips by Rail		0.439	0.762	1.830	2.869	4.076	5.813
Daily Trips by Road		3.222	3.999	5.489	6.694	7.570	8.719

Source: Development Plan for Chennai Metropolitan Area, 2006

The goals of the transportation system in CMA are as follows:

Table 2.4.11 Goals of Transportation in CMA

Description	Year		
	2011	2016	2021
Road Network as % of Total Area	12%	15%	15%
Share of Public Transport	45%	55%	75%
Rail Transport as share of Total Public Transport	10%	30%	40%
Average Speed (km/h)	20	30	35
Sidewalk Length to Total Road Length	50%	75%	95%
Reduction of Road Accidents	25%	50%	70%

Source: Development Plan for Chennai Metropolitan Area, 2006

(2) Second Master Plan for Chennai Metropolitan Area 2026, 2008

Outline

The plan was issued in 2008 by Chennai Metropolitan Development Authority. The plan consists of three volumes. Volume I contains 1) Review of the First Master Plan, 2) Demography, 3) Economy, 4) Traffic and Transportation, 5) Shelter, 6) Infrastructure, 7) Social Facilities, 8) Solid Waste Management, 9) Macro Drainage System in CMA, 10) Disaster Management, 11) Environment, 12) Special Strategy and Land Use Planning, 13) Development Regulations, and 14) Monitoring and Implementation of Master Plan. Volume II contains the details of Development Regulations. Volume III contains the Sectoral Background. The City Development Plan by JNNURM was also taken into consideration.

Objectives

The plan is the successor of the First Master Plan, which was issued in 1976 and has a target year of 2001. The master plan proposes (a) the manner in which the land in the planning area shall be used; (b) the allotment or reservation of land for residential, commercial, industrial and agricultural purposes, as well as for parks, playfields, and open spaces; (c) the provision for national highways, arterial roads, ring roads, major streets, lines of communication including railways, airports and canals; (d) the provision for regulating the zone, location, height, number of stories, and size of buildings and other structures, as well as the size of yards and other open spaces and the use of buildings, structures, and land; and, (e) the stages by which the master plan shall be carried out.

Population Projection

Population projections were carried out for CMA based on past trends. The following assumptions were made:

(1) The declining trend in the growth rate will also continue in the future years

(2) Past growth rates, existing density, potential for development, area available for development, accessibility to public transport system (especially the rail system), and the proximity to employment generating centers could be the basis for working out future projections and assignments.

The projection results are the same with the Development Plan for Chennai Metropolitan Area, 2006, as shown below:

Table 2.4.12 Population Projection

Unit: million

Description	Actual	Projection					
	2001	2006	2011	2016	2021	2026	Density*
Chennai City	4.343	4.628	4.950	5.239	5.540	5.856	333
Municipalities	1.581	1.852	2.175	2.560	3.020	3.569	149
Town Panchayats	0.386	0.473	0.589	0.741	0.945	1.222	78
Village Panchayats	0.731	0.870	1.059	1.296	1.599	1.988	32
CMA (Total)	7.041	7.896	8.871	9.966	11.197	12.582	105

*: Gross density (persons/ha) in 2026

Source: Second Master Plan for Chennai Metropolitan Area 2026, 2008

Economic Growth

The plan did not make explicit projections of the Gross Regional Domestic Products (GRDP), but made employment projections in CMA instead. It was worked out based on the existing and envisaged economic developments and past trends. The projection results are the same with the Development Plan for Chennai Metropolitan Area, 2006.

Projection of Travel Demand

The travel demands were projected based on the increase in per capita trips. The per capita trip that had been 1.44 in 2005 was projected to 1.60 by 2016 and 1.65 by 2026. The projection results are the same with the Development Plan for Chennai Metropolitan Area, 2006.

Water Demand

The future water demand at the rate of 150 liter per capita per day (lpcd) for the city and 100 lpcd for the rest of CMA were estimated. The estimates are the same with the Development Plan for Chennai Metropolitan Area, 2006.

Land Use Plan

The existing Land Use Plan for 2006 and the proposed Land Use Plan for 2026 are given in the table below.

Table 2.4.13 Land Use

Description	Chennai City				Rest of CMA			
	2006		2026		2006		2026	
	Extent (ha)	Share	Extent (ha)	Share	Extent (ha)	Share	Extent (ha)	Share
Residential[1)]	9,523	54.25%	8,343	47.36%	22,877	21.87%	45,594	45.01%
Commercial	1,245	7.09%	714	4.05%	390	0.37%	880	0.87%
Industrial[2)]	908	5.17%	823	4.67%	6,563	6.28%	10,690	10.55%
Institutional	3,243	18.48%	2,869	16.28%	3,144	3.01%	3,889	3.84%
Open Space and Recreation	366	2.09%	1,001	5.68%	200	0.19%	393	0.39%
Agricultural	99	0.56%	0	0.00%	12,470	11.92%	7,296	7.20%
Non-Urban	82	0.47%	113	0.64%	2,433	2.33%	2,333	2.30%
Others[3),4)]	2,087	11.89%	3,755	21.31%	56,507	54.03%	30,223	29.84%
Total	17,553	100.00%	17,618	100.00%	104,584	100.00%	101,298	100.00%

Notes 1): Data in 2026 contains "Mixed Residential Use"
2): Data in 2026 contains "Special and Hazardous Industrial Use"
3): Data in 2006 consists of "Vacant, Forest, Hills, Low Lying, Water Bodies, etc."
4): Data in 2026 consists of "Urbanizable, Roads, Water Bodies, Hills, Redhills Catchments Area, etc."
Source: Second Master Plan for Chennai Metropolitan Area 2026, 2008

(3) Vision Tamil Nadu 2023 (Strategic Plan for Infrastructure Development in Tamil Nadu), 2012

Outline

The plan was issued in 2012 by Tamil Nadu State with the assistance of ADB. The plan consists of three phases. Phase I contains vision formulation, namely: 1) Executive Summary, 2) Key Outcomes of the Vision, 3) Growth Strategies, and 4) Sectoral Investment Plans. Phase II contains detailed sector reports and project profiles. Phase III contains implementation road maps.

Objectives

The main objectives are 1) formulating a vision and growth strategy for the Tamil Nadu State, with sector-specific substrategies, 2) identifying thrust areas for growth and bottlenecks in such areas, and 3) identifying critical projects in important sectors including power, roads, port development, agriculture, irrigation, housing, health, higher education, urban development, public transport, industry, and tourism.

Population Projection

The plan does not clearly indicate the population projection. It just expects 15% increase over the next 11 years (1.28% in annual average). The goal of per capita gross domestic product (GDP) was set based on this population growth rate.

Economic Growth

Since one of the objectives is to formulate a growth strategy, the plan set the target of GRDP growth rates with GRDP shares for economic sectors. In addition, per capita income will increase from USD 1,625 in 2010 to USD 10,000 in 2023, which means that India will become an upper middle income nation in the world.

Table 2.4.14 GRDP Share by Sector

Sector	GDRP Share			Average Annual Growth Rate
	2004/05	2010/11	2022/23	
Primary	12.0%	12.6%	7.0%	5.1%
Manufacturing	20.0%	16.6%	22.0%	13.8%
Non-manufacturing	11.0%	9.2%	8.0%	9.5%
Services	57.0%	61.6%	63.0%	11.1%
Total	100.0%	100.0%	100.0%	10.9%

Source: Vision Tamil Nadu 2023 (Strategic Plan for Infrastructure Development in Tamil Nadu), 2012

Investment in Urban Infrastructure

The investment was focused on the following items with the purpose of developing state-of-the-art infrastructure, both physical and social, ensuring seamless connectivity between cities and rest of the state:

- development of Chennai City into a megapolis,
- development of ten world class cities,
- rehabilitation of 1.5 million families living in slums,
- universal access to 24 hours and 7 days water supply and sanitation services, and
- access to mass transit systems for efficient urban transport.

The summary of investment plan is shown below:

Table 2.4.15 Summary of Investment in Urban Infrastructure

Unit: billion INR

Project	Amount
Chennai City development	500
Urban development for the rest of Tamil Nadu	500
Development of ten world class cities (urban facilities estimated INR 100 billion per city)	1,000
Housing including housing for economically weaker sections	750
Total	2,750

Source: Vision Tamil Nadu 2023 (Strategic Plan for Infrastructure Development in Tamil Nadu), 2012

(4) Ponneri Industrial Node Development Plan in Comprehensive Integrated Master Plan for Chennai Bengaluru Industrial Corridor, 2015

Outline

The Ponneri Industrial Node Development Plan was formulated in 2015 under the Comprehensive Integrated Master Plan for Chennai Bengaluru Industrial Corridor (CBIC) with the assistance of JICA. The plan consists of 1) Executive Summary, 2) Introduction, 3) Overview of Thiruvallur District and Ponneri Industrial Node, 4) Node Development Vision, 5) Industrial Development Analysis, 6) Land Use Planning for Ponneri Node, 7) Infrastructure Development Plan, 8) Economic Cost Benefit Assessment, 9) Financial Assessment and Planning, 10) Environmental and Social Considerations for Node Development Plan, 11) Institutional & Financing Framework, 12) Investment Environment Improvement, and 13) Way Forward.

Objectives

The plan was formulated in consultation with related stakeholders with the following objectives:

- To prepare a Comprehensive Regional Perspective Plan for the Chennai-Bengaluru Industrial Corridor Region, along with the developing strategy for transforming the region into a globally competitive investment destination,
- To identify suitable nodes to be taken up for industrial development within the project influence area (States of Karnataka, Andhra Pradesh, and Tamil Nadu) and prepare a Master Plan and a Development Plan for at least two selected industrial nodes (amongst the various nodes identified under the study), and
- To identify components of infrastructure that need to be created and corrected to enable better functioning of the economy and industry and to enable development of the above nodes as a starting point to promote manufacturing and growth in the CBIC region.

Population Projection

The future population of the node, consisting of the working population and residential population, was projected in conjunction with the projected land offtake.

Table 2.4.16 Projected Population in Ponneri Node

	2016–2019	2020–2024	2025-
Working Population	90,665	373,475	888,074
Residential Population	0	0	400,000

Source: Ponneri Industrial Node Development Plan in Comprehensive Integrated Master Plan for Chennai Bengaluru Industrial Corridor, 2015

Economic Growth

Real GDP growth rate in India was projected as follows:

Table 2.4.17 Real GDP Growth Rate in India

Description	Actual		Projection		
	1980–1999	2000–2012	2013–2020	2021–2030	2030-
Real GDP Growth Rate (p.a.)	5.6%	6.9%	6.3%	6.9%	6.9%
Ratio to Previous Period	-	1.23	0.91	1.10	1.00

Source: Ponneri Industrial Node Development Plan in Comprehensive Integrated Master Plan for Chennai Bengaluru Industrial Corridor, 2015

Land Use Plan

Based on the development framework and the development concepts, the required area for each land use category in the priority area and the whole node area were estimated.

Table 2.4.18 Land Use Plan

Unit: ha

	2016-2019	2020-2024	2025-	Total
Industrial Area	399	622	2,885	3,906
Residential Area	0	0	1,054	1,054
Existing Settlement	0	0	885	885
Infrastructure (Road and Plant)	199	28	310	536
Water Body and Green Area	83	129	440	652
Others	319	36	403	757
Total	999	814	5,976	7,789
Existing Port Area				1,100
Grand Total				8,889

Source: Ponneri Industrial Node Development Plan in Comprehensive Integrated Master Plan for Chennai Bengaluru Industrial Corridor, 2015

Road Development Plan

Based on the proposed internal node development plan and the identified projects, the implementation plan for internal node development was proposed as shown below:

Table 2.4.19 Road Development Plan

Unit: million INR

	2016	2017	2018	2019	2020	2021	2022	2023	2024-30	2031-33
Internal Road Works	109	147	133	0	0	6	32	41	0	186
Inter Section Works	0	4	2	0	0	0	0	0	0	0
River Bridge Works	13	13	13	7	7	7	7	7	0	0
Flyover Bridge Works	32	26	23	2	2	2	2	0	0	0
Road Facilities	146	157	168	0	0	0	0	8	0	0
Internal Public Transport Facilities	0	1	22	0	0	0	1	22	0	0
Major River Bridge Works	17	17	17	0	0	0	0	0	0	0
Total	317	365	378	9	9	15	42	78	0	186

Note: Figures in 2024-30 and 2031-33 are the same every year.

Source: Ponneri Industrial Node Development Plan in Comprehensive Integrated Master Plan for Chennai Bengaluru Industrial Corridor, 2015

Water Supply

The domestic and industrial water demand in Ponneri Node was estimated as shown in the table below:

Table 2.4.20 Water Demand of Ponneri Node

Unit: million liters per day

Description	2018	2022	2033
Domestic Water			
Residential People Excluding Employees	0	0	38.6
Employees from the Inside of Node	0	0	15.4
Employees from the Outside of Node	3.4	10.4	34.8
Total	3.4	10.4	88.8
Including Water Loss	3.8	11.8	98.7
Industrial Water	16.2	41.4	158.6
Including Water Loss	18.0	46.0	176.2
Grand Total	21.8	57.8	274.9

Note: Water loss was assumed at 15% of water supply.
Source: Ponneri Industrial Node Development Plan in Comprehensive Integrated Master Plan for Chennai Bengaluru Industrial Corridor, 2015

The summary of the cost estimate of the construction are presented in the table below:

Table 2.4.21 Construction Cost of Water Infrastructures

Unit: million INR

Item	2016–2018	2019–2021	2022–2033	Total
Portable Water Supply Works	665	521	12,863	14,049
Non-portable Water Supply Works	2,878	1,725	8,278	12,880
Domestic Sewerage Works	337	256	2,521	3,114
Treated Sewerage and Industrial Effluent Collection Works	671	595	4,427	5,693
Drainage Works	492	781	3,208	4,480
Total	5,042	3,878	31,296	40,216

Source: Ponneri Industrial Node Development Plan in Comprehensive Integrated Master Plan for Chennai Bengaluru Industrial Corridor, 2015

The summary of the cost estimate of the O&M are presented in the table below:

Table 2.4.22 O&M Cost of Water Infrastructures

Unit: million INR

Item	2016–2018	2019–2021	2022–2033	Total
Portable Water Supply Works	69	268	5,172	5,509
Non-portable Water Supply Works	311	1,120	6,611	8,042
Domestic Sewerage Works	48	149	1,485	1,682
Treated Sewerage and Industrial Effluent Collection Works	89	324	2,786	3,199
Drainage Works	74	318	2,254	2,646
Total	591	2,180	18,307	21,078

Source: Ponneri Industrial Node Development Plan in Comprehensive Integrated Master Plan for Chennai Bengaluru Industrial Corridor, 2015

Solid Waste Management

Summary of cost estimate are presented in the table below.

Table 2.4.23 Cost of Solid Waste Management Infrastructure

Unit: million INR

Item	2014–2018	2019–2023	2024–2033	Total
Construction Cost				
Hazardous Waste Infrastructure	0.0	316.3	1178.0	1494.3
Municipal Solid Waste Infrastructure	31.1	34.1	819.8	885.0
O&M Cost				
Hazardous Waste Infrastructure	0.0	36.0	2017.7	2053.7
Municipal Solid Waste Infrastructure	10.6	34.6	797.7	842.9

Source: Ponneri Industrial Node Development Plan in Comprehensive Integrated Master Plan for Chennai Bengaluru Industrial Corridor, 2015

2.4.3 Road Development Plans and Projects Other than CPRR

(1) Outer Ring Road (ORR)

The ORR is being constructed in phases. The section of Phase 1 of ORR that has been opened is from Vandalur on NH45 to Nemilinchery on NH205. The section of Phase 2 is under construction from Nemilinchery on NH205 to Minjur on NH5. The project is being implemented by TNRDC which was formed under HMPD.

(2) Widening of NH205 Including Construction of Thiruvallur Bypass

The National Highways Authority of India (NHAI) is widening the Thiruninravur-Thiruttani-Tirupati Section of NH205 to four lanes, and construction is in progress. As part of the project, NHAI is constructing a bypass for Thiruvallur town. The bypass starts at KM 43/800 of NH205 on western side of Thiruvallur, crosses SH57 at KM 44/500 on the northern side of Thiruvallur, ends at KM 50/600 of NH 205, starts again at KM 50/800, and ends at KM 52/000 of NH205.

(3) Widening of Section of SH57 from Singaperumalkoil to Sriperumbudur

A section of SH57 from Singaperumalkoil to Sriperumbudur is ongoing widening to six lanes with service roads by TNRIDC. The SH57 crossing the railway lines with manned level crossing in Singaperumalkoil for which the Project Wing of the Highways Department of GoTN is constructing a Road over Bridge (ROB).

(4) Widening of Old Mahabalipuram Road (OMR) (Phase-II)

The IT Corridor Project, is an initiative of GoTN to develop OMR as a world-class facility. TNRDC has incorporated an SPV called 'IT Expressway Ltd' (ITEL) to develop the IT Corridor Project. The entire stretch will be built as six-lane road with service roads and footpaths on both sides. The project is being implemented in two phases – Phase-I (20 km) between Madhya Kailash Temple Junction and Siruseri, and Phase-II (26 km) between Siruseri and Mahabalipuram. As the improvement of Phase-I is completed, ITEL is now planning to widen Phase-II to a 6-lane carriageway with service roads on both sides. As part of Phase-II, two bypasses are proposed for Kelambakkam and Thiruporur.

(5) Widening of East Coast Road (ECR) (Phase-I)

The stretch of ECR from KM 22/300 (Akkarai) to KM 135/500 (Puducherry) is maintained as a toll road by TNRDC. Recognizing the rapid recreational, commercial, and residential developments along the ECR and its influencing areas, TNRDC has decided to upgrade the road as a dual two-lane facility with improved geometry in two phases. Phase-I spans from KM 22/300 to KM 55/800 (Mahabalipuram), and Phase-II is from KM 55/800 to KM 135/500. Phase-I is under construction.

(6) Improvement of Grid Roads along ORR

The State Highways Department and CMDA have jointly identified 18 road networks to be developed on either side of Chennai ORR. The DPR for the development of grid roads along the ORR is under preparation.

(7) Construction of Elevated Road along OMR

Due to enormous growth in employment at IT companies and other commercial and major institutional development that has taken place along OMR, Phase-I is experiencing traffic congestion which has resulted in considerable increase in travel time. Huge residential area developments coupled with Special Economic Zones are sprawling along OMR. These ongoing and contemplated developments are likely to have huge impacts on traffic flow along the corridor. Road widening requires considerable land acquisition which cause more social impact. Hence, GoTN desired to construct an elevated highway corridor along OMR from Taramani to Siruseri under Phase-I and Siruseri to Mahabalipuram under Phase-II, for a length of 45 km. The DPR for the project is under preparation.

(8) Construction of Elevated Road along NH45

NH45 is the gateway to Chennai from the southern part of Tamil Nadu. The stretch between the airport and Chengalpattu traverses through major urbanized areas and has major developments such as IT center, gated communities, malls, educational institutions, major industrial center, and SEZs. This area is also witnessing fast growth, and it will continue to attract more developments in the future also. The stretch experiences frequent traffic jam, and vehicles cannot move fast resulting to decrease in travel speed. Therefore, CMDA is preparing a detailed feasibility study report for construction of an exclusive elevated road for the thorough traffic from the Chennai Airport to the toll-plaza near Chengalpattu along NH45.

(9) Widening Project of TPP Road (State Highway 104)

TNRDC is executing the widening and improvement project of the road section from the IRR intersection to North Terminal Road, as “Ennore-Manali Road Improvement Project”.

2.4.4 Intelligent Transport System (ITS) Development Plans and Projects

(1) Integrated Traffic Management System (ITMS) Project

ITMS Project is the project of CTP that introduces systems and facilities for traffic management. It includes the replacement of traffic signals at approximately 100 junctions in the city and enforcement systems utilizing Automatic Number Plate Recognition (ANPR) cameras.

The tender for ITMS was awarded to M/s Purple InfoTech Ltd. a few years ago, but the termination notice was issued because of several reasons. For instance, the contractor did not carry out the first phase of the project in time. The project is under litigation.

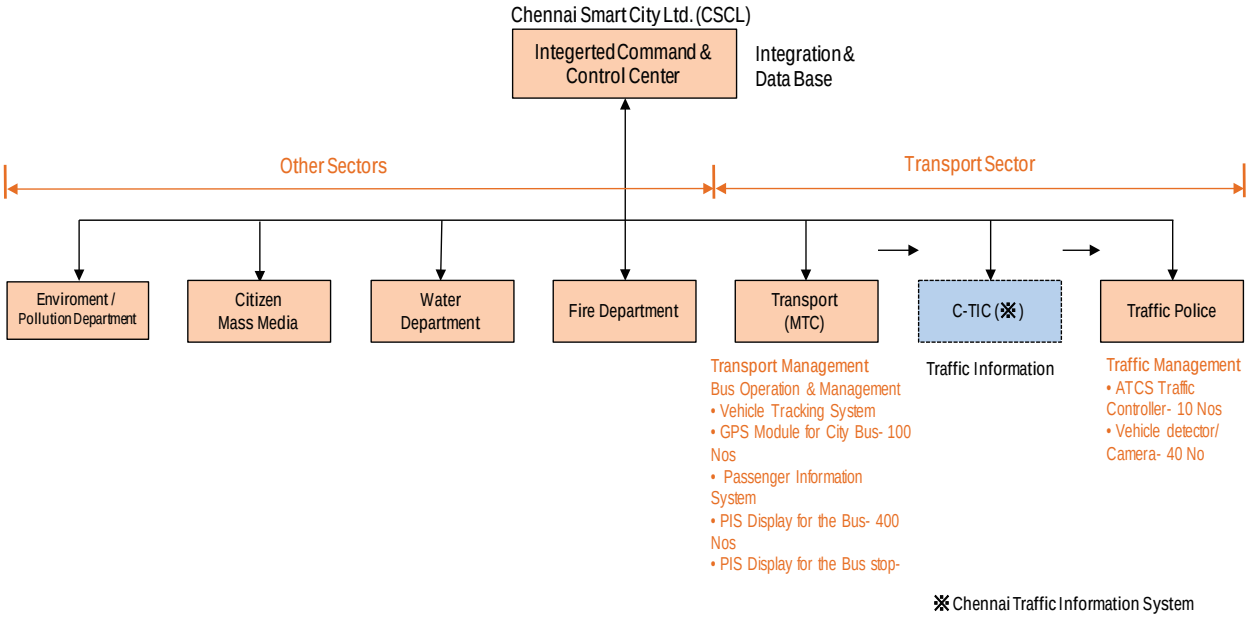
(2) Smart City Project

There is a plan under the Smart City Initiative to establish an Integrated Command Control Center (ICCC) and to develop information systems in several different sectors such as water, energy, environment, safety, etc. The ICCC will be developed under CSCL, and the information systems will collect data. The collected data will be aggregated in the ICCC and will be used for analysis. The analyzed data will be utilized for necessary measures. The Smart City Project targets to commence a part of service of any of the information systems from May 2018, and preparation of the specifications is underway.

The Chennai Traffic Information System, or Chennai Traffic Information Center (C-TIC), which is proposed to be developed by Japanese ODA Loan Project will be one of the information systems in the transport sector under the ICCC. The data collected by C-TIC will be shared and utilized by the ICCC in the future.

ICCC will be established in the building of GCC, and C-TIC will be in the building of CTP.

Figure 2.4.1 illustrates the concept of the Smart City Project establishing the ICCC and the information systems.



Source: Edited by the JICA Study Team based on interviews with CSCL

Figure 2.4.1 Concept of Smart City Project

A pilot project under the transport sector is planned to develop the Bus Tracking System by installing GPS devices on 100 buses, and the Passenger Information System by installing display boards at 50 bus stops and inside 400 buses. The installation of ten units of traffic signal controllers and 40 units of vehicle detection cameras are also included in the pilot project.

2.4.5 Present Condition of ITS for Arterial Roads

The current situation of ITS for arterial roads in Chennai is described in the Final Report of Data Collection Survey for Chennai Metropolitan Region ITS, which was completed in March 2017. This clause reports the latest situation of ITS obtained from this study.

(1) Responsible Organization for Arterial Roads and Project Implementation Scheme

There are nine arterial roads in Chennai. The IRR, ORR, SH49, and SH49A are under the jurisdiction of HMPD and TNRDC, while NH5, NH205, NH4, NH45, and Chennai Bypass are under the jurisdiction of NHAI. The following table shows the responsible organization and project implementation scheme for each arterial road:

Table 2.4.24 Responsible Organization for Arterial Roads and Project Implementation Scheme

Road Category		Responsible Organization	Project Scheme	BOT Contractor	Note
SH	IRR	HMPD	Public Works Project (EPC)		
	ORR	TNRDC	Private Project (BOT: Annuity *1)	GMR	
	SH-49		Public Works Project (EPC)		
	SH-49A		Public Works Project (EPC)		
NH	Chennai Bypass	NHAI	Public Works Project (EPC)		
	NH-5		Private Project (BOT: Toll *2)	L&T	Outside the boundary of GCC
	NH-205		Private Project (BOT: Toll *2)	Trans story Tirupati	
	NH-4		Private Project (BOT: Toll *2)	Essel	
	NH-45		Private Project (BOT: Anuuity *1)	Eagle	

*1: A scheme wherein the collected toll charges are first paid to the government and the Build-Operate-Transfer (BOT) Contractor receives annuities.

*2: A scheme that the BOT Contractor recovers the investment and gains profit by BOT style.

Source: Edited by the JICA Study Team based on interviews with related organizations and the report on the Data Collection Survey for Chennai Metropolitan Region ITS

The overview of the current situation of the arterial roads in Chennai is shown in the next page.

Source: Edited by the JICA Study Team based on interviews with related organizations and the report on the Data Collection Survey for Chennai Metropolitan Region ITS

Figure 2.4.2 Overview of the Current Situation of the Arterial Roads in Chennai

(2) Toll Plaza Plans

The locations for toll plazas in Chennai are shown in Figure 2.4.2 in the previous page. The current free roads of Section 1 (in service) and Section 2 (under construction) of ORR and IRR (in service) are planned to be converted into toll roads with new toll plazas to be built. The Kattupalli Port Access Road is also considered to be convert into a toll road.

(3) ITS Facilities for Arterial Roads

Highway Traffic Management Systems (HTMS) and Traffic Management Systems (TMS) have been introduced to arterial roads in Chennai. HTMS has been introduced only to ORR (Section 1) with limited facilities.

TMS has been introduced to NHs and Chennai Bypass under NHAI with the electronic toll collection (ETC) system of Radio Frequency Identifier (RFID) called FASTag, touch-and-go system using IC card, and manual toll collection system by cash. As for SH49 and SH49A under TNRD, touch-and-go system, and manual toll collection system have been introduced. The introduction of the ETC System is planned on ORR. The IC cards adopted for touch-and-go system are not the common type that can be used across different sections and/or transport modes; therefore, each card is available only for each specific road.

The following table shows the current situation for each road.

Table 2.4.25 Current Situation of ITS Facilities for Arterial Roads

Road Category		HTMS		TMS	
		Current Situation	Plan	Current Situation	Plan
SH	IRR	—	—	—	Cash
	ORR: Section 1	VMS, Emergency Call Box, Weather Observation	—	—	Cash, Touch & GO, ETC (FASTag)
	ORR: Section 2 (under construction)	—	VMS, Emergency Call Box, Weather Observation	—	Cash, Touch & GO, ETC (FASTag)
	SH49	—	—	Cash, Touch & Go	—
	SH49A	—	—	Cash, Touch & Go	—
NH	Chennai Bypass	—	—	Cash, ETC (FASTag)	—
	NH5	—	—	Cash, Touch & GO, ETC (FASTag)	—
	NH205	—	—	Cash	—
	NH4	—	—	Cash, Touch & GO, ETC (FASTag)	—
	NH45	—	—	Cash, Touch & GO, ETC (FASTag)	—

Source: Edited by the JICA Study Team based on interviews with related organizations and the report on the Data Collection Survey for Chennai Metropolitan Region ITS

CHAPTER 3 TRAFFIC SURVEY, ANALYSIS, AND FORECAST

3.1 Traffic Survey

3.1.1 Objectives of the Project

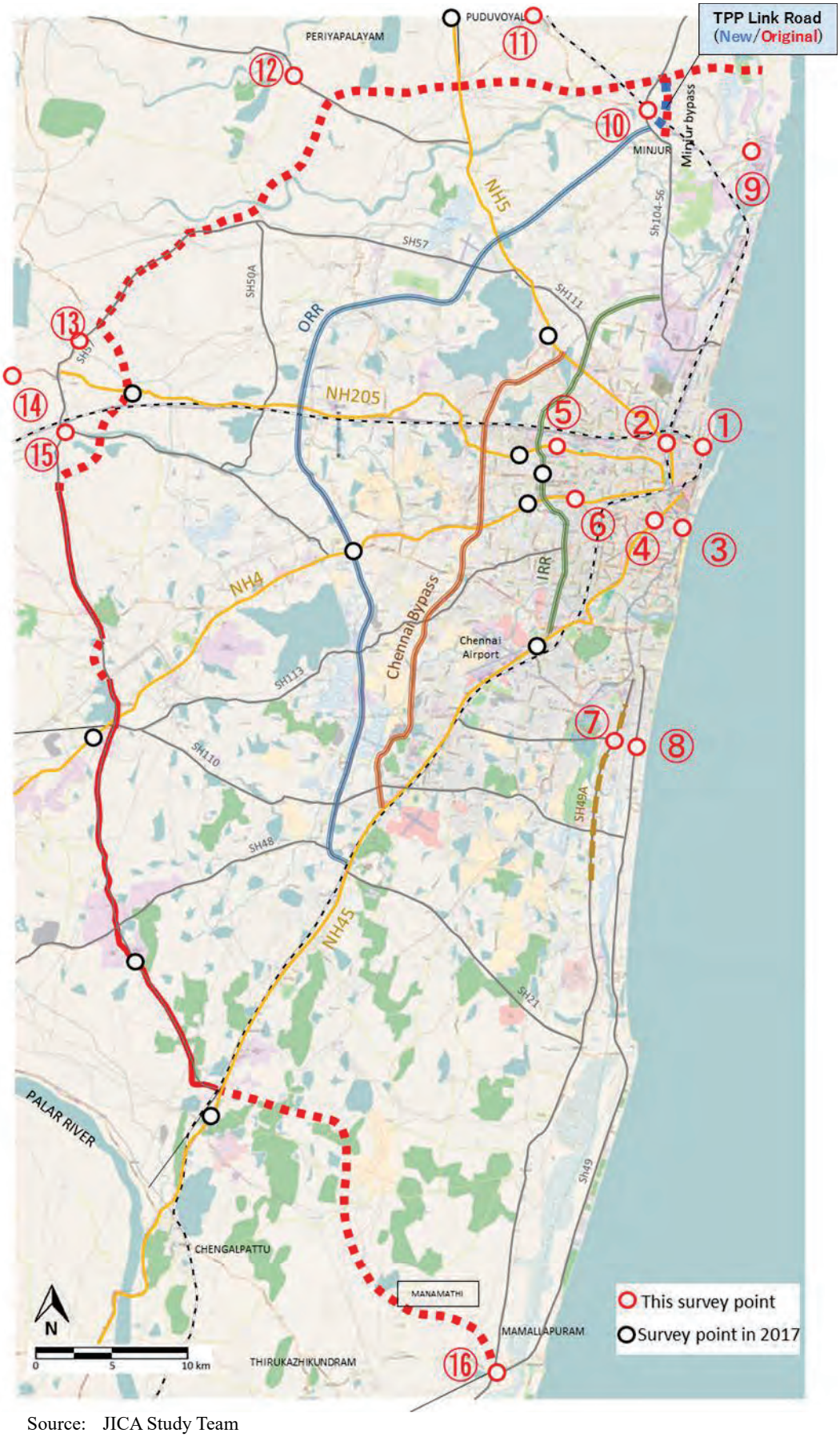
The target of the traffic survey is the central urban area which is the introduction area for the traffic signal control system and the Chennai Peripheral Ring Road (CPRR). In the central urban area, traffic survey was carried out inside the Inner Ring Road (IRR) and the information technology (IT) corridor, in which the number of IT companies increased remarkably. In the CPRR, traffic survey was carried out at the starting point and cross section of each section.

The outline of the traffic survey is shown in the table and figure below.

Table 3.1.1 Outline of Traffic Survey

Survey	Objectives	Contents
Intersection Traffic Volume Survey	Indicators for measuring the effect of introducing intelligent transport system (ITS)	Inside IRR × 6 places
	Check traffic distribution	Around the IT corridor × 2 places
	Update the Origin-Destination (OD) table	CPRR × 8 places

Source: JICA Study Team



Source: JICA Study Team

Figure 3.1.1 Traffic Survey Points

The JICA Study Team signed the entrustment contract with Expert Technologies, and the traffic volume survey was carried out with the following schedule. Prior to the survey, the JICA Study Team confirmed the work plan summarizing the survey spot, survey schedule, vehicle type classification, survey form, placement of investigators for each point, safety management, emergency contact list, etc.

During the survey, three members of the JICA Study Team confirmed whether the survey was properly implemented based on the work plan at the survey site. Table 3.1.2 and Figure 3.1.2 show the summary of the traffic volume survey and the survey site photos.

Upon inspection of the report, it was confirmed that the survey items and quantities in the specifications are being implemented, and the results are correctly counted.

Table 3.1.2 Outline of Traffic Survey

	Survey Points	Survey date
1	Clive Battery	30.Aug.2017(Wed)
2	Moolakothalam Basin Bridge	12.Sep.2017(Tue)
3	Ezhilagam/Madras University	29. Aug.2017(Tue)
4	Anna Statue/Mount Road	06. Sep.2017(Wed)
5	Villivakkam/New Avadi Road	30. Aug.2017(Wed)
6	Pachayappas College/New Avadi Road	05. Sep.2017(Tue)
7	OMR Thuraipakkam/Pallikaranai Radial Road	05. Sep.2017(Tue)
8	ECR (near VGP) Injambakkam	06. Sep.2017(Wed)
9	Ennore Kamarajar Port Trust	07. Sep.2017(Thu)
10	Minjur/Kattur Road	07. Sep.2017(Thu)
11	Ponneri/Thatchur/Pulicat Road	07. Sep.2017(Thu)
12	Periyapalayam/Thirunindravur Road	12. Sep.2017(Tue)
13	Ikkadu/Thiruvallur Road	06. Sep.2017(Wed)
14	Thiruvallur near Collectorate (3 road junctions)	06. Sep.2017(Wed)
15	Thiruvallur near Railway station (3 road junctions)	06. Sep.2017(Wed)
16	ECR/OMR/Chengalpattu/Mahabalipuram	07. Sep.2017(Thu)

Source: JICA Study Team

Source: JICA Study Team

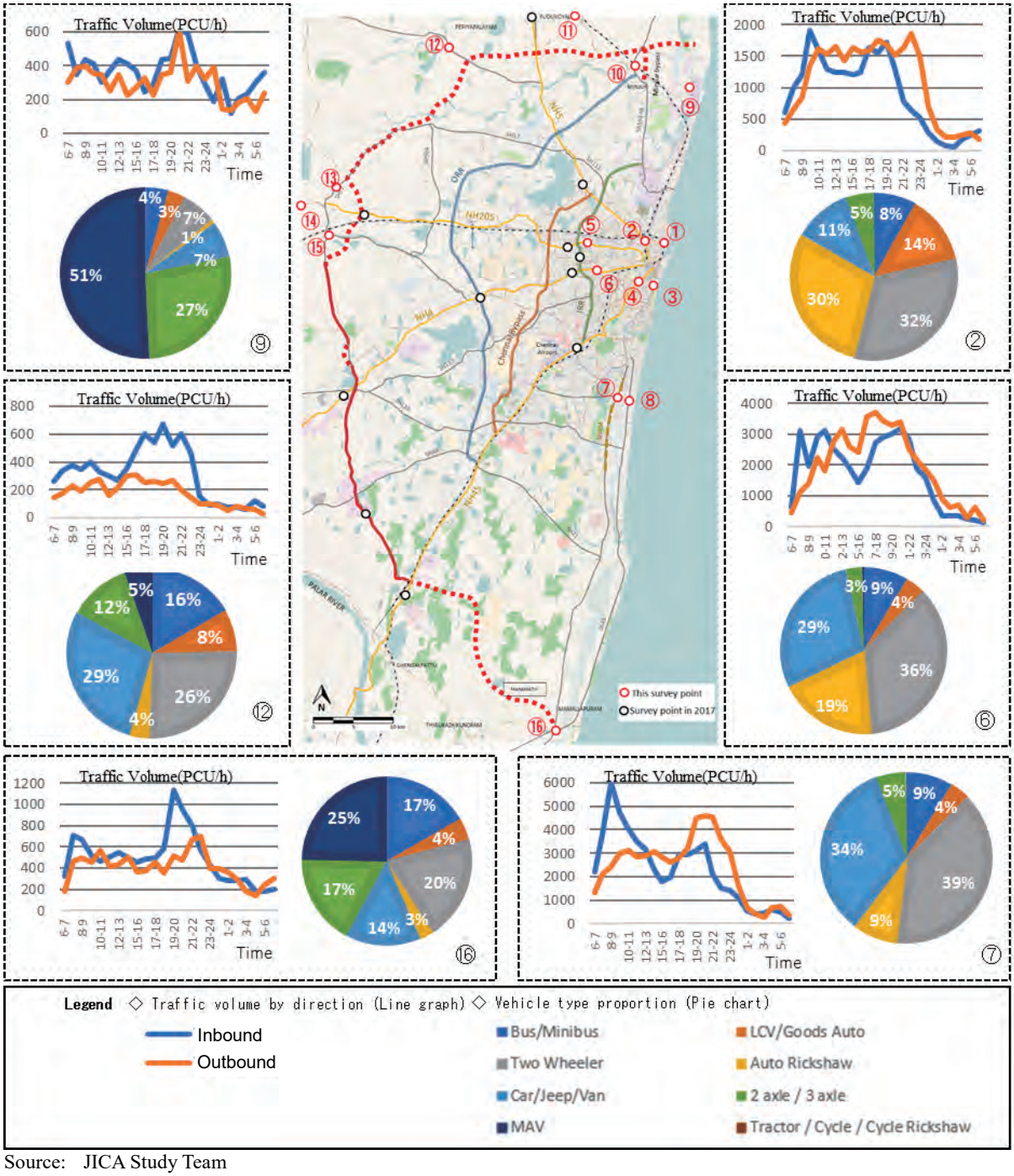
Figure 3.1.2 Traffic Survey

3.1.2 Results of the Traffic Survey

The outline and the summary of the results of the traffic volume survey are shown in the figure below. The survey was carried out for 24 hours at 16 points. The line graph shows the cross-sectional traffic volume of the main survey site. In the city, inbound traffic is high in the morning, and outbound traffic increases in the evening. On the other hand, traffic tends to increase in the suburbs from evening to midnight.

The pie chart shows the ratio by type of vehicle. Gray portions indicate the proportion of two-wheeled vehicles. There are many motorcycles in the center of the Chennai, such that two-wheeled vehicles account for 39% in SH49A. On the other hand, the proportion of large vehicles is relatively higher in the suburbs than in the city.

As such, the city road is used for commuting in the morning and evening, while the suburban road is used for large vehicles such as heavy trucks from evening to midnight.



Source: JICA Study Team

Figure 3.1.3 Outline of Traffic Volume Survey Results

3.2 Hearing Survey for Related Development Plans

3.2.1 Port Development Plans

Mr. Koyama and Mr. Suzuki of the Overseas Coastal Area Development Institute of Japan, who are implementing technical support for “Chennai Port Operation Management Improvement”, carried out a hearing survey on port development plan and future cargo volume.

The result of the hearing survey is shown in the table below.

Table 3.2.1 Results of the Hearing Survey

Item	Content
Date	2017/8/29 9:10-9:45
Location	Accord Hotel Business Center - Conference Room
Partner	The Overseas Coastal Area Development Institute - Executive Director: Koyama Akira - Second Survey Division Manager: Suzuki Hiroyasu
Content	- Port development plan and future handled cargo volume (Refer to the "Final Report for Sagarmala" (Vol. 1-6) which the Ministry of Shipping and the Indian Port Association entrusted to McKinsey in 2016.) - Competing ports in the Chennai Metropolitan Area (CMA) - Chennai Port (major port) - Ennore Port (major port) - Kattupalli Port (minor port) - Krishnapatnam Port (minor port, Andhra Pradesh State) - Statistic data on handled cargo volume Refer to the Indian Port Association site
Collected material	Chennai Port Operation Management Improvement

Source: JICA Study Team

3.2.2 Development Plans along the CPRR

A hearing survey to Mr. Haneda of Mahindra Industrial Park Chennai Limited was carried out. Mahindra Industrial Park Chennai is located along the CPRR (along NH5).

The result of the hearing survey is shown in the table below.

