Detailed Project Report
(Updated in August 2011)

Kochi Metro Project
Alwaye - Petta Corridor

Client : Government of Kerala

Prepared & Updated by

दिल्ली मेट्रो रेल कॉरपोरेशन लिमिटेड
DELHI METRO RAIL CORPORATION LTD.

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Contents

Salient Features

Kochi

Metro Project

Alwaye-Petta Corridor

1. **Route Length (between dead ends)** **25.612 Km**
2. **Route Length (between CL of Terminal Stations)** **24.912 Km**
3. **Number of Stations** **23**
4. **Traffic Forecast**

Year	Passenger / day	phpdt	Trip Length (Av. Km)
2015	381868	13681	7.33
2020	468130	17663	8.46
2025	539427	21065	9.55
2030	600526	23621	10.02

5. **Train Operation**

LINE	**YEAR**		
Alwaye – Petta Corridor	**2015**	**2020**	**2025**
Cars/trains	**3**	**3**	**3**
Head way (Minutes)	**5**	**4**	**3**
Max. PHPDT Demand	**13681**	**17663**	**21065**
PHPDT Capacity Available	**7200 (9144*)**	**9000 (11430*)**	**12000 (15240*)**
No. of Coach required	**66**	**81**	**108**

6. Traction Power Supply

a) Voltage	25 Kv AC
b) Power Supply source	110 Kv AC
c) No of receiving sub stations	2
d) SCADA system	Provided

7. Rolling Stock

a) 2.7 m wide modern rolling stock with stainless steel body, Standard Gauge

b) Axle load	-13 t
c) Seating arrangement	- Longitudinal
d) Capacity of 3 coach unit	- 600 passengers
e) Class of accommodation	- One

8. Maintenance Facilities

Maintenance Depot	- Muttom

9. Signaling, Telecommunication & Train Control

a) Type of Signaling	Cab Signalling and continuous Automatic Train Control with Automatic Train Protection (ATP)
b) Telecommunication	Integrated System with Fibre Optic cable, SCADA, Train Radio, PA system etc.

11. Fare Collection	Automatic Fare Collection system with POM and Smart Cards etc.
12. **Construction Methodology**	Elevated viaduct carried over pre-stressed concrete 'U' shaped/Box Girders with pile / Open foundations
13. Total estimated cost (without taxes) (August 2011 prices)	**Rs 3733 crores**

14. Completion cost (by Year 2016)

(i) including escalation and Central taxes only	**Rs. 4910 Crores**
(ii) including escalation, Central and State taxes	**Rs. 5146 Crores**

15. Financial Indices

a) FIRR	**3.04%**
b) EIRR	**14.2%**

Executive Summary

0.1 INTRODUCTION

Kochi with its wealth of historical associations and its unique setting reflects the eclecticism of Kerala. It is one of India's important ports and a major Naval base. It is a center of higher education as well. Cochin Shipyard, which is the biggest ship building yard in India, is situated here. Kochi consists of mainland Ernakulam; islands of Willingdon, Bolghatty and Gundu in the harbor, Fort Kochi/Mattancherry on the southern peninsula; and Vypeen Island, north of Fort Kochi.

Rapid urbanization and intense commercial developments in the recent past have resulted in steep rise in travel demand, putting Kochi's transport infrastructure to stress. With mega projects such as 'SMART CITY, 'INFO PARK', 'FASHION CITY' and "Vellarpadam Container Terminal", etc. on the anvil, travel demand is expected to shoot up, strengthening the need for augmenting the transport infrastructure in Kochi region.

- **POPULATION DENSITY IN COCHIN CORPORATION AREA**

Population of Greater Cochin Development Authority (GCDA) area was **1.67** million in 1991 and **1.81** million as per 2001 Census. Population density is 2600 persons per sq. Km in GCDA area and 6300 persons per sq. Km in Cochin Corporation area. Population of Greater Cochin area has been growing at a rate of 1.4% per annum.

- **EMPLOYMENT SCENARIO**

Occupational structure of population of Ernakulam District, Urban agglomeration of Kochi is given in Table 0.1 below:

Table 0.1
Occupational Structure (%) as per 1991 census

Area	Occupational Structure		
	Primary	Secondary	Tertiary
Ernakulam District	38.04	16.44	45.52
Kochi U.A.	15.23	20.29	64.48
Cochin Corporation (City and Outer growth)	8.65	17.52	73.83

- **REGISTERED MOTOR VEHICLES**

In the absence of a mass transport system, there has been a steep increase in the number of personalized motor vehicles in GCDA area. The number of registered motor vehicles in this area was 68,271 in 1987 and it grown to 4,46,959 in the year 2003. 64% of these vehicles are two wheelers. This large number of motor vehicles is resulting in rise in air pollution, increased number of road accidents, and slowing down of average vehicular speeds.

- **EARLIER STUDIES**

Amongst the earlier studies, 'Structure Plan' for the Central city for the year 2001 prepared by the Greater Cochin Development Authority (GCDA) is of foremost importance. Other important studies include the Kerala Urban Development Project sponsored by the World Bank, Vypeen Bridges Project by the Goshree Islands Development Authority (GIDA) and Master Plan for Development of Kochi Port by the Kochi Port Trust. M/s RITES also conducted a 'Comprehensive Study for Transport System for Greater Cochin Area, in 2001.

All the above studies except the Comprehensive Study for Transport System for Greater Cochin area conducted by RITES in 2001 recommended projects for improvement to road infrastructure, including provision of ROBs /Fly-overs. While, a few ROBs / Fly-overs have been completed, the rest of the improvements to road infrastructure are still in planning stage.

RITES Study of 2001 recommended provision of LRTS between Alwaye to Thripunithura as a long term measure, in addition to short term and medium term measures for improvement to road infrastructure.

0.2 TRAFFIC DEMAND FORECAST

The 4-stage traffic model has been adopted to carry out transport demand forecast. This comprises trip generation, trip distribution, modal split and trip assignment

To select the right corridor for Kochi Metro, different possible options were tried. The three main options tried were (i) Alwaye to Vytilla, (ii) Kalamassery to Thripunithura and (iii) Alwaye to Thripunithura. Based on the expected ridership of the corridor, Alwaye to Thripunithura was selected. For this corridor, two extensions were also tried, one to Kakkanad and the other to Thevra.

Impact of these two extensions is marginal on the ridership, hence these extensions are not considered and the corridor from Alwaye to Thripunithura is selected as the best option. After carrying out detailed engineering feasibility study for this corridor, it was found that construction of Petta to Thripunithura section of this corridor is not feasible till improvement to existing road infrastructure between these two places is done by the concerned authorities. Accordingly, ridership on the truncated corridor from Alwaye to Petta was worked out which is marginally less from ridership of Alwaye to Thripunithura Corridor.

Summary of the Transport Demand Forecast for various years for Alwaye – Petta Corridor are given in table 0.2

Table 0.2

Kochi METRO Ridership on Alwaye to Petta Corridor			
PARAMETER	**2015**	**2020**	**2025**
PHPDT	13681	17663	21065
Peak Hour Ridership	38187	46813	53943
Daily Ridership	381868	468130	539427
Average Trip Length (Km)	7.33	8.46	9.55

0.3 NEED FOR METRO

Public Transport System is an efficient user of space and with reduced level of air and noise pollution. As the population of a city grows, share of public transport, whether road or rail-based, should increase. Experience has shown that, in cities like Kochi where roads do not have adequate width and which cater to mixed traffic conditions comprising slow and fast moving vehicles, road transport can optimally carry 8,000 persons per hour per direction (phpdt). When traffic density increases beyond this level average speed of vehicles comes down, journey time increases, air population goes up and commuters are put to increased level, of inconvenience. In any case, it is not feasible to operate bus transport beyond 10,000 phpdt in mixed transport scenario, obtaining on Kochi city roads.

With growing population and mega development plans coming up for this port city, the travel demand is expected to grow steeply. With inadequate public transport services, passengers will shift to private modes, which is already evident from the high ownership trends in the region. This will not only aggravate the congestion on the city roads but will also increase the pollution level.

Peak hour traffic demand on Alwaye-Petta Corridor has been assessed as 13,681 phpdt for the year 2015 and this is likely to increase 21065 phpdt by the year 2025. Road-based public transport, therefore, can not meet this demand. There is an urgent need to introduce a light Metro system in the city to provide fast, safe, economic, and environment-friendly mode for mass movement of passengers. Carrying capacity of Light Metro System is upto 25,000 phpdt, which will be adequate to take care of the traffic problems for Greater Cochin area for the next about 25 years.

- **ADVANTAGES OF METRO SYSTEM**

  - Requires 1/5th energy per passenger km compared to road-based system.
  - Causes no air pollution in the city.
  - Causes lesser noise level
  - Occupies no road space if underground and only about 2 metres width of the road if elevated.
  - Carries same amount of traffic as 5 lanes of bus traffic or 12 lanes of private motor cars (either way), if it is a light capacity system.
  - Is more reliable, comfortable and safer than road based system
  - Reduces journey time by anything between 50% and 75% depending on road conditions.

0.4 SYSTEM SELECTION

A. PERMANENT WAY

- **CHOICE OF GAUGE**

Standard Gauge (1435mm) is invariably used for metro railways world over due to its inherent advantages. During the last decade, 20 new metros have been constructed in various cities of the world. All these metros have gone in for Standard Gauge even though the national gauge for mainline railways in some of these countries was different from Standard Gauge. In India the national gauge is Broad Gauge (1676mm). Reasons for selection of Standard gauge are described in the Report.

- **TRACK STRUCTURE**

Track on Metro Systems is subjected to intensive usage with very little time for day-to-day maintenance. Thus it is imperative that the track structure selected for Metro Systems should be long lasting and should require minimum or no maintenance and at the same time, ensure highest level of safety, reliability and comfort, with minimum noise and vibrations. Ballastless track with continuous welded head-hardened rails has been proposed as mainline track in elevated stretches. However for at-grade section and at Muttom depot the track structure shall be ballasted.

B. TRACTION SYSTEM

Keeping in view the ultimate traffic requirements, standardisation, and other techno-economic considerations, 25 KV OHE traction system is considered to be the best trade-off and hence, proposed for adoption on Kochi Metro System.

C. SIGNALLING AND TRAIN CONTROL

Metro carries large number of passengers at a very close headway requiring a very high level of safety enforcement and reliability. At the same time heavy investment in infrastructure and rolling stock necessitates optimization of its capacity to provide the best services to the public. These requirements of the metro are planned to be achieved by adopting 'Distance to go' ATP (Automatic Train Protection) and ATS (Automatic Train Supervision) sub-systems. This will:

- Provide high level of safety with trains running at close headway ensuring continuous safe train separation.
- Eliminate accidents due to driver passing Signal at Danger by continuous speed monitoring and automatic application of brake in case of disregard of signal / warning by the driver.
- Provides safety and enforces speed limit on section having permanent and temporary speed restrictions.
- Improve capacity with safer and smoother operations. Driver will have continuous display of Target Speed / Distance to Go status in his cab enabling him to optimize the speed potential of the track section. It provides signal / speed status in the cab even in bad weather.
- Increased productivity of rolling stock by increasing line capacity and train speeds, and enabling train to arrive at its destination sooner. Hence more trips will be possible with the same number of rolling stock.

- Improve maintenance of Signalling and telecommunication equipments by monitoring system status of trackside and train born equipments and enabling preventive maintenance.

  Signalling & Train Control system on the line shall be designed to meet the required headway during peak hours.

D. TELECOMMUNICATION

Telecommunication facilities proposed are helpful in meeting the requirements for supplementing the Signalling system for efficient train operation, exchange of managerial information, Crisis management during emergencies and Passenger information system etc. The proposed telecom system will cater to the following requirements:

- Train Traffic Control
- Maintenance Control
- Emergency Control
- Station to station dedicated communication
- Telephone Exchanges
- Standalone Passenger Announcement System at each station
- Standalone Clocks at Platforms
- Radio Communication between Central Control and Trains and maintenance personnel

E. FARE COLLECTION SYSTEM

The proposed ticketing system will be a combination of smart card and computerized paper ticket issued through the same ticket office machines (TOM) provided at each station counter/ booking office and at convenient locations. These TOMs will be connected to a local area network with a computer in the Station Master's room, which will be further connected to central computer.

For smart cards, simple turnstile type gates will be used. Smart cards will have provision for future applications such as bus, parking, toll etc. Manual checking will be done for paper tickets.

Ticketing System proposed is a foolproof system to avoid chances of ticketless travel. If so desired, a manual ticketing system similar to that of Indian Railways can also be adopted to reduce cost of ticketing system which may come down to about 15% to 20% of the automatic fare collection system proposed above. However, it will have its own inherent disadvantage of leakage of revenue due to chances of ticketless travel. Moreover man power requirement will also go up.

F. ROLLING STOCK

Rolling stock for Kochi Metro has been selected based on the following criteria:

- Proven equipment with high reliability;
- Passenger safety features, including fire resistance;
- Energy efficiency;
- Light weight equipment and coach body;
- Optimized scheduled speed;
- Aesthetically pleasing Interior and Exterior;
- Low life cycle cost; and
- Flexibility to meet increase in traffic demand.

The controlling criteria are reliability, low energy consumption, light weight and high efficiency, leading to lower annualized cost of service. The coach should have high rate of acceleration and deceleration.

Keeping the above features in mind, 2.7 m wide stainless steel light weight coaches are proposed for Kochi Metro, with length of 17.86 m for trailer coach and 18.00 m for motor coach (including couple buffers). Height of coach is 3.9 m. Train length for 3 coach train is 55.5 m. The axle load is 13 t for which the structures are to be designed.

Traction motors are 180 KW and propulsion system is 3-phase drive with variable voltage and variable frequency (VVVF) control. Trains will have regenerative braking system to save energy cost. Trains will be air-conditioned and provided with automatic door closing and opening system with 3 wide doors per coach on each side. The trains will have passenger information and announcement system. The rolling stock is provided with Train Protection and warning system to prevent driver passing the signals at danger. It is an accepted fact that 60-70% of accidents take place on account of human error. Adoption of this system will reduce the possibility of human error.

Coaches have longitudinal seats with a seating capacity of 35 and 156 standees per motor coach and 44 seating and 174 standees per trailer coach, thus total dense crush capacity of 191 (MC) to 218 (TC), at 6 persons/sqm.

The rolling stock proposed shall have design speed of 90 kmph and maximum running speed of 80 kmph. Maximum acceleration and deceleration is 01.0m/s^2 and 1.1 m/s^2. During emergency braking deceleration shall be 1.3m/s^2. Average commercial speed will be 33 kmph with station dwelling time of 30 seconds.

0.5 CIVIL ENGINEERING

Geometrical design norms are based on international practices adopted for similar metro systems with standard gauge on the assumption that the maximum permissible speed on the section is limited to 80 kms.

Tracks will be carried on U-shaped elevated decking supported by single circular piers, generally spaced at 28-m centres and located on the median of the road. Horizontal alignment and vertical alignment are, therefore, dictated to a large extent by the geometry of the road followed by the alignment.

Track centre on the elevated section will be 3.7 m on portions of tracks which are straight or having curvature upto radius of 150 m. Track centre will be increased to 4 m on curves with radius sharper than 150 m.

The standards adopted for horizontal and vertical alignments are as under: -

Curve radius in mid section:

Elevated Section		
Preferred	:	400 m and above
Minimum	:	200 m
Absolute minimum	:	90 m (in exceptional cases)

Minimum curve radius at stations	:	1000 m
Maximum permissible cant (Ca)	:	125 mm
Desirable cant (Ca)	:	110 mm
Maximum cant deficiency (Cd)	:	85 mm

- **Transition curves**

-	Minimum length of Transitions of Horizontal curves (m)	:	0.44 times actual cant or cant deficiency (in mm), which ever is higher.
-	Desirable	:	0.72 times actual cant or cant deficiency, (in mm) which ever is higher

- No overlap is allowed between transition curves and vertical curves.

-	Minimum straight between two Transition curves	:	either 25 m or NIL.
-	Minimum curve length between two transition curves	:	25

- **Route Alignment**

Alignment from Km -0.090 to Km 1.200

Northern terminal of the corridor is located at Alwaye at chainage Km - 0.090. From there on the alignment up to chainage 1.200 is on the side of existing service road This length is located partly on the government land and partly on private land. The private buildings getting affected The alignment is straight and on curve. At southern approach of Alwaye Metro station is on curve where a are mainly commercial shops housed in storeyed buildings. 650 m curve (followed by a 800 m curve) is provided. The Metro station entry has been planned in such a way to provide easy access for passengers from Rajiv Gandhi Bus Terminal located on the side of NH-47. For passengers coming from the Eastern side of the Metro Station (where KSRTC bus stand and Railway Station are located), will have to use existing connecting road of length around 325m.

Alignment from Km 1.200 to Km 10.850

This stretch of the alignment follows NH-47. An attempt has been made to keep the alignment on the median of the road with a view to minimize the requirement of land acquisition. There are three deviations from the median one from chainage Km. 4.400 to Km.4.900 at Muttom station and the second one from chainage Km. 5650 to Km.5850 where a new road bridge constructed and the third one from chainage Km. 6.850 to Km.7.350 where a road-over-bridge exists. The alignment has been diverted to cross the existing railway tracks parallel to the road-over-bridge. at chainage Km. 6.7. To follow the alignment of the NH-47, 18 curves varying in radius from 402 m to 12,000 m have been introduced. Nine Metro stations namely Pulinchodu (future station at chainage Km 1.814), Companypady (chainage Km 2.756), Ambattukavu (future station at chainage Km 3.764), Muttom (chainage Km 4.723), Apollo Tyres (chainage Km 6.209), Jacobite Church (chainage Km 7.399), Kalamassery (chainage Km 8.144), Pathadi Palam (future station at chainage Km 9.146) and Edapally junction (chainage Km 10.599) have been proposed. Rolling Stock Depot has been planned at Muttom on the Eastern side of the Metro alignment. Connection to the Depot takes off at chainage Km 4.600. The connection is elevated till it crosses Chennai – Trivandrum Railway line, whereafter it ramps down to the ground level so as to reach the Depot.

Land use in this stretch of alignment is mixed – commercial, residential and institu tional. A number of schools and institutions like Cochin University of Science & Technology and several major industrial establishments such as Apollo Tyres, Premier Tyres, HMT etc. exist along this stretch.

Alignment from Chainage Km 10.850 to Chainage Km 16.600

In this stretch, the alignment runs on the median of Banerji Road till it reaches Madhav Pharmacy Junction. There will be 5 Metro stations, i.e. Edapally (chainage Km 12.023), Palarivattom (chainage Km13.071), J.L.Nehru Stadium (chainage Km 14.126), Kaloor (chainage Km 15.221) and Lissi (chainage 15.711) on this stretch. The land use is mixed in this area and there are many high rise buildings on either side of the road. The area is very congested. Jawaharlal Nehru Stadium falls on this stretch where a Metro station has been planned. Kaloor Bus Stand used by City buses as well as buses coming from suburban areas is also located on this stretch. Other main commercial areas are Palarivattum, Kaloor, Kacheripadi. Ernakulam North Railway Station is situated on this route and Lissi Metro station will provide connectivity to it. A number of hospitals exist on this stretch. There is a road-over-bridge at Km 15.900 where the Metro alignment will pass over this bridge.

Alignment from Chainage Km 16.600 to Chainage Km 18.650

At chainage 16.600, the alignment takes sharp curve of 92.050 radius followed by another curve of radius 107.050 to reach the median of M.G. Road at chainage Km16.800. This sharp curvature was necessary to keep the land acquisition minimum. On this stretch, 2 Metro Stations, namely Madhav Pharmacy (chainage Km 16.899) and Maharaja's College (chainage Km 18.103) are located. This stretch has many centres of activities. In addition to having several high rise buildings, it serves Cochin Corporation Office, Colleges like Maharaja's College, Women's College, Law College as well as Boat Jetty, KSRTC Bus Stand, etc.

Alignment from Chainage Km 18.650 to Chainage Km 19.100

In this stretch the alignment turns from M.G. Road to South Railway Station Road. South Railway Station Road is highly congested, being a 2-lane road. There are commercial establishments and several high-rise buildings in this stretch.

Alignment from Chainage Km 19.100 to Chainage Km 19.600

From chainage Km 19.100 the alignment takes another sharp curve to move towards Railway quarters approach Road, where after it crosses the Railway tracks near the Route Relay Cabin of Ernakulam Junction Railway Station. At chainage Km 19.600, the alignment turns towards S.A Road. The Metro alignment runs partially over the approach of south over-bridge. Ernakulam South Metro Station (chainage Km 19.332) is located opposite to platform No.1 of Ernakulam Junction of Southern Railway. This will facilitate inter-change of passengers at this place.

Alignment from Chainage Km 19.600 to Chainage Km 22.450

In this stretch, the alignment mainly runs on the median of S.A Road. There will be 2 major Stations, i.e. GCDA (chainage Km 20.185), and Elamkulam (chainage 21.341). The alignment is mainly straight. Important establishments like GCDA Office, Rajiv Gandhi Indoor Stadium and several Hospitals office of the leading Malayalam Manorama and a Central School are located on this stretch. This stretch also provides access to a number of residential complexes like Panampally Nagar, Gandhi Nagar, Giri Nagar Colony etc.

Alignment from Chainage Km 22.450 to Chainage Km 25.612

There are 3 Metro Stations on the stretch of this alignment, i.e. Vytilla (chainage Km 22.447), Thaikoodam (chainage Km 23.703) and Petta (chainage Km 24.822). This stretch serves mainly residential areas.

- **Viaduct Structure**

The proposed viaduct structure for the Kochi Metro is a 'U'-shaped pre-stressed concrete deck, carrying two tracks supported on single pier located on the median of the road. Width of the deck is 9.0 m and the piers will be elliptical of 1.2 m x 1.85 m size. Road clearance of 5.5 m is ensured below the viaduct structure. The foundation shall be pile foundation at most of the locations. Open foundations are possible at certain isolated locations. The superstructure shall be pre-cast segmental construction which will cause minimal inconvenience to the road users during the execution stage.

- **Station Locations & Planning**

Stations have been located so as to serve major passenger destinations and to enable convenient integration with other modes of transport. However effort has also been made to propose station locations, such that inter station distances are as uniform and the average spacing of stations is close to one km as possible. Proposed stations along with their chainages are given in Table 0.3 below:'

Table 0.3
Proposed Metro Stations along with their chainages

S No	Nam e of Station	Chainage (in km) N – North S – South	Distance from Previous Station (in km)	Height of Rail Level in mtr. From road level	Platform Type and Nos	Alignment Description
1	Alwaye	**-0.090**		12.5	Side Platform,	On 1000 m curve
2	*Pulinchodu (future)*	**1.814**	**1.904**	12.5	Side Platforms, 2 Nos.	Curved
3	Companypady	**2.756**	**0.942**	12.5	Side Platforms, 2 Nos.	Straight
4	*Ambattukavu (future)*	**3.764**	**1.008**	12.5	Side Platforms, 2 Nos.	Straight
5	Muttom	**4.723**	**0.959**	12.5	Side Platform, 1 No. & Island Platform 1 No.	Straight Curved
6	Apollo Tyre	**6.209**	**1.486**	12.5	Side Platforms, 2 Nos.	Straight
7	Jacobite Church	**7.399**	**1.190**	12.5	Side Platforms, 2 Nos.	Curved
8	Kalamassery	**8.144**	**0.745**	12.5	Side Platforms, 2 Nos.	Straight
9	Pathadi Palam *(future)*	**9.146**	**1.002**	12.5	Side Platforms, 2 Nos.	Straight

S No	Nam e of Station	Chainage (in km) N – North S – South	Distance from Previous Station (in km)	Height of Rail Level in mtr. From road level	Platform Type and Nos	Alignment Description
10	Edapally Junction	**10.599**	**1.453**	12.5	Side Platforms, 2 Nos.	Straight
11	Edapally	**12.023**	**1.424**	12.5	Side Platforms, 2 Nos.	Straight
12	Palarivattom	**13.071**	**1.048**	12.5	Side Platforms, 2 Nos.	Straight
13	J L Nehru Stadium	**14.126**	**1.055**	12.5	Side Platforms, 2 Nos.	Straight
14	Kaloor	**15.221**	**1.095**	12.5	Side Platforms, 2 Nos.	Straight
15	Lissi	**15.711**	**0.490**	12.5	Side Platforms, 2 Nos.	Straight
16	Madhav Pharmacy	**16.899**	**1.188**	12.5	Side Platforms, 2 Nos.	Straight
17	Maharaja College	**18.103**	**1.204**	12.5	Side Platforms, 2 Nos.	Straight
18	Ernakulam South Station	**19.332**	**1.229**	12.5	Side Platforms, 2 Nos.	Straight
19	GCDA	**20.185**	**0.853**	12.5	Side Platforms, 2 Nos.	Straight
20	Elamkulam	**21.341**	**1.156**	12.5	Side Platforms, 2 Nos.	Straight
21	Vytilla	**22.447**	**1.106**	12.5	Side Platforms, 2 Nos.	Straight
22	Thaikoodam	**23.703**	**1.256**	12.5	Side Platforms, 2 Nos.	Straight
23	Petta	**24.822**	**1.119**	12.5	Side Platforms, 2 Nos.	Straight

Stations have been divided into two distinct areas, namely public and non-public (technical areas). The public area is further sub divided into unpaid and paid area. Provision for escalators are made at all stations in paid area from the beginning itself. Provision in civil structures at stations is being kept for providing lifts for disabled passengers in future.

Integration facilities at Metro stations include approach roads to the stations, circulation facilities, pedestrian ways and circulation areas for various modes likely to come to important stations, including feeder buses. Parking for private vehicles has not been proposed in view of the scarcity of land along the alignment

- **Geo technical Investigations**

A total of 51 bore holes have been drilled at an average distance of about 500 m each along the corridor.

Geotechnical investigations were carried out along the corridor upto a depth varying from 13m and 50m. Soil and rock samples were collected and tested in laboratory.

The soils in and around the Kochi City vary from lateritic soils on the Northern part to the Marine clays on the Southern part of the city. From Kochi towards Alwaye, we find the lateritic soils in the top layers changing to granitic rocks in the lower strata. Kochi being a city on the coast, we have marine clays, loose to stiff in nature for greater depth with dense sand layers underlying these clay layers. There are locations where this sand layer varies occurring from 40 – 60m.

For the elevated section 0.8m dia pile foundation is recommended. Bearing capacity is not likely to cause any problem for the foundations.

- **Utilities**

The proposed Metro alignment is passing along major arterial roads of the city road network, which are serving institutional, commercial and residential areas. A large number of surface and sub-surface utility services, viz. sewers, water-mains, storm water drains, telephone cables, electric poles, traffic signals, etc. are existing along the proposed alignment. Details of the existing utility services along the proposed alignment have been collected from the concerned authorities, The affected portions of the services with reference to the proposed alignment were identified and temporary diversion & relocation proposals of the affected services have been indicated.

- **Land Requirement**

Since land is a scarce commodity especially in metropolitan areas, every effort has been made to keep land requirement to the barest minimum and acquisition of private property is minimal. Land is mainly required for Depots and route alignment on sharp bends, station buildings, platforms, entry/exit structures, traffic integration, power sub-stations, ventilation shafts, administrative buildings and temporary construction depots / work sites etc.

Land requirement for the Alwaye -Petta Corridor is about 25.3347 hectares out which 9.3787 hectares belongs to Government, while the balance 15.9559 hectare is private land.

0.6 TRAIN OPERATION PLAN

The underlying operation philosophy is to make the MRT System more attractive and economical, the main features being:

- Selecting the most optimum frequency of Train services to meet sectional capacity requirement during peak hours on most of the sections.
- Economical & optimum train service frequency not only during peak period, but also during off-peak period.
- A short train consists of 3 coaches with high frequency service.
- Multi-tasking of train operation and maintenance staff.

Salient features of the proposed train operation plan are:

- Running of services for 19 hours of the day (5 AM to Midnight) with a station dwell time of 30 seconds,
- Make up time of 5-10% with 8-12% coasting.
- Scheduled speed for these corridors has been taken as 33 Kmph on account of higher inter-station distances

- **Train Composition**

To meet the above projected traffic demand, the possibility of running trains with composition of 3 Car has been examined.

The basic unit of 3-car train comprising of DMC-TC- DMC configuration has been selected for the Alwaye – Petta Corridor for the year 2015, 2020 & 2025.

Composition
DMC : Driving Motor Car
TC : Trailer Car
3 Car Train Composition DMC + TC + DMC
Capacity
DMC : 191 passenger (Sitting-35, Crush Standing-156)
TC : 218 passenger (Sitting-44, Crush Standing-174)
3 Car Train: 600 Passengers (Sitting-114, Crush Standing-486)

The PHPDT demand and the capacity provided for Alwaye – Petta Corridor in different years is given in Table 0.4

TABLE 0.4
CAPACITY PROVIDED

LINE	YEAR		
Alwaye – Peta Corridor	**2015**	**2020**	**2025**
Cars/trains	**3**	**3**	**3**
Head way (Minutes)	**5**	**4**	**3**
Max. PHPDT Demand	**13681**	**17663**	**21065**
PHPDT Capacity Available	**7200 (9144*)**	**9000 (11430*)**	**12000 (15240*)**
No. of Coach required	**66**	**81**	**108**

- **No. of Coaches required**

The of coaches required in the year 2015, 2020 and 2025 are given below in Table No. 0.5. These include operation and maintenance reserve.

Table No. 0.5
Requirement - Alwaye – Petta Corridor

Corridor	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches
Alwaye – Petta Corridor	**2015**	**5**	**22**	**3 car**	**66**
	2020	**4**	**27**	**3 car**	**81**
	2025	**3**	**36**	**3 car**	**108**

- **Sourcing of Rolling Stock**

M/s. BEML, Banglore is assembling coaches for Delhi Metro. They are acquiring transfer of technology for coach manufacture for other metros of the country. Kochi's requirement can also be sourced from BEML.

0.7 Power Requirements

Electricity is required for operation of Metro system for running of trains, station services (e.g. lighting, lifts, escalators, signaling & telecom, fire fighting etc) and workshops, depots & other maintenance infrastructure within premises of metro system. The power requirements of a metro system are determined by peak-hour demands of power for traction and auxiliary applications. Broad estimation of auxiliary and traction power demand is made based on the following requirements:-

(i) Specific energy consumption of rolling stock – 75KWh/1000 GTKM

(ii) Regeneration by rolling stock – 30%

(iii) Elevated station load – initially 200KW, which will increase to 300 KW in the year 2025

(iv) Depot auxiliary load - initially 2000KW, which will increase to 2500 KW in the year 2025

Keeping in view of the train operation plan and demand of auxiliary and traction power, power requirements projected for the year 2015 , 2020 and 2025 are summarized in Table 0.6 below:-

Table 0.6
Power Demand Estimation (MVA)

Corridor		Year		
		2015	2020	2025
Alwaye – Mutton - Petta Corridor [24.82 kms & 23 stations]	Traction Auxiliary Total	7.1 8.2 15.3	8.5 9.9 18.4	10.6 11.6 22.2

- **Sources of Power Supply**

The high voltage power supply network of Kochi has 220kV, 110KV and 66kV network to cater to various types of demand in vicinity of the proposed corridor. 220 KV sub-stations are generally located at outskirts of the city. 110 kV sub stations are located to the alignment of Corridors. Keeping in view the reliability requirements, two input sources of 110 kV Voltage level are normally considered for this corridor. Therefore, to achieve the desired reliability, two Receiving Sub Stations (110 / 33 / 25 kV) are proposed to be set up for this Corridor. M/s KSEB have given confirmation for supply of electricity at the following grid sub-stations at 110kV voltage vide their letter no. TCK/111/DB-1/Metro Rail/2005-06/394 dated:-27.06.2005 and letter no. T - 2(b) /Misc./klmsy/metro Kochi/57,dated:-26.04.2011

Table 0.7
Sources of Power Supply

S.N	Corridor	Grid sub-station (Input voltage)	Location of RSS of Metro Authority	Approx. length of 110kV cables
1.	Alwaye – Petta corridor	Kalamassery sub-station (110kV)	Kalamassarey	1.5km. (Double circuit)
2.		Kaloor sub-station (110kV)	Kaloor (in the compound of KSEB S/S)	0.5 km. (Double circuit)

The summary of expected power demand at various sources is given in Table 0.8.

Table 0.8
Power Demand Projections for Various Sources

Corridor	Input Source / Receiving Sub Station (RSS)	Peak Demand – Normal (MVA)			Peak Demand – Emergency (MVA)		
		2015	2020	2025	2015	2020	2025
Alwaye - Petta Corridor	**Kalamassery RSS.**						
	Traction	4.5	5.2	6.3	7.1	8.5	10.6
	Auxiliary	5.0	5.9	6.8	8.2	9.9	11.6
	Total (A)	9.5	11.1	13.1	15.3	18.4	22.2
	Kaloor RSS						
	Traction	2.6	3.3	4.3	7.1	8.5	10.6
	Auxiliary	3.2	4.0	4.8	8.2	9.9	11.6
	Total (B)	5.8	7.3	9.1	15.3	18.4	22.2
	TOTAL (A + B)	**15.3**	**18.4**	**22.2**			

* Incase of failure of other source of power

- **Auxiliary Supply Arrangements for Stations & Depot**

Auxiliary sub-stations (ASS) are envisaged to be provided at each station (1 ASS for elevated station) for stepping down 33 kV supply to 415 V for auxiliary applications. A separate ASS is required at depot. The ASS will be located at mezzanine or platform level inside a room. The auxiliary load requirements have been assessed at 200kW for elevated / at-grade stations which is likely to increase up to 300 KW in the year 2025. In order to meet the requirement of auxiliary power two dry type cast resin transformers (33/0.415kV) of 500 kVA capacity are proposed to be installed at the elevated stations (one transformer as standby). For Property Development within the footprints of the station, a provision to add third transformer at a later date may be kept at elevated station.

- **Standby Diesel Generator (DG) Sets**

In the unlikely event of simultaneous tripping of all the input power sources or grid failure, the power supply to stations as well as to trains will be interrupted. It is, therefore, proposed to provide a standby DG set of 180 KVA capacity at the elevated stations to cater to the following essential services:

(i) Essential lighting
(ii) Signaling & telecommunications
(iii) Fire fighting system
(iv) Lift operation
(v) Fare collection system

Silent type DG sets with low noise levels are proposed, which do not require a separate room for installation.

- **Supervisory Control and Data Acquisition (SCADA) System**

The entire system of power supply (receiving, traction & auxiliary supply) shall be monitored and controlled from a centralized Operation Control Centre (OCC) through SCADA system. Modern SCADA system with intelligent remote terminal units (RTUs) shall be provided. Optical fiber provided for telecommunications will be used as communication carrier for SCADA system.

Digital Protection Control System (DPCS) is proposed for providing data acquisition, data processing, overall protection control, interlocking, inter-tripping and monitoring of the entire power supply system consisting of 33kV ac switchgear, transformers, 25kV ac switchgear and associated electrical equipment. DPCS will utilize microprocessor-based fast-acting numerical relays & Programmable Logic Controllers (PLCs) with suitable interface with SCADA system.

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- **Energy Saving Measures**

Energy charges of any metro system constitute a substantial portion of its operation & maintenance (O & M) costs. Therefore, it is imperative to incorporate energy saving measures in the system design itself. The auxiliary power consumption of metros is generally more than the traction energy consumed by train movement during initial years of operation. Subsequently, traction power consumption increases with increase in train frequency/composition in order to cater more traffic. The proposed system of Kochi Metro includes the following energy saving features:

(i) Modern rolling stock with 3-phase VVVF drive and lightweight stainless steel coaches has been proposed, which has the benefits of low specific energy consumption and almost unity power factor.

(ii) Rolling stock has regeneration features and it is expected that 30% of total traction energy will be regenerated and fed back to 25kV ac OHE to be consumed by nearby trains.

(iii) Effective utilization of natural light is proposed. In addition, the lighting system of the stations will be provided with different circuits (33%, 66% & 100%) and the relevant circuits can be switched on based on the requirements (day or night, operation or maintenance hours etc).

(iv) Machine-room less type lifts with gearless drive has been proposed with 3-phase VVVF drive. These lifts are highly energy efficient.

(v) The proposed heavy-duty public services escalators will be provided with 3-phase VVVF drive, which is energy efficient & improves the power factor. Further, the escalators will be provided with infrared sensors to automatically reduce the speed (to idling speed) when not being used by passengers.

(vi) The latest state of art and energy efficient electrical equipment (e.g. transformers, motors, light fittings etc) have been incorporated in the system design.

(vii) Efficient energy management is possible with proposed modern SCADA system by way of maximum demand (MD) and power factor control.

- **Electric Power Tariff**

The cost of electricity is a significant part of Operation & Maintenance (O&M) charges of the Metro System, which constitutes about 25 – 35% of total annual working cost. Therefore, it is the key element for the financial viability of the project. The annual energy consumption is assessed to be about 41 million units in initial years (2015), which will increase to about 58 Million Units by year 2025 for this Corridor. In addition to ensuring optimum energy consumption, it is also necessary that the electric power tariff be kept at a minimum in order to contain the O& M costs. Therefore, the power tariff for this Corridor should be at effective rate of purchase price (at 110 kV voltage level) plus nominal administrative charges i.e. on a no profit no loss basis. This is expected to be in the range of Rs. 2.75-3.50 per unit. It is proposed that Government of Kerala takes necessary steps to fix power tariff for Kochi Metro at "No Profit No Loss" basis. Financial analysis has been carried out based on this tariff for the purpose of finalizing the DPR. Similar approach is being pursued for Delhi Metro

0.8 MAINTENANCE DEPOT

On the Alwaye-Petta corridor a maintenance depot along with minimum repairing facilities has been proposed at Muttom.

Daily tests and checks shall be done at stabling sidings. 7 day, 15 day and 45 day inspection shall be done inside the Inspection Shed. The facilities shall be provided in phases and augmented as the train frequency and formation increases due to growth in traffic.

0.9 ENVIRONMENT IMPACT ASSESSMENT AND MANAGEMENT

A detailed Environmental Impact Assessment Study has been carried out along the proposed alignment. As a part of this study, comprehensive environmental baseline data was collected. Both positive and negative impacts of the project were assessed in detail. The project has many positive environmental impacts like reduction in traffic congestion, saving in travel time, reduction in air and noise pollution, lesser fuel consumption, lesser road accidents etc. However, the project has some negative impacts especially during implementation of the project. An important environmental consideration of this project is that neither any forest area nor any plants/ trees of endangered species exist along the proposed alignment, though few residential / commercial properties are affected. To minimize the negative environmental impacts, a Environmental Management Plan has been drawn up.

0.10 COST ESTIMATES

The overall capital cost for Alwaye – Petta corridor, at August , 2011 price level, works out to Rs. 3733 crores, excluding taxes and duties, but including general charges @ 7% on all items except land and 3% contingencies on all items. The abstract capital cost estimates are shown at **Table 0.9**.

TABLE 0.9

CAPITAL COST ESTIMATE					
ALWAYE-PETTA					
Total Length(Dead End to Dead End) : 25.612Km, Ramp = 1.000 Km. UG : 0 Km, Elevated (Including ramp approach depot) = 26.612 Km, Depot At Grade : 1.175 Km					
Total Station =23, Elevated : 23					
S. No.	**Item**	**Unit**	**Rate as per Price level AUG-2011 (INR In Crores)**	**Qty.**	**Amount (INR in Cr.) (Cost Without Taxes & Duties) as per Price level AUG-2011**
1.0	**Land (INCLUDING R&R COSTS)**				
1.6	Permament	LS			604.00
	Sub Total (1)	LS			**604.00**
2.0	**Alignment and Formation**				
2.1	Elevated viaduct section	R. km.	30.142	25.612	771.98
2.2	At Grade	R. km.	21.099	1.000	21.10
	Sub Total (2)				**793.08**
3.0	**Station Buildings**				
3.1	Elevated stations (including finishes)				
a	Type (A) way side Civil works	Each	13.973	16.000	223.56
b	Type (A) way side E&Mworks	Each	2.254	16.000	36.06
c	Type (B) Way side with signaling civil works	Each	15.134	6.000	90.80
d	Type (B) Way side with signaling E&M works	Each	2.438	6.000	14.63
e	Type (C), Terminal station	Each	17.469	1.000	17.47

f	Type (C) Way side with signaling E&M works	Each	2.818	1.000	2.82
	Sub total (3)				**385.34**
4.0	**Depot**				
4.1	Muttom				
a	Civil works	LS			59.93
b	E&M	LS			82.02
	Sub total (4)				**141.95**
5.0	**P Way**				
5.1	Ballastless track for elevated alignment including ramp	R. km.	6.738	26.612	179.31
5.2	Ballastted track at grade	R. km.	6.738	1.175	7.92
	Sub total (5)				**187.23**
6.0	**Traction & power**				
	Traction & power supply incl. OHE, ASS etc.				
6.1	Elevated section	R. km.	8.560	27.787	237.86
6.2	Escalatoe at Elevated Section	R. km.	1.001	46.000	46.02
	Sub total (8)				**283.88**
7.0	**Signalling and Telecom.**				
7.1	Signalling & Telecom	R. km.	12.000	26.612	319.34
7.2	Automatic fare collection	Each Stn	3.079	23.000	70.82
	Sub Total (7)				**390.16**
8.0	**R & R incl. Hutments etc. (NO COST AS IT IS INCLUDED IN LAND COST)**	LS			0.00
	Sub Total (10)				**0.00**
9.0	**Misc. Utilities, other civil works such as median, road signages etc.**				
9.1	Civil works + E&M works	R. km.	2.500	26.612	66.53
	Sub Total (9)				**66.53**
10.0	**Rolling Stock (SG)**	Each	8.400	66	554.40
	Sub Total (10)				**554.40**
11.0	**CISF BARRACKS ETC.**	LS			20.00
	Sub Total (11)				**20.00**
12.0	**Total of all items except Land**				**2822.57**

13.0	**General Charges incl. Design charge @7% on all items except land**				**197.58**
14.0	**Total of all items including General charges except land**				**3020.15**
15.0	**Contingencies @ 3 %**				**90.60**
16.0	**Gross Total**				**3110.75**
COST WITHOUT LAND					**3111**
	Total of cost inclusive of land cost				**3733**

The completion cost with project completion in the year 2016-17 is Rs. 4910 crores including escalation but with central taxes only and it comes to Rs. 5146 Crores inclusive of state taxes.

0.11 CONCESSIONS FROM GOVERNMENT

Metro rail projects need very heavy investment. Loans have invariably to be taken to fund a part of the capital cost of the projects. These projects yield low financial internal rate of return though their economic internal rate of return is very high. With reasonable fair level, servicing of these loans often pose problems. To make the project financially viable, therefore, the fares need to be substantially increased to socially un-acceptable levels. This results in the ridership coming down significantly, as it is sensitive to increases in the fare level. Thus the very objective of constructing the metro rail system to provide an affordable mode of mass travel for public is defeated. It, therefore, becomes necessary to keep the initial capital cost of a metro project as low as possible so that the fare level of the metro system can be kept at reasonable level.

Experience of Delhi Metro project has shown that the taxes and duties constitute about 16 – 18% of the project cost. Following are the taxes and duties, which have to be borne by a metro project:

- Custom Duty on all imported rolling stock and other equipment needed for the project.
- Excise Duty on all indigenously manufactured rolling stock and other indigenously finished goods required for the project.
- Sales Tax on all purchases made for implementation of the project whether directly by the project implementation authority or by the contractors executing the project.

- Sales Tax on works contracts to be executed for the implementation of the -project.
- Tax on electricity required for operation and maintenance of the metro system.
- Municipal Taxes.

In the case of Delhi Metro project, the Union Government has granted exemption from payment of Custom Duty and Excise Duty while the Delhi Government has agreed to give exemption from payment of Sales Tax and Sales Tax on works contracts. Delhi Metro Rail Corporation is also pursuing with the Government for exemption from tax on electricity being consumed by Delhi Metro for its operation and maintenance.

It is recommended that similar exemptions from taxes and duties be granted by the Central Government/Kerala Government for Kochi Metro.

0.12 FINANCIAL VIABILITY, FARE STRUCTURE AND FINANCING OPTIONS

The FIRR of the project is 3.04 % .The fare structure has been estimated based on Delhi Metro fares duly escalating the same. The fare structure for the year 2016-17 is given below.

Table 0.10

Distance in kms.	Proposed fare for Kochi Metro (Rs.)
0-2	10.00
2-4	13.00
4-6	15.00
6-9	19.00
9-12	21.00
12-15	23.00
15-18	24.00
18-21	27.00
21-24	28.00
24-27	30.00

Subsequently, for the purpose of assessing returns from the project, the fares have been revised every second year with an escalation of 5% per annum.

After examining the various options for execution of Kochi Metro Project**,** It has been suggested that the project should be get executed on the funding pattern of Delhi Metro/Chennai Metro/Kolkata Metro or on deposit terms from DMRC. This funding pattern has been recommended due to the fact that the BOT / PPP pattern has so far nowhere been successful.The fund requirements from various agencyies are given in the table below.

Table 0.11

Particulars	Government of India		Government of Kerala		Total	
	%	Rs/Crore	%	Rs/Crore	%	Rs/Crore
Equity by GOI & GO Kerala	16%	785.50	16%	785.50	32%	1571.00
SD for land for land cost by GO Kerala	0%	0.00	14%	672.00	14%	672.00
Additional SD for Central Taxes by GOI (80%) & GO Kerala (20%)	8%	397.60	2%	99.40	10%	497.00
JICA Loan @ 1.40% PA/Market Borrowing @12% PA	44%	2170.00	0%	0.00	44%	2170.00
Total	**68%**	**3353.10**	**32%**	**1556.90**	**100%**	**4910.00**
Add: State Taxes to be borne by Govt. Of Kerala		**0.00**		**236.00**		**236.00**
Grand Total	**0**	**3353.10**	**0**	**1792.90**		**5146.00**

0.13 ECONOMIC ANALYSIS

The economic appraisal of Metro Corridor from Alwaye to Petta in Kochi has been carried out within the broad framework of Social Cost –Benefit Analysis Technique. It is based on the incremental costs and benefits and involves comparison of project costs and benefits in economic terms under the “**with**” and **“without” project** scenario. In the analysis, the cost and benefit streams arising under the above project scenarios have been estimated in terms of market prices and economic values have been computed by converting the former using appropriate shadow prices. This has been done to iron out distortions due to externalities and anomalies arising in real world pricing systems. The annual streams of project costs and benefit have been compared to estimate the net cost/ benefit and to calculate the economic viability of the project in terms of EIRR.

The Economic Internal Rate of Return (EIRR) for the project has then been arrived using Discounted Cash Flow technique to the net benefit stream at economic prices.

The cost and benefit streams arising under the above situations have been estimated in terms of market prices and economic values have been computed by converting the former using appropriate shadow prices.

The Economic Internal Rate of Return **(EIRR)** in economic terms works out to 14.2% for Alwaye-Petta Corridor of Kochi Metro. This falls to 13% and 12.9% respectively in case of increase in cost by 10% or decrease in traffic by 10%. With increase in cost by 10% together with reduction in traffic by 10%, the EIRR falls to 11.8%.

0.14 IMPLEMENTATION PLAN

Kochi Metro Project will be the biggest urban Project undertaken in Kerala state. The Project has to be implemented through densely populated area along highly congested routes. In spite of all efforts taken to mitigate inconveniences and hardships to the public, certain sensitive land acquisitions and certain disruptions in the city are unavoidable. If the Project has to go through fast, a visible positive support to the Project from the Government, City Corporation and GCDA should be available. Each day's delay in completing this Project will hike up the cost of the Project by 15 lakhs. If the Project implementation is delayed, the city will become more and more crowded and it will be practically impossible to carry out construction activities later on. Therefore, a carefully drawn up strategy is necessary for implementing this Project. As a first step, Kerala State Government should inform the Central Government of its plan to go in for Kochi Metro Project through a Concessionaire route and the support which it would need from the latter.

- **Institutional Arrangement**

Experience of implementing Delhi Metro project has shown that a Special Purpose Vehicle (SPV), vested with adequate powers, is an effective organisational arrangement to implement and subsequently operate and maintain a metro project. An SPV should, therefore, be set up for Kochi Metro and registered under the Companies Act, 1956. This SPV should be a PSU of the State Government and may be named as 'Kochi Metro Ltd.' (KML) as already decided by GoK. The Managing Director of KML is already in place and now the need is to get all the approval of Central Government expeditiously. The Board of Directors (BOD) are to be vested with full powers to implement the project with adequate delegation of power to the Managing Director for day to day working.

It is also recommended that a High Power Committee under the chairmanship of Chief Secretary, Kerala should be set up. Other members of this Committee should be Secretaries of the concerned Departments of the State Government and Heads of civic bodies who will be connected in one way or the other with the implementation of the project.

- **Implementation through SPV**

Once the SPV is formed, it has to start action for implementation of the project. There are two options in this regard; either the SPV implements/operates the project itself with funds provided by the Government or it entrusts the operation of the project to a Concessionaire after construction.

- **Legal Cover for Kochi Metro**

GoI has passed metro act named as "The Metro Railways (Amendment) Act 2009" which may readily be used for implementing the Kochi Metro

- **Implementation Programme**

A suggested project implementation schedule is given below. The proposed date of commissioning of the Alwaye-Petta Corridor with suggested dates of important milestones is given in **Table 0.12**.

Table 0.12
Implementation Schedule through SPV

S. No.	Item of Work	Completion Date
1	Obtain Central Government Clearances	30.11.2011
2	Finalisation of Major Contracts	29.02.2012
3	Execution of works and Procurement of equipments, coaches and installations	01.04.2012 – 31.12.2015
4	Testing and Commissioning	01.01.2016 – 31.03.2016
5	Revenue Operation	31.03.2016

0.15 PROPOSED ROAD-OVER-BRIDGES/FLYOVERS

- **ROBs AT PULLEPADY AND NEAR KSRTC BUS STAND**

Two Road-Over-Bridges (ROBs) across the railway track between Ernakulam town and Ernakulam junction railway stations – one at Pullepady level crossing and the other near KSRTC bus stand connecting Mullassery Canal Road and Salim Rajan Road on either sides of the railway track have been planned by GCDA.

Completion of these two ROBs will substantially relieve the present traffic congestion on MG Road and Baneji Road as well as on Salim Rajan Road by diversion of traffic towards Kaloor, Pallarivattom, Kakkanad, Thammanam, Vytilla, etc.

Since construction of Kochi Metro structures on the median of Banerji Road and MG Road will hamper the movement of road vehicles during the execution period, the State Government and the GCDA authorities have been apprised the necessity for early completion of the above two ROBs.

- **PROPOSED FLYOVER AT EDAPALLY**

At present Edapally junction is a staggered intersection where Alwaye – Ernakulam route is intersected by NH 47 – bypass and NH17 within a distance of 70m and hence it causes a lot of traffic confusion. There is a proposal by the National Highway Department to rectify the staggering to make a four-legged intersection. There is another proposal by GCDA to construct a four-lane flyover on the Alwaye-Ernakulam Road.

In case the proposal of National Highway Department to rectify the staggering to make 4-legged intersection is taken up, it will not affect the Metro alignment. If later, the flyover proposal by GCDA on Alwaye – Ernakulam Road at this junction is also taken up, the Metro alignment will go alongside it. This way Metro and flyover will not obstruct each other. If slight revision of Metro alignment is required, this can be done without any problem.

- **FLYOVER FROM PALARIVATTOM JUNCTION AT NH 47 BYE - PASS TO HIGH COURT JUNCTION**

The proposal aims to relieve traffic congestion on the major city road which has the highest volume of traffic by creating a flyover or a grade separator to take through traffic. The flyover will be 4582m long and is to be designed to carry 2 lanes and hence its width is kept as 8.5m supported on a central pillars. Width of existing road at this location is not adequate to accommodate the proposed flyover along with Kochi Metro. Besides, with the construction of Kochi Metro which will relieve substantial amount of traffic moving on the existing road, the need for flyover may not be necessary. It is, therefore, suggested that the State Government may give up the proposal of fly-over at this location.

- **PROPOSED FLYOVER AT VYTILLA**

GCDA has a proposal for constructing flyover at Vytilla Junction across NH 47 bye-pass, whose alignment will be the same as that of Kochi Metro at this location. Road width at this location is not adequate to accommodate proposed flyover as well as Kochi Metro. It is, therefore, suggested that the Metro should be constructed along the Median of road, while GCDA should change its proposal of flyover to that of an underpass below the NH 47 bye-pass. Changing the fly-over to under-pass will be much more cost effective for the State Government, than to allow construction of flyover as well as Kochi Metro with double elevation at this location. It is, therefore, strongly recommended hat GCDA should revise the above proposal and plan construction of the underpass along with the construction of Kochi Metro. Kochi Metro will be designed to cater for the underpass.

0.16 CONCLUSIONS AND RECOMMENDATIONS

Kochi is the commercial capital of Kerala. It is a center for higher education as well. Cochin Port has emerged as one of the most important ports in the country. With Vellarpadam Container Terminal, the Goshree Island Development Project and industrial activities centred around Cochin Shipyard, Cochin Refinery, Cochin Fertilizer Plant, etc., traffic in the city is expected to increase substantially. Being thickly populated area and with narrow roads, the city’s traffic needs cannot be met by any road-based system. Although Railway lines converge into the city from three different directions, they only help to bring commuters from nearby towns (suburban traffic) and do not serve the need of intra-city traffic. The city needs a rail-based Metro System to meet the traffic requirements beyond the year 2016. Unless the work is taken up immediately, a Metro System will not be in position by the year 2016.

Although as per the Planning Commission’s guidelines issued in the 10th Plan Document, Metros have been recommended for cities with more than 3 million population, on account of the peculiar type of developments, waterways, low-lying areas and heavy type of developments, a Metro System is justified for Kochi. A Light Metro with carrying capacity of about 25,000 phpdt will be adequate. The studies have brought out the urgent need for such a Metro System to be commenced. It is, therefore, strongly recommended that a Light Metro System from Alwaye to Petta (25.612 km), at an estimated completion cost of Rs. 5146 crores be taken up for execution and made operational by the year 2016.

Since the SPV set up to get the project implemented will not have the required expertise to check and monitor the work, it will be necessary to engage Consultant having the experience of implementation and operation & maintenance, from the very start who will do this job on behalf of the SPV.

Chapter 1

Introduction

1.1 BACKGROUND

1.1.1 Kerala is considered the "Gateway of South India". Kochi with its wealth of historical associations and its unique setting perfectly reflects the eclecticism of Kerala. Cochin is one of India's important ports and a major naval base. Cochin Shipyard, which is the biggest shipbuilding yard in India, is situated in the southern part of Ernakulam on the way to Willingdon Island. Set up with Japanese collaboration, this shipyard has a dock for building ships and another dock for ship repairs. Moti Lal Nehru, the first oil tanker made in India, was built here. Cochin Refinery and Fertilizer plant are also located at this place.

Kochi consists of mainland Ernakulam; the islands of Willingdon, Bolghatty and Gundu in the harbour; Fort Kochi and Mattancherry on the southern peninsula; and Vypeen Island, north of Fort Kochi. All these areas are linked by ferry; bridges link Ernakulam to Willingdon Island and the Fort Kochi/Mattancherry peninsula.

Kochi region lies between 9º-49' North latitude and 76º-31' East longitude.

The older parts of Fort Kochi and Mattancherry are an unlikely blend of medieval Portugal, Holland and an English country village grafted onto the tropical Malabar Coast – a radical contrast to the bright lights of mainland of Ernakulam.

Located on the western coast, the force of interaction between sea, river and land has imparted a peculiar topography to Kochi with a predominance of water sheets and lagoons. River periyar empties into the Kochi channel and gives rise to a number of Islands lying in the backwaters.

1.1.2 Rapid urbanization and intense commercial developments in the recent past have resulted in steep rise in travel demand putting Kochi's transport infrastructure to stress. With mega projects such as "SMART CITY', 'INFO PARK', 'FASHION CITY' and "Vellarpadam Container Terminal" etc, on the anvil, the travel needs are expected to shoot up, strengthening the need for augmenting the transport infrastructure in Kochi region. Like most Indian medium sized cities, Kochi also represents a chaotic situation as far as traffic and transport scenario is concerned.

1.1.3 The population of Greater Cochin Development Authority area was 1.67 million in 1991. Now it houses a population of about 1.9 million (1.81 million as per 2001 Census), with a population density of 2600 people per sq. Km. Cochin Corporation, the central portion of the study area has a population density of 6300 persons per Sq. Km., housing about 40% of the district's urban population. The population in the study area has been growing at a rate of 1.4% per annum.

1.1.4 Need of Revision of DPR

The original DPR was prepared in 2005 based on May-2005 Price Level. Since then there is a substantial hike in Price Index and prices of all commodities have largely increased. Originally, Alwaye station was proposed near the Alwaye Railway Goods Shed. However to cater for the need of the commuters using Rajiv Gandhi Bus Terminal and also in view of the future extension to Cochin International Airport, it was felt that a metro station in the vicinity of Rajiv Gandhi Bus Terminal should be located. Hence, Alwaye Station Location has been shifted closer to Rajiv Gandhi Bus Terminal and route is now aligned along the NH-47.

1.2 STUDY AREA

Looking at the spread of land-use, existing commuting patterns and future development proposals, Greater Cochin Area (GCA) has been considered as the study area which is shown in Fig. 1.1 Study area comprises Cochin Corporation, 6 other municipalities and 33 village panchayats spread over an area of 730 sq Km.

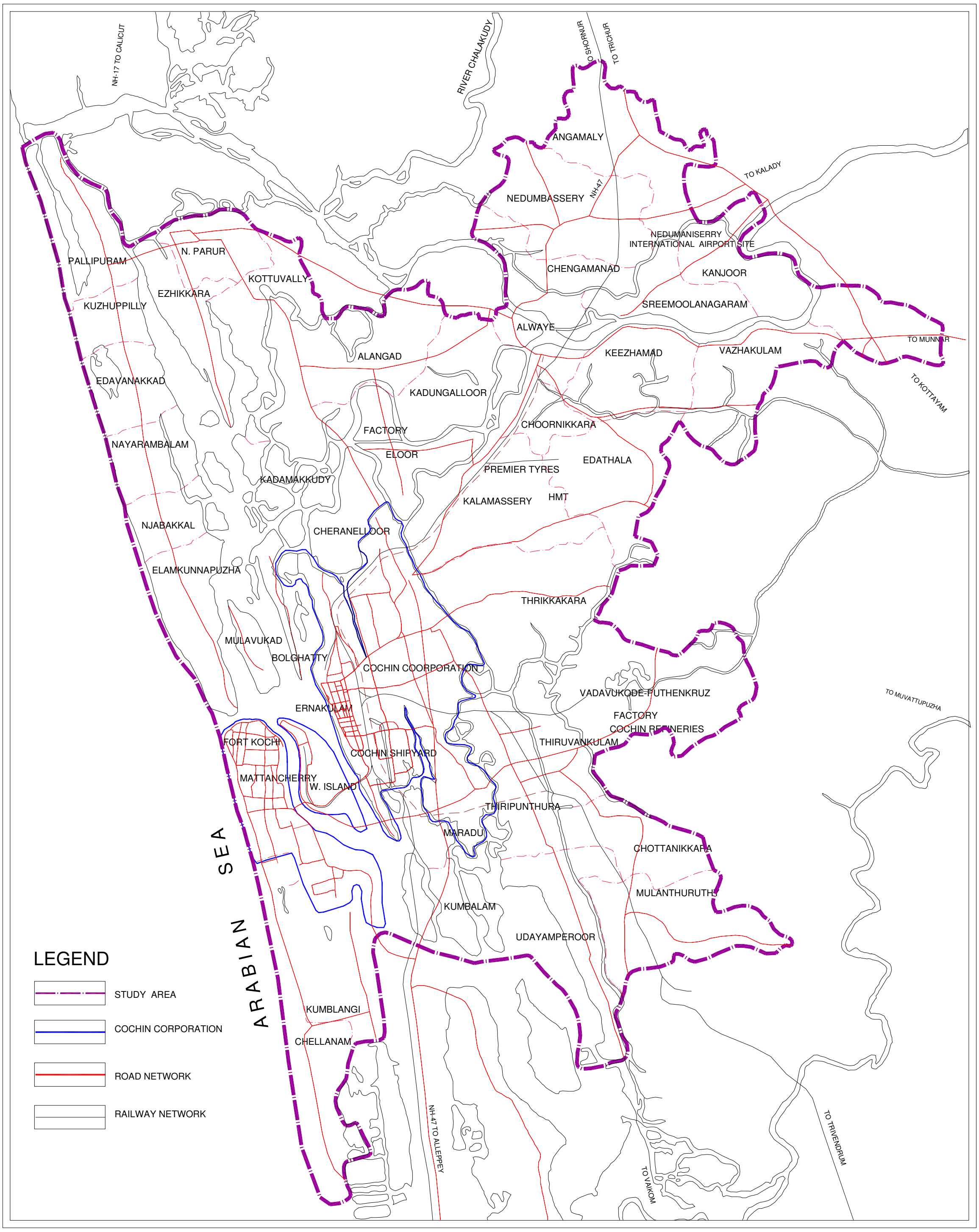


Fig 1.1 Greater Cochin Development Area

1.2.1 STUDY AREA

Existing land-use in the study area is shown in Fig. 1.2

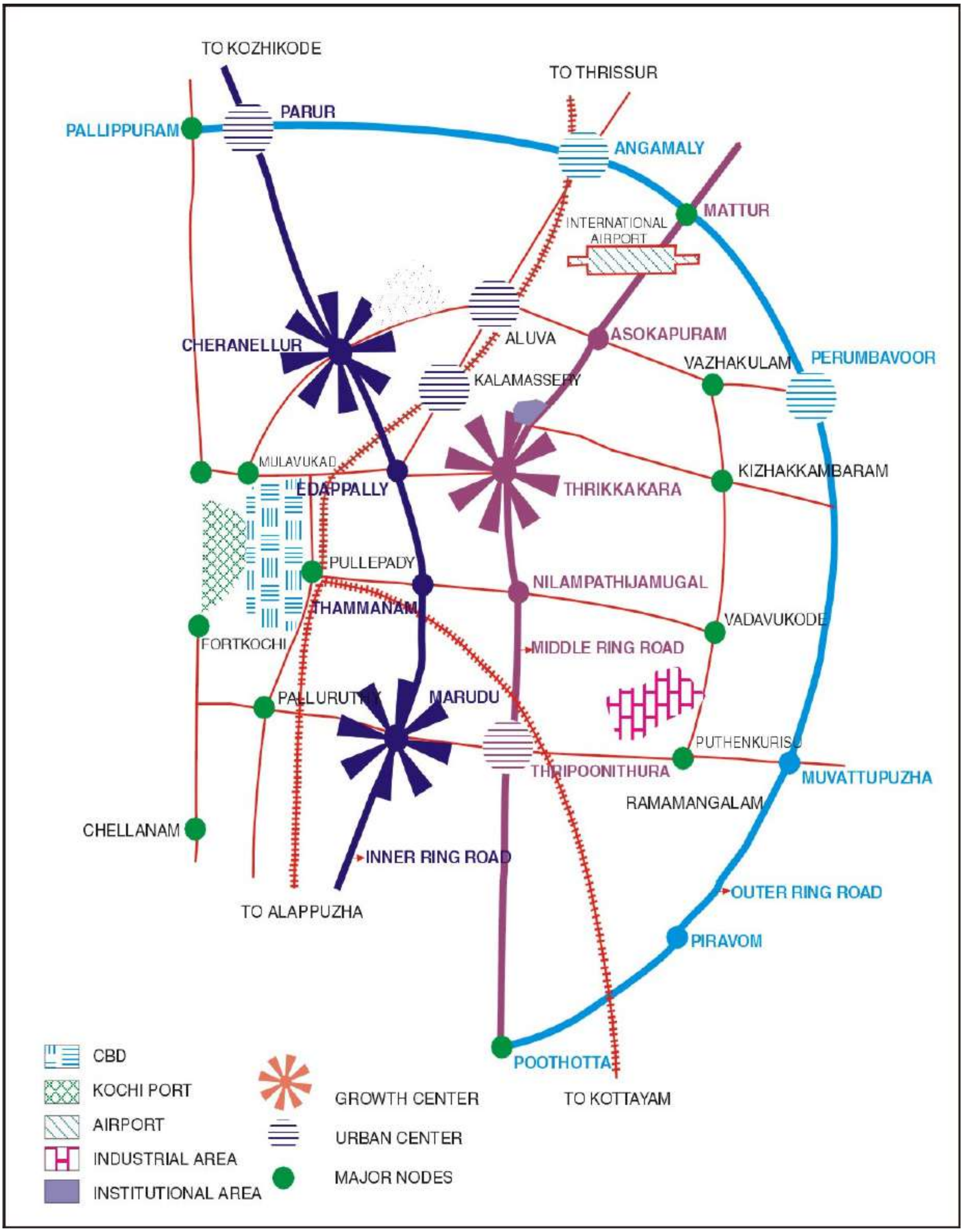


Figure 1.2 Land use scenario

1.3 DEMOGRAPHIC PROFILE

Growth of population of Greater Cochin area and Cochin Corporation alone in the last 4 decades is given in Tables 1.1 and 1.2 respectively.

Table 1.1
Growth of population in Study area (in millions)

Year	Population of Greater Cochin Area (in millions)	Decadal growth (%)
1961	0.958	-
1971	1.248	30.27
1981	1.481	18.66
1991	1.66	12.08
2001	1.81	9.50

Table 1.2
Growth of population in Cochin Corporation area (in millions)

Year	Population of Cochin Corporation Area (in millions)	Decadal growth (%)
1961	0.338	-
1971	0.439	30.27
1981	0.513	16.85
1991	0.564	9.94
2001	0. 596	13.47

1.4 Registered Motor Vehicles

The growth of Motor Vehicles in Study area during the period 1987 to 2003 is given in Table 1.3.

Table 1.3
Growth in the number of Registered Motor Vehicles in the Study Area

Type of Vehicle	1987	1988	1989	1990	1991	1995	2002	2003
Goods Vehicle	8665	10421	11205	12059	12367	15315	37245	36628
Bus	1780	1946	2062	2076	2113	5176	10048	9753

Type of Vehicle	1987	1988	1989	1990	1991	1995	2002	2003
Car/Jeep/ Stn. Wagon	19647	21067	22473	24737	26251	37481	71825	71404
3-Wheelers	4152	4635	5176	6219	6352	17012	27572	33478
2-Wheelers	32037	34637	37877	44129	46694	165250	253745	283283
Others	1990	2074	1959	2221	1526	1547	2703	12413
Total	**68271**	**74780**	**80752**	**91441**	**95303**	**241781**	**403138**	**446959**

1.5 Occupational structure of population

Occupational structure of population of Ernakulam District, Kochi Urban agglomeration and Kochi (City & Outer Growth) is given in Table 1.4.

Table 1.4
Occupational Structure (%) as per 1991 census

Area	Occupational Structure		
	Primary	Secondary	Tertiary
Ernakulam District	38.04	16.44	45.52
Kochi U.A.	15.23	20.29	64.48
Cochin Corporation (City and Outer growth)	8.65	17.52	73.83

1.6 EARLIER STUDIES

Amongst the earlier studies, preparation of the Structure plan for the Central city for the year 2001 by the Greater Cochin Development Authority (GCDA) is of foremost importance. Other important studies include the Kerala Urban Development Project sponsored by the World Bank, Vypeen Bridges Project by the Goshree Islands Development Authority (GIDA) and Master Plan for Development of Kochi Port by the Kochi Port Trust. M/s RITES also conducted a 'Comprehensive Study for Transport System for Greater Cochin Area' A short review of the various studies is presented hereunder.

1.6.1 Structure Plan For Central City Kochi – 2001

A structure plan was prepared by the GCDA in 1985 with the assistance of the State Town Planning Department for the Central City of Kochi for the horizon year 2001. The plan area comprised Cochin Corporation, Tripunithura Municipality and the Panchayats of Kalamassery, Eloor, Thrikkakara, Maradu, Mulavukadu, Njarakkal, Elamkunnapuzha, Cheranalloor, Thiruvankulam and Kadamakudy - spread over an area of 275.85 sq.km. The structure plan was aimed at providing a framework of planned growth of the Central City over two decades (1981-2001) through spatial distribution of the population, land uses and activity centres in the Central City.

The planning concept for the traffic network and transportation envisaged maximising the operational efficiency and serviceability by the expansion and integration of different modes.

At the inter-city level, the plan proposed;

i) Early completion of NH-47 bye-pass (since completed) and NH-17 Road (work in progress);
ii) Early completion of coastal railway line to Alleppey (since completed) and investigation of coastal link railway from Kochi to Madurai and to Kuttipuram (not taken up so far);
iii) Deepening of the shipping channels and extension of wharf facilities by the sides of Vallarpadam Island for catering to the needs of container traffic, passenger berths and export production zone (nearing completion)
iv) Extension of the old airport runway to the South of Wellington Island (not taken up so far).

At the city level, the plan proposed;

i) Realignment, widening and improvement of radial roads;
ii) Alignment, widening, improvement and completion of missing links along earmarked ring roads linking the radial roads;
iii) Planning of secondary road network for improvement and development of missing links;
iv) Redesign of major intersections;
v) Creation of grade separated facilities for pedestrians;
vi) Allocation of parking spaces in CBD area;
vii) System of traffic terminals and transit stations for passengers and goods in the city, the major proposal being creation of a Central Bus Station and a Truck Terminal for the city; and
viii) Improvement of inland navigation routes and landing facilities in the city for passengers and goods

All the above works are still in planning stage.

1.6.2 Kerala sustainable Urban Development Project (KUDP) - 2005

The Kerala Urban Development Project (KUDP) of the Government of Kerala initiated the World Bank aided study on Road Development and Traffic Management for the three major cities of Kerala, viz. Thiruvanthapuram, Kochi and Kozhikode. The principal objectives of the study were to:

i) Develop plans and programmes for establishing and strengthening selected urban transportation institutions in the state, viz. Urban Road and Traffic Engineering (URTE) Unit, Traffic enforcement by Police, Road Rehabilitation and Maintenance and Mechanisms for financing urban transport;
ii) Establish adequate Traffic and Transport baseline data for planning and designing urban transport facilities;
iii) Prepare road construction and major reconstruction schemes for high priority roads;
iv) Prepare rolling road rehabilitation and maintenance programmes;
v) Prepare a Traffic Engineering and Management Programme aimed at increasing system capacity and safety at relatively low cost

The study proposed the development of the following schemes;

i) Kaloor-Kadavanthara Road; (since completed)
ii) Pullepady-Thammanm Road; (since completed upto bridge)
iii) Sahodaran Ayyappan Road (Since completed);
iv) Indira Gandhi Bridge to Sahodaran Ayyappan Road (via Pannampilly Avenue);
v) New Bridge across Mattancherry Channel (In progress)

Additionally, the following roads were identified for carriageway widening under the corridor development programme:

i) P.T. Jacob Road and Sandogopalan Road;
ii) Elamakkara Road and Pottakuzhy-Pachalam Road;
iii) Mullesary Canal Road (now taken up partially)

The above schemes are still in the planning stage

1.6.3 Vypeen Bridges Project

The development of missing links and bridges in the study area over the years had been concentrated mainly along the Southern islands. Consequently, the densely populated Northern islands of Vypeen, Vallarpadam and Bolghatty have low level of infrastructure development due to the absence of a direct road connection to the Ernakulam mainland. Recognising the need for an integrated development of the islands sprawled on the Northern side of Kochi backwaters, Government of Kerala formed the Goshree Islands Development Authority (GIDA) in 1994.

The project was envisaged as a financially self-supporting scheme, as the financial resources to undertake the massive bridge building project were not available with GIDA or the State Government. The project estimated to cost Rs. 68 crores, involves construction of Ernakulam-Vypeen Road connecting the islands through 3 bridges namely Ernakulam mainland to Mulavukad, Mulavukad to Vallarpadam and Vallarpadam to Vypeen Islands (since completed). Besides, the project envisages reclamation of 25 hectares (initially proposed 250 hectares) along the Ernakulam mainland. The project is proposed to be executed by raising finance at a high rate of return through sale of the reclaimed and developed land.

Currently, the reclamation work is nearing completion and the construction of the 3 bridges along with the connecting road has been completed**.**

1.6.4 Master Plan For Development of Kochi Port

Kochi Port, located on Wellington Island, is a major port on India's south-west coast with proximity to the International sea route between Europe, Far East and Australia. Its hinterland comprises of Kerala alongwith major parts of Tamilnadu and Karnataka. With the establishment of Inland Container Depots at different centres in India and development of Konkan Railway, this hinterland has further spread to various parts of the country. The total traffic handled at the port has been growing at a steady rate over the past decade and it was 126.25 lakh tonne in 1998-99.

Realising the need to provide more facilities for the increased traffic in future, Kochi Port Trust has formulated a Master Plan for the development of Kochi Port. The major development proposals for expansion of the port are :

- Development of Vallarpadam Island as Container Transhipment terminal (work nearing completion)
- Development of Puthuvypeen Island for handling of LNG/LPG, Crude Oil and POL products (work is in progress)

1.6.5 Greater Cochin Development Authority Area - Perspective Plan - 2021

The perspective plan for GCDA area under preparation for the year 2021 is expected to take care of the growing and anticipated infrastructural deficiencies for the city. The areas proposed to be developed in near future and the residential density for the various pockets shall play an important role in deciding the transport infrastructure for the study area. Related papers are under preparation for almost all urban planning aspects including traffic & transport, environment, sanitation, industry, housing, port activities, tourism etc.

The present study is in line with the overall growth and development of the city as envisaged in the perspective plan for the year 2021.

1.6.6 Report for Integrated Development Of Kochi and Adjoining Islands, 1988

Thirty-two big and small islands adjoin the Kochi mainland, separated by varying widths of backwaters. Together with the mainland, these constitute the ‘Kochi Region’ or the Greater Cochin area as referred in the context of the study. In consultation with the State Government of Kerala, a Centre-State team for integrated development of Kochi and the adjoining islands was set up by the Planning Commission, Government of India in 1987. The main objectives of the study were

- To identify programmes for integrated development of Kochi area keeping in view the industrial, commercial and strategic installations in the area in a setting of islands and backwaters
- To identify the need for reclamation of land, deepening of waterways and construction of road links to the islands
- To advise on the implementation strategy and ways to integrate activities and financial resources of Central and State organisations operating in the region.

The observations in the road transport sector included poor alignment and geometries, uncontrolled ribbon development and narrow bridges, all causing frequent bottle necks at peak hours. Various recommendations given by the team regarding roadways included provisions for Bus Stations, Truck Terminal, and renewal and construction of bridges, etc. The team submitted its report in 1988 and since then only partial improvement has been achieved.

Hence, except for the study on the Vypeen Bridges, no other major transport study has been carried out earlier exclusively bringing forth the transportation needs and demands in terms of transport infrastructure in form of either joint systems or otherwise for present or near future.

1.6.7 Comprehensive Study for Transport System for Greater Cochin Area by RITES in 2001.

This study conducted in 2001 recommended improvement to the existing road infrastructure as short and medium term measures and provision of Light Rail Transit System between Alwaye to Tripunithura. The recommendations of this study are yet to be implemented.

Chapter 2

Traffic Study

2.1 STUDY AREA AND TRAFFIC ZONING

2.1.1 Looking at the spread of land-use, existing commuting patterns and future development proposals, Greater Cochin Area (GCA) was taken as the study area. GCA comprises Kochi Corporation, 6 other municipalities and 33 village panchayats spread over an area of 730 Sq. Km.

2.1.2 Traffic zone system of the Study has been designed based on following criteria:

- Conformance with ward boundaries
- Conformance with census section boundaries (as far as possible)
- Regular shape of the zone
- Un-skewed land use distribution
- Conformance with natural and artificial boundaries such as water bodies, major roads, rail corridors etc.
- Zoning adopted by the past studies conducted in the region

2.1.3 The study area was divided into 89 Traffic Analysis Zones (TAZ) to establish and predict the travel behavior, of which 50 zones fall within the Kochi Corporation area and 39 fall outside the Corporation limits. The traffic zones within Corporation and those outside are shown in Figure 2.1 and Figure 2.2 respectively. In addition to the 89 internal zones, six external zones have been considered to account for the external traffic.

2.2 METHODOLOGY FOR RIDERSHIP FORECAST

The Study methodology followed for ridership forecast on Kochi Metro consists of the following five stages.

1. Database Preparation
2. Estimation of Base Year Trip Matrices

3. Base Year O-D Validation
4. Base year Model Development
5. Ridership forecasting and Sensitivity Analysis

Broad framework for traffic forecasting is shown in Figure 2.3 and various steps involved are discussed in following sub sections:

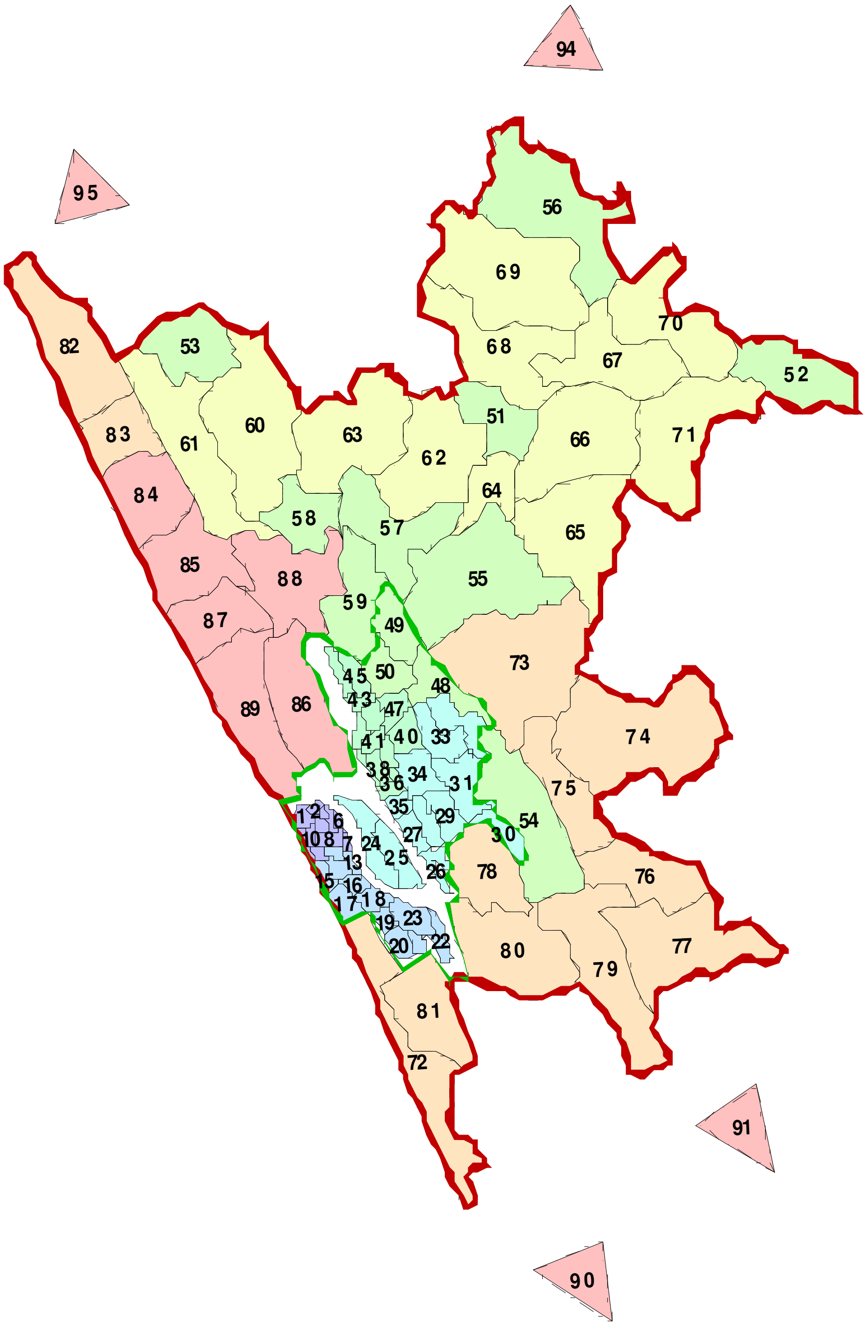


Figure 2.1 Greater Cochin Area Traffic Zone System

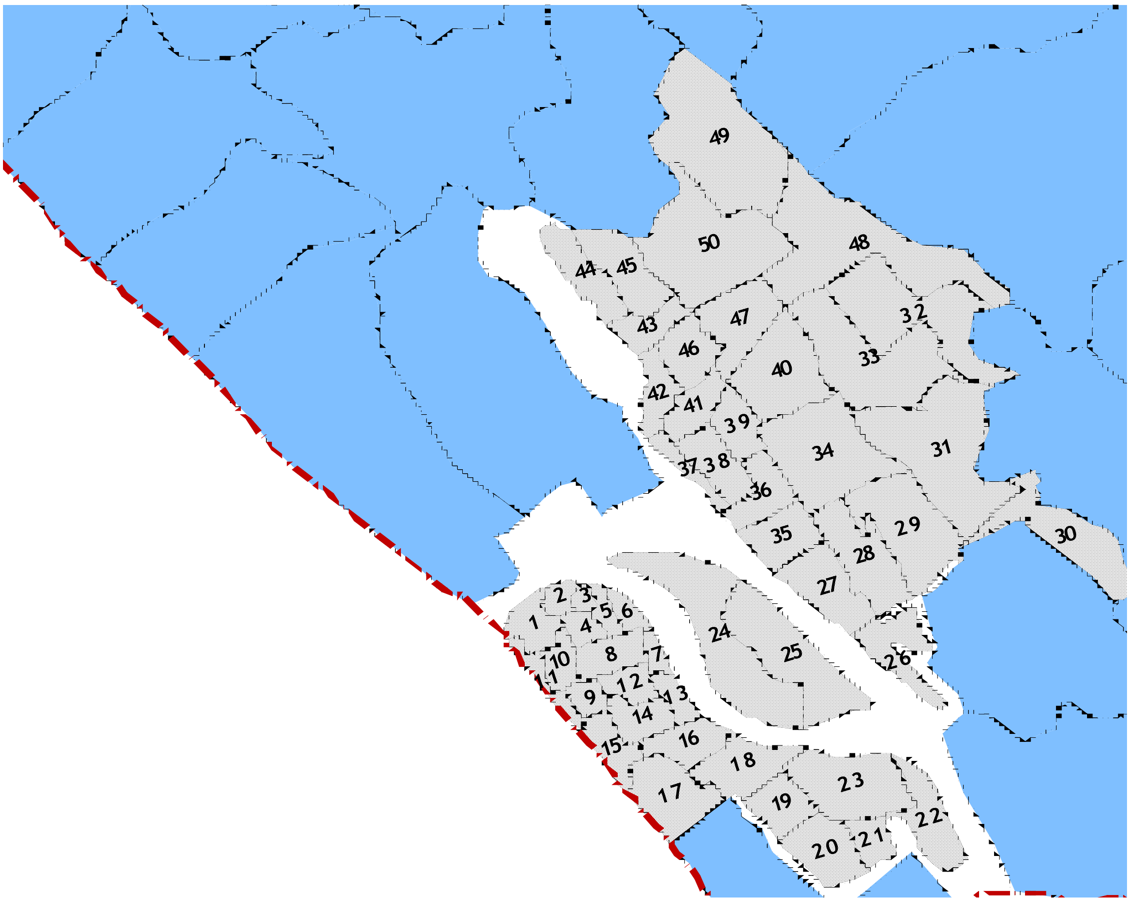


Figure 2.2 Kochi Corporation Traffic Zone System

2.2.1 Stage – 1 Database Preparation

In order to obtain the travel pattern information in the Greater Cochin Area data was collected both from secondary and primary sources. Data from the project surveys conducted in the recent past was collected and updated by conducting primary surveys.

The secondary data collected comprised of :

- Study area maps including land-use, road network, regional network, perspective plans, etc;
- Population and employment statistics from Census;
- Future land-use and transport development proposals from GCDA, Kochi Corporation, State PWD, District Collectorate; and

- Public transport i.e., bus, ferry and rail service characteristics such as routes, frequency, fare structure, system capacity etc.

Following primary surveys were conducted:

a) Household Interview Surveys – Collection of trip information of full family on previous working day by interviewing the head of the household and other members where ever possible. A sample of about 1000 households spread across the study area was collected to augment the 7000 sample data collected by RITES as a part of the Comprehensive Transport Study in 2001. The data collected as a part of House Hold Interview survey include:

  - Factual data on household location, size, employment details of the members, students and the vehicle ownership.
  - Income of each household member and other pseudo income parameters such as telephones, mobiles, credit cards, computers etc was also collected.
  - Details of the trips made on the preceding day of the interview by the residents of over 5 years of age. The details include the origin, destination, purpose, mode used, time of start and the end of the journey, etc.
  - Willingness to Pay

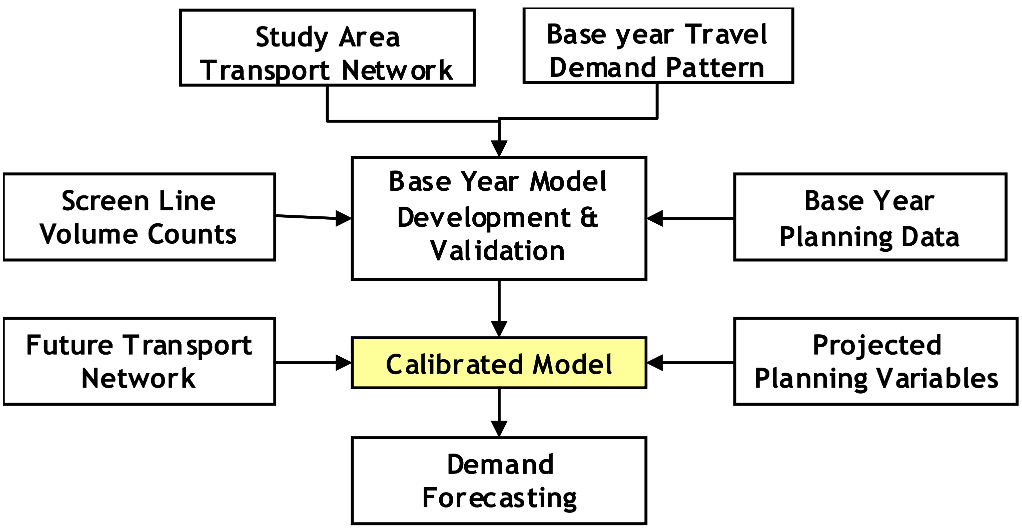


Figure 2.3 Methodology Travel Demand Forecasting

b) Road Side Interview Surveys – Collection of information on trip being performed by stopping a private vehicle (Car, TW and Auto) at a given location. The locations of the Roadside interview survey are fixed along the screen lines carefully so as to capture all the movements towards and away from the CBD across the screen lines. The screen lines for the study are shown in figure 2.4. Roadside interview (RSI) surveys were carried out from 08.00 hrs to 14.00 hrs. RSI surveys are conducted at selected locations by stopping the vehicles with the help of police covering both peak and off peak periods in morning. The roadside interview survey locations were combined with the Volume count survey locations in order to calculate the expansion factors. The information collected includes Origin, Destination, Occupancy, Purpose, type of trip (home based / Non home based). The sample covered was calculated on the spot and care was taken to obtain a minimum sample of 10% for any hour of the data collected.

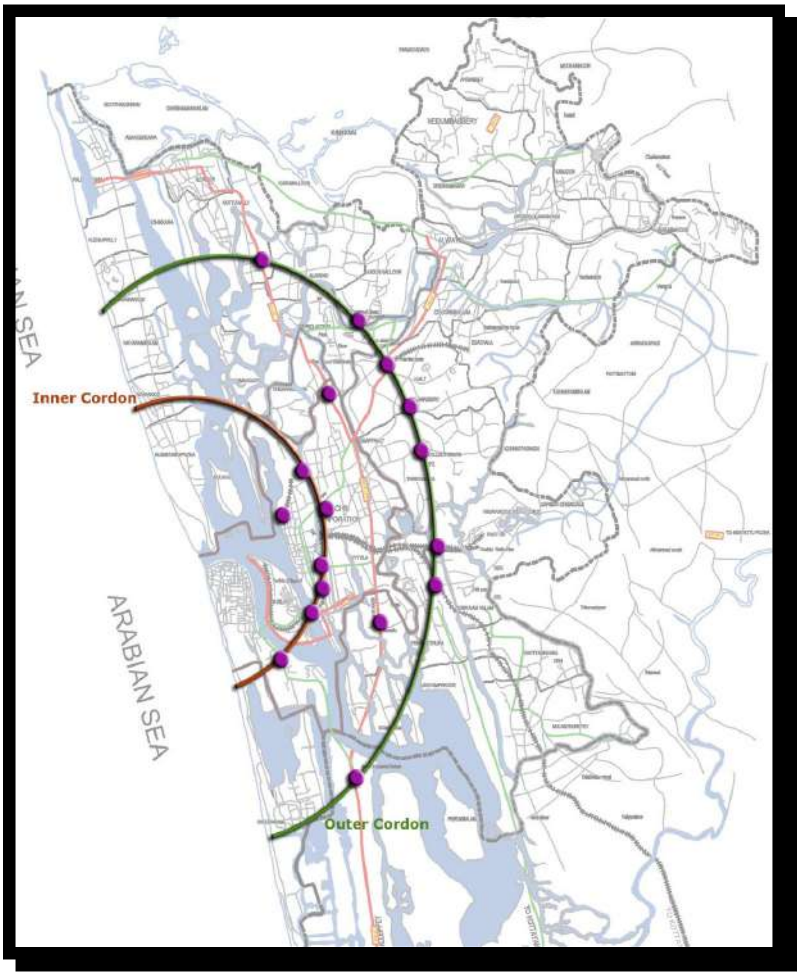


Figure 2.4 Screen Lines for the Study Area

c) Public Transport terminal Interview Surveys – Collection of information on a particular bus/ferry/rail trip by interviewing passengers (boarding or alighting) at a terminal/stop. The surveys were carried out from 08.00 hrs to 14.00 hrs and was conducted across 50 locations along the proposed MRTS corridor were surveyed to cover the passengers likely to use the proposed system. Passengers who were boarding or alighting the bus/ferry/rail at selected stops were interviewed as part of the survey. The information collected includes the time of interview, origin of the passenger, time taken and mode used for him to travel to the bus stop, destination, ticket fare, etc.

d) Screen line Counts – Collection of classified volume of vehicles traversing across the screeline in the study area. Two screen lines, first covering the inner portion i.e. fort Kochi and the CBD area and second covering the area between the inner screen and the study area boundary. The screen lines are shown in Figure 2.4. Screen line counts were conducted in order to obtain the vehicular volume that is moving into and out of the CBD of the city. At each identified station, both directional counts were carried out by vehicle type. i.e. cars, jeeps, vans, buses, trucks, MAVs, LCV's tractors, motorized two wheelers and three wheelers, and slow moving vehicles.

e) Speed and Delay Studies – Collection of the speeds in different sections of road network and the delays at several junctions.

Socio-Economic Indicators

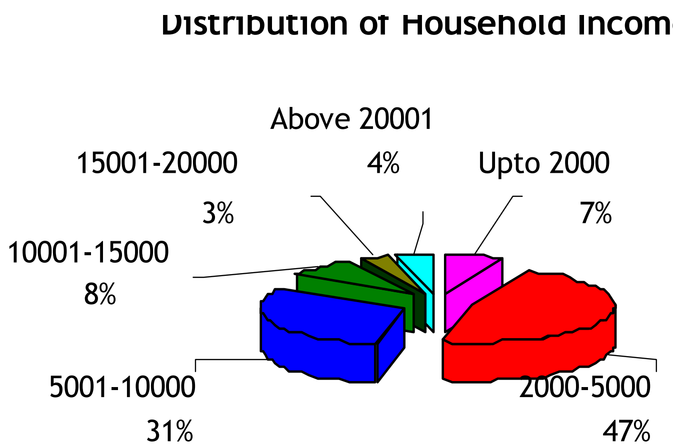
a) Population: Greater Cochin Area, houses a population of about. 1.91 Million (1.79 Million as per 2001 Census) with a population density of 2600 people per Sq. Km. Kochi Corporation, the central portion of the study area has a population density of 6300 persons per Sq. Km housing about 40% of the district's urban population. The population in the study area has been growing at a rate of 1.4% per annum

b) Employment: The study area houses an employment of 7.0 lakh which is growing at 1.57% per annum. The work-force participation ratio is about 0.33.

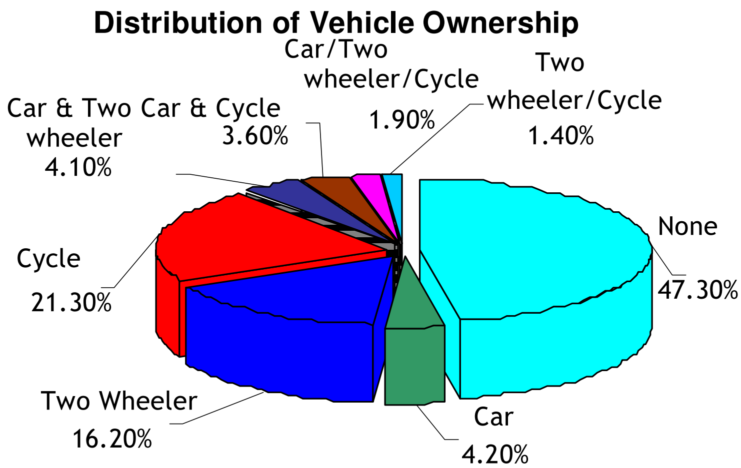
Travel Demand Characteristics

a) Household Size: The average household size in the study area is 4.9 persons.

b) Household Income: The average monthly household income in the study area is Rs.6470.Distribution of household by income shows that more than 50% of the households are having income less than Rs.5000.It can be seen from the figure that about 37% of the households have monthly income Rs.5000 to 10000 and 15% having more than Rs.10000.An analysis on the expenditure pattern shows that average expenditure on transport is Rs.633.

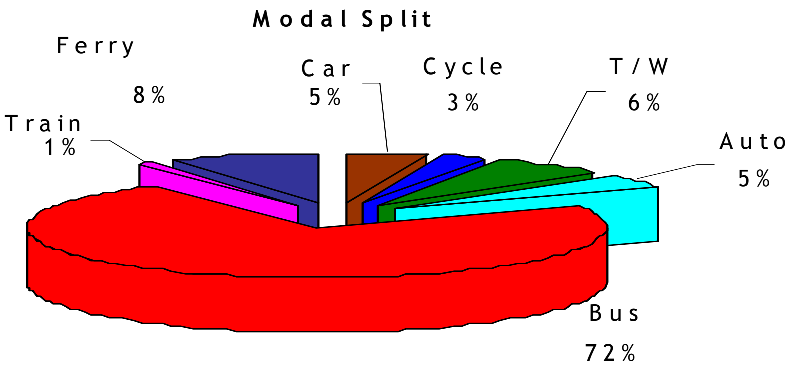


(c) Vehicle Ownership: The distribution of households by vehicle ownership shows that around 11% of households have more than two vehicles per household. Around 16% are two wheeler owned and 4.2% car owned.



(d) Purpose of Trips: The purpose wise analysis of trips shows that work trips dominates with 58% of the total trips followed by 24% of education trips and 18% social trips.

(e) Mode Choice: Modal split in the study area. Modal split on the study area reveals the dominance of the public transport system with modal share of bus as 72% followed by train and ferry recorded 1% and 8% respectively.



(f) Vehicle Occupancy: Vehicle occupancy recorded in the study area are presented below.

- Car/Jeep 2.27
- Two Wheeler 1.25
- Auto Rickshaw 1.80
- Buses 41.82

Peak Duration in the Study Area was observed as between 8 AM to 11 AM in the morning and 5 PM to 8 PM in the evening. The peak hour to daily flow ratio was found to be 10%.

2.2.2 Stage – 2 Estimation of Base Year Trip Matrices

In order to make the model responsive to the availability of competing modes, including public transit facilities, the base year (2005) travel demand data for the study area in the form of O-D matrices were derived separately by mode i.e. Two-wheeler, Car, Auto and Public transport. Since this data was not available from the secondary sources/past projects, consultants have adopted a quick response technique to derive the same. Using the link volume counts obtained from the secondary sources i.e. past reports and the fresh volume count surveys conducted by the Consultants, the peak hour mode-wise trip matrices have been derived using the "Matrix Estimation from Link Counts" algorithm available in TransCAD-the state-of-the-Art travel demand modeling software. These matrices were then updated using the O-D data obtained from roadside and terminal interview surveys.

The summary of the derived trip matrices is give below:

a) Peak Hour Travel Demand: 2.84 Lakh

b) Modal Share:

- Two-Wheeler – 8%
- Car – 6%
- Auto – 5%
- Public Transport – 81%

c) Average Trip Length:

- Two-Wheeler – 9.4 Km.
- Car – 12.5 Km.
- Auto – 7.8 Km.
- Public Transport – 14.0 Km.

2.2.3 Stage – 3 Base year Observed O-D Validation

Both highway (Road) and public transit networks were checked thoroughly and corrected wherever necessary in order to achieve reliability and accuracy The methodology followed is prescribed in Fig. 2.5.

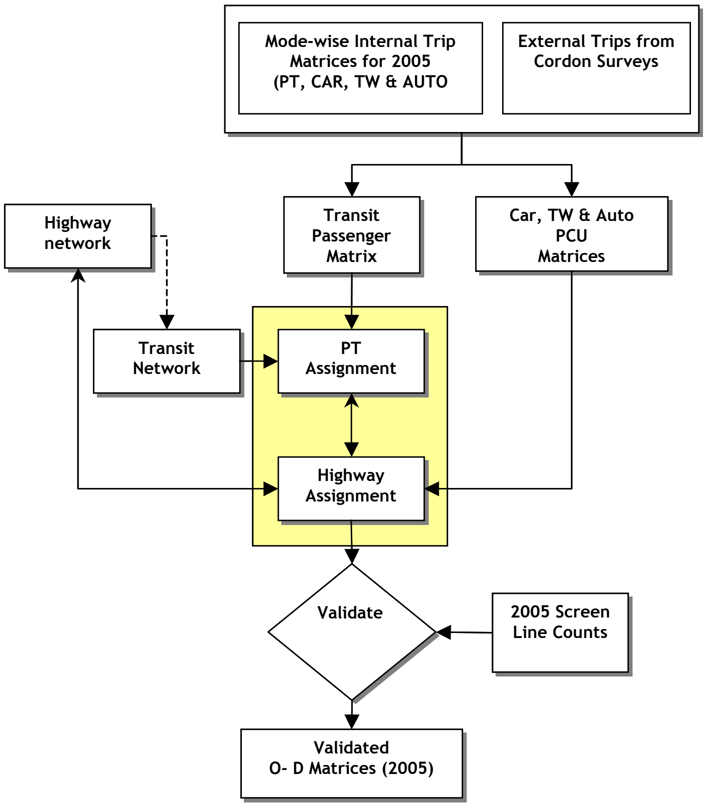


Figure 2.5 Observed O-D Validation

The mode-wise O-D matrices were assigned on the highway and transit networks respectively and the mode-wise link flows across the screen lines were compared with the corresponding traffic volume counts. At both the screen lines the difference in PCU's was observed to be within the acceptable rage of ±15%. Public transport passenger trips were closely matching with a difference of less than 5%. Table 2.1 gives the comparison of assigned flows with the traffic volume observed on the road.

Table 2.1 Observed O-D Validation

MODE	INWARDS			OUTWARDS		
	OBS	ASS	% DIFF	OBS	ASS	% DIFF
INNER SCREEN LINE						
TW	2321	2669	-15%	4469	3784	15%
CAR	1338	1240	7%	2390	2266	5%
AUTO	2020	2180	-8%	3730	3185	15%
TOTAL PCU	5679	6089	-7%	10589	9235	13%
PT PASS	22716	21870	4%	45550	44890	1%
OUTER SCREEN LINE						
TW	2106	2403	-14%	3056	2695	12%
CAR	1794	1703	5%	2143	2005	6%
AUTO	1481	1594	-8%	1984	2104	-6%
TOTAL PCU	5381	5700	-6%	7183	6804	5%
PT PASS	22584	21950	3%	28940	27890	4%

2.2.4 Stage – 4 Base Year Model Development and Validation

Methodology adopted for development and validation of the base year travel demand model is shown in Figure 2.6. Using the planning variables and validated total O-D matrix for base year (2005), trip end models were calibrated for the total internal passenger travel. A single gravity model was calibrated using the validated trip ends and skims (generalized cost) obtained from Stage 3 assignment process as the seed values. The revised skims obtained after successive modal split and traffic assignments were used to calibrate the gravity model.

A multinomial logit modal split model was devised, to determine the share of public transport and Car, Two wheeler and Auto trips. The model was based on the generalized cost functions developed using disaggregate travel data derived based on the observed O-D matrices, zone-to-zone travel time and travel cost data that were obtained from the assignments.

The peak hour public transport passenger matrix was assigned to the public transport network, which includes a) Bus network (prepared by coding all the 130 bus routes), and b) Rail Network with all the existing rail links. The public transport assignment was based on generalized time, which was a combination of In-Vehicle Travel Time (IVTT), Waiting Time (WT), Transfer Time (TR) and Fare in time units.

2.2.5 Trip End Models (Within Corp and Outside Corp)

Zone-wise observed trip ends were related with the socio economic parameters of respective zones available from secondary sources for the study area i.e.

population and employment and regression equations were calibrated Trip end equations were built separately for Kochi Corporation and the suburbs separately for peak hour.