Table 3.2.2 Outline of Traffic Survey

Item	Content
Date	2017/9/13 14:30-15:30
Location	Mahindra Towers - Conference Room
Partner	Mahindra Industrial Park Chennai Limited - Head of Sales and Marketing: Toru Haneda
Content	- Mahindra Industrial Park Chennai area is 300ha. Currently, the sales of the first phase (100 ha) has started. It is possible to provide a physical distribution volume of the industrial park of the same scale in Southeast Asia. - It is considered that the companies of Mahindra Industrial Park Chennai mainly use Kattupalli Port (Adani). It is impossible to expect the expansion of Chennai Port in the future because there is a permanent urban area behind Chennai Port. Since there is no space to place the cargo, the import cargo must be carried to the surrounding container freight station (CFS) immediately. Also, to load the export cargo immediately, the container trailer must be assembled with the arrival of the vessel. On the other hand, it is possible to extend the container yard in Kattupalli Port, because there is nothing around there.
Collected material	Outline of Kattupalli Port (Adani)

Source: JICA Study Team

3.2.3 Results of Hearing Survey

(1) Access to the Port

1) Access to Ennore Port

There are two entrance and exit gates at Ennore Port, Gate 1 and Gate 2 (Figure 3.2.1). Gate 1 is used by bulk trucks, and Gate 2 is used by tank trucks.

It is accessible from the south and the north sides to Ennore Port as shown in the figure below. However, it is impossible for container trailer trucks to pass the north side because of the unpaved road as shown in the figure below. Therefore, access to Ennore Port is limited to the route shown below.

Source: JICA Study Team

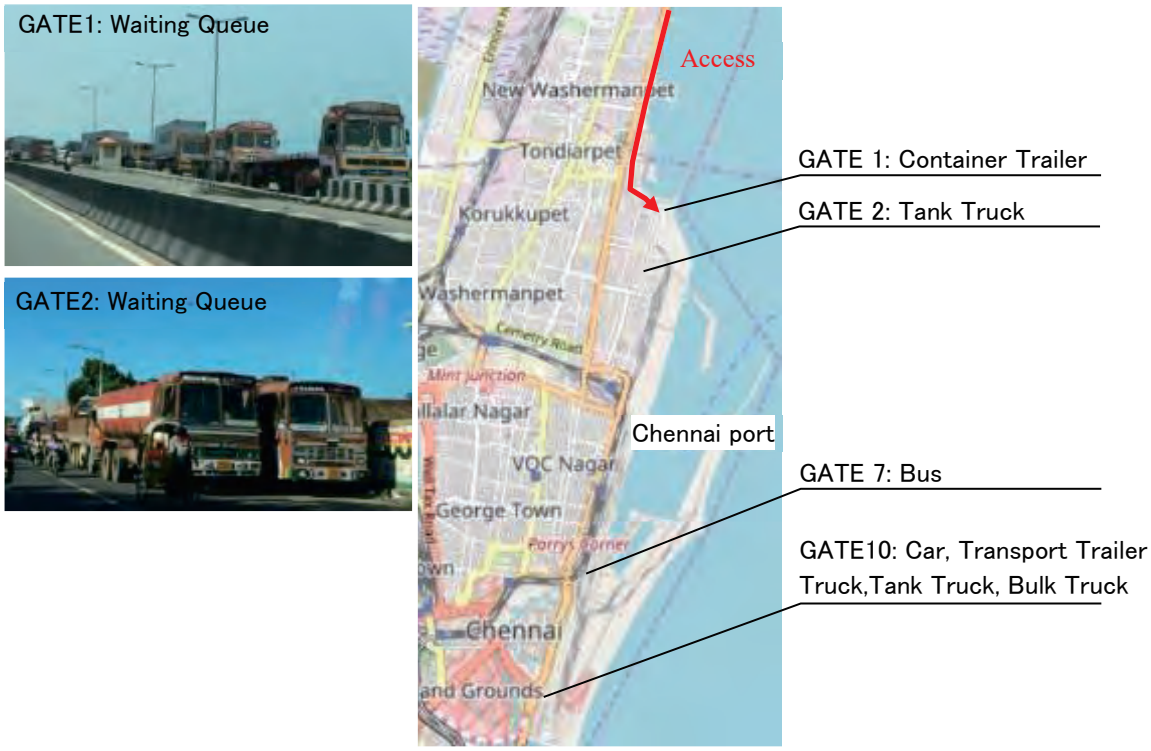
Figure 3.2.1 Access to Ennore Port

2) Access to Chennai Port

There are ten entrance and exit gates at Chennai Port, Gate 1 to Gate 10. However, there are only four available gates as shown in the figure below.

The problem is the waiting queue of container trailer of Gate 1. Many container trailer trucks are parked along the Ennore High Road (about 7.5 km) and Manali High Road (about 5 km).

Such a problem occurs because the container yard at Chennai Port is too narrow to fit a container, so export cargo is loaded by forming a queue of container trailer trucks.



Source: JICA Study Team

Figure 3.2.2 Access to Chennai Port

3) Access to Kattupalli Port

Access to Kattupalli Port uses the same route to Ennore Port because Kattupalli Port is located north of Ennore Port.

There are three entrance and three exit gates in Kattupalli Port. There is a lay bay (500 m*20 m) for the queue of the trailer trucks in front of the entrance gate. Therefore, a few trailer trucks are parked on the road around Kattupalli Port, which is not found in Chennai Port.

Source: JICA Study Team

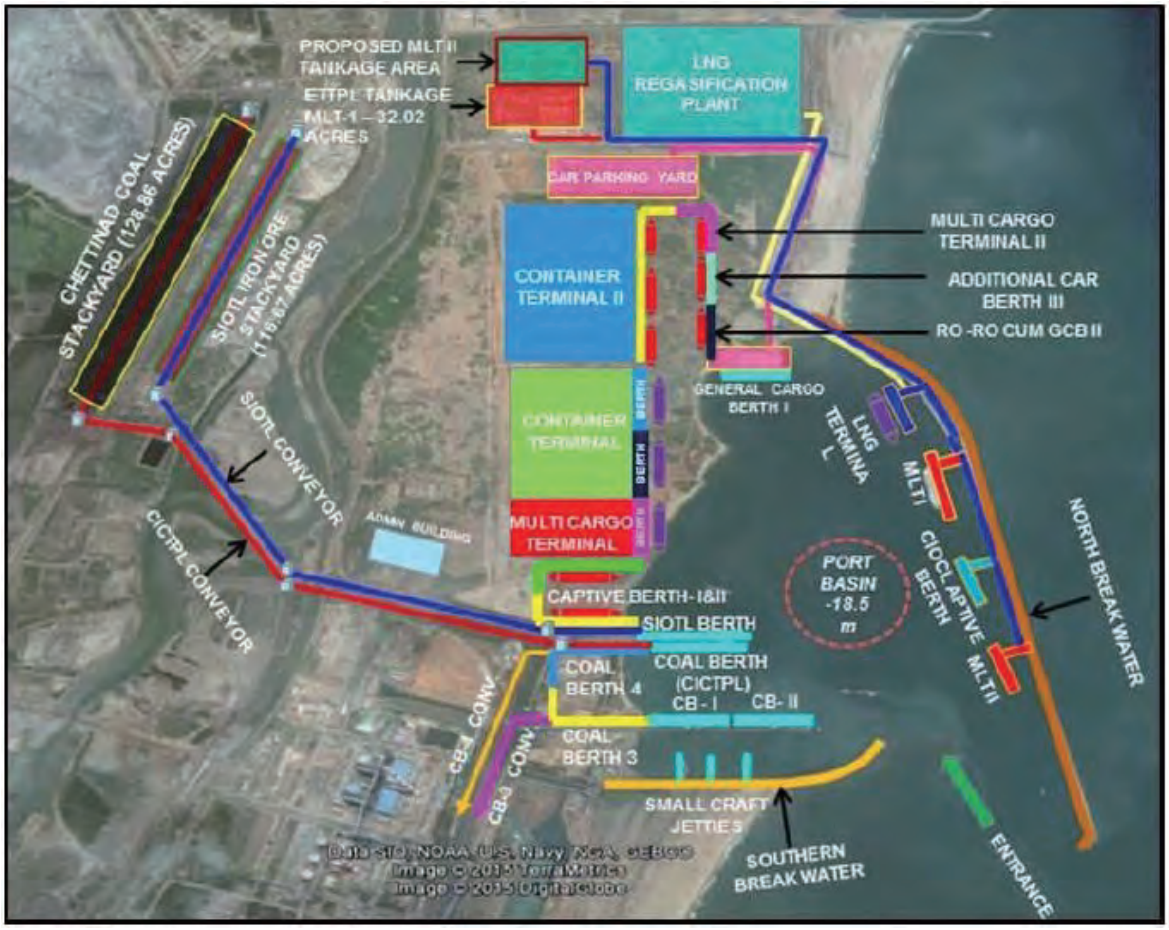
Figure 3.2.3 Vicinity of the Entrance and Exit Gates of Kattupalli Port

(2) Port Development Plan

1) Development Plan of Ennore Port

The development plan of Ennore Port follows its master plan.

The location of each project and the outline of ongoing projects, projects to be completed by 2020, and projects to be completed by 2035 are shown in the figure and table below.



Source: Final Report for Sagarmala (Vol. 4)

Figure 3.2.4 Projects to be Completed by Year 2035 (Ennore Port)

Table 3.2.3 Outline of the Project (Ennore Port)

No.	Project Name	Capacity Addition		Investment Required (INR in Crores)	Mode of Implementation	Remarks
		MTPA	MnTEU			
1	Development of LNG Terminal	5	-	5,151	PPP	Ongoing projects
2	TNEB Coal Berth CB 3	9	-	250	Port's funds	
3	TNEB Coal Berth CB 4	9	-	250	Port's funds	
4	Multi-Cargo Terminal	2	-	151	PPP	
5	Construction of Container Terminal Phase 1 Stage 1	15.4	0.8	800	PPP	
6	Development of Ro-Ro Terminal	1	-	150	Port's funds	
7	Capital Dredging Phase III	-	-	300	Port's funds	
	Subtotal	41.4	0.8	7,352		
1	IOC-POL Captive Jetty	3	-	465	PPP	Projects to be completed by Year 2020
2	Multi-User Liquid Terminal 2 (MLT 2)	3	-	393	PPP	
3	Construction of Container Terminal Phase 1 Stage 2	11.62	0.6	470	PPP	

No.	Project Name	Capacity Addition		Investment Required (INR in Crores)	Mode of Implementation	Remarks
		MTPA	MnTEU			
4	Modification of Existing Iron Ore Terminal to handle coal (SIOTL)	6	-	220	PPP	
5	Capital Dredging Phase-V for providing water depth of -16 m CD for the proposed Ro-Ro cum GCB 2, LNG, MLT 2 and IOCL Captive Jetty berths	-	-	250	Port's funds	
6	Development of Northern Port Access Road (4.35 km)	-	-	271	State Govt./ Stakeholders	
7	Development of Northern Rail Connectivity	-	-	244	Port's funds / IPRCL	
8	Upgrading the Southern Port Access Road	-	-	200	PPP	
9	FTWZ	-	-	850	Port's funds	
Subtotal		41.4	0.6	7,352		
1	Container Terminal Phase II	38.6	2.0	2,000	PPP	Projects to be completed by Year 2035
2	Coal Berths/Bulk Terminal (2 × 9 MTPA)	18	-	700	PPP	
3	Ro-Ro and General Cargo Berth	1	-	350	Port's funds	
4	Second Multi-Cargo Terminal	2	-	200	PPP	
Subtotal		41.4	2.0	7,352		
Projects Total		124.6	3.4	13,965		All projects

Source: Edited by the JICA Study Team based on the Final Report for Sagarmala (Vol. 4)

2) Development Plan of Chennai Port

The development plan of Chennai Port follows its master plan.

The outline of ongoing projects, projects to be completed by 2020, and projects to be completed by 2035 are shown in the table below.

Table 3.2.4 Outline of the Project (Chennai Port)

No.	Project Name	Capacity Addition (MTPA)	Investment Required (INR in Crores)	Mode of Implementation	Remarks
1	Development of Common Rail Yard inside the Port - 19 Port's Funds	-	19	Port's funds	Ongoing projects
Subtotal		-	19		
1	Development of Bunker Berth at Bharathi Dock	1	44	Port's funds	Projects to be completed by Year 2020
2	Development of Dry Dock at Timber Pond/Boat basin or Development of Marina	-	500	PPP	
3	Upgradation of JD East Berths and Paving of the Backup Area	1	90	Port's funds	
4	Development of Coastal Terminal	1.1	80	Port's funds	
Subtotal		3.1	714		
1	Conversion of JD East into Multi-Cargo Berth	1	110	PPP	Projects to be completed by

No.	Project Name	Capacity Addition (MTPA)	Investment Required (INR in Crores)	Mode of Implementation	Remarks
2	Development of BD II Back-up Area for Additional Container Storage or Developing BDII Berth and Back-up Space as Fully-Mechanized Fertilizer Terminal	2	100	PPP	Year 2025
3	SBM Terminal at Chennai	10	600	PPP	
	Subtotal	13	810		
	Projects Total	16.1	1,543		All projects

Source: Edited by the JICA Study Team based on the Final Report for Sagarmala (Vol. 4)

3) Development Plan of Kattupalli Port

The development plan of Kattupalli Port follows that of Adani Kattupalli Port.

Table 3.2.5 Outline of the Project (Kattuppalli Port)

Project Name	Details	Phase I
Quay Length	2 berths, 710 m	1 berth, 400 m
Capacity	1.2 million TEUs	0.8 million TEUs
Depth	16 m	16 m
Reefer Plugs	360 plugs, expandable	150
Ground Slots	5,120	4,000
Quay Cranes	6 post panamax cranes	4 units (22 across)
Rubber Tyre Gantry (RTG) Cranes	15 units for yard operations.	12 e-RTGs

Source: Edited by the JICA Study Team based on the Outline of Kattupalli Port (Adani)

(3) Amount of Future Cargo Handled at Ports

1) Amount of Cargo Handled of Ennore Port

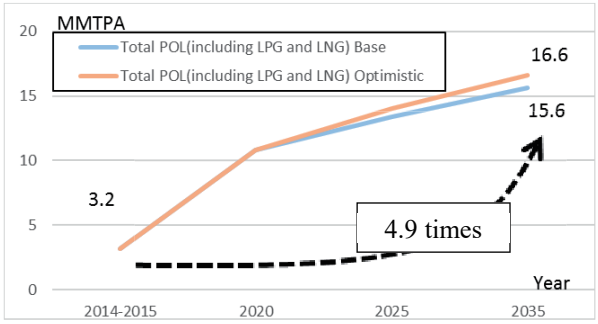
The amount future cargo handled of Ennore Port is shown in the figure below.

The amount of current liquid cargo handled is 3.2 million metric tonnes per annum (MMTPA), dry and break-bulk cargo is 24.32 MMTPA, and others is 2.7 MMTPA.

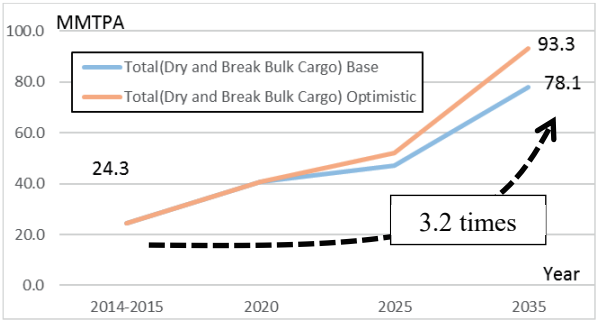
There are two scenarios for the amount of future cargo handled, basic scenario and optimistic scenario.

Regarding the basic scenario, it is predicted that handled cargo from 2014 to 2035 will increase by 4.9 times for liquid cargo, 3.2 times for bulk, and 3.4 times for others.

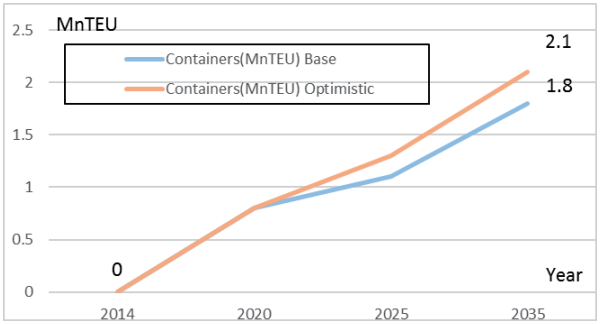
The container terminal of Ennore Port started operations in June 2017, but it has not been used as of the end of July 2017. However, the container handling volume in 2035 is estimated to be 1.8 million twenty-foot equivalent units (MnTEU). It is possible to handle 3.4 MnTEU containers until 2035, and future cargo handled is expected to reach half capacity.



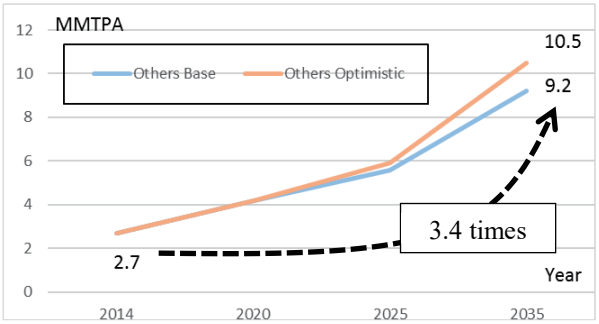
< Liquid Cargo >Photo①



< Dry and Break Bulk > Cargo



< Containers >



< Others >

Source: Edited by the JICA Study Team based on the Final Report for Sagarmala (Vol. 4)

Figure 3.2.5 Prediction of Cargo Handled by Year 2035 (Ennore Port)

Table 3.2.6 Prediction of Cargo Handled by Year 2035 (Ennore Port)

Ennore Port - Traffic Projections

Units: MMTPA (except Containers)

xx Base Scenario xx Optimistic Scenario

Commodity	2014-15	2020	2025		2035		Remarks
Liquid Cargo'							
POL product (EXIM and coastal)		6.3	6.6	7.0	8.1	8.8	• Shifting of POL product traffic from Chennai
LPG		1.5	1.8	2.0	2.5	2.8	
LNG		3.0	5.0	5.0	5.0	5.0	• 5 MTPA LNG terminal by IOCL
Total POL (including LPG and LNG)	3.2	10.8	13.4	14.0	15.6	16.6	
Dry and Break Bulk Cargo							
Thermal Coal (Loading)	0.0	0.0	0.0	0.0	0.0	0.0	
Thermal Coal (Unloading)	24.0	40.2	46.5	51.4	77.0	92.0	• Coastal increase; could also capture traffic from Cuddalore and Katupalli
Coking Coal	0.3	0.5	0.6	0.7	1.1	1.3	
Iron Ore	0.0	0.0	0.0	0.0	0.0	0.0	
Fertilizers	0.0	0.0	0.0	0.0	0.0	0.0	
Containers and other Cargo							
Containers (MnTEU)	0.0	0.8	1.1	1.3	1.8	2.1	
Others	2.7	4.2	5.6	5.9	9.2	10.5	• Vehicle Exports and Other commodities

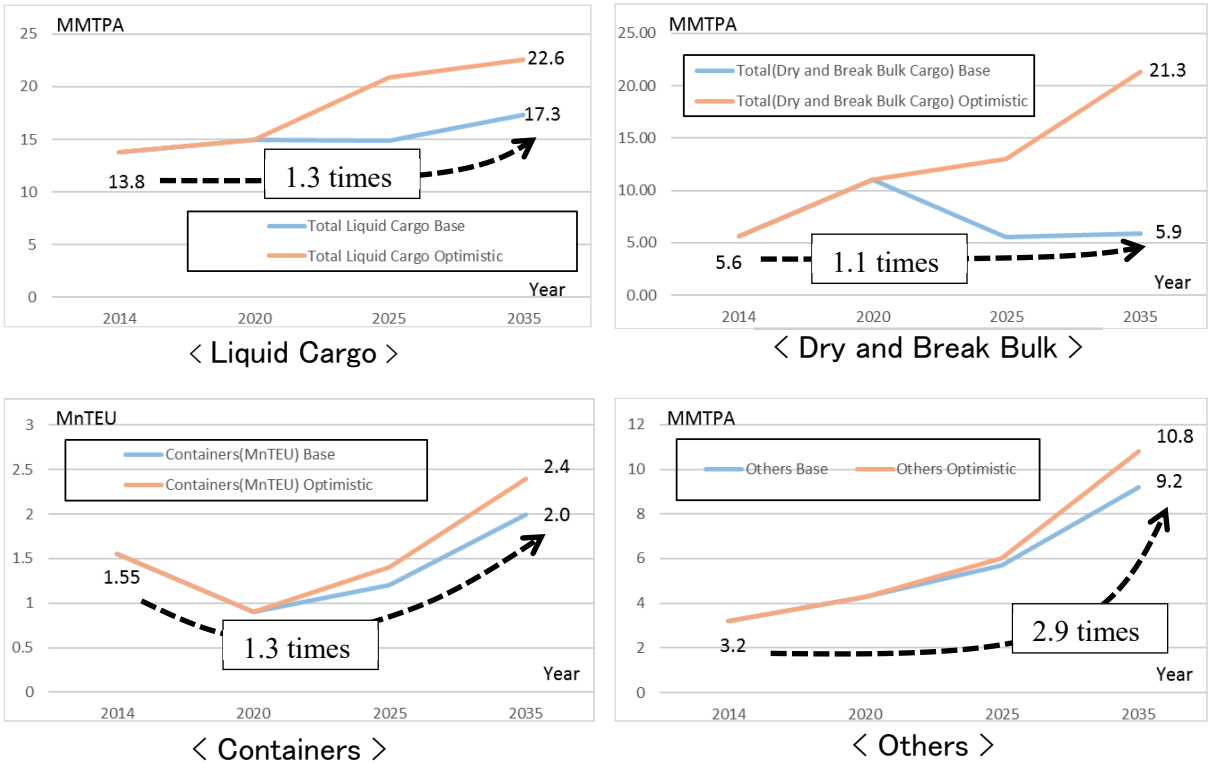
Source: Final Report for Sagarmala (Vol. 4)

2) Amount of Cargo Handled of Chennai Port

The amount of future cargo handled of Chennai Port is shown in the figure below.

The amount of current liquid cargo handled is 13.8 MMTPA, dry and break-bulk cargo is 5.6 MMTPA, container is 2.0 MnTEU, and others is 3.2 MMTPA.

Regarding the basic scenario, it is predicted that handled cargo from 2014 to 2035 will increase by 1.3 times for liquid cargo, 1.1 times for dry and break bulk, 1.3 times for containers, and 2.9 times for others.



Source: Edited by the JICA Study Team based on the Final Report for Sagarmala (Vol. 4)

Figure 3.2.6 Prediction of Cargo Handled by Year 2035 (Chennai Port)

Table 3.2.7 Prediction of Cargo Handled by Year 2035 (Chennai Port)

Chennai Port - Traffic Projections

xx Base Scenario xx Optimistic Scenario

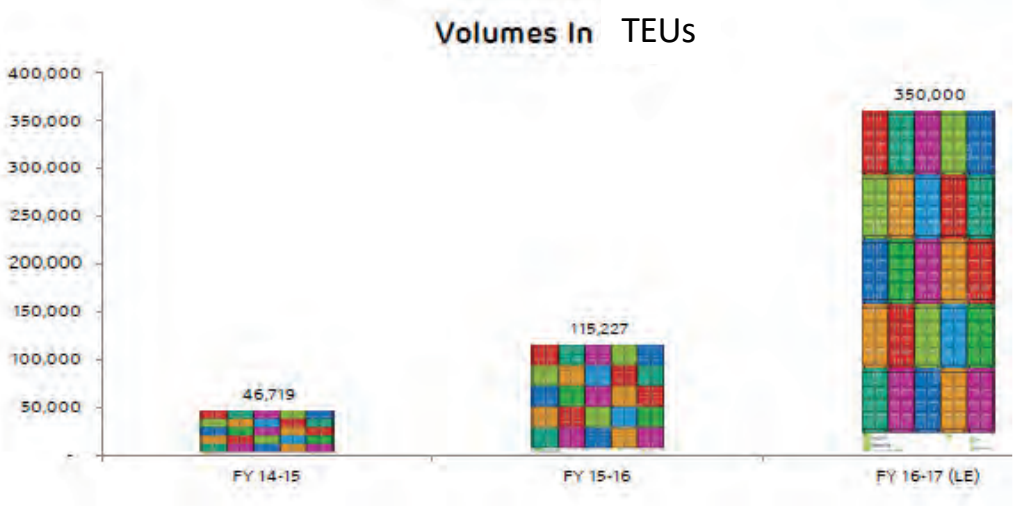
Commodity	2014-15	2020	2025		2035		Remarks
Liquid Cargo							
POL	12.7	13.3	13.1	18.8	14.3	19.2	• CPCL expansion considered in optimistic case
Vegetable Oil	1.1	1.7	1.8	2.1	3.0	3.4	
Dry and Break Bulk Cargo							
Thermal Coal (Loading)	0.0	0.0	0.0	0.0	0.0	0.0	
Thermal Coal (Unloading)*	0.0	6.1	0.0	7.0	0.0	12.5	• Traffic projections are contingent on permission to the port by Hon'ble SC to handle coal
Coking Coal	0.0	0.0	0.0	0.0	0.0	0.0	
Iron Ore	0.1	0.2	0.3	0.3	0.4	0.4	
Steel	1.4	1.9	2.5	2.9	3.0	5.5	
Limestone	2.6	1.5	1.4	1.4	1.2	1.2	
Dolomite	1.0	0.6	0.5	0.5	0.3	0.3	
Fertilizers	0.5	0.7	0.8	0.9	1.0	1.4	
Containers and other Cargo							
Containers (MnTEU)	1.55	0.9	1.2	1.4	2.0	2.4	• Traffic may further reduce by 2025 if Enayam comes up
Others	3.2	4.3	5.7	6.0	9.2	10.8	• Highly fragmented
Total (MMTPA)	52.5	47.7	49.3	66.9	71	101.0	

Source: Final Report for Sagarmala (Vol. 4)

3) Amount of Cargo Handled of Kattupalli Port

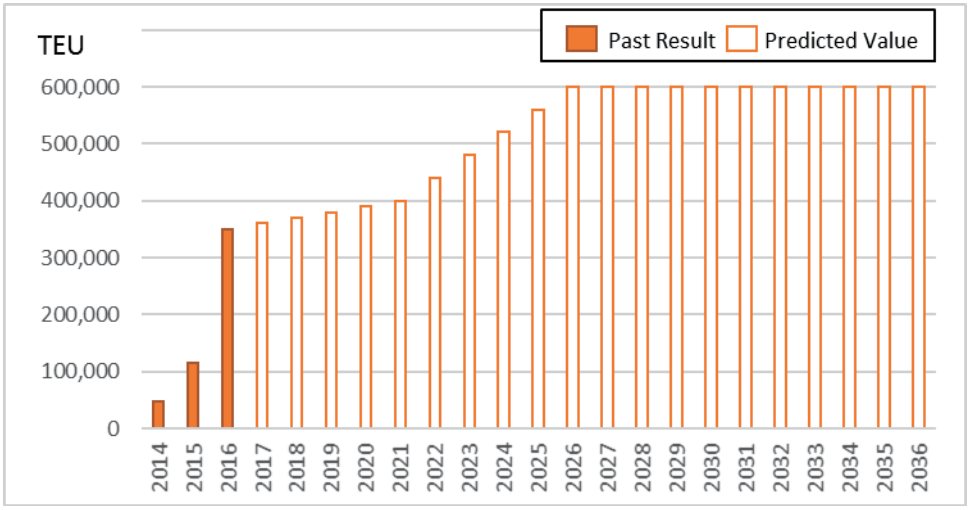
The amount of cargo handled from 2014 to 2016 in Kattupalli Port is shown in the figure below. It has increased dramatically each year.

There is no data on the future cargo handled in Kattupalli Port. Therefore, the amount of future cargo handled by Kattupalli Port is estimated as the capacity of cargo handled with reference to the estimates for Ennore Port.



Source: Outline of Kattupalli Port (Adani)

Figure 3.2.7 Cargo Handled from 2014 to 2016 (Kattupalli Port)



Source: Edited by the JICA Study Team based on the Outline of Kattupalli Port (Adani)

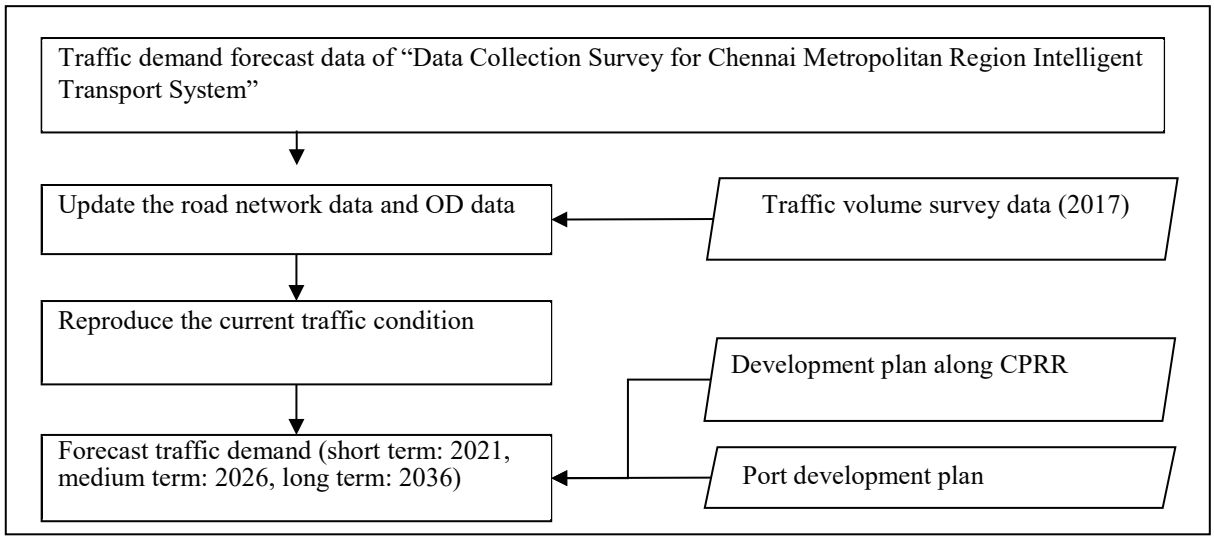
Figure 3.2.8 Estimation Result of Container Cargo Handled (Kattupalli Port)

3.3 Traffic Demand Forecast

In this survey, traffic demand forecast was reasonably carried out using network analysis of the "Data Collection Survey for Chennai Metropolitan Region Intelligent Transport System" in 2017. Specifically, the method and year of estimation of traffic demand forecast were set to be the same as that of the survey. The following points were also considered:

- Data update using the result of traffic volume survey.
- Future traffic demand considering the development plan along CPRR and port development plan.

The flow of traffic demand forecast is shown in the figure below.



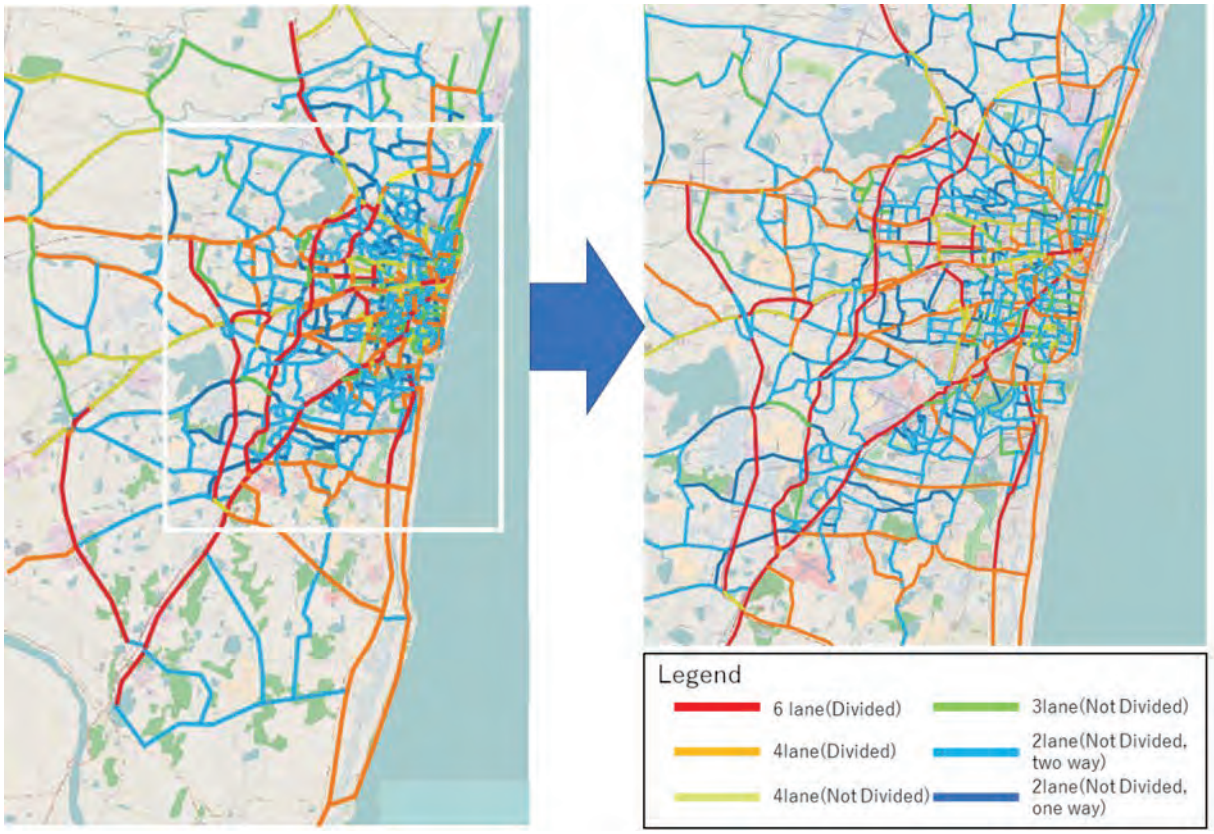
Source: JICA Study Team

Figure 3.3.1 Flow of Traffic Demand Estimate

3.3.1 Reproduction of Present Traffic Situation

(1) Update of Road Network

The road network of the "Data Collection Survey for Chennai Metropolitan Region Intelligent Transport System" was adopted with modifications such as the addition of new road links. The road network condition was set by referring to design service volume (passenger car units (PCUs) per hour) described in the "Guidelines for Capacity of Urban Roads in Plain Areas (IRC: 106-1990)". The daily capacity was calculated by dividing the design service volume per hour by the average peak rate of 8.7% in the traffic volume survey.



Source: JICA Study Team

Figure 3.3.2 Road Network Adopted in Traffic Analysis

Table 3.3.1 Recommended Design Service Volume

ID	No. of Lane	Divided /Not	Direction	Design Service Volume (PCU/hour)		
				Arterial*	Sub-arterial**	Collector***
1	2	undivided	one way	2,400	1,900	1,400
2	2	undivided	two ways	1,500	1,200	900
3	3	undivided	one way	3,600	2,900	2,200
4	4	undivided	two ways	3,000	2,400	1,800
5	4	divided	two ways	3,600	2,900	-
6	6	undivided	two ways	4,800	3,800	-
7	6	divided	two ways	5,400	4,300	-
8	8	divided	two ways	7,200	-	-

*: Roads with no frontage access, no standing vehicles, and very little cross traffic
**: Roads with frontage access but no standing vehicles and high capacity intersections.
***: Roads with free frontage access, parked vehicles, and heavy cross traffic
Source: Edited by the JICA Study Team based on IRC:106-1990

Table 3.3.2 Daily Capacity

ID	Line	Divided /Not	Direction	Daily Capacity Volume (PCU/day)		
				Arterial*	Sub-arterial**	Collector***
1	2	undivided	one way	27,600	21,900	16,100
2	2	undivided	two ways	17,300	13,800	10,400
3	3	undivided	one way	41,400	33,400	25,300
4	4	undivided	two ways	34,500	27,600	20,700
5	4	divided	two ways	41,400	33,400	-
6	6	undivided	two ways	55,200	43,700	-
7	6	divided	two ways	62,100	49,500	-
8	8	divided	two ways	82,800	-	-

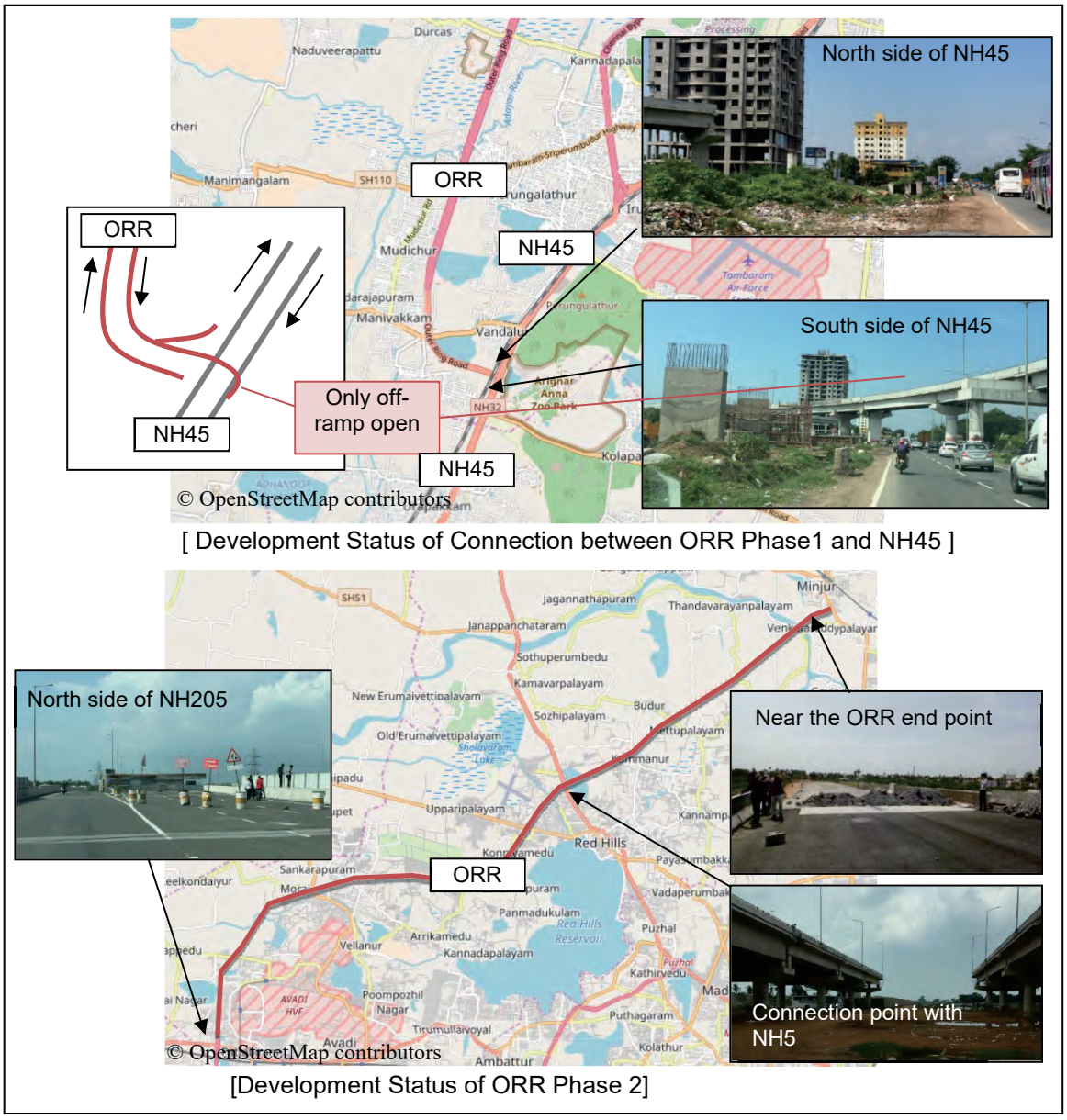
*: Roads with no frontage access, no standing vehicles, and very little cross traffic
**: Roads with frontage access but no standing vehicles and high capacity intersections.
***: Roads with free frontage access, parked vehicles, and heavy cross traffic
Source: JICA Study Team

The development status of ORR is shown in the figure below.

Connection between ORR Phase 1 and NH45: Only the off-ramp to the south side of NH45 was opened.

ORR phase 2: Although there is progress, the connection with the current road is not developed.

Thus, the off-ramp to the south side of NH45 was reflected in the current road network.



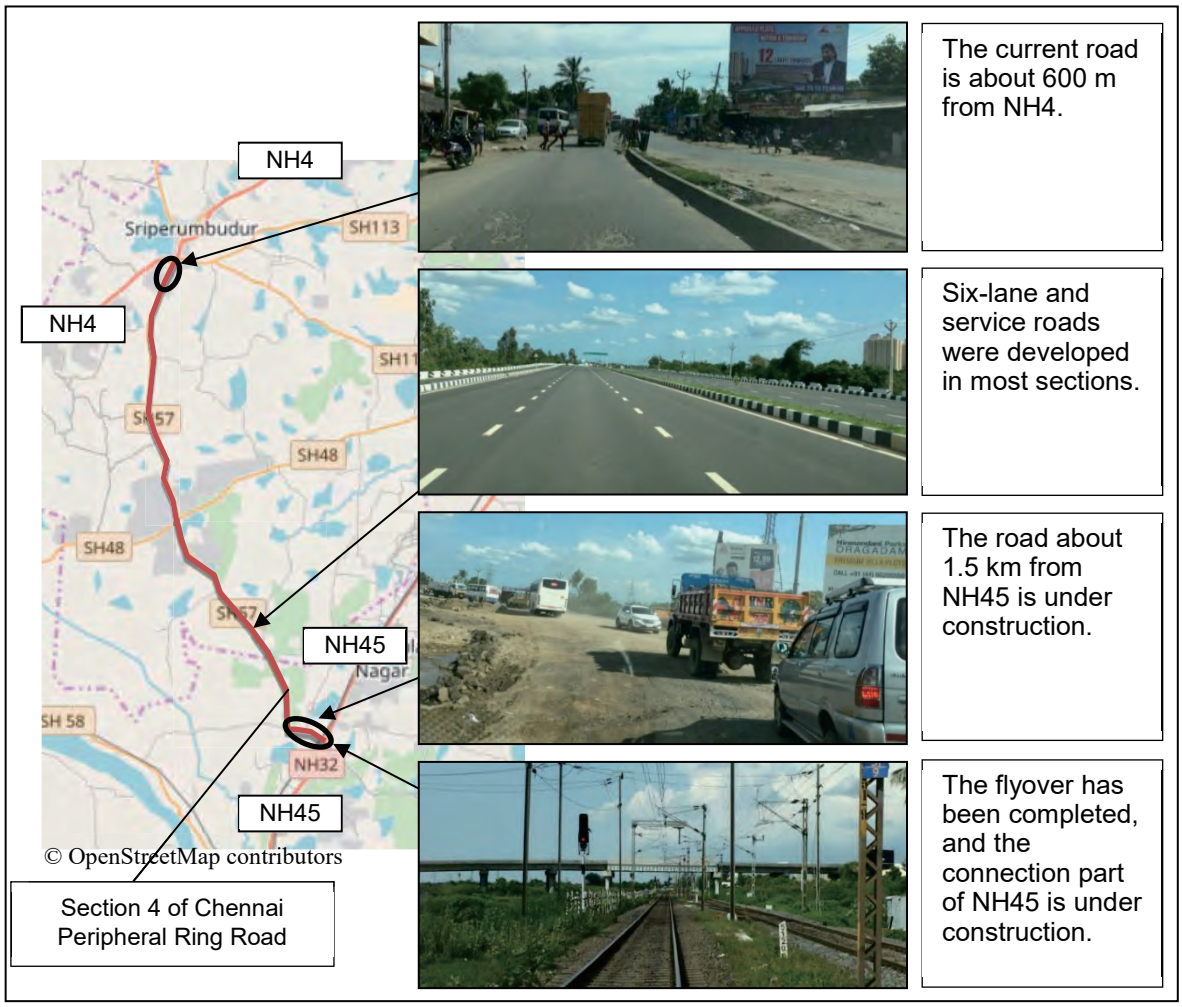
Source: JICA Study Team

Figure 3.3.3 Development Status of ORR

Connection between ORR Phase 1 and NH45: Only the off-ramp to the south side of NH45 was opened.

The development status of Section 4 of CPRR is shown in the figure below. Six-lane and service roads were developed in most sections. The connection point for NH4 and NH45 are under construction.

From the above, Section 4 of CPRR was reflected in the current road network.

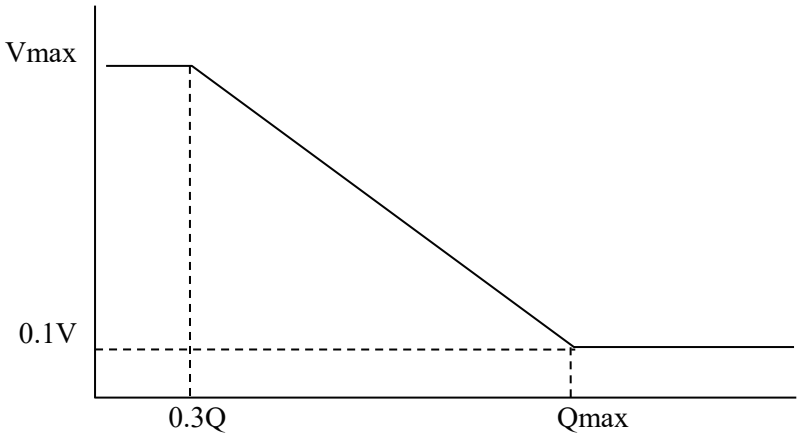


Source: JICA Study Team

Figure 3.3.4 Development Status of Sec. 4 of CPRR

(2) QV Conditions

QV conditions for the relationship of capacity and velocity were set as shown in Figure 3.3.5.

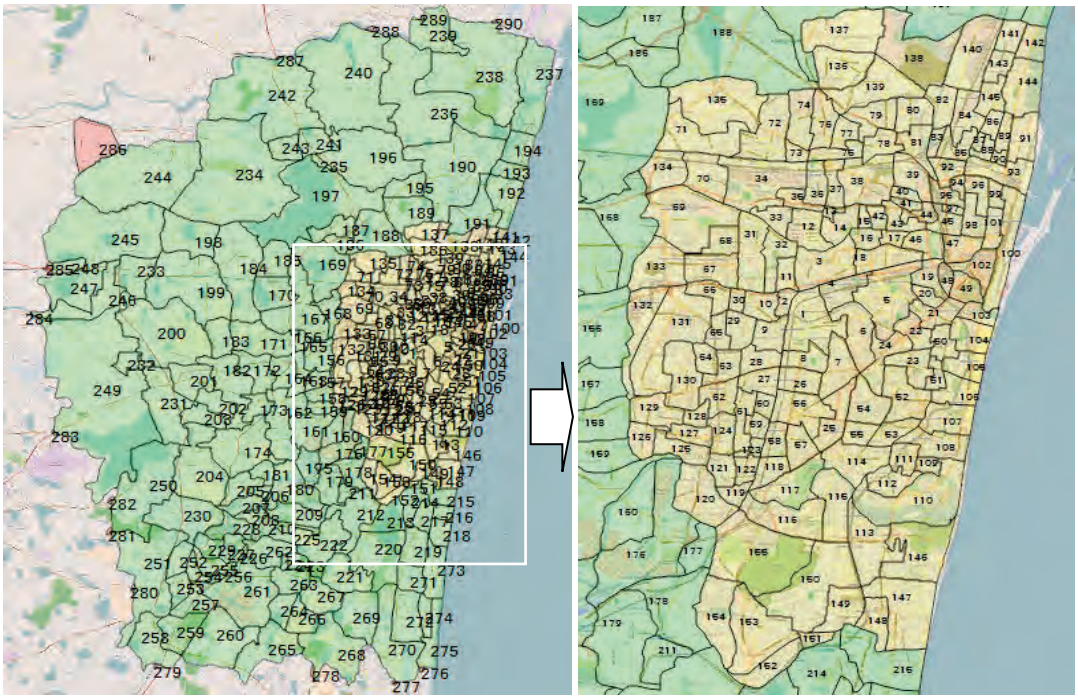


Source: JICA Study Team

Figure 3.3.5 QV Conditions

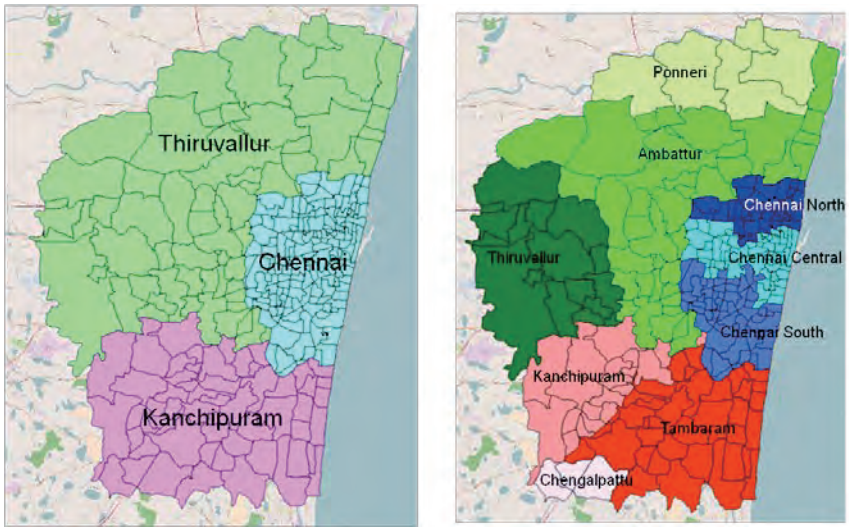
(3) Update of Origin-Destination (OD) Data

Zone divisions of OD matrix are set to be the same as those of the "Data Collection Survey for Chennai Metropolitan Region Intelligent Transport System". A total of 290 traffic analysis zones were divided into: 155 zones in the city area, 120 zones in the rest of the CMA, 15 external zones.



Source: JICA Study Team

Figure 3.3.6 Zone Divisions



Source: JICA Study Team

Figure 3.3.7 Zone Division Adopted in Traffic Analysis

Table 3.3.3 List of Zones (1)

Zone	Large	Middle	Small
1	Chennai	Chennai Central	Nungambakkam
2	Chennai	Chennai Central	Kilpauk (South)
3	Chennai	Chennai Central	Kilpauk (North)
4	Chennai	Chennai Central	Chetpet
5	Chennai	Chennai Central	Egmore, Pudupet
6	Chennai	Chennai South	Thousand Lights
7	Chennai	Chennai South	Nakkeerar Nagar
8	Chennai	Chennai South	Ko.Su. Mani Nagar
9	Chennai	Chennai South	Periyar Nagar(North), Periyar Nagar (South)
10	Chennai	Chennai Central	Aminjikarai (East)
11	Chennai	Chennai Central	Shenoy Nagar
12	Chennai	Chennai Central	Panneerselvam Nagar
13	Chennai	Chennai North	Maraimalai Adigal Nagar (North)
14	Chennai	Chennai North	Maraimalai Adigal Nagar (South)
15	Chennai	Chennai North	Anjugam Ammaiyar Nagar
16	Chennai	Chennai Central	Purasawalkam
17	Chennai	Chennai Central	Kannappar Nagar
18	Chennai	Chennai Central	Gangadaraeswarar Koil, DrAmbedkar Nagar
19	Chennai	Chennai Central	Adikesavapuram
20	Chennai	Chennai Central	Chintadripet
21	Chennai	Chennai Central	Nehru Nagar
22	Chennai	Chennai Central	Komaleeswaranpet, Balasubramaniam Nagar
23	Chennai	Chennai Central	Azad Nagar(North), Ameer Mahal
24	Chennai	Chennai South	Azagiri Nagar
25	Chennai	Chennai South	Sathyamurthi Nagar
26	Chennai	Chennai South	Kalaivanar Nagar
27	Chennai	Chennai South	Navalar
28	Chennai	Chennai South	Vadapalani (East)
29	Chennai	Chennai Central	Aminjikarai (Central)
30	Chennai	Chennai Central	Aminjikarai (West)
31	Chennai	Chennai Central	Anna Nagar (Central)
32	Chennai	Chennai Central	Anna Nagar (East)
33	Chennai	Chennai Central	Ayanavaram
34	Chennai	Chennai Central	Viduthalai Guru Samy Nagar
35	Chennai	Chennai Central	Nagamma Ammaiyar Nagar (South)
36	Chennai	Chennai North	Thiru Vi. Ka. Nagar
37	Chennai	Chennai North	Nagamma Ammaiyar Nagar (North)
38	Chennai	Chennai North	Wadia Nagar
39	Chennai	Chennai North	Dr. Sathyavanimuthu Nagar
40	Chennai	Chennai North	Pulianthope
41	Chennai	Chennai Central	Dr. Beasant Nagar
42	Chennai	Chennai North	Kosapet, Perumalpet
43	Chennai	Chennai Central	Choolai, Pattalam, Arivazhan Nagar
44	Chennai	Chennai Central	Thattankulam
45	Chennai	Chennai Central	Elephant Gate
46	Chennai	Chennai Central	Park Town
47	Chennai	Chennai Central	Edapalayam
48	Chennai	Chennai Central	Nehru Nagar
49	Chennai	Chennai Central	Nehru Nagar
50	Chennai	Chennai Central	Thruvateeswaranpet, DrNatesan Nagar, Zambazaar,
51	Chennai	Chennai Central	Umaru Pulavar Nagar, Bharathi Nagar
52	Chennai	Chennai Central	Azad Nagar (South)
53	Chennai	Chennai Central	Vivekanandapuram, Thiruvalluvar Nagar
54	Chennai	Chennai South	Royapettah,
55	Chennai	Chennai South	Alwarpet (North)
56	Chennai	Chennai South	Theagaraya Nagar
57	Chennai	Chennai South	V. O. C. Nagar
58	Chennai	Chennai South	Rajaji Nagar
59	Chennai	Chennai South	Kamaraj Nagar (South)
60	Chennai	Chennai South	Kamaraj Nagar (North)

Source: JICA Study Team

Table 3.3.4 List of Zones (2)

Zone	Large	Middle	Small
61	Chennai	Chennai South	M.G.R. Nagar
62	Chennai	Chennai South	Ashok Nagar
63	Chennai	Chennai South	Vadapalani (West)
64	Chennai	Chennai South	Saligramam
65	Chennai	Chennai Central	Aminjikarai (Central)
66	Chennai	Chennai Central	Aminjikarai (West)
67	Chennai	Chennai Central	Anna Nagar (West)
68	Chennai	Chennai Central	Anna Nagar (West)
69	Chennai	Chennai Central	Villivakkam (south)
70	Chennai	Chennai Central	Villivakkam (North)
71	Chennai	Chennai North	Kulathur
72	Chennai	Chennai North	Agaram (North)
73	Chennai	Chennai North	Agaram (South)
74	Chennai	Chennai North	Sembiam
75	Chennai	Chennai North	Perambur (South)
76	Chennai	Chennai North	Siruvallur
77	Chennai	Chennai North	Perambur (North)
78	Chennai	Chennai North	Elango Nagar
79	Chennai	Chennai North	Perambur (East)
80	Chennai	Chennai North	Vyasarpadi (North)
81	Chennai	Chennai North	Vyasarpadi (South)
82	Chennai	Chennai North	Kumarasamy Nagar (South)
83	Chennai	Chennai North	Kumarasamy Nagar (North)
84	Chennai	Chennai North	Korukkupet
85	Chennai	Chennai North	Dr. Radhakrishnan Nagar (South)
86	Chennai	Chennai North	Sanjeeviroyanpet
87	Chennai	Chennai North	Mottai Thottam, Dr. Vijayarahavalu Nagar
88	Chennai	Chennai North	Narayanappa Naicken Garden, DrRadhakrishnan Nagar (North)
89	Chennai	Chennai North	Grace Garden
90	Chennai	Chennai North	Singara Garden
91	Chennai	Chennai North	Ma.Po.Si. Nagar, Royapuram
92	Chennai	Chennai North	Basin Bridge
93	Chennai	Chennai North	Meenakshiammanpet
94	Chennai	Chennai Central	Kondithope
95	Chennai	Chennai Central	Peddu Naickenpet
96	Chennai	Chennai Central	Seven Wells (south)
97	Chennai	Chennai Central	Perumal Koil Garden
98	Chennai	Chennai Central	Seven Wells (North), Amman Koil,Sowcarpet
99	Chennai	Chennai Central	Muthialpet
100	Chennai	Chennai Central	Vallal Seethakathi Nagar
101	Chennai	Chennai Central	Katchaleeswarar Nagar
102	Chennai	Chennai Central	Nehru Nagar
103	Chennai	Chennai Central	Nehru Nagar
104	Chennai	Chennai Central	Chepauk
105	Chennai	Chennai Central	Thiruvallikeni, Marina
106	Chennai	Chennai Central	Krishnampet, Bharathidasan Nagar
107	Chennai	Chennai Central	Madha Perumal Puram, Karaneeswarapuram
108	Chennai	Chennai South	Santhome, Mylapore
109	Chennai	Chennai South	Avvai Nagar (North)
110	Chennai	Chennai South	Raja Annamalai Puram
111	Chennai	Chennai South	Bheemannapet
112	Chennai	Chennai South	Avvai Nagar (South)
113	Chennai	Chennai South	Adayar (West)
114	Chennai	Chennai South	Alwarpet (South)
115	Chennai	Chennai South	G.D. Naidu Nagar (East)
116	Chennai	Chennai South	G.D. Naidu Nagar (West)
117	Chennai	Chennai South	G.D. Naidu Nagar (West)
118	Chennai	Chennai South	Kalaignar Karunanithi Nagar
119	Chennai	Chennai South	saidapet (East)
120	Chennai	Chennai South	Guindy (west)

Source: JICA Study Team

Table 3.3.5 List of Zones (3)

Zone	Large	Middle	Small
121	Chennai	Chennai South	saidapet (West)
122	Chennai	Chennai South	Kumaran Nagar (south)
123	Chennai	Chennai South	Kumaran Nagar (North)
124	Chennai	Chennai South	Navalar Nedunchezhian Nagar(West)
125	Chennai	Chennai South	Kodambakkam (south)
126	Chennai	Chennai South	Virugambakkam (South)
127	Chennai	Chennai South	Kodambakkam (North)
128	Chennai	Chennai South	Kodambakkam(North)
129	Chennai	Chennai South	Virugambakkam(South)
130	Chennai	Chennai South	Saligramam
131	Chennai	Chennai South	Virugambakkam(North)
132	Chennai	Chennai South	Virugambakkam (North)
133	Chennai	Chennai Central	Villivakkam (south)
134	Chennai	Chennai Central	Villivakkam (North)
135	Chennai	Chennai North	Kulathur
136	Chennai	Chennai North	Kodungaiyur (West)
137	Chennai	Chennai North	Kodungaiyur (West)
138	Chennai	Chennai North	Jeeva Nagar (South)
139	Chennai	Chennai North	Jeeva Nagar (South)
140	Chennai	Chennai North	Kodungaiyur (East)
141	Chennai	Chennai North	Cherian Nagar (North)
142	Chennai	Chennai North	Cherian Nagar (South)
143	Chennai	Chennai North	Old Washermanpet
144	Chennai	Chennai North	Tondiarpet
145	Chennai	Chennai North	Jeeva Nagar(North)
146	Chennai	Chennai South	Adayar (East)
147	Chennai	Chennai South	Thiruvanmiyur (East)
148	Chennai	Chennai South	Thiruvanmiyur (East)
149	Chennai	Chennai South	Thiruvanmiyur (west)
150	Chennai	Chennai South	Guindy (East)
151	Chennai	Chennai South	Thiruvanmiyur(west)
152	Chennai	Chennai South	Velachery
153	Chennai	Chennai South	Velachery
154	Chennai	Chennai South	Velachery
155	Chennai	Chennai South	Guindy (East)
156	Thiruvallur	Ambattur	Nerkundram, Maduravoyal
157	Thiruvallur	Ambattur	Valasaravakam
158	Thiruvallur	Ambattur	Valasaravakam, Ramapuram
159	Thiruvallur	Ambattur	Ramapuram
160	Thiruvallur	Ambattur	Namdambakkam
161	Thiruvallur	Ambattur	Manapakkam, Mugalivakkam
162	Thiruvallur	Ambattur	Karambakkam, Porur, Madanandapuram, Kulapakkam
163	Thiruvallur	Ambattur	Maduravoyal
164	Thiruvallur	Ambattur	Maduravoyal, Sivabudam, vanagaram
165	Thiruvallur	Ambattur	Nolambur
166	Thiruvallur	Ambattur	Nolambur
167	Thiruvallur	Ambattur	Kakapallam, Mannur, Athipattu, Mogappair
168	Thiruvallur	Ambattur	Padi
169	Thiruvallur	Ambattur	Korattur
170	Thiruvallur	Ambattur	Pattravakkam, Menambeu
171	Thiruvallur	Ambattur	Ayanambakkam, Perumalagaram, Adayalampattu, Koladi
172	Thiruvallur	Ambattur	vanagaram, Chettiyaragaram, Thandalam, Numbal
173	Thiruvallur	Ambattur	Kulathuvancheri, Thelliyarangaram, Ayyappanthangal
174	Kanchipuram	Kanchipuram	Tharapakkam, Mouli pentankattalai, Thandalam, Kovur, Gerugambakkam, Peripanicheri,
175	Kanchipuram	Kanchipuram	Minambakkam
176	Thiruvallur	Ambattur	StThomas Mount
177	Thiruvallur	Kanchipuram	Guindy
178	Thiruvallur	Tambaram	Adayar ward - F
179	Kanchipuram	Tambaram	Palavanthangal, Nanganallur
180	Kanchipuram	Kanchipuram	Cowl Bazaar, Minambakkam cum

Source: JICA Study Team

Table 3.3.6 List of Zones (4)

Zone	Large	Middle	Small
181	Kanchipuram	Kanchipuram	Polichalur
182	Thiruvallur	Thiruvallur	Chinnapanicheri, Paraniputhur, SennSirinivasapuram, Katturpakkam, Goparasanallur
183	Thiruvallur	Thiruvallur	Sundrasholavaram
184	Thiruvallur	Ambattur	Ayapakkam, Thirumullaivoyal
185	Thiruvallur	Ambattur	Oragadam
186	Thiruvallur	Ambattur	Puttagaram
187	Thiruvallur	Ambattur	Surappattu, Kathirvedu
188	Thiruvallur	Ambattur	Villakkupattu
189	Thiruvallur	Ambattur	Manjambakkam
190	Thiruvallur	Ambattur	Chinna sekkadu, Amulavoyal, Vaikkadu, Elanthancheri, Sadayankuppam, Ariyalur, Kada
191	Thiruvallur	Ambattur	Sathangadu
192	Thiruvallur	Ambattur	Tiruvottiyur
193	Thiruvallur	Ambattur	Tiruvottiyur bit
194	Thiruvallur	Ambattur	Ernavur.
195	Thiruvallur	Ambattur	Mathur
196	Thiruvallur	Ambattur	Mathur, Layon, Vadapurambakkam, Vadakarai, Layongrant, Naravarikuppam, Alinjivakkam
197	Thiruvallur	Ambattur	Puzhal Redhills, Tundalkalani
198	Thiruvallur	Ambattur	Kovilpadagai
199	Thiruvallur	Thiruvallur	Palaripattu, Sekkadu, Paruthipattu, Vilinjiambakkam
200	Thiruvallur	Thiruvallur	Thukkanampattu, Pidarithangal, Parivakkam, Veerar, Kolappancheri, Panavaduthottam
201	Thiruvallur	Thiruvallur	Ariyamarundanallur, Agraharam
202	Thiruvallur	Thiruvallur	Kulamanivakkam, Mangadu
203	Thiruvallur	Thiruvallur	Mangadu
204	Kanchipuram	Kanchipuram	Kunrathur, Vengatapuram, Manancheri, Thirunageswaram, Munnankattalai, Kollaicheri
205	Kanchipuram	Kanchipuram	Anakaputur, Polichalur
206	Kanchipuram	Kanchipuram	Pammal
207	Kanchipuram	Kanchipuram	Pammal
208	Kanchipuram	Kanchipuram	Pammal
209	Kanchipuram	Tambaram	Pallavaram
210	Kanchipuram	Tambaram	Pallavaram, Issa Pllavaram
211	Kanchipuram	Tambaram	Thalakkanacheri
212	Kanchipuram	Tambaram	Muvarasampattu, Madipakkam, Perundavakkam
213	Kanchipuram	Tambaram	Pallikaranai
214	Kanchipuram	Tambaram	Perungudi
215	Kanchipuram	Tambaram	Kottivakkam
216	Kanchipuram	Tambaram	Plavakkam, Sivaram
217	Kanchipuram	Tambaram	Perungudi, Plavakkam, Neelangarai
218	Kanchipuram	Tambaram	Neelangarai
219	Kanchipuram	Tambaram	Okkiam thurai pakkam
220	Kanchipuram	Tambaram	Pallikaranai
221	Kanchipuram	Tambaram	Medavakkam, Jaladampettai
221	Kanchipuram	Tambaram	Medavakkam, Jaladampettai
222	Kanchipuram	Tambaram	Nanmangalam, Kulathur, Kovilambakkam, Keelakattaalai
223	Kanchipuram	Tambaram	Sembakkam
224	Kanchipuram	Tambaram	Sembakkam
225	Kanchipuram	Tambaram	Nemilicheri
226	Kanchipuram	Tambaram	Thambaram
227	Kanchipuram	Kanchipuram	Thambaram
228	Kanchipuram	Kanchipuram	Thiruneermalai
229	Kanchipuram	Kanchipuram	Thambaram
230	Kanchipuram	Kanchipuram	Rhirumudivakkam, Palanthendalam
231	Thiruvallur	Thiruvallur	Meppur, Melagaram, Malayambakkam, NazarathPettai, Varadharajapuram
232	Thiruvallur	Thiruvallur	Kattirambakkam, Chettipattu, Palanjur, Kuttambakkam, Chembarambakkam, Madavilagam, Ne
233	Thiruvallur	Thiruvallur	Thandari
234	Thiruvallur	Ambattur	Pottur, Vellanur, Pammadukulam, Alamadi
235	Thiruvallur	Ambattur	Naravarikuppam
236	Thiruvallur	Ponneri	Vichoor, Chinn Edayanchavadi, Vellivoyal, Thirunilai, Kodipallam, Periamullavoyal
237	Thiruvallur	Ambattur	Ennor
238	Thiruvallur	Ponneri	Vallur, Athipattu, Nandiyambakkam, Kollati, Ariyanvoyal

Source: JICA Study Team

Table 3.3.7 List of Zones (5)

Zone	Large	Middle	Small
239	Thiruvallur	Ponneri	Minjur
240	Thiruvallur	Ponneri	Sothupakkam, Perungavur, Pudur, Kummanur, Kandigai, Marambedu, Ankadu, Arumandai
241	Thiruvallur	Ambattur	Pdiyanallur, Thiruthakiriyampattu
242	Thiruvallur	Ponneri	Vijayanallur, Pannivakkam, Nallur, Siruniyam, Sembilivaram, Palayaermaivettipalaya
243	Thiruvallur	Ambattur	Attanthangal
244	Thiruvallur	Ambattur	Alathur, Velacheri, Pulikutti, Kadavur, Tenambakkam, Keelakondaiyur, Karlapakkam
245	Thiruvallur	Thiruvallur	Nadukuttagai, Pakkam, Palavedu, Mittanamalli, Mukthapudupattu
246	Thiruvallur	Thiruvallur	Agraharam, Annambedu, Karunakaracheri, Nemilicheri, Thiruninravur
247	Thiruvallur	Thiruvallur	Thiruninravur
248	Thiruvallur	Thiruvallur	Thiruninravur
249	Thiruvallur	Thiruvallur	Thirumazhisai
250	Kanchipuram	Kanchipuram	Poonthandalam, Nandambakkam, Daravur, Kavanur, Sirukulathur
251	Kanchipuram	Kanchipuram	Mudichur, Varadharajapuram, Naduveerapattu, Erumaiyur
252	Kanchipuram	Kanchipuram	Perungalathur
253	Kanchipuram	Kanchipuram	Perungalathur
254	Kanchipuram	Kanchipuram	Thambaram
255	Kanchipuram	Kanchipuram	Thambaram
256	Kanchipuram	Tambaram	Thambaram
257	Kanchipuram	Tambaram	Peerkankaranai, Perungalathur
258	Kanchipuram	Chengalpattu	Vandalur, Mannivakkam, Kelambakkam
259	Kanchipuram	Chengalpattu	Vandalur
260	Kanchipuram	Chengalpattu	Puthur, Nedukundram, Kulapakkam
261	Kanchipuram	Tambaram	Irumbuliyur, Meppedu, Thiruvanjeri
262	Kanchipuram	Tambaram	Hasthinapuram, Chitlapakkam
263	Kanchipuram	Tambaram	Sembakkam, Gowrivakkam, Rajakilpakkam
264	Kanchipuram	Tambaram	Madambakkam
265	Kanchipuram	Tambaram	Madambakkam, Kaspapuram, Vengambakkam, Agaramten
266	Kanchipuram	Tambaram	Vengavasal
267	Kanchipuram	Tambaram	Madambakkam
268	Kanchipuram	Tambaram	SithalaPakkam, Arasankalani, KovilanCheri, Madurapakkam, Otiyambakkam, Mulacheri
269	Kanchipuram	Tambaram	Perumbakkam
270	Kanchipuram	Tambaram	Sholinganallur, Uthandi, Semmancheri
271	Kanchipuram	Tambaram	karapakkam, Okkiam thurai pakkam
272	Kanchipuram	Tambaram	Sholinganallur
273	Kanchipuram	Tambaram	Okkiam thurai pakkam, Injambakkam
274	Kanchipuram	Tambaram	Sholinganallur
275	Kanchipuram	Tambaram	Sholinganallur, Uthandi
279-296	External Zone		

Source: JICA Study Team

The travel modes are set to be the same as those in the "Data Collection Survey for Chennai Metropolitan Region Intelligent Transport System". The passenger car unit (PCU) and the number of passengers per vehicle are shown in the table below.

The travel modes are categorized as shown in the table below to create current OD data which matched the traffic survey using the Root Mean Square Error Minimizing Model.

Table 3.3.8 Trip Mode Categories, Passenger Car Unit, Number of Passengers per Vehicle

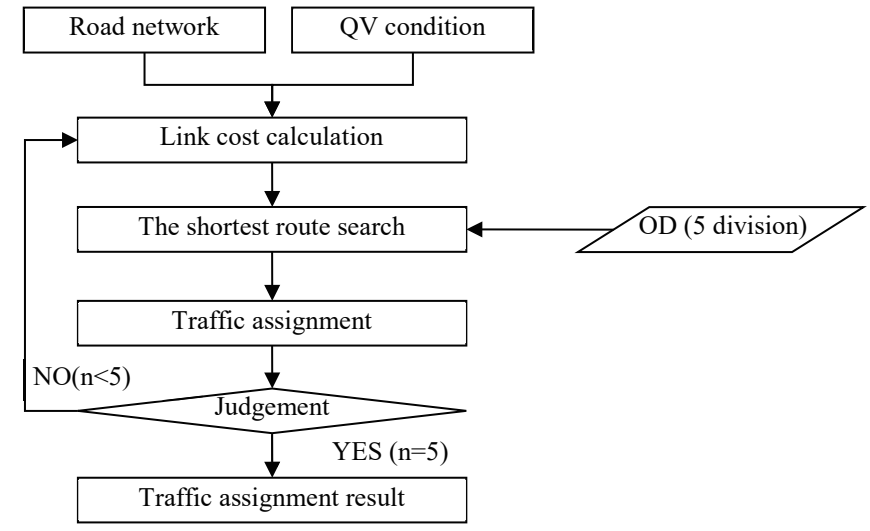
ID	Traffic Survey	ID	Traffic Demand Forecast	PCU *	Number of passengers per vehicle**	Average load tonnage
1	Two-wheeler	1	Two-wheeler	0.5	1.5	-
2	Car/Jeep	2	Car	1.0	2.6	-
3	Trip van/Maxi Cab/ Share Auto	3	Auto-Rickshaw	1.0	2.3	-
4	Auto-Rickshaw					
5	Bus	4	Bus	3.0	65	-
6	Mini Bus					
7	LCV*1	5	LCV	1.5	-	1.0 ***
8	Goods Auto					
9	2-axle	6	Truck	3.0	-	10.0 ****
10	3-axle					
11	MAV*2	7	MAV	4.5	-	29.0*****

*1: LCV (light commercial vehicle)
*2: MAV (multi-axle vehicle)
*source: Manual on Economic Evaluation of Highway Projects in India 2009
**source: Chennai Comprehensive Transportation Study
***source: Edited by JICA Study Team based on Network for Transport Measures
****source: Edited by JICA Study Team based on Northern Port Access Road FS NHAI 2008
*****source: Edited by JICA Study Team based on Northern Port Access Road FS NHAI 2008

(4) Reproduction of the Current Traffic Situation

The Incremental Traffic Assignment Method was used to divide the input OD traffic data into user-specified increments and to assign each increment to the minimum route where the generalized cost (i.e., the impedance calculated from travel time, distance, etc.) is the least.

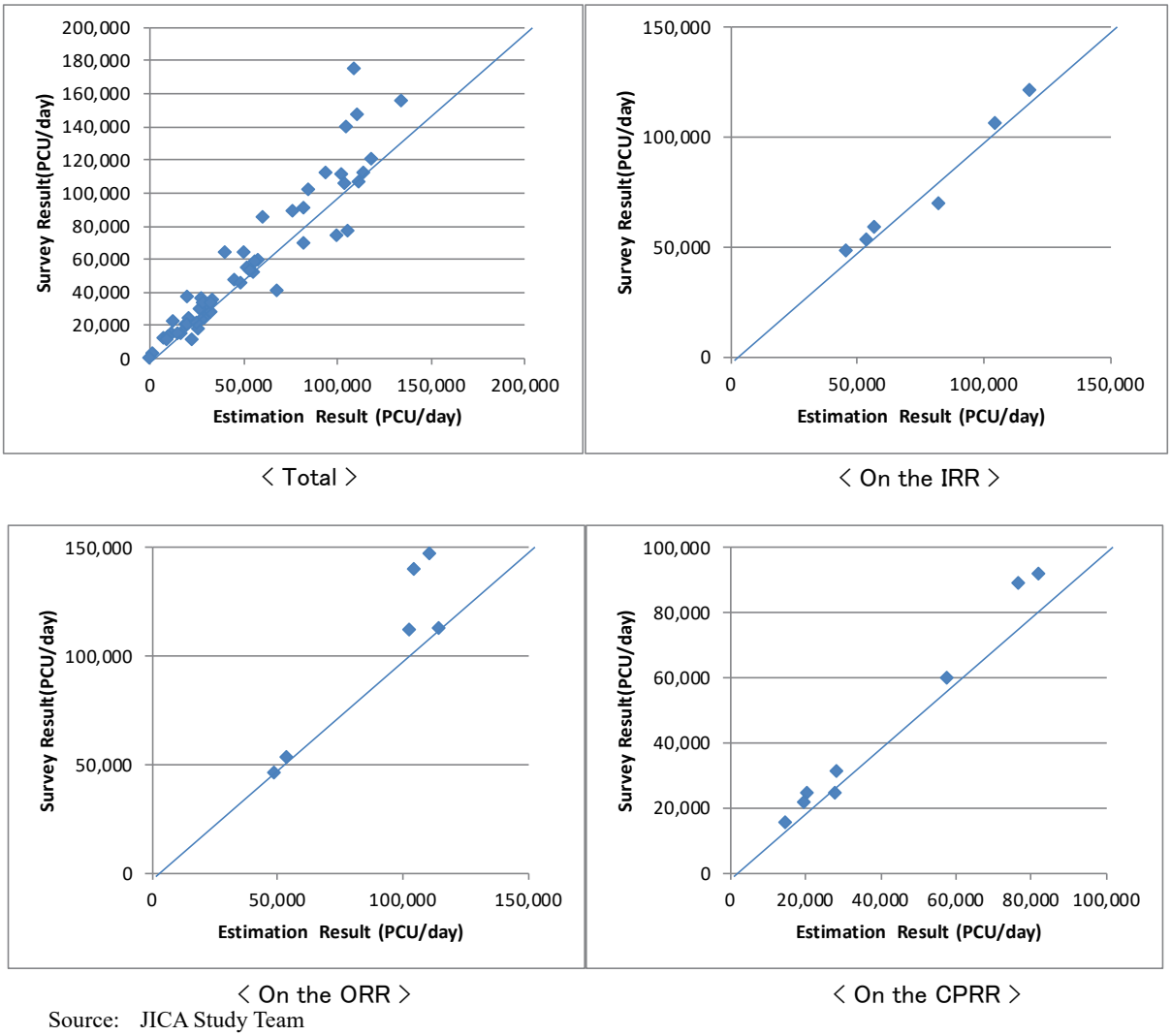
The origin-destination data has 5 divisions, distributing 20% for each. Road network, QV condition and origin-destination data show earlier were used as shown below.



Source: JICA Study Team

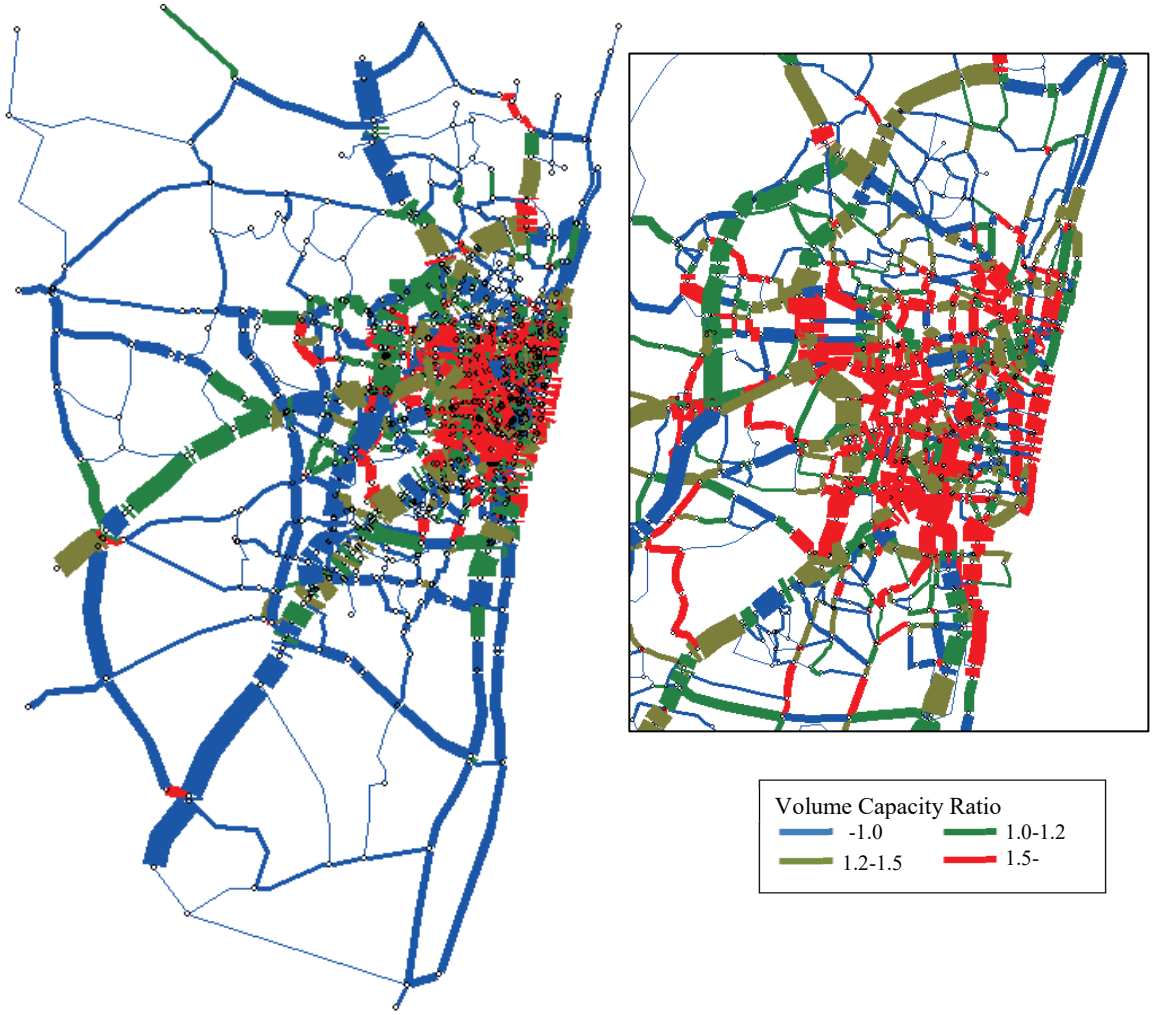
Figure 3.3.8 Traffic Assignment Flow

The result of the comparison with reproduction of the present traffic condition and the result of the traffic volume survey is shown in the figure below. It shows that r-squared is 0.929 in this correlation (on the IRR: 0.980, on the ORR: 0.933, on the CPRR: 0.994). Thus, it is judged that the reproducibility was mostly obtained.



Source: JICA Study Team

Figure 3.3.9 Survey Result and Estimation Result



Source: JICA Study Team

Figure 3.3.10 Traffic Assignment Result

3.3.2 Estimate of Developed Traffic Volume

(1) Future Traffic Demand

The growth rate of the future demand and the modal share are set to be the same as those of the "Data Collection Survey for Chennai Metropolitan Region Intelligent Transport System". The values are shown in the table below. Double counting of changes in freight vehicles due to changes in future cargo volumes to avoid trucks and multi-axle vehicles (MAVs) are not taken into consideration.