Productions

TP (Corporation) = 0.2921 * POPULATION + 829.50
TP (SUBURBS) = 0.0633 * POPULATION - 11.54

Attractions

TA (Corporation) = 0.2784 * EMPLOYMENT + 525.46
TA (SUBURBS) = 0.0885 * EMPLOYMENT + 103.18

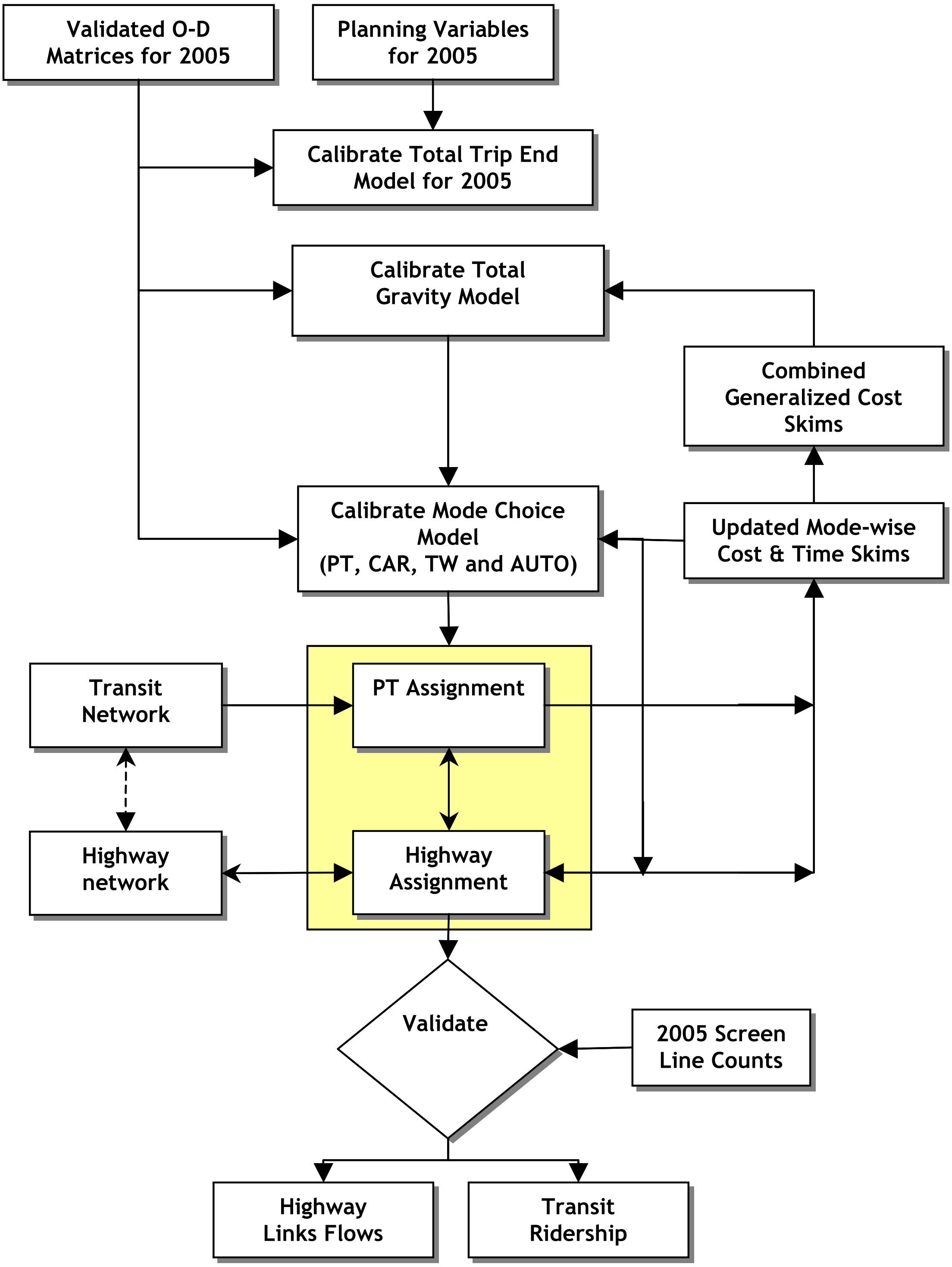


Figure 2.6 Base Year Model Development and Validation

2.2.6 Distribution Model

The trip ends derived from the trip end models were distributed into a matrix to obtain inter zonal traffic in the city. A combined total gravity (distribution) model formulation was calibrated. Base year trip ends, zone-to-zone cost skims were used to fit a Gamma function representing the current travel pattern.

The equation for distribution function is as follows:

$$T_{ij} = A_i O_i B_j D_j F_{ij}$$

$$F_{ij} = aC^{b}_{ij} e^{-cC_{ij}}$$

Where, ‘C’ is the generalized cost of travel from one zone to other
‘a, b, c’ are the Calibration functions
‘P’ Trip Productions
‘A’ Trip Attractions
‘F’ Deterrence Function

The table below gives the calibrated results

	a	b	C
Total OD	171.92	1.0189	0.0163

2.2.7 Mode Choice Model

A multinomial mode choice model of the following form shown below is calibrated in order to split the trips among the modes, public transport, private vehicle and IPT (Auto/Taxi). The public transport assignment module shall achieve the modal split among the public-transport modes i.e., Bus, Rail and METRO (proposed). Utility functions (VM) for each mode were calibrated using the disaggregate person trip and mode choice data derived from the observed o-d, travel time and travel cost for each individual. The information on the alternate modes, i.e., travel time and travel cost, available to user, was generated from the time and cost skims obtained in public transport and highway assignment procedures.

$$V_M = \alpha\, TT_M + \beta\, TC_M$$

Where,

TTM - Travel Time by Mode M

TCM - Travel Cost by Mode M

α and β are calibration parameters specific to each mode

The calibrated parameters are given in Table below

Mode	α	β
Two Wheeler	-0.004135	-0.056340
Car	-0.033165	0.004823
Auto	0.007399	-0.059878
Public Transport	-0.011230	0.42232

Using the calibrated mode-wise utility functions, the probability of a user choosing a particular mode from performing a trip between an O-D pair is calculated using the equation below.

$$P_j = \frac{e^{V_j}}{\sum_{\text{all } l} e^{V_l}}$$

Where,
Pj = probability of choosing mode j,
Vj = deterministic component of utility for mode j and
j and i are indices for modes

In order to see the validity of the above model, using the travel time and travel cost skims obtained from public transport and highway assignment, the utilities for all the modes were calculated. The probability of choosing each mode was then worked out for each cell of the O-D matrix of intra-city trips made by residents. These probabilities were then applied only to the trip makers in order to get the exact number of trips by two wheeler, car, auto and public transport. The mode wise trips in each cell of the O-D matrix were obtained by using the following equation

$$T_{ij}{}^{M} = T_{ij} * P^{M}$$

Where,
T_{ij} = Total person trips from i to j
P^{M} = Probability of choosing a mode for passenger
Thus the base year mode-wise O-D matrices were derived. Also the model when applied in the future scenarios shall predict the shift from the existing modes to the proposed Metro Corridor. Comparisons of observed and synthetic modal shares are given in Table below.

Mode	Observed	Estimated
Two Wheeler	8%	7.5%
Car	6%	7%
Auto	5%	5.5%
Public Transport	81%	80%

2.2.8 Assignment and Synthetic Model Validation

Peak hour mode-wise passenger trip matrices for the base year were re-established using the trip ends obtained from the trip end, distribution and mode choice models. The synthetic matrices, thus derived, were assigned on respective highway and transit networks. The resulting link flows (Vehicle PCU's and Transit Passengers) were compared with the observed traffic across the screen lines and found to be within acceptable limits. The validation comparison is given in Table 2.2 below. The model is thus calibrated to the ground traffic scenario in the study area with reasonable accuracy and hence can be used to predict the ridership on the proposed system.

Table 2.2 Synthetic O-D Validation

MODE	INWARDS			OUTWARDS		
	OBS	ASS	% DIFF	OBS	ASS	% DIFF
INNER SCREEN LINE						
TW	2321	2751	-19%	4469	3901	13%
CAR	1338	1180	12%	2390	2157	10%
AUTO	2020	2369	-17%	3730	3461	7%
TOTAL PCU	5679	6300	-11%	10589	9519	10%
PT PASS	22716	23850	-5%	45550	46580	-2%
OUTER SCREEN LINE						
TW	2106	2403	-14%	3056	2695	12%
CAR	1794	1703	5%	2143	2005	6%
AUTO	1481	1594	-8%	1984	2104	-6%
TOTAL PCU	5381	5700	-6%	7183	6804	5%
PT PASS	22584	21660	4%	28940	27270	6%

2.2.9 Stage – 5 Ridership Forecast

The planning variables i.e. population and employment were projected for all the horizon years for the study area. Calibrated Trip End models were used to predict the number of trips generated /attracted from/to each of the zones in the study area. Using the projected trip ends along with the respective cost/time skims were provided as inputs to the distribution and modal split models to arrive at future trip matrices for Car, Two Wheeler, Auto and Public Transport. Under each of the landuse and network scenarios, Car, Two Wheeler, Auto and Public Transport matrices will be assigned on respective highway and transit networks iteratively till the flows on the links get stabilized. After each iteration the cost and time skims were updated from the network and are used to re-distribute and further split the trips w.r.t different modes. Once the convergence is reached the transit passenger ridership figures will be extracted along the project corridor. The methodology for travel demand forecast in the study area is presented in the Figure 2.7.

2.2.10 Horizon Year Landuse Scenario

Greater Cochin Area has been attracting lot of investments in the recent past towards development projects which have huge employment potential. Some of the major development projects in the pipeline for implementation are:

a) SMART CITY
b) INFO PARK
c) FASHION CITY
d) VALLARPADAM CONTAINER TERMINAL
d) PORT BASED SPECIAL ECONOMIC ZONE (SEZ)

All the above projects apart from attracting investments shall provide employment opportunities to the tune of one lakh in the next 15 Years.

The land use data (planning variables) for the present study include i.e., population, and employment for the base year (2005) were projected based on the data on development proposals collected from different secondary sources.

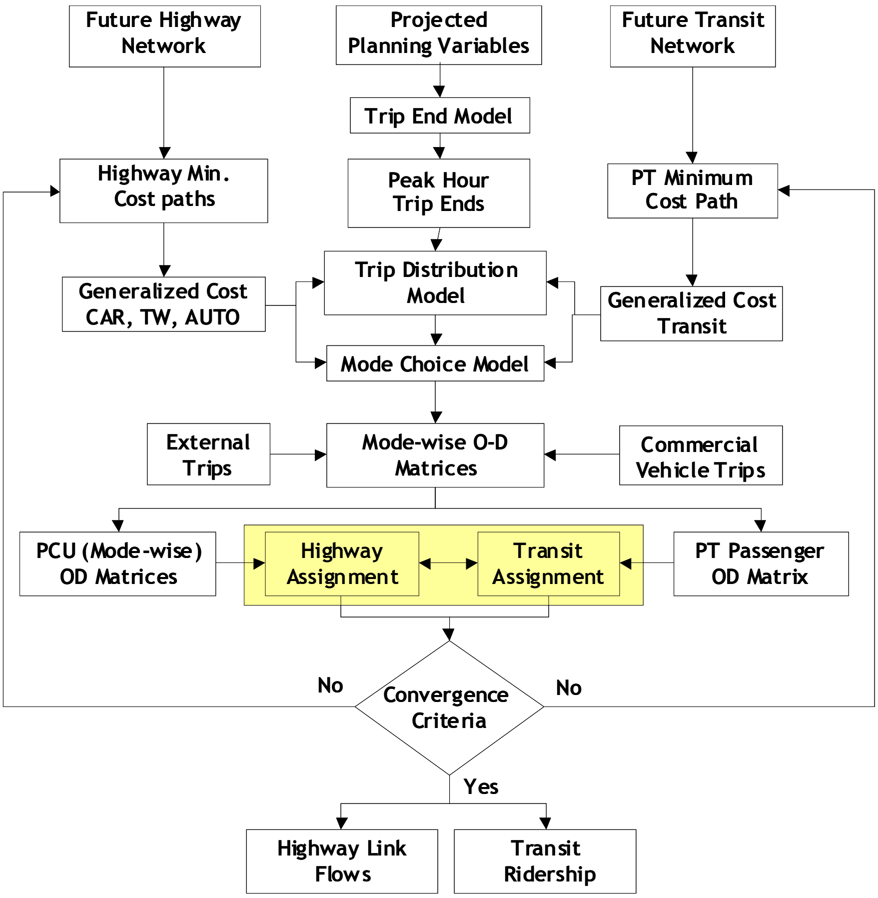


Figure 2.7 Methodology Flowchart for Ridership Forecast

2.2.11 Population

The population projections of Kochi City, other municipalities and village panchayats of Greater Cochin Area as given by the planning division of GCDA are shown in Table 2.3A and Table 2.3B. The corresponding annual growth rates of population are given in Table 2.4.

Table 2.3 A
Area wise Population Projection in 2001, 2011 and 2016 for Greater Cochin Area

Name of the Area	2001		2011		2016	
	Population	Share	Population	Share	Population	Share
Greater Cochin Area	**2055165**	**100.0%**	**2359304**	**100.0%**	**2537037**	**100.0%**
Kochi	595575	29.0%	628529	26.6%	644400	25.4%
Other Municipalities	237195	11.5%	303630	12.9%	345208	13.6%
Village Panchayats	985200	47.9%	1177612	49.9%	1290647	50.9%

Table 2.3 B
Area wise Population Projection in 2021 and 2025 for Greater Cochin Area

Name of the Area	2021		2025	
	Population	Share	Population	Share
Greater Cochin Area	**2732409**	**100.0%**	**2732409**	**100.0%**
Kochi	660672	24.2%	660672	24.2%
Other Municipalities	392480	14.4%	392480	14.4%
Village Panchayats	1414531	51.8%	1414531	51.8%

Table 2.4
Annual Growth Rates: Greater Cochin Area

Name of the Area	1991-2001	2001-2011	2011-2021	2021-2031
Greater Cochin Area	**2.16%**	**1.39%**	**1.48%**	**1.46%**
Kochi	0.54%	0.54%	0.50%	0.48%
Other Municipalities	2.00%	2.50%	2.60%	2.40%
Village Panchayats	1.40%	1.80%	1.85%	1.90%

2.2.12 Employment

The employment projections for Kochi City, other municipalities and village panchayats of Greater Cochin as provided by the planning departments of GCDA are as shown in **Table 2.4**. The corresponding annual growth rates of employment are given in **Table 2.5**.

Table 2.5
Area-wise Employment Projections for Greater Cochin

Area	2001	2011	2016	2021	2025
Greater Cochin Area	650990	724794	765268	827840	904503
Kochi	209002	240176	257466	287061	313843
Other Municipalities	155550	180522	194474	214715	239396
Village Panchayats	286438	304096	313329	326064	351264

Table 2.6
Annual Growth Rates of Employment for Greater Cochin

Area	2001-11	2011-21	2021-2031
Greater Cochin Area	1.08%	1.34%	1.69%
Kochi	1.40%	2.20%	1.80%
Other Municipalities	1.50%	2.00%	2.20%
Village Panchayats	0.6%	0.80%	1.50%

2.3 Ridership Forecast

To select the right corridor for Kochi Metro, different possible options were tried. The three main options tried were (i) Alwaye to Vytilla, (ii) Kalamassery to Thripunithura and (iii) Alwaye to Thripunithura. The expected ridership for the year 2011 for these three options are given in Table 2.7

Table No 2.7

Corridor	PHPDT	Daily Ridership in 2011
Alwaye to Vytilla	12997	330845
Kalamasserry to Tripunithura	12313	226841
Alwaye to Tripunithura	14589	404293

Based on the above figures, the corridor from Alwaye to Thripunithura was selected. For this corridor, two extensions were also tried, one to Kakkanad and other to Thevra. The corresponding ridership is given below in Table 2.8

Table No 2.8

Corridor	PHPDT	Daily Ridership in 2011
Alwaye to Tripunithura	14589	404293
Alwaye to Tripunithura + extension to Kakkanad	15049	422350
Alwaye to Tripunithura + extension to Thevra	15049	421030

The impact of these two extensions is marginal on the ridership hence these extensions are not considered and the corridor from Alwaye to Thripunithura is selected as the best option. After carrying out the detailed engineering feasibility study for this corridor, it was found that construction of Petta to Thripunithura section of this corridor is not feasible. Accordingly, the ridership on truncated corridor from Alwaye to Petta was worked out which is marginally less from the ridership of Alwaye to Tripunithura Corridor. The traffic in these two cases is given in Table 2.9 .

Table No 2.9

Corridor	PHPDT	Daily Ridership in 2011
Alwaye to Tripunithura	14589	404293
Alwaye to Petta	13681	381868

In view of the above, the Metro Corridor is recommended from Alwaye to Petta for a length of 25.360 km.

2.3.1 Ridership on Alwaye - Petta Metro Corridor

The station to station sectional loading and boarding/ alighting in both directions during peak hours and in the years 2015, 2020, and 2025 are given in the Table 2.10, 2.11

Table No 2.10

Station to station sectional loading in 2015,2020 and 2025 (PEAK HOUR)

			2015		2020		2025	
	From Station	To Station	Forward	Reverse	Forward	Reverse	Forward	Reverse
1	Alwaye	Polinchodu	3636	3780	5783	4450	7359	4835
2	Polinchodu	Companypady	3636	4370	5783	5491	9215	6106
3	Companypady	Ambattukaru	5035	4370	7943	5491	11874	13473
4	Ambattukaru	Muttom	5035	11594	7943	13158	13904	14138
5	Muttom	Appolo Tyre	5992	11594	9277	13158	15726	14728
6	Appolo Tyre	Jacobite Church	6035	11897	9277	13736	15369	15996
7	Jacobite Church	Kalamassarey	6100	12037	9258	13778	15580	17671
8	Kalamassarey	Pathadipalam	9157	13016	9375	13778	15927	18772
9	Pathadipalam	Edapally Junction	10700	13216	12882	14756	17127	20623
10	Edapally Junction	Edapally	13266	11306	14762	14482	19065	18970
11	Edapally	Palari vattom	11695	7433	17663	12497	21065	15795
12	Palari vattom	J.L. nehru Stadium	12481	5673	15463	8493	17564	10421
13	J.L. nehru Stadium	Kaloor	12928	3124	16119	6544	17795	8502
14	Kaloor	Lissi	13681	3104	16784	3708	17659	5748
15	Lissi	Madhav Pharmacy	5247	3319	17555	3677	18418	5783
16	Madhav Pharmacy	Maharaja College	3132	2861	7478	3905	11206	4722
17	Maharaja College	Ernakulam South	902	2853	5051	3365	8243	4301
18	Ernakulam South	GCDA	910	1557	2102	3297	4488	4091
19	GCDA	Elamkulam	840	1524	2001	1849	4083	2451
20	Elamkulam	Vytilla	840	1558	1857	1819	3730	1868
21	Vytilla	Thaikoodam	668	1502	1151	1707	2074	1754
22	Thaikoodam	Petta	714	1481	1163	1685	2049	1712

Table No 2.11

Peak Hour Boarding and Alighting in 2015, 2020 and 2025

		2015		2020		2025	
	Station_Name	**Boarding**	**Alighting**	**Boarding**	**Alighting**	**Boarding**	**Alighting**
1	Alwaye	3636	1481	5783	1685	7359	1712
2	Pulinchodu	700	10	1100	10	1875	61
3	Companypadi	699	11	1060	12	2781	236
4	Ambattukavu	475	25	633	52	2062	545
5	Muttom	482	31	710	59	1888	137
6	Appolo	538	461	538	567	740	2736
7	Jacobite Church	116	84	202	115	326	325
8	Kalamassery	2000	1026	2303	1112	1112	1186
9	Pathadipalam	1399	614	1610	742	1337	1199
10	Edapally Junction	1645	110	2099	287	2472	498
11	Edapally	2691	583	3154	793	2513	3266
12	Palarivattom	345	1701	568	2540	706	6127
13	J.L.Stadium	1210	444	1292	667	1406	6549
14	Kaloor	1564	3665	1963	4134	2145	5457
15	Lissi	1306	2313	1510	2688	1710	2604
16	Madhav Pharmacy	2172	14479	2425	16506	2560	7921
17	Maharaja College	1461	5486	1718	6130	1721	3584
18	Ernakulam South	1638	3667	1847	5070	2548	4628
19	GCDA	1690	610	1811	1034	1739	686
20	Elamkulam	437	157	869	305	1006	292
21	Vyttila	7549	497	8043	1070	7742	2031
22	Thykoodam	654	18	1125	72	1360	114
23	Petta	3780	714	4450	1163	4835	2049
	Total	**38187**	**38187**	**46813**	**46813**	**53943**	**53943**

2.4 Summary of transport Demand Forecast

Summary of the Transport Demand Forecast for various years are given in table 2.12

Table 2.12

PARAMETER	2015	2020	2025
PHPDT	13681	17663	21065
Peak Hour Ridership	38187	46813	53943
Daily Ridership	381870	468130	539427
Average Trip Length (Km)	7.33	8.46	9.55

Chapter 3

Need for a Metro

3.1 Why a Metro?

Public Transport System is an efficient user of space and energy, with reduced level of air and noise pollution. As the population of a city grows, share of public transport, road or rail-based, should increase. For a city with population of 1.0 million, the share of public transport should be about 40% - 45%. The percentage share of public transport should progressively increase with further growth in the city population, reaching a value of about 75% when the population of the city touches 5 million mark.

Whether public transport system on a corridor in the city should be road-based or rail-based will depend primarily on the traffic density during peak hours on the corridor. Experience has shown that in mixed traffic conditions, comprising slow and fast moving traffic prevailing in most of our cities, road buses can optimally carry 8,000 persons per hour per direction (phpdt). When traffic density on a corridor exceeds 8,000 phpdt, average speed of buses comes down, journey time increases, air pollution goes up, and commuters are put to increased level of inconvenience. Thus when on a corridor, traffic density during peak hours crosses this figure, provision of rail-based mass transport, i.e. Metro system should be considered. In any case, Metro system may become inescapable if the traffic density on a corridor reaches 15,000 phpdt. However, in a city like Kochi, where road widths are inadequate, this figure may no be more than 10,000 phpdt.

With the growing economy and inadequate public transport services, the passengers shall shift to private modes, which is already evident from the high vehicle ownership trends in the region. This would not only aggravate the congestion on streets but also increase the pollution. Hence, it is essential to plan and provide for a Light Metro System in Cochin.

A study carried out by Delhi Metro Rail Corporation has shown that the break-even point between bus transport and rail-based metro system is 8,000 phpdt considering only Operation and Maintenance (O&M) cost and depreciation. If, however, along with O&M cost and depreciation the cost of capital at 10%

interest rate is also taken into account, the break-even point is about 15,000 phpdt. However, it may not be technically feasible to operate bus transport beyond 10,000 phpdt in the mixed transport scenario obtaining on Kochi city roads.

The peak traffic demand on Alwaye – Petta corridor has been assessed 13,681 phpdt and this is likely to increase to 21,065 phpdt by the year 2025. Pollution in the city has already crossed the acceptable limit. Road accidents are on the rise. Therefore, road based public transport will not serve the purpose and there is an urgent need to introduce a Metro system in the city to provide fast, safe and economic and environment friendly mode for mass movement of passengers.

3.2 Types of metros and their capacity

Rail based mass transport in cities can be brought mainly under three categories:-

Mode		Carrying capacity (passengers/hour) phpdt
a)	Light Rail Metro System (LRTS)	Up to 25,000
b)	Medium Capacity Metro System	25,000-50,000
c)	Heavy Capacity Metro System	50,000-80,000

Since, the number of commuters to be dealt is relatively less in Light Metro System, its trains consist of 3 Coaches (which can be increased to 6 Coaches in future) and other related infrastructure is also of a smaller size.

For medium capacity Metro systems, the train generally comprises 3 to 6 coaches with ultimate train headway of about 3 minutes. The other related infrastructure, e.g. civil works, stations, passenger-handling equipment etc. are also planned accordingly.

Heavy capacity metro systems have to deal with large traffic densities ranging from 50,000 to 80,000 phpdt. Accordingly, the trains have 6 to 9 coaches and other related infrastructure is also of large size. Beyond the traffic level of 80,000 phpdt, additional parallel lines are normally planned. The metro system being planned for Delhi is heavy capacity system.

In view of the present and projected phpdt on the proposed corridor of Kochi city, Light Metro system will suit

3.3 Advantages of a Metro system

Metro systems are superior to other modes because they provide higher carrying capacity, faster, smoother and safer travel, occupy less space, are non-polluting and energy-efficient. To summarise, a Metro system:

(i) Requires 1/5th energy per passenger km compared to road-based system
(ii) Causes no air pollution in the city
(iii) Causes lesser noise level
(iv) Occupies no road space if underground and only about 2 metres width of the road if elevated
(v) Carries same amount of traffic as 5 lanes of bus traffic or 12 lanes of private motor cars (either way), if it is a light capacity system.
(vi) Is more reliable, comfortable and safer than road based system
(vii) Reduces journey time by anything between 50% and 75% depending on road conditions.

Chapter 4

System Selection

4.1 Consideration for selecting Light Metro System

Traffic to be catered by metro services on Alwaye –Petta Corridor in the years 2015, 2020 and 2025 has been discussed in detail in Chapter 2 on ‘Traffic Study’. It will be seen from this Chapter that peak hour peak direction trips (phpdt) on the proposed Corridor are as under:

Year	2015	2020	2025
PHPDT	13681	17663	21065

Road-based systems can optimally carry up to a maximum of 8,000 phpdt. Since the phpdt of the Alwaye –Petta Corridor exceed 8,000, it qualify for a rail-based Mass Transit System. A rail-based system may be either Light Capacity Metro System or Medium Capacity Metro System, or Heavy Capacity Metro System. While the Light Metro System is suitable for corridors with phpdt in the range of 15,000 to 25,000, medium capacity and heavy capacity Metro Systems can optimally handle traffic densities ranging between 25,000 - 50,000 phpdt and between 50,000 – 80,000 phpdt respectively.

Light Capacity Metro System is to be adopted for Alwaye –Petta Corridor as the phpdt is below 25,000 even in 2025, and also to keep down the capital and operating costs.

4.2 Selection of Gauge

Standard Gauge (1435mm) is generally adopted for metro railways world-over. During the last decade, 20 new metros have been constructed in various cities of the world. All these metros have gone in for Standard Gauge even though the national gauge for main-lines in some of the cases was different from Standard Gauge. In India the national gauge is Broad Gauge (1676mm). The question whether Kochi Metro should go in for Broad Gauge or Standard Gauge has, therefore, been examined:

(i) Metro alignments in a city have to pass through heavily built-up areas and this imposes severe restrictions on the selection of curves. In such a situation adoption of Standard Gauge is advantageous since it permits adoption of sharper curves compared to Broad Gauge.

(ii) In Standard Gauge 1 in 7 and 1 in 9 turn-outs, which occupy lesser length, are feasible compared to 1 in 8 ½ and 1 in 12 turn-outs for Broad Gauge. Length of cross-overs for Standard Gauge is thus lesser than for Broad Gauge. Land requirement for depots where a large number of lines connected together in the shape of ladder is thus also lower. Standard Gauge is, therefore, more suited for use in city environment where land availability is scarce.

(iii) For Standard Gauge, optimized state-of-the-art rolling stock designs are available 'off-the-shelf'. This is not so for Broad Gauge where new designs for rolling stock have to be specially developed which entails extra time and cost.

(iv) For the same capacity gross weight of a metro coach is lower for Standard Gauge than for Broad Gauge. Standard Gauge rolling stock thus results in recurring saving in energy consumption during operation.

(v) Because of the availability of a very large market, constant up-gradation of technology takes place for Standard Gauge coaches. Thus upgraded technology is available on a continued basis in case of Standard Gauge. This is not so in case of Broad Gauge.

(vi) Once technology for Standard Gauge coaches get absorbed and a manufacturing base for them is set up, there will be considerable export potential for the coaches, since almost all the countries use Standard Gauge for their metros. This is not so in case of Broad Gauge.

(vii) It is some time argued that adoption of Broad Gauge for metros will enable inter-running of metro trains with Indian Railways since the latter uses Broad Gauge. Inter-running is, however, technically or operationally not feasible due to the two networks having different:

Rolling Stock characteristics,
Signalling Systems,
Headways,
Tariffs,
Moving dimensions, and
Loading standards.

Since inter-running is not feasible, choice of Gauge for a metro system should be based solely on technical and economic considerations on which Standard Gauge turns out to be superior.

(viii) Track gauge is not a technical parameter for any metro rail system. It is a planning parameter. Choice of gauge is, therefore, a matter which lies within the jurisdiction of the metro rail organisation entrusted with the responsibility of implementing and operating the metro systems.

From the above, it is seen that Standard Gauge will be cost-effective, will enable Kochi Metro to be at par with world-class metros and enable it to remain technically up-dated in future. Standard Gauge will also enable setting up a manufacturing base for coaches required for metros in other cities of the country as well create an export potential for such coaches. Adoption of Standard Gauge is, therefore, recommended for Kochi Metro. A wider gauge is not justified as coach width is small and axle loads are as low as 13 ton.

4.3 TRACK STRUCTURE

Track on Metro Systems is subjected to intensive usage with very little time for day-to-day maintenance and therefore, it is imperative that the track structure selected for Metro Systems should be long lasting and should require minimum or no maintenance and at the same time, ensure highest level of safety, reliability and comfort, without undue noise and vibrations. The track structure has been proposed keeping the above philosophy in view.

4.3.1 General

Track will be ballasted type for ‘At-Grade’ portion and Depot (except inside the Workshops, inspection lines and washing plant lines, where the track will be ballastless type), whereas on Viaducts, it will be ballastless type.

From considerations of maintainability, riding comfort and also to contain vibrations and noise levels, complete track is proposed to be jointless and for this purpose even the turnouts will have to be incorporated in LWR/CWR.

Tack will be laid with 1 in 20 canted rails and wheel profile of Rolling Stock should be compatible with the rail cant and rail profile.

4.3.2 Rail Section

Keeping in view the proposed axle load and the practices followed abroad, it is proposed to adopt UIC-54 (54 kg./m) rail section as shown in Fig. 4.1. Since on main lines, sharp curves and gradients would be present, the grade of rail on main lines should be 1080 Head Hardened as per IRS-T- 12-96, whereas on Depot lines, the grade of rails should be 880. Since head hardened rails are not manufactured in the Country, rails will need to be imported.

4.3.3 Ballastless Track on Main Lines (Viaducts)

On the viaducts, it is proposed to adopt plinth type ballastless track structure, having RCC derailment guards integrated with the plinths (shown in Fig4.2).

Further, it is proposed to adopt Vossloh-336 Fastenings System (shown in Fig 4.3) on ballastless track structure, with a base-plate to base-plate spacing of 65 cm. on viaducts. Most of the components of Vossloh-336 fastening system are now indigenously available. Any other fastening system satisfying to the Performance criteria laid down by Railway Board may also be adopted.

4.3.4 Ballasted Track on Depot Lines

It is proposed to have a 250 mm ballast cushion below the PSC Sleepers. Sleeper density should be 1540 Nos. per km. (sleeper spacing being 65 cm) for the Depot. Fastenings system on ballasted track may be same as prevalent on Indian Railways, i.e. ERC Mark III clips with GR Sole plates and GFN liners. Standard Gauge PSC sleeper for ballasted track would need to be designed on the same lines as done on Indian Railways or an appropriate ready design from abroad adopted.

4.3.5 Transition between Ballasted and Ballastless Track

An approach slab of 6 to 8 m length should be provided at the junction of Viaduct and earth formation. The transition from Ballastless to Ballasted Track should be made smooth over this length.

4.3.6 Ballastless Track in Depot

The ballastless track in Depot may be of the following types :

(a) Discretely supported on concrete/steel pedestal for inspection lines.
(b) Embedded rail type inside the Workshop.
(c) Plinth type for Washing Plant line.

4.3.7 Turnouts

4.3.7.1 From considerations of maintainability and riding comfort, it is proposed to lay the turnouts also with 1 in 20 cant. Further, it is proposed to adopt the following two types of turnouts :

(1) On main lines, 1 in 9 type turnout with a lead radius of 300 metres and permissible speed on divergent track as 40 kmph (shown in Fig 4.4).

(2) On Depot lines, 1 in 7 type turnout with a lead radius of 140 metres and permissible speed on divergent track as 25 kmph (shown in Fig 4.5).

The Scissors X-overs on Main Lines (1 in 9 type) will be with a minimum track centres of 4.5 m (shown in Fig 4.6).

4.3.7.2 Proposed specifications for turnouts are given below :-

(a) Turnouts should have fan-shaped layout throughout the turnout so as to have same sleepers/base-plates and slide chairs for both LH and RH turnouts.

(b) Switches and crossings should be interchangeable between ballasted and ballastless turnouts.

(c) Switch rail should be with thick webbed sections, having forged end near heel of switch for easy connection with lead rails, behind the heel of switch. The switches should have anti creep device at heel of switch for minimising the additional LWR forces transmitted from tongue rail to stock rail.

(d) Crossings should be made of cast manganese steel and with welded leg extensions. These crossings should be explosive hardened type for main lines and without surface hardening for Depot lines.

Check rails should be with UIC-33 rail section without being directly connected to the running rails.

4.3.8 Buffer Stops

On main lines and Depot lines, friction buffer stops with mechanical impact absorption (non-hydraulic type) should be provided. In elevated portion. The spans, on which friction buffer stops are to be installed, should be designed for an additional longitudinal force of 85 T, which is likely to be transmitted in case of Rolling Stock impacting the friction Buffer Stops.

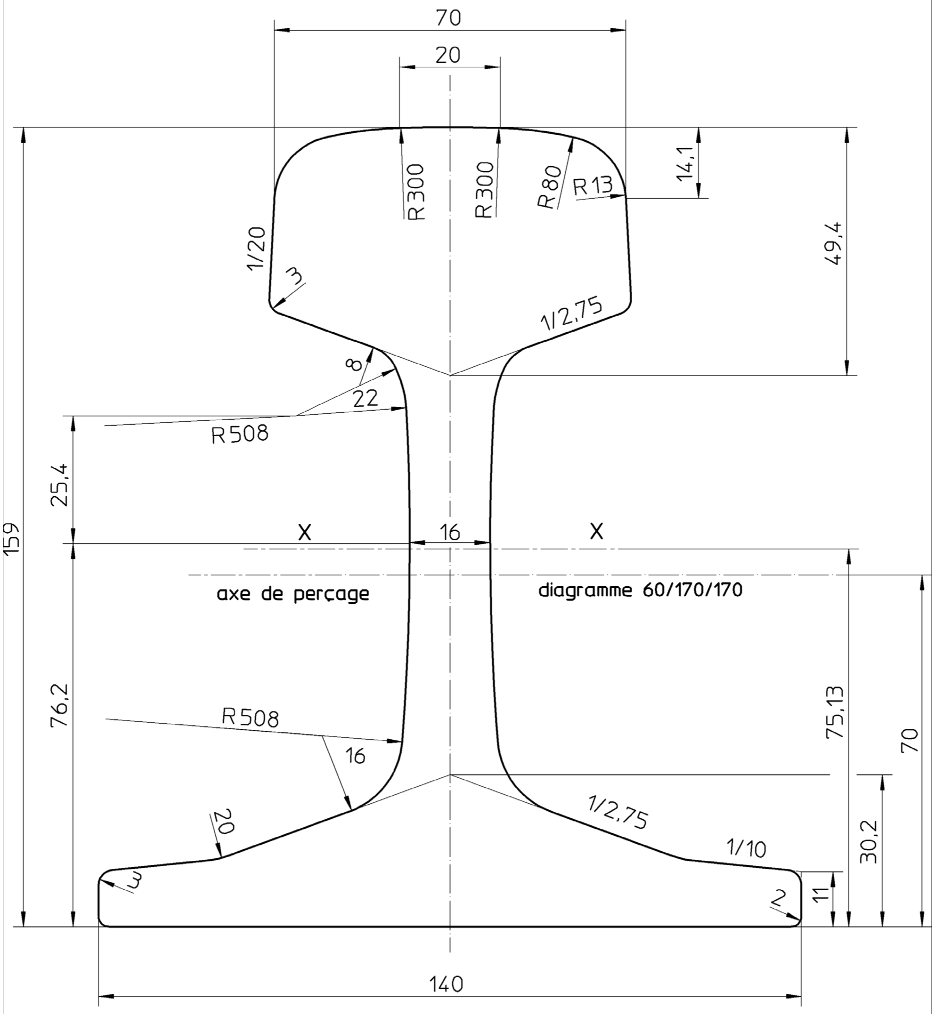
4.3.9 Rail Structure Interaction

For continuing LWR/CWR on Viaducts, the elevated structures should be adequately designed for the additional longitudinal forces likely to be transmitted as a result of Rail-Structure interaction. Rail structure interaction study will determine the need and locations of Rail Expansion Joints (REJ) required to be provided. REJ in ballasted track will be for a maximum gap of 120 mm, whereas on ballastless track for a maximum gap of 180 mm.

4.3.10 Welding

Flash Butt Welding Technique should be used for welding of rails. Alumino-Thermic Welding should be done only for those joints which cannot be welded by Flash Butt Welding Technique, such as destressing points and approach welds of switches & crossings. For minimising the population of Thermit welds mobile (rail-cum-road) Flash Butt Welding Plant will have to be deployed.

RAIL PROFIL : 54 E1 (UIC54)



P = 54.77 kg/m Ix = 2337.9 cm4 Ix/v= 278.7 cm3

S = 6977 mm2 Iy = 419.1 cm4 Iy/u= 59.9 cm3

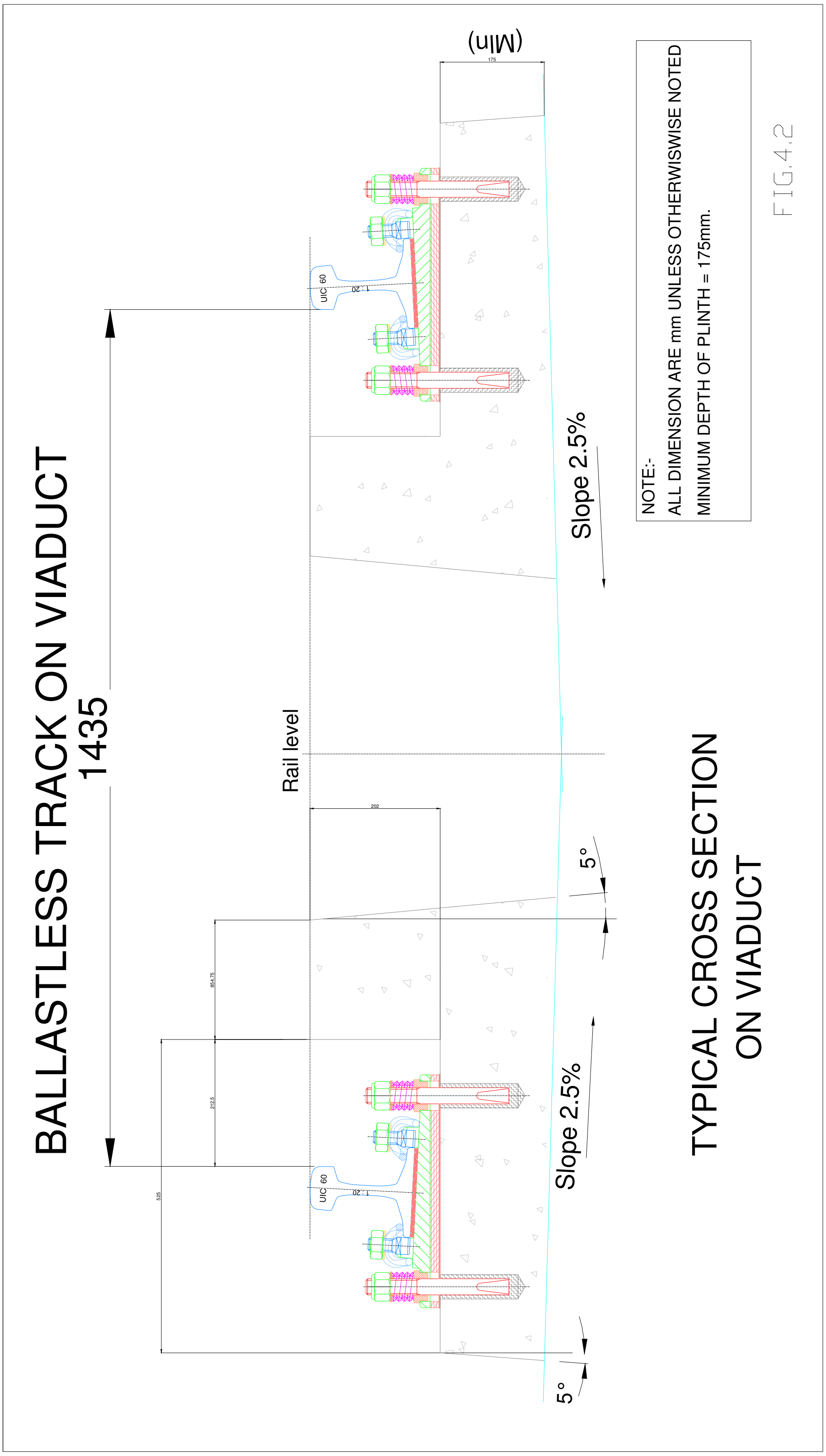
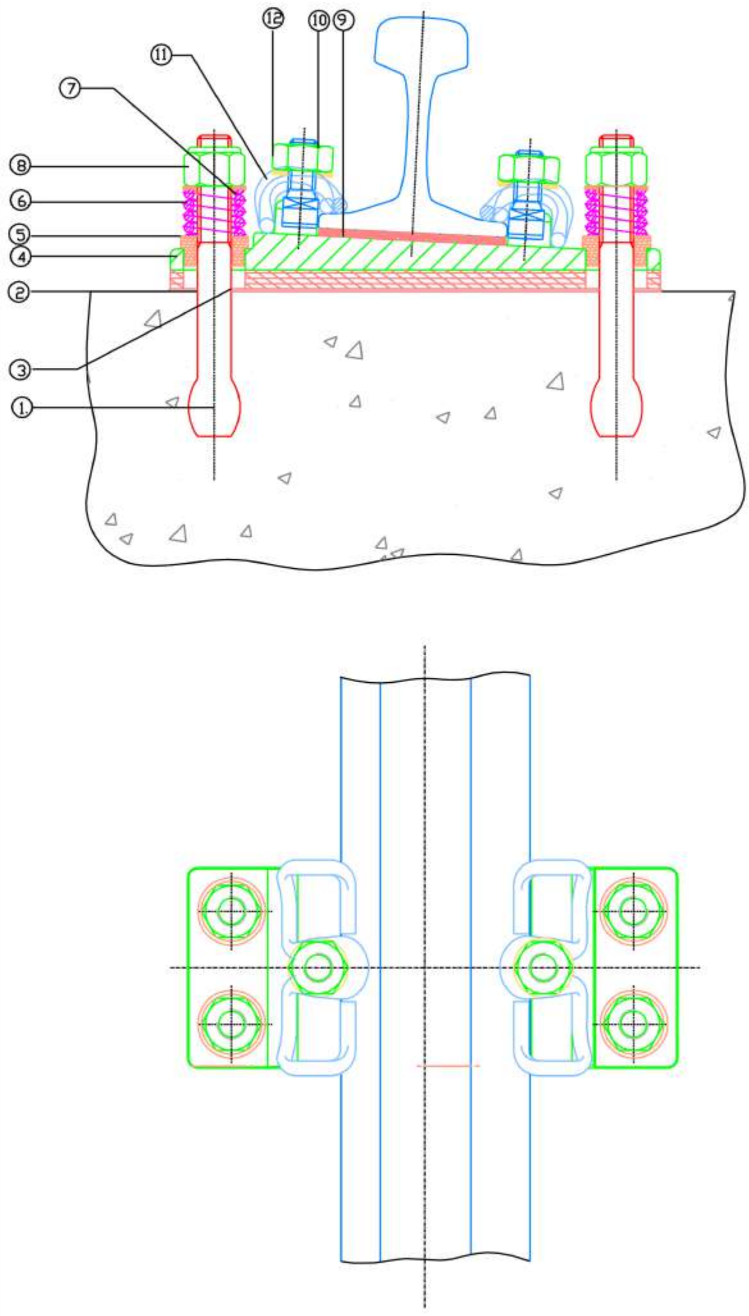
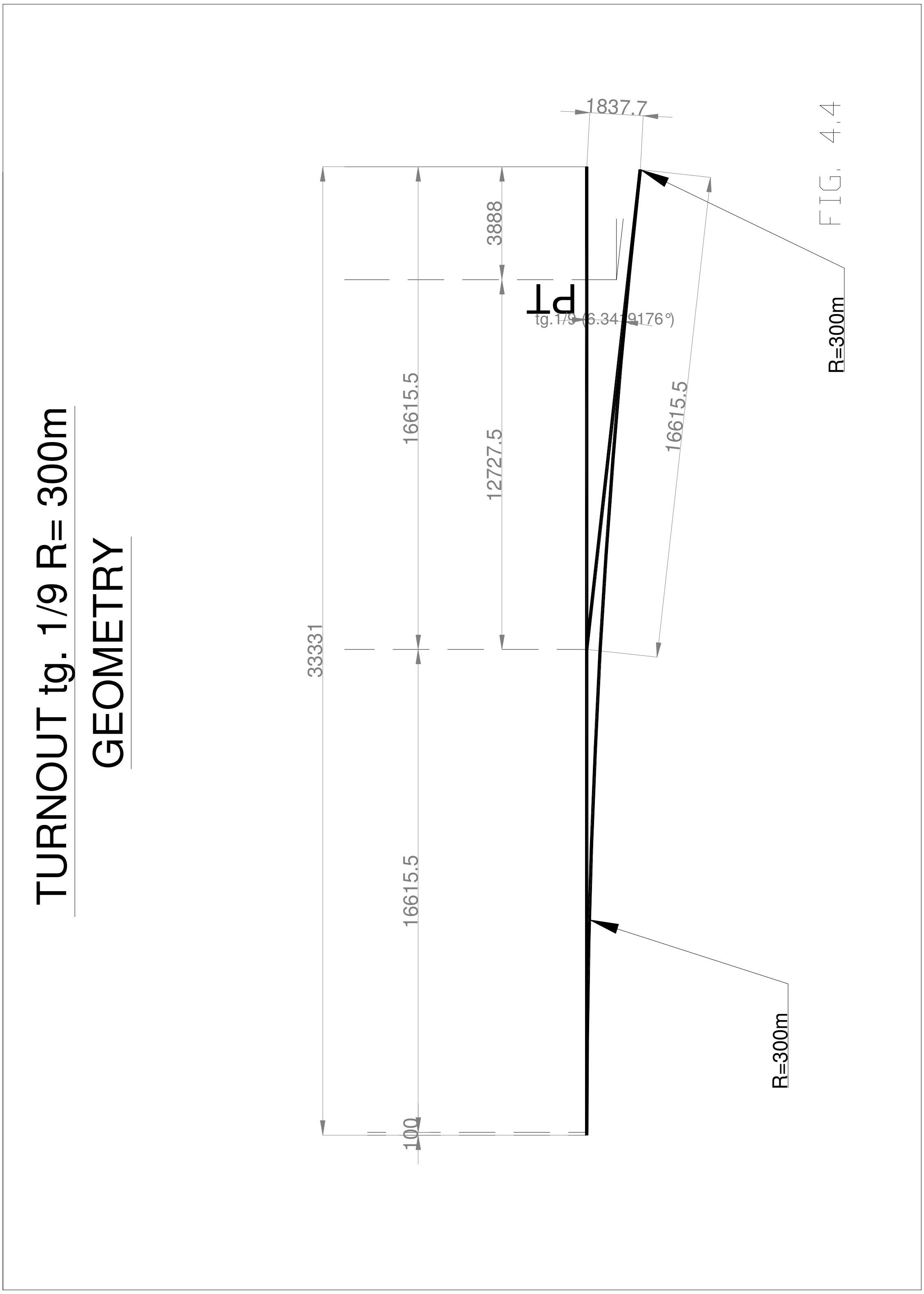

BALLASTLESS TRACK ON VIADUCT
1435
Rail level
UIC 60
1 : 20
(Min)
175
202
Slope 2.5%
Slope 2.5%
5°
5°
NOTE:-
ALL DIMENSION ARE mm UNLESS OTHERWISWISE NOTED
MINIMUM DEPTH OF PLINTH = 175mm.
TYPICAL CROSS SECTION
ON VIADUCT

FIG.4.2



NO.	DESCRIPTION
1.	ANCHOR BOLT
2.	INTERMEDIATE PAD
3.	ELASTOMERIC PAD
4.	RIBBED BASE PLATE
5.	INSULATING BUSH
6.	HELICAL SPRING
7.	COLLARED WASHER
8.	HEXAGON NUT
9.	RAIL PAD
10.	T-HEAD BOLT WITH NUT
11.	TENSION CLAMP
12.	WASHER FOR T-HEAD BOLT

FIG.4.3


TURNOUT tg. 1/9 R= 300m
GEOMETRY
1837.7
3888
PT
tg.1/9 (6.3429176°)
16615.5
12727.5
16615.5
33331
16615.5
100
R=300m
R=300m
FIG. 4.4

TURNOUT tg. 1/7 R= 140m
GEOMETRY

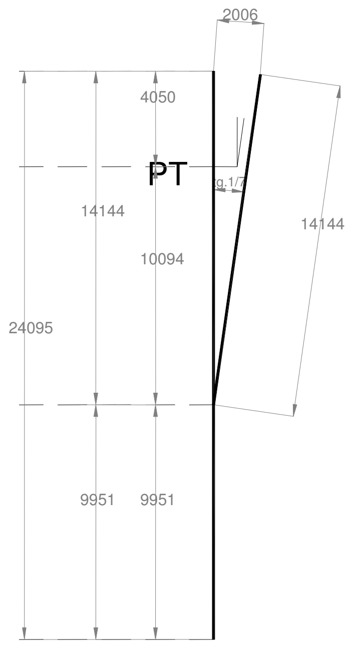
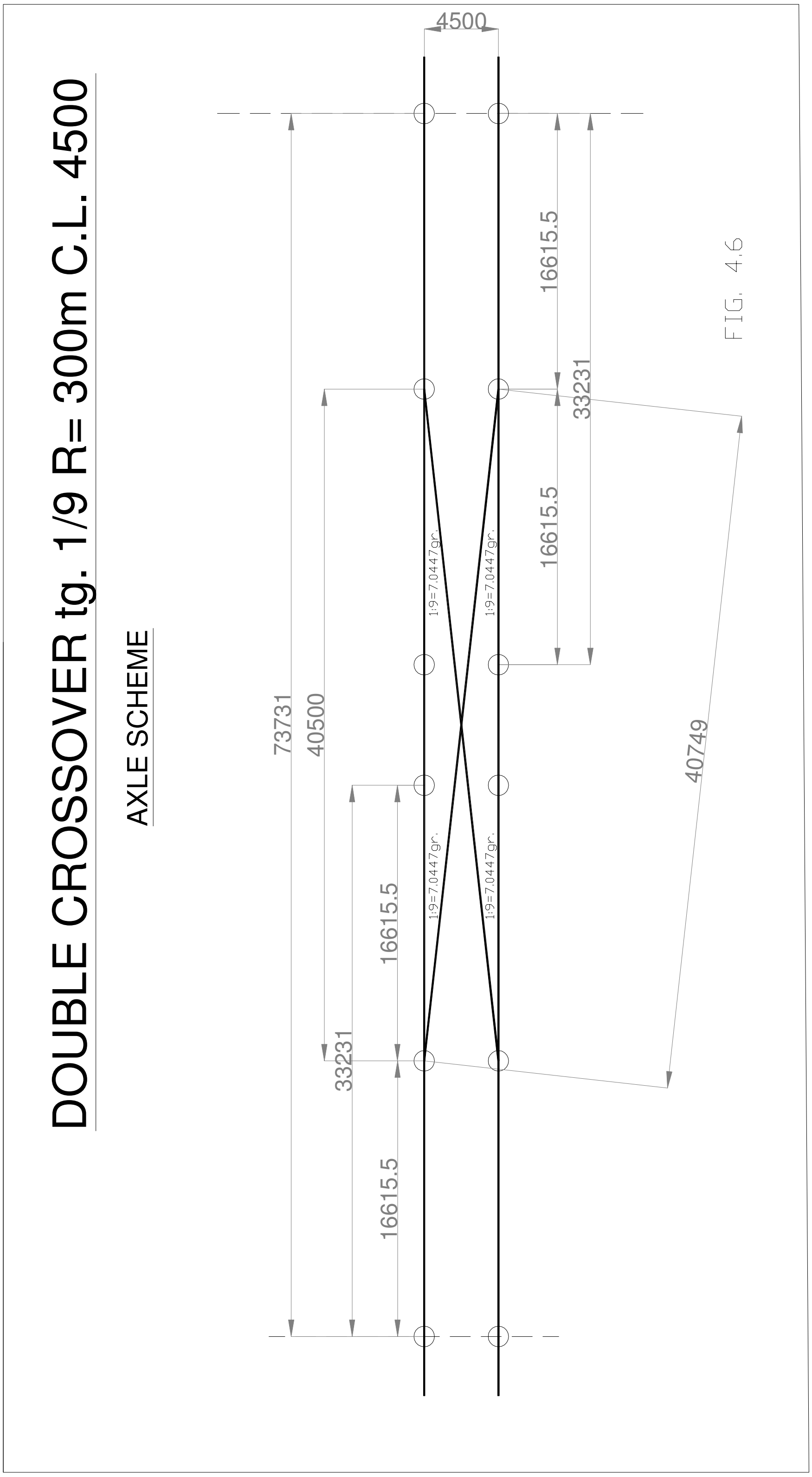


FIG. 4.5


DOUBLE CROSSOVER tg. 1/9 R= 300m C.L. 4500
AXLE SCHEME
4500
16615.5
33231
16615.5
73731
40500
16615.5
33231
16615.5
40749
1:9=7.0447gr.
1:9=7.0447gr.
1:9=7.0447gr.
1:9=7.0447gr.
FIG. 4.6

4.4 ROLLING STOCK

The required transport demand forecast is the governing factor for the choice of the Rolling Stock .

4.4.1 Optimisation of Coach Size

Considering the clearances and also the space required for service etc., the coach with following principal dimensions has been prescribed at **Table 4.1**

Table 4.1
Size of the coach

	Length	Width	Height
Driving Motor Car	18.00 m	2.70 m	3.9 m
Trailer car	17.86 m	2.70 m	3.9 m

Principal dimensions are shown in Figure 4.7 & Figure 4.8.

4.4.2 PASSENGER CARRYING CAPACITY

In order to maximize the passenger carrying capacity, longitudinal seating arrangement shall be adopted. The whole train shall be vestibuled to distribute the passenger evenly in all the coaches. Criteria for the calculation of standing passengers are 3 persons per square meter of standing floor area in normal state and 6 persons in crush state of peak hour.
Therefore, for the Light Rail Vehicles (LRV) with 2.7 m maximum width and longitudinal seat arrangement, conceptually the crush capacity of 35 seated, 156 standing thus a total of 191 passengers for a Driving Motor Car, and 44 seated, 174 standing thus a total of 218 for a trailer car is envisaged.
Following train composition is recommended:

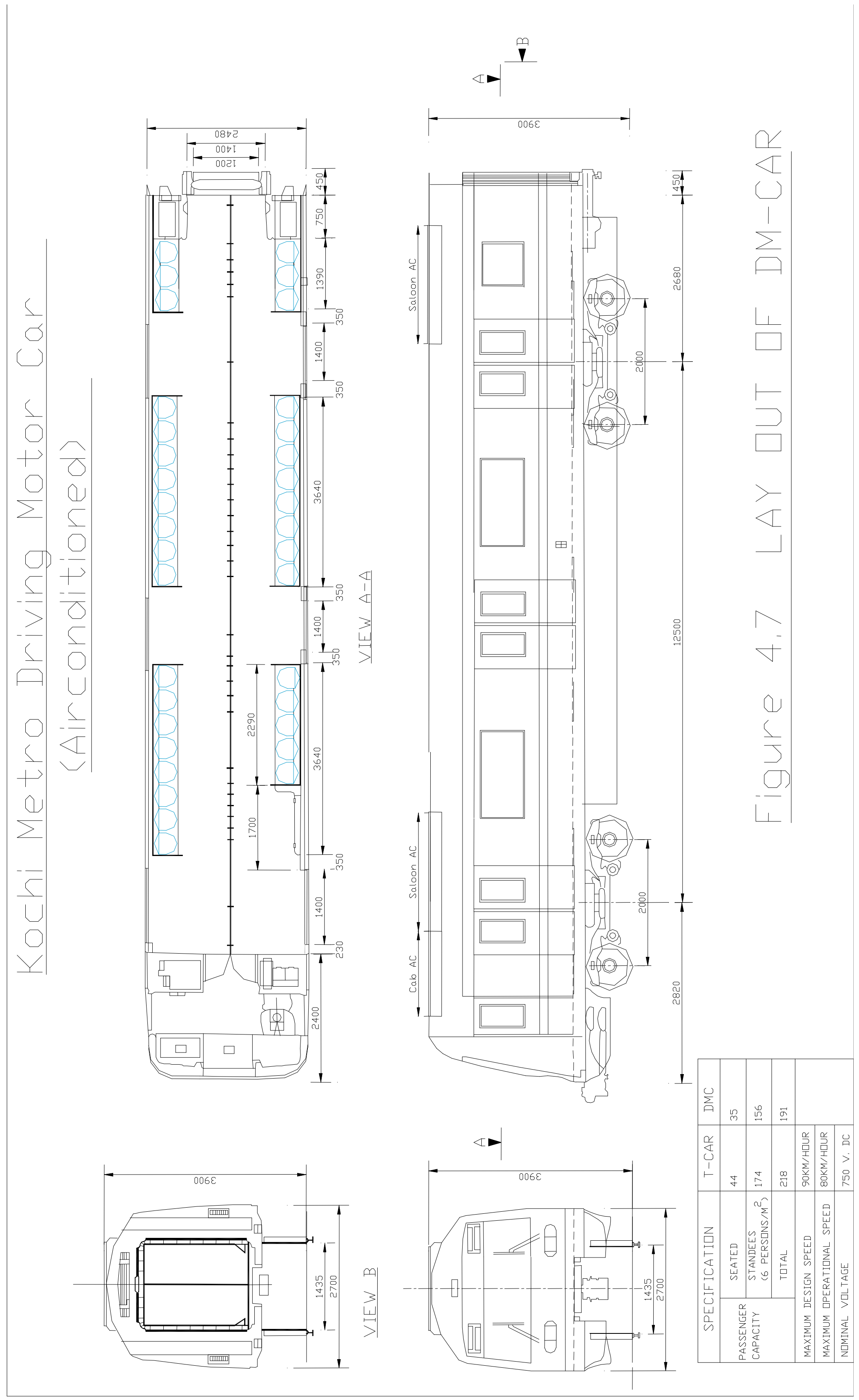
3- Car Train: DMC+ TC+ DMC

Table 2 shows the carrying capacity of Light Rail Vehicles.

Table 4.2
Carrying Capacity of Light Rail Vehicles

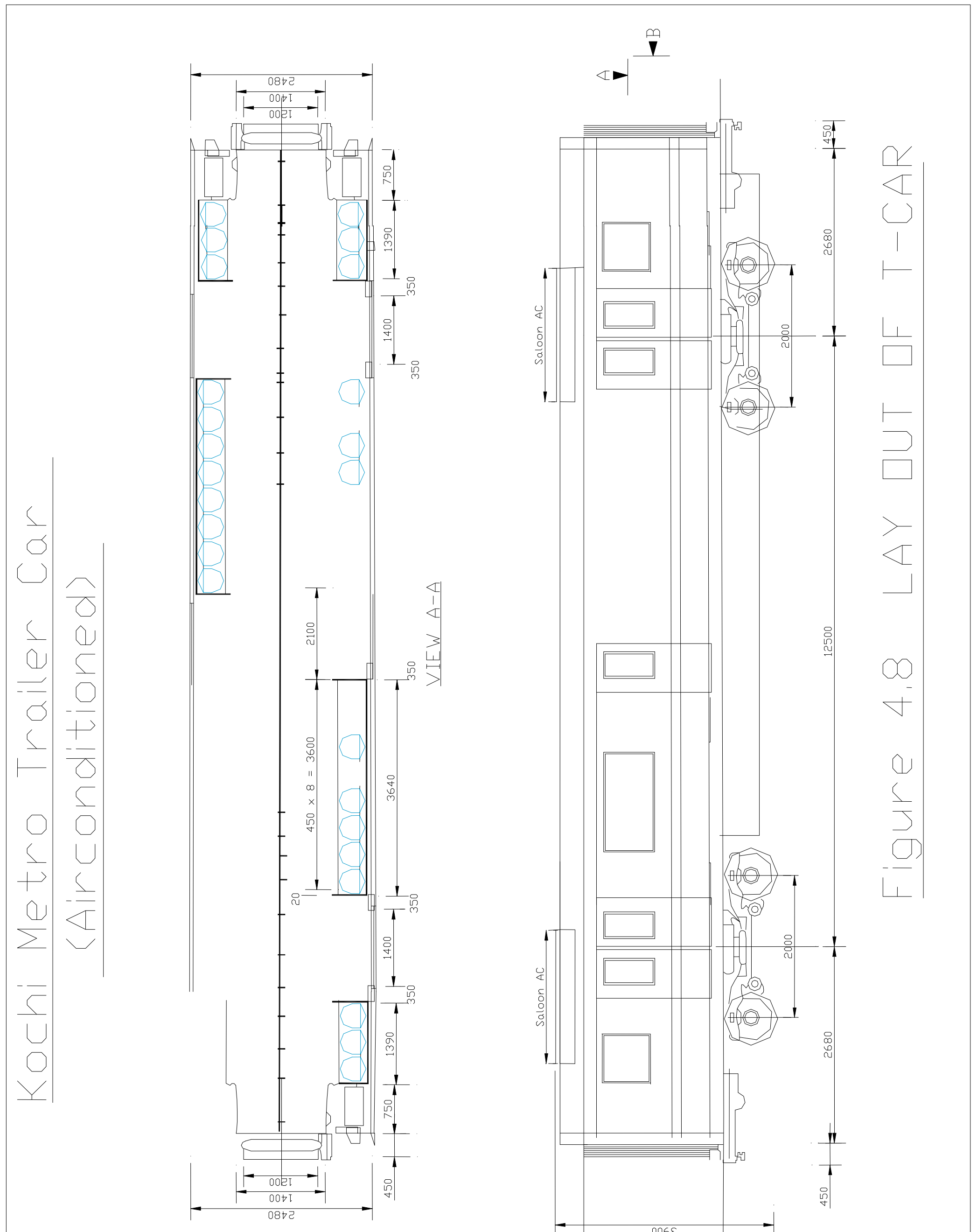
	Driving Motor Car		Trailer Car		3 Car Train	
	Normal	Crush	Normal	Crush	Normal	Crush
Seated	35	35	44	44	114	114
Standing	78	156	87	174	243	486
Total	113	191	131	218	357	600

NORMAL-3 Person/sqm of standee area
CRUSH -6 Person/sqm of standee area



SPECIFICATION		T-CAR	DMC
PASSENGER CAPACITY	SEATED	44	35
	STANDEES (6 PERSONS/M^2)	174	156
	TOTAL	218	191
MAXIMUM DESIGN SPEED		90KM/HOUR	
MAXIMUM OPERATIONAL SPEED		80KM/HOUR	
NOMINAL VOLTAGE		750 V. DC	

Figure 4.7 LAY OUT OF DM-CAR



SPECIFICATION		T-CAR	
PASSENGER CAPACITY	SEATED	44	35
	STANDEES (6 PERSONS/M^2)	174	156
	TOTAL	218	191
MAXIMUM DESIGN SPEED		90KM/HOUR	
MAXIMUM OPERATIONAL SPEED		80KM/HOUR	
NOMINAL VOLTAGE		750 V. DC	

Figure 4.8 LAY OUT OF T-CAR

4.4.3 WEIGHT

he weights of motorcar and trailer cars have been estimated as in Table 3, referring to the experiences in Delhi Metro. The average passenger weight has been taken as 65 kg.

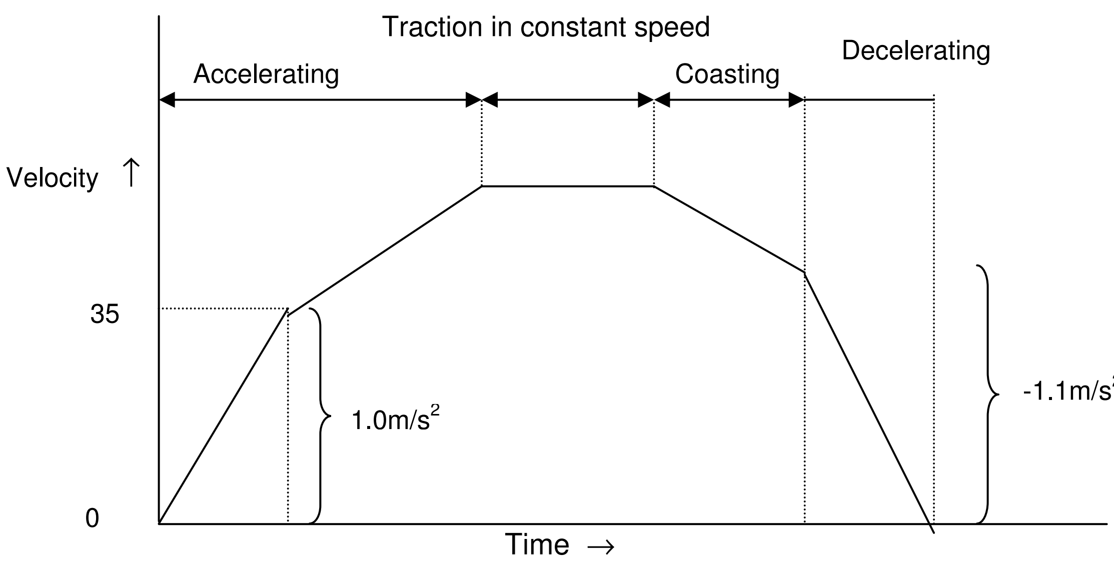
Table 3
Weight of Light Rail Vehicles (TONNES)

	DMC	TC	3 Car train
TARE	36	34	106
Passenger			
(Normal)	7.345	8.515	23.205
(Crush@6)	12.415	14.17	39
Gross			
(Normal)	43.345	42.515	126.21
(Crush)	48.415	48.17	142
Axle Load @6 person/sqm	12.104	12.043	
Axle Load @8 person/sqm	12.949	12.985	

The axle load @ 6persons/sqm of standing area works out in the range of 12.104T to 12.043 T. Heavy rush of passenger, having 8 standees per sq. meter can be experienced occasionally. It will be advisable to design the coach with sufficient strength so that even with this overload, the design will not result in over stresses in the coach. Coach and bogie should, therefore, be designed for **13 T axle** load.

4.4.3 Required Power

Following values of acceleration and deceleration are assumed in consideration of riding comfort, adhesion and requirement of make up time.
Max. Acceleration : 1.0 m/s^2
Max. Deceleration 1.1 m/s^2 (Normal brake)
More than 1.3 m/s^2 (Emergency brake)



Since the track on a viaduct could possibly be constructed on a level and the traction motors could be operated with overload for a short time, 8 traction motors with about 180 KW installed on a three car train would be enough, even if the equivalent gradients on a curved section of track are considered.

4.4.5 Coach design and basic parameters

The important criteria for selection of rolling stock are as under:

(i) Proven equipment with high reliability
(ii) Passenger safety feature
(iii) Energy efficiency
(iv) Light weight equipment and coach body
(v) Optimized scheduled speed
(vi) Aesthetically pleasing Interior and Exterior
(vii) Low Life cycle cost
(viii) Flexibility to meet increase in traffic demand
(ix) Anti-telescopic

The controlling criteria are reliability, low energy consumption, lightweight and high efficiency leading to lower annualized cost of service. The coach should have high rate of acceleration and deceleration.

4.4.6 Selection of Technology

Low life cycle cost

Low life cycle cost is achieved by the way of reduced scheduled and unscheduled maintenance and high reliability of the sub-systems. It is possible to achieve these objectives by adopting suitable proven technologies. Selection of following Technologies has been recommended to ensure low life cycle cost-.

(i) Car body

In the past carbon high tensile steel was invariably used for car bodies. In-fact almost all the coaches built by Indian Railways are of this type. These steel bodied coaches need frequent painting and corrosion repairs, which may have to be carried out up to 4-5 times during the service life of these coaches. It is now a standard practice to adopt stainless steel or aluminium for car body.

The car bodies with aluminium require long and complex extruded sections which are still not manufactured in India. Therefore aluminium car body has not been considered for use. Stainless steel sections are available in India and therefore stainless steel car bodies have been specified. No corrosion repair is necessary on stainless steel cars during their service life.

Stainless steel car body leads to energy saving due to its lightweight. It also results in cost saving due to easy maintenance and reduction of repair cost from excellent anti corrosive properties as well as on improvement of riding comfort and safety in case of a crash or fire.

(ii) Bogies

Bolster less lightweight fabricated bogies with rubber springs are now universally adopted in metro cars. These bogies require less maintenance and overhaul interval is also of the order of 4,20,000km. Use of air spring at secondary stage is considered with a view to keep the floor level of the cars constant irrespective of passenger loading unlike those with coil spring. Perturbation from the track are also dampened inside the car body on account of the secondary air spring along with suitable Vertical Hydraulic Damper .The primary suspension system improve the curve running performance by reducing lateral forces through application of conical rubber spring. A smooth curving performance with better ride index is being ensured by provision of above type of bogies.

(iii) Braking System

The brake system shall consist of –

(i) An electro-pneumatic (EP) service friction brake
(ii) A fail safe, pneumatic friction emergency brake
(iii) A spring applied air-release parking brake
(iv) An electric regenerative service brake
(v) Provision of smooth and continuous blending of EP and regenerative braking

The regenerative braking will be the main brake power of the train and will regain the maximum possible energy and pump it back to the system and thus fully utilize the advantage of 3 phase technology .The regenerative braking should have air supplement control to bear the load of trailer car. In addition, speed sensors mounted on each axle, control the braking force of the axles with anti skid valves, prompting re-adhesion in case of a skid .The brake actuator shall operate either a tread brake or a wheel disc brake.

(iv) Propulsion System Technology

In the field of Electric Rolling Stock, DC series traction motors have been widely used due to its ideal characteristics and good controllability for traction applications. But these required intensive maintenance because of commutators and electro-mechanical contactors, resistors etc

The brush less 3 phase induction motors has now replaced the D.C. Series motors in traction applications. The induction motor, for the same power output, is smaller and lighter in weight and ideally suited for rail based Mass Rapid Transit applications. The motor tractive effort and speed is regulated by 'Variable Voltage and Variable frequency'

control and can be programmed to suit the track profile and operating requirements. Another advantage of 3 phase a.c. drive and
VVVF control is that regenerative braking can be introduced by lowering the frequency and the voltage to reverse the power flow and to allow braking to very low speed.

For this corridor, three phase a.c. traction drive that are self-ventilated, highly reliable, robust construction and back up by slip/slid control have been recommended for adoption.

The AC catenary voltage is stepped down through a transformer and converted to DC voltage through converter and supply voltage to DC link, which feeds Inverter operated with Pulse Width Modulation (PWM) control technology and using Insulated Gate Bipolar Transistors (IGBT). Thus three-phase variable voltage variable frequency output drives the traction motors for propulsion.

Advanced IGBT has been developed for inverter units. The advanced IGBT contains an Insulated Gate Bipolar Transistor (IGBT) and gate drive circuit and protection. The advanced IGBT incorporates its own over current protection, short circuit protection, over temperature protection and low power supply detection. The IGBT has internal protection from over current, short circuit, over temperature and low control voltage.

The inverter unit uses optical fiber cable to connect the control unit to the gate interface. This optical fiber cable transmits the gate signals to drive the advanced IGBT via the gate interface. This optical fiber cable provides electrical isolation between the advanced IGBT and the control unit and is impervious to electrical interference. These are recommended for adoption in Trains of MRTS.

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(v) Interior and gang ways

Passenger capacity of a car is maximized in a Metro System by providing longitudinal seats for seating and utilizing the remaining space for standing passenger. Therefore all the equipments are mounted on the under frame for maximum space utilization. The gangways are designed to give a wider comfortable standing space during peak hours along with easy and faster passenger movement especially in case of emergency.

Interior View

(vi) Passenger Doors

For swift evacuation of the passenger in short dwell period, three doors of adequate width, on each side of the coach have been considered. These doors shall be of such dimensions and location that all the passenger inside the train are able to evacuate within least possible time without conflicting movement .As the alignment passes through elevated section above ground, automatic door closing mechanism is envisaged from consideration of passenger safety. Passenger doors are controlled electrically by a switch in Driver cab. Electrically controlled door operating mechanism has been preferred over pneumatically operated door to avoid cases of air leakage and sluggish operation of doors.

Passenger Doors

The door shall be of Bi-parting Sliding Type as in the existing coaches of DMRC.

(vii) Air–conditioning

With heavy passenger loading of 6 persons/sqm for standee area and doors being closed from consideration of safety and with windows being sealed type to avoid transmission of noise, air conditioning of coaches has been considered essential. Each coach shall be provided with two air conditioning units capable of automatically controlling interior temperature throughout the passenger area all the times under varying ambient condition up to full load. For emergency situations such as power failure or both AC failure etc, ventilation provision supplied from battery will be made. Provision shall be made to shut off the fresh air intake and re-circulate the internal air of the coach, during an emergency condition, such as fire outside the train causing excessive heat and smoke to be drawn in to the coach.

(viii) Cab Layout

The modern stylish driver panel shall be FRP moulded which give maximum comfort and easy accessibility of different monitoring equipments to the driver along with clear visibility .The driver seat has been provided at the left side of the cabin.

Driving cab

4.4.7 Communication

The driving cab of the cars are provided with continuous communication with base Operational Control Center and station control for easy monitoring of the individual train in all sections at all the time .

Public Address and Passenger Information Display System is provided in the car so that passengers are continuously advised of the next stoppage station, final destination station, interchange station, emergency situations if any, and other messages. The rolling stock is provided with Talk Back Units inside the cars, which permit conversation between passengers and the drivers in case of any emergency.

4.4.8 Noise and Vibration

The trains will pass through heavily populated urban area .The noise and vibration for a metro railway become an important criteria from public acceptance view point. The source of noise are (i) rail-wheel interaction (ii) noise generated from equipment like Blower, Compressor, air conditioner, door , Inverter etc.(iii) traction motor in running train .For elimination and reduction of noise following feature are incorporated :-

- Provision of anti drumming floor and noise absorption material
- Low speed compressor , blower and air conditioner
- Mounting of under frame equipments on anti-vibration pad
- Smooth and gradual control of door
- Provision of GRP baffle on the via-duct for elimination of noise transmission
- Provision of sound absorbing material in the supply duct and return grill of air conditioner

- Sealing design to reduce the aspiration of noise through the gap in the sliding doors and piping holes

The lower vibration level has been achieved by provision of bolster less type bogies having secondary air spring.

4.4.9 Passenger Safety Features

(i) ATP & ATO/CBTC

The rolling stock shall be compatible with ATP and ATO/CBTC to ensure absolute safety in the train operation. It is an accepted fact that 60-70% of the accidents take place on account of human error. Adoption of this system reduces the possibility of human error.

(ii) Fire

The rolling stock is provided with fire retarding materials having low fire load, low heat release rate, low smoke and toxicity inside the cars. The electric cables used are also normally low smoke zero halogen type which ensures passenger safety in case of fire.

(iii) Emergency door

The rolling stock is provided with emergency doors at both ends of the cab to ensure well directed evacuation of passengers in case of any emergency including fire in the train,

(iv) Crash worthiness features

The rolling stock is provided with inter car couplers having crashworthiness feature which reduces the severity of injury to the passengers in case of accidents.

(v) Gangways

Broad gangways are provided in between the cars to ensure free passenger movement between cars in case of any emergency.

Gangways

4.5 Traction System

Traditionally, electric traction is used in Metro systems for requirement of high acceleration and pollution-free services in urban areas. There are three standard and proven systems of electric traction for use in suburban and metro lines, viz:- 750V dc third rail, 1500V dc overhead catenary and 25kV ac overhead catenary system. All these three systems are presently in use in India.

1500V dc catenary system has been adopted by some of heavy metros to overcome the limitation imposed by 750V dc system for catering to traffic level of 60,000-80,000 PHPDT (e.g. Singapore, Hong Kong, Guangzhou etc.). This system requires use of catenary masts and messenger wires on elevated viaducts thereby affecting aesthetics of the city.

Stray current corrosion is often encountered in dc-electrified railways and therefore, suitable measures are required for protection against corrosion of metallic structures, reinforcement and utility pipes caused by dc stray current.

Alwaye to Petta is a stand alone line. In Earlier 2005 DPR the city aesthetics was the main consideration for recommending 750 V d. c.

On techno-economic consideration, it is recommended to adopt 25 KV single phase A.C. Traction, it in addition has the following merits.

- Lower initial cost.
- Lower operating and maintenance cost as in case of 25 KV ac traction the regeneration is up-to 30% and the line losses are around 0.5% in comparison to D.C. losses up-to 6 – 7%.
- A.C. system poses lesser Fire hazards as current levels are much lower than D.C.
- Stray current problems and hence the corrosion is controlled.

Typical 25kV AC Catenary Arrangement

4.6 SIGNALLING

4.6.1 Introduction

The signaling system shall provide the means for an efficient train control, ensuring safety in train movements. It assists in optimization of metro infrastructure investment and running of efficient train services on the network.

4.6.2 Signalling and Train Control

4.6.2.1 Overview

Metro carries large number of passengers at a very close headway requiring a very high level of safety enforcement and reliability. At the same time heavy investment in infrastructure and rolling stock necessitates optimization of its capacity to provide the best services to the public. These requirements of the metro are planned to be achieved by adopting 'Distance to go' ATP (Automatic Train Protection) and ATS (Automatic Train Supervision) sub-systems. This will:

- Provide high level of safety with trains running at close headway ensuring continuous safe train separation.
- Eliminate accidents due to driver passing Signal at Danger by continuous speed monitoring and automatic application of brake in case of disregard of signal / warning by the driver.
- Provides safety and enforces speed limit on section having permanent and temporary speed restrictions.
- Improve capacity with safer and smoother operations. Driver will have continuous display of Target Speed / Distance to Go status in his cab enabling him to optimize the speed potential of the track section. It provides signal / speed status in the cab even in bad weather.
- Increased productivity of rolling stock by increasing line capacity and train speeds, and enabling train to arrive at its destination sooner. Hence more trips will be possible with the same number of rolling stock.
- Improve maintenance of Signalling and telecommunication equipments by monitoring system status of trackside and train born equipments and enabling preventive maintenance.

Signalling & Train Control system on the line shall be designed to meet the required headway during peak hours.

4.6.2.2 System Description and Specifications

The Signalling and Train Control system shall be as below. Sub-system/ components will conform to international standards like CENELEC, IEC, BS, IS, ITU-T etc:

a. Continuous Automatic Train Control

Continuous Automatic Train Control will consist of - ATP (Automatic Train Protection), ATO (Automatic Train Operation) and ATS (Automatic Train Supervision) sub-systems:

(i) Automatic Train Protection (ATP)

Automatic Train Protection is the primary function of the train control systems. This sub-system will be inherently capable of achieving the following objectives in a fail-safe manner. Line side signals will be provided at diverging routes (i.e. at points & crossings), which shall serve as backup signalling in case of failure of ATP system. However, in such cases, train speed will be automatically restricted to 25 kmph.

- Cab Signalling
- Track Related Speed Profile generation based on line data and train data continuously along the track
- Continuous monitoring of braking curve with respect to a defined target point
- Monitoring of maximum permitted speed on the line and speed restrictions in force
- Detection of over-speed with audio-visual warning and application of brakes, if necessary
- Maintaining safety distance between trains
- Monitoring of stopping point
- Monitoring of Direction of Travel and Rollback

The cab borne equipment will be of modular sub-assemblies for each function for easy maintenance and replacement. The ATP assemblies will be fitted in the vehicle integrated with other equipment of the rolling stock.

(ii) Automatic Train Operation (ATO)

This system will operate the trains automatically from station to station while remaining within the safety envelope of ATP & open the train doors. Driver will close the train doors and press a button when ready to depart. In conjunction with ATP/ ATS, ATO can control dwell time at stations and train running in accordance with headway/ timetable.

(iii) Automatic Train Supervision (ATS)

A train supervision system will be installed to facilitate the monitoring of train operation and also remote control of the station. The train supervision will log each train movement and display it on the workstations with each Traffic Controller at the OCC and on one workstation placed in the Station Control room (SCR) with each Station Controller.

The centralized system will be installed in the Operation Control Centre. The OCC will have a projection display panel showing a panoramic view showing the status of tracks, points, signals and the vehicles operating in the relevant section/ whole system. ATS will provide following main functionalities:

- Automatic Route setting
- Automatic Train Regulation
- Continuous Tracking of train position
- Display Panel & Workstation interface
- Adjustment of station dwell time
- Link to Passenger Information Display System for online information
- Computation of train schedules & Timetable

b. Interlocking System:

(i) Computer Based Interlocking (CBI)

At all stations with points and crossings, Computer Based Interlocking (CBI) will be provided for operation of points and crossings and setting of routes.

The setting of the route and clearing of the signals will be done by workstation, which can be either locally (at station) operated or operated remotely from the OCC.

This sub-system is used for controlling vehicle movements into or out of stations automatically from a workstation. All stations having points and crossings will be provided with workstations for local control. Track occupancy, point position, etc. will be clearly indicated on the workstation. It will be possible to operate the workstation locally, if the central control hands over the operation to the local station. The interlocking system design will be on the basis of fail-safe principle.

The equipment will withstand tough environmental conditions encountered in a Mass Transit System. Control functions in external circuits will be proved both in the positive and negative wires. Suitable IS, IRS, BS standards or equivalent international standards will be followed in case wiring, installation, earthing, cabling, power supply and for material used in track circuits / axle counter, relays, point operating machines, power supply etc.

(ii) Train Detection

Audio Frequency Track Circuit / Axle Counter may be used for vehicle detection.

(iii) Point Machines

Non-Trailable Electrical Point Machine capable of operating with either 110V DC or 3-phase 380V AC will be used on main line. The depot point machine will preferably be trailable type.

c. Train Depot: Signalling

All depot lines except the one which is used for shunting and in the workshop shall be interlocked. A workstation shall be provided in the Depot Control Centre for electrical operation of the points, signals and routes of the depot yard. Audio Frequency Track Circuits may be used in the depot as well.

4.6.2.3 Standards

The following standards will be adopted with regard to the Signalling system.

Description	Standards
▪ Interlocking	Computer based Interlocking adopted for station having switches and crossing. All related equipment as far as possible will be centralised in the equipment room at the station. The depot shall be interlocked except for lines mainly used for shunting, workshop/inspection shed areas.
▪ Operation of Points	With Direct current 110V D.C. point machines or 380 volts 3 phase, 50 Hz. AC point machines.
▪ Train Detection	Audio frequency Track circuits / Axle Counter on running section and test track.
▪ Signals at Stations with point & crossings	Line Side signals to protect the points (switches). LED type signals for reliability and reduced maintenance cost.
▪ UPS (uninterrupted power at stations as well as for OCC)	For Signalling and Telecommunications
▪ Train protection system	Automatic Train Protection system.
▪ Train Describer System	Automatic Train Supervision system. Movement of all trains to be logged on to a central computer and displayed on workstations in the Operational Control Centre and at the SCR. Remote control of stations from the OCC.
▪ Redundancy for TP/ Train Describer.	Redundant Train borne equipment and ATS equipment at OCC.
▪ Cables	Outdoor cables will be steel armoured as far as possible.
▪ Fail Safe Principles	SIL-4 safety levels as per CENELEC standard for signal application.
▪ Immunity to External Interface.	All data transmission on telecom cables/OFC/Radio. All Signalling and telecom cables will be separated from power cables. CENELEC standards to be implemented for EMC.
▪ Train Working under emergency	Running on site with line side signal with speed automatically restricted between 15-25 kmph.
▪ Environmental Conditions	Air-conditioners for all equipment rooms.
▪ Maintenance philosophy	Philosophy of continuous monitoring of system status and preventive & corrective maintenance of Signalling equipments shall be followed. Card / module / sub-system level replacement shall be done in the field and repairs under taken in the central laboratory/ manufacturer's premises.

4.6.3 Space Requirement for Signalling Installations

Adequate space for proper installations of all Signalling equipment at each of the stations has to be provided keeping in view the case of maintenance and use of instrumentation set up for regular testing and line up of the equipment/system. The areas required at each of the stations for Signalling equipment shall be generally 60 sq.m for UPS Room (common for signalling and telecom) and for Signalling Equipment Room 50 sq.m at interlocked station with points & 20 sq.m at other stations. These areas shall also cater to local storage and space for maintenance personnel to work. At the OCC and the Depot, the areas required shall be as per the final configuration of the equipments and network configuration keeping space for further expansion.

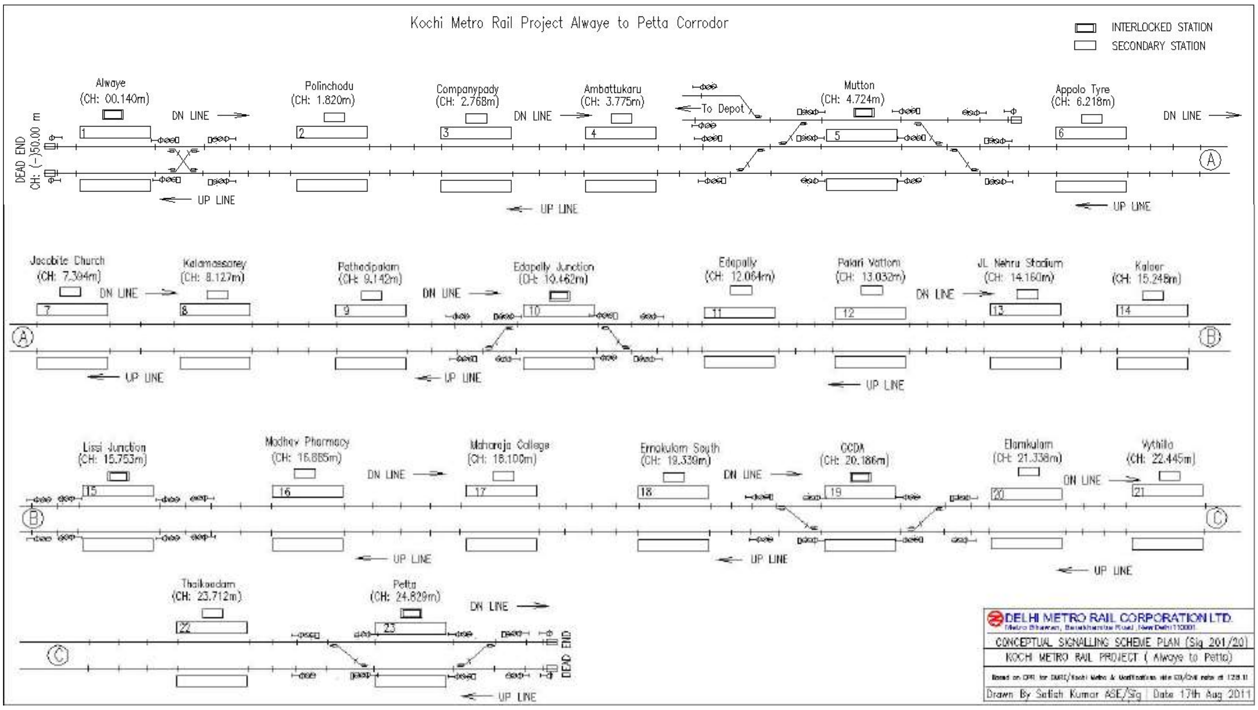
4.6.4 Maintenance Philosophy for Signalling systems

The philosophy of continuous monitoring of system status and preventive & corrective maintenance of Signalling and telecommunication equipments shall be followed. Card / module / sub-system level replacement shall be done in the field. Maintenance personnel shall be suitably placed at intervals and they shall be trained in multidisciplinary skills. Each team shall be equipped with a fully equipped transport vehicle for effectively carrying out the maintenance from station to station.

The defective card/ module / sub-system taken out from the section shall be sent for diagnostic and repair to a centralized S&T repair lab suitably located on the section. This lab will be equipped with appropriate diagnostic and test equipments to rectify the faults and undertake minor repairs. Cards / modules / equipments requiring major repairs as specified in suppliers documents shall be sent to manufacturer's workshop.

4.6.5 Conceptual Signalling Scheme Plan

Conceptual Signalling Scheme Plan of Kochi Metro Rail Project, based on revised P. Way plan is enclosed herewith for further disposal.



Interlocking cubicles

4.7 TELECOMMUNICATION

The telecommunication system acts as the communication backbone for Signaling and other systems and provides telecommunication services to meet operational and administrative requirements of metro network.

4.7.1 Overview

The Telecommunication facilities proposed are helpful in meeting the requirements for supplementing the Signaling system for efficient train operation, exchange of managerial information, Crisis management during emergencies and Passenger information system etc. The proposed telecom system will cater to the following requirements:

- Train Traffic Control
- Maintenance Control
- Emergency Control
- Station to station dedicated communication
- Telephone Exchanges
- Standalone Passenger Announcement System at each station
- Standalone Clocks at Platforms
- Radio Communication between Central Control and Trains and maintenance personnel

4.7.2 Telecommunication System and Transmission Media

4.7.2.1 Optical Fibre Cable - Main Telecommunication Bearer

The main bearer of the bulk of the telecommunication network is proposed with optical fibre cable system. Optical fiber cable will be laid in ring configuration with path diversity. SDH STM-1/4 system shall be adopted with SDH nodes at every station, central control and depot. Access 2MB multiplexing system will be adopted for the lower level at each node, equipped for channel cards depending on the requirement of channels in the network. Further small routers and switches shall be provided for LAN network at station.

4.7.2.2 Telephone Exchange

A mix of medium and small exchanges are planned connected together through optical fiber at multiple 2 MB level, which will provide communication at each stations and depots. Three EPABX of 512 ports will be provided at locations preferably one at the central control, one at an intermediate station and the other at depot. Small exchanges of 30 port each will be provided at each station. The Exchanges will be software partitioned for EPABX and Direct Line Communication.

4.7.2.3 Mobile Radio Communication

Mobile Radio communication system is planned for emergency communication between Driver (Front end and Rear end) of moving train and the Central Control. The system shall be based on Analog Trunk Radio Technology. All the stations and Depot will be provided with fixed radio sets. Mobile communication facility for maintenance parties and Security Personnel will be provided with handheld sets. These persons will be able to communicate with each other as well as with central control. To provide adequate coverage, based on the RF site survey to be carried out, base stations for the system will be located at a site conveniently selected after detailed survey, generally every 5 km.

Radio Tower

4.7.2.4 Passenger Announcement System

Standalone system will be provided, capable of announcements from the local station.

4.7.2.5 Clocks

Standalone Analog drum Clocks will be provided at platforms only.

4.7.2.6 NP-SCADA System

NP-SCADA is not planned.

4.7.2.7 Network Monitoring and Management

For efficient and cost effective maintenance of the entire communication network, a network management systems (NMS) is planned, which will help in diagnosing faults immediately from a central location and attending the same with least possible delay, thus increasing the operational efficiency and reduction in manpower requirement for maintenance. The proposed NMS system will be covering radio communication, Optical Fiber Transmission system and Telephone Exchange.

4.7.2.8 Standards

The standards proposed to be adopted for telecommunication systems are shown in Table below:

System	Standards
• Transmission System	**SDH based** for the entire telecom network.
• Transmission Media	**Optical Fibre system** as the main bearer for bulk of the telecommunication network
• Telephone Exchange	Small exchanges at each station. EPABX of 512 ports will be provided at central control, at an intermediate station and at depot(s).
• Train Radio System	**Analog Train radio** communication between train drivers, stations, maintenance personnel and central control.
• Train Destination Indicator System	**Display boards** at stations not planned. Can be added on later.
• NP-SCADA system	Not planned
• Clock system	Standalone analog drum clocks at platforms.
• Passenger Announcement System	**Standalone Passenger Announcement System** covering all platform concourse areas at each station.
• Environmental Conditions	Telecom equipment room to be air-conditioned.
• Maintenance Philosophy	System to have, as far as possible, automatic switching facility to alternate routes/circuits in the event of failure. Philosophy of preventive checks of maintenance to be followed. System networked with NMS for diagnosing faults and co-ordination. Card/module level replacement shall be done in the field and repairs undertaken in the central laboratory/manufacture's premises.

4.7.2.9 Depot

Depot will be provided with a mobile radio dispatcher system for depot/ yard communication connected from the central infrastructure at the central control, to provide communication from the Depot Control Room to Mobile sets in the Cabs of the cars and hand held sets with the maintenance personnel of the depot.

All the offices and the Maintenance installations at Car Depot will be connected with EPABX telephones and will be fed from the nearest Exchange.

4.7.2.10 Space Requirement for Telecom Installations

Adequate space for proper installations of all Telecommunication equipment at each of the stations has to be provided keeping in view the case of maintenance and use of instrumentation set up for regular testing and line up of the equipment/system. The area required at each of the stations will be generally 30 sqm each for Telecom Room. Radio tower shall be located at approximately 5 km interval along the section. The tower may be placed as near to Base Station Equipment Rooms as possible generally not more than 50 m away.

4.7.2.11 Maintenance Philosophy for Telecom systems

The philosophy of continuous monitoring of system status and preventive & corrective maintenance of Signalling and telecommunication equipments shall be followed. Card / module / sub-system level replacement shall be done in the field. Maintenance personnel shall be suitably placed at intervals and they shall be trained in multidisciplinary skills. Each team shall be equipped with a fully equipped transport vehicle for effectively carrying out the maintenance from station to station.

The defective card/ module / sub-system taken out from the section shall be sent for diagnostic and repair to a centralized S&T repair lab suitably located on the section. This lab will be equipped with appropriate diagnostic and test equipments to rectify the faults and undertake minor repairs. Cards / modules / equipments requiring major repairs as specified in suppliers documents shall be sent to manufacturer's workshop.

4.8 FARE COLLECTION SYSTEM

Metro Systems handle large number of passengers. Ticket issue and fare collection play a vital role in the efficient and proper operation of the system. To achieve this objective, ticketing system will be simple, easy to use/ operate and maintain, easy on accounting facilities, capable of issuing single/ multiple journey tickets, amenable for quick fare changes and be cost effective. In view of above, a combination of computerized paper ticket and smart card based fare collection system is proposed. It is planned to use indigenous sources for implementation of the proposed system.

The proposed ticketing system will be a combination of smart card and computerized paper ticket issued through the same ticket office machines (TOM) provided at each station counter/ booking office and at convenient locations. These TOMs will be connected to a local area network with a computer in the Station Master's room, which will be further connected to central computer.

For smart cards, simple turnstile type gates will be used. Smart cards will have provision for future applications such as bus, parking, toll etc. Manual checking will be done for paper tickets.

Turnstile Gate

4.8.1 Standards

The standard proposed for AFC systems are as under:

Standards	Description
• Fare media	Smart Card and Computerised Paper Ticket for single and multiple journeys.
• Ticket office machine	Manned Ticket office machine installed in the stations for selling paper tickets and smart cards to the passengers.
• Power Supply	UPS (Uninterrupted Power Supply).
• Gate	Turnstile type gates for smart card users

4.8.2 Ticketing System proposed is a foolproof system to avoid chances of ticketless travel. If so desired, a manual ticketing system similar to Indian Railway can also be adop ted to reduce cost of ticketing system which may come down to 15 to 20 % of the automatic fare collection system proposed above. However, it will have its own inherent disadvantage of leakage of revenue due to chances of ticketless travel. Moreover man power requirement will also go up

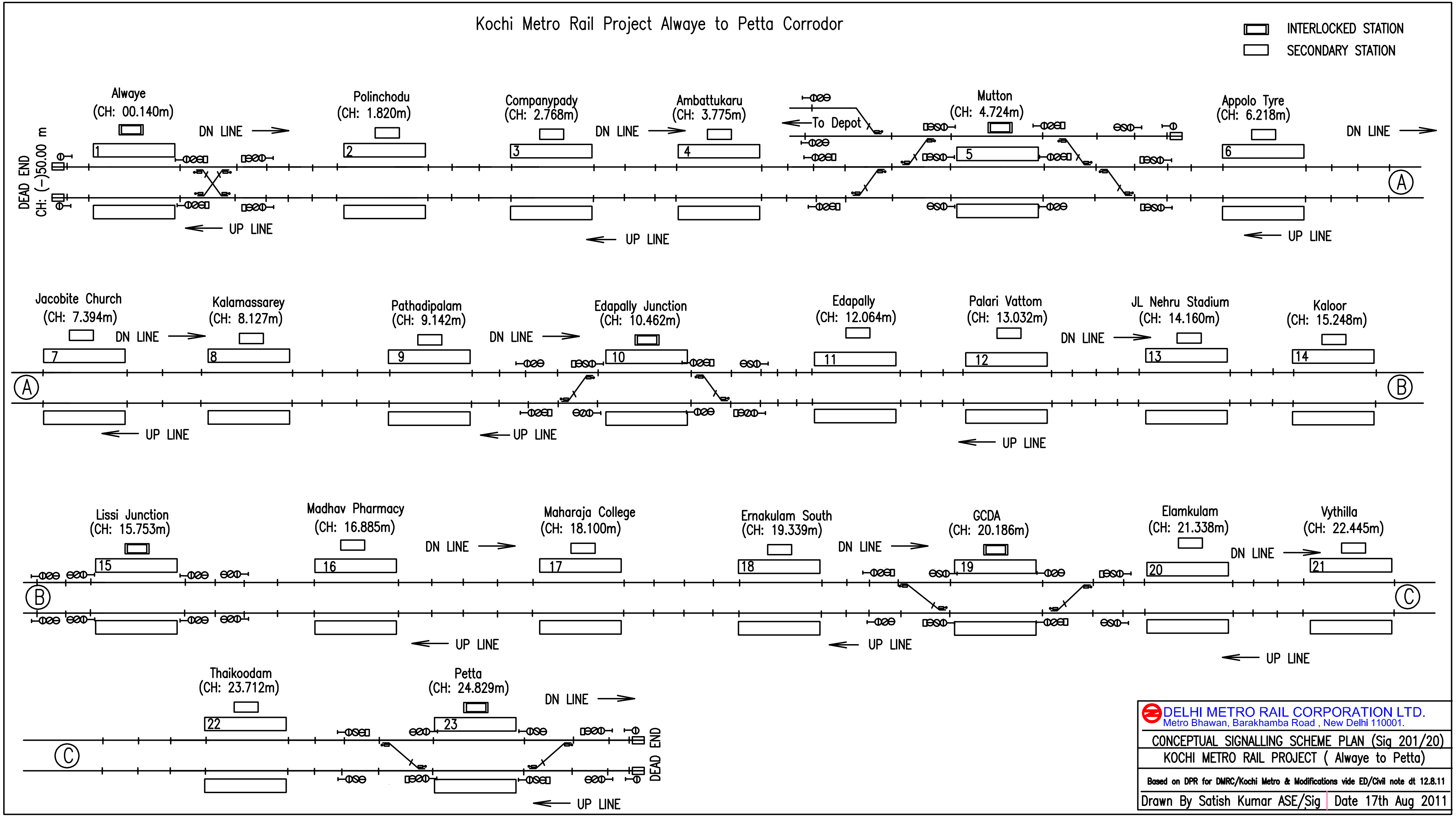
Attachment I

Salient Features of LRTS Rolling Stock for Kochi Metro

S.No.	Parameter	Details
1	**Gauge** (Nominal)	1435mm
2	**Traction system**	
2.1	Voltage	25 KV ac
2.2	Method of current collection	Overhead Current Collection System
3	**Train composition**	
3.1	3 car :	DMC + TC + DMC
4	**Coach Body**	Stainless Steel
5	**Coach Dimensions**	
5.1	Height	3.9 m
5.2	Width	2.7 m
5.3	Length (approx)	18 m
5.4	Locked down Panto height (if applicable)	4048 mm
5.5	Floor height	1100mm
6	**Designed - Passenger Loading**	
6.1	Design of Propulsion equipment	8 Passenger/ m^2
6.2	Design of Mechanical systems	10 Passenger/ m^2
7	**Carrying capacity- @ 6 standees/sqm**	
7.1	Coach carrying capacity	
	DMC	191 (seating - 35 ; standing - 156)
	TC	218 (seating - 44 ; standing - 174)
7.2	Train Carrying capacity	
	3 car train	600 (seating - 114 ; standing - 486)
8	**Weight (Tonnes)**	
8.1	Tare weight	
	DMC	36
	TC	34
8.2	Passenger Weight in tons (@ 6 standees/sqm)	@ 0.065 T per passenger
	DMC	12.415
	TC	14.17
8.3	Gross weight in tons	

	DMC	48.415
	TC	48.17
9	**Axle load(T)(@ 8 persons per sqm of standee area)**	**12.99**
		System should be designed for 13T axleload
10	**Maximum Train Length (3 car)- Approximate**	57 m approx.
11	**Speed**	
10.1	Maximum Design Speed	90 Kmph
10.2	Maximum Operating Speed	80 Kmph
12	**Wheel Profile**	UIC 510-2
13	**Noise Limits (ISO 3381 and 3095 - 2005)**	
13.1	Stationary (Elevated and at grade)	
13.1.1	Internal (cab and saloon)	L_{pAFmax} 65 dB(A)
13.1.2	External (at 7.5 mtr from centre line of track)	L_{pAFmax} 68 dB(A)
13.2	Running at 80 kmph (Elevated and at grade)	
13.2.1	Internal (cab and saloon)	$L_{pAeq,30}$ 72 dB(A)
13.2.2	External (at 7.5 mtr from centre line of track)	L_{pAFmax} 85 dB(A)
13.3	Stationary (Underground)	
13.3.1	Internal (cab and saloon)	L_{pAFmax} 72 dB(A)
14	**Traction Motors Ventilation**	Self
15	**Acceleration on level tangent track**	1.0 m/sec^2
16	**Deceleration on level tangent track**	1.1 m/sec^2 (>1.3 m/sec^2 during emergency)
17	**Type of Bogie**	Fabricated
18	**Secondary Suspension springs**	Air
19	**Brakes**	Wheel disc/ TBU
20	**Coupler**	
20.1	Driving Cab end of DMC:	Automatic Coupler with Mechanical and Pneumatic coupling but without Electrical coupling head.
20.2	Between Cars of same unit:	Semi permanent Coupler
21	**Detrainment Door**	Front

22	**Type of Doors**	Sliding
23	**Passenger Seats**	Stainless Steel
24	**Cooling**	
24.1	Transformer	N.A
24.2	CI & SIV	Self/Forced
24.3	TM	Self ventilated
25	**Control System**	Train based Monitor & Control System (TCMS/TIMS)
26	**Traction Motors**	3 phase VVVF controlled
27	**Temperature Rise Limits**	
27.1	Traction Motor	Temperature Index - 70 deg C
27.2	CI & SIV	10 deg C temperature margin for Junction temperature
27.3	Transformer	IEC specified limit-20 deg C
28	**HVAC**	Cooling, Heating & Humidifier (As required)
29	**PA/PIS including PSSS (CCTV)**	Required
30	**Passenger Surveillance**	Required
31	**Battery**	Ni-Cd
32	**Headlight type**	LED (1 No.)
33	**Propulsion equipment:**	
33.1	Pantograph	2 Nos. on T car
33.2	LCB	1 No.
33.3	Transformer	1 No.
33.4	SIV	1 No.
33.5	CI	Car based for each DMC


Kochi Metro Rail Project Alwaye to Petta Corrodor
INTERLOCKED STATION
SECONDARY STATION
DEAD END
CH: (-)50.00 m
Alwaye (CH: 00.140m)
Polinchodu (CH: 1.820m)
Companypady (CH: 2.768m)
Ambattukaru (CH: 3.775m)
To Depot
Mutton (CH: 4.724m)
Appolo Tyre (CH: 6.218m)
DN LINE
UP LINE
Jacobite Church (CH: 7.394m)
Kalamassarey (CH: 8.127m)
Pathadipalam (CH: 9.142m)
Edapally Junction (CH: 10.462m)
Edapally (CH: 12.064m)
Palari Vattom (CH: 13.032m)
JL Nehru Stadium (CH: 14.160m)
Kaloor (CH: 15.248m)
Lissi Junction (CH: 15.753m)
Madhav Pharmacy (CH: 16.885m)
Maharaja College (CH: 18.100m)
Ernakulam South (CH: 19.339m)
GCDA (CH: 20.186m)
Elamkulam (CH: 21.338m)
Vythilla (CH: 22.445m)
Thaikoodam (CH: 23.712m)
Petta (CH: 24.829m)
DEAD END
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
A B C
DELHI METRO RAIL CORPORATION LTD.
Metro Bhawan, Barakhamba Road , New Delhi 110001.
CONCEPTUAL SIGNALLING SCHEME PLAN (Sig 201/20)
KOCHI METRO RAIL PROJECT (Alwaye to Petta)
Based on DPR for DMRC/Kochi Metro & Modifications vide ED/Civil note dt 12.8.11
Drawn By Satish Kumar ASE/Sig
Date 17th Aug 2011

Chapter 5

Civil Engineering

5.1 General

This chapter deals with geometrical standards adopted for horizontal and vertical alignments, route description, station locations, soil conditions, land requirements, Utility services, etc.