Table 3.3.9 Growth Rate of Future Traffic Demand for Target Years Estimated by this Study from Current Origin-Destination Data (2016)

Term	Year	Motor-cycle	Passenger Auto	Car/ Jeep	Bus	LCV*1	2&3Axle Trucks	MAV*2	All Type
Short	2021	1.394	1.219	1.383	1.222	1.580	1.300	1.251	1.361
Mid	2026	2.042	1.556	2.007	1.559	2.672	1.755	1.617	1.954
Long	2036	3.933	2.302	3.805	2.334	6.605	2.942	2.510	3.657

*1: LCV (light commercial vehicle)
*2: MAV (multi-axle vehicle)
Source: JICA Study Team edited based on the Detailed Project Report on CPRR

Table 3.3.10 Modal Share of Future Traffic Demand for Target Years

	Short	Mid	Long	Current	CCTS
	2021	2026	2036	2016	2026
Public Transport	62%	70%	70%	54.9%	70%
IPT	6%	8%	8%	4.6%	8%
Private Transport	32%	22%	22%	40.5%	22%

Source: CCTS, Chennai

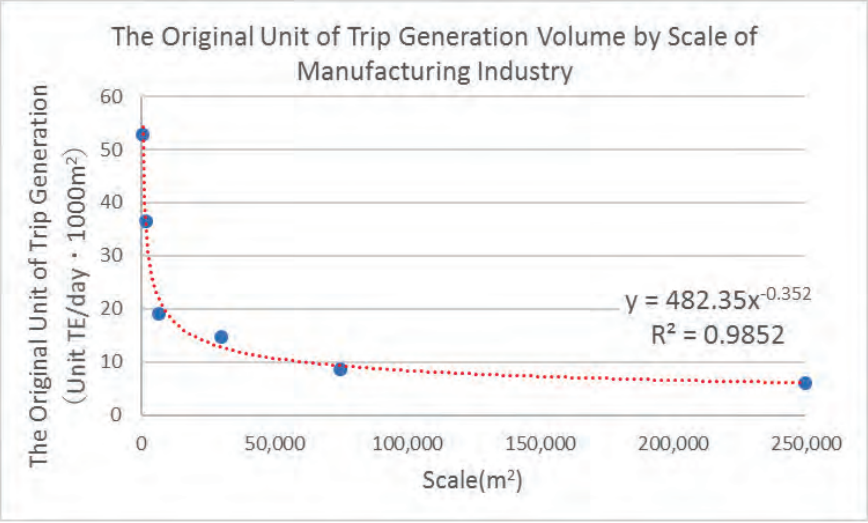
Note: The above table excludes non-motorized transport.

Note: Construction of Mass Rail Transit, Metro Rail, Mono Rail, Light Rail Transit, Bus Rapid Transit based on the plans is required, so that the public transport share rises to 70%. In addition, it is also important that parking lots, transfer stations, traffic information systems, etc., adjacent to the transport hub such as a bus stop or the railroad station is constructed. Besides, as measures of the policies, improvement of the user convenience by introducing the common card and securing regular schedule of trains are required. Most of city buses which are the citizen's main transportation are timeworn vehicles having low comfort. Thus, it is recommended that a new vehicle is introduced to improve the comfort of the user. It is necessary for these measures to be carried out totally so that public transport share rises to 70%.

(2) Reflecting Traffic Volume in Consideration of the Development Plan

1) Mahindra Industrial Park Chennai

Mahindra Industrial Park Chennai is scheduled to develop 300 ha and has completed development and sales in the short term (2021). The original unit of trip generation volume from the Mahindra Industrial Park Chennai was set using the basic unit of manufacturing industry based on the scale below. The trip generation rate is multiplied by the mixing ratio of large vehicles, and the arrival and departure point of the large vehicles are set to Ennore Port. Since Mahindra Industrial Park Chennai is located along NH5, the mixing ratio of large vehicles is set to the value of NH5.



Source: Edited by the JICA Study Team based on the National Institute for Land and Infrastructure Management, Research Report No. 21

Figure 3.3.11 Original Unit of Trip Generation Volume by Scale of Manufacturing Industry

Table 3.3.11 Trip Generation Rate at Mahindra Industrial Park Chennai

Trip Generation Volume	Trip Generation Volume	Mixing Ratio of Large Vehicles	Number of Large Vehicles
2.5 unit TE/day・1000 m^2	3,750 units/day	・Truck: 22.2% ・MAV: 9.6%	・Truck: 833 units/day ・MAV: 360 units/day

Source: JICA Study Team

(3) Cargo Vehicles Accompanying an Increase of Traffic Handled

1) Modal Split of Traffic Handled at the Port

The modal split of traffic handled at the Chennai Port in 2015 is assumed as shown in the table below. The same rates were applied to Ennore Port. It is assumed that only the road is used for Kattupalli Port. Future modal split was set to be the same as the current values.

Since the container does not use pipelines, it was set that 87% use the road and 13% use the railway.

Table 3.3.12 Modal Split of Traffic Handled

Year	Total Traffic Handled	Road		Rail		Pipeline	
		Tonnage	Ratio	Tonnage	Ratio	Tonnage	Ratio
2015	50.06	33.12	66%	4.2%	10%	12.09	24%

Source: Final Report for Sagarmala (Vol. 4)

2) Increase of Traffic Handled at the Port

The results of calculating the increment of future traffic handled from 2017 is shown in the table below.

Table 3.3.13 Increase of Traffic Handled per Year

	Commodity	Increase of Traffic Handled per Year		
		Chennai Port	Ennore Port	Kattupalli Port
Short (2021)	Liquid Cargo (MMTPA)	0.58	4.32	-
	Bulk Cargo (MMTPA)	1.60	9.48	-
	Container (MnTEU)	-0.27	0.46	0.04
	Other (MMTPA)	0.83	1.09	-
Mid (2026)	Liquid Cargo (MMTPA)	0.5	6.40	-
	Bulk Cargo (MMTPA)	-2.80	14.6	-
	Container (MnTEU)	-0.03	0.70	0.24
	Other (MMTPA)	1.95	2.45	-
Long (2036)	Liquid Cargo (MMTPA)	3.14	8.82	-
	Bulk Cargo (MMTPA)	-2.36	48.7	-
	Container (MnTEU)	0.86	1.47	0.24
	Other (MMTPA)	5.80	6.08	-

Source: JICA Study Team

The increase of traffic handled per day, where the number of working days is set to be 330 days per year, is shown in the table below.

Table 3.3.14 Increase of Traffic Handled per Day

	Commodity	Increase of Traffic Handled per Year		
		Chennai Port	Ennore Port	Kattupalli Port
Short (2021)	Liquid Cargo (MMTPA)	1,758	13,091	-
	Bulk Cargo (MMTPA)	4,848	28,727	-
	Container (MnTEU)	-803	1,394	121
	Other (MMTPA)	2,515	3,303	-
Mid (2026)	Liquid Cargo (MMTPA)	1,515	19,394	-
	Bulk Cargo (MMTPA)	-8,485	44,242	-
	Container (MnTEU)	-76	2,121	727
	Other (MMTPA)	5,909	7,424	-
Long (2036)	Liquid Cargo (MMTPA)	9,515	26,727	-
	Bulk Cargo (MMTPA)	-7,152	147,576	-
	Container (MnTEU)	2,591	4,455	727
	Other (MMTPA)	17,576	18,424	-

Source: JICA Study Team

3) Calculation of Increase of Number of Trucks

With reference to similar cases in India, load capacity by car type is set as shown in the table below.

Table 3.3.15 Load Capacity by Car Type

Commodity	Car type	Load Capacity
Liquid Cargo	Truck	10 tons/unit
Bulk Cargo	Truck	12 tons/unit
Container	Trailer	1.5 TEU/unit
Other	Truck	10 tons/unit

Source: Edited by the JICA Study Team based on the Northern Port Access Road FS NHAI 2008

The increase of traffic using the road was calculated based on the modal split of traffic handled.

Table 3.3.16 Increase of Traffic Handled using Road

	Commodity	Increase of Traffic Handled per Year		
		Chennai Port	Ennore Port	Kattupalli Port
Short (2021)	Liquid Cargo (MMTPA)	1,472	8,640	-
	Bulk Cargo (MMTPA)	4,062	18,960	-
	Container (MnTEU)	-887	1,213	154
	Other (MMTPA)	2,107	2,180	-
Mid (2026)	Liquid Cargo (MMTPA)	1,269	12,800	-
	Bulk Cargo (MMTPA)	-7,108	29,200	-
	Container (MnTEU)	-84	1,845	923
	Other (MMTPA)	4,950	4,900	-
Long (2036)	Liquid Cargo (MMTPA)	7,971	17,640	-
	Bulk Cargo (MMTPA)	-5,991	97,400	-
	Container (MnTEU)	2,861	3,875	923
	Other (MMTPA)	14,723	12,160	-

Source: JICA Study Team

The increase in the number of trucks that was calculated using load capacity by car type is shown in the table below. These trucks were allocated from each port to the CFS and the industrial park.

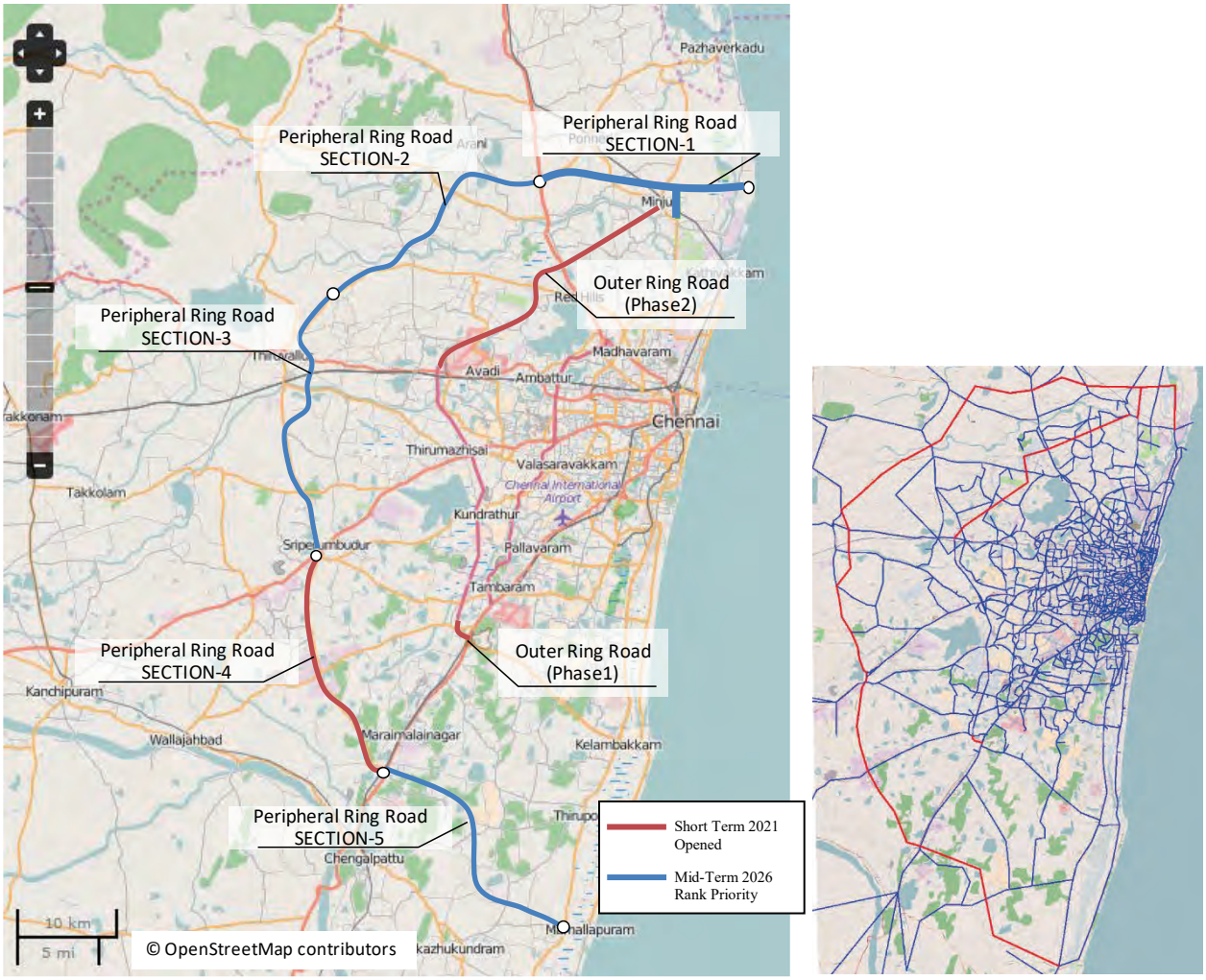
Table 3.3.17 Future Increase of Trucks at the Port

		Increase of Trucks		
		Chennai Port	Ennore Port	Kattupalli Port
Short (2021)	Trailer (unit/day)	-591	808	81
	Truck (unit/day)	764	2,978	-
Mid (2026)	Trailer (unit/day)	-56	1,230	485
	Truck (unit/day)	-89	4,690	-
Long (2036)	Trailer (unit/day)	1,907	2,584	485
	Truck (unit/day)	1,670	12,720	-

Source: JICA Study Team

(4) Preparation of Future Network Data

The planned major roads are the ORR (Phase 1 and Phase 2) and CPRR (from Section 1 to Section 5). These roads were added to the future network data. The opening year of each road is assumed as shown in the table below.



Source: JICA Study Team

Figure 3.3.12 Future Road Network

Table 3.3.18 Opening Year of Major Road

Term	Opening	Road
Short	2021	ORR (Phase 1, Phase 2), CPRR (Section 4)
Mid	2026	Review priority of CPRR (Sections 1 to 5)
Long	2036	CPRR (Sections 1 to 5)

Source: JICA Study Team

(5) Future Traffic Demand Forecast

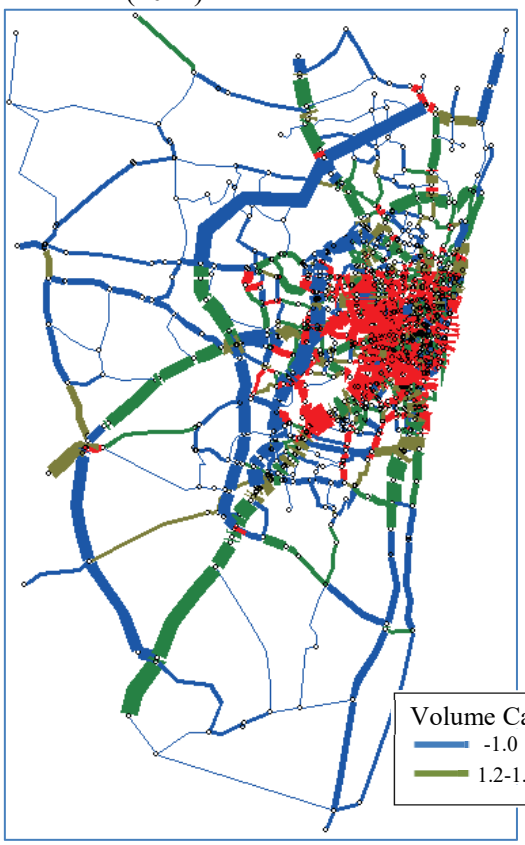
The results of the future traffic demand forecast for short term, mid-term and long term are shown in the figure below.

In the short term, the traffic capacity of the access road to the Ennore Port is expected to increase due to the increase in the cargo volume brought about by the improvement of the processing capacity at the Ennore Port. In addition, it is expected that there will be no problem in increasing the traffic volume of the ORR and the CPRR (Section 4), but it is expected that congestion will occur in the section from the ORR to the Ennore Port.

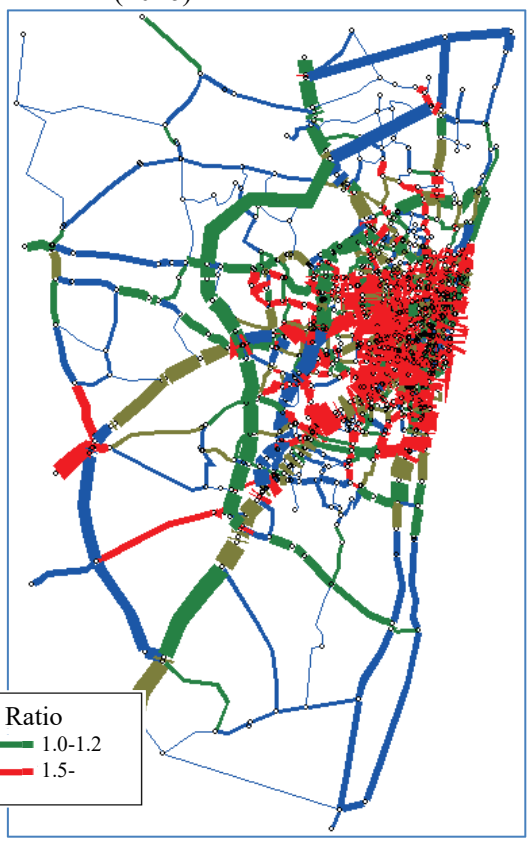
In the mid-term, it is expected that the congestion in the section from the ORR to the Ennore Port will be alleviated by constructing the CPRR (Section 1).

In the long term, traffic congestion occurrs in the city due to the increase in total traffic volume.

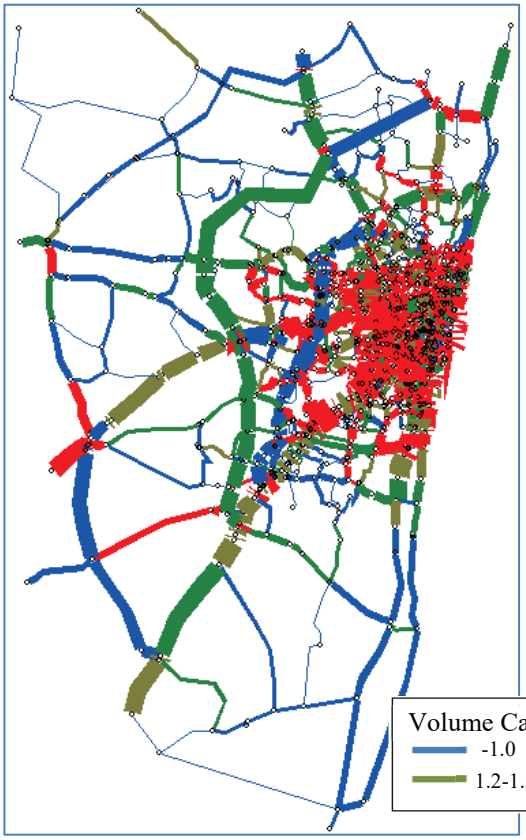
Short Term (2021) Sec. 4



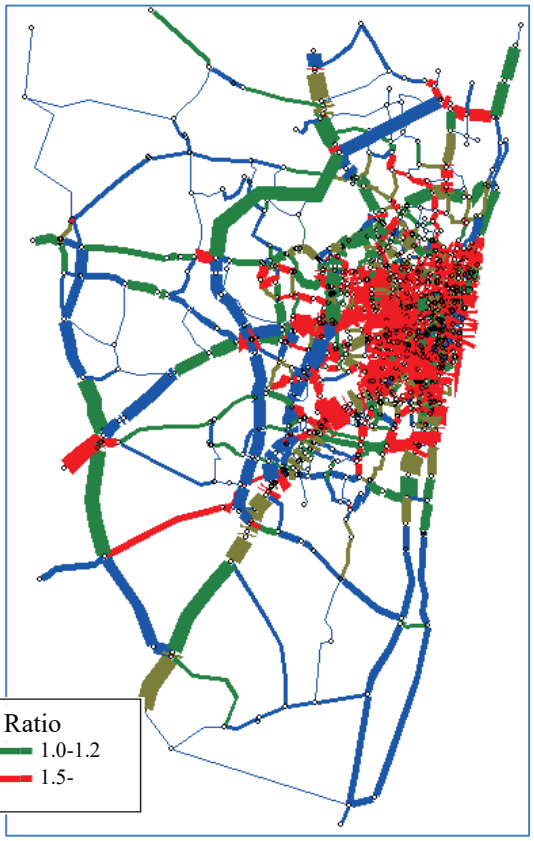
Mid Term (2026) Sec. 1 + Sec. 4



Mid Term (2026) Sec. 2 + Sec. 4



Mid Term (2026) Sec. 3 + Sec. 4



Source: JICA Study Team

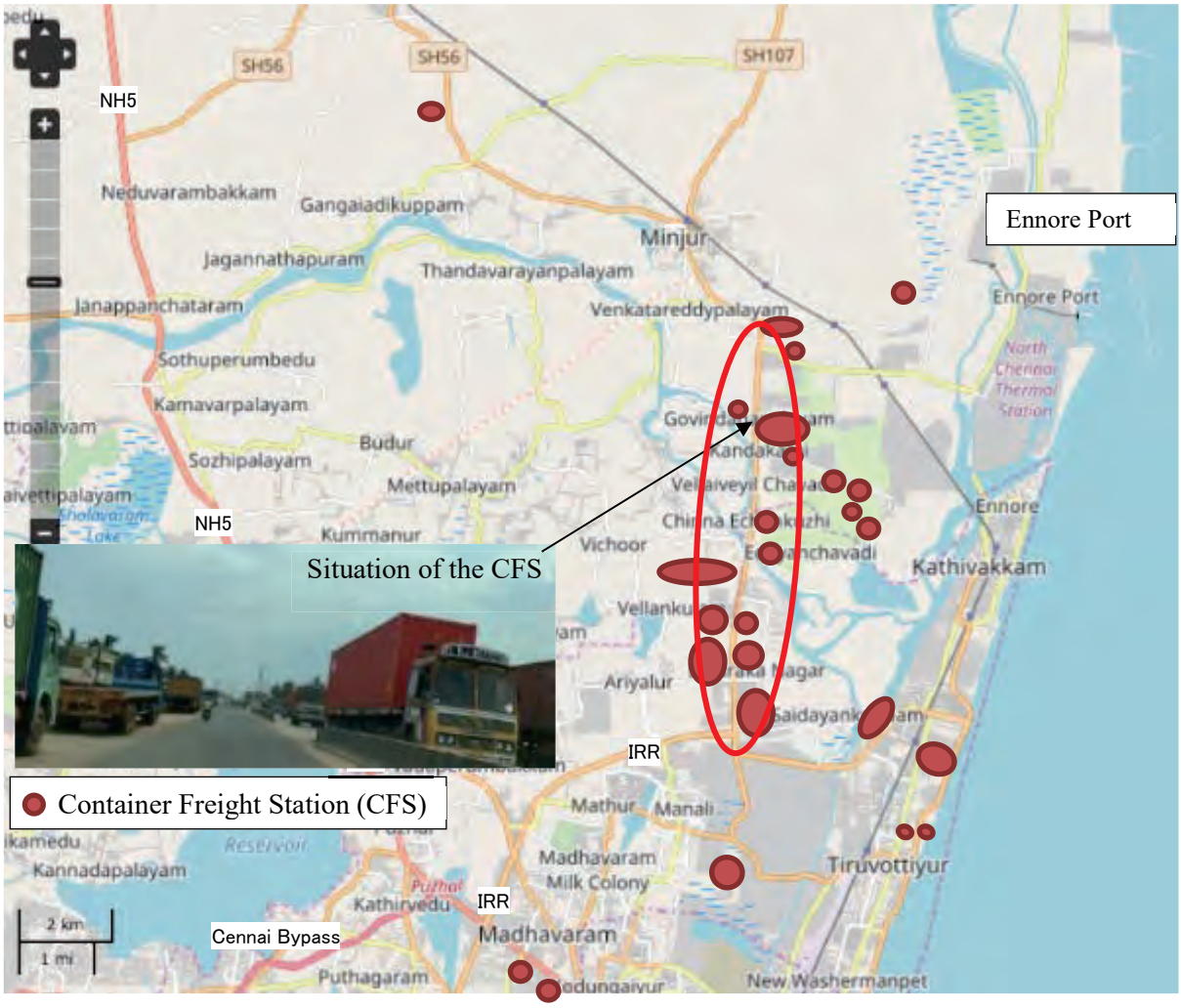
Figure 3.3.13 Traffic Assignment Result

(6) Road and Traffic Issues

1) Congestion around Container Freight Stations

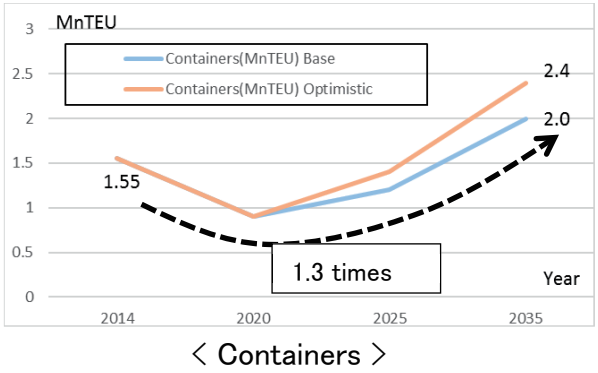
Several container freight stations are installed around the Chennai Port to compensate for the lack of capacity, as the yard is narrow and the capacity of Chennai Port is too small to accommodate containers . Congestion occurs around the Chennai Port by freight vehicles moving between Chennai Port and the CFS. In particular, the CFSs are concentrated in the area surrounded by the red frame in the figure below, and it is still crowded due to the influence of the large vehicles parked.

Although the amount of containers handled by the Chennai Port in the future temporarily decreases, it is indicated in the Chennai Port Master Plan that the amount of containers will increase, which may cause further congestion.



Source: JICA Study Team

Figure 3.3.14 Location of the Container Freight Stations



Source: Edited by the JICA Study Team based on the Final Report for Sagarmala (Vol. 4)

Figure 3.3.15 Prediction of Cargo Handled by Year 2035 (Chennai Port)

2) Connection of ORR and CPRR

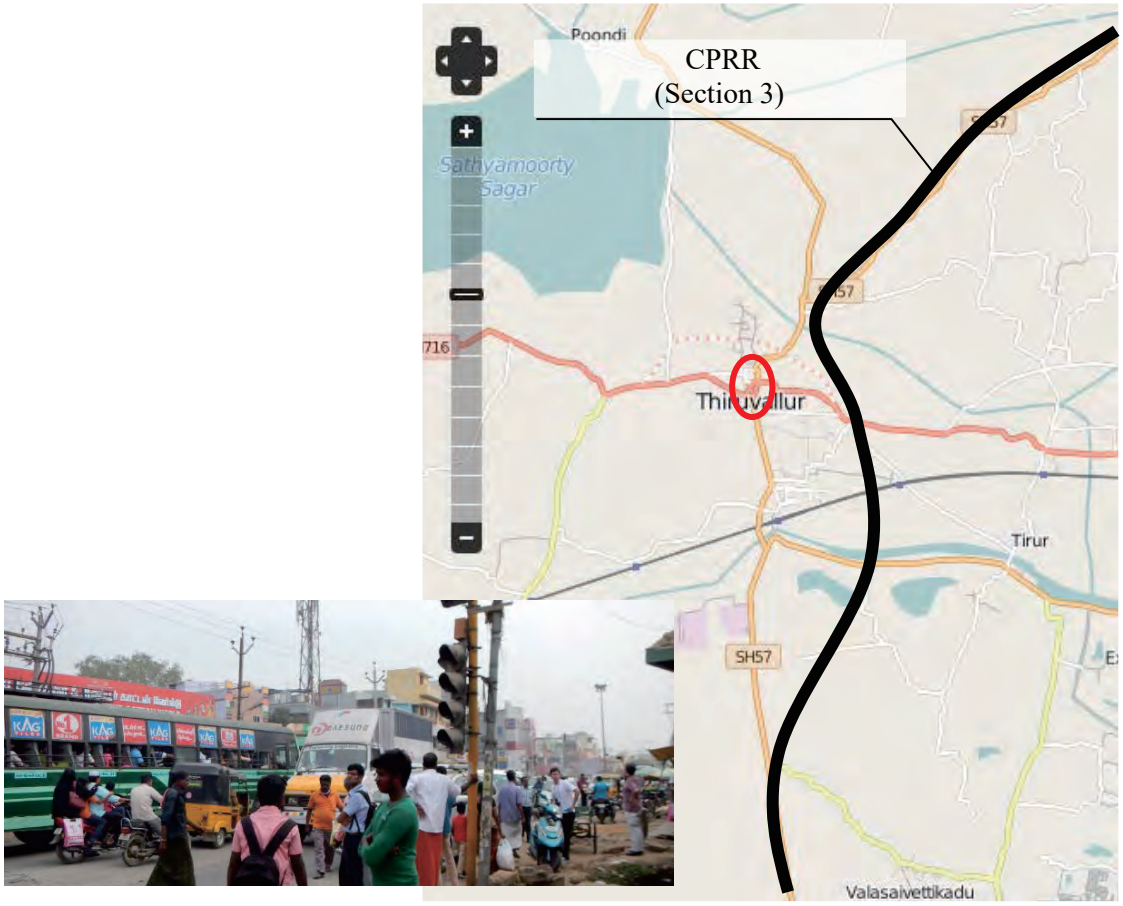
Currently, the ORR (Phase 2) and Section 1 of the CPRR are not planned to be connected. Both roads are planned to connect to the road in Minjur Village. This road in the village is a 2-lane road, and there are a number of houses and shops along the road, as shown in the photograph below. There is concern that this will be a bottleneck and traffic accidents may occur because there are many people on the roadside.

Source: JICA Study Team

Figure 3.3.16 Connection of ORR and CPRR

3) Intersection of NH205 and SH57

Section 3 of the CPRR is planned to bypass the intersection of NH205 and SH57 in Thiruvallur. This intersection is a four-lane section and is frequently used by a number of large vehicles, such as buses and trailer trucks, as shown in the photograph below. There are a number of houses and shops around the intersection. Thus, the traffic capacity has declined significantly. It is expected that this will be a bottleneck and may cause traffic accidents.



Source: JICA Study Team

Figure 3.3.17 Problems of Intersection of NH205 and SH57

(7) Sensitivity Analysis

1) Modal Share

As shown in the table below, the sensitivity analysis was carried out for the case that modal shift occurred from the current condition to the short – medium – long–term terget year.

Table 3.3.19 Modal Share of Future Traffic Demand for Target Years

	Current	Short	Mid	Long
	2016	2021	2026	2036
Public Transport	54.9%	58%	62%	70%
IPT	4.6%	5%	6%	8%
Private Transport	40.5%	37%	32%	22%

Source: JICA Study Team

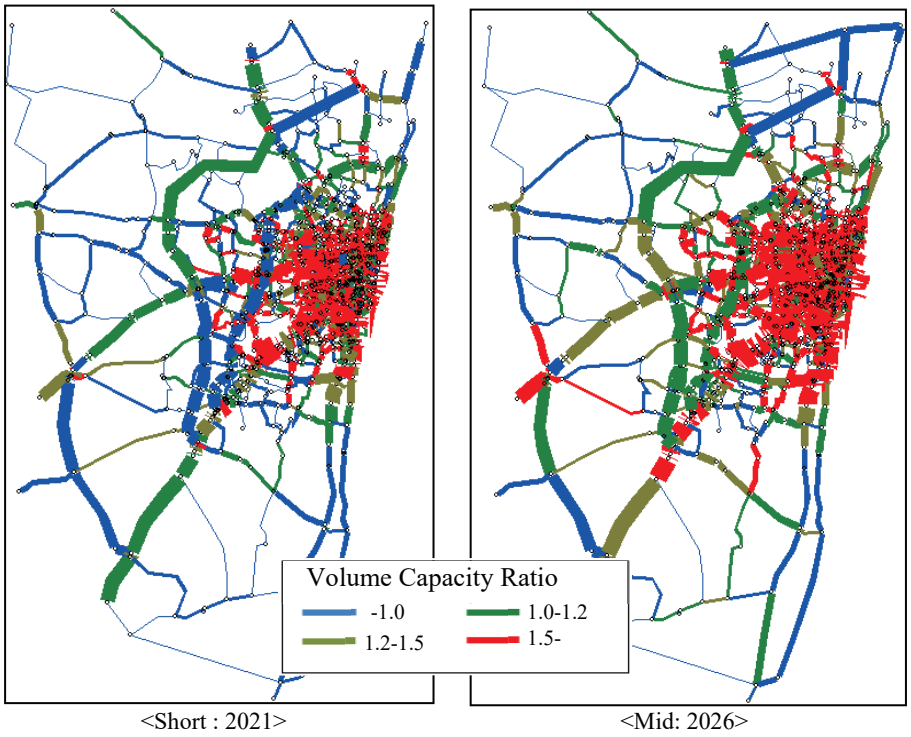
2) The Results of Sensitivity Analysis

The results of sensitivity analysis were compared using the total travel time for evaluating the efficiency of the road traffic in the survey area for the short and middle-term (CASE A: Sec.4 + Sec.1). As a result of comparing CCTS case and the case that the modal shift is carried out gradually toward the long-term (2036), the CCTS case, total travel time increased by 15% in the short term, 20% in the middle term.

Table 3.3.20 Total Travel Time of Each Analysis Case (unit: Vehicle Hour)

	Short 2021	Mid 2026
CCTS, Chennai [A]	3,226,956	4,377,730
Sensitivity Analysis [B]	3,712,172	5,314,043
[C] = [B] / [A]	1.15	1.21

Source: JICA Study Team



<Short : 2021> <Mid: 2026>

Source: JICA Study Team

Figure 3.3.18 The Result of Sensitivity Analysis

CHAPTER 4 PRIORITIZATION AND FORMULATION OF THE PROJECT FOR JICA LOAN SCHEME

4.1 Chennai Peripheral Ring Road (CPRR) Components

4.1.1 Approved Alignment and Sectioning of CPRR

According to the Detailed Project Report (DPR), the alignment for CPRR was approved by the Steering Committee and was finalized by the Principal Secretary of the Highways and Minor Ports Department (HMPD) on 9 July 2014. The CPRR starts at Ennore Port and ends at Poonjeri Junction (KM 56/800 of ECR) in Mahabalipuram. The alignment connects four national highways, namely NH5, NH205, NH4, and NH45, as well as eight state highways, namely SH51, SH50A, SH50, SH48, SH57, SH49B, SH49A (OMR), and SH49 (ECR). The length of the alignment is 133 km and is divided into five sections as follows:

- Sec. 1: Northern Port Access Road-Ennore Port to Thatchur on NH5, and
  CPRR (Ch.6+200) to Tiruvottiyur Ponneri Pancheti (TPP) Road via TPP Link Road
  (Connected point on TPP Road differs in original alignment and new alignment)
- Sec. 2: Thatchur on NH5 to the start of Thiruvallur Bypass
- Sec. 3: Start of Thiruvallur Bypass to Sriperumbudur on NH4
- Sec. 4: Sriperumbudur on NH4 to Singaperumalkoil on NH45
- Sec. 5: Singaperumalkoil on NH45 to Mahabalipuram

The outline of the sections is summarized in Table 4.1.1.

Table 4.1.1 Outline of Sections of CPRR

		Sec.1		Sec.2	Sec.3	Sec.4	Sec.5	TOTAL
		Main Road	TPP Link	Main Road	Main Road	Main Road	Main Road	
Section Length		21.51km	3.6km	25.61km	29.55km	24.85km	27.5km	132.62km
Scope of Work	New Construction	21.51km	3.6km (4.21km)	25.61km	19.95km	0km	25.5km	96.17km
	Improvement	0km	0km	0km	9.6km	24.85km	2km	36.45km
ROW		100m	45-60m	60m	60m	40-60m	60m	
Land Acquisition Area		255ha		188ha	208ha		163ha	814ha
Number of Lane	Main Line	2x2Lane	2x2Lane	2x3Lane	2x3Lane	2x3Lane	2x2Lane	
	Service Rd	2x2Lane	2x2Lane	2x2Lane	2x2Lane	2x2Lane	2x2Lane	
BP		Ch.0+000 /Ennore Port	TPP Link Ch.0+351 /CPRR (Ch.6+200)	Ch.21+506 /NH5 (29/000)	SH57 (50/500)	NH4 (42/100)	NH45 (47/400)	
EP		Ch.21+506 /NH5 (29/000)	TPP Link Ch.3+950 /TPP Rd	SH57 (50/500)	NH4 (42/100)	NH45 (47/400)	Ch.129+171 (Poonjeri)	
Structures	IC	0	0	1	2	0	1	4
	ROB	1	1	0	1	0	1	4
	MJB	1	0	2	1	0	1	5
	MNB	1	0	6	8	0	11	26
	VUP	6	0	5	6	9	6	32
	LVUP	6	0	4	2	4	7	23
	BC	39	0	0	1	0	7	47
	PC	8	0	204	107	0	132	451
	Entry/Exit Ramps	0	0	2	2	0	2	6

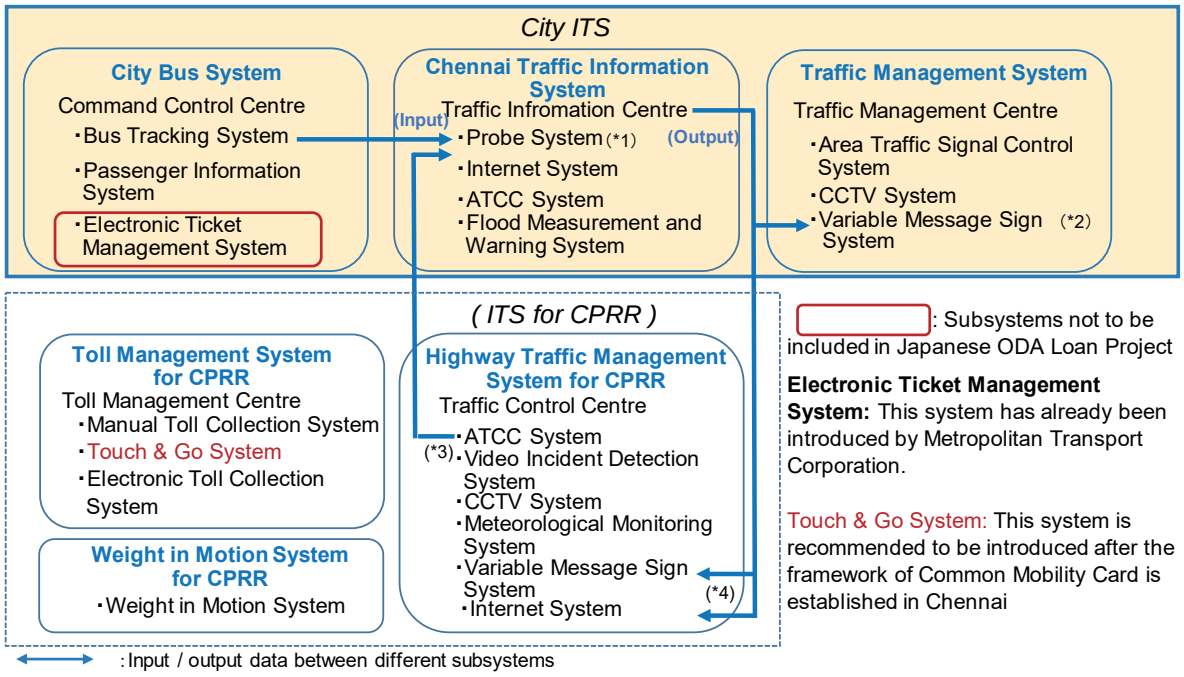
Source: Land Acquisition Area: STUP's Letter E/14518/149/NJW/GK/0132 dated 11 Aug 2017,
Chainage of BP/EP of each section: JICA Study Team estimates, Other Items: DPR Main Report, From P7-2 To P7-5
Note: 1) CPRR: Chennai Peripheral Ring Road, IC: Interchange, ROB: Railway Over Bridge, MJB: Major Bridge, MNB: Minor Bridge, VUP: Vehicular Underpass, LVUP: Light Vehicular Underpass, BC: Box Culvert, PC: Pipe Culvert
2) BC and PC are planned for irrigation and utility crossings.
3) MJB: Sec.1: Buckingham Canal, Sec.3: Kannigaipper Tank, Kosathalai River, Sec.4: Coovam River, Sec.5: Sengundram Tank
4) The alignment of TPP Link was modified and the section length was changed from 4.21km to 3.6km.

With respect to the TPP Link Road, HMPD conducted a survey on alternate alignments in May to June 2018, as the inhabitant's opposition were encountered on the original alignment. In early July, the state government decided that the new alignment would start from the TPP road around Minjur to the Northern Port Access Road (NPAR) (as a main line of Section 1), having a length of 3.6 km, Also, the new alignment connects to the Outer Ring Road (ORR) near Minjur.

4.2 ITS Components

4.2.1 Overall ITS Components

Figure 4.2.1 shows the overall Intelligent Transport System (ITS) components which are candidates for the Japanese ODA Loan Project. As described in 1.1 in this report, the ITS for CPRR was considered separately from the City ITS. The system linkage with the City ITS, as shown in Figure 4.2.1, will be established after introducing the ITS for CPRR.



*1: To generate congestion information on the road network based on the probe data obtained from Bus Tracking System

*2: To provide congestion information on the general roads under the authority of Traffic Police

*3: To complement the Probe System to generate congestion information after completion of CPRR

*4: To provide congetion information generated by Chennai Traffic Information System. Other information will be generated by Highway Traffic Management System for CPRR and provided.