5.2 Geometric Design Norms

The geometrical design norms are based on international practices adopted for similar metro systems with standard gauge on the assumption that the maximum permissible speed on the section is limited to 80 kms. Planning for any higher speed is not desirable as the ultimate average inter-station distances will be only about one Km and trains will not be able to achieve higher speed.

The tracks will be carried on U-shaped elevated decking supported by single circular piers, generally spaced at 28-m centres and located on the median of the road. The horizontal alignment and vertical alignment are, therefore, dictated to a large extent by the geometry of the road followed by the alignment.

The track centre on the elevated section will be 3.7 m on portions of tracks which are straight or have curvature upto 150 m radius. The track centre will be increased to 4 m on curves with a radius of 150 m or sharper.

The standards adopted for horizontal and vertical alignments are as under: -

5.2.1 Horizontal Alignment

The standards adopted for horizontal and vertical alignments are as under: -

Curve radius in mid section:

Elevated Section

	Preferred	: 400 m and above
	Minimum	: 200 m
	Absolute minimum	: 90m (in exceptional cases)
Minimum curve radius at stations		: 1000 m
Maximum permissible cant (Ca)		: 125 mm
Maximum desirable cant (Ca)		: 110 mm
Maximum cant deficiency (Cd)		: 85 mm

Transition curves

- Minimum length of Transitions of Horizontal curves (m) : 0.44 times actual cant or cant deficiency (in mm), which ever is higher.
- Desirable : 0.72 times actual cant or cant deficiency, (in mm) which ever is higher
- No overlap is allowed between transition curves and vertical curves.
- Minimum straight between two Transition curves : either 25 m or NIL.
- Minimum curve length between two transition curves : 25 m

5.2.2 Vertical Alignment

The viaducts carrying the tracks will have a vertical clearance of minimum 5.5 m above road level. For meeting this requirement with the 'U' shaped pre-stressed concrete girders, the rail level will be about 8.5 m above the road level. However, at stations which are located above central median, the rail level will be 10.5 m above the road level if no mezzanines are provided and the ticketing and other technical areas are located outside the right of way of the roads. If, however, concourses are provided below the station structures, then the rail level shall be 12.5m above road level. These levels will, however, vary marginally depending upon where the stations are located.

Gradients

Normally the stations shall be on level stretch. In limiting cases station may be on a grade of 0.1 %. Between stations, generally the grades may not be steeper than 2.0 %. However, there are a few situations, where steeper grades are unavoidable as existing roads are steeper.

The gradients adopted are as under: -

- Maximum gradient at stations	:	0.1 %
- Desirable gradient at stations	:	level
- Maximum gradient in mid section	:	
Normal	:	2.0 %
Exceptional	:	4.0 %

5.2.3 Vertical Curves

Vertical curves are to be provided when change in gradient exceeds 0.4%. However it is recommended to provide vertical curves at every change of gradient.

- Minimum radius of vertical curves:
    - On main line : 2500 m
    - Other Locations : 1500 m
    - Minimum length of vertical curve : 20 m

5.2.4 Design Speed

The maximum sectional speed will be 80 km/h. A higher sectional speed cannot be attempted when inter-station distances are so short. However, the applied cant, and length of transition will be decided in relation to normal speeds at various locations, as determined by simulation studies of alignment, vertical profile and station locations. This is with the objective of keeping down the wear on rails on curves to the minimum.

Table 5.1
Cant, Permitted speed and Minimum Transition length for curves

Radius	Actual Cant	Cant Deficiency	Permitted Speed	Minimum Transition
(m)	(mm)	(mm)	(kmph)	(m)
3000	20	8.72	80	10
2000	30	13.09	80	15
1000	50	36.17	80	25
800	60	47.72	80	30
500	90	82.35	80	40
400	110	85	80	55
300	110	85	70	55
200	110	85	55	55
150	110	85	45	55
120	110	85	40	55
100	110	85	40	55
90	110	85	35	55

5.2.5 Station Locations

Stations have been located so as to serve passenger requirements and to enable convenient integration with other modes of transport. Effort have been made to propose station locations at a uniform inter-station distance as feasible. The average spacing of stations will be close to one km after the three future stations also come into existence.

5. 3 Route Alignment

5.3.1 General Description

Alwaye – Petta Corridor is 25.612 Km long and runs in North – South West direction for its initial 19 Km length (up to Ernakulam South Station) whereafter it turns towards East, terminating at Petta. Starting from a point, about 125 m away from the Rajiv Gandhi Bus Terminal, Alwaye The corridor runs parallel to the existing NH-47 service road up to chainage Km 1.200. From this point onwards the alignment runs along the median of NH-47 up to Edapally (chainage Km 10.850). After this the alignment follows Banerji Road up to Madhav Pharmacy Junction (chainage Km16.600). From Madhav Pharmacy Junction the alignment turns towards M.G. Road to reach Jose Junction at chainage Km 18.650. From there onwards it turns towards Ernakulam South Railway Station following Ernakulam South Station Road up to chainage Km 19.100. The alignment then crosses Ernakulam South Railway Yard and enters S.A. Road at chainage Km 19.600. Here onwards the alignment runs along the S.A. Road up to Vytilla (chainage Km 22.450). At this chainage, the alignment crosses NH-47 bye-pass to enter NH-49 and reaches Petta (chainage Km 24.822). The alignment finally terminates at chainage Km 25.612.

5.3.2 Alignment from Km -0.090 to Km 1.200

Northern terminal of the corridor is located at Alwaye at chainage Km - 0.090. From there on the alignment up to chainage 1.200 is on the side of existing service road This length is located partly on the government land and partly on private land. The private buildings getting affected The alignment is straight and on curve. At southern approach of Alwaye Metro station is on curve where a are mainly commercial shops housed in storeyed buildings. 650 m curve (followed by a 800 m curve) is provided. The Metro station entry has been planned in such a way to provide easy access for passengers from Rajiv Gandhi Bus Terminal located on the side of NH-47. For passengers coming from the Eastern side of the Metro Station (where KSRTC bus stand and Railway Station are located), will have to use existing connecting road of length around 325m.

5.3.3 Alignment from Km 1.200 to Km 10.850

This stretch of the alignment follows NH-47. An attempt has been made to keep the alignment on the median of the road with a view to minimize the requirement of land acquisition. There are three deviations from the median one from chainage Km. 4.400 to Km.4.900 at Muttom station and the second one from chainage Km. 5650 to Km.5850 where a new road bridge constructed and the third one from chainage Km. 6.850 to Km.7.350 where a road-over-bridge exists. The alignment has been diverted to cross the existing railway tracks parallel to the road-over-bridge. at chainage Km. 6.7. To follow the alignment of the NH-47, 18 curves varying in radius from 402 m to 12,000 m have been introduced. Nine Metro stations namely Pulinchodu (future station at chainage Km 1.814), Companypady (chainage Km 2.756), Ambattukavu (future station at chainage Km 3.764), Muttom (chainage Km 4.723), Apollo Tyres (chainage Km 6.209), Jacobite Church (chainage Km 7.399), Kalamassery (chainage Km 8.144), Pathadi Palam (future station at chainage Km 9.146) and Edapally junction (chainage Km 10.599) have been proposed. Rolling Stock Depot has been planned at Muttom on the Eastern side of the Metro alignment. Connection to the Depot takes off at chainage Km 4.600. The connection is elevated till it crosses Chennai – Trivandrum Railway line, whereafter it ramps down to the ground level so as to reach the Depot.

Land use in this stretch of alignment is mixed – commercial, residential and institu tional. A number of schools and institutions like Cochin University of Science & Technology and several major industrial establishments such as Apollo Tyres, Premier Tyres, HMT etc. exist along this stretch.

5.3.4 Alignment from Chainage Km 10.850 to Chainage Km 16.600

In this stretch, the alignment runs on the median of Banerji Road till it reaches Madhav Pharmacy Junction. There will be 5 Metro stations, i.e. Edapally (chainage Km 12.023), Palarivattom (chainage Km13.071), J.L.Nehru Stadium (chainage Km 14.126), Kaloor (chainage Km 15.221) and Lissi (chainage 15.711) on this stretch. The land use is mixed in this area and there are many high rise buildings on either side of the road. The area is very congested. Jawaharlal Nehru Stadium falls on this stretch where a Metro station has been planned. Kaloor Bus Stand used by City buses as well as buses coming from suburban areas is also located on this stretch. Other main commercial areas are Palarivattum, Kaloor, Kacheripadi. Ernakulam North Railway Station is situated on this route and Lissi Metro station will provide connectivity to it. A number of hospitals exist on this stretch. There is a road-over-bridge at Km 15.900 where the Metro alignment will pass over this bridge.

5.3.5 Alignment from Chainage Km 16.600 to Chainage Km 18.650

At chainage 16.600, the alignment takes sharp curve of 92.050 radius followed by another curve of radius 107.050 to reach the median of M.G. Road at chainage Km16.800. This sharp curvature was necessary to keep the land acquisition minimum. On this stretch, 2 Metro Stations, namely Madhav Pharmacy (chainage Km 16.899) and Maharaja's College (chainage Km 18.103) are located. This stretch has many centres of activities. In addition to having several high rise buildings, it serves Cochin Corporation Office, Colleges like Maharaja's College, Women's College, Law College as well as Boat Jetty, KSRTC Bus Stand, etc.

5.3.6 Alignment from Chainage Km 18.650 to Chainage Km 19.100

In this stretch the alignment turns from M.G. Road to South Railway Station Road. South Railway Station Road is highly congested, being a 2-lane road. There are commercial establishments and several high-rise buildings in this stretch.

5.3.7 Alignment from Chainage Km 19.100 to Chainage Km 19.600

From chainage Km 19.100 the alignment takes another sharp curve to move towards Railway quarters approach Road, where after it crosses the Railway tracks near the Route Relay Cabin of Ernakulam Junction Railway Station. At chainage Km 19.600, the alignment turns towards S.A Road. The Metro alignment runs partially over the approach of south over-bridge. Ernakulam South Metro Station (chainage Km 19.332) is located opposite to platform No.1 of Ernakulam Junction of Southern Railway. This will facilitate inter-change of passengers at this place.

5.3.8 Alignment from Chainage Km 19.600 to Chainage Km 22.450

In this stretch, the alignment mainly runs on the median of S.A Road. There will be 2 major Stations, i.e. GCDA (chainage Km 20.185), and Elamkulam (chainage 21.341). The alignment is mainly straight. Important establishments like GCDA Office, Rajiv Gandhi Indoor Stadium and several Hospitals office of the leading Malayalam Manorama and a Central School are located on this stretch. This stretch also provides access to a number of residential complexes like Panampally Nagar, Gandhi Nagar, Giri Nagar Colony etc.

5.3.9 Alignment from Chainage Km 22.450 to Chainage Km 25.612

There are 3 Metro Stations on the stretch of this alignment, i.e. Vytilla (chainage Km 22.447), Thaikoodam (chainage Km 23.703) and Petta (chainage Km 24.822). This stretch serves mainly residential areas.

5.3.10 Major Roads Along this Corridor

The major roads along the corridor with details of 'Right of Way' are given in Tables 5.2, 5.3 and 5.4 below.

Table 5.2
Major Roads along the Alignment

S. No.	Road Name	Chainage (m)	Right-of-Way (m)
1	Banerji Road	10900 – 16800	36
2	M. G. Road	16800 – 18500	36
3	M. G. Road to Vyttila	18500 – 22400	36
4	Vyttila to Petta	22400 – 24860	33

Table 5.3
ROADS ACROSS THE CORRIDOR

S. No.	Chainage (m)	Road Names	Type Of Road
1	420	MASJID ROAD (MAJOR ROAD)	BT
2	2018	PERUMPAVOOR ROAD	BT
3	2287	-	BT
4	2700	COMPANIPADY ROAD	BT
5	7500	KALAMASSERY ROAD (MAJOR ROAD)	BT
6	8034	COCHIN UNIVERSITY ROAD (MAJOR ROAD)	BT
7	15544	JUDGOS AVENUE ROAD	BT
8	15787	SRM ROAD	BT
9	16532	CHITTOOR ROAD (MAJOR ROAD)	BT
10	17142	JEWS STREET	BT
11	17317	VISHAL STREET	BT
12	17835	MULLASSERY CANAL ROAD	BT
13	18218	HOSPITAL ROAD	BT

S. No.	Chainage (m)	Road Names	Type Of Road
14	18480	-	BT
15	18637	SOUTH RAILWAY STATION ROAD	BT
16	18817	CHITTOOR ROAD (MAJOR ROAD)	BT
17	19086	KARSHAKA ROAD	BT
18	20391	KP VALLON ROAD (MAJOR ROAD)	BT
19	22487	BYE-PASS ROAD (MAJOR ROAD)	BT
20	25780	-	UN METALED ROAD
21	26500	THEVARAKKVU ROAD	BT
22	26615	EROOR ROAD (MAJOR ROAD)	BT
23	26816	-	UN METALED ROAD

Table 5.4
OTHER ROADS ALONG THE CORRIDOR

S. No.	Chainage (m)	Road Name	Type Of Road	Side
1	1567	PULINCHODUKADAVU ROAD	BT	RIGHT
2	1810	-	UM	RIGHT
3	2475	-	BT	RIGHT
4	2867	INDIRA LANE	BT	RIGHT
5	2874	-	UM	LEFT
6	2903	-	UM	RIGHT
7	2985	-	BT	RIGHT
8	3325	-	BT	RIGHT
9	3694	AMBATTUKAVU TEMPLE ROAD	BT	RIGHT
10	3808	-	BT	RIGHT
11	4028	-	UM	RIGHT
12	4140	-	UM	RIGHT

S. No.	Chainage (m)	Road Name	Type Of Road	Side
13	4251	-	BT	RIGHT
14	4617	-	UM	RIGHT
15	4845	-	BT	RIGHT
16	4871	-	BT	RIGHT
17	4969	-	BT	RIGHT
18	5038	JAWAHARLAL NEHRU ROAD	BT	RIGHT
19	5040	THAIKAVU ROAD	BT	LEFT
20	5210	-	WBM	RIGHT
21	5265	-	UM	RIGHT
22	5285	-	BT	LEFT
23	5364	-	BT	RIGHT
24	5434	-	UM	RIGHT
25	5632	-	BT	RIGHT
26	5933	-	BT	LEFT
27	6236	-	BT	LEFT
28	6400	ELOOR ROAD (MAJOR ROAD)	BT	RIGHT
29	6575	EMS ROAD	BT	RIGHT
30	6657	-	BT	RIGHT
31	6824	BISHOP LANE	BT	RIGHT
32	7000	JAWAHARLAL NEHRU ROAD (HMT ROAD) (MAJOR ROAD)	BT	LEFT
33	7815	-	UM	LEFT
34	7825	-	BT	RIGHT
35	8338	-	UM	LEFT
36	8352	KALAMASSERY ROAD (MAJOR ROAD)	BT	RIGHT
37	8378	-	BT	RIGHT
38	8430	-	BT	LEFT

S. No.	Chainage (m)	Road Name	Type Of Road	Side
39	8464	AISWARYA ROAD	BT	RIGHT
40	8532	-	BT	LEFT
41	8562	GANGA NAGAR ROAD	BT	RIGHT
42	8579	CHANGAMPUZHA ROAD	BT	LEFT
43	8742	MATHER NAGAR ROAD	BT	RIGHT
44	8777	MATHER NAGAR ROAD	BT	RIGHT
45	8803	-	BT	LEFT
46	8966	PARIJATHA ROAD	BT	LEFT
47	9087	ILLIKKAL MOITHIN ROAD	BT	LEFT
48	9093	MOHMMED BAZHER ROAD	BT	LEFT
49	9400	-	UM	LEFT
50	9457	DAYARI METHANAM ROAD	BT	RIGHT
51	9520	-	BT	LEFT
52	9682	BEERA KUTTY ROAD	BT	RIGHT
53	9708	AMBALAM ROAD	BT	LEFT
54	9794	NH AKG ROAD	BT	LEFT
55	10032	AKG ROAD	BT	LEFT
56	10121	-	BT	LEFT
57	10254	VP MARAIKKER ROAD	BT	RIGHT
58	10273	POOKKATTUPADY ROAD (MAJOR ROAD)	BT	LEFT
59	10644	-	WBM	LEFT
60	10843	BYE-PASS ROAD (MAJOR ROAD)	BT	LEFT
61	10902	MARKET ROAD	BT	RIGHT
62	10904	PARUR ROAD (MAJOR ROAD)	BT	RIGHT
63	10963	PRASHANTHI NAGAR ROAD	BT	RIGHT
64	11087	ASHARIPARAMBU ROAD	BT	RIGHT

S. No.	Chainage (m)	Road Name	Type Of Road	Side
65	11139	MARKET ROAD	BT	LEFT
66	11300	MARKET ROAD	BT	LEFT
67	11310	BALAKRISHNAMENON ROAD	BT	LEFT
68	11315	EDAPALLI PALACE ROAD (MAJOR ROAD)	BT	RIGHT
69	11506	MANIMALA ROAD	BT	RIGHT
70	11509	RANUDHIVE ROAD	BT	LEFT
71	11612	CHANDRADIL ROAD	BT	LEFT
72	11678	CHANGAMPUZHA SAMATHI ROAD(MAJOR ROAD)	BT	RIGHT
73	11766	KANNAN THOTTATHU ROAD	BT	LEFT
74	11908	CHANGAMPUZHA SAMATHI ROAD	BT	RIGHT
75	11910	-	BT	LEFT
76	11982	-	BT	RIGHT
77	12136	EDAPALLI RAGAVANPILLAI ROAD (MAJOR ROAD)	BT	RIGHT
78	12147	VIJAYA NAGAR ROAD	BT	RIGHT
79	12155	KANNAN THOTTATHU ROAD	BT	LEFT
80	12211	-	BT	RIGHT
81	12355	MANGATTU ROAD	BT	RIGHT
82	12369	BEENA ANCHUMANA ROAD	BT	LEFT
83	12503	KANNAYATH ROAD	BT	RIGHT
84	12642	PARIMALA PRINTERS ROAD	BT	LEFT
85	12673	-	BT	LEFT
86	12722	ANCHUMANA ROAD	BT	LEFT
87	12729	MAMANGALAM POTTOKUZHI ROAD	BT	RIGHT
88	12795	-	BT	LEFT
89	12860	YATHRI NIVAS LANE	BT	LEFT

S. No.	Chainage (m)	Road Name	Type Of Road	Side
90	12895	-	BT	RIGHT
91	12956	-	BT	LEFT
92	12952	-	BT	LEFT
93	12962	AUTOMOBILE ROAD	BT	RIGHT
94	13143	SAROM MATHOMA CHURCH ROAD	BT	RIGHT
95	13160	KOMATH ROAD	BT	RIGHT
96	13267	PALARIVATTUM ROAD (MAJOR ROAD)	BT	LEFT
97	13290	-	BT	RIGHT
98	13432	PUTHANPURAIKKAL ROAD	BT	RIGHT
99	13659	PALARIVATTUM ROAD (MAJOR ROAD)	BT	LEFT
100	13662	ST.MARTIN ROAD	BT	LEFT
101	13771	NORTH JANATHA ROAD	BT	RIGHT
102	13780	SOUTH JANATHA ROAD	BT	LEFT
103	13887	AISWARYA ROAD	BT	RIGHT
104	13902	KAYYATH LANE	BT	LEFT
105	13984	SABARMATHI ROAD	BT	LEFT
106	14055	VASANTH NAGAR ROAD	BT	RIGHT
107	14259	-	BT	LEFT
108	14280	MASTER COACHING ROAD	BT	RIGHT
109	14358	CHOORAPPARAMBIL ROAD	BT	RIGHT
110	14491	DESHABHIMANI ROAD	BT	RIGHT
111	14502	PONUTHU ROAD	BT	LEFT
112	14638	BANK ROAD	BT	LEFT
113	14670	ST.ANTONY ROAD	BT	RIGHT
114	14792	AZAD ROAD	BT	LEFT
115	14826	ASHOKA ROAD	BT	RIGHT

S. No.	Chainage (m)	Road Name	Type Of Road	Side
116	14981	KRISHNAMENON ROAD	BT	RIGHT
117	14987	SHENOY ROAD	BT	LEFT
118	15123	PERANDOR ROAD	BT	RIGHT
119	15135	KALOOR BRANCH ROAD (MAJOR ROAD)	BT	LEFT
120	15328	-	BT	RIGHT
121	15374	-	BT	LEFT
122	15632	KASHIM ROAD	BT	LEFT
123	16000	NORTH RAILWAY STATION ROAD (MAJOR ROAD)	BT	RIGHT
124	16081	MATHEW PALY ROAD	BT	RIGHT
125	16138	PARAMARA ROAD	BT	RIGHT
126	16154	MATHEW PALY ROAD	BT	RIGHT
127	16268	ST.VINCENT ROAD	BT	RIGHT
128	16280	PEYOLI ROAD	BT	LEFT
129	16402	ASHIRBHAVAN ROAD	BT	RIGHT
130	16878	VEEKSHANAM ROAD	BT	LEFT
131	16915	VITTAPPA PRABHU ROAD	BT	RIGHT
132	17288	-	WBM	LEFT
133	17391	DURAISAMY IYAR ROAD	BT	LEFT
134	17396	GOPALA PRABU ROAD	BT	RIGHT
135	17515	RAJAJI ROAD	BT	LEFT
136	17721	CONVENT ROAD	BT	RIGHT
137	17729	SHENOYS THEATRE ROAD	BT	LEFT
138	17738	NARAKATHARA ROAD	BT	RIGHT
139	18746	-	BT	LEFT
140	18966	CARRIER STATION ROAD	BT	LEFT
141	18974	KALATHI PARAMBIL ROAD	BT	RIGHT

S. No.	Chainage (m)	Road Name	Type Of Road	Side
142	19539	-	WBM	LEFT
143	19572	KARSHAKA ROAD	BT	LEFT
144	19794	-	BT	RIGHT
145	19828	-	WBM	LEFT
146	19900	-	BT	LEFT
147	19973	THRIPTHI LANE	BT	LEFT
148	20020	-	BT	RIGHT
149	20064	-	BT	LEFT
150	20214	GIRI NAGAR ROAD	BT	RIGHT
151	20318	-	BT	RIGHT
152	20343	PALARIVATTUM ROAD (MAJOR ROAD)	BT	LEFT
153	20440	TEMPLE ROAD	WBM	LEFT
154	20515	MITTATHIL LANE	BT	LEFT
155	20518	-	BT	LEFT
156	20607	CHERUPARAM ROAD	BT	RIGHT
157	20676	ROYAL LANE	BT	LEFT
158	20696	-	BT	RIGHT
159	20762	CHERUPUSHPAM LANE	BT	RIGHT
160	20807	-	BT	RIGHT
161	20822	-	CC	LEFT
162	20850	-	CC	LEFT
163	20884	RAVEENDRAN ROAD	BT	RIGHT
164	20946	FATHIMA CHURCH ROAD	BT	LEFT
165	20978	CHILAVANOOR ROAD	BT	RIGHT
166	21039	FATHIMA CHURCH ROAD	BT	LEFT
167	21176	DAVID COLONY ROAD	BT	RIGHT
168	21221	SUNOORO CHURCH ROAD	CC	RIGHT

S. No.	Chainage (m)	Road Name	Type Of Road	Side
169	21373	-	WBM	RIGHT
170	21685	JUNIOR JANATHA ROAD	BT	LEFT
171	21699	TOC HIGH SCHOOL ROAD	BT	RIGHT
172	21752	JUNIOR JANATHA ROAD	BT	LEFT
173	21857	JANATHA ROAD	BT	RIGHT
174	22025	MAJOR ROAD	BT	RIGHT
175	22088	KACHAPALLAY ROAD	BT	LEFT
176	22191	-	UM	LEFT
177	22207	SHINE ROAD	BT	RIGHT
178	22272	MAPALACHERY ROAD	BT	RIGHT
179	22351	-	UM	RIGHT
180	22557	-	BT	LEFT
181	22889	-	CC	RIGHT
182	23076	-	BT	RIGHT
183	23285	-	WBM	RIGHT
184	23388	-	BT	RIGHT
185	23483	SILVER SAND ISLAND ROAD	BT	LEFT
186	23527	JAWAHAR ROAD	BT	RIGHT
187	23736	KOVILAGAM ROAD	BT	RIGHT
188	23827	MES ROAD	BT	LEFT
189	23863	CHURCH ROAD	BT	RIGHT
190	23921	KADAVIL ROAD	BT	LEFT
191	23975	KADAVIL ROAD	BT	LEFT
192	23995	AKG ROAD	BT	RIGHT
193	24037	UDAYA ROAD	BT	LEFT
194	24378	-	BT	RIGHT
195	24418	CHAMBAKARA ROAD	BT	RIGHT
196	24454	MARKET ROAD	BT	LEFT

S. No.	Chainage (m)	Road Name	Type Of Road	Side
197	24528	-	BT	RIGHT
198	24595	BHUVANESWARI TEMPLE ROAD	BT	RIGHT
199	24636	VANDIPETTA ROAD	BT	LEFT
200	24755	-	BT	LEFT
201	24775	VALLOOR ROAD	BT	RIGHT
202	24876	-	BT	RIGHT
203	24918	-	BT	RIGHT
204	24946	-	BT	RIGHT
205	24955	VADAKKATHARA	BT	LEFT
206	25013	ILLATHU PARAMBU ROAD	BT	LEFT
207	25136	-	BT	LEFT
208	25269	PATTANCHERY ROAD	BT	LEFT
209	25525	-	BT	LEFT
210	25618	-	BT	LEFT
211	25686	-	BT	LEFT
212	25707	-	UM	LEFT
213	25713	-	UM	RIGHT
214	25780	-	UM	LEFT

Note BT - Bituminous Road
UM - Un-metalled Road,
WBM - Water Bound metalled Road
CC - Cement Concrete Road

5.3.11 Vertical Alignment

The existing road gradients and average road levels are indicated in Table 5.5

Table 5.5
ROAD GRADIENT

S. No.	Chainage	Gradient (%)	Road Level (Avg.)

S. No.	Chainage	Gradient (%)	Road Level (Avg.)
1	1500 - 1725	0.656 (Rise)	7.557
2	1725 - 2000	0.601 (Fall)	7.441
3	2000 - 2000	0.820 (Rise)	7.435
4	2210 - 2800	0.568 (Fall)	6.489
5	2815 - 3150	0.794 (Rise)	6.156
6	3150 - 3675	0.421 (Fall)	6.381
7	3675 - 4500	1.321 (Rise)	10.727
8	4500 - 5425	1.065 (Fall)	11.252
9	5425 - 6425	1.005 (Rise)	11.352
10	6425 - 7575	0.328 (Fall)	14.489
11	7575 - 9400	0.131 (Fall)	11.404
12	9400 - 9950	1.007 (Fall)	7.440
13	9950 - 10400	0.389 (Fall)	3.798
14	10400 - 10660	0.841 (Rise)	4.017
15	10660 - 11350	0.063 (Rise)	5.327
16	11350 - 11700	0.469 (Fall)	4.724
17	11700 - 11900	0.325 (Rise)	4.229
18	11900 - 12150	0.204 (Fall)	4.298
19	12150 - 12750	0.130 (Rise)	4.432
20	12750 - 13200	0.147 (Fall)	4.491
21	13200 - 13400	0.333 (Rise)	4.493
22	13400 - 14060	0.418 (Fall)	3.445
23	14250 - 14700	0.334 (Rise)	2.762
24	14700 - 15475	0.273 (Fall)	2.457
25	15475 - 15770	0.816 (Rise)	2.604
26	16100 - 16540	0.162 (Rise)	2.730
27	16750 - 17600	0.027 (Fall)	1.831
28	17600 - 18475	0.090 (Rise)	2.111

S. No.	Chainage	Gradient (%)	Road Level (Avg.)
29	18475 - 18730	0.051 (Fall)	2.441
30	18730 - 19050	0.296 (Fall)	1.902
31	19550 - 19950	0.192 (Rise)	2.240
32	19950 - 20100	1.047 (Rise)	3.410
33	20100 - 20425	0.702 (Fall)	3.054
34	20425 - 20800	0.160 (Rise)	2.212
35	20800 - 21005	0.217 (Fall)	2.289
36	21005 - 21200	0.231 (Rise)	2.293
37	21200 - 21450	0.313 (Rise)	2.909
38	21450 - 21775	0.381 (Fall)	2.681
39	21775 - 22075	0.222 (Rise)	2.394
40	22075 - 22625	0.160 (Rise)	3.168
41	22625 - 23375	0.227 (Fall)	2.759
42	23375 - 25025	0.019 (Fall)	1.749

Due to these reasons the gradient along the proposed alignment also varies The Vertical profile (gradient list) is given in Table 5.6.

Table 5.6

VERTICAL PROFILE

VERTICAL PROFILE							
S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
1	-1028.59	340	1368.590	17.5	17.5	0.00%	Level
2	340	800	460.000	17.5	16.5	-0.22%	Fall
3	800	1512.024	712.024	16.5	20.45	0.55%	Rise
4	1512.024	1957.286	445.262	20.45	20.45	0.00%	Level
5	1957.286	2136.657	179.371	20.45	17.311	-1.75%	Fall
6	2136.657	2900	763.343	17.311	17.311	0.00%	Level
7	2900	3366.359	466.359	17.311	14.28	-0.65%	Fall
8	3366.359	3653.092	286.733	14.28	18.638	1.52%	Rise
9	3653.092	4012.879	359.787	18.638	18.638	0.00%	Level

10	4012.879	4484.594	471.715	18.638	26.861	1.74%	Rise
11	4484.594	4835.195	350.601	26.861	26.861	0.00%	Level
12	4835.195	5445.744	610.549	26.861	14.955	-1.95%	Fall
13	5445.744	6103.421	657.677	14.955	27.78	1.95%	Rise
14	6103.421	6336.059	232.638	27.78	27.78	0.00%	Level
15	6336.059	6783.241	447.182	27.78	24.203	-0.80%	Fall
16	6783.241	7151.406	368.165	24.203	26.117	0.52%	Rise
17	7151.406	7491.897	340.491	26.117	26.117	0.00%	Level
18	7491.897	7746.676	254.779	26.117	24.4	-0.67%	Fall
19	7746.676	8006.814	260.138	24.4	26.862	0.95%	Rise
20	8006.814	8251.897	245.083	26.862	26.862	0.00%	Level
21	8251.897	8825.683	573.786	26.862	18.829	-1.40%	Fall
22	8825.683	9404.792	579.109	18.829	18.829	0.00%	Level
23	9404.792	10157.785	752.993	18.829	13.106	-0.76%	Fall
24	10157.785	10495.375	337.590	13.106	17.765	1.38%	Rise
25	10495.375	10724.63	229.255	17.765	17.765	0.00%	Level
26	10724.63	11567.314	842.684	17.765	12.576	-0.62%	Fall
27	11567.314	11943.445	376.131	12.576	16.62	1.08%	Rise
28	11943.445	12209.675	266.230	16.62	16.62	0.00%	Level
29	12209.675	12595.375	385.700	16.62	13.149	-0.90%	Fall
30	12595.375	12858.326	262.951	13.149	16.83	1.40%	Rise
31	12858.326	13201.897	343.571	16.83	16.83	0.00%	Fall
32	13201.897	13793.476	591.579	16.83	14.582	-0.38%	Fall
33	13793.476	14307.909	514.433	14.582	14.582	0.00%	Fall
34	14307.909	14703.82	395.911	14.582	11.999	-0.65%	Rise
35	14703.82	15121.736	417.916	11.999	15	0.72%	Fall
36	15121.736	15352.154	230.418	15	15	0.00%	Level
37	15352.154	15546.598	194.444	15	18.5	1.80%	Rise
38	15546.598	15986.897	440.299	18.5	18.5	0.00%	Rise
39	15986.897	16284.754	297.857	18.5	14.33	-1.40%	Rise
40	16284.754	17001.897	717.143	14.33	14.33	0.00%	Level
41	17001.897	17455.569	453.672	14.33	10.247	-0.90%	Fall
42	17455.569	17946.725	491.156	10.247	14.52	0.87%	Rise
43	17946.725	18226.897	280.172	14.52	14.52	0.00%	Level
44	18226.897	18628.46	401.563	14.52	10.705	-0.95%	Rise
45	18628.46	19157.666	529.206	10.705	14.145	0.65%	Rise
46	19157.666	19481.897	324.231	14.145	14.145	0.00%	Level
47	19481.897	19684.684	202.787	14.145	10.393	-1.85%	Fall
48	19684.684	20048.98	364.296	10.393	14.765	1.20%	Rise
49	20048.98	20301.71	252.730	14.765	14.765	0.00%	Level
50	20301.71	20668.434	366.724	14.765	11.8	-0.81%	Fall

51	20668.434	21100	431.566	11.8	15.7	0.90%	Rise
52	21100	21520	420.000	15.7	15.7	0.00%	Level
53	21520	21980	460.000	15.7	11.9	-0.83%	Fall
54	21980	22326.157	346.157	11.9	15.4	1.01%	Rise
55	22326.157	22651.897	325.740	15.4	15.4	0.00%	Level
56	22651.897	22950.143	298.246	15.4	12.418	-1.00%	Fall
57	22950.143	23277.771	327.628	12.418	11.009	-0.43%	Fall
58	23277.771	23604.397	326.626	11.009	14.275	1.00%	Rise
59	23604.397	23951.064	346.667	14.275	14.275	0.00%	Level
60	23951.064	24226.774	275.710	14.275	15.929	0.60%	Rise
61	24226.774	24433.965	207.191	15.929	14.1	-0.88%	Fall
62	24433.965	27995.88462	3561.920	14.1	14.1	0.00%	Level

5.3.12 Curvature

At few locations sharp curves are provided due to curves along the roads. Curves are also provided to turn at various intersections. The radius of curves at intersections is kept as low as 90 m to reduce property acquisition. The list of curves along the alignment is enclosed in Table 1. Nearly 31.09% of the length of the alignment is on curves.

Table 5.7
DETAILS OF CURVES

CHAINAGE				RADIUS	TRANSI TION	CURVE LENGHT	STRAIGHT BETWEEN TWO CURVES
TP1	TP2	TP3	TP4				
-1028.59	START OF ALIGNMENT						856.091
-172.499	-122.499	-90.909	-40.909	251.85	50	31.59	73.2
32.291	62.291	268.583	298.583	1051.85	30	206.292	86.66
385.243	410.243	510.216	535.216	1001.85	25	99.973	3.521
538.737	578.737	906.047	946.047	651.85	40	327.31	224.447
1170.494	1190.494	1249.823	1269.823	-2001.85	20	59.329	37.936
1307.759	1342.759	1622.807	1657.807	-801.85	35	280.049	63.965
1721.772	1751.772	2229.853	2259.853	1176.85	30	478.082	579.906
2839.759	2859.759	3253.235	3273.235	-10001.85	20	393.476	33.857
3307.092	3327.092	3582.101	3602.101	-2001.85	20	255.008	292.975
3895.076	3950.076	4091.995	4146.995	426.85	55	141.919	272.528
4419.523	4459.523	4707.462	4747.462	-1956.85	40	247.939	20.052
4767.514	4807.514	4957.064	4997.064	1501.85	40	149.55	290.113
5287.177	5312.177	5572.652	5597.652	-1001.85	25	260.475	46.148

5643.8	5673.8	6036.876	6066.876	1001.85	30	363.075	192.659
6259.535	6319.535	6625.422	6685.422	-631.85	60	305.886	139.291
6824.713	6859.713	6908.18	6943.18	-601.85	35	48.467	123.946
7067.126	7113.126	7171.04	7217.04	401.85	46	57.915	56.357
7273.397	7313.397	7376.93	7416.93	-1001.85	40	63.533	151.705
7568.635	7588.635	7708.072	7728.072	-2001.85	20	119.438	45.388
7773.46	7793.46	7978.997	7998.997	5001.85	20	185.537	291.321
8290.318	8310.318	8340.915	8360.915	-5001.85	20	30.598	380.039
8740.954	8760.954	8994.612	9014.612	2001.85	20	233.658	601.854
9616.466	9641.466	9819.5	9844.5	1801.85	25	178.034	125.198
9969.698	9989.698	10026.95	10046.95	-6501.85	20	37.256	256.49
10303.44	10323.44	10362.39	10382.39	-8001.85	20	38.943	444.574
10826.96	10846.96	10912.03	10932.03	12001.85	20	65.067	247.903
1179.93	11204.93	11234.97	11259.97	-1501.85	25	30.034	36.49
11296.46	11326.46	11351.97	11381.97	901.85	30	25.509	67.297
11449.26	11493.26	11610.96	11654.96	561.85	44	117.699	7.965
11662.93	11692.93	11838.85	11868.85	-686.85	30	145.921	32.207
11901.05	11921.05	11977.57	11997.57	-151.85	20	56.516	132.18
12129.75	12149.75	12181.96	12202	-145.85	20	32.245	344.799
12546.79	12566.79	12633.75	12653.75	-2201.85	20	66.96	31.29
12685.04	12705.04	12808.82	12828.82	-7001.85	20	103.774	287.099
13115.92	13165.92	13516.15	13566.15	365.85	50	350.232	20.624
13586.77	13636.77	13711.31	13761.31	201.85	50	74.535	184.224
13945.53	14000.53	14040.81	14095.81	-251.85	55	40.275	155.857
14251.67	14291.67	14382.39	14422.39	-1001.85	40	90.724	162.992
14585.38	14605.38	14650.61	14670.61	2001.85	20	45.299	76.868
14747.48	14777.48	14807.28	14837.28	1001.85	30	29.803	104.816
14942.1	14967.1	14993.96	15018.96	-1001.85	25	26.86	64.921
15083.88	15113.88	15143.68	15173.68	-401.85	30	29.801	226.789
15400.47	15435.47	15461.05	15496.05	1001.85	35	25.577	103.714
15599.76	15624.76	15714.92	15739.92	1001.85	25	90.157	31.886
15771.8	15821.8	15823.52	15873.52	-161.85	50	1.72	86.078
15959.6	15989.6	16029.36	16059.36	-801.85	30	39.756	37.584
16096.94	16136.94	16312.24	16352.24	501.85	40	175.3	2.82
16355.06	16405.06	16459.49	16509.49	383.85	50	54.426	54.54
16564.03	16614..026	16642.67	16692.67	-96.85	50	28.642	0.089
16692.76	16742.76	16772.89	16822.89	-107.85	50	30.13	235.242
17058.13	17103.13	17151.7	17196.7	501.85	45	48.569	109.678
17306.38	17351.38	17386.06	17431.06	-501.85	45	34.679	71.787
17502.84	17527.84	17560.87	17585.87	-851.85	25	33.029	0.009
17585.88	17610.88	17652.26	17677.26	852.85	25	41.377	62.038

17739.3	17759.3	17823.37	17843.37	1201.85	20	64.074	37.194
17880.56	17905.56	17969.55	17994.55	-2001.85	25	63.985	0.466
17995.01	18020.01	18192.01	18217.01	1544.573	25	171.991	103
8320.01	18360.01	18416.36	18456.36	-561.85	40	56.358	74.193
18530.56	18585.56	18652.34	18707.34	-91.85	55	66.785	21.779
18729.12	18759.12	18772.89	18802.89	171.85	30	13.767	0.16
18803.05	18833.05	18852.52	18882.52	-161.85	30	19.469	112.299
18994.82	19059.82	19174.26	19239.26	126.85	65	114.447	161.545
19400.81	19455.81	19537.95	19592.95	-91.85	55	82.138	77.665
19670.61	19665.61	19725.22	19750.22	-1001.85	25	29.612	60.557
19810.78	19835.78	19875.9	19900.9	1001.85	25	40.122	13.363
19914.27	19927.27	19945.24	19958.24	-5001.85	13	17.975	3.521
19961.76	19976.76	20233.81	20248.81	-1345.82	15	257.051	134.066
20382.88	20437.88	20498.3	20553.3	351.85	55	60.418	320.766
20874.06	20929.06	20997.11	21052.11	251.85	55	68.047	95.195
21147.3	21197.3	21223.1	21273.1	-121.85	50	25.797	102.498
21375.6	21390.6	21440.73	21455.73	3001.85	15	50.13	131.444
21587.17	21602.17	21797	21812	-5001.85	15	194.829	289.238
22101.24	22123.24	22160.46	22182.46	1001.85	22	37.216	60.124
22242.58	22292.58	22377.31	22427.31	171.85	50	84.724	72.973
22500.28	22550.28	22694.06	22744.06	141.85	50	143.777	12.489
22756.54	22806.54	22829	22879	-121.86	50	22.454	133.203
23012.2	23062.2	23094.21	23144.21	-121.85	50	32.006	175.291
23319.5	23364.5	23401.27	23446.27	-301.85	45	36.774	15.638
23461.91	23496.91	23516.24	23551.24	501.85	35	19.33	219.829
23771.07	23811.07	24038.08	24078.08	501.85	40	227.007	350.305
24428.38	24478.38	24505.28	24555.28	-91.85	50	26.902	9.928
24565.21	24615.21	24686.04	24736.04	141.85	50	70.826	39.644
24775.68	24795.68	24870.02	24890.02	-1501.85	20	74.34	134.943
25024.97	25074.97	25154.37	25204.37	-91.85	50	79.407	26.16
25230.53	25280.53	25290.13	25340.13	-351.85	50	9.598	0.987
25341.12	25391.12	25447.59	25497.59	351.85	50	56.478	31.66
25529.25	25569.25	25589.63	25629.63	-501.85	40	20.376	163.279
25792.91	25817.91	25845.32	25870.32	1051.85	25	27.407	157.116
26027.43	26047.43	26101.77	26121.77	-3001.85	20	54.336	73.924
26195.69	26220.69	26256.48	26281.48	1501.85	25	35.788	201.453
26482.93	26507.93	26534.32	26559.32	1101.85	25	26.389	236.15
26795.47	26830.47	26877.13	26912.13	-601.85	35	46.654	30.584
26942.71	26977.71	27026.2	27061.2	601.85	35	48.491	934.651

5.4 Viaduct Structure

5.4.1 Choice of Superstructure

The choice of superstructure has to be made keeping in view the ease of constructability and the maximum standardization of the form-work for a wide span ranges.

5.4.2 The following type of superstructures have been considered.

(i) Precast segmental box girder using external unbonded tendon.

(ii) Precast segmental U-Channel superstructure with internal pre-stressing.

The segmental construction has been chosen mainly due to the following advantages.

- Segmental construction is an efficient and economical method for a large range of span lengths and types of structures. Structures with sharp curves and variable super elevation can be easily accommodated.
- Segmental construction permits a reduction of construction time as segments may be manufactured while substructure work proceeds, and assembled rapidly thereafter.
- Segmental construction protects the environment, as only space required for foundation and sub-structure is required at site. The superstructure is manufactured at a place away from busy areas and placement of superstructure is done with the system erected from piers at heights.
- Segments are easy to stack in the casting yard/stocking yard in more than one layer, thereby saving in requirement of space.
- It is easier to transport smaller segments by road trailers on city roads.
- It is easy to incorporate last minute changes in span configuration if the site situation so warrants.
- Interference to the traffic during construction is significantly reduced.
- Segmental construction contributes toward aesthetically pleasing structures and good finishes.
- The overall labour requirement is less than that for conventional methods.
- Better quality control is possible in the casting yard.
- During construction, the technique shows an exceptionally high record of safety.

5.4.3 Comparative advantages/disadvantages of the above two types of superstructures are given below.:

5.4.3.1 Precast Segmental Box Girder using External Unbonded Tendon.

This essentially consists of pre-cast segmental construction with external pre-stressing and dry joints and is by far most preferred technique in fast track projects. In such construction the pre-stressing is placed outside the structural concrete (inside the box section) and protected with high density polyethylene tubes which are grouted with special wax or cement. The match cast joints at the interface of two segments are provided with shear keys as in traditional segmental construction. However, epoxy is dispensed with because water tight seal at the segment joints is not required in association with external tendons. The schematic arrangement is shown at Fig. 1 (enclosed).

The main advantages of dry-jointed externally pre-stressed pre-cast segmental construction can be summarized as follows:-

- Simplification of all post-tensioning operations, especially installation of tendons.
- Reduction in structural concrete thickness as no space is occupied by the tendons inside the concrete.
- Good corrosion protection due to tendons in polyethylene ducts; the grout inspection is easier and leaks, if any, can be identified during the grouting process.
- Simplified segment casting. There is no concern about alignment of tendons. Increased speed of construction.
- The elimination of the epoxy from the match-cast joints reduces costs and increases speed of construction further.
- Replacement of tendons in case of distress is possible and can be done in a safe and convenient manner.
- Facility for inspection and monitoring of tendons during the entire service life of the structure.

5.4.3.2 Precast Segmental U-Channel Superstructure with Internal Pre-stressing.

The single U type of viaduct structure is also a pre-cast segmental construction with internal pre-stressing and requires gluing and temporary pre-stressing of segments. The match cast joints at the interface of two segments are also provided with shear keys. The main advantages for this type of structural configuration of superstructure are:-

- Built in sound barrier.
- Built in cable support and system function.

- Possibility to lower the longitudinal profile by approximately 1m compared to conventional design.
- Built in structural elements capable to maintain the trains on the bridge in case of derailment (a standard barrier design allow this)
- Built in maintenance and evacuation path on either side of the track.

Although, there may be a saving in the construction time for Option 1 by almost one day but the option 2 is recommended for Kochi Metro Project considering the advantages as highlighted above, particularly, considering the fact that option 2 has an inbuilt features such as top flange of ‘U’ Channel acts as an evacuation path on either side of the tracks and also possibility to lower the longitudinal profile of the elevated viaduct. For option 2 Fig.2 is enclosed.

5.4.3.3 Construction Methodology

Pre-Cast Construction

For the elevated sections it is recommended to have pre-cast segmental construction for super structure for the viaduct. For stations also the superstructure is generally of pre-cast members. The pre-cast construction will have following advantages:-

- Reduction in construction period due to concurrent working for substructure and superstructure.
- For segmental, pre-cast element (of generally 3.0m length), transportation from construction depot to site is easy and economical.
- Minimum inconvenience is caused to the public utilising the road as the superstructure launching is carried out through launching girder requiring narrow width of the road.
- As the pre-cast elements are cast on production line in a construction depot, very good quality can be ensured.
- The method is environment friendly as no concreting work is carried at site for the superstructure.

5.4.3.4 Casting of Segments

For viaducts segmental pre-cast construction requires a casting yard. The construction depot will have facilities for casting beds, curing and stacking area, batching plant with storage facilities for aggregates and cement, site testing laboratories, reinforcement steel yard and fabrication yard etc. An area of about 2.5 Hact. To 3 Hact is required for each construction depot.

For casting of segments both long line and short line method can be adopted. However the long line method is more suitable for spans curved in plan while short line method is good for straight spans. A high degree of accuracy is required for setting out the curves on long line method for which pre calculation of offsets is necessary. Match casting of segments is required in either method. The cast segments are cured on the bed as well as in stacking yard. Ends of the segments are to be made rough through sand blasting so that gluing of segments can be effective.

The cast segment will be transported on trailers and launched in position through launching girders.

5.4.3.5 Launching Scheme

Launching girder is specially designed for launching of segments. The suggested launching scheme is designed in such a way that initially the launching girder is erected on pier head at one end of the work. The segments are lifted in sequence and when the lifting is over, they are dry matched while hanging from the launching girder. After dry matching, the segments are glued with epoxy and pre-stressed from one end. The girder is lowered on the temporary / permanent bearings after pre-stressing. The launching girder then moves over the launched span to next span and the sequences continue.