Source: JICA Study Team

Figure 4.2.1 Overall ITS Components for Japanese ODA Loan Project

Regarding the Touch & Go System, the Japan International Cooperation Agency (JICA) Study Team recommended to adopt the common mobility card which can be used for other transport modes, e.g., Chennai Metro Rail, city buses, etc. In case the common mobility card does not exist yet in Chennai, the Touch & Go System should be introduced after the framework of the common mobility card is established in Chennai.

4.3 Prioritization of Components for Implementation

4.3.1 Prioritization of CPRR Components

In this Study, the priority of CPRR for the JICA Loan was examined from three viewpoints, mainly: (1) effect on improvement of traffic situation, (2) magnitude of environmental and social impact, and (3) economic rationality.

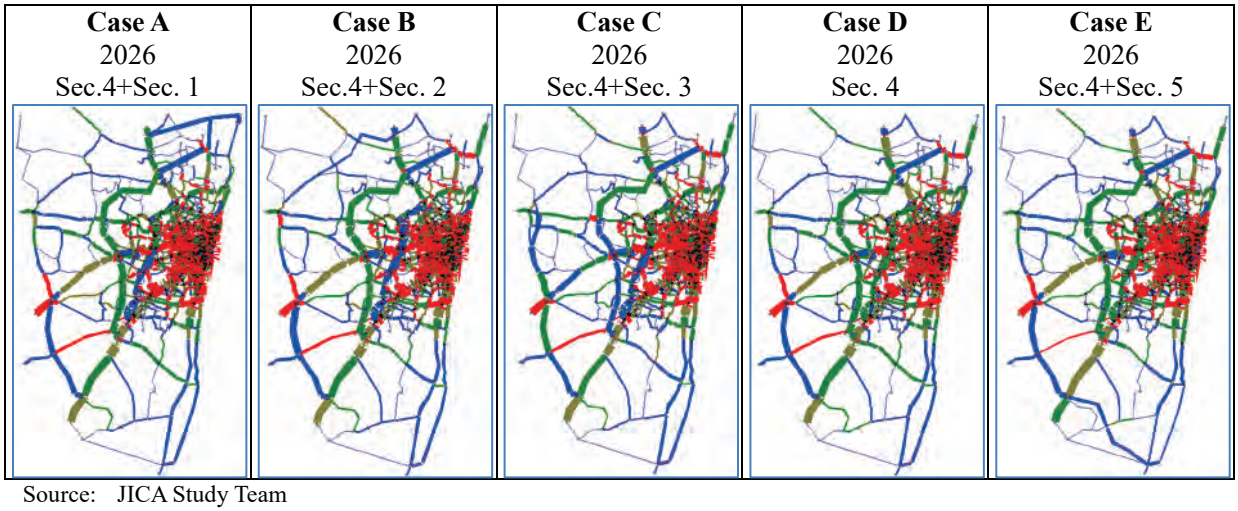
(1) Effect on the Improvement of Traffic Situation

Roads in Chennai City are suffering from severe traffic congestion. Thus, alleviation of traffic congestion on major roads is the main objective of the Project. With this in mind, particular attention shall be paid to the effect of the improvement on the traffic situation. The effect is evaluated in this Study through two indicators, 1) traffic volume in the focused section and 2) reduction of total travel time on the road network.

1) Traffic Volume

A simple reference index which indicates the effect of the Project is the traffic volume in the focused section. Traffic volumes are estimated in the traffic analysis assuming the situation in which only one focused section of the CPRR exists while other sections do not exist. The conditions of traffic simulation including the target year, the socio-economic framework, and the road network other than CPRR should be the same for fair comparison.

Figure 4.3.1 presents the results of the traffic simulation (Case A to E) that was made for the comparison of sections (see Figure 3.3.13 for details). It is considered that Case D is the "Without Project" case since widening of Section 4 is substantially completed.



Source: JICA Study Team

Figure 4.3.1 Results of Traffic Simulation for the Comparison of Sections

Cross-sectional traffic volumes of every section are summarized in Table 4.3.1.

Table 4.3.1 Traffic Volume of Every Section for Each Case

Case	A	B	C	D	E
Section	**Sec. 1**	**Sec. 2**	**Sec. 3**	**Sec. 4**	**Sec. 5**
Traffic Volume (pcu/day)	58,324	31,184	89,528	73,196	43,282
Sec. 4 (pcu/day)	75,091	72,402	69,714	73,196	74,940

Source: JICA Study Team

Section 3, with 89,528 passenger car units (pcu)/day, recorded the highest volume, followed by Section 4 with 73,196 pcu/day, while Section 2 with 31,184 pcu/day recorded the lowest volume.

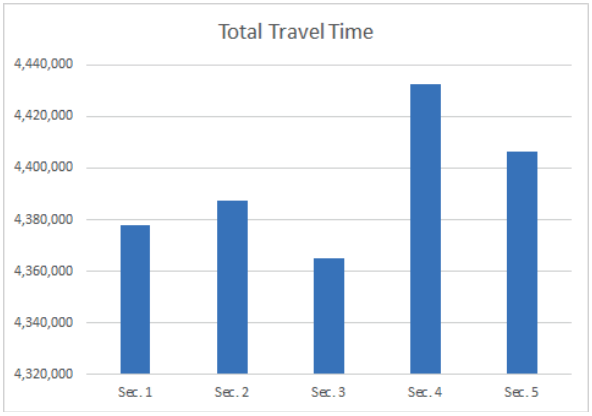
2) Reduction of Total Travel Time of the Road Network

Another index of the effect of the Project is the impact on the total travel time of the road network in Chennai Metropolitan Area (CMA). In this Study, it was considered that the degree of reduction in total travel time induced by the construction of a section represents the scale of contribution made by the section to the CMA road network.

The reduction in total travel time of every section are shown in Figure 4.3.2 and Table 4.3.2.

Case C (Sec. 3 + Sec. 4), with 67,494 vehicle hours, marked the largest impact followed by Case A (Sec. 1 + Sec. 4) with 54,871 vehicle hours, while Case E (Sec. 5 + Sec. 4), with 26,239 vehicle hours, marked the smallest impact.

Unit: Vehicle Hour



Source: JICA Study Team

Figure 4.3.2 Reduction in Total Travel Time Made by Every Section for Each Case

Table 4.3.2 Reduction in Total Travel Time Made by Every Section for Each Case

Case		A	B	C	D	E
Total Travel Time (vehicle hour)	Total	4,377,730	4,387,409	4,365,107	4,432,601	4,406,362
	Inside of CPRR	4,214,124	4,240,501	4,195,454	4,267,919	4,282,490
	Inside of ORR	2,196,586	2,229,587	2,196,052	2,245,832	2,261,239
	Inside of IRR	579,334	590,500	578,146	588,820	608,981
Difference from Case D (vehicle hour)	Total	54,871	45,192	67,494	-	26,239
	Inside of CPRR	53,795	27,418	72,465	-	-14,571
	Inside of ORR	49,246	16,245	49,780	-	-15,407
	Inside of IRR	9,486	-1,680	10,674	-	-20,161

Source: JICA Study Team

3) Large Vehicle Rate

In the existing road network, especially in the vicinity of the proposed alignment of CPRR, it was observed that a considerable number of large vehicles are travelling even on community roads as stated in Section 2.2.2 of this report. Such large vehicles running through small towns and villages severely affect the traffic environment in the community. Therefore, it is expected that CPRR shall cater to the industrial traffic of large vehicles and shall alleviate the traffic load from the community roads. In this sense, the large vehicle rate is considered in the prioritization of the project.

Table 4.3.3 Large Vehicle Rate of Every Section for Each Case

Case	A	B	C	D	E
Section	**1**	**2**	**3**	**4**	**5**
Large Vehicle Rate (%)	76%	13%	25%	27%	27%
Sec. 4	27%	26%	27%	27%	25%

Source: JICA Study Team

Case A (Sec. 1 + Sec. 4), with a percentage of 76%, marked the largest by a wide margin compared to the other cases.

(2) Magnitude of Environmental and Social Impact

Negative environmental and social impacts of the Project may constitute serious obstacles to the implementation of the Project, although every effort is made to mitigate those impacts through the Project phase of planning, design, construction, and operation. Therefore, the magnitude of environmental and social impacts shall be considered in the evaluation of the project prioritization. In this Study, 1) impact on Reserved Forest (RF) and Coastal Regulation Zone (CRZ) is taken as an index for the Project to assess the environmental condition, while the 2) area of land to be acquired is used as a barometer of the social impact of the Project.

1) Impact on Reserved Forest (RF) and Coastal Regulation Zone (CRZ)

a) Reserved Forest (RF)

The alignment of Section 3 passes through the Mannur RF with a length of 0.2 km, while Section 5 passes through the Thirutteri RF and Sengunram RF with lengths of 0.5 km and 1.26 km, respectively.

In accordance with the Forest (Conservation) Act of 1980, the diversion of forest land is required for the affected RF. The areas of land where diversions are required are shown in Table 4.3.4.

Table 4.3.4 Area of Forest Land to be Diverted

Section	1	2	3	4	5
Area of Forest Land to be Diverted (ha)	0	0	0.28	0	9.95 (2.56 + 7.39)

Source: HMPD's Letter 362/2014/JD01 dated 30 May 2016

b) Coastal Regulation Zone (CRZ)

The alignment of Section 1 passes through a CRZ Category III as explained in Chapter 11 of this report.

The CRZ Notification (2011) defines Category III as follows:

CRZ-III: areas that are relatively undisturbed and those that do not belong to either a CRZ-I or II, which include coastal zones in the rural areas (developed and undeveloped) and also areas within municipal limits or in other legally designated urban areas not substantially built up.

Since the development in the CRZ is controlled and monitored by the Environment and Forests Department, a CRZ Clearance shall be obtained before the project is initiated.

Table 4.3.5 Impact on CRZ

Section	1	2	3	4	5
Impact on CRZ	Category III	None	None	None	None

Source: HMPD's Letter 362/2014/JD01 dated 30 May 2016

2) Area of Land to be Acquired

The DPR consultant summarized the area of land to be acquired by section based on the Land Plan Schedule (LPS) as shown in Table 4.3.6.

Table 4.3.6 Area of Land to be Acquired

Section	1	2	3	4	5
Area of Land to be Acquired (ha)	255	188	208	0	163

Source: Land Acquisition Area: STUP's Letter E/14518/149/NJW/GK/0132 dated 11 Aug 2017

Section 1 requires the largest land of 255 ha since it is proposed to be a new road with a right of way (ROW) of 100 m, followed by Section 3 which requires 208 ha and where two interchanges are planned to be developed. No new land acquisition is required in Section 4 as it has already been widened to six-lane highway.

(3) Economic Rationality

It is a common practice for governments to evaluate projects with economic indicators to help in the decision-making process for implementation. In this report, the Economic Internal Rate of Return (EIRR) of each project (of each section of the CPRR) is preliminarily calculated to examine the economic rationality of the projects for prioritization.

The EIRR is an indicator that represents cost-effectiveness of the projects and thus it is widely used to evaluate projects of a different scale. The EIRR is defined as the interest rate at which the economic cost and benefit of a project discounted over its lifetime are equal.

Conditions for the calculation of the EIRR are as follows:

Cost: Project costs estimated in the DPR are converted to economic costs by multiplying with a factor of 0.90. Project costs estimated in the DPR are shown in Table 4.3.7.

It is assumed that the ratio of O&M costs to construction costs are 0.1% (recurrent) and 0.4% (periodic).

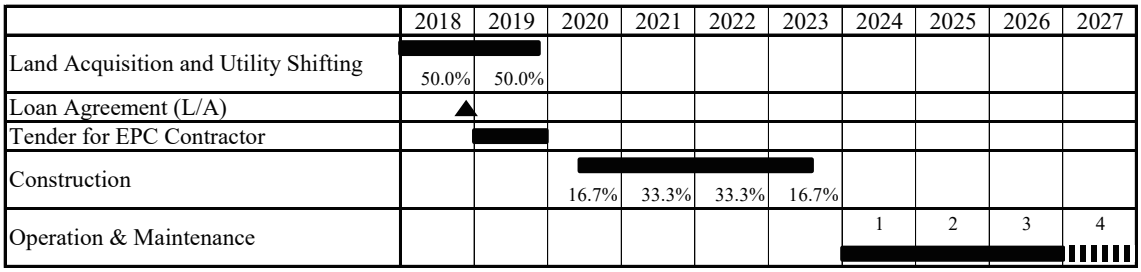
Table 4.3.7 Project Costs of CPRR Estimated in DPR

Bill Nos.	Description	Section 1	Section 1 Link	Section 2	Section 3	Section 4	Section 5	Total in Rs.
A	**ROAD WORKS**							
	Sub Total (A)	**6,354,592,067**	**1,136,510,877**	**10,362,136,578**	**9,250,954,218**	**3,651,623,435**	**9,454,555,452**	**40,210,372,627**
B	**STRUCTURES**							
	Sub Total (B)	**2,993,255,732**	**804,476,707**	**3,346,032,227**	**7,423,411,876**	**1,866,531,163**	**2,923,406,526**	**19,357,114,231**
C	**EMP**							
19	Cost for EMP implementation	**24,290,569**	**4,892,981**	**23,856,800**	**36,241,150**	**20,705,300**	**30,019,000**	**140,005,800**
	Construction Cost Total (A)+(B)+(C)	**9,372,138,368**	**1,945,880,565**	**13,732,025,605**	**16,710,607,244**	**5,538,859,898**	**12,407,980,978**	**59,707,492,658**
	Say in Crores	**937**	**195**	**1,373**	**1,671**	**554**	**1,241**	**5,971**
D	**LUMPSUM PROVISIONS**							
20	Project Management charges at 4 % on Construction cost	374,885,535	77,835,223	549,281,024	668,424,290	221,554,396	496,319,239	2,388,299,707
21	Labour Welfare fund@1.0 %	93,721,384	19,458,806	137,320,256	167,106,072	55,388,599	124,079,810	597,074,927
22	Quality Control at 1%	93,721,384	19,458,806	137,320,256	167,106,072	55,388,599	124,079,810	597,074,927
23	Contingencies at 3.0%	281,164,151	58,376,417	411,960,768	501,318,217	166,165,797	372,239,429	1,791,224,779
	Total (D)	**843,492,454**	**175,129,252**	**1,235,882,304**	**1,503,954,651**	**498,497,391**	**1,116,718,288**	**5,373,674,340**
	Total (A+B+C+D)	**10,215,630,822**	**2,121,009,817**	**14,967,907,909**	**18,214,561,895**	**6,037,357,289**	**13,524,699,266**	**65,081,166,998**
	Say in Crores	**1,022**	**212**	**1,497**	**1,821**	**604**	**1,352**	**6,508**
E	**LA & RR**							
24	Land Acquisition	9,988,052,569	2,011,947,431	3,950,000,000	22,650,000,000	NA	9,950,000,000	48,550,000,000
25	Resettlement & Rehabilitation Cost	202,642,744	40,819,424	67,504,770	408,399,675	NA	243,462,168	962,828,781
	Sub Total (E)	**10,190,695,313**	**2,052,766,855**	**4,017,504,770**	**23,058,399,675**		**10,193,462,168**	**49,512,828,781**
F	**UTILITY SHIFTING**							
26	TANGEDCO Cost	179,255,200	63,851,040	78,112,842	85,767,158	NA	79,255,200	486,241,440
27	TWAD Cost	26,738,600	5,347,720	15,575,074	18,052,926	NA	26,738,600	92,452,920
28	BSNL Cost	22,758,570	4,551,714	21,872,087	25,351,737	NA	22,758,570	97,292,678
		228,752,370	**73,750,474**	**115,560,003**	**129,171,821**		**128,752,370**	**675,987,038**
	GRAND TOTAL (A+B+C+D+E+F)	**20,635,078,505**	**4,247,527,146**	**19,100,972,682**	**41,402,133,391**	**6,037,357,289**	**23,846,913,804**	**115,269,982,817**
	Say in Crores	**2,064**	**425**	**1,910**	**4,140**	**604**	**2,385**	**11,528**

Source: DPR

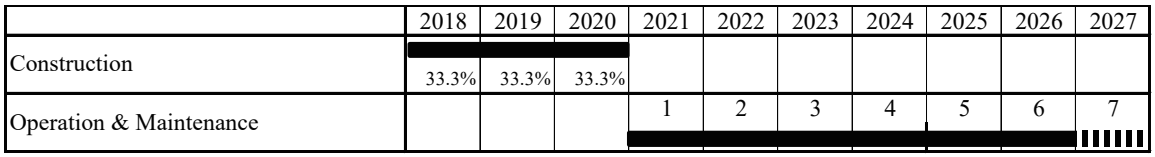
Benefit: Traffic volumes by vehicle type and average travel speed of each link in the road network model are estimated in the traffic simulation, while the determined unit rates of vehicle operation cost and travel time cost are referred from the Indian Road Congress (IRC) documents and from past practices in India.

Project Implementation Schedule: In this evaluation, the project implementation schedule shown in Figure 4.3.3 is considered for all sections, except for Section 4 which has already been substantially widened to a six-lane highway. It is assumed that the remaining works for Section 4 is to be completed as per the assumed schedule shown in Figure 4.3.4.



Source: JICA Study Team

Figure 4.3.3 Assumed Project Implementation Schedule for Sections 1, 2, 3, and 5



Source: JICA Study Team

Figure 4.3.4 Assumed Project Implementation Schedule for Section 4

From the above premise, calculations of the EIRR for each case is shown in Table 4.3.8. (Cash flow is explained in Section 12.3.)

Table 4.3.8 EIRR for Each Case

Case No.	Case	EIRR
1	Section 4 and 1 are constructed.	18.1%
2	Section 4 and 2 are constructed.	19.7%
3	Section 4 and 3 are constructed.	20.2%
4	Section 4 and 5 are constructed.	12.8%

Source: JICA Study Team

(4) Prioritization of CPRR Components

In this Study, the prioritization is made by setting out the evaluation criteria shown in Table 4.3.9.

As a result, it is recommended that the 1st priority be given to Section 1, the 2nd priority to Sections 2 and 3, and the 3rd priority to Section 5 considering that Sections 2 and 3 shall be developed simultaneously since they will form a united road section from the viewpoint of completeness of the CPRR.

Table 4.3.9 Evaluation Criteria for Prioritization

Criteria		Indicator	Evaluation (Score)		
			High	Middle	Low
1	Effect on Improvement of Traffic Situation	Traffic Volume (pcu/day)	**10:** 100,001- **9:** 75,001-10,000 **8:** 50,001-75,000	**7:** 40,001-50,000 **6:** 30,001-40,000 **5:** 20,001-30,000 **4:** 10,001-20,000	**3:** 7,501-10,000 **2:** 5,001-7,500 **1:** 2,501-5,000 **0:** -2,500
		Reduction in Total Travel Time (vehicle hour)	**10:** 100,001- **9:** 75,001-10,000 **8:** 50,001-75,000	**7:** 40,001-50,000 **6:** 30,001-40,000 **5:** 20,001-30,000 **4:** 10,001-20,000	**3:** 7,501-10,000 **2:** 5,001-7,500 **1:** 2,501-5,000 **0:** -2,500
		Large Vehicle Rate (%)	**10:** 41- **9:** 36-40 **8:** 31-35	**7:** 26-30 **6:** 21-25 **5:** 16-20 **4:** 10-15	**3:** 8.0-9.9 **2:** 6.0-7.9 **1:** 4.0-5.9 **0:** -3.9
2	Magnitude of Environmental and Social Impact	Impact on Reserved Forest and Coastal Regulation Zone	**5:** RF: - **5:** CRZ: -	**2:** RF: 0-4ha **2:** CRZ: III	**0:** RF: 5ha- **0:** CRZ: I, II
		Area of Land to be Acquired (ha)	**10:** -50 **9:** 51-100 **8:** 101-150	**7:** 151-200 **6:** 201-250 **5:** 251-350 **4:** 351-400	**3:** 401-600 **2:** 601-800 **1:** 801-1,000 **0:** 1,001-
3	Economic Rationality	EIRR (%)	**10:** 28.0- **9:** 24.0-27.9 **8:** 21.0-23.9	**7:** 18.0-20.9 **6:** 15.0-17.9 **5:**12.0-14.9 **4:** 9.0-11.9	**3:** 8.0-8.9 **2:** 7.0-7.9 **1:** 6.0-6.9 **0:** -5.9

Source: JICA Study Team

Table 4.3.10 Evaluation Results for Prioritization

Criteria		Indicator		Sec.1	Sec.2	Sec.3	Sec.5
1	Effect on Improvement of Traffic Situation	Traffic Volume (pcu/day)		58,324	31,184	89,528	43,282
			SCORE	**8**	**6**	**9**	**7**
		Reduction in Total Travel Time (vehicle hour)		54,871	45,192	67,494	26,239
			SCORE	**8**	**7**	**8**	**5**
		Large Vehicle Rate (%)		76	13	25	27
			SCORE	**10**	**4**	**6**	**7**
2	Magnitude of Environmental and Social Impact	Impact on Reserved Forest and Coastal Regulation Zone		RF: - CRZ: Cat..III	RF: - CRZ: -	RF: 0.28 CRZ: -	RF: 9.95 CRZ: -
			SCORE	**7**	**10**	**7**	**5**
		Area of Land to be Acquired (ha)		255	188	208	163
			SCORE	**5**	**7**	**6**	**7**
3	Economic Rationality	EIRR (%)		18.1	19.7	20.2	12.8
			SCORE	**7**	**7**	**7**	**5**
TOTAL SCORE				45	41	43	36
PRIORITY				**1**	**3**	**2**	**4**

Source: Land Acquisition Area: STUP's Letter E/14518/149/NJW/GK/0132 dated 11 Aug 2017,
Project Cost: Construction Cost shown in DPR Main Report, P9-3

1st **2nd** **3rd**

During the consultation with inhabitants around the site of the TPP Link Road (Original Alignment), it was found that it is very important to obtain social consensus for the road construction. As an alternative solution to minimize the social impact, the south end of the TPP Link Road is to be shifted approximately 1.5 km west of the original alignment. This new alternative alignment has a total length of 3.6 km from the connecting point with Northern Port Access Road to the southern end. The length of 1.65 km in the northern part is the same as the original alignment, and the remaining 1.95 km in the southern part is different from the original alignment.

4.4 Consulting Services for the Prioritized Project

4.4.1 CPRR

(1) Mode of Contract Scheme

A model of the Engineering, Procurement, and Construction (EPC) contract mode has been published by the Planning Commission for highway projects in India based on past experiences in infrastructure development, where the conventional item-rate contract is said to be generally prone to time and cost overruns. This is particularly evident in the national highway sector, resulting in enhanced cost to the financing institutions, and also considerable delay in the completion of projects.

Most of the EPC contracts in India, except for the projects financed by the multilateral development banks World Bank and Asian Development Bank awarded since 2014, seem to have been affected by Local Competitive Bidding (LCB) in accordance with the procedures used in India. EPC has also been introduced in state highway projects, and applications of the EPC for CPRR is one of options according to HMPD.

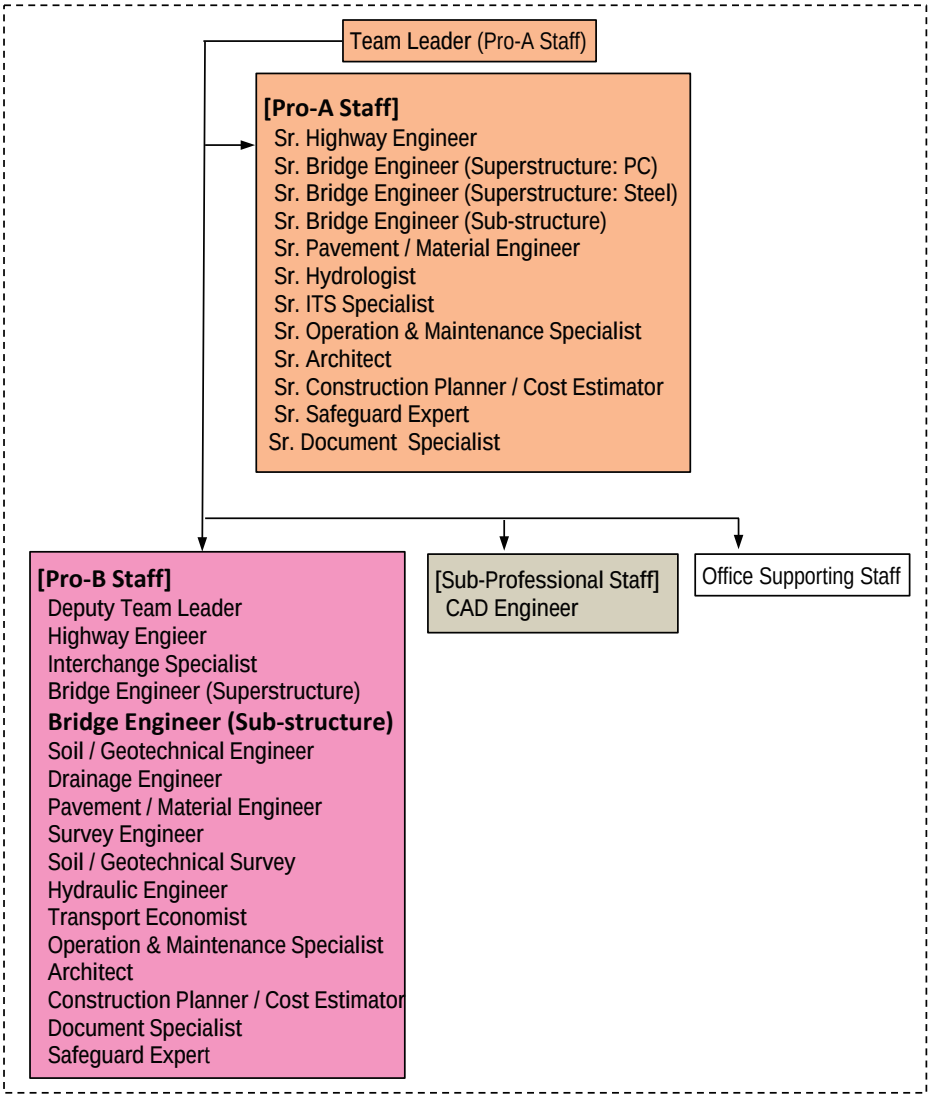
(2) Tender Method of Consultant Procurement

A supervising consultant selected by the executing agency through International Competitive Bidding (ICB) will discharge the functions and duties of an Authority's Engineer (AE) as per the Terms and Conditions of the EPC Agreement.

With the intention of maintaining high quality in the works executed by the contractor, the JICA Study Team recommends applying 'Procurement of Works' of the 'JICA Standard Bidding Documents Under Japanese ODA Loans (Works)' which follows the general conditions of the Federation International des Ingenious-Conseils (FIDIC MDB) Harmonized Edition. Review of detailed design is also recommended to identify shortage of design and suggest design update for bidding by the JICA SBD.

(3) Proposed Organization of the Detailed Design (D/D) Review Consultant

The proposed organization of the D/D Review Consultant for CPRR is shown in Figure 4.4.1.

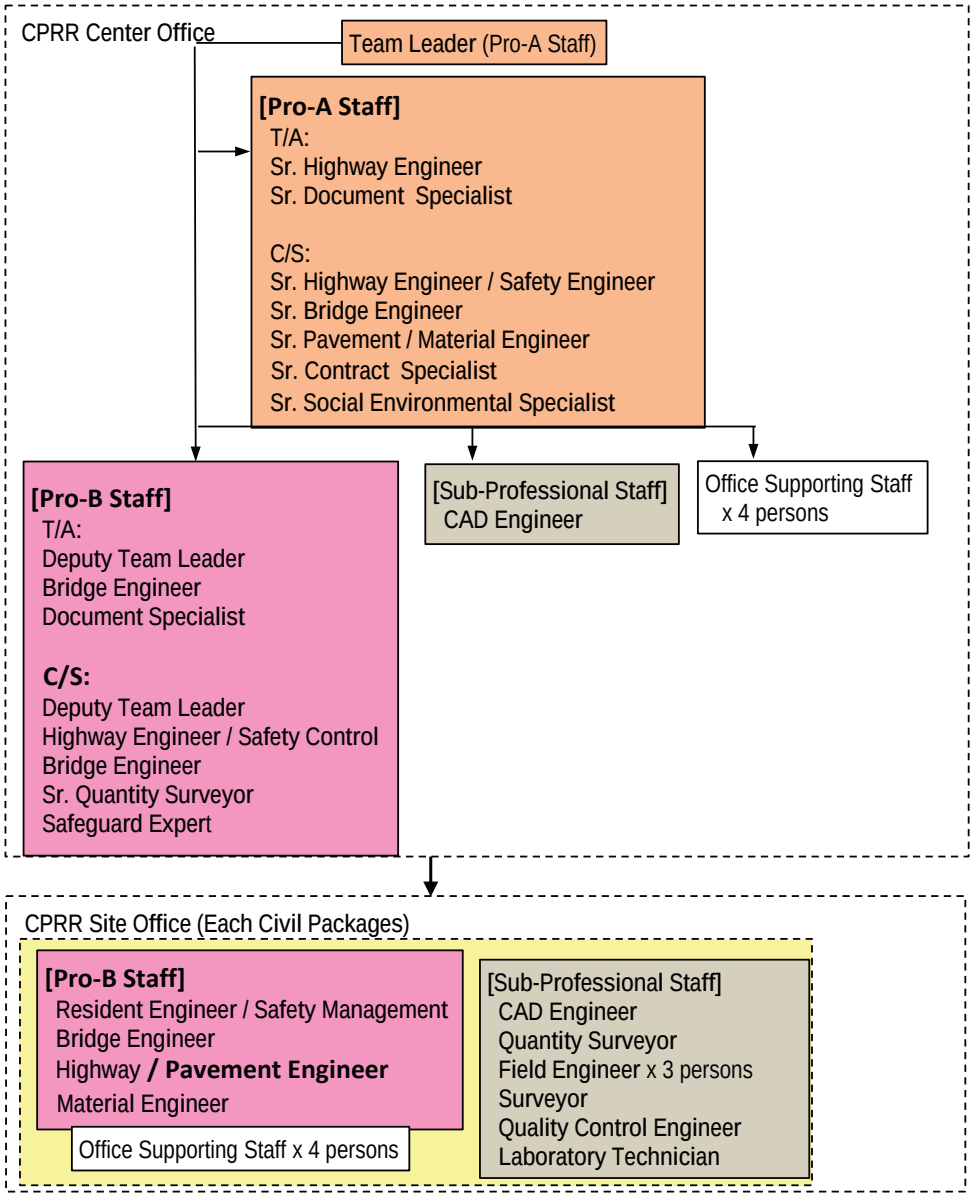


Source: JICA Study Team

Figure 4.4.1 Proposed Organization Structure of D/D Review Consultant

(4) Proposed Organization of the Construction Supervision (C/S) Consultant

The proposed organization of the C/S Consultant for CPRR is shown in Figure 4.4.2. The organization of Tender Assistance (T/A) is also provisionally proposed. A site office shall be provided to each section of the CPRR, with proposed staff as shown in Figure 4.4.2.



Source: JICA Study Team

Figure 4.4.2 Proposed Organization Structure of C/S Consultant

4.4.2 CPRR ITS

(1) Mode of Contract Scheme

The 'Design Build' scheme, i.e., design, supply, and installation, wherein the employer prescribes the requirement of the systems and performance and the contractor carries out the detailed design, is best suited because ITS is a project which is mainly composed of systems and equipment.

The 'Design Build' scheme was also adopted to other public projects of ITS in India. Some major examples are the MITRA Project of the City Bus Monitoring and Passenger Information System in Mysore in Karnataka State (World Bank), the KSRTC Project of the Inter-City Bus Monitoring and Passenger Information System in Karnataka State (state budget), and the B-TRAC Project of the Traffic Management System of Bengaluru traffic police in Karnataka State (state budget).

The 'Procurement of Electrical and Mechanical Pant, and for Building and Engineering Works, Designed by the Contractor' from the 'JICA Standard Bidding Documents Under Japanese ODA Loans (SBD, Design Build)' which is based on FIDIC is recommended to be used for this Japanese ODA Loan Project. This SBD

has been used in the ITS project under the Japanese ODA Loan Project in other city in India.

(2) Tender Method of Consultant Procurement

It is very important that the requirements are clearly defined/prescribed so that bidders can properly reflect the requirement on their proposals, particularly because the ITS project utilizes advanced technology. This is a different method from 'Turn Key Project' or EPC, where the contractor takes almost the entire responsibility regarding the design and construction. In particular, the Indian local contractors do not have sufficient experience on ITS projects yet. As such, ensuring the quality throughout the project, particularly the upper stage (basic design and contractor procurement), is very important because the quality of the upper stage will affect the entire project including the stages of implementation, operation, and maintenance. Therefore, procuring the Consultant through ICB, including the stages of basic design and contractor procurement, is recommended.

(3) Selection Method of Contractor Procurement: Quality and Cost Based Selection (QCBS)

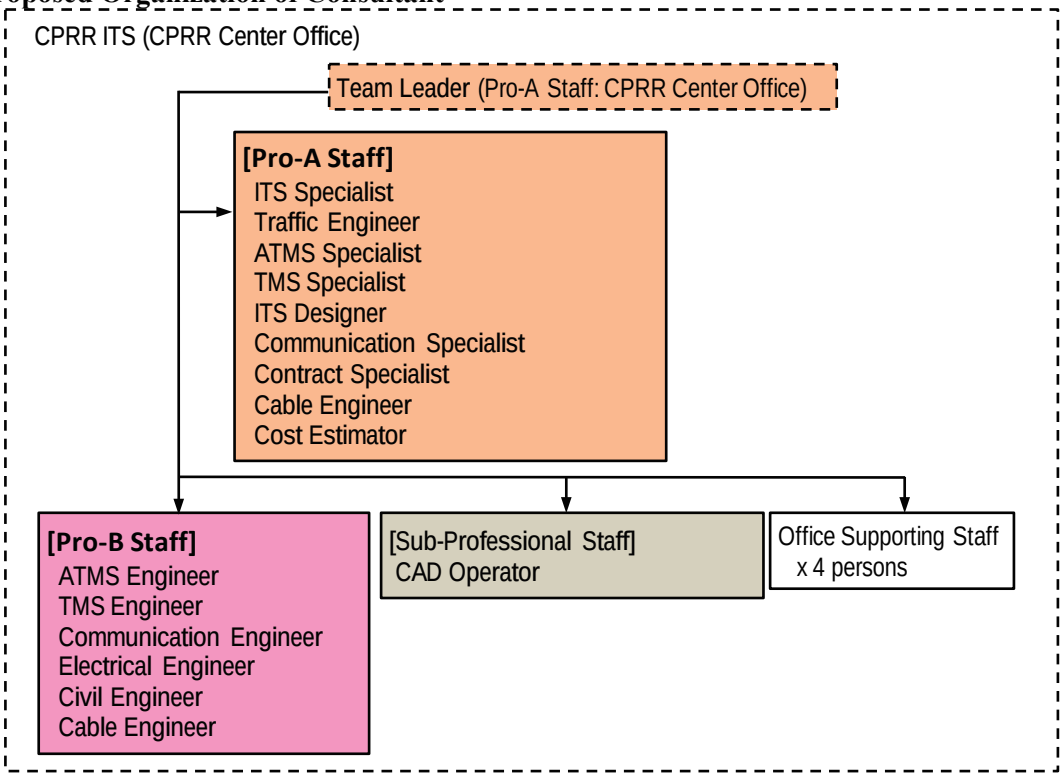
ITS facilities such as an emergency call box, traffic counter, CCTV, weather monitoring facility, VMS, and center system are all obligated to be installed on national highways under the jurisdiction of NHAI, where a certain level of traffic volume is expected (i.e., more than 40,000 daily traffic volume). However, there is currently no road where these facilities have been installed correctly, and no information is actually provided. As for the City ITS in India, Ahmadabad in Gujarat State is the only city where the dynamic traffic information has been provided in real time by an installed traffic information system. The system was introduced by a Japanese company under a support scheme of the Japanese small and medium enterprise overseas business developments by JICA.

It is considered that the above situation of ITS in India is caused by the fact that the contractors who have sufficient technical capabilities for developing and handling the advanced system are not selected, and the selection method of the contractor procurement is considered one of the predominant factors behind this. ITS consists of several subsystems wherein technical aspects are vitally important, such as software processing methods, interface between subsystems or external systems, and integration of systems. Therefore, selecting a contractor with enough technical capabilities determines the success of a project. To properly evaluate the technical capabilities of bidders and to select an appropriate contractor, adopting QCBS as an evaluation point of technical evaluation as reflected in addition to the financial evaluation is strongly recommended.

The Smart City Mission, which will develop 100 smart cities, is the case in India that drove the selection method from the conventional Cost Based Selection to QCBS. The first several cities such as Mumbai and Surat adopted Cost Based Selection for cost savings, but later on fell into a situation wherein the integration of the system could not be achieved because the contractor did not possess enough technical capabilities for it. In line with this, it was decided to adopt a QCBS method for the Smart City Mission. For example, the ratio of technical evaluation and financial evaluation for QCBS is 8:2 in Agra and 7:3 in Jabalpur and Lucknow.

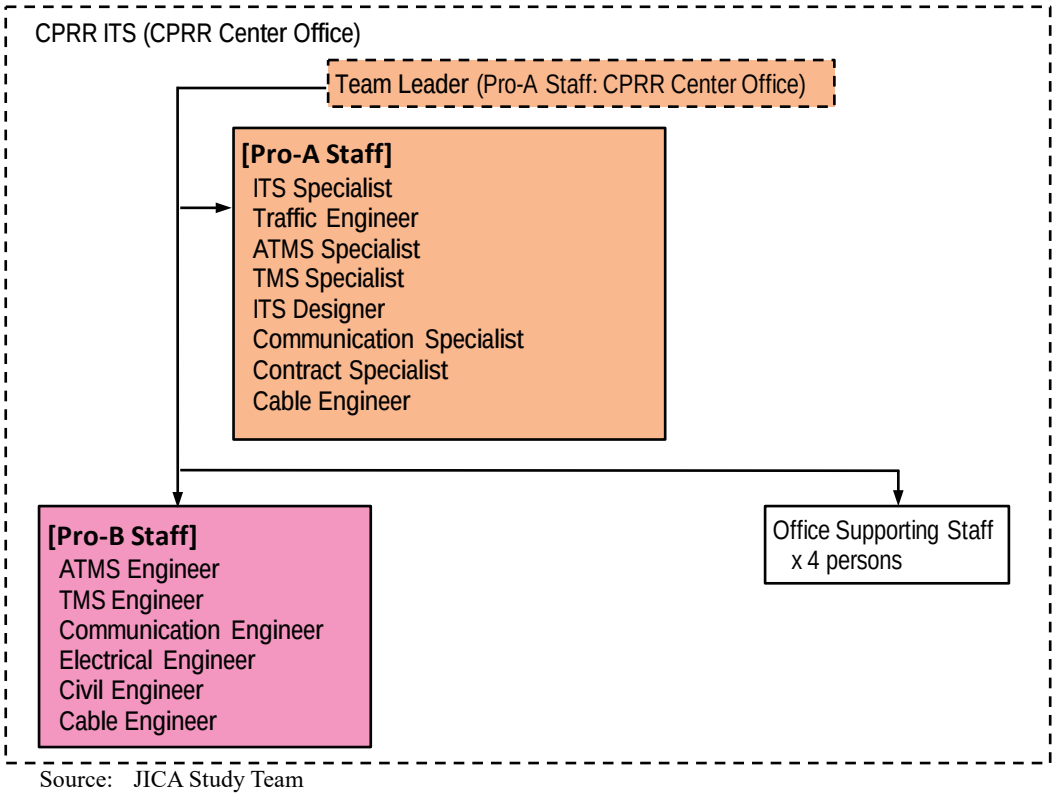
Furthermore, QCBS was used for a City Bus System project in Mysore, Karnataka State and was financed by the World Bank to select a contractor. The ratio of technical evaluation and financial evaluation was 6:4. The system has already been in operation, and the project earned a high reputation as one of the successful ITS projects in India.

(4) Proposed Organization of Consultant



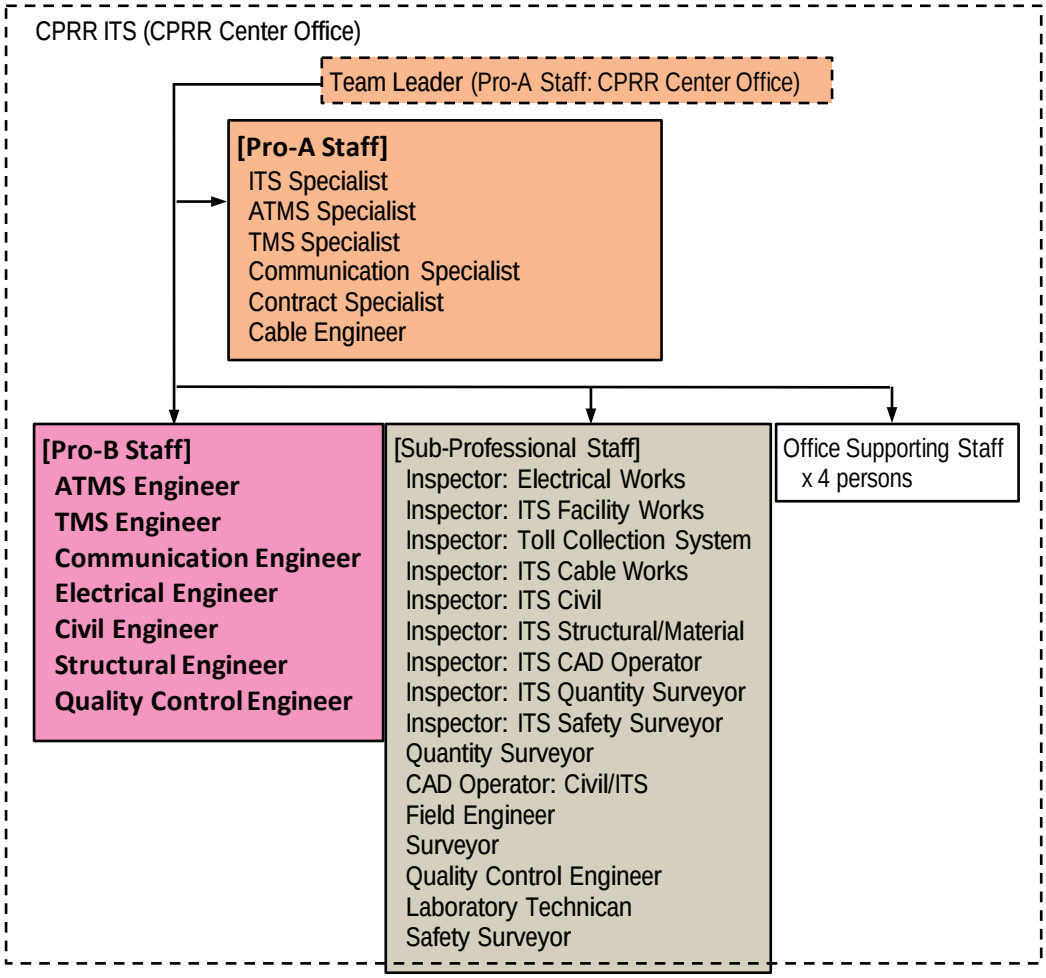
Source: JICA Study Team

Figure 4.4.3 Proposed Organization Structure of ITS Consultant (CPRR: B/D)



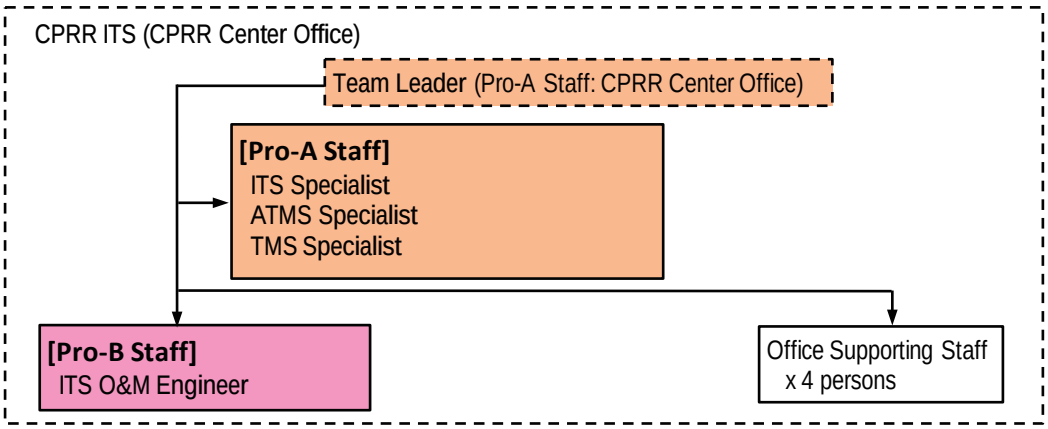
Source: JICA Study Team

Figure 4.4.4 Proposed Organization Structure of ITS Consultant (CPRR ITS: T/A)



Source: JICA Study Team

Figure 4.4.5 Proposed Organization Structure of ITS Consultant (CPRR ITS: C/S)



Source: JICA Study Team

Figure 4.4.6 Proposed Organization Structure of ITS Consultant (CPRR ITS: O/M)

CHAPTER 5 HIGHWAY OPERATION AND MAINTENANCE (O&M) STRUCTURE

5.1 Outline of Roads in Tamil Nadu

5.1.1 National Highways (NHs)

NHs compose the road network connecting state capitals, major cities, major ports, large industrial areas, and important tourist centers, and are noted by the Ministry of Road Transport and Highways (MORTH), Government of India. NHs form the economic backbone of the country enhancing quick movement of people and materials to their requisite destinations on time and facilitate rapid development along their routes.

The 4,994-km long national highways run through the Tamil Nadu State. Out of this, 1,985 km are maintained by the State National Highways Wing, and the balance of 3,009 km are maintained by the National Highways Authority of India (NHAI). Although NH are developed with funds from the MORTH, some of them are also funded through a Public Private Partnership (PPP) model.

5.1.2 State Highways (SHs)

SHs connect the district headquarters with NHs and with neighboring states. SHs get maximum importance because most have heavy traffic. The total length of SHs in Tamil Nadu State is 12,095 km.

5.1.3 Major District Roads (MDRs)

MDRs connect towns and municipal areas with district headquarters. These roads connect the production and marketing centers with NHs and SHs. In Tamil Nadu State, the total length of MDRs is 11,628 km.

5.1.4 Other District Roads (ODRs)

ODRs are the backbone of the rural economy and day to day activities of the public, connecting villages with marketing, educational, and health care centers, taluk headquarters, and other nearby important roads. Based on the traffic intensity, ODRs are maintained as single-lane or intermediate-lane roads.

Sugarcane development roads are also under the ODR category, which connect the sugarcane cultivating areas with sugar mills and nearby marketing centers. There are 33,751 km of ODRs, including 1,676 km of sugarcane development roads in Tamil Nadu State.

The details of the road network in Tamil Nadu State are given in Table 5.1.1.

Table 5.1.1 Details of Road Network in Tamil Nadu (as of 2016)

No.	Road Kind	Length (km)	Maintained by
1	National Highway (NH)	1,985	NH Wing
		3,009	NHAI
2	State Highway (SH)	12,095	C&M Wing
3	Major District Roads (MDRs)	11,628	
4	Other District Roads (ODRs)	33,751	
	Total	62,468	

Source: JICA Study Team based on Highway and Minor Ports Department, Policy Note 2016-2017

5.2 Highways and Minor Ports Department (HMPD), Tamil Nadu

5.2.1 Organization of HMPD

Tamil Nadu State traditionally has a strong industrial base which contributes substantially to the industrial production of the country. Roads and bridges along with ports play a vital role in the development of key sectors of the economy like industry, technology, and agriculture. HMPD administers the road infrastructure and the minor ports in Tamil Nadu State.

Tamil Nadu State is the forerunner in bringing out standard specifications for the roads and bridges in 1954. The department is also in-charge of the improvement and maintenance of NH in the state. Minor ports were later brought under the purview of this department. Subsequently, this department was renamed as the HMPD. The Highways Department aims to develop and maintain the highway network in the state, ensuring road safety and hassle-free traffic.

HMPD is made up of the following five substructures:

a) Highways Department

b) Tamil Nadu Road Development Company (TNRDC) and IT Expressway Limited (special purpose vehicle: subsidiary company owned by TNRDC)

c) Tamil Nadu Road Infrastructure Development Corporation (TNRIDC)

d) Tamil Nadu Maritime Board

e) Poompuhar Shipping Corporation Limited

Source: JICA Study Team base on the website of Highway Department
＜http://www.tnhighways.net/pdf/Organisation_Chart.pdf＞(Final access 20 July 2017)

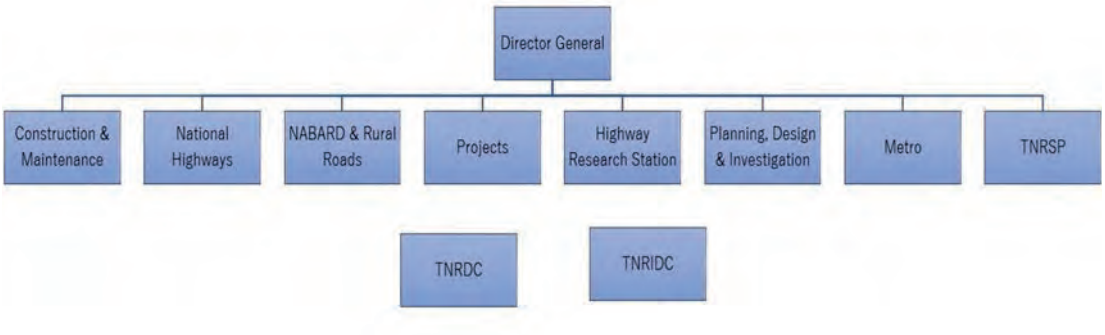
Figure 5.2.1 Organizational Structure of HMPD

5.2.2 Highways Department

(1) Organization of the Highways Department

The Highways Department of the Government of Tamil Nadu was established in 1946. Currently, the Highways Department maintains 62,468 km of road network spread across the entire length and the breadth of the state. The department has a clear-cut mandate of creating, augmenting, and maintaining the road infrastructure of the state with the vision to "increase the capacity, connectivity, efficiency, and safety" of the highway system.

The organization is strengthened by the coordination of eight wings under the control of the Director General. The research works are being done by the Highways Research Station Wing. The designs and the required field investigations are being done by the Designs and Investigation Wing. The two mentioned wings are non-execution wings, and the remaining six wings are for execution of works of the department. There are two road corporations that oversee special projects.



Source: JICA Study Team base on the website of the Highways Department
＜http://www.tnhighways.net/pdf/Organisation_Chart.pdf＞(Final access 20 July 2017)

Figure 5.2.2 Organizational Structure of the Highways Department

(2) Recent Activities of Highways Department

The Highways Department has come up with integrated e-PATHAI system which helps to maintain the road network at the desired service level by fixing performance indicators based on the roughness index, traffic density, and surface conditions for effective, efficient, and transparent functioning of the department.

In addition, the e-PATHAI system helps to identify the black spots on the road network. The department has taken up a massive project to rectify the black spots all over the state with the latest standard engineering practices to reduce accidents and fatalities using more budgetary allocation to enhance road safety.

Lots of innovative methods and latest technological inputs are being progressively adopted for all highway projects. The implementation of major projects are increasingly being undertaken through Engineering, Procurement, and Construction (EPC) modes of contract, which enables the department to shift the risks onto the contractor and avoids cost and time overrun thereby reducing burden on governments exchequer.

The maintenance of roads is being done in selected districts employing innovative Performance Based Maintenance Contracts (PBMC) and Output and Performance Based Road Contracts (OPRC), which considerably reduces the overall expenditure of this department. Investments are being attracted through PPP projects, engaging prospective investors to provide good transport infrastructure for the development of society, thus contributing to nation building.

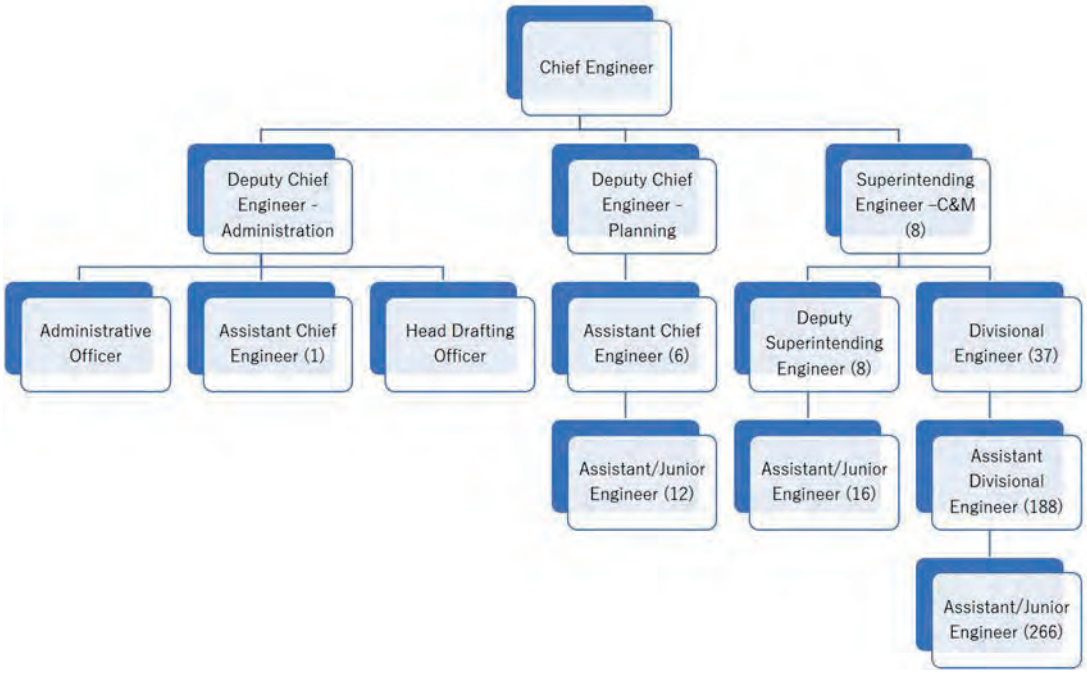
5.2.3 Construction and Maintenance Wing

(1) Organization of Construction and Maintenance Wing

The Construction and Maintenance Wing of the Highways Department maintains a total length of 57,466 km of roads categorized as SHs, MDRs, and ODRs. This wing undertakes major infrastructure projects involved in the widening, strengthening, and improvement of roads, including the construction of bridges/grade separators, and culverts, as well as the formation of bypasses and road safety works among others.

Maintenance work is assigned to private contractors. Although the contracts have been on a single fiscal year basis, the contracts are being replaced with five-year long PBMC contracts.

To execute these works, eight circles and 41 divisions function under the Chief Engineer. The details of various categories of work and schemes undertaken by this wing are as follows:



Source: JICA Study Team base on the website of the Highways Department
＜http://www.tnhighways.net/pdf/Organisation_Chart.pdf＞(Final access 20 July 2017)

Figure 5.2.3 Organizational Structure of Construction & Maintenance Wing

(2) Works of Construction and Maintenance Wing

1) Comprehensive Road Infrastructure Development Program (CRIDP)

CRIDP was formulated in 2004 to 2005 for the economic and industrial development of Tamil Nadu State. Infrastructure development like widening and improvement of roads; construction of bridges, culverts, protective works, center medians, crash barriers, and drains; road safety works; and formation of bypasses are undertaken in CRIDP. Sanction has been accorded for an amount of INR 15,205 crore in the last five years.

It has been announced that all SHs will be widened to double lanes and all MDRs will be widened to an intermediate lane. Accordingly, large-scale widening was undertaken in the CRIDP. In the last five years, a total length of 913 km of SHs has been widened to double lanes, and a total length of 3,041 km of MDRs has been widened to intermediate lanes.

2) PART-II Scheme

The Part-II scheme is carried out to improve the working environment for employees. It includes the construction/purchase of offices, traveler bungalows, office equipment, laboratory equipment, and software for conducting research. During 2015 to 2016, spill over works of 13 buildings were undertaken for construction. New works have been sanctioned for construction of the office buildings for five divisions, 20 quality control subdivisions, and one traveler's bungalow at a cost of INR 7.50 crore. These works are in progress. During 2015 to 2016, 19 buildings have been completed at a cost of INR 5.78 crore. The revised budget provision of INR 4.00 crore has been allotted for 2016 to 2017.

3) New Works in Chennai Extended Corporation Area

In the Chennai Extended Corporation area, 250 km of roads are taken up under this scheme in the Thiruvallur District and the Kancheepuram District. Works will be taken up for INR 1,033.00 crore. As an initiating step, the government has sanctioned INR 250.00 crore for seven works in SHs, three works in MDRs, and four works in ODRs, and all the works are in progress. In the 2nd phase, INR 150.00 crore has been sanctioned for 2015 to 2016. There are 22 works covering a length of 60.10 km that have been taken up and are in progress. During 2016 to 2017, three works totalling a length of 91.26 km have been completed at a cost of INR 152.72 crore. The revised budget provision of INR 60.86 crore has been allotted for 2017 to 2018.

4) Formation of Bypasses

Bypasses help in reducing traffic congestion in major towns and create a diversion for thorough traffic. There are 13 bypasses that have been completed in the last five years. The present status of bypass works being carried out by this wing are as follows: 13 complete, five in progress, 19 loan agreements (LA) in progress, four Detailed Project Reports (DPRs) in progress, and two under consideration.

5) Railway Over Bridge (ROB) at Railway Level Crossing

Construction of an ROB in Thiruvallur District at a cost of INR 23.30 crore is in progress under the Railway Works Programme (RWP). In Nagapattinam District, the construction of an ROB was completed by the Railway Authorities, and the construction of approaches to ROB was taken up through state funds. This work has been taken up at a cost of INR 12.00 crore and is nearing completion. The construction of ROB in Coimbatore District, under the CRIDP scheme at a cost of INR 20.00 crore, was completed and opened for traffic.

6) Performance Based Maintenance Contract (PBMC)

The PBMC for roads is designed to increase the efficiency and effectiveness of road asset management. PBMC ensures the good condition of the roads, fulfilling the adequate needs of road users throughout the entire period of the contract. This scheme includes initial rectification, periodic renewal, minor improvements, ordinary maintenance, and emergency works.

In the Pollachi Highways Division, PBMC is being implemented in 191.40 km of SHs and 185.98 km of MDRs for a period of five years at a cost of INR 233.93 crore. Initial rectification works for 152.59 km have been completed, periodic renewal works for 81.15 km have been completed, and balance works are in progress.

Subsequently, in the Krishnagiri Highways Division, the maintenance of 307 km SHs and 274 km MDRs are also undertaken through PBMC. A sanction of INR 450 crore was accorded. Initial rectification works for 151.40 km have been completed, and balance works are in progress.

In the Ramanathapuram Highways Division, sanction was accorded for INR 460 crore for the maintenance of 229 km of SHs and 340 km of MDRs under PBMC. Out of the total 196.67 km for initial rectification works, 185.37 km has been completed, and balance works are in progress.

In the Thiruvallur Highways Division sanction was accorded for INR 630.38 crore for the maintenance of 498 km of SHs and 278 km of MDRs under this scheme. Out of the total 211.19 km for initial rectification works, 79.60 km has been completed, and balance works are in progress.

Now, the PBMC scheme will be extended to the Virudhunagar Highways Division in the current financial year.

7) CPRR Development Plan

The Government of Tamil Nadu is in the process of identifying and implementing infrastructure projects. One of the major projects included in Vision 2023 is the CPRR, which was conceptualized to provide better connectivity around the city, catering future traffic requirements and providing efficient commercial transportation by enhancing port connectivity. This road will facilitate container movement from southern districts to Ennore Port.

This road starts at Ennore Port and ends at Poonjeri Junction near Mamallapuram, having a total length of 133 km which is split into five sections as follows:

a) Section-I: Northern Port Access Road – Ennore Port to Thatchur on NH5 (25.11 km)

   Northern Port Access Road-Ennore Port to Thatchur on NH5, 21.51 km, and

   TPP Link Road (original alignment) 4.21 km (new alignment) 3.6 km

b) Section-II: Thatchur on NH5 to start of Thiruvallur Bypass (25.61 km)

c) Section-III: Start of Thiruvallur Bypass to Sriperumbudur on NH4 (29.55 km)

d) Section-IV: Sriperumbudur on NH4 to Singaperumalkoil on NH45 (24.85 km)

e) Section-V: Singaperumalkoil on NH45 to Mamallapuram (27.50 km)

The government has sanctioned INR 10 crore for the preparation of the DPR for this work, which has already been completed. The project cost, including land acquisition, has been worked out to INR 12,301 crore. The proposal for external funding for civil works (85% of construction cost) through JICA has been sent to the central government and is under consideration. Currently, utility mapping on the proposed corridor is being carried out.

8) Formation of Road Grids along Chennai Outer Ring Road (CORR)

The CORR is a major orbital corridor for the Chennai Metro region. Traffic originating from this corridor will have to be provided with an effective dispersal system to link with the radial corridors. Thus, a grid system of roads with radial and orbital linkages have been proposed. Macro grid linkages at 18 locations have been identified, and all these are to be developed in accordance with the stipulations stated in the Second Master Plan of Chennai Metropolitan Development Authority (CMDA).

Out of 18 macro linkages, 15 grids are taken up by the Construction and Maintenance Wing. The government has proposed to create road grids for effective dispersal of traffic originating from the CORR and has sanctioned INR 5.22 crore for the preparation of the DPR. The preparation of the DPR has been completed for 15 road grids.

9) Road Safety Works

A comprehensive proposal to improve the black spots in government roads has been prepared at an estimated cost of INR 1,130 crore. The proposal includes the following engineering measures:

a) widening of narrow culvert (where the width of the culvert is less than the carriage way),
b) widening of narrow culvert (where the width of the culvert is narrow as per the Indian Road Congress (IRC)),
c) realignment of 'S' curve (radius of the curve is less than 90 m),
d) realignment of 'S' curve (radius of the curve is more than 90 m),
e) construction of safety wall/crash barrier around the road side open well/tank bunds,
f) construction of safety wall/crash barrier along high embankment,
g) construction of safety wall/crash barrier in ghats roads,
h) construction of center median,
i) provision for road furniture (gantry boards, studs, delineators, and center line marking), and
j) junction improvements.

The above road safety works are being implemented in a phased manner. During 2015 to 2016, 2,113 works have been completed at an expense of INR 99.57 crore. During 2016 to 2017, INR 150 crore under the CRIDP scheme for road safety works and INR 100 crore under the road safety fund was proposed.

10) Non-Plan Maintenance Works

During 2016 to 2017, an allocation of INR 859.27 crore has been made for the maintenance of roads and bridges, and 2,862 km of roads has been completed at an expense of INR 805.57 crore. Budget provision of INR 897.24 crore has been made for 2017 to 2018.

5.2.4 Tamil Nadu Road Development Company Ltd (TNRDC)

(1) Outline of TNRDC

TNRDC was established in 1998 as a 50:50 joint venture between government-owned Tamil Nadu Industrial Development Corporation Ltd (TIDCO) and private Infrastructure Leasing and Financial Service Ltd (IL&FS). Later in 2009, government-owned TIDEL Park Ltd (TIDEL) acquired the entire equity held by IL&FS, making it a completely government-owned entity.

The mandate of TNRDC is to develop initiatives in the road sector by catalyzing private sector resources and investments under the PPP framework. TNRDC's activities span the entire project from project conceptualization to implementation, operations, and maintenance. The core strength of TNRDC is in formulating appropriate implementation and financing strategies for infrastructure projects so that they are

implemented in an efficient and time bound manner while adhering to the costs and quality.

IT Expressway Ltd (ITEL) was incorporated by TNRDC in the year 2004 as its wholly government-owned subsidiary for the implementation of the IT Corridor Project, with a shareholding pattern of 77% by TNRDC and balance 23% by TIDCO.

TNRDC is managed by the board comprising the nominees of the government, TIDCO, TIDEL, and an independent director. ITEL, being a government-owned investment vehicle, and TNRDC as its managing associate is responsible for project implementation, operations, and maintenance of the IT Corridor.

(2) Works of TNRDC

The company is responsible for the implementation of projects that are viable on a standalone basis or of projects that are marginally viable as a principal project sponsor. For projects that are socially and economically relevant but cannot be implemented under a commercial format, the company provides a range of services to the respective project sponsors on a on-fee basis.

1) Chennai Outer Ring Road (CORR)

The Government of Tamil Nadu has decided to provide a major connectivity corridor on the western side to ease congestion and to allow for free and quick flow of traffic. Administrative sanctions have been accorded for the development of the CORR Project Phase-1 as a green field project with the formation of dual three lanes with service roads for a length of 29.65 km from Vandalur in NH45 to Nemilichery in NH205 via Nazarathpet in NH4 at a cost of INR 1,081.40 crore. Land acquisition for this greenfield project has been done by the CMDA.

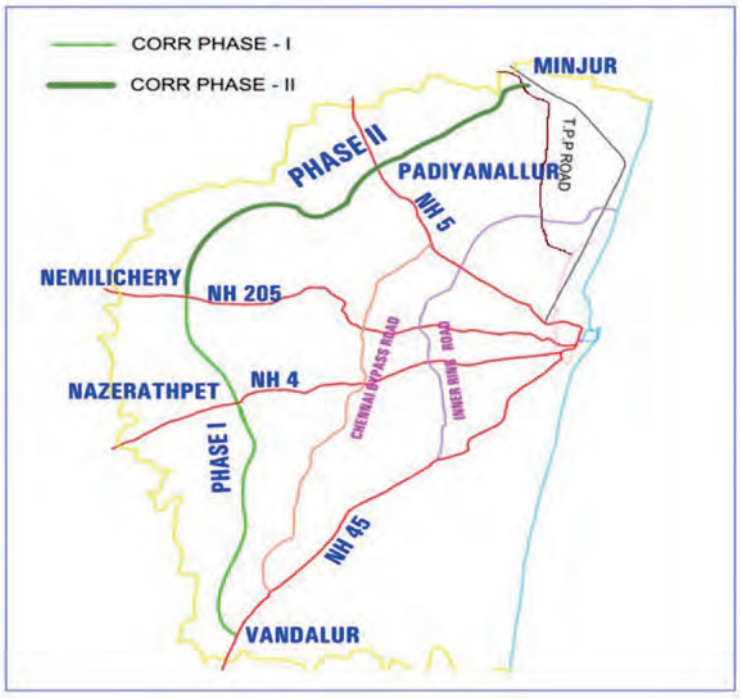
The implementation of this project was awarded to M/s GMR Outer Ring Road Pvt. Ltd (a consortium of M/s GMR Infrastructure Ltd, M/s GMR Energy Ltd, and M/s NAPC Ltd), on a Design-Build-Finance-Operation-Transfer (DBFOT) semi-annuity basis, through an ICB process. The concession period will be 20 years, consisting of two and a half years of construction period and 17½ years of operations and maintenance period.

The completed portion of the project, with a total length of 27.00 km from Mannivakkam to Nemilichery, was inaugurated on 28 August 2014 and was opened to public. At present, 97% of works have been completed. The land acquisition process was expected to be completed by September 2016, and the remaining 3% of works were targeted to be completed by September 2017.

The government has sanctioned the CORR Phase-II, a major six-lane road connectivity project, to a length of 30.50 km from Nemilicheri in NH205 to Minjur in TPP Road via Padiyanallur in NH5 at a cost of INR 1,075 crore under the Design-Build-Finance-Operate-Transfer (DBFOT) mode with semi-annual annuity payment in the same model as that of Phase-I. Phase-II of the project started on 28 August 2014.

The work has been awarded to M/s GVR Ashoka Chennai Outer Ring Road Ltd, with the concession period of 20 years comprising of two and a half years of construction period and 17½ years of operations and maintenance period.

At present, 82% of works have been completed, and the remaining works are in progress. The project should be completed by September 2016 as per the concession agreement, but due to heavy rainfall in November and December 2015 resulting in heavy floods, the project is likely to be extended.



Source: JICA Study Team base on the website of Highway Department
＜http://www.tnhighways.net/pdf/Organisation_Chart.pdf＞(Final access 20 July 2017)

Figure 5.2.4 Location Map of Chennai Outer Ring Road (CORR)

2) Ennore Manali Road Improvement/Chennai Ennore Port Road Connectivity

The Project envisages the improvement of about 30 km of road network in North Chennai with the objective of establishing seamless and efficient road connectivity from Chennai Port and Ennore Port to the NH network. The roads that are being improved include the Ennore Expressway, the Manali Oil Refinery Road, the northern part of IRR, and the TPP Road.

NHAI, the project lead sponsor, has engaged TNRDC as its managing associate and subsequently as its supervision consultant. As of late, 93% of works have been completed, and the remaining works will be completed soon.

3) Improvement of North Chennai Thermal Power Station Road and Ennore Port Road

Toshiba, a Japanese concern-JSW Turbine and Generator Pvt. Ltd., (JV) has set up a manufacturing plant on the TPP Road. Shipments from this manufacturing unit should be transported by a special heavy transport vehicle (525 MT) which needs to travel 7.35 km on the TPP Road, 4.8 km on North Chennai Thermal Power Station (NCTPS) Road, and 2.4 km on the Ennore Port Road to reach the Ennore Port. Among these three roads, the TPP Road which is part of the Ennore Manali Road Improvement Project (EMRIP), is being improved in the project.

TNRDC is the managing associate for the project in the other two roads (i.e., North Chennai Thermal Power Station Road and Ennore Port Road).

This is a unique project wherein the roads and bridges are designed to sustain 525 MT, especially over-designed shipment for the first time in Tamil Nadu State. The railway bridge also faces massive technical challenges because of the difficult terrain and because its location is near the sea. All these challenges were overcome successfully, and all the bridges have been completed and tested successfully.

All works have been completed and were inaugurated on 14 February 2016. Toshiba successfully transported the manufactured equipment from its plant by a special transport vehicle carrying over-dimensional cargo through the project roads and bridges to the Ennore Port on 11 April 2016.

4) Northern Port Access Road (NPAR) (CPRR Phase-I)

The proposed the NPAR is an important link to the fast growing Ennore Port and Kattupalli Port, which handle major cargo movements. The proposed new road will connect the northern gate of Ennore Port and Thatchur on NH5 with an additional spur road linking the TPP Road.

This will also cater to the needs of the recently developed Kattupalli Port by L&T. The total length of this road connecting the Ennore Port to Thatchur is about 21.15 km, and length of the TPP link Road is 4.35 km. Two phases are proposed. Phase-I totals 10.550 km and consists of the construction of the road from the Ennore Port entrance to Neidavoyal Village, from Neidavoyal Village to the Vallur link road (km 4.350); and Phase-II consists of the construction of the remaining 14.95 km from Neidavoyal to Thatchur in NH5.

On 19 February 2016, HMPD accorded an administrative sanction for the NPAR for a sum of INR 951 crore towards land acquisition in 15 villages of Ponneri Taluk in Thiruvallur District. Land acquisition is ongoing.

5) Improvement and Widening of East Coast Road into a Four-Lane Road

The East Coast Road from Akkarai to Koonimedu on the outskirts of the Puducherry State limit was initially improved to a two-lane carriageway with hard shoulders and was maintained by TNRDC as a toll road on 24 March 2002. The increasing traffic intensity is the cause of increased accident rates in the absence of a center median. Besides, the insufficient carriageway necessitated the widening of this road to four lanes with divided carriageway from Akkarai to Mamallapuram as Phase I, including the geometric improvements to curves and junctions between the border of Mamallapuram and Puducherry.

Accordingly, an administrative sanction was accorded by the government for INR 272.10 crore. Out of this, a sum of INR 108.84 crore was set by the government as the Viability Gap Fund (VGF), which is 40% of project cost to TNRDC. The balance should have been mobilized by TNRDC.

Works commenced on 28 February 2014, and 77% have been completed and further works are in progress. Out of the 13-curve improvement works, seven works have been completed, and out of seven junction improvement works, three are completed. The balance works are held up owing to the order of the Honorable National Green Tribunal (southern zone).

5.2.5 Tamil Nadu Road Infrastructure Development Corporation (TNRIDC)

(1) Outline of TNRIDC

TNRIDC was established in 2005 as a non-profitable organization to implement, upgrade, and maintain road infrastructure in the Tamil Nadu State. The Oragadam Industrial Corridor project and the four-laning project of the Madurai Ring Road are being implemented by the TNRIDC.

(2) Works of TNRIDC

1) Oragadam Industrial Corridor Project

Oragadam and Sriperumbudur are the largest and most developed industrial areas in Kancheepuram District. The four State Industries Promotion Corporation of Tamil Nadu Ltd (SIPCOT) units, having several prominent Indian and multinational companies, six global car manufacturing companies, and the National Automotive Testing Research Infrastructure Project (NATRIP) are situated in and around Oragadam and Sriperumbudur.

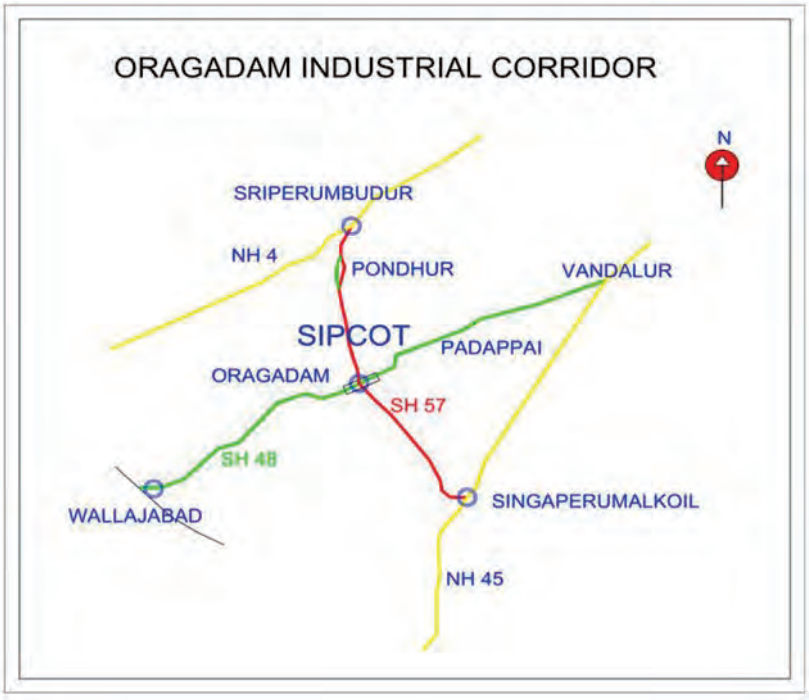
Considering the speedy development of industries in and around Sriperumbudur in Kancheepuram District, it was decided to improve the road infrastructure facilities for the Oragadam Industrial Park.

Out of the 57.40 km length of the Oragadam Industrial Corridor Project, 55.10 km had been completed in the Phase-I work. The remaining 2.30 km will be completed after finishing land acquisition. The construction of a grade separator at the Oragadam junction has been completed and is in public use. The total expenditure incurred in Phase-I is INR 463.00 crore, which includes an expenditure of INR 184.62 crore for the land acquisition.

In Phase-II, out of 12.00 km, 11.20 km (excluding the Sriperumbudur and Mathur LA stretches) has been completed in March 2016, and the remaining 0.80 km will be done after the completion of land acquisition. An expenditure of INR 96.41 crore has been incurred so far.

Phase-III works will be completed during this financial year. Out of 16.60 km in the Phase-IV, a 4.20-km

work is in progress in various stages. Phase-IV works will be completed in the next financial year.



Source: JICA Study Team base on the website of the Highways Department
＜http://www.tnhighways.net/pdf/Organisation_Chart.pdf＞(Final access 20 July 2017)

Figure 5.2.5 Location Map of Oragadam Industrial Corridor

2) Four-Laning of Madurai Ring Road

The Madurai Ring Road, having a total length of 27.20 km, is the main arterial road with two lanes and caters to the Madurai City traffic. There is heavy traffic flow in this road due to the connectivity provided by the Rameswaram Road (NH49), Tuticorin Road (NH45B), Tirunelveli Road (NH7), and Thondi Road (NH230).

The four-laning work of the Madurai Ring Road is implemented through TNRIDC under BOT (toll) scheme at a cost of INR 213.69 crore during the fiscal year 2015 to 2016. The existing two-lane road is proposed to be transformed to a four-lane road by widening both sides to have a 9.0-m carriageway on either side with a center median of 1.20 m. Furthermore, it involves the widening of two railway-over-bridges and one river bridge. The project is to be executed under the BOT basis with suitable VGF.

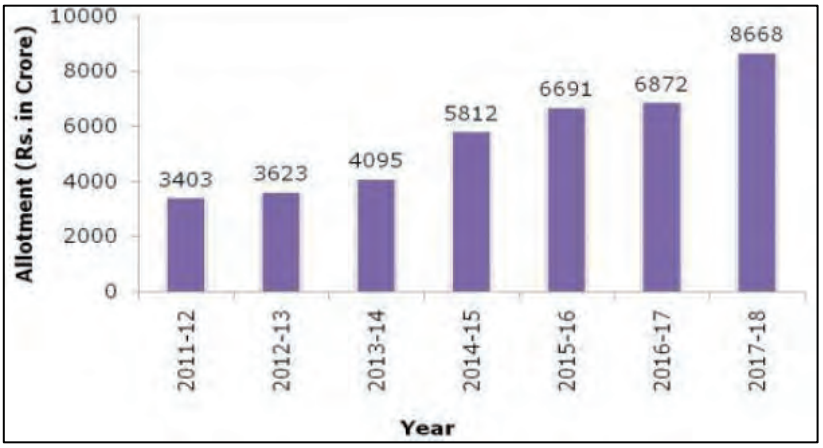
For this work, an agreement has been executed, and preliminary activities are in progress. The concessionaire is in the process of finalizing the financing arrangements. After which, construction work will commence.

5.3 Financial Situation of the Highways Department

5.3.1 Changes in Annual Financial Allotment

The figure below shows the growth of financial allotment to the road sector of the Tamil Nadu State. The financial allotment has significantly increased during the past ten years, i.e., multipliedd three times. This increase has contributed to the overall improvement of the state road network. The increased allocation has aided in achieving the policy of the state government to upgrade all SHs into two-lane roads at least. This has resulted in improved road safety conditions. The latest statistics (Road Accidents in India 2015 by MORTH) reveals that the severity of accidents (the number of fatalities per 100 accidents) in Tamil Nadu State is 22.7, which is lower than the national average of 29.1. Further, while at the national level, fatal accidents have generally increased by 5.7% comparing the 2012 and 2015 data, whereas in Tamil Nadu State,

it has reduced by 3.3%.

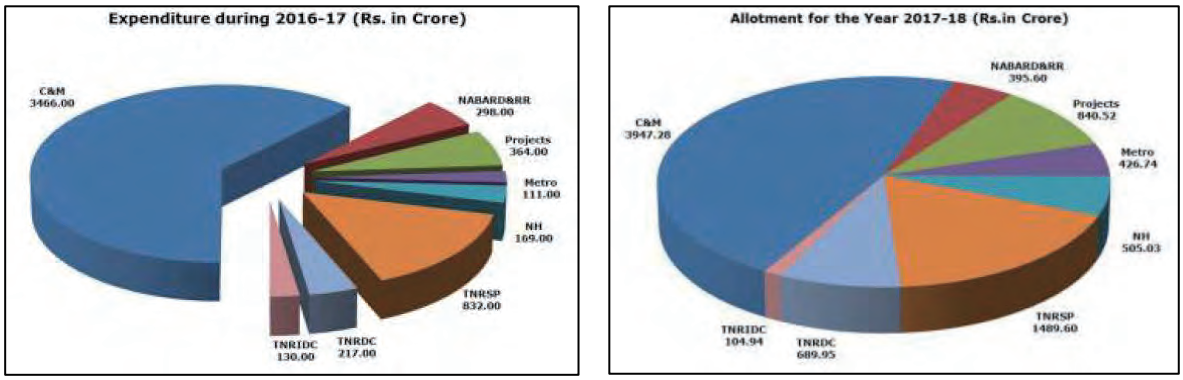


Source: Policy Note 2017-2018, HMPD

Figure 5.3.1 Changes in Annual Financial Allotment to the Highways Department

5.3.2 Breakdown of Annual Financial Allotment

The Highways Department constructs and maintains roads in various schemes, utilizing funds from the state, and central and external funding agencies. For 2016 to 2017, INR 6,875.40 crore has originally been allotted to the Highways Department for implementation of planned works. Later, in the revised budget estimate, the allocation has been reduced to INR 6,255.67 crore, of which an expenditure of INR 5,588.09 crore have been incurred (89%). A total of INR 6,871.87 crore was allotted in the Revised Budget Estimate to the Highways Department for 2017 to 2018.