5.4.4 Structural System of Viaduct

5.4.4.1 Super-structure

The superstructure of a large part of the viaduct comprises of simply supported spans. However at major crossing/over or along existing bridge, special steel or continuous unit will be provided.

Normally the U-Channel girder having a soffit width of 9.0 m (approx) accommodates the two tracks situated at 3.7m (Tangent & upto 150m curvature) to 4.0m (90m curvature) c/c. The U-Channel superstructure for almost all the simply supported standard spans will be constructed by pre-cast pre-stressed segmental construction with epoxy bonded joints.

The max spans c/c of piers of standard simply supported spans constructed by pre-cast segmental construction technique has been proposed as 28.0m. The usual segments shall be 3.0m in length except the Diaphragm segments, which shall be 2.0m each. The other standard spans (c/c of pier) comprises of 25.0m, 31.0m, 22.0m, 19.0m & 16.0m, which shall be made by removing/adding usual segments of 3.0m each from the center of the span. Depth of the superstructure is so choosen that top of flange of U-Channel will be used as a evacuation walkway in an emergency.

The dimensions of end diaphragm will be finalized based on simply supported span of 31.0m and the same will be also kept for all simply supported standard span. The top level of both the end diaphragms of adjoining spans on the same piers is kept same so that expansion joint can be installed at top and continuity of profile of end diaphragm on the same pier can be maintained. The arrangement has been selected from aesthetic considerations.

The economical span (i.e. with optimum pre-stressing ratio) will be designed for the 25m situation.

Standard span up to 28.0m will be provided throughout the viaduct as far as possible. At crossings, where spans requires to be increased upto 31.0m, simply supported spans will be provided.

The location where the open foundations are possible, the spans of 16m will be provided.

For major crossing having spans greater than 31.0m, special units normally of 3 – span construction or steel girders have been envisaged.

All these continuous units (in case provided at obligatory location) will be constructed by cast-in-situ balanced cantilever construction technique. The top profile of superstructure of continuous unit (for the full length) will be retained the same as for standard spans so that evacuation walkway will be available even in continuous units. The increase in depth of U-channel will be accomplished by thickening the soffit slab (towards downside). At the end of continuous unit, the profile and thickness of soffit slab will be done to the extent that it will match with the profile and depth of end diaphragm of adjoining simply supported spans. The thickness of soffit slab will be increased smoothly toward penultimate support. In order to reduce the dead weight of the girder, voids will be also provided in the thickened soffit slab at bottom. These will be circular near the end of continuous unit and oblong near the penultimate support.

5.4.4.2 Sub-structure

The viaduct superstructure will be supported on single cast-in-place RC pier.

The shape of the pier follows the flow of forces. For the standard spans, the pier gradually widens at the top to support the bearing under the box webs.

At this preliminary design stage, the size of pier is found to be limited to 1.2m circular for most of its height so that it occupies the minimum space at ground level where the alignment often follows the central verge of existing roads.

To prevent the direct collision of vehicle to pier, a Jersey Shaped crash barrier of 1.0m height above existing road level has been provided all around the pier. A gap of 25mm has been also provided in between the crash barrier and outer face of pier. The shape of upper part of pier has been so dimensioned that a required clearance of 5.5m is always available on road side beyond vertical plane drawn on outer face of crash barrier. In such a situation, the minimum height of rail above the existing road is 8.5m.

The longitudinal center to center spacing of elastomeric/pot bearing over a pier would be about 1.8m. The space between the elastomeric bearings will be utilized for placing the lifting jack required for the replacement of elastomeric bearing. An outward slope of 1:200 will be provided at pier top for the drainage due to spilling of rainwater , if any.

The transverse spacing between bearings would be 3.0m (to be studied in more details).

The orientation and dimensions of the piers for the continuous units or steel girder (simply supported span) have to be carefully selected to ensure minimum occupation at ground level traffic. Since the vertical and horizontal loads will vary from pier to pier, this will be catered to by selecting the appropriate structural dimensions.

5.4.5 Construction Methods

5.4.5.1 Deck – Simple Spans 'U' Girder

Salient features of the pre-cast segmental construction method technique as envisaged for the project under consideration are indicated below:

The superstructure shall be constructed "span by span" sequentially, starting at one end of a continuous stretch and finishing at the other end. Nos. of launching girders may be required so as to work on different stretches simultaneously to enable completion of the project in time.

The number of "breaks" in the stretch can be identified by nos of continuous units.

The suggested method of erection will be detailed in drawings to be prepared. The launching girder (or, more accurately, the "assembly truss") is capable of supporting the entire dead load of one span and transferring it to the temporary brackets attached to the pier. The governing weight of the segments will be of the order of 55t (to be finalized). The launching girder envisaged will be slightly greater than two span lengths. It must be able to negotiate curves in conjunction with temporary brackets.

Transportation of segments from casting yard to the point of erection will be effected by appropriately designed low-bedded trailors (tyre-mounted). The segments can be lifted and erected using erection portal gantry moving on launching girder.

U-girder segments shall be match cast at the casting yard before being transported to location and erected in position. Post-tensioned cables shall be threaded in-situ and tensioned from one end. It is emphasized that for pre-cast segmental construction only one-end pre-stressing shall be used.

The pre-stressing steel and pre-stressing system steel accessories shall be subjected to an acceptance test prior to their actual use on the works. The tests for the system shall be as per FIP Recommendations as stipulated in the special specifications. Only multi-strand jacks shall be used for tensioning of cables. Direct and indirect force measurement device (e.g. Pressure Gauge) shall be attached in consultation with system manufacturer.

The Contractor shall be responsible for the proper handling, lifting, storing, transporting and erection of all segments so that they may be placed in the structure without damage. Segments shall be maintained in an upright position at all times and shall be stored, lifted and/or moved in a manner to prevent torsion and other undue stress. Members shall be lifted, hoisted or stored with lifting devices approved on the shop drawings.

5.4.5.2 Epoxy Bonded Joints and Shear Keys.

A minimum compressive stress of 3 kg/sqcm shall be provided uniformly over the cross-section for the closure stress on the epoxied joint until the epoxy has set. The curing period for application of the compressive stress, method of mixing and application of epoxy and all related aspects including surface preparation shall be as per approved manufacturer’s specifications.

The purpose of the epoxy joint, which is about 1mm on each mating surface, shall be to serve as lubricant during segment positioning, to provide waterproofing of the joints for durability in service conditions and to provide a seal to avoid cross-over of grout during grouting of one cable into other ducts.

The epoxy shall be special purpose and meet requirements of relevant provision of FIP (International Federation of Pre-stressed Concrete)

The temporary compressive stress during the curing period shall be applied by approved external temporary bar pre-stressing (such as Macalloy or Diwidag bar systems or approved equivalent).

5.4.6 Construction of the Stations

5.4.6.1 It is proposed to construct the elevated stations with elevated concourse over the road at most of the locations to minimize land acquisition. To keep the rail level low, it is proposed not to take viaduct through the stations. Thus a separate structural configuration is required (although this may necessitate the break in the launching operations at each station locations)

5.4.6.2 Sub-structure for the station portion will also be similar to that of viaduct and will be carried out in the same manner. However, there will be single viaduct column in the station area which will be located on the median and supporting the concourse girders by a cantilever arm so as to eliminate the columns on right of way.

5.4.6.3 Super-structure will consist of 3 pre-cat U Girders for supporting the track structure and I Girder / Double T Girders for supporting the platform and concourse areas. A pre-cast or cast in-situ pre-stressed cross girder will be required over the middle piers for supporting platform structure. Box shaped in-situ pre-stressed cantilever cross girders are planned for supporting the concourse girders and escalators at mezzanine level. All the members will be pre-cast in a construction depot and launched at site through cranes.

5.4.7 Grade of Concrete

It is proposed to carry out construction work with design mix concrete through computerised automatic Batching Plants with following grade of concrete for various members as per design requirement/durability considerations.

i)	Pile cap and open foundation	-	M -30
ii)	Piers	-	M –40/M-50
iii)	All pre-cast element for viaduct and station	-	M -45
iv)	Cantilever piers and portals	-	M -45
		-	M -60
v)	Other miscellaneous structure	-	M - 30

For all the main structures, permeability test on concrete sample is recommended to ensure impermeable concrete.

5.4.8 Reinforcement and pre-stressed Steel

It is proposed to use HYSD 415 or TMT steel as reinforcement bars.

For pre-stressing work, low relaxation high tensile steel strands with the configuration 12 T 13 and or 19 K 15 is recommended (confirming to IS:14268).

5.4.9 Road width required during Construction

As most of the construction is to be carried out on the middle of the road, central two lanes including median will be required for construction activities. During piling and open foundation work, a width of about 8m will be required for construction and the same will be barricaded. It is proposed that two lanes are provided for traffic on either sides during construction by widening of roads, if necessary. In certain cases, one way traffic may be resorted to.

All these actions will require a minimum period of about 4 to 6 months. During this period, the State Government can go ahead with the following preliminary works:

i) Preliminary action for diversion of utility and preparation of estimates there of.

ii) Reservation of land along the corridor, identification and survey for acquisition.

Once the Corporation is formed, the Corporation has to take action for appointment of consultant for Project Management and proof checking including preparation of tender documents. Simultaneously, action is also to be taken for detailed design for structures for elevated corridors.

5.5 Soil Characteristics & Field Investigation

5.5.1 Field Investigations

- Four boring rigs with all requisite equipments and accessories were mobilised at the work site. A team of technical personnel with skilled labours were also deputed.

- Fifty one boreholes of 150mm diameters were bored to a maximum depth of 45.0 metres below the existing ground level from Alwaye to Thripunithura. The boreholes were made as per IS: 1892-1979.

- Disturbed samples were collected at every change of strata or about 1.5 metres depth interval whichever was earlier. The samples so collected were carefully sealed and numbered with full particulars for identification and sent to the laboratory for conducting the required tests.

- Standard Penetration Tests were conducted in the boreholes at regular intervals of 1.5m as per IS: 2131-1981. In this test, the standard split spoon sampler is driven into the ground at the required depth by means of standard hammer of 63.5 Kgs weight, falling from a height of 75cm. Number of blows for the first 15cm is not taken into consideration because of possible disturbances or presence of settled, suspended matters at the bottom of the bore- holes. The total number of blows for the next 30cm depth of penetration is considered as SPT ‘N’ values

5.5.2 Laboratory Investigation

The following laboratory tests were conducted on the selected samples recovered from the test bore-holes:

(a) Particle size analysis:
  (i) Sieve analysis
  (ii) Hydrometer analysis

(b) Particle size
  (i) Liquid limit
  (ii) Plastic limit

(c) Dry & wet density
(d) Water content
(e) Specific gravity
(f) Direct shear test
(g) Tri-axial test

All the above laboratory tests were carried out as per relevant Indian Standard. All the samples were identified and classified as per IS: 1498-197

5.5.3 General Geology and Related Characteristics

(a) Location: The Geo technical site investigation carried out from Alwaye to Tripunithura, via Edapally , Madhav Pharmacy junction, Ernakulam south , Vytilla and Petta.

(b) Physiography and Climate: The city is generally having warm tropical climate with the temperature in summer varying between 24^0C to 33^0C and in winter between 22^0C to 32^0C. The period between January to April and September to December is generally dry whereas in June, July, October and November it is rainy season. The city has an average annual rainfall of 2540mm.

(c) General Geology: The soils in and around the Cochin City vary from lateritic soils on the Northern part to the Marine clays on the Southern part of the city.From Kochi towards Alwaye, we find the lateritic soils in the op layers changing to granitic rocks in the lower strata. Cochin being a city on the coast, we have marine clays, loose to stiff in nature for greater depth with dense sand layers underlying these clay layers. There are locations where this sand layer varies occurring from 40 – 60m.

5.5.3.1 Field Investigations

(d) This proposed Kochi Metro Rail is from Alwaye to Petta via Edappally, Madhav Pharmacy, Ernakulam South and Vyttila. A total of 51 bore holes have been drilled at an average distance of 0.5 km each, all along the length of the proposed Metro corridor. Details of Boreholes are given below in Table 5.7.

TABLE 5.8
DETAILS OF BOREHOLES

Borehole No	Ground R.L (m)	Ground water table (m)	Depth of investigation		
			In Soil	In Rock (Soft/ Hard)	Total
BH-1	6.375	3.10	21.00	5.00	26.00
BH-2	6.535	2.50	10.50	5.00	15.50
BH-3	5.623	2.25	13.00	5.00	18.00
BH-4	7.280	3.50	11.00	5.00	16.00
BH-5	3.249	2.50	13.00	5.00	18.00
BH-6	7.527	2.50	5.00	5.00	18.00
BH-7	1.777	1.50	11.00	5.00	16.00
BH-8	9.703	2.80	18.00	5.00	23.00
BH-9	1.454	0.50	8.50	5.00	13.50
BH-10	1.654	0.95	8.30	5.00	13.30
BH-11	9.490	7.00	15.00	5.00	20.00
BH-12	12.334	1.50	10.00	5.00	15.00
BH-13	6.196	9.50	13.00	5.00	18.00
BH-14	12.471	10.00	16.00	5.00	21.00
BH-15	13.060	3.50	17.00	5.00	22.00
BH-16	8.545	10.00	16.00	5.00	21.00
BH-17	3.707	2.00	18.00	5.00	23.00
BH-18	3.410	0.80	23.00	5.00	28.00
BH-19	3.100	0.80	17.50	5.00	22.50
BH-20	4.300	2.00	15.50	5.00	20.50
BH-21	3.981	2.80	40.00	0.00	40.00
BH-22	4.527	1.00	40.00	0.00	40.00
BH-23	4.005	0.50	40.00	0.00	40.00
BH-24	1.779	3.50	40.00	0.00	40.00
BH-25	2.729	3.20	48.00	0.00	48.00
BH-26	3.540	5.00	40.00	0.00	40.00
BH-27	1.655	0.50	45.00	0.00	45.00
BH-28	1.607	1.50	43.00	0.00	43.00
BH-29	2.221	2.50	40.00	0.00	40.00
BH-30	1.860	2.00	45.00	0.00	45.00
BH-31	1.593	1.25	43.00	0.00	43.00
BH-32	1.483	1.25	43.00	0.00	43.00
BH-33	1.351	1.50	41.00	0.00	41.00
BH-34	2.573	2.75	43.00	0.00	43.00
BH-35	inside river	water boring (length of water column 2.5m)	45.00	0.00	45.00
BH-36	3.428	3.00	50.00	0.00	50.00
BH-37	2.724	4.00	44.50	0.00	44.50
BH-38	3.573	2.50	40.00	0.00	40.00
BH-39	1.710	3.10	40.00	0.00	40.00
BH-40	1.732	1.50	40.00	0.00	40.00

Borehole No	Ground R.L (m)	Ground water table (m)	Depth of investigation		
			In Soil	In Rock (Soft/ Hard)	Total
BH-41	inside river	Water boring (length of water column 4.0m)	40.00	0.00	40.00
BH-42	2.355	3.00	40.00	0.00	40.00
BH-43	2.439	2.00	40.00	0.00	40.00
BH-44	inside river	Water boring (length of water column 4.0m)	36.00	4.00	40.00
BH-45		2.00	36.00	0.00	36.00
BH-46	3.710	1.50	30.00	5.00	35.00
BH-47	3.404	1.95	16.00	3.00	19.00
BH-48	1.720	2.00	28.00	5.00	33.00
BH-49	5.052	3.00	10.30	5.20	15.50
BH-50	2.500	1.50	41.00	0.00	41.00
BH-51	2.436	1.50	45.00	0.00	45.00

5.5.3.2 Engineering Design Parameters – Based upon the investigation done and the analysis made thereafter, the following design parameters have been finalized as discussed in the subsequent paragraphs.

5.5.3.3 Design Parameters for Kochi Metro Rail – The subsoil strata at the proposed site was found to consist of various types of layers which have been given in Table 5.9 below.:

Table 5.9
LAYER TYPE AND DESCRIPTION FOR BH-1 TO 51

Layer	Description	Classification as per IS:1498-1970	Relative Density/ Consistency	Observed in Bore hole No.
1	Gravely silty sand	GM-SM	Loose to medium	BH 1,2,3,4,6,15
3	Fine sand	SP-SM, SP	Loose to Dense	BH3, 9,10,,17,18,20,21
4	Clayey silt	CH,MH,CI,MI	Very loose to stiff	BH 1,5,6,9,11,14,16,20,21
5.	Silty sand	SM	Loose to Dense	BH 22,23,24,26,27,28,30,32,33, 37,39,42,43,44,45,46,47,48,49,
6.	Gravely silty sand	GM-SM,GC,GP	Medium to dense	BH 26,34,36,37,45,46

Layer	Description	Classification as per IS:1498-1970	Relative Density/ Consistency	Observed in Bore hole No.
7	Fine sand	SP-SM, SP	Loose to dense	BH 22,23,24,25,26,27 ,29,31,32 33,35 ,37,38,40,41,42,4 3,48,50, 51
8	Clayey silt	CH, CI, MH, MI	Soft to stiff	BH 22,23,24,25,26,27 ,28,29,30, 31,32,33,34,35,36 ,37,38,39,40, 41,42,43,44,45,46 ,47,48,49,50, 51
9	Sandy silt	ML,CL,	Very dense	BH26,29,36,37,38 ,48
10	Clayey sand	SC	Very Dense	BH 22,23,28,34,36,37 ,40,43,47, 50,51
11	Peat, Decayed Wood	Pt, OL		BH 24,25,

5.5.4 Discussion And Type of Foundation

5.5.4.1 Type of Foundation

Depending on the nature of soil, type of proposed structure and expected loads on foundations, the recommended type of foundation is generally pile foundation except for a few locations where hard strata was located close to ground level. Pile capacities have been calculated as per IS 2911 Part 2 and IRC 78 while allowable bearing capacity for shallow open footing has been computed from the equation as per IS: 6403 – 1981.

5.5.4.2 Depth of Foundation

A foundation must have an adequate depth from considerations of adverse environmental influences. It must also be economically feasible in terms of overall structure.

5.5.4.3 Pile Foundation

For the prevailing soil conditions and type of structures, bored cast-in-situ piles of 750, 900 or 1000 mm diameter are proposed to be adopted.

Piles transmit foundation loads through soil strata of low bearing capacity to deeper soil having a higher bearing capacity value. Piles carry loads as a combination of side friction and point bearing resistance. The minimum diameter of pile should be 1000mm.

Piles are suitable due to the following specific advantages over spread footings/raft foundation:

- Completely non-displacement.
- Carry the heavy superstructure loads into or through a soil stratum. Both vertical and lateral loads may be involved.
- Controls settlements when spread footing/raft foundation is on a marginal soil.
- Can resist uplift, or overturning.
- Applicable for a wide variety of soil conditions.
- Recommended safe vertical load carrying capacity of piles of various diameters for all the boreholes and borehole wise pile lengths below ground level are shown in Tables 5.10 and 5.11 respectively.

Table 5.10
Pile Capacity (in T)

Bore Hole No.	For 75cm diameter	For 90cm diameter	For 100cm diameter
BH – 1	165.0	235.0	290.0
BH – 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17	170.0	245.0	300.0
BH-7	155.0	225.0	275.0
BH-18	145.0	210.0	255.0
BH 19 & 20	150.0	215.0	270.0
BH-21	160.0	240.0	300.0
BH-22	200.0	285.0	355.0
BH-23, 24, 25, 26, 28	215.0	300.0	390.0
BH-27	200.0	265.0	320.0
BH-29	215.0	295.0	355.0
BH-30	185.0	260.0	315.0
BH 31,32, 34, 37, 38, 39, 42, 43, 45, 46, 47	220.0	315.0	390.0
BH-35	150.0	225.0	290.0
BH-36	185.0	230.0	270.0
BH-40	175.0	220.0	250.0
BH-41	150.0	205.0	275.0
BH-44	160.0	215.0	255.0
BH-48	140.0	200.0	250.0
BH-49	155.0	220.0	275.0

Table 5.11
BOREHOLE WISE PILE LENGTHS BELOW GROUND LEVEL (IN M)

BH No	Minimum pile length (B.G.L) in M	Pile termination depth B.G.L (in cm)		
		For 75 cm dia	For 90 cm dia	For 100 cm dia
BH- 1	21+3D	23.25	23.7	24.0
BH-2	10.5+3D	12.75	13.2	13.5
BH-3	13+3D	15.25	15.7	16.0
BH-4	17+3D	19.25	19.7	20.0
BH-5	13+3D	15.25	15.7	16.0
BH-6	13+3D	15.25	15.7	16.0
BH-7	11+3D	13.25	13.7	14.0
BH-8	18+3D	20.25	20.7	21.0
BH-9	8.5+3D	10.75	11.2	11.5
BH-10	8.5+3D	10.75	11.2	11.5
BH-11	15+3D	17.25	17.7	18.0
BH-12	10+3D	12.25	12.7	13.0
BH-13	13+3D	15.25	15.7	16.0
BH-14	16+3D	18.25	18.7	19.0
BH-15	17+3D	19.25	19.7	20.0
BH-16	16+3D	18.25	18.7	19.0
BH-17	18+3D	20.25	20.7	21.0
BH-18	23+3D	25.25	25.7	26.0
BH-19	17.5+3D	19.75	20.2	20.5
BH-20	15.5+3D	17.75	18.2	18.5
BH-21	38.0	38.0	38.0	38.0
BH-22	40.0	40.0	40.0	40.0
BH-23	38.0	38.0	38.0	38.0
BH-24	38.0	38.0	38.0	38.0
BH-25	48.0	48.0	48.0	48.0
BH-26	40.0	40.0	40.0	40.0

BH No	Minimum pile length (B.G.L) in M	Pile termination depth B.G.L (in cm)		
BH-27	44.0	44.0	44.0	44.0
BH-28	41.0	41.0	41.0	41.0
BH-29	40.0	40.0	40.0	40.0
BH-30	46.0	46.0	46.0	46.0
BH-31	42.0	42.0	42.0	42.0
BH-32	42.0	42.0	42.0	42.0
BH-33	40.0	40.0	40.0	40.0
BH-34	40.0	40.0	40.0	40.0
BH-35	44.0	44.0	44.0	44.0
BH-36	50.0	50.0	50.0	50.0
BH-37	40.0	40.0	40.0	40.0
BH-38	40.0	40.0	40.0	40.0
BH-39	38.0	38.0	38.0	38.0
BH-40	38.0	38.0	38.0	38.0
BH-41	40.0	40.0	40.0	40.0
BH-42	32.0	32.0	32.0	32.0
BH-43	36.0	36.0	36.0	36.0
BH-44	35.0	35.0	35.0	35.0
BH-45	36.0	36.0	36.0	36.0
BH-46	30+3D	32.25	32.7	33.0
BH-47	15+3D	17.25	17.7	18.0
BH-48	28+3D	30.25	30.7	31.0
BH-49	10+3D	12.25	12.7	13.0
BH-50	40.0	40.0	40.0	40.0
BH-51	43.0	43.0	43.0	43.0

5.5.4.4 Shallow Open Footing

For the prevailing soil conditions and type of structures, it was observed that shallow open footings can be provided at certain locations. The details of shallow open footing with SBC in those locations were calculated and have been given Table 5.12 below:

Table 5.12

BH No	Depth (m)	Safe Bearing Capacity (T/m2) restricted to
2	1.50	40.0
3	2.00	25.0
6	2.00	30.0
7	2.00	25.0
8	1.50	40.0
11	1.50	25.0
13	1.50	40.0
15	2.50	30.0
16	1.50	35.0
37 & 38	1.50	30.0
48	1.50	35.0

5.5.4.5 Recommendations

The general recommended type of foundation is generally pile foundation except for the few locations where hard strata was located close to ground level . The pile capacities for various diameters of pile at various depths below ground level and safe bearing capacities of shallow open footings wherever feasible have been given above in the Tables. 5.9, 5.10 and 5.11

Station Planning

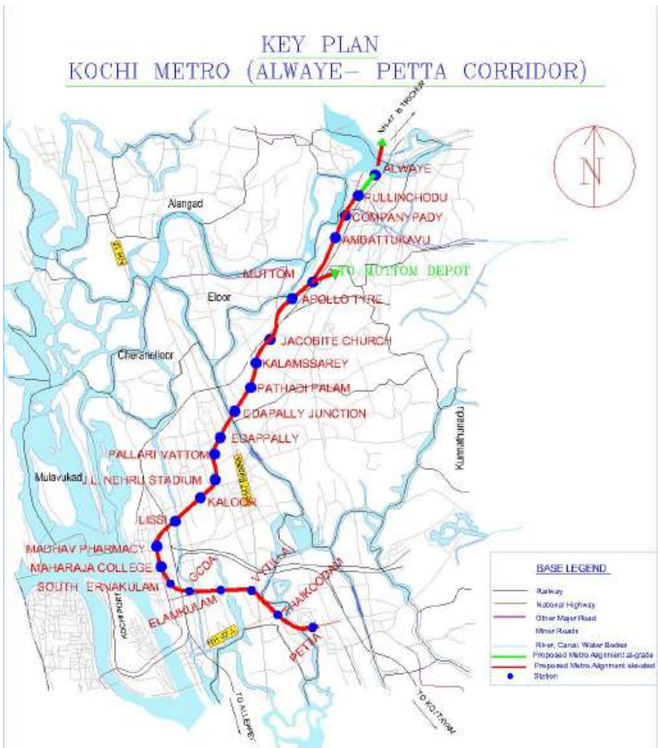
5.6.1 General

Stations on the Line

The proposed Alwaye-Edapally-Petta MRTS corridor runs southwards from Alwaye to Petta via Polinchodu, Companypady, Ambattukaru, Muttom, Appolo Tyre, Jacobite Church, Kalamassery, Pathadi Palam, Edapally Junction, Edapally, Palarivattom, J L Nehru Stadium, Kaloor, Lissi, Madhav Pharmacy, Maharaja College, Ernakulam South Station, GCDA, Elamkulam, Vytilla and Thaikodam covering a distance of 25.612 Kms. from centre of Alwaye station to Petta Station.

A total of 23 stations have been planned along the proposed Corridor. All stations are proposed to be elevated. Average inter-station distance is one km, though it varies from 0.50-km to 1.90-km due to landuse and topographic reasons. (Refer **Figure 5.6.1**).

Figure 5.6.1 ALWAYE EDAPALLY PETTA MRTS CORRIDOR



Rail Levels and Alignment

Proposed elevated alignment traverses 25.612 kms. The general rail level is 12.5-m above road and is governed by a ground clearance of 5.50-m. This in turn determines the level of the entire station structure on the elevated section. In order to keep the land acquisition to minimum, alignment is planned generally in middle of the road and a two-level elevated station design has been proposed. Entry/exit structures to the proposed stations have been planned in the space available within the right of way as proposed by Greater Cochin Development Authority (GCDA) in its development plan. Wherever necessary, roads are aligned to match the alignment of rail tracks of proposed MRTS to place the viaduct on median of the road.

Platforms

All the elevated stations have been planned along side platforms. Care has been taken to locate stations on straight alignment only. However, in some stations, site constraints have become the deciding criteria and a curve of 1000-m radius has been introduced.

The sequence of stations along with their respective chainages, site and platform characteristics are presented in the **Table 5.6.1**.

Table 5.6.1
STATION LOCATION CHARACTERISTICS

S No	Nam e of Station	Chainage (in km) N – North S – South	Distance from Previous Station (in km)	Height of Rail Level in mtr. From road level	Platform Type and Nos	Alignment Description
1	Alwaye	**-0.090**		12.5	Side Platform,	On 1000 m curve
2	*Pulinchodu (future)*	**1.814**	**1.904**	12.5	Side Platforms, 2 Nos.	Curved
3	Companypady	**2.756**	**0.942**	12.5	Side Platforms, 2 Nos.	Straight
4	*Ambattukavu (future)*	**3.764**	**1.008**	12.5	Side Platforms, 2 Nos.	Straight
5	Muttom	**4.723**	**0.959**	12.5	Side Platform, 1 No. & Island Platform 1 No.	Straight Curved
6	Apollo Tyre	**6.209**	**1.486**	12.5	Side Platforms, 2 Nos.	Straight
7	Jacobite Church	**7.399**	**1.190**	12.5	Side Platforms, 2 Nos.	Curved
8	Kalamassery	**8.144**	**0.745**	12.5	Side Platforms, 2 Nos.	Straight
9	Pathadi Palam *(future)*	**9.146**	**1.002**	12.5	Side Platforms, 2 Nos.	Straight

S No	Nam e of Station	Chainage (in km) N – North S – South	Distance from Previous Station (in km)	Height of Rail Level in mtr. From road level	Platform Type and Nos	Alignment Description
10	Edapally Junction	**10.599**	**1.453**	12.5	Side Platforms, 2 Nos.	Straight
11	Edapally	**12.023**	**1.424**	12.5	Side Platforms, 2 Nos.	Straight
12	Palarivattom	**13.071**	**1.048**	12.5	Side Platforms, 2 Nos.	Straight
13	J L Nehru Stadium	**14.126**	**1.055**	12.5	Side Platforms, 2 Nos.	Straight
14	Kaloor	**15.221**	**1.095**	12.5	Side Platforms, 2 Nos.	Straight
15	Lissi	**15.711**	**0.490**	12.5	Side Platforms, 2 Nos.	Straight
16	Madhav Pharmacy	**16.899**	**1.188**	12.5	Side Platforms, 2 Nos.	Straight
17	Maharaja College	**18.103**	**1.204**	12.5	Side Platforms, 2 Nos.	Straight
18	Ernakulam South Station	**19.332**	**1.229**	12.5	Side Platforms, 2 Nos.	Straight
19	GCDA	**20.185**	**0.853**	12.5	Side Platforms, 2 Nos.	Straight
20	Elamkulam	**21.341**	**1.156**	12.5	Side Platforms, 2 Nos.	Straight
21	Vytilla	**22.447**	**1.106**	12.5	Side Platforms, 2 Nos.	Straight
22	Thaikoodam	**23.703**	**1.256**	12.5	Side Platforms, 2 Nos.	Straight
23	Petta	**24.822**	**1.119**	12.5	Side Platforms, 2 Nos.	Straight

5.6.2 Station Locations

5.6.2.1 Alwaye Station

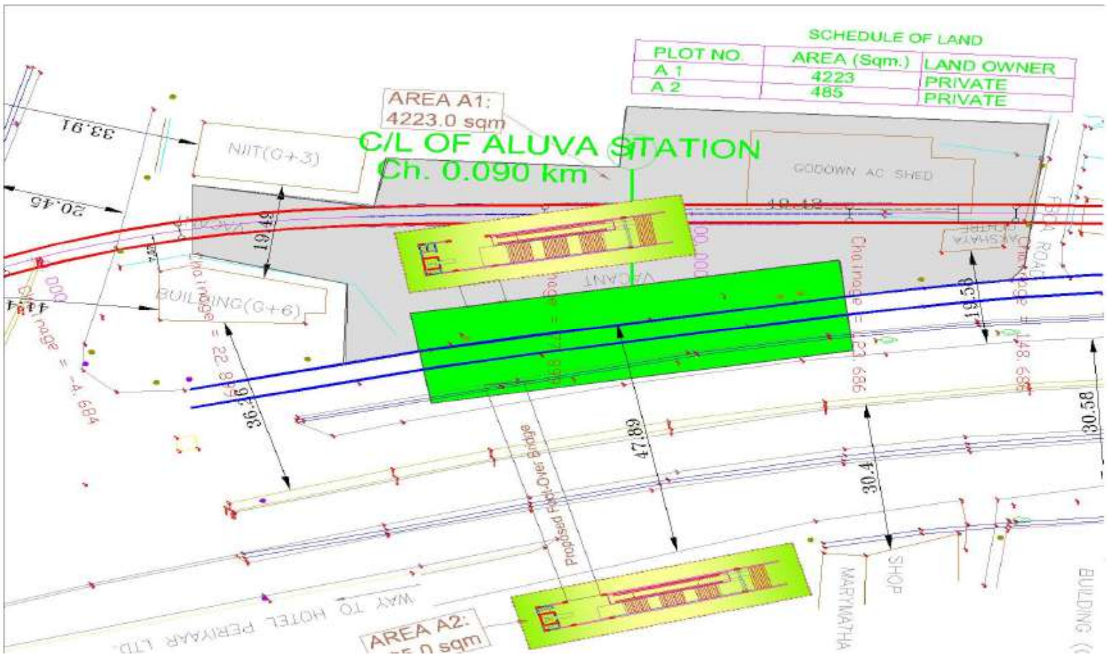
Chainage : Km - 0.090

Rail level : **12.5** above road level

Location	:	Located near the Rajiv Gandhi Bus Terminal, Alwaye on the eastern side of the existing NH 47.
Entry/Exit Stairs	:	Approach road available on the eastern side station. nal). For passengers from the Railway Station and KSRTC bus stand, will be using the existing road (325m long).
Catchment Area	:	This is the interchange point for the commuters traveling from Shoranur to Ernakulam by regular train service and also by State and private buses from the northern as well as eastern places like Perumbavur. Alwaye town is a Municipal where a lot of business, commercial and also banking activities take place. The headquarters of a leading non-scheduled bank 'Federal Bank' is situated in this town. A sizable commuting travelers also generate from the local population of the town in addition to the population of nearby villages and places like Perumbarur etc. Alura is also a pilgrim center - The Siva temple at the shores of Periyar is very famous and attracts lot of pilgrims from the whole of Kerala State during the bivarathri festival period. Birthplace of 'Adi Sankara' is also near Alura at Kalady. One of the Christian pilgrimage centre 'Malayattur' will also be served by this station. The Cochin International Airport at Nedumbasssery village – is also close to this station.

Figure 5.6.2: Site Conditions- Alwaye

Figure 5.6.3: Proposed Alwaye Station Area Development Plan

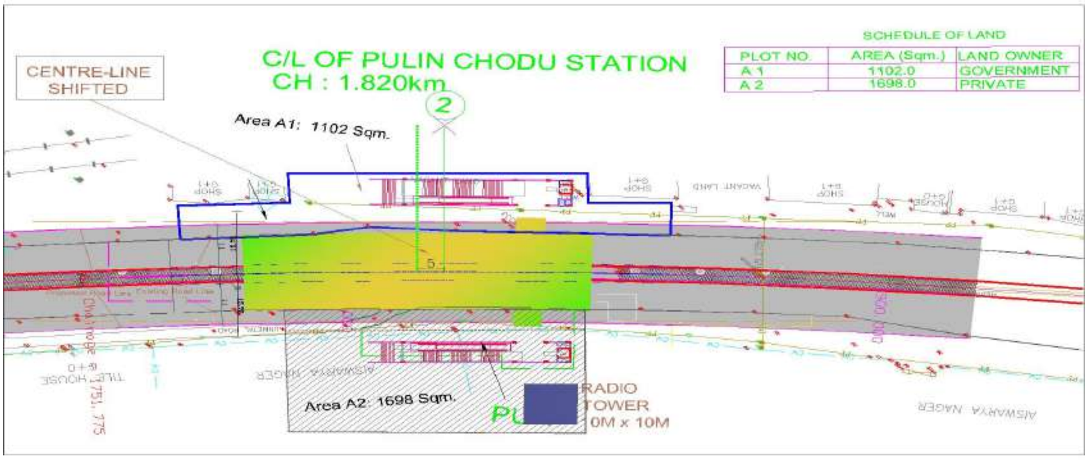


5.6.2.2 Pulinchodu Station

Chainage	**:**	Km 1.814
Inter Station Distance	**:**	Km 1.904
Rail Level	**:**	12.5m above road level
Location	**:**	The station is located around 120m from the Rajiv Gandhi bus Terminal.
Entry/Exist Stairs	**:**	Planned at both sides of the station
Catchment Area	**:**	Main source of passengers to this station is the local residents from villages like Thaikkattukara and will also serve commuters to nearby KSRTC regional workshop *(Refer fig 5.6.5)*

Figure 5.6.4: Site Conditions- Pulinchodu Station

Figure 5.6.5: Proposed Pulinchadu Station Area Development Plan

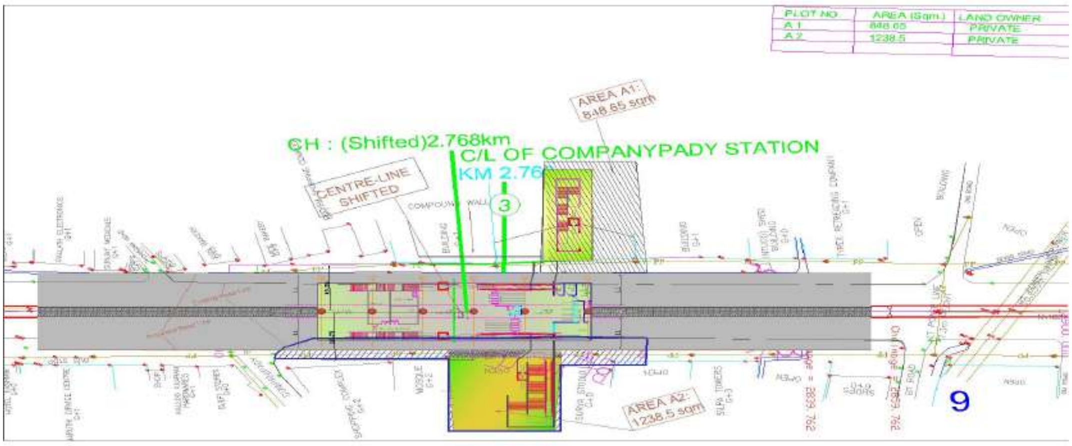


5.6.2.3 Companypady Station

Chainage	:	Km 2.756
Inter Station Distance	:	Km 0.942
Rail Level	:	12.5m above road level
Location	:	This station is situated in front of the mosque of Companypady locality.
Entry/Exit Stairs	:	Provided at both sides of station.
Catchment Area	:	A number of medium size industrial and commercial establishments are situated in this locality which will also attract lot of commuters in addition to the patronage from the local residential population. *(Refer fig 5.6.7)*

Figure 5.6.6: Site Conditions- Companypady Station

Figure 5.6.7: Proposed Companypady Station Area Development Plan

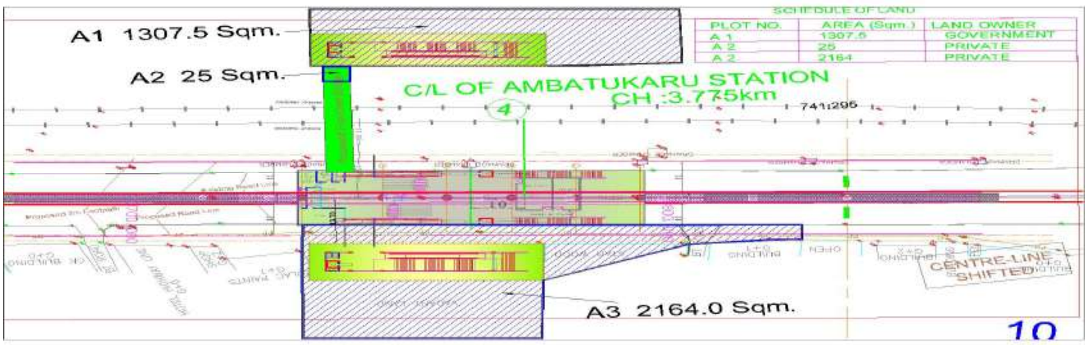


5.6.2.4 Ambattukavu Station

Chainage	:	Km 3.764
Inter Station Distance	:	Km 1.008
Rail Level	:	12.5m above road level
Location	:	This station is located in Ambattukaru village. The Electrified BG lines of Southern Railway are running parallel and close to the road alignmentat this location and there are no private structures between the road and the railway tracks.The eastern side entry is provided on the eastern side of existing Railway line.
Entry/Exit Stairs	:	Provided at both sides of the station.
Catchment Area	:	Passengers are mainly from the adjacent villages like Chonuikaray, Ambattukaru etc. Several medium size commercial and industrial establishment are also existing at both sides of the road which attract sizeable passengers, commuting to and from the various industrial establishment at Kalamarvu etc. *(Refer fig 5.6.9)*

Figure 5.6.8: Site Conditions - Ambattukavu Station

Figure 5.6.9: Proposed Ambattukavu Station Area Development Plan

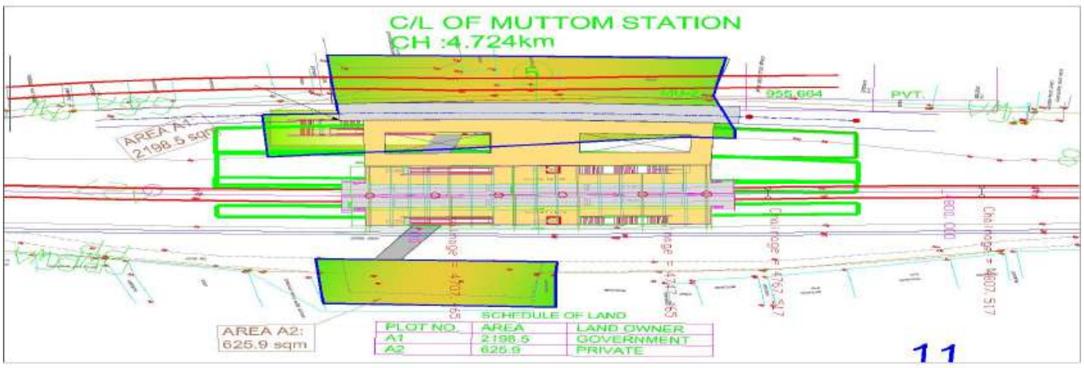


5.6.2.5 Muttom Station

Chainage	:	Km 4.723
Inter Station Distance	:	Km 0.959
Rail Level	:	12.5m above road level
Location	:	A three line station is proposed at this location station to facilitate entry/exit to the Muttom Car Maintenance Depot for Kochi Metro planned in this area. The alignment of the elevated metro is deviated towards the eastern side where sufficient land belonging to the highway authorities is available to accommodate the metro station also.
Entry/Exit Stairs	:	Provided at eastern and western side.
Catchment Area	:	This area is thickly populated being the adjoining area of the industrial belt at Kalamarreri, Cochin University of Science & Technology etc. *(Refer fig 5.6.11)*

Figure 5.6.10: Site Conditions- Muttom Station

Figure 5.6.11: Proposed Muttom Station Area Development Plan

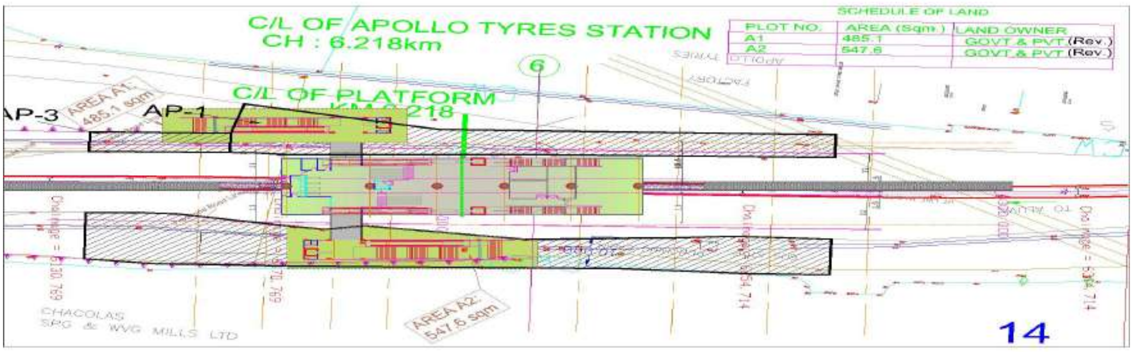


5.6.2.6 Apollo Tyres Station

Chainage	**:**	Km 6.209
Inter Station Distance	**:**	Km 1.486
Rail Level	**:**	12.5m above road level
Location	**:**	It is located in front of the Apollo tyres at the median of N.H. 47.
Entry/Exit Stairs	**:**	Provided at both side of station.
Catchment Area	**:**	It is in the central point where various industrial establishments like Apollo tyres, Premier tyres, HMT Ltd. etc. are situated along with a densely populated residential area. Govt. establishments like KSEB, and several educational institutions are also situated at nearly locations of this station. *(Refer fig 5.6.13)*

Figure 5.6.12: Site Conditions - Apollo Tyres Station

Figure 5.6.13: Proposed Apollo Tyres Station Area Development Plan

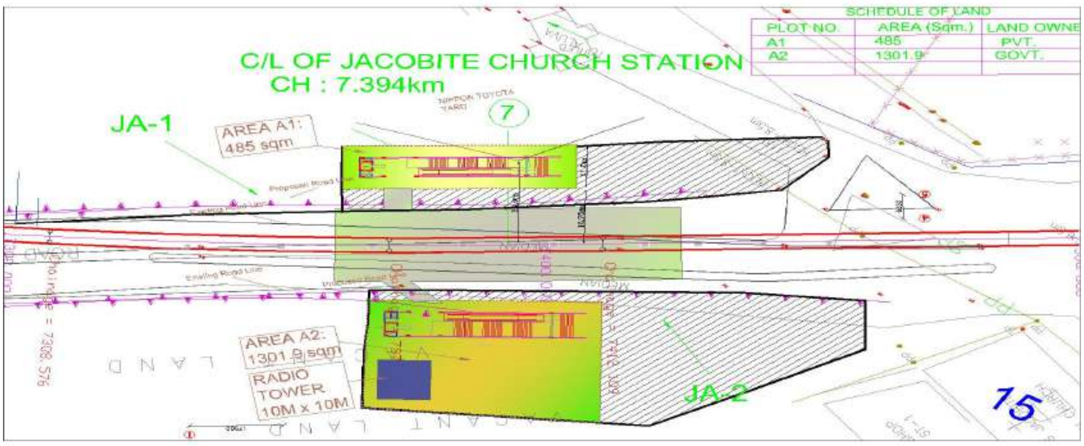


5.6.2.7 Jacobite Church Station

Chainage	:	Km 7.399
Inter Station Distance	:	Km 1.190
Rail Level	:	12.5 m above road level
Location	:	It is located at the southern end (Ernakulam side) of the approach road of Kalamassy Road-Over – Bridge, near the Jacobite Church and the junction point of the road from HMT Jn. with NH 47.
Entry/Exit Stairs	:	Provided at both sides of the station.
Catchment Area	:	Station will feed the residential area located nearby. Also for the people from and beyond the HMT junction towards east, this station will be nearest and convenient. *(Refer fig 5.6.15)*

Figure 5.6.14: Site Conditions- Jacobite Church Station

Figure 5.6.15: Proposed Jacobite Church Station Area Development Plan

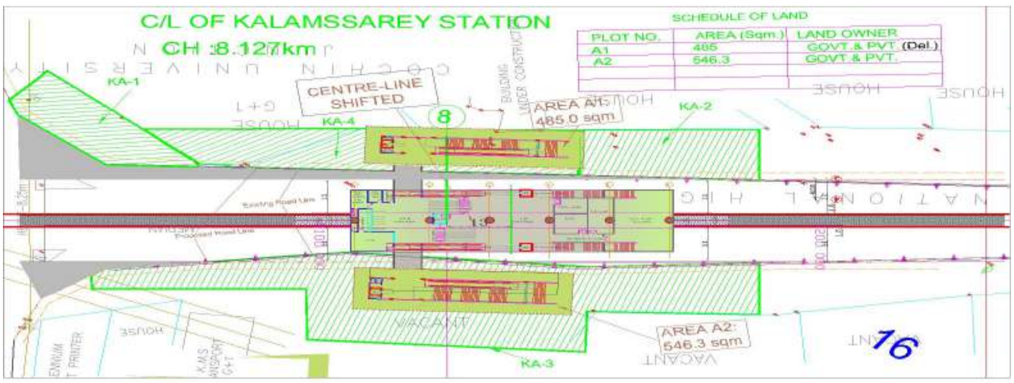


5.6.2.8 Kalamassery Station

Chainage	**:**	Km 8.144
Inter Station Distance	**:**	Km 0.745
Rail Level	**:**	12.5 m above road level
Location	**:**	This metro station is located at the southern side of the junction of the road from Cochin University Campus with NH 47 from the east and from Kalamassery village from the south.
Entry/Exit Stairs	**:**	Provided at both sides of station.
Catchment Area	**:**	This is the serving metro station for the Cochin University of Science and Technology Campus which is situated at about 1 km at the eastern side of the road junction and for the villages on both sides. This locality is considerably thickly populated. (Refer fig 5.6.17)

Figure 5.6.16: Site Conditions - Kalamassery Station

Figure 5.6.17: Proposed Kalamassery Station Area Development Plan

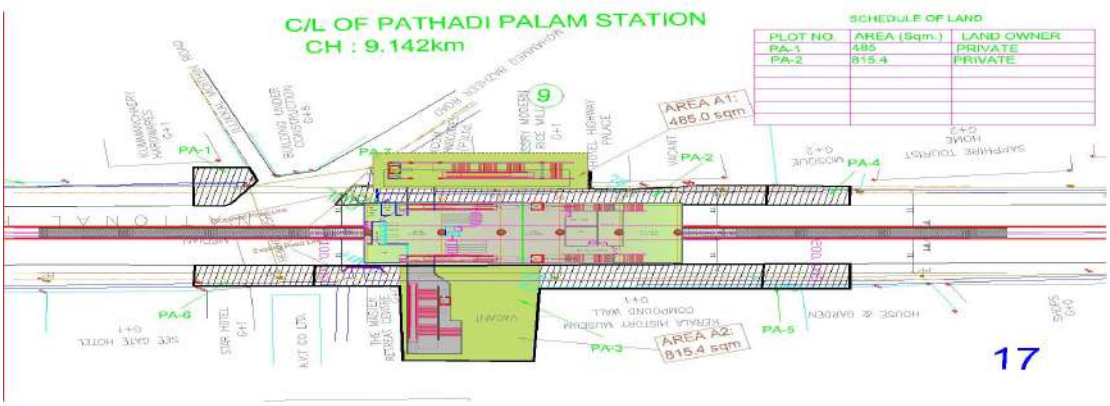


5.6.2.9 Pathadipalam Station

Chainage	**:**	Km 9.146
Inter Station Distance	**:**	Km 1.002
Rail Level	**:**	12.5 m above road level
Location	**:**	This station is located near the Kerala History Museum where a number of commercial establishments are also situated on both sides of the NH-47.
Entry/Exit Stairs	**:**	Provided at both sides of station.
Catchment Area	**:**	This is mainly a residential area spread over a radius of 5 km on both eastern and western sides of the highway. *(Refer fig 5.6.19)*

Figure 5.6.18: Site Conditions- Pathadipalam Station

Figure 5.6.19: Proposed Pathadipalam Station Area Development Plan

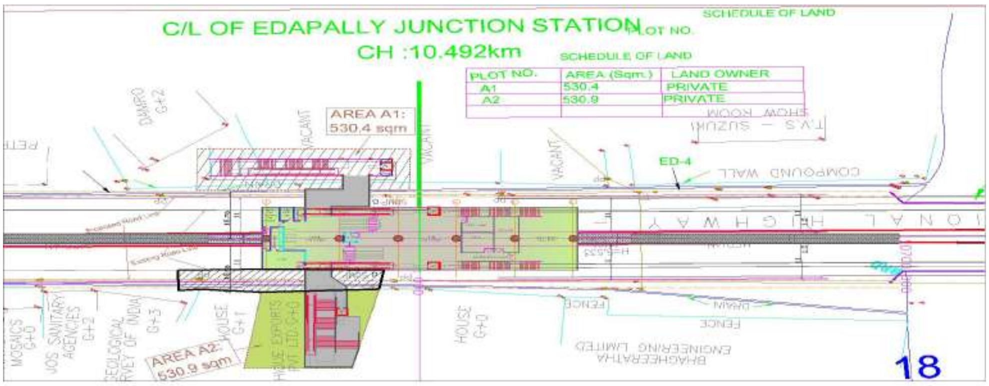


5.6.2.10 Edapally Junction Station

Chainage	:	Km 10.599
Inter Station Distance	:	m 1.453
Rail Level	:	12.5m above road level
Location	:	This station is located just before the bye-pass junction of NH-47 at Edapally. The location facilitates extention of Metro along the NH-47 bye-pass also in future
Entry/ Exit Stairs	:	Provided at both sides of station
Catchment Area	:	People from the local residential areas. *(Refer fig 5.6.21)*

Figure 5.6.20: Site Conditions - Edapally Junction Station

Figure 5.6.21: Proposed Edapally Junction Station Area Development Plan

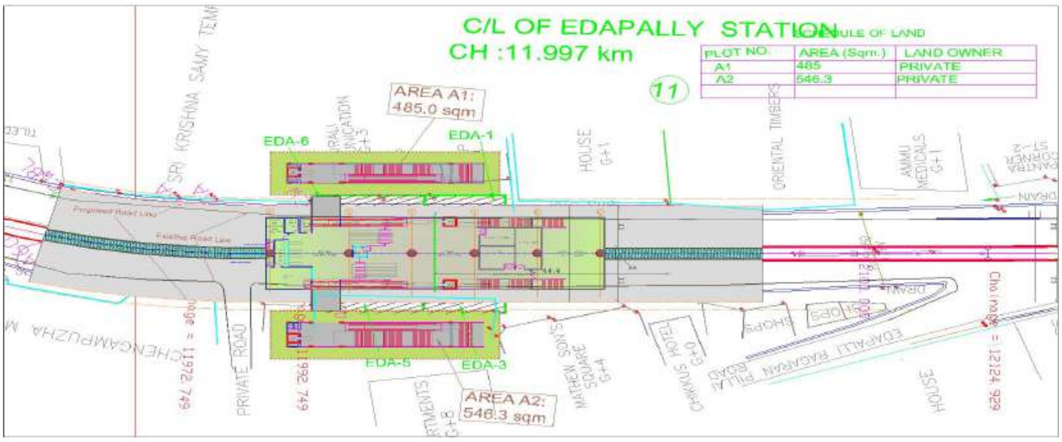


5.6.2.11 Edapally Station

Chainage	:	Km 12.023
Inter Station Distance	:	Km 1.424
Rail Level	:	12.5 m above road level
Location	:	This station is located close to the Edapally bus stop, near the Changampuga Memorial Park.
Entry/ Exit Stairs	:	Provided at both sides of the station.
Catchment Area	:	The locality is a very busy commercial center in addition to various educational institutions, commercial establishments and industrial units like Modern Bread, which generate lot of commuter traffic. *(Refer fig 5.6.23)*

Figure 5.6.22: Site Conditions Edapally Station

Figure 5.6.23: Proposed Edapally Station Area Development Plan

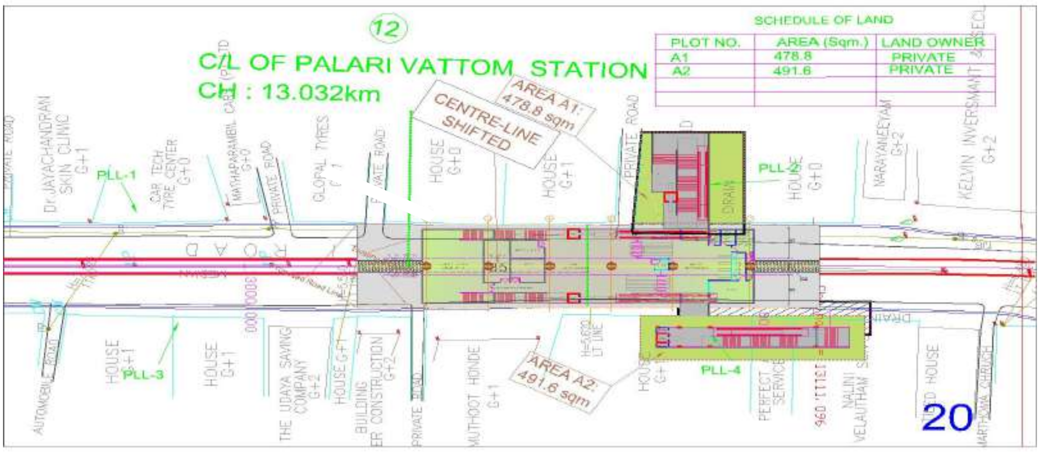


5.6.2.12 Palarivattom Station

Chainage	**:**	Km 13.071
Inter Station Distance	**:**	Km 1.048
Rail Level	**:**	12.5 m above road level
Location	**:**	This station is located on the busy Banergi Road of the city, before Palarivattom junction.
Entry/ Exit Stairs	**:**	Provided at both sides of station.
Catchment Area	**:**	The locality is a very busy commercial center where people from various parts of the city visit frequently throughout the day. *(Refer fig 5.6.25)*

Figure 5.6.24: Site Conditions- Palarivattom Station

Figure 5.6.25: Proposed Palarivattom Station Area Development Plan

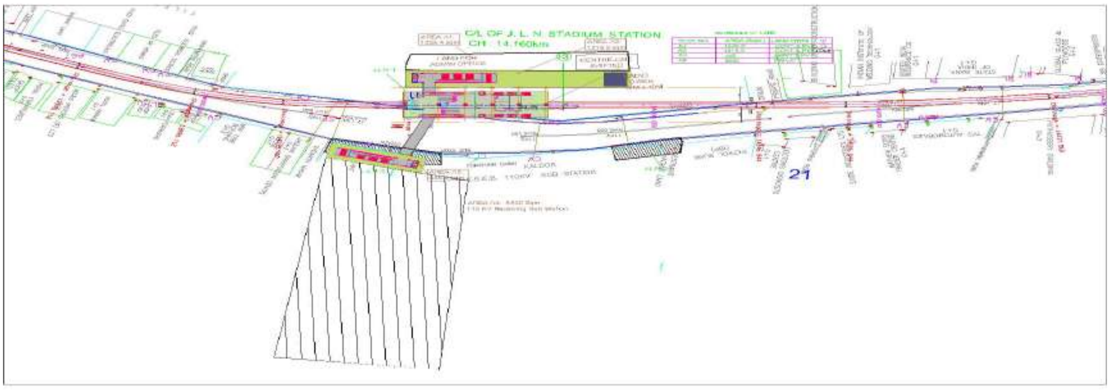


5.6.2.13 Jawahar Lal Nehru Stadium Station

Chainage	**:**	Km 14.126
Inter Station Distance	**:**	Km 1.055
Rail Level	**:**	12.5m above road level**.**
Location	**:**	This station is located off the road in front of the Jawaharlal Nehru Stadium, just opposite to the Kaloor KSEB Sub station.
Entry/ Exit Stairs	**:**	Provided at both sides of station.
Catchment Area	**:**	In addition to feeding the very busy area in which the station is located, the station is also designed to meet the requirement of J.L.Nehru Stadium where frequent sport and cultural events take place. For important sports events, people from all over the state assemble here to witness the event. *(Refer fig 5.6.27)*

Figure 5.6.26: Site Conditions- Jawahar Lal Nehru Stadium Station

Figure 5.6.27: Proposed Jawahar Lal Nehru Stadium Station Area Development Plan



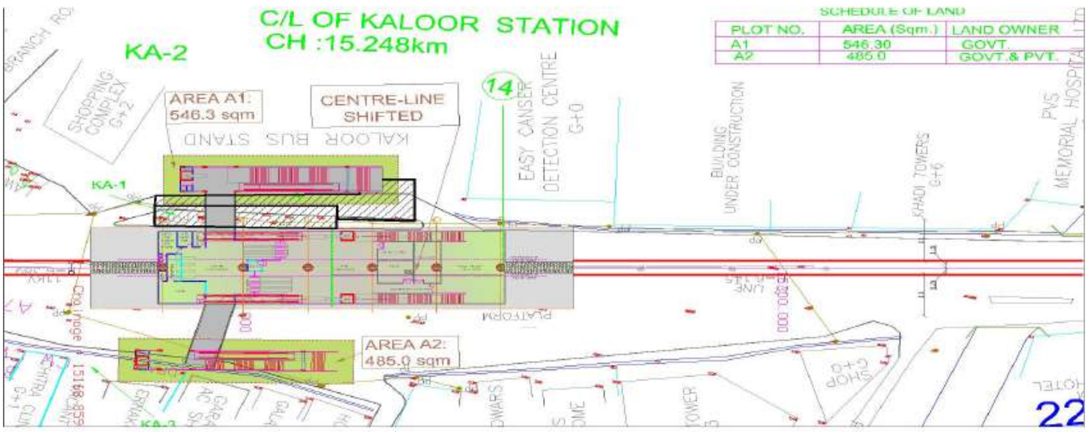
5.6.2.14 Kaloor Station

Chainage	:	Km 15.221
Inter Station Distance	:	Km .1.095
Rail Level	:	12.5 m above road level
Location	:	This station is located close to the busy bus stand at Kaloor for city buses as well as suburban buses.
Entry/ Exit Stairs	:	Provided at both sides of station
Catchment Area	:	It is a major sub-urban transport node, with Kaloor Junction being the city level bus terminus. The metro station is proposed to be integrated with the bus stand so as to provide a convenient inter modal transport facility to the passengers..

(Refer fig 5.6.31)

Figure 5.6.30: Site Conditions- Kaloor Station

Figure 5.6.31: Proposed Kaloor Station Area Development Plan

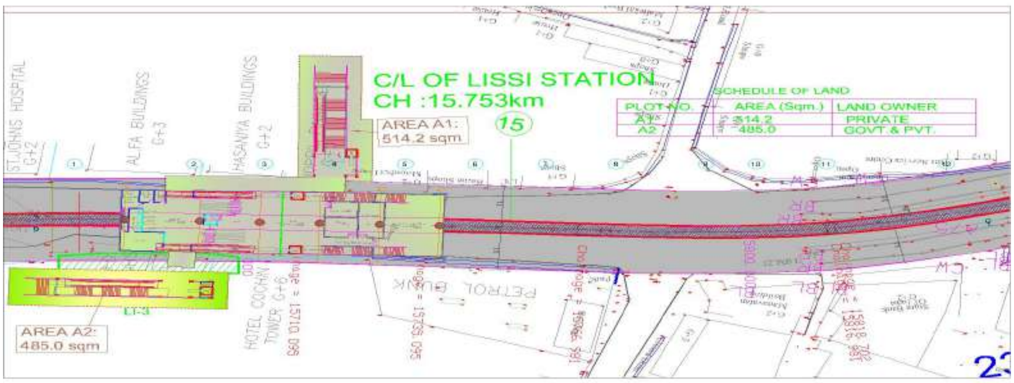


5.6.2.15 Lissi Station

Chainage	:	Km 15.771
Inter Station Distance	:	Km 0.490
Rail Level	:	12.5 above road level
Location	:	This station is located near Lissi junction with roads leading to the Lissi Hospital on the western side and to the residential and commercial centers towards east. .
Entry/ Exit Stairs	:	Provided at both sides of station.
Catchment Area	:	This centre is commercially very busy with a number of Medical/Nursing centres situated around. This is also close to the Ernakulam Town Railway Station where from interchange of lot of commuters to the metro is expected. *(Refer fig 5.6.29)*

Figure 5.6.28: Site Conditions- Lissi Station

Figure 5.6.29: Proposed Lissi Station Area Development Plan

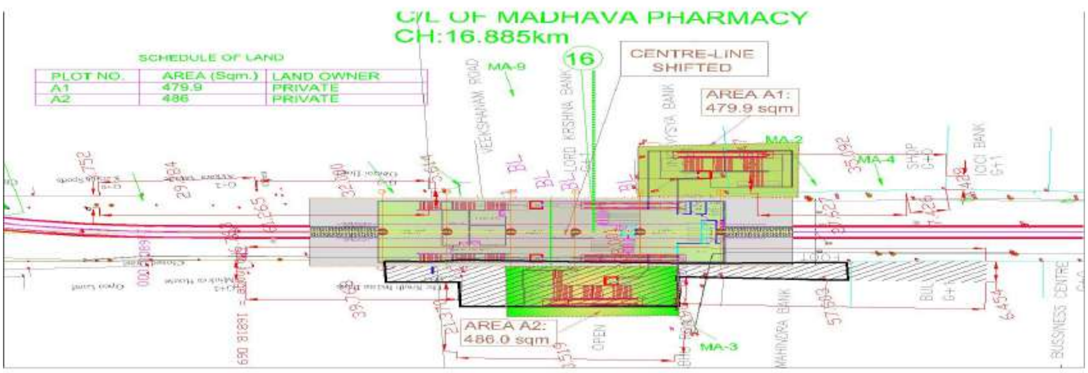


5.3.2.16 Madhav Pharmacy Station

Chainage	:	Km 16.889
Inter Station Distance	:	Km 1.188
Rail Level	:	12.5 m above road level
Location	:	This is the first metro station on the MG road located in front of the Minerva House and Acara Arcade on either sides.
Entry Exit Stairs	:	Provided at both sides of station.
Catchment Area	:	M.G. Road is a very busy commercial center and people frequent this area throughout the day. Many important commercial, shoping and business establishments are situated in the area attracting commuters round the period. *(Refer fig 5.3.33)*

Figure 5.3.32: Site Conditions- Madhav Pharmacy Station

Figure 5.3.33: Proposed Madhav Pharmacy Station Area Development Plan

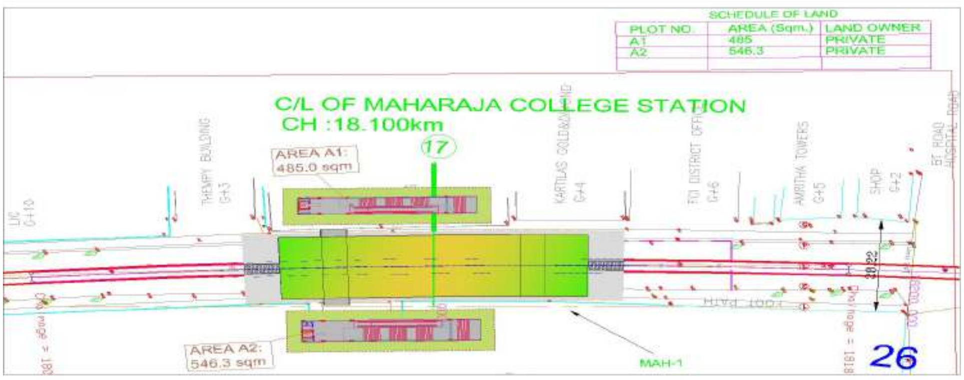


5.6.2.17 Maharaja College Station

Chainage	:	KM 18.103
Inter Station Distance	:	1.204 km
Rail Level	:	12.5 m above road level
Location	:	The station is located in front of Maharaja College's Stadium.
Entry/Exit Stairs	:	Provided at both sides of the station
Catchment Area	:	This area is also the commercial center. In addition, there are several educational institutions like Maharaja college, Women's College, Law college, and several Govt. offices like Coachin Corporation, Water Authority in its close vicinity. This will be also the serving station for the boat jetty and KSRTC bus stand which is an interchange point for lot of commuters. *(Refer fig 5.6.35)*

Figure 5.6.34: Site Conditions- Maharaja College Station

Figure 5.6.35: Proposed Maharaja College Station Area Development Plan

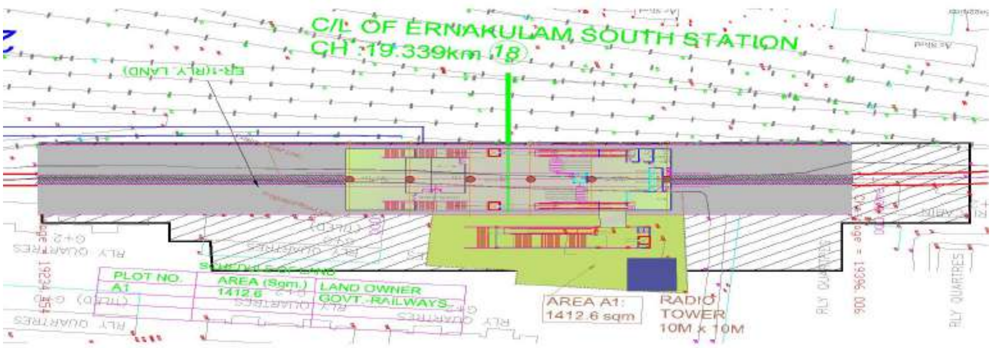


5.6.2.18 Ernakulam Junction Station

Chainage	:	KM 19.332
Inter Station Distance	:	1.229 km
Rail Level	:	12.5 m above road level
Location	:	It is located in front of the existing Ernakulam Junction Railway Station, near the CHTS end of station building.
Entry/Exit Stairs	:	Provided at both sides of the station
Catchment Area	:	This is envisaged as one of the main locations for interchange passengers to Metro from Ernakulam Junction Railway station which serves several long distance trains as well as local trains from District headquarters like Kottayam, Trichur and from the eastern parts of the city like Mattancherry, Willingdon Island etc. *(Refer fig 5.6.37)*

Figure 5.6.36: Site Conditions- Ernakulam Junction Station

Figure 5.6.37: Proposed Ernakulam Junction Station Area Development Plan

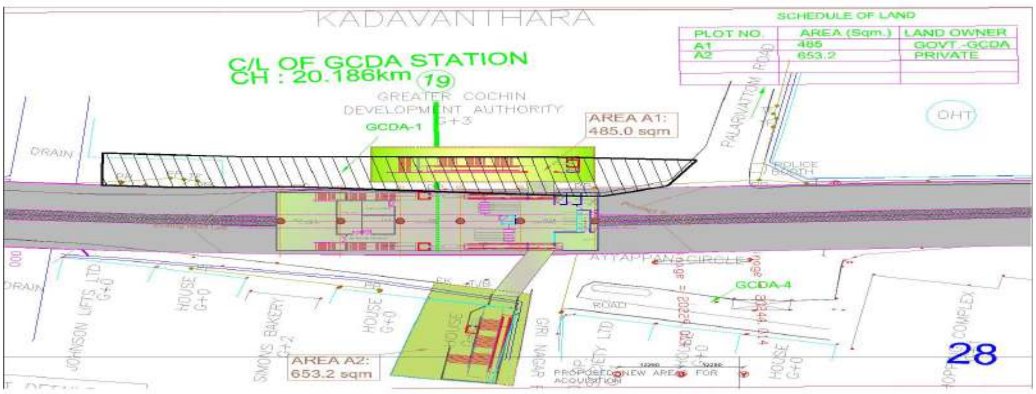


5.3.2.19 GCDA Station

Chainage	:	KM 20.185
Inter Station Distance	:	0.853 km
Rail Level	:	12.5 m above road level
Location	:	It is the first station in the S.A. road located in front of the GCDA Headquarter office.
Entry/Exit Stairs	:	Planned at both sides of the station
Catchment Area	:	This is a commercial center in the north eastern part of the city. There are several Medical Institutes/ Nursing homes situated close to the proposed station. The Rajeev Gandhi Indoor Stadium is situated closely. In addition, many residential complexes like Parampally Nagar, Gandhi Nagar, Girinagar etc. are in its close vicinity which will provide great patronage to the Metro. *(Refer fig 5.3.39)*

Figure 5.3.38: Site Conditions- G.C.D.A Station

Figure 5.3.39: Proposed G.C.D.A Station Area Development Plan

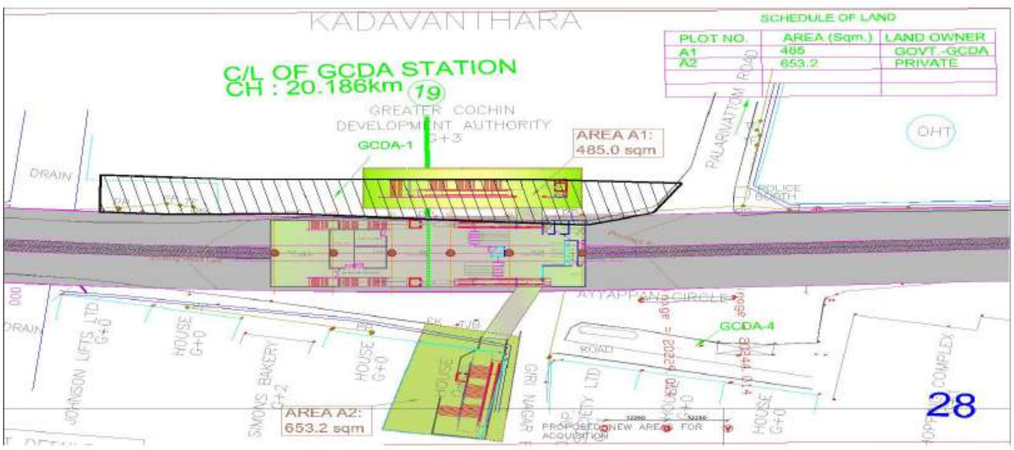


5.6.2.20 Elamkulam Station

Chainage	:	Km 21.341
Inter Station Distance	:	1.156 Km
Rail Level	:	12.5 m above road level
Location	:	This station is located opposite to a cross road – Janatha road – which is leading to commercial establishments and residential areas.
Entry/ Exit Stairs		Provided at both sides.
Catchment Area	:	This station is located in a commercial center and there are lot of residential complexes on either side. *(Refer fig 5.6.43)*

Figure 5.6.42: Site Conditions- Elamkulam Station

Figure 5.6.43: Proposed Elamkulam Station Area Development Plan

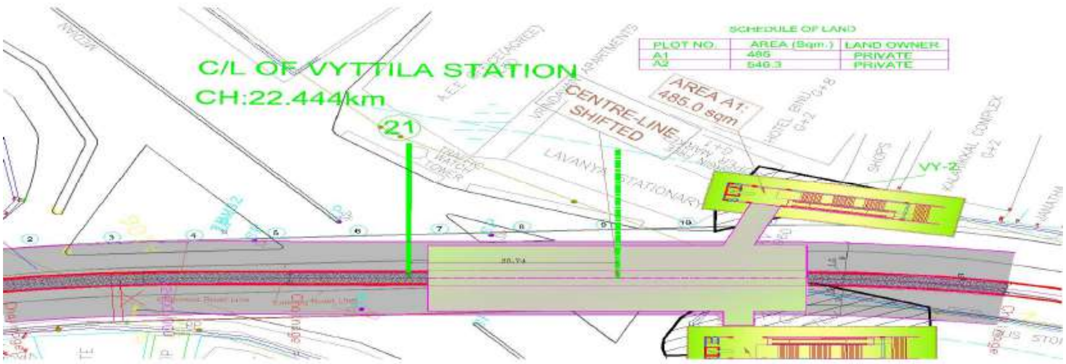


5.6.2.21 Vytilla Station

Chainage	:	Km 22.447
Inter Station Distance	:	1.106 Km
Rail Level	:	12.5 m above road level
Location	:	This station is located at the intersection point of NH 47 bye pass and S.A. Road.
Entry/ Exit Stairs	:	Planned at both sides of the station.
Catchment Area	:	This is also one of the main commercial areas. In addition, several State/ Central Govt. offices are situated in and around. Also lot of buses plying along the NH bypass provide interchange of passengers for the proposed Mobility Hub at Vyttila. *(Refer fig 5.6..45)*

Figure 5.6.44: Site Conditions- Vytilla Station

Figure 5.6.45: Proposed Vytilla Station Area Development Plan

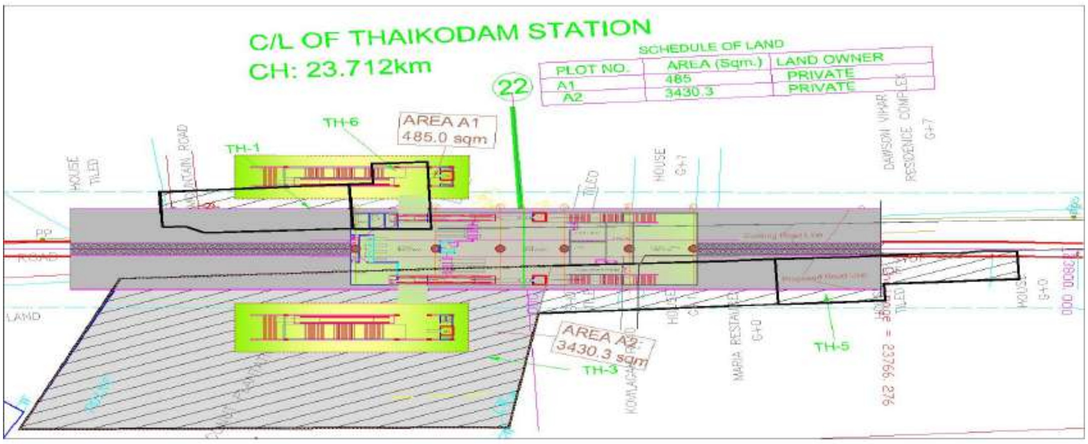


5.6.2.22 Thaikoodam Station

Chainage	:	Km 23.703
Inter Station Distance	:	1.256 Km
Rail Leve	:	12.5 m above road level
Location	:	This station is located in front of the K.S.E.B. Staff Quarters at Thaikoodam.
Entry/Exit Stairs	:	Planned at both sides of the station.
Catchment Area	:	This is mainly a residential location from where lot of people commute towards Tripunithura and Ernakulam area. *(Refer fig 5.6.47)*

Figure 5.6.46: Site Conditions- Thaikoodam Station

Figure 5.6.47: Proposed Thaikoodam Station Area Development Plan

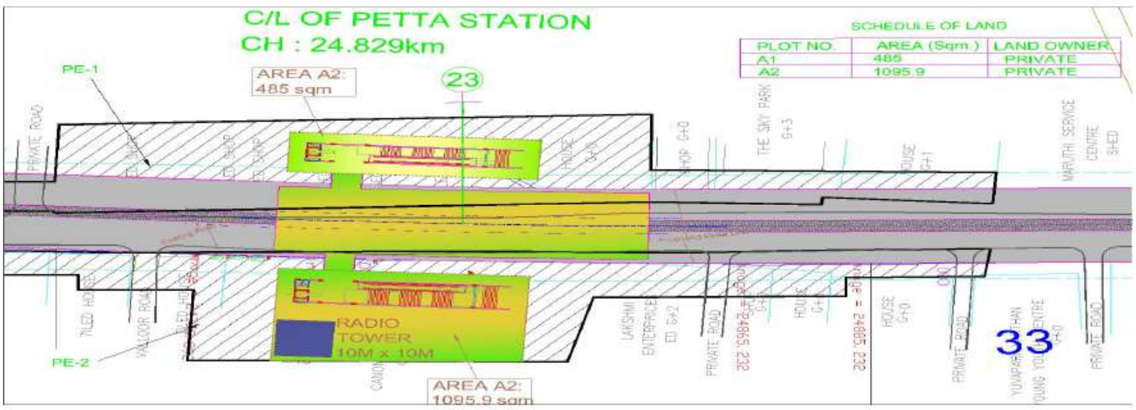


5.6.2.23 Petta Station

Chainage	:	Km 24.822
Inter Station Distance	:	1.119 Km
Rail Level	:	12.5 m above road level
Location	:	This station is located just before the Petta junction of NH 49.
Entry/Exit Stairs	:	Planned at both sides of the station
Catchment Area	:	Tripunithura town center is less than 2 km from this Metro station. A sizeable portion of the present commuters to Ernakulam and onwards who now depend on the private bus service will use Metro service saving considerable travel time. *(Refer fig 5.6.49)*

Figure 5.6.48: Site Conditions- Petta Station

Figure 5.6.49: Proposed Petta Station Area Development Plan



5.6.3 STATION PLANNING

5.6.3.1 Planning and Design Criteria for Stations

Salient features of a typical station are as follows:

1. The station can be divided into public and non-public areas (those areas where access is restricted). The public areas can be further subdivided into paid and unpaid areas.

2. The platform level has adequate assembly space for passengers for both normal operating conditions and a recognized abnormal scenario.

3. The platform level at elevated stations is determined by a critical clearance of 5.50-m under the concourse above the road intersection, allowing 3.00-m for the concourse height, about 1-m for concourse floor and 2.00-m for structure of tracks above the concourse. Further, the platforms are 1.09-m above the tracks. This would make the platforms in an elevated situation at least 12.50-m above ground.

4. The concourse contains automatic fare collection system in a manner that divides the concourse into distinct areas. The 'unpaid area' is where passengers gain access to the system, obtain travel information and purchase tickets. On passing through the ticket gates, the passenger enters the 'paid area', which includes access to the platforms.

5. The arrangement of the concourse is assessed on a station-by-station basis and is determined by site constraints and passenger access requirements. However, it is planned in such a way that maximum surveillance can be achieved by the ticket hall supervisor over ticket machines, automatic fare collection (AFC) gates, stairs and escalators. Ticket machines and AFC gates are positioned to minimize cross flows of passengers and provide adequate circulation space.

6. Sufficient space for queuing and passenger flow has been allowed at the ticketing gates.

7. Station entrances are located with particular reference to passenger catchment points and physical site constraints within the right-of-way allocated to the Metro.

8. Office accommodation, operational areas and plant room space is required in the non-public areas at each station. The list of such areas is given below in **Table 5.6.2**

Table 5.6.2
STATION ACCOMMODATION

1. Station Control Room	11. Traction Substation
2. Information & Enquiries	12. Signaling Room
3. Ticket Office	13. Communications Room
4. Ticket Hall Supervisor & Excess Fare Collection (Passenger Office)	14. Station Substation
5. Cash and Ticket Room	15. Fire Tank and Pump Room
6. Staff Area	16. Commercial Outlets and Kiosks
7. Staff Toilets	17. UPS and Battery Room
8. Refuse Store	*18. Miscellaneous Operations Room*
9. Cleaner's Room	*19. Train Crew Supervisor's Office*
10. Security Room	*20. Train Crew Room*

9. Areas listed under item no 18, 19 and 20 shall be required only at the terminal stations.

10. The DG set, bore well pump houses, ground tank and pump houses would be located in one area on ground.

11. The system is being designed to maximize its attraction to potential passengers and the following criteria have been observed:

    - Minimum distance of travel to and from the platform and between platforms for transfer between lines.
    - Adequate capacity for passenger movements.
    - Convenience, including good signage relating to circulation and orientation.
    - Safety and security, including a high level of protection against accidents.

12. Following requirements have been taken into account:

    - Minimum capital cost is incurred consistent with maximizing passenger attraction.
    - Minimum operating costs are incurred consistent with maintaining efficiency and the safety of passengers.
    - Flexibility of operation including the ability to adapt to different traffic conditions changes in fare collection methods and provision for the continuity of operation during any extended maintenance or repair period, etc.

- Provision of good visibility of platforms, fare collection zones and other areas, thus aiding the supervision of operations and monitoring of efficiency and safety.
- Provision of display of passenger information and advertising.

13. The numbers and sizes of staircases/escalators are determined by checking the capacity against AM and PM peak flow rates for both normal and emergency conditions.
14. In order to transfer passengers efficiently from street to platforms and vice versa, station planning has been based on established principles of pedestrian flow and arranged to minimize unnecessary walking distances and cross-flows between incoming and outgoing passengers**.**
15. Passenger handling facilities comprise of stairs/escalators, lifts and ticket gates required to process the peak traffic from street to platform and vice-versa (these facilities must also enable evacuation of the station under emergency conditions, within a set safe time limit).

5.6.3.2 Typical Elevated Station-The station is generally located on the road median. Total length of the station is ~70-m. All the stations are two-level stations. The concourse is divided into two parts at either end of the station, with staircases leading from either side of the road. Passenger facilities like ticketing, information, etc as well as operational areas are provided at the concourse level. Typically, the concourse is divided into public and non-public zones. The non-public zone or the restricted zone contains station operational areas such as Station Control Room, UPS & Battery Room, Signalling Room, Security Room, Staff Toilets, etc. The public zone is further divided into paid and unpaid areas.

Since the station is generally in the middle of the road, minimum vertical clearance of 5.5-m has been provided under the concourse. Concourse floor level about 6.5-m above the road. Consequently, platforms are at a level of about 12.5-m from the road. To reduce physical and visual impact of the elevated station, in general stations have been made end loaded with staircases from concourse discharging at the end of the platforms.

With respect to its spatial quality, an elevated Metro structure makes a great impact on the viewer as compared to an *At-grade* station. The positive dimension of this impact has been accentuated to enhance the acceptability of an elevated station and the above ground section of tracks. Structures that afford maximum transparency and look similar to the surroundings have been envisaged. A slim concrete form is proposed with sloping tiled roof, as it would look compatible in both; the modern high-rise environment as well as the lesser-built, low-rise developments along most parts of the corridor.

Platform roofs have been proposed to be of steel frame with tile cladding to achieve a look compatible with the traditional sloping roof structures around. Platforms would be protected from the elements by providing an overhang of the roof and sidewalls would be avoided, thereby enhancing the transparent character of the station building, while also allowing for the air flow required in the warm and humid tropical climate. In order to allow unhindered traffic movement below the stations, the station structure is supported on a single column, which lies unobtrusively on the central verge.

5.6.3.3 Passenger Amenities-Passenger amenities such as ticketing counters / automatic ticket vending machines, ticketing gate, etc. are provided in the concourse. Uniform numbers of these facilities have been provided for system wide uniformity, although the requirement of the facilities actually varies from station to station. The same applies to provision of platform widths and staircase/escalators. Maximum capacity required at any station by the year 2025 for normal operation has been adopted for all stations. For this purpose, *peak minute traffic* is assumed to be 2% of the *peak hour traffic*.

5.6.3.4 Concourse-Concourse forms the interface between street and platforms. In elevated stations, this is contained at both ends of the station. This is where all the passenger amenities are provided. The concourse contains automatic fare collection system in a manner that divides the concourse into distinct *paid* and *unpaid* areas. The *'unpaid area'* is where passengers gain access to the system, obtain travel information and purchase tickets. On passing through the ticket gates, the passenger enters the *'paid area', which* includes access to the platforms. The concourse is planned in such a way that the ticket hall supervisor can achieve maximum surveillance over ticket machines, automatic fare collection (AFC) gates, stairs and escalators. Ticket machines and AFC gates are positioned to minimize cross flows of passengers and provide adequate circulation space. Sufficient space for queuing and passenger flow has been allowed in front of the ticketing gates.

5.6.3.5 Ticketing Gates-Ticketing gates' requirement has been calculated taking the gate capacity as 20 persons per minute per gate. Passenger forecast for the horizon year 2025 has been used to compute the maximum design capacity. At least two ticketing gates shall be provided at any station even if the design requirement is satisfied with only one gate. Uniform space has been provided in all stations where gates can be installed as and when required.

5.6.3.6 Ticket Counters and Ticket Issuing Machines (TIMs)-It is proposed to deploy manual ticket issuing in the beginning of the operation of the line. At a later stage, automatic TIMS would be used for which space provision has been made in the concourse. At present, ticket counters would be provided, which would be replaced with TIMS in future. Capacity of manual ticket vending counters is taken to be 10 passengers per minute and it is assumed that only 40% of the commuters would purchase tickets at the stations while performing the journey.

The rest are expected to buy season tickets or prepaid card, etc. Accordingly, the requirement of ticket counters has been calculated and the same provided for in the plans.

5.6.3.7 Platforms-A uniform platform width of 3.0-m wide excluding staircases and escalators in the end section is proposed for the elevated stations. This platform width has been checked for holding capacity of the platform for worst-case scenario (two missed headways) in the design year.

5.6.3.8 Stairs, Escalators and Lifts for Normal and Emergency Operations- Provision has been made for escalators in the paid area i.e. from concourse to platforms. On each platform, one escalator has been proposed. In addition, two staircases with a combined width of 6-m is provided on each Side platform connecting to the concourse. These stairs and escalator together provide an escape capacity adequate to evacuate passengers in emergency from platforms to concourse in 5.5 minutes. While calculating the waiting passengers on the platform in emergency, 2 missed headways are assumed and the train arriving is assumed to be carrying peak section load. In addition provisions has been kept in Civil structure of stations to provide lifts in future one each on either platform. Since the rise from road to concourse is about 6.5-m, it is proposed to provide escalators and lifts in addition to stairs for vertical movement of passengers from street to concourse in future.

5.6.3.9 Passenger Information Kiosks and Commercial Kiosks-Passenger Information Kiosks and Commercial Kiosks are provided in the unpaid and paid areas of the concourse respectively.

5.6.3.10 Summary of passenger amenities required and proposed at stations based on projected traffic for the year 2025 is given in the Table 5.6.3.

Table 5.6.3
PASSENGER TRAFFIC AND REQUIREMENT OF AMENITIES IN STATIONS
(Projections for Year 2025)

Station	Daily Traffic	Peak Minute Board-ing	Total Peak Minute Traffic Including Alighting	Ticketing Gates required E-E-R	Ticket Counter Reqd.	Stairs Width (in m) On Each Platform	Escalators Provided At Each Station		*Future Provision of Lifts At Each Station*	
							C to P	G to C	*C to P*	*G to C*
1 Alwaye	102630	167	205	2-2-6	8	6.60	-	2	*1*	*2*
2 Pulinchodu	21900	42	44	2-2-2	2	6.60	-	2	*1*	*2*
3 Companypady	34370	63	68	2-2-2	3	6.60	-	2	*1*	*2*
4 Ambattukavu	28940	46	58	2-2-2	2	6.60	-	2	*1*	*2*
5 Muttom	22470	42	45	2-2-2	2	6.60	-	2	*1*	*2*
6 Apollo Tyre	38880	17	78	2-2-2	1	6.60	-	2	*1*	*2*
7 Jacobite Church	7200	7	14	2-2-2	1	6.60	-	2	*1*	*2*
8 Kalamassery	25710	25	52	2-2-2	1	6.60	-	2	*1*	*2*
9 Pathadi Palam	28100	30	56	2-2-2	2	6.60	-	2	*1*	*2*
10 Edapally Junction	32790	55	66	2-2-2	3	6.60	-	2	*1*	*2*
11 Edapally	64130	56	128	2-2-2	3	6.60	1#	2	*1*	*2*
12 Pallari Vattom	78300	16	157	2-2-4	1	6.60	1#	2	*1*	*2*
13 J L N Stadium	87830	31	176	2-2-4	2	6.60	1#	2	*1*	*2*
14 Kaloor	83940	47	168	2-2-2	2	6.60	1#	2	*1*	*2*
15 Lissi	47780	38	96	2-2-2	2	6.60	-	2	*1*	*2*
16 Madhav Pharmacy	115940	57	232	2-2-4	3	6.60	1#	2	*1*	*2*
17 Maharaja College	58570	38	137	2-2-2	2	6.60	1#	2	*1*	*2*
18 Ernakulam SouthStation	80250	56	160	2-2-2	3	6.60	1#	2	*1*	*2*
19 GCDA	21360	31	43	2-2-2	2	6.60	-	2	*1*	*2*
20 Elamkulam	8900	15	18	2-2-2	1	6.60	-	2	*1*	*2*
21 Vytilla	108000	171	216	2-2-4	8	6.60*	1#	2	*1*	*2*
22 Thaikoodam	16270	30	33	2-2-2	2	6.60	-	2	*1*	*2*
23 Petta	76000	107	152	2-2-2	5	6.60	1#	2	*1*	*2*

Note: G- ground/ street level, C- concourse level, P- platform level

∗ Staircase width of 8.00 mt (1.4 mt extra) and platform width of 4.5 mt shall be provided for evacuation purposes. For details refer to station layout figure no. 5.6.45.

These escalators shall be provided in future. Adequate provision shall be made in the Civil Structure for the same.

5.7 LAND

Alignment for Alwaye - Petta corridor traverses through major city roads having commercial, institutional and residential complexes including Alwaye Rajiv Gandhi Bus terminal, Appolo Tyres, Cochin University & Science Technology Edapally, Pallarivittam, J.L. Nehru Stadium, Ernakulam North & South Stations, major hospitals and colleges, GCDA Office, KSRTC Bus-stand at Alwaye Kaloor, Malayalam Manorama etc.

Maintenance Depot for the corridor is located in vacant land in Muttom area on National High way adjacent to the Metro corridor. Since land is a very scarce commodity in Kochi, the alignment has been so chosen that land requirement is reduced to the minimum. Acquisition of private property has also been kept to bare minimum.

Land is normally required for the following:

i) Metro structures along the Alignment, Station building, Platforms, Entry and Exit structures, Traffic integration facilities, etc.
ii) Depot/Car shed.
iii) Receiving and Traction Sub stations.
iv) Property Development.
v) Temporary Construction Depots and work sites

5.7.1 Land for Elevated Stretches

For elevated section, single pier supporting the viaduct will generally be located on the median of road so that the existing roads remain in use as usual. Accordingly, necessary permission for using such right-of-way will have to be obtained from the concerned authorities. Elevated stations are generally proposed with elevated concourse so that land requirement for locating the entry/exit structures is only required. A minimum land is also proposed to be required for traffic integration facilities at individual stations. In stretches, where the elevated alignment has to be located away from road, a strip of 20-m width, is proposed for acquisition.

For construction of elevated structures required land will, however, be temporarily occupied during the construction phase.

In addition land is to be acquired for receiving substations. Auxiliary substations are proposed to be provided at concourse level.

5.7.2 Land for Depot

A small stretch of corridor of 1.000 Km length including ramp portion is required on the eastern side of Muttom Station for the approach to the maintenance Depot.

5.7.3 Private Land

In order to keep acquisition of private land to the barest minimum, alignment has been so chosen that it follows the main arterial roads or within the government land. However, in a few stretches private land is to be acquired for providing curves at sharp bends on existing roads. Besides, to negotiate some of the mandatory structural/planning requirements, acquisition of some private land is unavoidable. The displaced persons are to be compensated suitably or rehabilitated near by.

In order to ease the problem of acquisition of the above mentioned private properties, which may result in delay in execution of the project, it is suggested that owners of these properties may be suitably compensated or offered alternative plots of equivalent land in nearby area. In this arrangement, the owners of the affected residential structures will be required to be paid only the monetary compensation for their existing structures, provision for which has been made in the cost estimates under the head 'Rehabilitation'.

The locations/ chainages of the land to be acquired are given in the **Table 5.12**

Table 5.14
LAND REQUIREMENT ON ALWAYE TO PETTA CORRIDOR

S. No.	Chainage (m)	Total Pvt. Land area (sq. m)	Total Govt. Land area (sq. m)	Total Land area (sq. m)
1	0.000 - 160	0.00	8622.56	8622.56
2	160 - 420	0.00	3285.16	3285.16
3	420 - 680	0.00	3051.68	3051.68
4	680 - 920	0.00	3033.32	3033.32
5	920 - 1170	0.00	3049.03	3049.03

S. No.	Chainage (m)	Total Pvt. Land area (sq. m)	Total Govt. Land area (sq. m)	Total Land area (sq. m)
6	1170 - 1410	0.00	3049.90	3049.90
7	1410 - 1590	0.00	1447.43	1447.43
8	1700 - 1900	321.31	2581.99	2903.30
9	2700 - 2850	785.87	1802.12	2587.99
10	3680 - 4500	110123.05	819.74	110942.79
11	4680 - 4760	1704.85	749.19	2454.03
12	5500 - 5980	20352.71	20352.71	40705.42
13	6140 - 6270	2233.38	583.94	2817.32
14	7300 - 7460	1792.86	2640.11	4432.97
15	8080 - 8190	1622.78	1622.78	3245.56
16	9070 - 9220	778.13	1483.30	2261.43
17	10540 - 10670	1299.44	2257.08	3556.51
18	11995 - 12130	355.20	753.75	1108.94
19	12960 - 13120	650.95	650.95	1301.90
20	14060 - 14260	3261.04	3261.04	6522.08
21	15170 - 15310	424.04	615.23	1039.27
22	15660 - 15820	415.82	549.82	965.64
23	16560 - 16780	782.61	2228.01	3010.62
24	16795 - 16940	1012.31	1199.42	2211.72
25	18030 - 18170	575.59	1105.25	1680.83
26	19250 - 19430	0.00	6315.76	6315.76
27	20120 - 20290	0.00	1585.43	1585.43
28	20760 - 20905	1270.08	1270.08	2540.16
29	21780 - 21950	783.32	1571.31	2354.63
30	22360 - 22540	876.32	876.32	1752.64
31	23500 - 23805	4894.50	8105.42	12999.91
32	24765 - 24910	3243.68	3267.97	6511.65
	Total	**159559.82**	**93787.77**	**253347.59**

5.7.4 LAND FOR CONSTRUCTION DEPOTS

Additional land will be required during construction period for setting up of a construction Depots. These will subsequently be used for providing residential accommodation for essential categories of staff for Operation & Maintenance and other related facilities.

Summary of land requirements

Abstract of land requirement for different components of this corridor is given in below

<u>Alwaye - Petta Corridor</u>

A– Government Land

i)	For Maintenance Depot & Construction Depot	-	2.7874
ii)	For Stations & Section	-	6.5913
iii)	**Total Govt. Land**		**9.3787 hectares**

B – Private Land .

ii)	For Maintenance Depot & Construction Depot	-	12.8096
ii)	For Stations & Section	-	3.1463
iii)	**Total Pvt. Land -**		**15.9559 hectares**

C – Total Land to be acquired {A+ B} **<u>25.3347 hectares</u>**

5.8 UTILITY DIVERSION

The proposed Metro alignment is passing along major arterial roads of the city road net work, which are serving Institutional, Commercial and residential areas. Large number of sub-surface, surface and over head utility services, viz. Sewers, water mains, storm water drains, telephone cables, electrical transmission lines, electric poles, traffic signals etc. are existing along the proposed alignment. These utility services are essential and have to be maintained in working order during different stages of construction by temporary / permanent diversions or by supporting in position. As such, these may affect construction and project implementation time schedule / costs, for which necessary planning / action needs to be initiated in advance.

Organisations / Departments responsible for concerned utility services are provided in **Table 5.13**

Table 5.15
ORGANISATION RESPONSIBLE FOR UTILITIES AND SERVICES

S. No.	Organisation/Department	Utility Services
1	Kerala Water Authority	Sewerage and drainage conduits. Water mains, their service lines, including hydrants and fountains etc, water treatment plants, pumping station etc.
2	Cochin Corporation	Roads, Surface water drains, nallahs, street lights, high mast lights etc.
3	Kerala State PWD	Roads, Surface water drains, nallahs etc., pertaining to State Highways & Major District Roads
4	National Highways and NHAI	Roads, Surface water drains, nallahs etc., pertaining to National Highways.
5	Kerala State Electricity Board	Power cables and their appurtenances, pole mounted transformers, power cables of 33 & 11 KVs.
6	Kerala State Electricity Board	H.T. Lines, their pylons, sub-station, etc.
7	Bharat Sanchar Nigham Ltd. (BSNL)	Telecommunication cables, junction boxes, telephone posts, O.H. Lines etc.
8	Office of Commissioner of City Police Kochi	Traffic signal posts, junction boxes and cable connection etc.
9	Reliance Mobile India Ltd.,	Telecommunication cables, junction boxes etc.,
10	Idea, Airtel & Tata Teleservices India Ltd.,	Telecommunication cables, junction boxes etc.,
11	South Railway Chennai (Trivanduram Division)	Sanitary, water supply, electrical cable, telephone cable in station yard & Railway quarters premises.

Assessment of the type and location of underground & above ground utilities running along and across the proposed route alignments has been undertaken with the help of concerned authorities, who generally maintain plans and data of such utility services. Particulars of main utilities i.e. trunk and main sewers / drainage conduits, water mains etc., wherever possible, were also verified at site by correlating their plan location and on site location with the help of man holes. Locations of these utilities have been marked on alignment plans and checked along with concerned agencies at selected sites. In some cases, the manholes are buried under the road surface, which could not be opened for verification.

5.8.1 Diversion of Underground Utilities

While planning for diversion of underground utility services e.g. sewer lines, water pipe lines, cables etc., during construction of Metro alignment, the following guidelines have been adopted:

i) Utility services have to be kept operational during the entire construction period and after completion of project. All proposals should therefore, ensure their uninterrupted functioning.

ii) The elevated viaduct does not pose any serious difficulty in negotiating the underground utility services, especially those running across the alignment. In such situation, the spanning arrangement of the viaduct may be suitably adjusted to ensure that no foundation need be constructed at the location, where utility is crossing the proposed Metro alignment. In case of utility services running along the alignment either below or at very close distance, the layout of piles in the foundations is to be suitably modified such that the utility service is either encased within the foundation piles or remains clear of them.

5.8.2 Utility Diversions

The proposed alignments along the corridor is mainly elevated and running mostly along the central verge of the road except at few locations while negotiating existing/proposed flyovers, curves and other obligatory points etc. The sewer / drainage lines generally exist away from main carriageway. However, in certain stretches, these might have come near the central verge or under main carriageway, as a result of subsequent road widening.

The sewer / drainage lines and water mains running across the alignment and getting affected by the normal location of column foundations are proposed to be taken care of by relocating column supports of viaduct by change in span length or by suitably adjusting the layout of pile foundation. Where, this is not feasible, these utilities lines will be suitably diverted. Provision has been made in the project cost estimate towards diversion of utility service lines.

Details of underground water pipe lines along the corridor affected are indicated in Table 5.14. Only some of these are to be diverted which can be identified at detailed design stage.