Source: Policy Note 2017-2018, HMPD

Figure 5.3.2 Breakdown of Annual Financial Allotment to the Highways Department

The acronyms in Figure 5.3.2 stand for respectively as follows:

C&M	: Construction and Maintenance
TNRDC	: Tamil Nadu Road Development Company
TNRIDC	: Tamil Nadu Road Infrastructure Development Corporation
NABARD	: Execution of bridges and roads with loan assistance from the National Bank for Agriculture and Rural Development (NABARD)
PROJECTS	: Road over and under bridges at railway level crossings and major bridges
METRO	: Execution of Chennai Metropolitan Development Plan (CMDP) works
NH	: National Highway

TNRSP : Road upgradation works with World Bank assistance

HRS : Highway Research Station

5.3.3 Non-Plan Maintenance Works

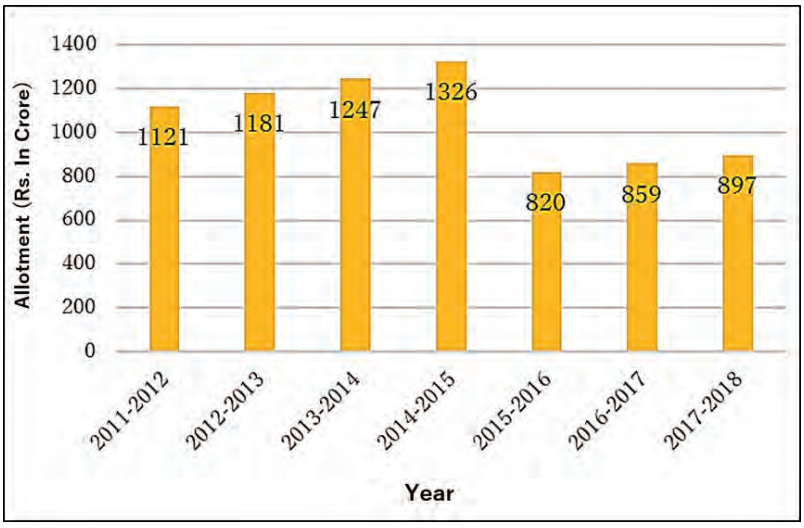
During 2016 to 2017, an allocation of INR 859.27 crore has been made for the maintenance of roads and bridges and for the renewal of 2,862 km of roads.

The financial performance indicating the details of expenditure incurred during 2016 to 2017 under various heads of non-plan maintenance works and the allocation for 2017 to 2018 is given in Table 5.3.1.

Table 5.3.1 Non-Plan Financial Allocation and Expenditure (Rs. in Lakhs)

No.	Name of Scheme	2015-2016		2016-2017 Revised Budget Estimate
		Budget Estimate	Expenditure	
1	NH (Urban)	234.52	234.52	234.52
2	Certain important roads in Chennai City taken from the Corporation of Chennai	2,110.64	2,100.00	2,110.64
3	SH	15,984.22	16,406.31	16,667.10
4	MDR	14,439.01	13,965.34	15,197.74
5	ODR	51,219.67	46,213.11	53,571.73
6	Sugarcane Roads	1,849.79	1,549.93	1,849.79
7	Improvements to Nigiris Ghat Roads	90.00	87.96	92.35
	Total	85,927.85	80,557.17	89,723.87

Source: Performance Budget 2016-2017, Highways Department



Note: Since the central government grant for rural road maintenance ended, the allotment in and after 2015-2016 has decreased.
Source: JICA Study Team

Figure 5.3.3 Changes in Annual Financial Allotment to the Highways Department for Non-Plan Maintenance

5.4 Recent Model Contracts for Operations and Maintenance in India

5.4.1 Performance Based Maintenance Contract (PBMC)

(1) Features of the PBMC Contract

The Tamil Nadu State Highway Department used to contract out road maintenance works to private contractors on a single fiscal year basis. The contracts, however, are currently being replaced with the PBMC model.

PBMCs are not new to the transport sector, with many variations used in different countries for the past two decades. International lending institutions, such as the World Bank, have played a significant role in pushing PBMCs into developing nations as part of loan assistance packages.

The contractor in a road PBMC is paid on an output basis (i.e., maintaining the road at a specified service standard) rather than on an input basis as in traditional maintenance contracts.

PBMCs have several benefits over traditional input-based contracts. By paying contractors based on the level of service they deliver, output based contracts provide a clear financial incentive for contractors to meet performance standards. Private contractors are also incentivized to improve their efficiency and minimize cost because they are paid at a set level for performance, not based on the value of the inputs used.

Durations of PBMCs are usually longer than traditional maintenance contracts, which incentivize private contractors to take measures that improve the road conditions for the duration of the contract rather than on ad hoc repairs. Longer maintenance contracts also commit governments to fund maintenance for several years, reducing the risk of delaying maintenance for budget reasons. Tamil Nadu State has adopted five years.

The Public-Private Infrastructure Advisory Facility (PPIAF)[1] has addressed five key lessons learned in designing and implementing road PBMCs as follows:

a) Successful performance-based contracts require sufficient dedicated fiscal resources and realistic performance expectations.

b) Private operators may need training and capacity building to bid for and implement performance-based contracts.

c) Clear baseline data is needed to establish and monitor performance indicators and standards.

d) Simple performance indicators and user monitoring can improve contract performance.

e) Vehicle overloading is a major challenge to implementing effective output-based maintenance contracts.

According to the pre-qualification document of the "Performance Based Maintenance Contract for Five Years for State Highways and Major District Roads in Pollachi (H) C&M Division", bidders must demonstrate that they own or have assured ownership for the key equipment. It is only the minimum level of suggested major equipment, however, notwithstanding the above, wherein the contractor shall be required to provide all necessary items and equipment, as well as plants and materials to carry out the prescribed works within the required timeframes.

Table 5.4.1 Minimum Mandatory Requirement of Plant and Equipment

No.	Equipment Type and Characteristics	Minimum Number Required
1	10-ton Tipper Truck	15
2	Loader/Back Hoe (0.5 m^3 bucket)	3
3	Excavator (0.75 m^3 bucket)	3
4	Asphalt Plant (60 ton/hr capacity)	3
5	Mechanical/Sensor Asphalt Paver (3.5 m)	3
6	Bitumen Distributor (2,000 liter)	3

[1] The Public-Private Infrastructure Advisory Facility (PPIAF) is a multi-donor technical assistance facility that is financed by 11 multilateral and bilateral donors. It was established in 1999 as a joint initiative of the Governments of Japan and the United Kingdom, working closely with and housed inside the World Bank Group.

No.	Equipment Type and Characteristics	Minimum Number Required
7	Motorized Grader (min. 120 hp.)	3
8	Water Bowser	3
9	8-10-ton Vibratory Steel Drum Roller	3
10	12-ton Pneumatic Tired Roller	3
11	Vibrating Plate/Rammer	3
12	Emulsion Sprayer	3
13	Tractor or Rubber Tired Dozer with Adjustable Back Blade	3
14	Mini Vibrating Roller	3
15	Tandem Roller	6
16	Power-broom or Tractor Mounted Compressor	3
17	6-ton Truck for Patrol Maintenance Unit	2
18	Concrete Mixer Machine with Bucket Loader	4

Source: Performance Based Maintenance Contract for Five Years for State Highways and Major District Roads in Pollachi (H) C&M Division

(2) Issues in India

Currently, four road sections in Tamil Nadu, namely Pollachi (SH 191.40 km and MDR 185.98 km), Krishnagiri (SH 307 km and MDR 274 km), Ramanathapuram (SH 229 km and MDR 340 km), and Thiruvallur (SH 498 km and MDR 278 km), totaling SH 1,225.4 km and MDR 1,077.98 km, are being maintained under PBMCs and are getting assistance from the World Bank. The contracts include the following five components:

a) Ordinary (or routine) maintenance: paid as a lump sum evenly divided into 60 monthly payments (five years)

b) Initial Rectification Works: to be completed within the first six months to bring the road to below intervention standards; initial rectification works is a firm lump sum that will be measured and paid on the actual works output

c) Periodic Maintenance: paid based on a schedule when work is completed

d) Minor Improvement Works: paid based on a schedule when work is completed

e) Emergency Works (day works): paid on a unit rate basis for time/quantity used when ordered

The first PBMC came into the road sections in Pollachi in 2014, and it is still early to evaluate the contract effectiveness. The conventional single-year maintenance contract, however, requires about three months (April to June) to prepare tendering, and the actual maintenance work starts only after July. Regarding the practicability of continuous maintenance work over several years, the Construction and Maintenance Wing, which oversees the maintenance of SH and MDRs, highly appreciate the new contract.

As addressed by PPIAF, it is a prerequisite to clearly indicate expected performances and corresponding prices for a successful PBM contract. Expected performances are often called as Key Performance Indicators (KPIs). These indicators, however, vary with road categories, importance of locations, and local economic activity situations and are required to have a baseline for performances and costs. Then, by monitoring actual performances, it is possible to determine the appropriate KPIs. It is necessary to carefully monitor current PBMC performances together with corresponding prices for the coming years to establish PBMCs in India.

5.4.2 Operation-Maintenance-Transfer (OMT) Contract

(1) Features of the OMT Contract

Regarding road projects awarded on a PPP contract, completed road stretches are operated and maintained on a long-term basis by the concessionaires. Whereas for road stretches constructed through public-funded projects, the central and state road authorities undertake operations and maintenance (O&M) through item-rate-based short-term contracts, which entailed excessive monitoring burden on road authorities. Besides, in the past, repair and maintenance of roads have not received the fair attention it requires primarily due to the lack of funds available for O&M. Furthermore, there are separate contracts for O&M and tolling, often leading to multiplicity of contracts and huge monitoring requirements.

In 2009, authorities introduced a new contract concept, the OMT contract, combining a tolling contract and a contract for O&M and drastically reducing the number of contracts by integrating multiple road section contracts together. Under the OMT Contract, the primary objective is to outsource the O&M of the road to a private entity for a definite concession period. OMT contracts include each construction work of toll plazas, toll collection, and O&M. The concession period is basically nine years considering the renewal period of road facilities. After which, the concessionaire must transfer the project stretch back to the government authorities.

The selection of the concessionaires is based on competitive bidding where selected bidders specify the concession fee they offer to the authority, or in some cases the O&M support required if their operational expenditures exceed the toll revenues expected.

The response from the private sector to OMT contracts has been very strong. Between 2009 and 2014, NHAI awarded a total of around 2,400 km of NH (12 projects) to be maintained on an OMT basis. State authorities that followed the suite include Maharashtra State Road Development Corporation, Madhya Pradesh State Road Development Corporation, Karnataka Road Development Corporation, and Bihar State Road Development Corporation.

(2) Issues in India

The central government has taken the lead in promoting the OMT contract. In 2012, the OMT policy was approved and a model concession agreement (MCA) for OMT contracts was drafted. The tolling policy for NH was also revised along with finalization of the standardized technology. New policies and many projects at the national and state levels have been providing a wide range of business opportunities for OMT contractors, equipment manufacturers, and material suppliers.

The OMT contract has gained momentum in the roads sector. Governments at both central and state levels have emphasized on outsourcing OMT to private service providers. Many OMT projects have been identified and awarded at both central and state levels.

However, some key issues need to be resolved to sustain growth. Some identified issues include risk allocations between highway authorities and OMT players, lack of expertise in tolling and O&M, delay in handing over the project road to OMT players, lack of coordination between related agencies, incomplete sections of project road, mismatch in delivery timelines between EPC and OMT contracts, lower traffic growth on some project stretches, and the short concession period of nine years.

5.4.3 Toll-Operate-Transfer (TOT) Contract

(1) Features of the TOT Contract

The Cabinet Committee on Economic Affairs (CCEA) approved the Toll-Operate-Transfer (TOT) Contract in August 2016. Then, CCEA has authorized NHAI to monetize 75 public funded NHs that are operational and that have been generating toll revenues for at least two years. According to the rating agency ICRA Ltd, these 75 projects with a road length of 4,376 km can yield around INR 35,600 crore.

The TOT Contract is also aimed at overcoming some limitations of the OMT model, which include a relatively short concession period of nine years in principle depending on when the major period maintenance is due, the restriction of participation only to contractors and developers, and a high level of toll exemptions.

The TOT Contract is designed to monetize public-funded operational toll-based roads on the condition that the roads have been generating revenues for a minimum of two years after the commercial operation

date. In the bidding of the TOT Contract, concession fees for the O&M and the tolling of NH will be auctioned to domestic and international players. This way, the TOT model helps secure future cash inflows and utilize those for creation of new road assets. The model produces one-time monetization of the concession fee of tolls with an established traffic for the coming 30-year concession term.

The TOT model also offers new business opportunities to new investors in partnership with developers specializing in O&M of highways. It will open doors to various categories of investors such as institutional investors, insurance funds willing to invest in low-risk assets, and the like. Although these investors do not want to take road construction risks, they are ready to make long-term investments in completed toll roads that are producing revenue.

The first bunch of toll roads to be monetized on a TOT Contract comprises nine roads spanning 680 km across the states of Andhra Pradesh and Gujarat and will be bid out for a tenure of 30 years. According to the bid document, the concession period of 30 years could be reduced by more than five years or be increased by more than ten years based on a mutual consent of both concessionaire and NHAI.

Under the TOT contract, the rights of collection of toll fees on selected NH are proposed to be auctioned and assigned to a concessionaire for a period of 30-years against an upfront payment of a lump-sum amount to the government. The concessionaire is responsible for the O&M and tolling of the NH during the tenure.

According to MORTH, the project has drawn interest from several international investors including Abu Dhabi Investment Authority (ADIA), Singapore's Sovereign Wealth Fund GIC Pte. Ltd, Singapore's state-run investment firm Temasek Holdings Pte. Ltd, Hastings Funds Management Ltd, Keppel Infrastructure Fund Management Pte. Ltd, Mizuho Asia Infra Capital, Macquarie Group Ltd, Morgan Stanley Infrastructure Inc., Equirus Capital Pte. Ltd, I Squared Capital Advisors LLC, JP Morgan Asset Management Inc., and Infrastructure Leasing & Financial Services Ltd.

(2) Issues in India

The TOT Contract has already been tested internationally including the Chicago Skyway, the Indiana Toll Road, the Puerto Rico Highway PR-22, and the Malaysian Penang Bridge with concession periods ranging between 40 and 99 years. The responsibility of O&M of the road lies with the TOT concessionaire. Though the TOT model is yet to be practically introduced to India, it is important to ensure sound implementation by making contract procedures transparent to all stakeholders.

Issues that need to be tackled during the implementation of the TOT model should include duration of concession periods, minimum portfolio size, contract termination payment clause, and capacity augmentation after project awarding. It is also required to address prevailing issues in the Indian road sector such as the lack of trained manpower, ambiguous certification process, neglect of safety parameters, high rate of toll exemptions and leakages, and unstable regulatory environment. It is also advisable for TOT players to enhance their technical capacity by positively introducing efficient intelligent transport system (ITS) and effective O&M methodology practiced internationally.

5.4.4 Engineering-Procurement-Construction (EPC) Contract (Maintenance Clause)

(1) Features of the EPC Contract

The Government of India has decided to build NH primarily under PPP since 2005 and has been using the BOT model for the procurement contracts. However, the Government of India has been facing problems such as the following:

a) frequent cost and time overrun because of aggressive bidding,

b) stretched financial position of road developers, and

c) decelerating global and domestic economic growth.

These problems adversely affect the further development of the NH projects, and the Government of India has frequently had unsuccessful biddings as well as contractual defaults one after another. These situations have led to a review of the contract models. MORTH has decided to shift from the PPP models, which use the financial procurement by road developers, to road construction using government funds.

Since the 1980's, the Government of India ceased the use of the conventional contract model of design-bid-build (DBB), which is generally accepted around the world. Instead, the government conducted research to develop new models. As a result, the "Standard Agreement for Road & Bridge Works on Engineering-

Procurement-Construction (EPC) Model" was developed in 2012, referring to the "Conditions of Contract for EPC/Turnkey Projects (1/1999)" by FIDIC. The rate of the application of the Indian version of the EPC for national highway projects in the country has gradually been increasing since 2012.

The EPC contract obligates the contractor to maintain the Project Highway for a period of four years, commencing from the date of the provisional certificate[2]. For the performance of its maintenance obligations, the contractor shall be paid 0.5% of the contract price for the first year and 1%, 1.5%, 2% for the second, third, and fourth year, respectively. In case of a standalone project like a bridge, the rates of the payment are 0.25%, 0.5%, 0.5%, and 0.5%.

The contractor shall be responsible for all defects and deficiencies until the expiry of the 4-year period commencing from the date of the provisional certificate. The defects and liability period shall in no case be less than 42 months from the date of the completion certificate. The defects and liability correlate with the maintenance obligations, and the period is also four years.

Regarding the maintenance of the project road, the contractor will be responsible for four years after completion of the construction. The contractor will be obliged to prepare (in consultation with the independent engineer) a maintenance program, ten days prior to the month in which the O&M will commence. The contractor will also be obliged to conduct a road inspection together with the independent engineer. The required maintenance level shall be based on the Schedule-E maintenance requirement of the contract. The contractor's obligation based on the contract will include the following items during the period of the maintenance:

a) permitting safe, smooth, and uninterrupted flow of traffic on the project highway;

b) undertaking routine maintenance including prompt repairs of potholes, cracks, joints, drains, embankments, structures, pavement markings, lighting, road signs and other traffic control devices;

c) undertaking repairs to structures;

d) informing the authority of any unauthorized use of the project highway;

e) informing the authority of any encroachments on the project highway; and

f) operations and maintenance of all communication, patrolling, and administrative systems necessary for the efficient maintenance of the project highway in accordance with the provisions of the contract

The contractor shall ensure and procure that, during the maintenance period, the project highway conforms to the maintenance requirements set forth in Schedule-E (the "Maintenance Requirements").

(2) Issues in India

The EPC Contract was introduced in 2012, and there exists only a few experiences of O&M under the contract. Issues should be identified while accumulating experience. The following are some issues that should be addressed to smoothly implement O&M under the EPC contract model successfully in the future.

The major part of the EPC contract is road construction. The part of O&M is only 3%, totaling four years after completion of the construction. The major concerns of the contractor, therefore, centers on the construction part, and the contractor is not necessarily well-versed in O&M. Moreover, the duration of O&M is as short as four years, and the contractor may have difficulty in planning O&M equipment and manpower from the long-term viewpoint.

The four-year term of O&M and liabilities for defects and deficiencies is longer than international practices and should be shortened by half. The road will be transferred to the road administrator after the completion of the term, then the road administrator will decide whether they will maintain the road directly or outsource the O&M to private entities. There is a marked tendency to outsource road O&M to private companies in India, and the Tamil Nadu State has been positively introducing Performance Based Maintenance (PBM) contracts.

Other outsourcing methods of road O&M include the OMT Contract and the TOT Contract, which are

[2] MORTH. 2017. Article 14.1 Maintenance obligation of the Contractor: *EPC (Engineering Procurement and Construction) Agreement for Construction of Two-Lane National Highway Works*. New Delhi

about to accumulate experience in India and are expected to be effective O&M contracts in the future.

5.4.5 Public-Private-Partnership (PPP) Contract (Maintenance Clause)

(1) Features of PPP Contract

The scope of a PPP Contract includes O&M of the project road during the concession period in accordance with the provision of Article 17 "Operation and Maintenance". The details are stated as follows:

> 17.1 O&M Obligations of the Concessionaire
>
> 17.1.1 During the Operation Period, the Concessionaire shall operate and maintain the Project in accordance with this Agreement either by itself, or through the O&M Contractor and if required, modify, repair or otherwise make improvements to the Project to comply with the provisions of this Agreement, Applicable laws and Applicable Permits, and conform to Specifications and Standards and Good Industry Practice. The obligations of the Concessionaire hereunder shall include:

a) Procuring and ensuring safe, smooth, and uninterrupted use of the Project, including prevention of loss or damage thereto, during normal operating conditions

b) Minimizing disruption in the event of accidents or other incidents affecting the safety and use of the Project by providing a rapid and effective response and maintaining liaison with emergency services of the Sate

c) Carrying out periodic preventive maintenance of the Project

d) Undertaking routine maintenance including prompt repairs of potholes, cracks, joints, drains, embankments, structures, markings, lighting, signage, and other control devices

e) Undertaking major maintenance such as resurfacing, repairs to structures, and repairs and refurbishment of system and equipment

f) Preventing, with the assistance of concerned law enforcement agencies, any unauthorized use of the Project

g) Preventing, with the assistance of the concerned law enforcement agencies, encroachments on or unauthorized entry to the Project

h) Protection of the environment and provision of equipment and materials thereof

i) Operations and maintenance of all communication, control, and administrative systems necessary for the efficient operation of the project and for providing safe, smooth, and uninterrupted use of the Project

j) Maintaining a public relations unit to interface with and attend to suggestions from the users, government agencies, media, and other agencies

k) Complying with safety requirements in accordance with Article 18

The concessionaire shall procure that at all times during the operation period, the Project conforms to the maintenance requirements set forth in Schedule-K (the "Maintenance Requirements).

(2) Issues in India

Long concession periods under PPP contracts may affect the O&M of the projects. O&M under a PPP Contract entails the work during the entire contract period, which are usually long, ranging from 15 to 30 years. It is difficult to accurately predict some important factors for a long period such as economic fluctuation, traffic volume increase rate, change in road users' response to toll, change in government policy on toll roads, etc. In the past, India saw some cases of PPP Contract termination due to various reasons. Some examples include the following: the actual traffic volume was much lower than expected; the contractor was unable to solve prevailing long queues in front of the toll plaza; and the road users started a strong and large campaign against tolling.

When the actual traffic volume is lower than expected, the effect on O&M can be severe. If toll revenue decreases, a loan repayment receives preferential treatment from the toll revenue, and allotment to O&M gets smaller resulting in lower quality of O&M.

Inefficient O&M also affects the quality of O&M in great deal. Efficient O&M involves such practices as effective measures against overloaded vehicles and accidents, effective measures against natural disaster using preventive management, efficient O&M with an asset management system, efficient O&M with application of ITS, etc. The lack of efficient O&M results in higher cost and lower quality in O&M.

Appropriate supervision of concessionaires by road administrators influences the quality of O&M as well. Since the present maintenance requirements carries item-wise repairs on identified defects, it involves long-time and laborious work for road administrators to oversee concessionaires, whether or not concessionaires are conforming to the maintenance requirements. It is needed to simplify the work for the road administrators to oversee the PPP concessionaires.

5.4.6 Maintenance Requirements (Schedule-K in PPP and Schedule-E in EPC)

(1) Maintenance Requirements

The Concessionaire shall, always maintain the project highway in accordance with the provisions of the agreement, applicable laws and applicable permits. The concessionaire shall, always during the operation period, conform to the maintenance requirements set forth in the schedule (the "Maintenance Requirements").

The Concessionaire shall repair or rectify any defect or deficiency set forth in Paragraph 2 of the Schedule-K within the time limit specified therein and any failure in this behalf shall constitute a breach of the agreement. Upon occurrence of any breach hereunder, the Authority shall be entitled to recover damages as set forth in Clause 17.8 of the agreement, without prejudice to the rights of the Authority under this agreement, including termination thereof.

(2) Repair/Rectification of Defects and Deficiencies

The obligations of the Concessionaire with respect to the maintenance requirements shall include repair and rectification of the defects and deficiencies specified in Annex-I of Schedule-K within the time limit set forth therein.

(3) Other Defects and Deficiencies

With respect to any defect or deficiency not specified in Annex-I of Schedule-K, the Concessionaire shall undertake repair or rectification in accordance with good industry practice and within the time limit specified by the Independent Engineer.

With respect to any defect or deficiency not specified in Annex-I of Schedule-K, the Independent Engineer may, in conformity with good industry practice, specify the permissible limit of deviation or deterioration with reference to the specifications and standards, and any deviation or deterioration beyond the permissible limit shall be repaired or rectified by the Concessionaire within the time limit specified by the Independent Engineer.

(4) Extension of Time Limit

Notwithstanding anything to the contrary specified in Schedule-E, if the nature and extent of any defect or deficiency justifies more time for its repair or rectification than the time specified herein, the Concessionaire shall be entitled to additional time in conformity with good industry practice. Such additional time shall be determined by the Independent Engineer and conveyed to the Concessionaire and the Authority with reasons thereof.

(5) Emergency Repairs/Restoration

Notwithstanding anything to the contrary contained in Schedule-K, if any defect, deficiency, or deterioration in the project highway poses danger to the life or property of the users thereof, the Concessionaire shall promptly take all reasonable measures for eliminating or minimizing such danger.

(6) Daily Inspection by the Concessionaire

The Concessionaire shall, through its engineer, undertake a daily visual inspection of the project highway and maintain a record thereof in a register to be kept in such form and manner as the Independent Engineer may specify. Such record shall be kept in safe custody of the Concessionaire and shall be open to inspection by the Authority and the Independent Engineer at any time during office hours.

(7) Pre-Monsoon Inspection/Post-Monsoon Inspection

All defects and deficiencies specified in Schedule-K shall be repaired and rectified by the Concessionaire so that the project highway conforms to the maintenance requirements on the transfer date.

(8) Display of Schedule-K

The Concessionaire shall display a copy of Schedule-K at the toll plaza(s) along with the Complaint Register stipulated in Article 46.

(9) Repair/Rectification of Defects and Deficiencies

The Contractor shall repair and rectify the defects and deficiencies specified in Annex-I of Schedule-K within the time limit set forth in the table below.

Table 5.4.2 Repair/Rectification of Defects and Deficiencies (Annex-I)

Roads	Nature of Defect or Deficiency	Time Limit for Repair/Rectification
(a)	**Carriageway and paved shoulders**	
(i)	Breach or blockade Temporary restoration Permanent restoration	 24 hours 15 days
(ii)	Roughness value exceeding 2,500 mm in a stretch of 1 km (as measured by a calibrated bump integrator)	180 days
(iii)	Pot holes	48 hours
(iv)	Cracking in more than 5% of road surface in a stretch of 1km	30 days
(v)	Rutting exceeding 10 mm in more than 2% of road surface in a stretch of 1 km (measured with 3 m straight edge)	30 days
(vi)	Bleeding/skidding	7 days
(vii)	Raveling/stripping of bitumen surface exceeding 10 sqm	15 days
(viii)	Damage to pavement edges exceeding 100 mm	15 days
(ix)	Removal of debris	6 hours
(b)	**Hard/earth shoulders, side slopes, drains, and culverts**	
(i)	Variation by more than 2% in the prescribed slope of camber/cross fall	30 days
(ii)	Edge drop at shoulders exceeding 40 mm	7 days
(iii)	Variation by more than 15% in the prescribed side (embankment) slopes	30 days
(iv)	Rain cuts/gullies in slope	7 days
(v)	Damage to or silting of culverts and side drains during and immediately preceding the rainy season	7 days
(vi)	Desilting of drains in urban/semi-urban areas	48 hours
(c)	**Road side furniture including road signs and pavement marking**	
(i)	Damage to shape or position; poor visibility or loss of retro-reflectivity	48 hours
(d)	**Street lighting and telecom (ATMS)**	
(i)	Any major failure of the system	24 hours
(ii)	Faults and minor failures	8 hours
(e)	**Trees and plantation**	
(i)	Obstruction in a minimum head-room of 5 m above carriageway or obstruction in visibility of road signs	24 hours
(ii)	Deterioration in health of trees and bushes	Timely watering and treatment
(iii)	Replacement of trees and bushes	90 days
(iv)	Removal of vegetation affecting sight line and road structures	15 days
(f)	**Rest areas**	
(i)	Cleaning of toilets	Every 4 hours
(ii)	Defects in electrical, water, and sanitary installations	24 hours
(g)	**Toll plaza**	
(i)	Failure of toll collection	8 hours
(ii)	Damage to toll plaza	7 days

Roads	Nature of Defect or Deficiency	Time Limit for Repair/Rectification
(h)	**Other project facilities and approach roads**	
(i)	Damage or deterioration in approach roads, (pedestrian facilities, truck lay-bys, bus-bays, bus-shelters, cattle crossings, traffic aid posts, medical aid posts, and other works	15 days
Bridges	**Nature of Defect or Deficiency**	**Time Limit for Repair/Rectification**
(a)	**Superstructure of bridges**	
(i)	Cracks Temporary measures Permanent measures	 48 hours 45 days
(ii)	Spalling/scaling	15 days
(b)	**Foundations of bridges**	
(i)	Scouring and/or cavitation	15 days
(c)	**Piers, abutments, return walls, and wing walls of bridges**	
(i)	Cracks and damages including settlement and tilting	30 days
(d)	**Bearings (metallic) of bridges**	
(i)	Deformation	15 days
(e)	**Joints in bridges**	
(i)	Loosening and malfunctioning of joints	15 days
(f)	**Other items relating to bridges**	
(i)	Deforming of pads in elastomeric bearings	7 days
(ii)	Gathering of dirt in bearings and joints; or clogging of spouts, weep holes, and vent-holes	3 days
(iii)	Damage or deterioration in parapets and handrails	3 days
(iv)	Rain-cuts or erosion of banks of the side slopes of approaches	15 days
(v)	Damage to wearing coat	15 days
(vi)	Damage or deterioration in approach slabs, pitching, apron, toes, floor, or guide bunds	30 days
(vii)	Growth of vegetation affecting the structure or obstructing the waterway	15 days

Source: Schedule-K in MCA for PPP

5.5 Operations and Maintenance (O&M) of Chennai Outer Ring Road (CORR)

5.5.1 O&M Requirements

The CORR runs in parallel with the CPRR on the east side. It was opened to traffic in 2013. Since both roads are similar in road configurations, CORR offers the reference in preparation of the O&M for CPRR.

CORR is a project based on a Design-Build-Finance-Operate-Transfer (DBFOT) annuity contract. Its O&M manual was prepared by the concessionaire, GMR Chennai Outer Ring Road Private Limited, and sets out the methodology of carrying out the O&M for CORR. The JICA Study Team has studied, interpreted, and summarized the content of the O&M manual in the succeeding paragraphs.

As per clause 17 of the concession agreement of CORR, the concessionaire shall operate and maintain the project highway either by itself or through O&M contractors, and if required, modify, repair, or otherwise make improvements to the project highway to comply with provisions of concession agreement, applicable laws, and permits, and confirm to specifications, standards, and other requirements and manufacturer's guidelines and instructions with respect to the toll system.

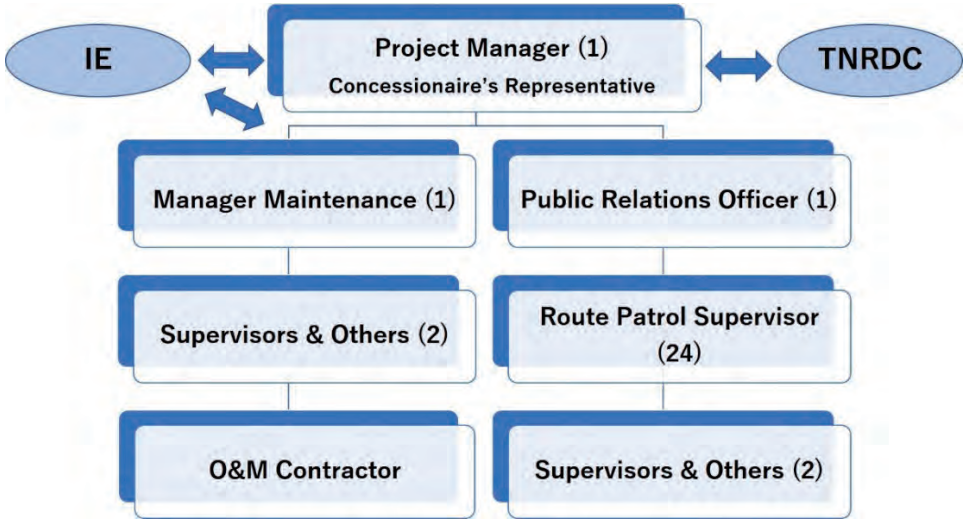
CORR O&M Field Office

Source: JICA Study Team

Figure 5.5.1 CORR and O&M Field Office

5.5.2 O&M Team

The structure of the O&M team of the concessionaire of CORR to carry out the obligations and responsibilities during the O&M period is shown in Figure 5.5.2. Although it outsources part of maintenance works to an O&M contractor, the concessionaire carrys out all the other parts on their own.



Source: JICA Study Team based on O&M Manual of CORR

Figure 5.5.2 Organizational Chart of O&M Team

5.5.3 Traffic Management

(1) Highway Patrol

Highway patrolling shall be done to ensure safe, uninterrupted, and smooth traffic flow so that:

a) Vehicles should not be allowed to park on the carriageway or on the shoulder, and parked vehicles should be removed with the help of traffic aid police.

b) Immediate assistance is provided to accident victims and their rescuers.

c) Minor debris and stalled vehicles are removed from carriageways within reasonable time after clearance from concerned authorities.

d) In the event of traffic congestion, adequate measures shall be taken to mitigate further congestion with the help of the police from traffic aid posts, and approaching traffic is duly cautioned about it.

(2) Initial Response to Safety, Vehicle Breakdowns, and Accidents

a) In case of unsafe conditions, vehicle breakdowns, and accidents, the concessionaire shall follow the

relevant operating procedures, which shall include the setting up of temporary traffic cones and lights, as well as the removal of obstruction and debris expeditiously.

b) The concessionaire shall ensure that any diversion or interruption of traffic is remedied without delay, and liaison with police is done. Their cooperation is sought to overcome any difficulty.

(3) Control Room Operator (CRO)

The CRO shall prepare a Management Information System (MIS) to provide all functions stated below:

a) to provide rapid and effective response to incidents,

b) to provide static and real-time transportation information to users,

c) to attend to emergency calls and, accordingly, public safety dispatch and emergency operations,

d) to provide incident information to route patrol (RP),

e) to communicate via Radio Mobile System (RMS),

Control Room

Ambulance

Source: JICA Study Team

Figure 5.5.3 Control Room and Ambulance

(4) Emergency Operations

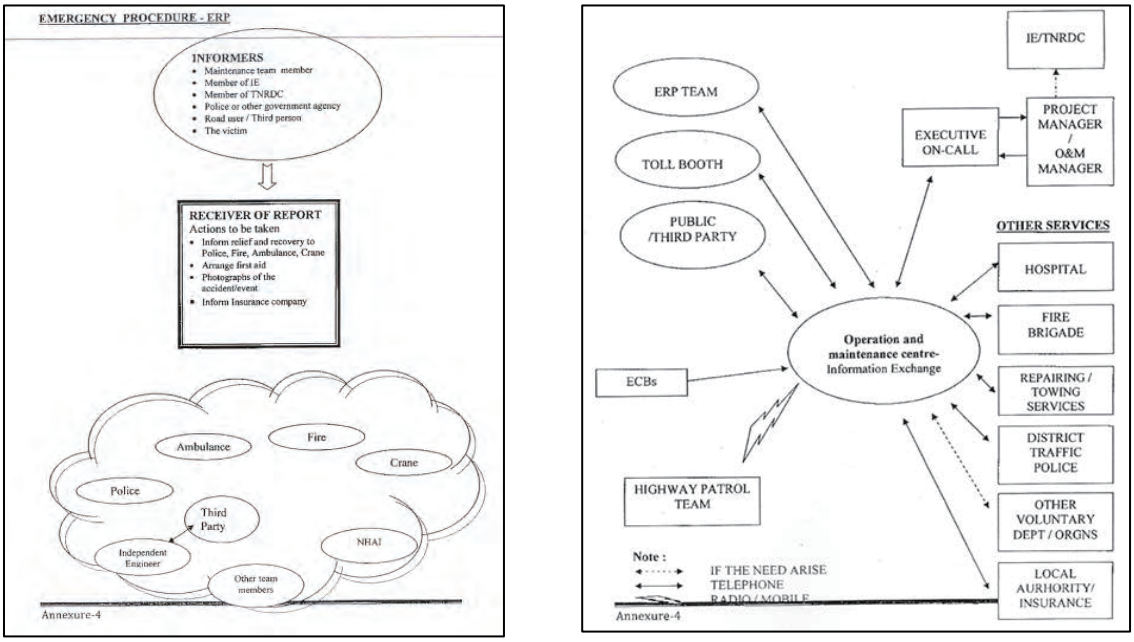
Highway patrolling/control room operator teams are continuously monitoring the project highway and respond and try to reach the site to extend assistance within a maximum of 10 minutes, subject to traffic bottlenecks. Emergency operations are done to minimize disruption to traffic in the event of accidents and/or incidents affecting the safety and use of the project highway by providing a rapid and effective response and maintaining liaison procedures as indicated in the figure below, with emergency services using the following setups:

a) Ambulance will be stationed at middle of the stretch and will be made available for accident victims. If required, more ambulance services will be made available to road users through the local hospitals.

b) Tow-truck/cranes of adequate capacity shall have all requisite arrangement of pulling and shifting accident/breakdown vehicles and will also be available on call.

c) Fire tender services from fire stations available along the project highway will be extended to the project by the local authorities.

d) The concessionaire will display all emergency service information at salient points for the benefit of road users.



Source: O&M Manual of CORR

Figure 5.5.4 Emergency Service Procedure

(5) Traffic Control for Work Zone Safety

It is important to limit/minimize the closure of roads and to ensure that traffic is delayed as little as possible by repair operations. A traffic control zone can be defined as an area of the project highway which involves conflict on the right of use between road users and the authority responsible for maintenance/improvement of the project highway. From a traffic safety point of view, a repair work zone comprises four zones as described herein and shown in the left side of Figure 5.5.5. The length of all zones shall be basically governed by the speed of approaching vehicles and shall be referred from the table below, as stipulated in IRC:SP:55-2001 Guidelines on Safety in Road Construction Zones:

a) Advanced Warning Zone

b) Approach Transition Zone

c) Working Zone

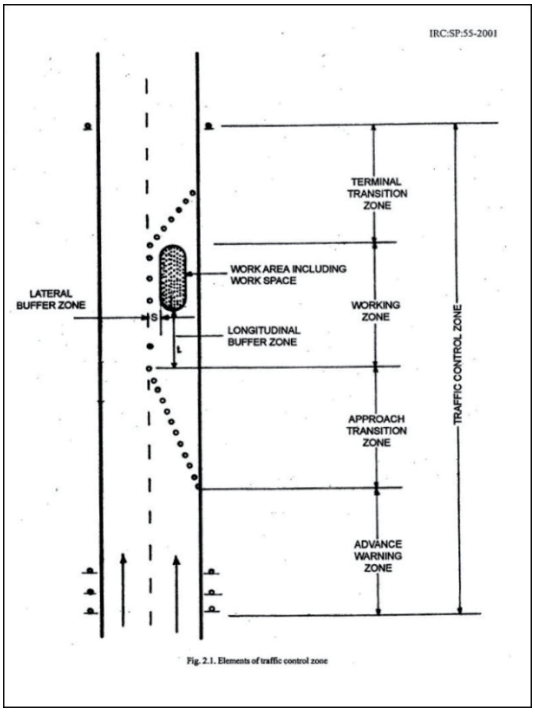
d) Terminal Transition Zone

Table 5.5.1 Recommended Length of Traffic Control Zones

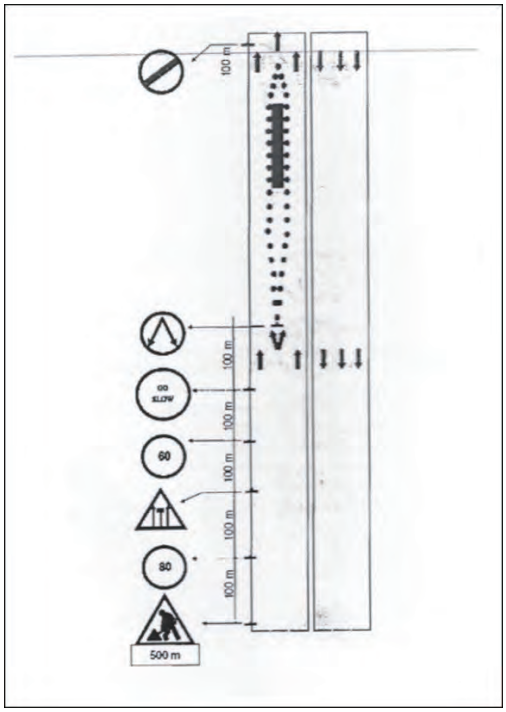
Average Speed (km/h)	Advance Warning Zone (m)	Approach Transition (m)	Working Zone (m)
50	100	50	Varies
51-80	100-300	50-100	
81-100	300-500	100-200	
Over 100	1000	200-300	

Source: IRC:SP55-2001

When the work to be done in the middle of the carriageway is of small magnitude, such as minor repairs of potholes, cracks, and patches, then traffic control measures shall mainly consist of providing cautionary signs of "Men at Work" about 500 m before the work zone for the approaching vehicles, and other cautionary signs of "Road narrows" shall be placed 100 m ahead of the work area. Regulatory signs of "Keep Left/Right" shall be placed at the commencement point of the work zone and next to the barriers for the approaching vehicles. Movable types of barriers shall also be placed on both sides of the work area. Cones or drums shall be placed at a suitable interval to demarcate the work area as indicated in the right side of Figure 5.5.5.



Source: IRC:SP55-2001



Source: O&M Manual of CORR

Figure 5.5.5 Traffic Control for Work Zone Safety

(6) Traffic Control for Work Zone Safety

The objectives of the rescue and medical aid services are to save the lives of road users from accidental death by attending to the victim within the "Golden Hour". For that purpose, the medical aid post with round-the-clock ambulance services shall be established. The function of the rescue and medical aid services are as follows:

a) to rush to the accident spot after receiving emergency messages from the control room operator,

b) to provide first aid service to accident victims, then transfer the victims to the nearest hospital for further treatment,

c) to rescue road users from any kind of accident/incident/breakdown on the project highway,

d) to coordinate with emergency and rescue services like police, hospital, fire, crane, etc., and

e) to provide actual information of the incident/accident to the police/authorities.

5.5.4 Highway Maintenance

(1) Types of Maintenance

Road maintenance can be divided into four basic types:

a) Routine Maintenance: a group of recurrent activities, which relates to the repair of faults and to the attention to road structure and facilities within the entire right of way (ROW) in the required condition, to ensure the preservation of the asset and the convenience and safety of traffic

b) Preventive Maintenance: an organized, systematic process for applying a series of preventive treatments over the life of the pavement to minimize life cycle costs

c) Periodic Maintenance: a group of activities which can normally be predicted and planned for by nature, location, and extent, and can be carried out periodically with a view to safeguard the pavement crust and improve riding quality

d) Special Repairs: a group of activities performed to restore the roadway following damage due to natural calamities such as heavy floods, sand storms, hurricanes, cyclones, earthquakes, or landslides

which are unpredictable

(2) Plant, Machinery, and Laboratory Equipment

The concessionaire will provide the following equipment for routine maintenance as and when required:

a) Patrolling vehicle

b) Maintenance vehicle

c) Water tankers

d) Debris trucks

e) Sweeping machine

f) Tractor with trolley

g) Hydra crane (as and when required on call basis)

For periodic maintenance activities, the plant, machinery, and equipment will either be outsourced or established by the concessionaire. For emergency activities, the patrolling vehicles as described are available. Other services of rescue activities will be outsourced.

Road Cleaner

Mobile Crane

Source: JICA Study Team

Figure 5.5.6 Examples of Maintenance Equipment

(3) Highway Inspection

Highway inspection is conducted to ensure the safety of the road and to identify any necessary actions to keep the soundness of the road.

a) Daily Inspection: Checking is conducted visually from the patrol vehicle travelling at a slow speed (<30 kph) with stops and foot inspections if necessary. Patrols are to be timed to ensure that all parts of the road are visited at peak and off-peak periods and both in daylight and in the dark.

b) Close Inspection: Monthly/bi-monthly inspection of all junctions, urban lengths, road crossing, toll plaza, amenity areas, barriers, fences, structures, bridges, and other significant roadside features and installations.

c) Through Inspection: Done before the preparation of maintenance programs and at least annually on lightly trafficked lengths, or six-monthly on heavily trafficked lengths, detailed inspections, if necessary, complete relevant checks and assessment including checking of drains, culverts, access covers, road marking, signs, lighting, and all other roads.

d) Additional Inspection: Done during, for instance, heavy rain, flooding risk, and exceptional congestion (festivals), and if necessary at other occasions, in addition to the management of accidents, other incidents, and routine maintenance activities.

Table 5.5.2 Frequency of Inspection

Object	Item	Daily	Monthly	Quarterly	Before/After Rains
Riding Surface	Pavement	V	C		T
	Expansion Joints	V	C		T
Median	Kerb	V	C		T
Side Slopes	Shape	V		C	T
	Turfing		V		T
	Pitching and Masonry		V		T
	Retaining Wall		C		T
Drainage	Side/Toe Drain	R	C		
	Gullies and Catch Pits	R	C		
Bridges	Superstructure			C	T
	Substructure			C	T
	Head Wing Walls and Aprons			C	T
	Painting				T
	Hand Rail		C	T	
Culverts/Underpass					T
Safety Barrier		R		C	T
Traffic Operation Facilities	Signs		T*		T
	Marking	R	C*	C	T
	Delineator	R	C*	C	T
	Lighting	R	C*	C	T
Other Facilities	Vegetation/Landscaping	R	C	T	
	Toll Plaza	R	C	T	
	Truck Lay Bay/Wayside Amenities	R	C	T	
Traffic Conditions		R	T	C	
Encroachments		R	T		

Legend
V: Visual Inspection C: Close Inspection T: Thorough Inspection R: Visual Inspection (during rainy season only) *: at night also

Source: O&M Manual of CORR

(4) Performance Criteria/Standards

Operational performance criteria/standards and acceptable limits shall be maintained throughout the concession period as per Table 5.5.3. Time limits for repair/rectification of defects and deficiencies are set forth in Table 5.4.2. The performance criteria/standards of the O&M Manual of CORR are slightly higher than those stipulated in IRC: SP:95-2011 “Model Contract Document for Maintenance of Highways”.

Table 5.5.3 Maintenance Standards of O&M Manual for CORR

No.	Service Factor	Level 1 (Acceptable)
1	Roughness by bump integrator (maximum permissibility)	2,200 mm/km for main carriageway and 2,500 mm/km for service road
2	Potholes per km (max) i) less than 75 mm deep ii) more than 75 mm deep	 2 sizes of <5 sqm nil
3	Percent cracking	<5% of pavements in any 1 km section
4	Rutting	Not exceeding 10 mm in more than 2% of road surface in a stretch of 1 km
5	Raveling/stripping of bitumen	Not exceeding 10 sqm
6	Earthen shoulder, side slope, drains, and culverts	Earthen shoulder variation not exceeding 2% of camber, edge drop at shoulders not exceeding 40 mm, embankment slope variation not more than 15%
7	Sign boards and pavement marking	Good reflectivity

Source: O&M Manual of CORR

(5) Horticultural Maintenance

Visual inspections regarding horticulture shall be performed bi-annually. During routine and periodic maintenance operations, the concessionaire shall carry out visual inspections. Any noticeable problems or any item which represents immediate or imminent hazard will be treated with the same priority as immediate defects. The schedule of operations including watering is given in the table below.

Table 5.5.4 Frequency of Operations for Horticultural Maintenance

No.	Operations	Frequency
1	Making of plant basin for holding water	3 months
2	Cleaning of plant basin for holding water	1 month
3	Hoeing and weeding	1 month
4	Training, trimming, and pruning of plants	3 months
5	Watering of plants	2 days
6	Cutting of grass	As required
7	Cleaning of medians	1 month
8	Removal of weeds	1 month
9	Control of monsoon growth	After monsoon
10	Dressing and levelling median ground	After monsoon
11	Sprinkling of water in median	1 month

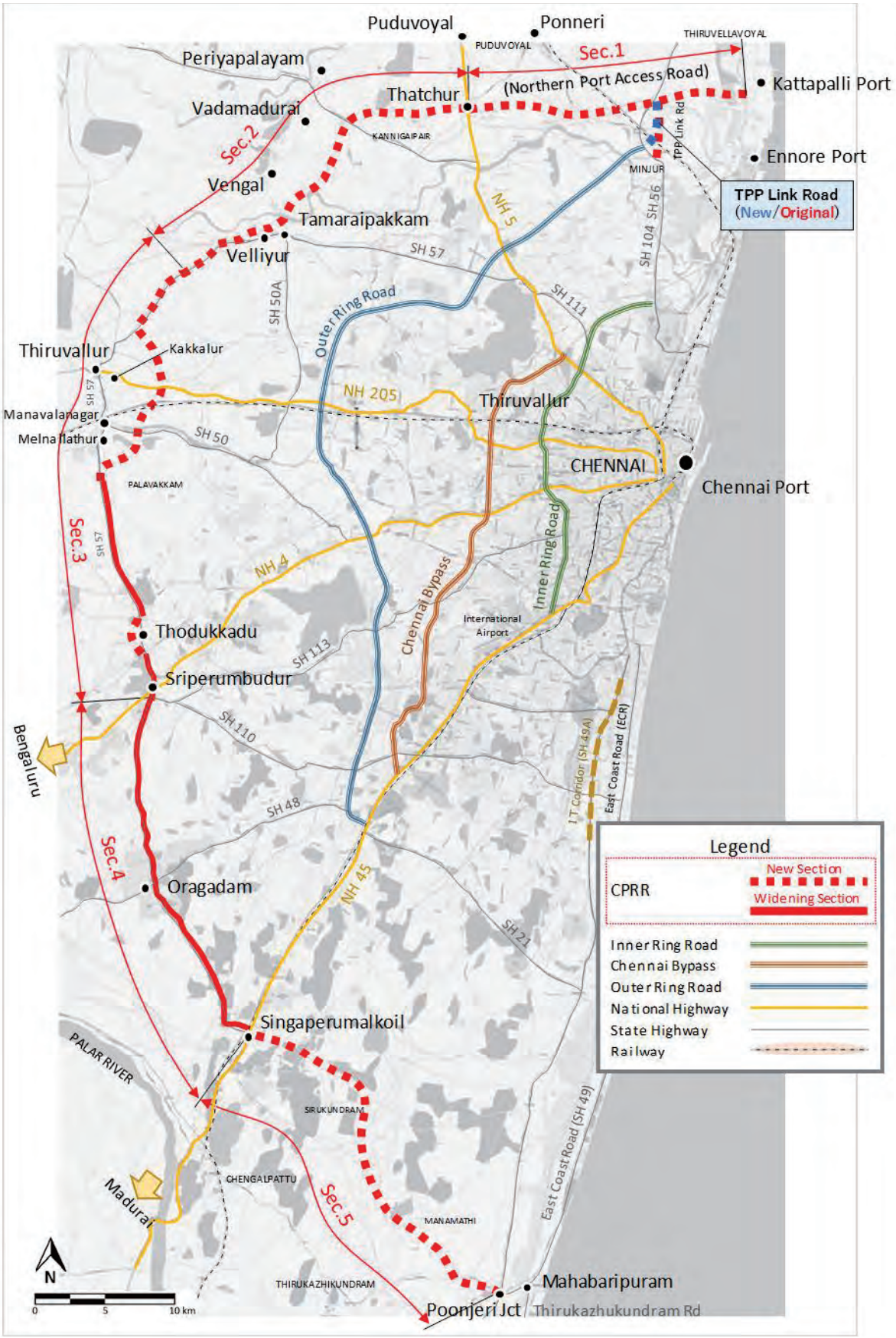
Source: O&M Manual of CORR

5.6 Recommendations on the O&M Plan

5.6.1 Basic Data of CPRR for O&M

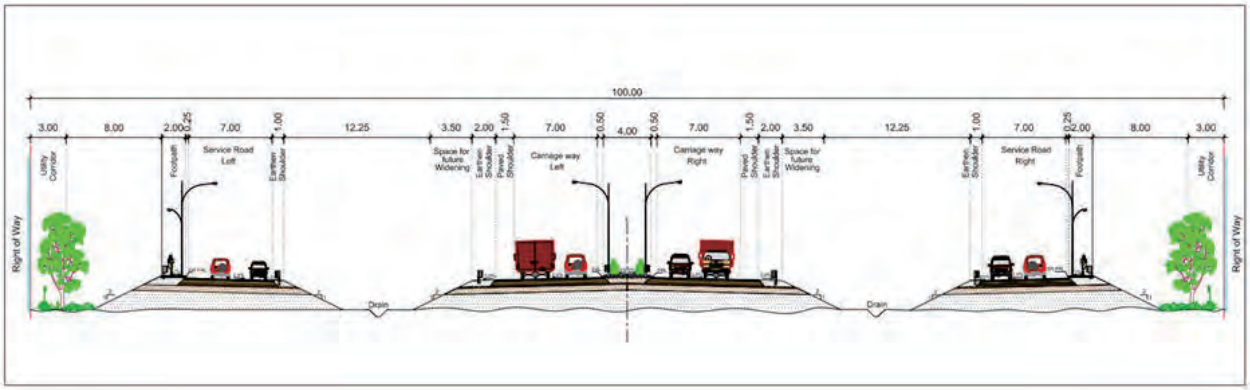
(1) Locations of Roads and Typical Cross Sections required for O&M

It is indispensable for the O&M to prepare figures and tables that carry basic data of the project road. A description of the CPRR is stated as, “starts at Ennore Port and ends at Poonjeri Junction (East Coast Road) in Mamallapuram. CPRR connects four National Highways, namely NH5, NH205, NH4 and, NH45, and eight State Highways, namely SH51, SH50A, SH50, SH48, SH57, SH49B, SH49A (OMR), and SH49 (ECR). The total length of CPRR is 133 km, which is split into five road sections.” The locations of each section and crossing roads are indicated in Figure 5.6.1. The typical cross sections of each road section are shown in Figure 5.6.2.

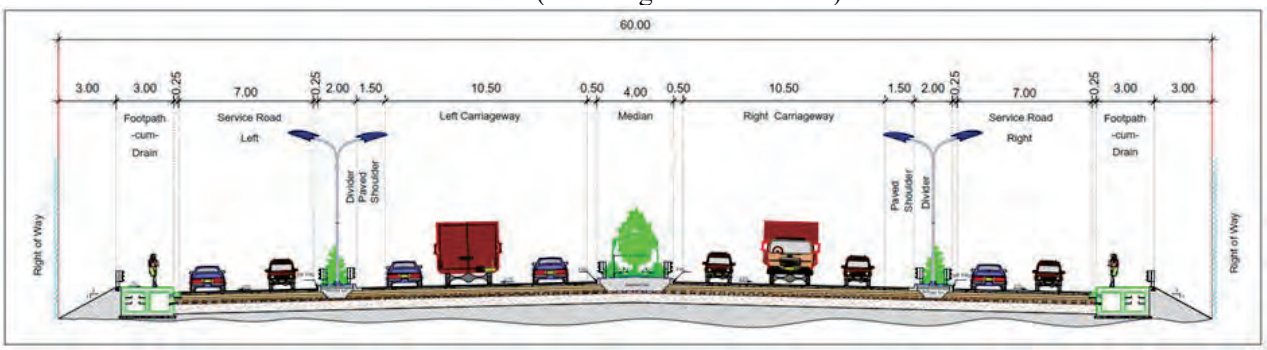


Source: JICA Study Team

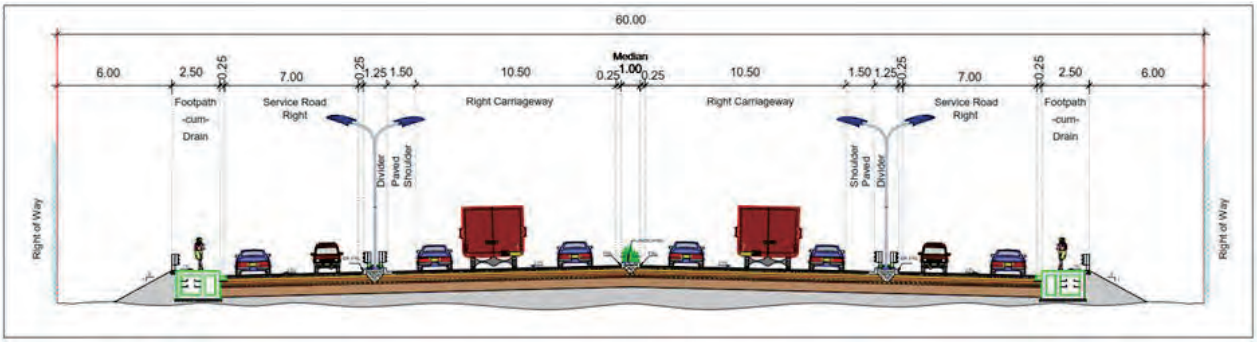
Figure 5.6.1 Location of Project Road and Crossing Roads



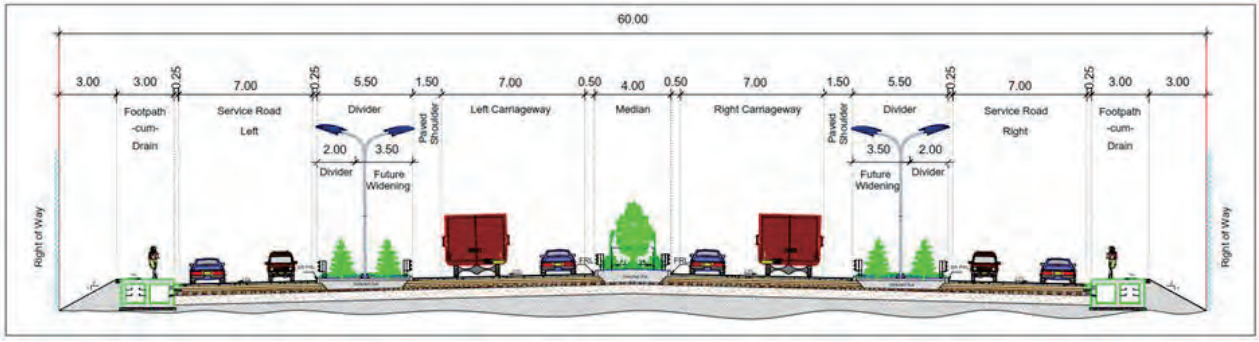
Section 1 (Including TPP Link Road)



Section 2 and Section 3



Section 4



Section 5

Source: JICA Study Team based on DPR

Figure 5.6.2 Typical Cross Sections of Each Road Section

(2) Road Details Required for O&M

The details of each section are shown in Table 5.6.1.

Table 5.6.1 Details of Each Road Section (New Construction Portion Only)

		Total	Section 1		Section 2	Section 3	Section 4	Section 5
Road Name		Chennai Peripheral Ring Road (CPRR)						
Features of Road Structure		The scope of the project consists of the main road and the service road, with footpaths cum drain on both sides. The main road is access-controlled and connects national highways with interchanges. The service roads connect all crossing roads with at-level intersections. There are dividers between the main road and the service roads with several entry/exit ramps.						
Start/End Points		Ennore Port/ Mamallapura	Ennore Port/ Thatchur	TPP Link (Original Alignment)	Thatchur/ Thiruvallur Bypass	Thiruvallur Bypass/ Sriperumbudur	Sriperumbudur/ Singaperumalkoil	Singaperumalkoil/ Mamallapuram
Length (km)		133.23	21.51	4.21	25.61	29.55	24.85	27.50
Construction Type		-	New alignment	New alignment	New/widening	New/widening	Widening	New/widening
No. of Lanes		Main Road	Road 4, Bridge 6	Road 4, Bridge 6	Road 6, Bridge 6	Road 6, Bridge 6	Road 6, Bridge 6	Road 4, Bridge 6
		Service Road	2 x 2	2 x 2	2 x 2	2 x 2	2 x 2	2 x 2
Width of ROW (m)		-	100	100	60	60	60, 40 (Main Road)	60
Thickness of Pavement (Bituminous)		Main Road	615 mm	615 mm	615 mm	615 mm	635 mm	610 mm
		Service Road	590 mm	590 mm	590 mm	590 mm	590 mm	590 mm
Design Speed (km/h)		Main Road	100, 65 (Start)	100, 80 (End)	100	100, 80 (Partial)	100/80 (Mainly)	100
		Service Road	40	40	40	40	40	40
Interchange		4	0	0	1	2	0	1
At-level Intersection		5	2	2	0	2	0	1
No. of Bridges	IC	4	1	0	0	2	0	1
	Railway	3	1	1	0	1	0	0
	River	5	1	0	2	1	0	1
	Road	19	1	1	5	1	0	11
No. of Cross Structures	L Vehicle	31	5	0	5	6	9	6
	S Vehicle	17	1	2	3	1	3	7
No. of Cross Culverts	Box	113	47	6	13	20	0	27
	Pipe	216	11	2	84	61	0	58
No. of Truck Parking		10	2	1	2	2	0	3
No. of Bus Bay		17	2	1	1	4	0	9
ITS	Toll Plaza	3	2	1	0	0	0	0
	Weigh-in-Motion	3	2	1	0	0	0	0
	VMS*	15	2	0	3	3	5	2
	CCTV*	20	3	1	4	4	6	2
	VIDS*	3	2	1	0	0	0	0
	ATCC*	134	21	5	26	30	25	27
	MET*	6	2	0	0	1	1	2

Note*: Variable Message Sign (VMS), Video Incident Detection System (VIDS), Automatic Traffic Counter cum Classifier (ATCC), Meteorological Monitoring System (MET)
Source: JICA Study Team

5.6.2 Proposal on O&M Plan

(1) Proposal on O&M Contracting

The Highways and Minor Ports Department (HMPD) of the Government of Tamil Nadu will oversee the construction and O&M of the CPRR. Most probably, the Project Wing of the Highways Department will take charge of the construction of CPRR, and the Construction and Maintenance Wing will take charge of the O&M.

During the meeting held in February 2018 between HMPD and JICA, HMPD agreed in principle to apply the Standard Bidding Documents (SBD) issued by JICA for the contract for Section 1, although HMPD and JICA are discussing which particular SBD is to be applied in the project. The JICA mission stated that the SBD for "Procurement of Works" is generally mandatory in similar types of Japanese ODA Loan Projects.

When the construction of CPRR is completed, the supervision of O&M will be shifted from the Project Wing to the Construction and Maintenance Wing.

After the completion of construction, most probably a PBMC will be used for the O&M works. Currently, the Highways Department has been switching one-by-one to PBMC from the conventional single-year maintenance contract. It is being introduced successively to one of the highway divisions in eight circles in the state, and up to date, four highway divisions are using PBMC, namely Pollachi, Krishnagiri, Ramanathapuram, and Thiruvallur. Now the PBMC scheme will be extended to the Virudhunagar Highways Division in the current financial year.

Section 1, Section 2, and a part of Section 3 of CPRR fall under the jurisdiction of the Thiruvallur Highways Division, where PBMC was introduced on 24 February 2016. The O&M of SHs and MDRs with a total length of 498 km is being carried out with the contract worth INR 630.38 crore.

The remaining Section 3, Section 4, and Section 5 of CPRR fall under the jurisdiction of the neighboring Chengalpattu Highway Division. This division has not yet introduced PBMC. It is assumed, however, that it will be introduced by the time the CPRR is completed.

PBMC includes ordinary maintenance, initial rectification works, minor improvement works, periodic maintenance works, and emergency works. The amount as stated in a contract is a provisional estimate excluding emergency works. Ordinary maintenance will be payable as a proportionate monthly lumpsum over the 60-month period of the contract. Other works will be measured and paid based on the actual work output. The project scope and the duration of the PBMC for Pollachi[3] is described below:

Project Scope and Duration of Performance Based Maintenance Contracts (PBMC) for Pollachi

To undertake Ordinary Maintenance, Initial Rectification Works, Periodic Maintenance Work, Minor Improvement Works and Emergency Works on select roads totaling approximately 377.388 Kilometers. The maintenance work will also include cross drainage works, minor work on bridges, and roadside maintenance within the select road limits. Ordinary Maintenance will be payable as a proportionate monthly Lump Sum over the 5-year period of the Contract on issuance of certificate by the Engineer in the reach where the black top by the contractor under this contract for the items listed in the specification and it will be item wise for the actual output in the reaches where the block top was not renewed under this contract. Initial Rectification, Minor Improvements and Periodic Maintenance will be paid on measured quantity to the quoted rate. Emergency work has to be carried out as identified by the Contractor and with the approval of the Engineer for the provisional rate quoted. There is a requirement for specialized maintenance equipment and the contract obligation is for continuous input over a period of five years.

(2) Proposal on O&M Structure and Cost Estimate

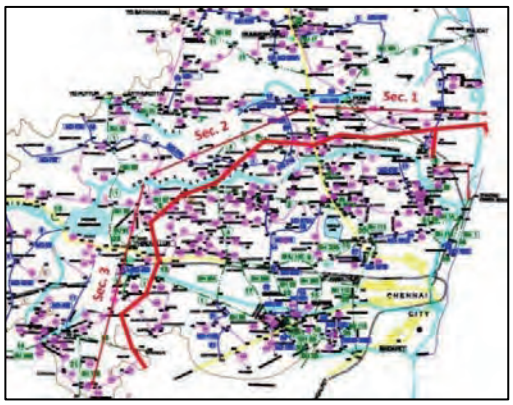
1) O&M Structure

Regarding the O&M for Section 1 of CPRR, it is assumed that the execution entity TNRDC will be in

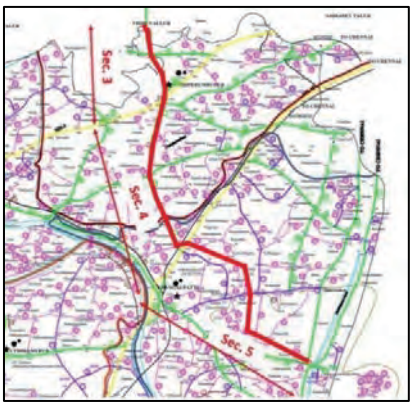
[3] Government of Tamil Nadu Highways Department. 2013. *Performance Based Maintenance Contract (PBMC) Volume - 1 Pre-Qualification Document. Performance Based Maintenance contract for 5 years for State Highways and Major District roads in Pollachi (H) C&M, Division*

charge. The maintenance work will be contracted out to private companies.

Section 2 and a part of Section 3 of the CPRR will fall under the jurisdiction of the Thiruvallur Highways Division. Regarding the remaining sections, Section 3, Section 4, and Section 5 will fall under the jurisdiction of the neighboring Chengalpattu Highways Division. The Thiruvallur Highways Division has been contracting out to private O&M contractors with PBMC and will incorporate newly completed sections into the contract. It is assumed that the PBMC will be introduced to the Chengalpattu Highways Division by the time the CPRR is completed. If the introduction is delayed, a single-year maintenance contract will be used.



Thiruvallur Highways Division

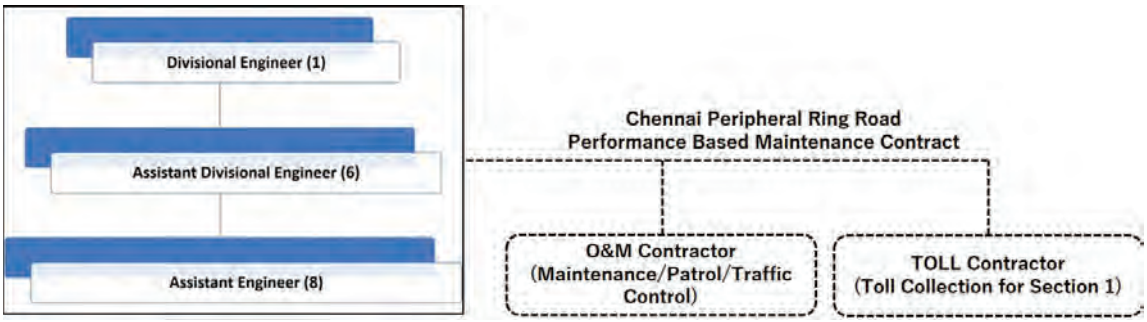


Chengalpattu Highways Division

Source: JICA Study Team

Figure 5.6.3 Highways Divisions Responsible for O&M of CPRR

The structure of the Thiruvallur Highways Division consists of one divisional engineer, six assistant divisional engineers, and eight assistant engineers. The Thiruvallur Highways Division will outsource the work of maintenance/patrol/traffic control with PBMC to an O&M contractor. There is a plan to collect toll for Section 1. When this is carried out, toll collection work will also be outsourced to a toll contractor (Figure 5.6.4). There is one field office for the divisional engineer and six field offices for the assistant divisional engineers (left side of Figure 5.6.5) taking charge of road construction other than large-scale projects and maintenance for SHs and MDRs (right side of Figure 5.6.5).



Source: JICA Study Team

Figure 5.6.4 Structure of Thiruvallur Highways Division

Field Office of Thiruvallur Highways Division

Removal of Sediment from Side Drain

Source: JICA Study Team

Figure 5.6.5 Examples of Field Office and Maintenance Work

2) Cost Estimate of O&M

Table 5.6.2 shows the examples of O&M costs for the four highways divisions that have already introduced the PBMC and the CORR. Although the cost of CORR is about 30% higher than those of other roads, it is assumed that the higher cost comes from the road composition of CORR, which contains service roads on both sides. The road composition of CPRR is like that of CORR and INR 0.223 crore/year/km is adopted for the calculation of the O&M cost.

Table 5.6.2 Examples of O&M Costs (INR in Crore)

No.	Highways Division	Length (km)	5-year Cost	5-year/km	1-year/km
1	Pollachi	377	233.9	0.620	0.124
2	Krishnagiri	581	450.0	0.775	0.155
3	Ramanathapuram	569	460.0	0.808	0.161
4	Thiruvallur	776	630.4	0.812	0.162
5	CORR	30	33.0	1.113	0.223

Source: JICA Study Team

By using the unit rate of INR 0.223 crore/year, the 133.23-km CPRR will produce an annual O&M cost of INR 29.71 crore.

Table 5.6.3 Annual O&M Cost of CPRR (INR in Crore)

	All Sections	Section 1	Section 2	Section 3	Section 4	Section 5
Length (km)	133.23	25.72	25.61	29.55	24.85	27.50
O&M (INR lakh)	29.71	5.74	5.71	6.59	5.54	6.13

Note: Original Alignment of TPP Link Road (4.21 km) is included in length of Section 1.
Source: JICA Study Team

(3) Proposal on Improvement in O&M Manual

1) Preparation of O&M Manual

Regarding O&M of CPRR, an O&M manual, which will be a guideline for the work, should be prepared. The IRC: SP: 95-2011[4] will be the basis for the preparation. The road maintenance standards stipulated in this document is also the basis for Schedule-K in the model contract agreement for PPP and Schedule-E in the standard agreement for EPC.

[4] IRC: SP: 95-2011 Model Contract Document for Maintenance of Highways

CORR runs parallel to CPRR and is already carrying out O&M. This road was constructed using a semi-annuity contract in DBFOT and has service roads on both sides as CPRR for its road configurations. The O&M manual for this road is described in detail in "5.5 Operations and Maintenance (O&M) of Chennai Outer Ring Road (CORR)".

Although the O&M manual for CORR covers all aspects of O&M activities, there are some points that need to be improved. Especially for the methodology in preventive maintenance, the description is no more than a concept. As for preventive maintenance standards, the Guidelines for Expressways[5] compiled by MORTH stipulates a detailed methodology. The O&M manual can be improved by incorporating this part. The JICA Study Team proposes that the detailed methodology in preventive maintenance should be incorporated to improve the O&M manual.

2) Merits of Preventive Maintenance

Preventative maintenance takes a proactive approach in the maintenance of roads by properly addressing defects and faults in the early stages of deteriorations to improve the effectiveness, and by grouping repairs to enhance the efficiency and to reduce hindrances to traffic, thereby minimizing the life-cycle cost of roads. It is widely known that repairs at an early stage of deterioration can be smaller in size and can be simpler, leading to a smaller total life-cycle cost including the maintenance cost.

Inspection is the key element in preventive maintenance which triggers all the necessary activities. By detecting an early symptom of deterioration and by checking the development pattern of deterioration, it is possible to find an optimal intervention level to arrest the deterioration. It lengthens the life span of road structures and reduces the life-cycle cost. This also helps to equalize the maintenance workforce and the cost over the maintenance period, consequently leading to pre-scheduled and efficient maintenance implementations.

Table 5.6.4 Merits and Contents of Preventive Maintenance

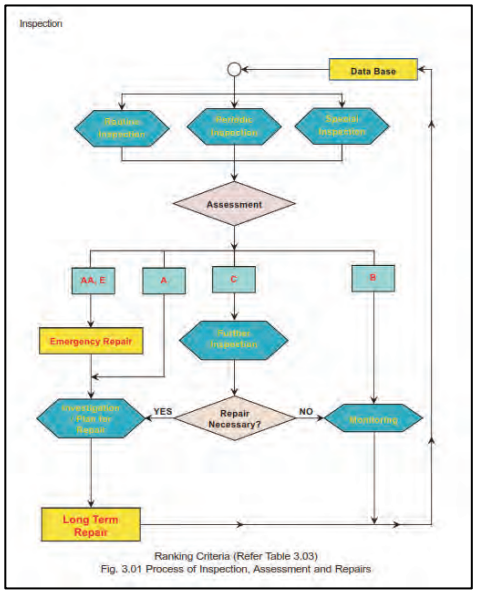
Benefit	Outcome
Pre-planned Maintenance	Maintenance intervention items and timing are known.
	Optimal usage of workforce, machine, spare parts, and equipment.
Optimal Maintenance Level (most cost-effective treatment)	Best intervention timing and type to treat the deterioration.
	Planning of grouping interventions, which will minimize disturbance to traffic.

Source: JICA Study Team

3) Inspection Assessment Methodology for Preventive Maintenance

Figure 5.6.6 shows various processes for each inspection works from Chapter 3 - Inspection, Volume IV - Maintenance, Guidelines for Expressways. It is important to establish this process to ensure that each inspection is followed up with appropriate action systematically. Any damage or defects detected during these inspections will be recorded and assessed according to the specified ranking criteria. Based on the results of the assessment, the maintenance plan over the year will be formulated and implemented.

[5] MORTH. 2010. Guidelines for Expressways. New Delhi. IRC



Ranking Criteria

Table 3.03 Typical Ranking of Inspection

Ranking			Typical Condition
Functional deterioration (including visual structural distresses)	AA		Has severe damage/deformation. **Requires immediate repair to recover its functionality**
	A		Has damage/deformation and functional deterioration. **Requires repair but not immediately**
		A1*	Does not require immediate repair, but has functional deterioration which is expected to worsen rapidly. **Estimated to require repair within 2 years.**
		A2*	Does not require immediate repair, but has functional deterioration which is expected to worsen gradually. **Estimated to require repair within 5 years.**
		A3*	Has functional deterioration but the speed of deterioration is slow. **Requires monitoring continuously or after 5 years' time, and determining the timing of repair accordingly.**
	B		No sign of functional deterioration albeit damage/deformation. **Requires continuous monitoring of damage/deformation**
	C		**Requires investigation** in order to assess its functionality
	OK		**No or only slight sign of damage/deformation**
Affect Traffic Safety	E		Has risk of affecting the safe traffic condition. **Requires immediate attention.**

Typical Ranking of Inspection

Source: MORTH. 2010. Volume - IV Maintenance: Chapter - 3 Inspection: *Guidelines for Expressways*. New Delhi. IRC

Figure 5.6.6 Inspection Assessment Methodology for Preventive Maintenance

(4) Proposal on O&M of ITS

The total length of CPRR is 133.23 km (including the original alignment of TPP Link Road), and it is divided into five sections. Section 1, or the Northern Port Access Road (NPAR), is connected to the Ennore Port. Although it has not been decided yet, the Government of Tamil Nadu is considering to make Section 1 an access-controlled toll road. Therefore, it is recommended that a toll management system (for Section 1) and a highway traffic management system (for all sections) be introduced as ITS components for the CPRR.

1) Toll Management System, TMS (Section 1)

The completion of CPRR will contribute to the drastic improvement of connectivity from suburban areas to the Ennore Port. A great number of large vehicles on CPRR is then accordingly expected. Large vehicles are likely to damage the pavement; therefore, maintenance will be a very important issue. A toll management system collects toll, and the revenue can be utilized for the maintenance of CPRR. Regulating over-loaded vehicles is also crucial to protect the pavement. An access-controlled Section 1 makes it possible to monitor over-loaded vehicles by installing a weight measurement equipment at the entrance to the road.

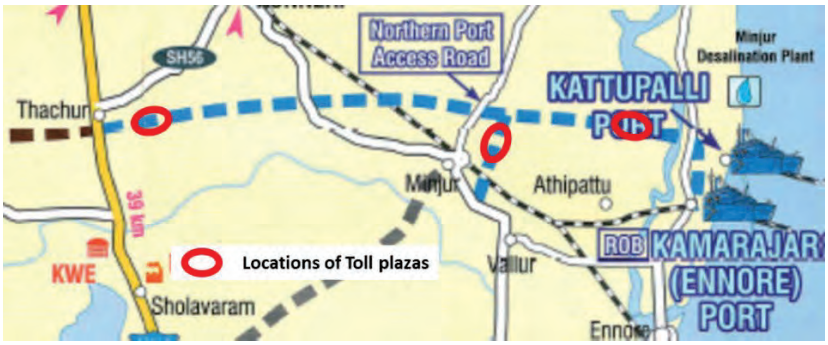
Therefore, a toll management system together with a weigh-in-motion to regulate over-loaded vehicles, is proposed on Section 1 of CPRR for both purposes of collecting toll and controlling over-loaded vehicles.

In Section 1, toll plazas will be required at least in three locations. They are Thatchur, the ending point of Section 1 which connects Section 2 and NH-5, Minjur, which is an ending point of the branch line of Section 1 near the north end of ORR, and the other ending point of Section 1, which is near the gate of the Ennore Port.

Regarding the implementation of a toll system to the CPRR, it has not yet been determined whether a distance-base or a fixed rate system will be used for the toll rates. Considering the configuration of the roads in Section 1, it is better to adopt the distance-based toll, which varies the fee according to the travelled distance in view of the sense of fairness for the users of the CPRR.

In the case of distance-based toll rates, toll plazas will be required at both entry and exit points of the toll road. There are mainly three methods for toll collection, namely manual collection, Touch-and-Go, and ETC. For manual collection, a ticket or transit card carries information such as vehicle class, entered interchange, and date and time of entry. Toll collectors confirm this information at the exit booth, and the toll calculated based on the length traveled is charged to the driver. For Touch-and-Go and ETC, the basic procedure is the same but is processed automatically by the system.

The figure showin in Figure 5.6.7 shows the proposed locations of the toll plazas in Section 1 of CPRR.



Source: JICA Study Team

Figure 5.6.7 Locations of Toll Plazas in Section 1 of CPRR

2) Highway Traffic Management System (HTMS) (All Sections)

The highway traffic management system is to ensure safety and smooth traffic on CPRR. The system consists of the following major parts:

a) Data/information collection

b) Data processing and monitoring

c) Information dissemination

The above information will be exchanged with the Chennai Traffic Information Center (CTIC) and other related agencies as well.

Data on road and traffic conditions is collected by Automatic Traffic Counter cum Classifier (ATCC), video incident detection system (VIDS), meteorological monitoring system (MET), and CCTV camera installed along the CPRR. Data collected by these devices are sent to the Traffic Control Center of CPRR through the digital transmission system.

The operators in the Traffic Control Center monitor the conditions of CPRR through the video displays and workstations. Certain measures, if necessary, are taken in case of incidents such as congestion, accident, road or lane closure, and construction/maintenance work. The information on traffic/road/weather conditions of CPRR will be disseminated to road users through the VMS Boards installed on the CPRR and on the access roads through the internet. An SMS will also be sent to the registered users in case of an incident. The same data and information is also sent to the CTIC, which covers all areas in Chennai City. Cooperation with relevant organizations such as traffic police, ambulance, and wrecker services will be arranged so that coordinated operations can be made for all incidents.

3) Cost Estimate of ITS O&M

Table 5.6.5 Cost Estimate of ITS O&M (INR in Crore)

	All Sections	Section 1	Section 2	Section 3	Section 4	Section 5
Length (km)	133.23	25.72	25.61	29.55	24.85	27.50
TMS	25.14	25.14	-	-	-	-
HTMS	15.1	2.88	2.97	3.34	2.81	3.11

Note: Original Alignment of TPP Link Road (4.21 km) is included in the length of Section 1.
Source: JICA Study Team

Item	Location			Objective	Q'ty
Variable Message Sign (VMS)	Main Road	Section 1	200 m upstream of starting point of off-ramp	To provide information of CPRR	1
		Other Sections	200 m upstream of junction		9
	Access Road	Section 1	200 m upstream of on-ramp toward the city	To provide information of CPRR and city roads	1
		Other Sections	200 m upstream of junction of major radial road toward the city		4
CCTV	Main Road	All Sections	200 m upstream of diverting and merging point	To monitor traffic condition at site	20
Video Incident Detection System (VIDS)	Main Road	Section 1	200 m upstream of diverting and merging point	To detect abnormal traffic event	3
Automatic Traffic Counter cum Classifier (ATCC)	Main Road	All Sections	Every 2 km	To measure traffic volume, vehicle speed, and occupancy (for CTIC as well)	134
Meteorological Monitoring System (MET)	Main Road	All Sections	In vicinity of interchange/major junction	To measure weather condition	6

Source: JICA Study Team

Figure 5.6.8 Highway Traffic Management System Equipment Deployment Plan

(5) Proposal on Training in Japan for Technical Enhancement in O&M

CPRR is the third semicircle ring road centering Chennai and running outside the IRR and the ORR. It connects four national highways (NH5, NH205, NH4, and NH45) that radiate from the center of Chennai, extending to the Ennore Port in the north and to the East Coast Road in the south. The radii of the ring road are about 25 km in the north, about 50 km in the south, and about 40 km in the west.

In comparison with the Tokyo Metropolitan area, it resembles the Metropolitan Inter-City Expressway with radii varying between about 40 km and about 60 km from the center of Tokyo. The role of CPRR includes alleviating traffic flow in urban areas, improving environment condicitons, strengthening intercity connections in the corridor, supporting regional development, and offering alternative routes during disasters. The function is widely diversified and very important to keep daily life safe and comfortable in the region.

The Metropolitan Inter-City Expressway has completed 90% of its total length of 300 km and is already carrying out the O&M works. The expressway is not only seeking for efficient O&M works but also enhances wide-ranging functional effects such as logistics management, attracting enterprise, developing tourist resources, preventing the effects of disasters, and protecting environment.

It is very valuable for the staff of the Highways Department of Tamil Nadu State, who are in charge of the CPRR, to learn this example as precedent of the Metropolitan Inter-City Expressway. The JICA Study Team proposes a training in Japan for technical enhancement in O&M, where attendees can acquire wide-ranging practical knowledge including O&M structures, actual examples of O&M manuals, responses to various traffic incidents at site, information dissemination at traffic control centers, structure and management of toll collection, emergency response to disasters/accidents, and ways to enhance road functions among others.