Similarly, the affected above ground utilities, viz. street light poles mostly located on the central verge of the roads , electrical poles, Telecom poles, Traffic signal posts and electric transformers etc. are also identified and tabulated here for the corridor and given in Table 5.15 to 5.16

Table 5.16
DETAILS OF AFFECTED WATER LINES

S. No.	CHAINAGE (M)	Description	Affected Length (m)	Position w. r. t Alignment
1	11910	700 mm dia Premo	--	Crossing
2	11910	300 mm dia CI	--	Crossing
3	10900 - 15900	300 mm dia CI	5000	Right
4	10900 - 15900	100 mm dia AC	5000	Right / Left
5	15150	700 mm dia Premo	--	Right
6	14200 - 14900	200 mm dia CI	700	Center
7	14500	100 mm dia AC	--	Crossing
8	16000 - 16650	600 mm dia CI	650	Right
9	16000 - 16650	100 mm dia AC	650	Right
10	16520	150 mm dia CI	--	Crossing
11	16535	150 mm dia CI	--	Crossing
12	16750 – 18240	300 mm dia CI	1490	Left
13	16750 – 18650	700 mm dia Premo	1900	Left
14	16800 – 18200	600 mm dia CI	1400	Right
15	17150	600 mm dia CI	--	Crossing
16	18200	600 mm dia CI	--	Crossing
17	18650	600 mm dia CI	--	Crossing
18	17720	900 mm dia CI	--	Crossing
19	17720 – 18650	900 mm dia CI	930	Right
20	18240	300 mm dia CI	--	Crossing
21	18240 – 18650	300 mm dia CI	410	Left
22	17750 – 18650	600 mm dia CI	900	Left
23	16750 – 18650	100 mm dia AC	1900	Right/Left
24	20250 – 21750	450 mm dia CI	1500	Left
25	21750	450 mm dia CI	--	Crossing

S. No.	CHAINAGE (M)	Description	Affected Length (m)	Position w. r. t Alignment
26	22400 - 24900	350 mm dia CI	--	Left
27	22400 - 24900	400 mm dia Premo	--	Right
28	22400 - 24900	100 mm dia AC	--	Right

TABLE 5.17
DETAILS OF AFFECTED UNDER GROUND ELECTRICAL CABLES

S. No.	Chainage (m)	Description	Position w .r. t Alignment
1	14150	110 KV	Crossing
2	15150	11 KV	Crossing
3	15350	11 KV	Crossing
4	15400	11 KV	Crossing
5	15470	11 KV	Crossing
6	15505	11 KV	Crossing
7	15600	11 KV	Crossing
8	17075	11 KV	Crossing
9	17700	11 KV	Crossing
10	17960	11 KV	Crossing
11	18020	11 KV	Crossing
12	18200	11 KV	Crossing
13	18380	11 KV	Crossing
14	18570	11 KV	Crossing
15	18620	11 KV	Crossing

TABLE 5.18
DETAILS OF AFFECTED ABOVE GROUND ELECTRIC UTILITIES

S. No.	Chainage (m)	KV	Type	Vertical Clearance in (m)
1	470.665	11kv	LT	14.370
2	510.000	11kv	LT	14.370
3	680.270	110kv	HT	10.064
4	1879.320	11kv	LT	8.278
5	2205.050	-	D- line	7.624
6	2310.690	11kv	LT	7.991
7	2355.890	11kv	LT	8.742
8	2426.750	-	D-line	8.317
9	2477.370	66kv	HT	8.044
10	2623.770	66kv	HT	10.280
11	2872.080	-	D-line	7.300
12	2889.000	110kv	HT	10.650
13	3110.200	66kv	HT	9.120
14	3384.120	-	D-line	7.220
15	3454.420	11kv	LT	8.870
16	34873.550	-	D-line	8.480
17	5284.510	110kv	HT	10.789
18	5389.110	11kv	LT	7.545
19	5494.950	110kv	HT	9.038
20	5557.450	-	D-line	8.130
21	5607.730	110kv	HT	8.157
22	6171.810	-	D-line	8.637
23	6294.250	66kv	HT	8.104
24	6821.910	11kv	LT	8.200
25	6876.530	-	D-line	8.2m
26	7468.870	11kv	LT	8.500
27	7503.500	-	D-line	5.750
28	7824.850	11kv	LT	8.250

S. No.	Chainage (m)	KV	Type	Vertical Clearance in (m)
29	8006.570	110kv	HT	19.157
30	8041.400	11kv	LT	8.250
31	8538.840	11kv	LT	7.228
32	8797.170	11kv	LT	7.150
33	8966.670	-	D-line	8.995
34	9087.680	11kv	LT	6.550
35	9367.180	-	D-line	6.603
36	9661.830	-	D-line	6.204
37	9798.900	-	D-line	5.646
38	10030.970	-	D-line	6.854
39	10243.950	-	D-line	6.847
40	10551.000	-	D-line	6.037
41	10645.200	11kv	LT	5.533
42	10904.640	-	D-line	5.647
43	10953.630	-	D-line	6.680
44	11135.380	11kv	LT	6.780
45	11239.100	-	D-line	6.506
46	1132.150	-	D-line	5.950
47	11510.870	-	D-line	5.950
48	11609.130	11kv	LT	7.655
49	11695.740	11kv	LT	7.550
50	11769.600	-	D-line	5.750
51	12101.090	11kv	LT	5.460
52	12144.920	-	D-line	5.650
53	12217.840	11kv	LT	8.478
54	12353.240	-	D-line	5.070
55	12506.790	11kv	LT	5.770
56	12730.600	-	D-line	5.761
57	12968.360	11kv	LT	7.765
58	13019.650	-	D-line	5.540

S. No.	Chainage (m)	KV	Type	Vertical Clearance in (m)
59	13065.060	-	D-line	5.620
60	13052.690	-	D-line	6.480
61	13158.940	11kv	LT	8.386
62	13389.430	-	D-line	5.973
63	13437.830	11kv	LT	6230.000
64	13493.310	-	D-line	5.300
65	13616.380	11kv	LT	8.840
66	13675.282	-	D-line	5.794
67	13769.280	-	D-line	4.735
68	14054.729	11kv	LT	7.600
69	14059.940	-	D-line	5.550
70	14069.010	11kv	LT	6.250
71	14248.810	11kv	LT	6.300
72	14313.700	11kv	LT	6.550
73	14357.620	-	D-line	5.331
74	14501.000	-	D-line	6.110
75	14671.060	-	D-line	5.912
76	14830.340	-	D-line	6.167
77	14968.970	-	D-line	5.974
78	14986.040	11kv	LT	7.102
79	15071.740	11kv	LT	8.772
80	15114.340	11kv	LT	6.462
81	15171.260	11kv	LT	6.389
82	15302.280	-	D-line	6.145
83	15453.685	-	D-line	4.866
84	15559.770	11kv	LT	7.420
85	15662.870	11kv	LT	6.436
86	15782.980	11kv	LT	7.050
87	16147.160	11kv	LT	8.350
88	16264.930	11kv	LT	9.300

S. No.	Chainage (m)	KV	Type	Vertical Clearance in (m)
89	16333.160	11kv	LT	8.550
90	16406.530	11kv	LT	8.450
91	16528.040	11kv	LT	8.660
92	16623.983	11kv	LT	7.500
93	16871.760	-	D-line	5.070
94	17140.510	-	D-line	5.310
95	17149.650	-	D-line	6.790
96	17240.000	11kv	LT	9.000
97	17393.670	-	D-line	5.500
98	17413.970	11kv	LT	9.000
99	17476.600	-	D-line	5.500
100	17521.760	11kv	LT	8.500
101	17722.024	-	D-line	6.500
102	17797.200	11kv	LT	7.150
103	17839.500	-	D-line	6.800
104	17887.264	-	D-line	5.000
105	17935.580	-	D-line	5.000
106	17956.180	-	D-line	5.000
107	17985.350	-	D-line	4.800
108	18005.890	-	D-line	4.200
109	18076.720	-	D-line	5.600
110	18130.640	-	D-line	6.500
111	18210.620	11kv	LT	6.300
112	18304.340	-	D-line	5.800
113	18470.653	-	D-line	6.050
114	18819.760	-	D-line	6.500
115	18959.970	-	D-line	4.500
116	19077.580	-	D-line	6.500
117	19750.580	-	D-line	7.336
118	19754.000	-	11kv	8.439

S. No.	Chainage (m)	KV	Type	Vertical Clearance in (m)
119	19892.550	-	D-line	5.750
120	19941.450	-	D-line	5.663
121	19985.650	-	D-line	5.650
122	20026.750	-	D-line	5.110
123	20128.430	11kv	LT	7.230
124	20218.950	11kv	LT	6.279
125	20321.880	11kv	LT	6.102
126	20383.060	11kv	LT	6.665
127	20463.744	-	D-line	5.940
128	20512.840	-	D-line	8.710
129	20608.810	11kv	LT	6.000
130	20642.780	-	D-line	6.120
131	26722.000	-	D-line	6.840
132	20765.150	-	D-line	6.355
133	20816.425	-	D-line	6.265
134	20881.879	-	D-line	5.400
135	20929.900	-	D-line	6.150
136	20989.470	11kv	LT	6.000
137	21104.230	11kv	LT	7.860
138	21181.130	-	D-line	5.480
139	21220.730	11kv	LT	5.180
140	21277.500	-	D-line	6.350
141	21313.670	11kv	LT	4.860
142	21487.730	11kv	LT	7.890
143	21600.450	-	D-line	5.570
144	21679.770	11kv	LT	8.210
145	21824.900	-	D-line	6.220
146	21903.360	-	D-line	5.400
147	21959.321	11kv	LT	5.870
148	22028.840	-	D-line	7.200

S. No.	Chainage (m)	KV	Type	Vertical Clearance in (m)
149	22047.260	-	D-line	5.430
150	22088.540	-	D-line	6.340
151	22109.380	11kv	D-line	5.824
152	22235.315	-	LT	5.740
153	22330.060	-	D-line	5.340
154	22361.100	-	LT	5.800
155	22515.843	11kv	LT	7.960
156	22622.650	11kv	LT	7.955
157	22891.240	-	D-line	6.405
158	23070.550	66kv	HT	10.380
159	23087.550	11kv	LT	7.765
160	23286.500	-	D-line	5.600
161	23394.720	11kv	LT	6.190
162	23450.970	-	D-line	5.550
163	23523.100	-	LT	5.850
164	23532.220	11kv	HT	19.318
165	23736.920	-	D-line	5.550
166	23859.520	-	D-line	5.775
167	24006.130	-	D-line	5.950
168	24097.490	-	D-line	6.530
169	24420.520	11kv	LT	6.722
170	24774.870	-	D-line	5.820
171	24962.820	11kv	HT	15.950
172	24985.880	-	D-line	6.260
173	25054.470	11kv	LT	6.000
174	25575.550	11kv	LT	6.800
175	25827.780	11kv	LT	7.510
176	25844.210	-	D-line	6.830
177	25918.680	-	D-line	7.580
178	26060.190	11kv	LT	8.360

S. No.	Chainage (m)	KV	Type	Vertical Clearance in (m)
179	26135.940	11kv	LT	6.555
180	26157.060	-	D-line	5.410
181	26499.250	11kv	LT	6.830
182	26622.560	11kv	LT	5.820
183	26720.870	-	D-line	6.200
184	26947.220	-	D-line	6.767
185	27015.420	-	D-line	6.700

D-line – Distribution Line, HT – High Tension Line, LT – Low Tension Line

In addition to above utilities traction masks, railway station posts, power poles, signal poles, telephone poles, light poles and telephone junction boxes are also affected and the details of such affected utilities are as follows:

TABLE 5.19

S. No.	Description	Total number of affect No. of Utilities
1	Traction Mask	32
2	Rly Signal Post	3
3	Power Pole	494
4	Signal Pole	25
5	Telephone Pole	39
6	Light Pole	351
7	Telephone Junction Box	36

5.9 PROPOSED ROAD-OVER-BRIDGES/FLYOVERS

5.9.1 ROBs AT PULLEPADY AND NEAR KSRTC BUS STAND

Two Road-Over-Bridges (ROBs) across the railway track between Ernakulam town and Ernakulam junction railway stations – one at Pullepady level crossing since completed and the other near KSRTC bus stand connecting Mullassery Canal Road and Salim Rajan Road on either sides of the railway track now taken up have been planned by State government.

The ROB near KSRTC bus stand is awarded. The proposal has been jointly sponsored by the Government of Kerala.

Completion of these two ROBs will substantially relieve the present traffic congestion on MG Road and Banerji Road as well as on Salim Rajan Road by diversion of traffic towards Kaloor, Pallarivattom, Kakkanad, Thammanam, Vytilla, etc.

Since construction of Kochi Metro structures on the median of Banerji Road and MG Road will hamper the movement of road vehicles during the execution period, the State Government and the GCDA authorities have been apprised the necessity for early completion of the above two ROBs.

5.9.2 PROPOSED FLYOVER AT EDAPALLY

Edapally bye pass junction is strategically a very important location as it is the merging point of NH 47. Before the formation of NH bypass from Aroor to Edapally, the NH 47 was passing through the CBD area of the city. At present Edapally junction is a staggered intersection where Alwaye – Ernakulam route is intersected by NH 47 – bypass and NH17 within a distance of 70m and hence it causes a lot of traffic confusion. There is a proposal by the National Highway Department to rectify the staggering to make a four-legged intersection. There is another proposal by Government to construct a four-lane flyover on the Alwaye-Ernakulam Road.

In case the proposal of National Highway Department to rectify the staggering to make 4-legged intersection is taken up, it will not affect the Metro alignment. If later, the flyover proposal by GCDA on Alwaye – Ernakulam Road at this junction is also taken up, the Metro alignment will go alongside it. This way Metro and flyover will not obstruct each other. If slight revision of Metro alignment is required, this can be done without any problem.

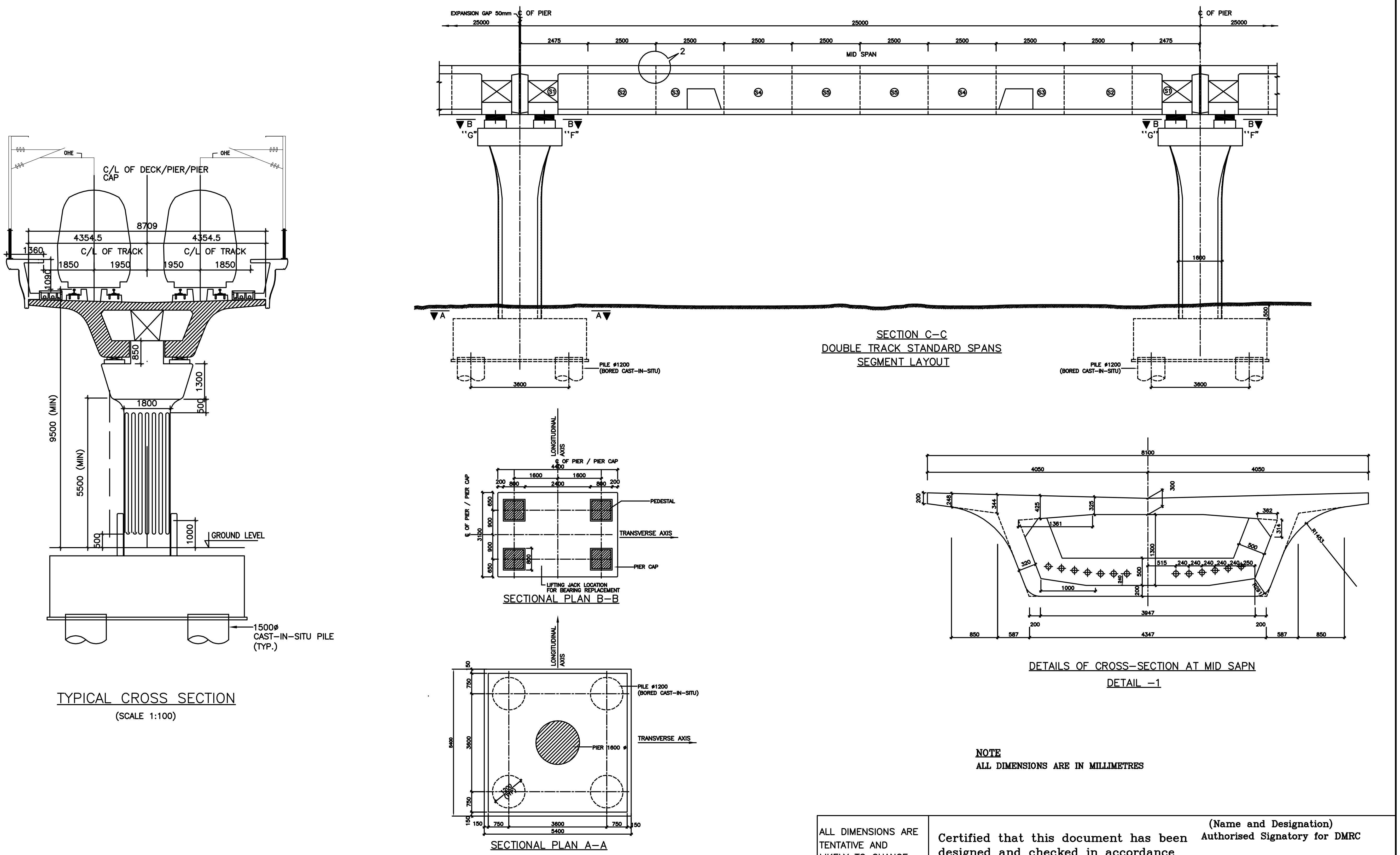
5.9.3 FLYOVER FRM PALARIVATTOM JN AT NH 47 BYPASS TO HIGH COURT JUNCTION

The proposal aims to relieve traffic congestion on the major city road which has the highest volume of traffic by creating a flyover or a grade separator to take through traffic. The flyover will be 4582m long and is to be designed to carry 2 lanes and hence its width is kept as 8.5m supported on a central pillars. The pillars are provided at 25m centre to centre. The width of existing road at this location is not adequate to accommodate the proposed flyover along with Kochi Metro. Besides, with the construction of Kochi Metro which will relieve substantial amount of traffic moving on the existing road, the need of flyover may not be necessary. It is, therefore, suggested that the State Government may give up the proposal of fly-over at this location.

5.9.4 PROPOSED FLYOVER AT VYTILLA

GCDA has a proposal for constructing flyover at Vytilla Junction across NH 47 bye-pass, whose alignment will be the same as that of Kochi Metro at this location. Road width at this location is not adequate to accommodate proposed flyover as well as Kochi Metro. It is, therefore, suggested that the Metro should be constructed along the Median of road, while NHAI should change its proposal of flyover to that of an underpass below the NH 47 bye-pass. Changing the fly-over to under-pass will be a much more cost effective for the State Government, than to allow construction of flyover as well as Kochi Metro with double elevation at this location. It is, therefore, strongly recommended hat GCDA should revise the above proposal and plan the construction of the underpass along with the construction of Kochi Metro. Kochi Metro will be designed to cater for the underpass.

Fig.No.5.1



NOTE
ALL DIMENSIONS ARE IN MILLIMETRES

ALL DIMENSIONS ARE TENTATIVE AND LIKELY TO CHANGE DURING DETAIL DESIGN

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VERIFIED BY	
DATE	

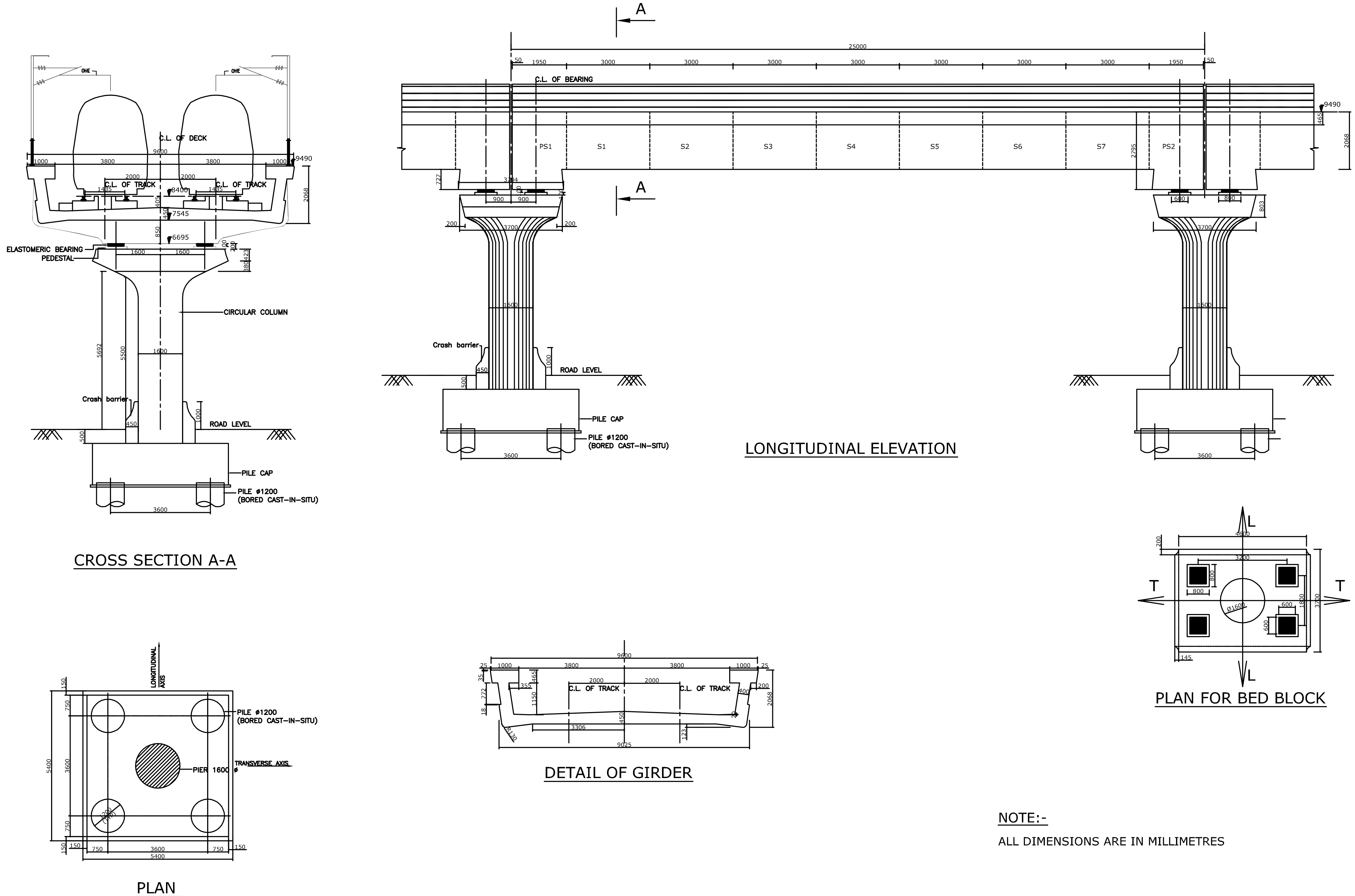
KOCHI METRO PROJECT
GENERAL ARRANGEMENT OF STANDARD SPAN
BOX GIRDER WITH EXTERNAL PRESTRESSING
FIGURE- 5.1

DRG. NO.	REV.	SCALE	STATUS

STRUCTURAL

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

FIGURE-5.4



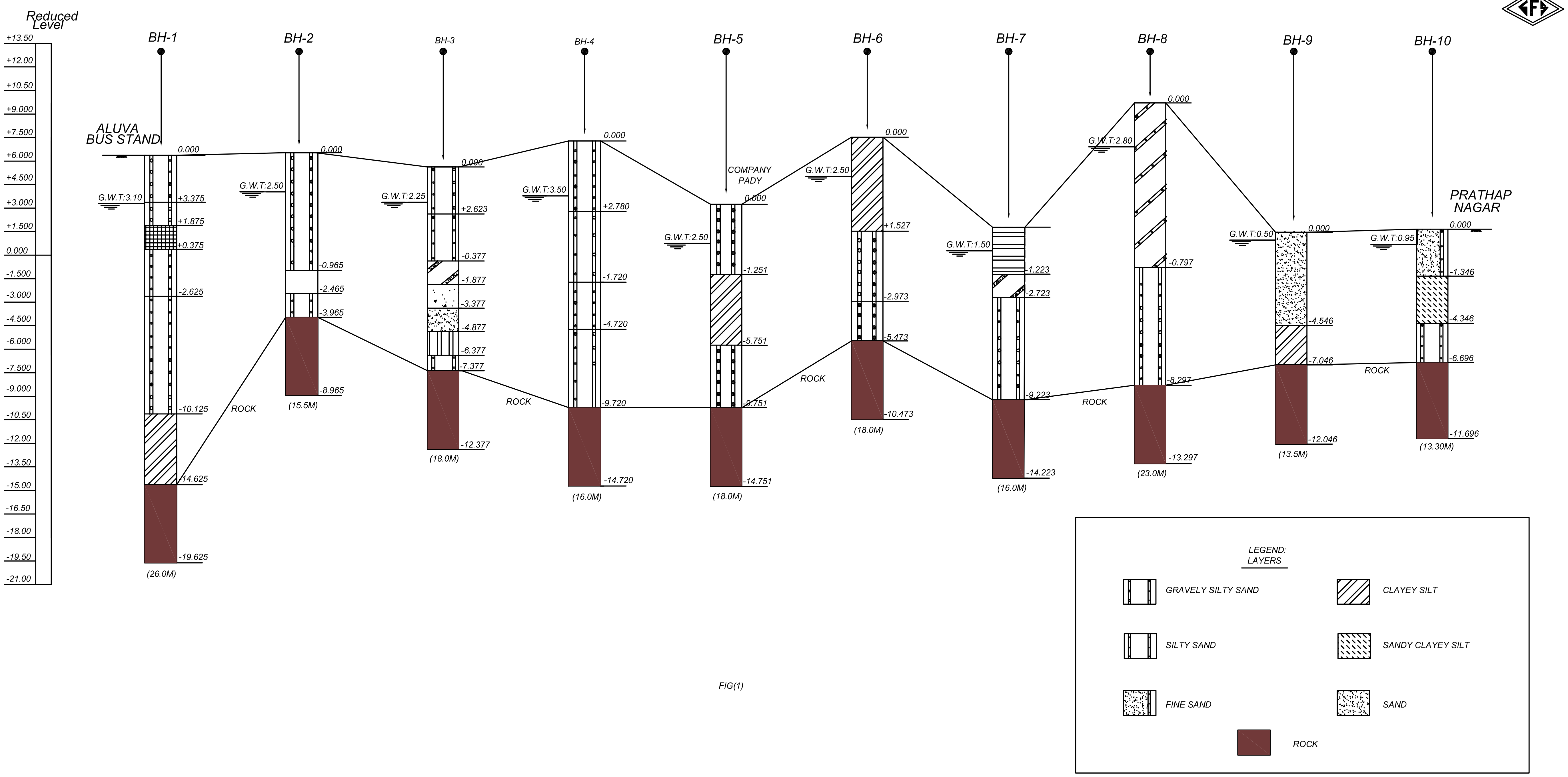
NOTE:-

ALL DIMENSIONS ARE IN MILLIMETRES

Kochi Metro Project
GENERAL ARRANGEMENT OF VIADUCT U-GIRDER WITH INTERNAL PRESTRESSING
Figure 5.2

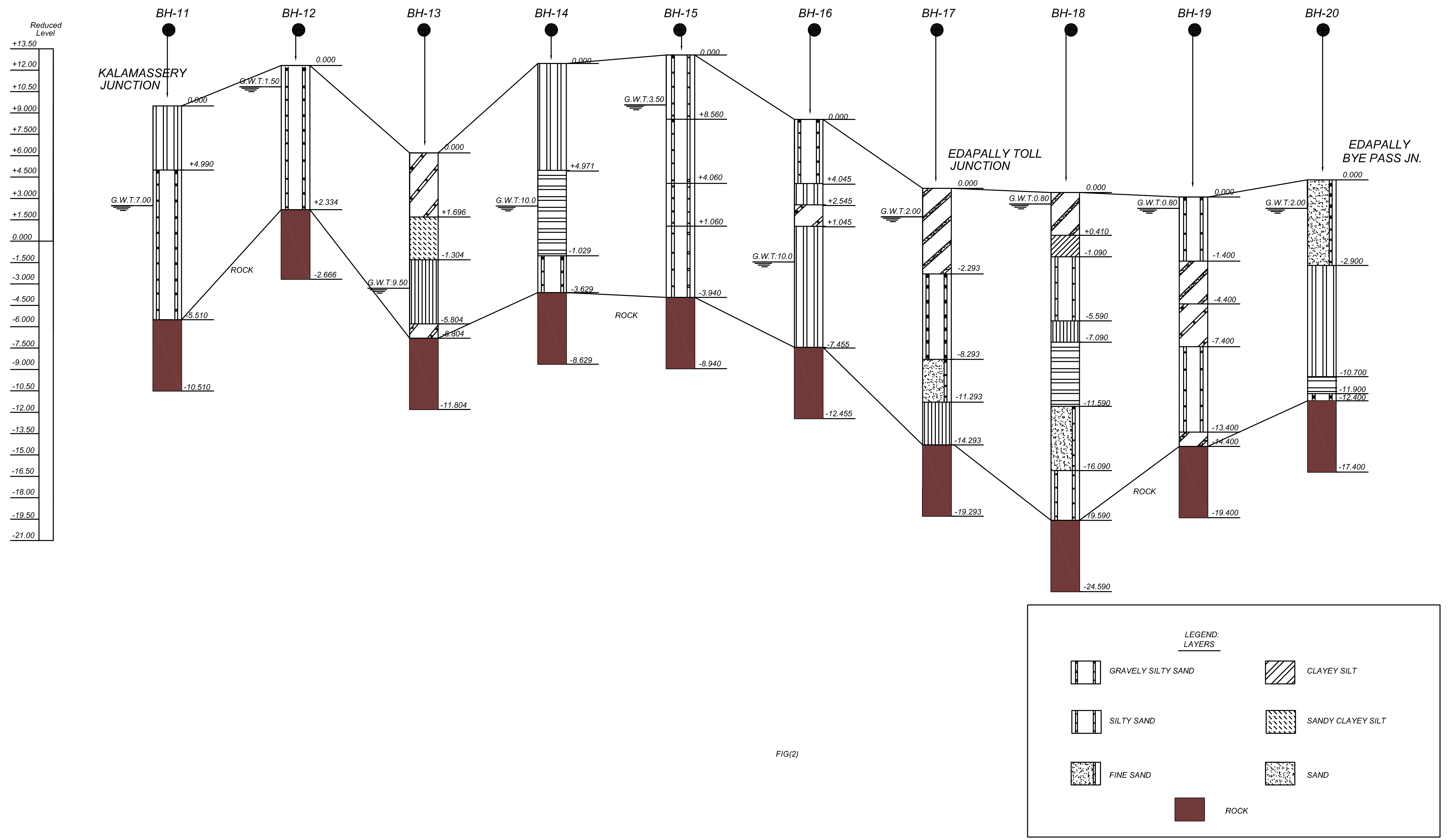
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT
PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

SUB SURFACE PROFILE



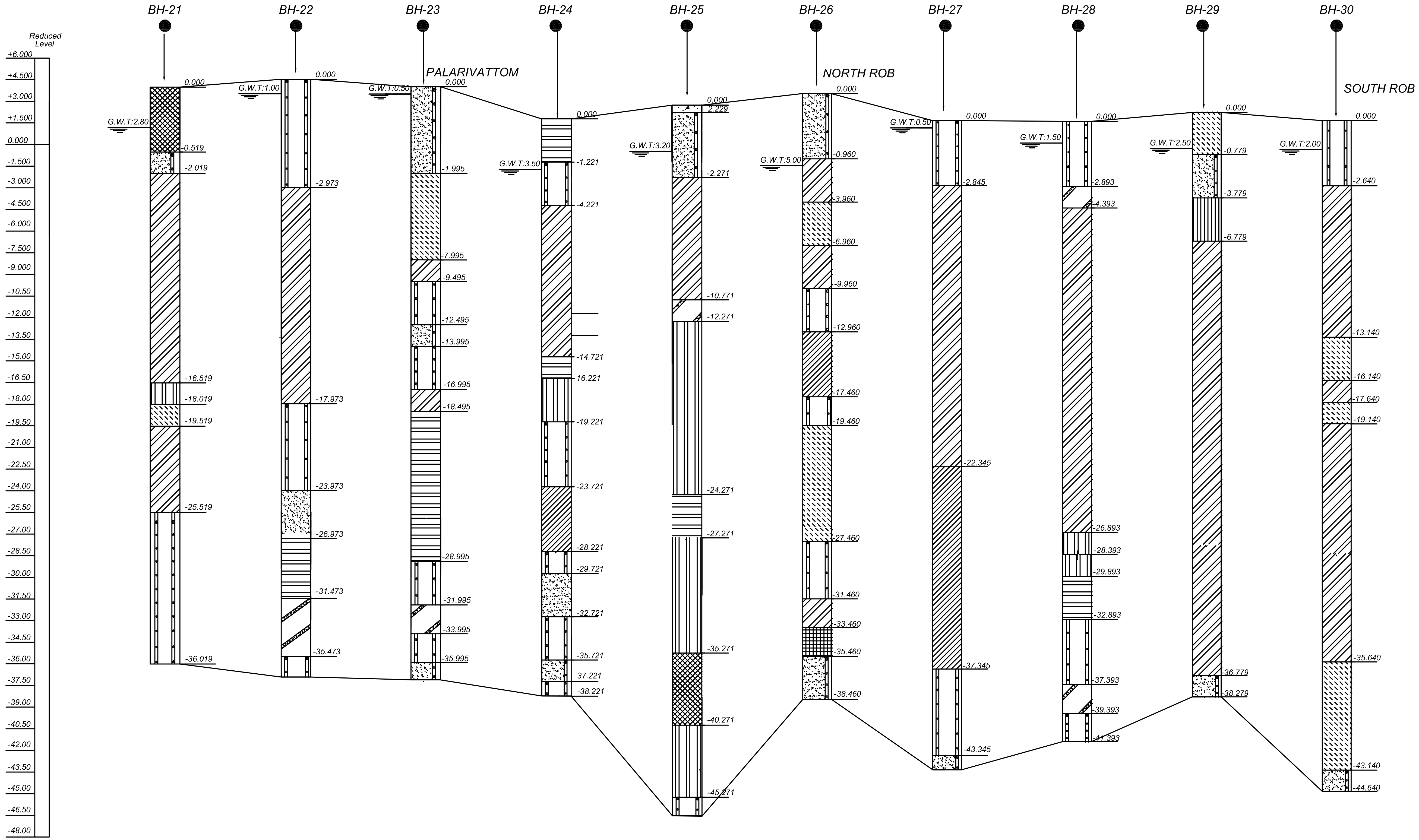
FIG(1)

SUB SURFACE PROFILE



FIG(2)

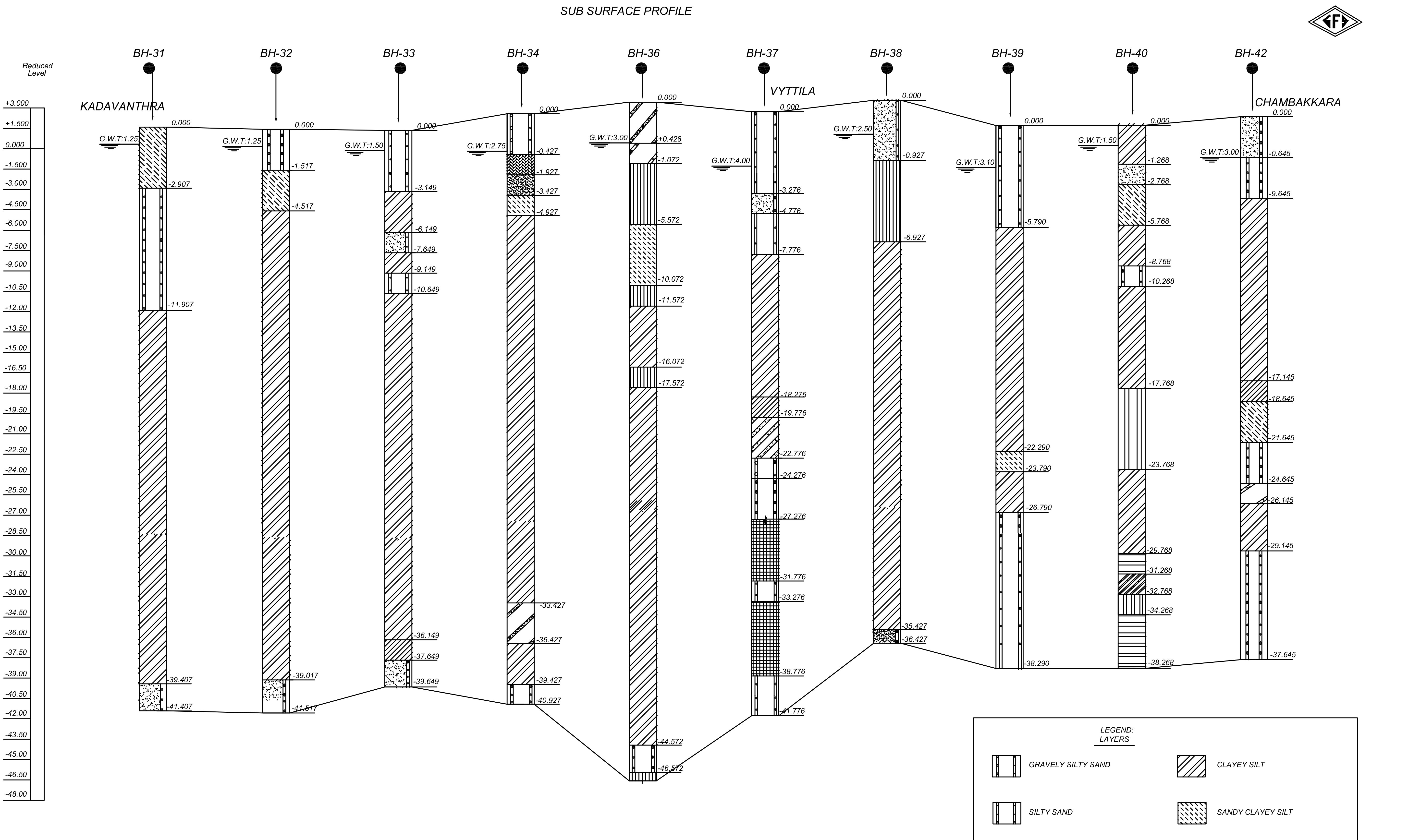
SUB SURFACE PROFILE



LEGEND:
LAYERS

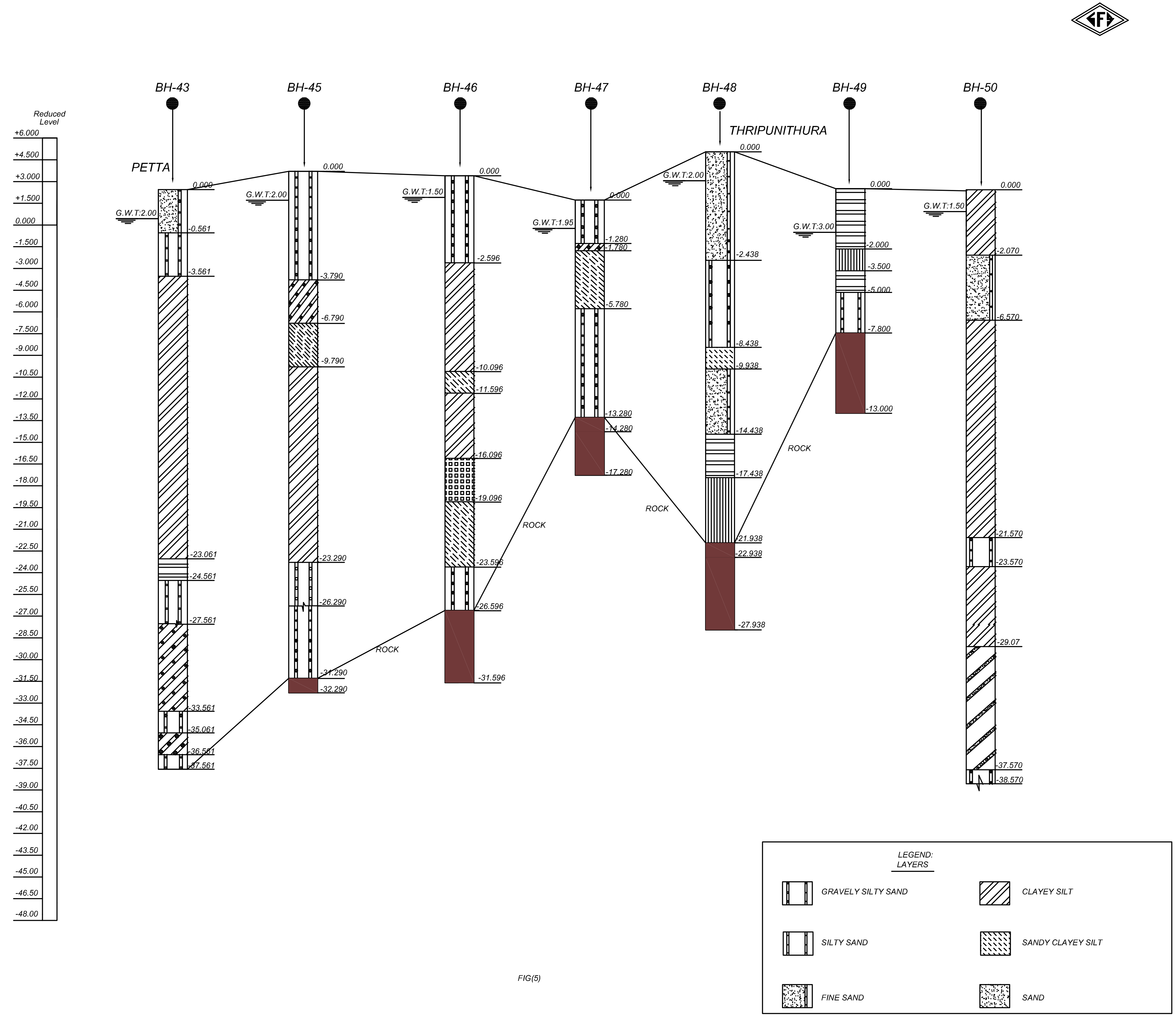
GRAVELY SILTY SAND	CLAYEY SILT
SILTY SAND	SANDY CLAYEY SILT
FINE SAND	SAND

FIG(3)


SUB SURFACE PROFILE
BH-31
BH-32
BH-33
BH-34
BH-36
BH-37
BH-38
BH-39
BH-40
BH-42
KADAVANTHRA
VYTTILA
CHAMBAKKARA
Reduced Level
LEGEND:
LAYERS
GRAVELY SILTY SAND
CLAYEY SILT
SILTY SAND
SANDY CLAYEY SILT
FINE SAND
SAND

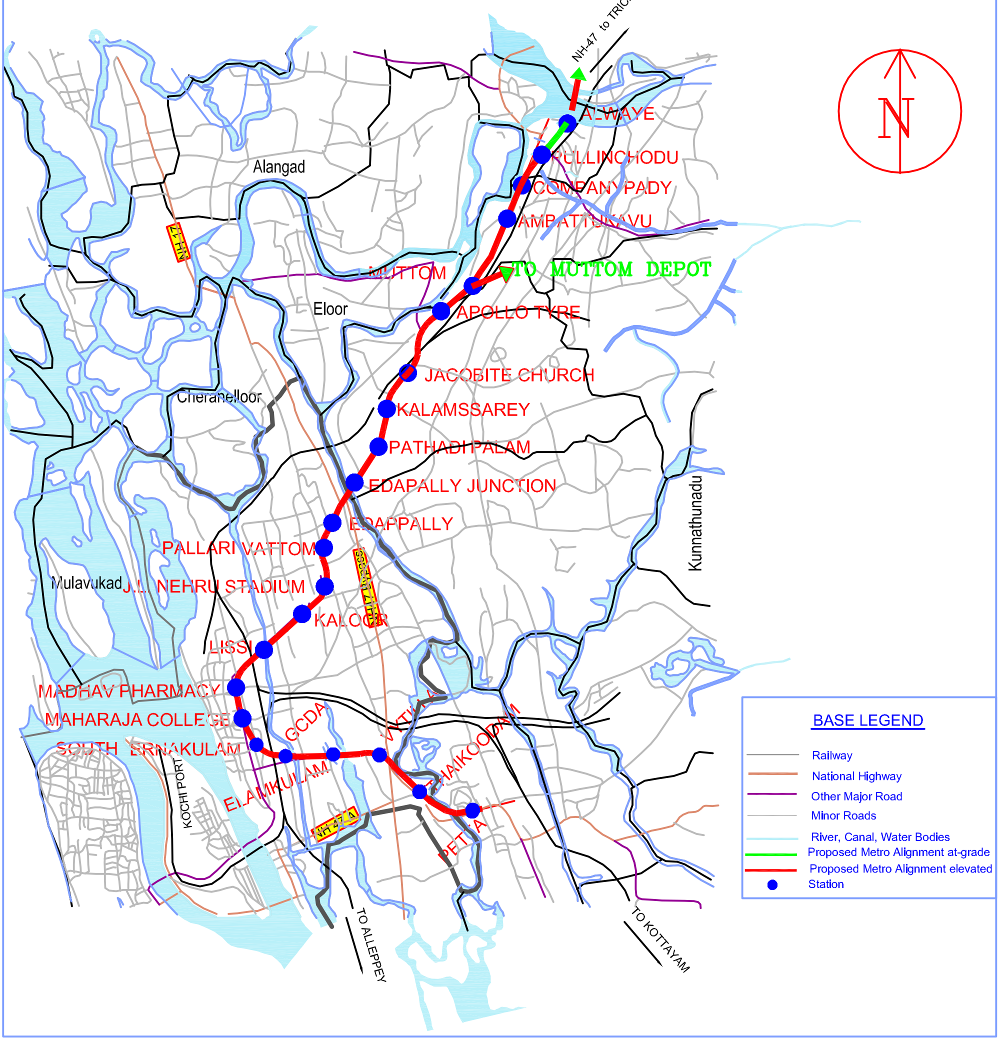
FIG(4)

SUB SURFACE PROFILE



FIG(5)

KEY PLAN
KOCHI METRO (ALWAYE– PETTA CORRIDOR)



Chapter 6

Train Operation Plan

6.1 Operation Philosophy

The underlying operation philosophy is to make the MRT System more attractive and economical, the main features being:

- Selecting the most optimum frequency of Train services to meet sectional capacity requirement during peak hours on most of the sections.
- Economical & optimum train service frequency not only during peak period, but also during off-peak period.
- A short train consists of 3 coaches with high frequency service.
- Multi-tasking of train operation and maintenance staff.

6.2 Stations

List of stations for Alwaye - Petta Corridor of Kochi Metro are given below:

ALWAYE – PETTA CORRIDOR				
S.No	**Name of Stations**	**Change (in km)**	**Inter – Station Distance (in km)**	**Remarks**
1	Alwaye	-0.090	-	Elevated
2	Polinchodu	1.814	1.904	Elevated
3	Companypady	2.756	0.942	Elevated
4	Ambattukaru	3.764	1.008	Elevated
5	Muttom	4.723	0.959	Elevated
6	Appolo Tyre	6.209	1.486	Elevated
7	Jacobite Chruch	7.399	1.190	Elevated
8	Kalamassarey	8.144	0.745	Elevated
9	Pathadipalam	9.146	1.002	Elevated

ALWAYE – PETTA CORRIDOR				
S.No	**Name of Stations**	**Change (in km)**	**Inter – Station Distance (in km)**	**Remarks**
10	Edapally Junction	10.599	1.453	Elevated
11	Edapally	12.023	1.424	Elevated
12	Palari Vattom	13.071	1.048	Elevated
13	J.L.Nehru Stadium	14.126	1.055	Elevated
14	Kaloor	15.221	1.095	Elevated
15	Lissi Junction	15.711	0.490	Elevated
16	Madhav Pharmacy	16.899	1.188	Elevated
17	Maharaja College	18.103	1.204	Elevated
18	Ernakulam South	19.332	1.229	Elevated
19	GCDA	20.185	0.853	Elevated
20	Elamkulam	21.341	1.156	Elevated
21	Vythilla	22.447	1.106	Elevated
22	Thaikoodam	23.703	1.256	Elevated
23	Petta	24.822	1.119	Elevated

6.3 Train Operation Plan

6.3.1 The salient features of the proposed train operation plan are:

- Running of services for 19 hours of the day (5 AM to Midnight) with a station dwell time of 30 seconds,
- Make up time of 5-10% with 8-12% coasting.
- Scheduled speed for these corridors has been taken as 33 Kmph on account of higher inter-station distances.

6.3.2 Traffic Demand

Peak hour peak direction traffic demands (PHPDT) for the Alwaye – Petta Corridor for the year 2015, 2020 and 2025 for the purpose of planning are indicated in Attachment I/A, B and C respectively and has been taken as the maximum of the PHPDT in the forward & reverse directions.

6.3.3 Train formation

To meet the above projected traffic demand, the possibility of running trains with composition of 3 Car has been examined.

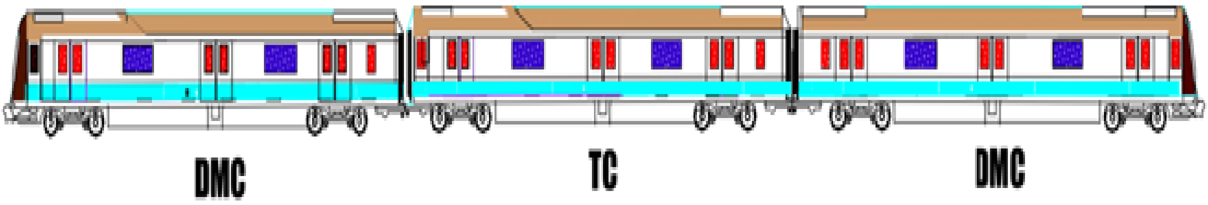
The basic unit of 3-car train comprising of DMC-TC- DMC configuration has been selected for the Alwaye – Petta Corridor for the year 2015, 2020 & 2025.

Composition

DMC : Driving Motor Car
TC : Trailer Car
3 Car Train Composition DMC + TC + DMC

Capacity

DMC : 191 passenger (Sitting-35, Crush Standing-156)
TC : 218 passenger (Sitting-44, Crush Standing-174)
3 Car Train: 600 Passengers (Sitting-114, Crush Standing-486)



3 Car Composition

6.3.4 Train Operation Plan

Based on the projected PHPDT demand, train operation has been planned for Alwaye – Petta Corridor for the year 2015, 2020 and 2025 as detailed below:

<u>Alwaye – Petta Corridor</u>
Train operation plan with train carrying **capacity @ 6 persons per square meter of standee area** on Alwaye – Petta Corridor is given below:

- **Year 2015** (Refer Attachment I/A)

Train operation with **3 car Trains** with headway of **5 min** between Alwaye – Petta is planned in the first year of operation i.e. **2015** with Peak Hour Peak Direction Capacity of **7200@ 6 persons per square meter of standee area (Capacity of 9144@ 8 persons per square meter of standee area under dense loading conditions)**.
The maximum PHPDT demand of 13681 is in the Section between Kaloor and Lissi Junction and the PHPDT demand in the section between Edapally Junction and Edapally is 13266, demand in the remaining sections is in the range of 13216 to 1481 only. The planned capacity of 7200(9144 under dense loading) is less than the PHPDT demand in twelve (eleven, with dense loading capacity) sections out of twenty two sections. With this planned PHPDT capacity, optimum utilization of Rolling Stock will be achieved and empty running of trains will be considerably reduced. However, the Rolling Stock is designed for carrying higher density loading @ 8 standee passengers per square meter and in the sections in which PHPDT capacity exceeds the planned capacity, overloading during these periods will help in reducing the demand for increased deployment of Rolling Stock. Traffic demand and train capacity for this corridor in the year 2015 is tabulated and represented on a chart enclosed as Attachment I/A.

- **Year 2020** (Refer Attachment I/B)

Train operation with **3 car Trains** with headway of **4 min** between Alwaye – Petta is planned in the year **2020** with Peak Hour Peak Direction Capacity of **9000 @ 6 persons per square meter of standee area (Capacity of 11430 @ 8 persons per square meter of standee area under dense loading conditions)**.
The maximum PHPDT demand of 17663 is in the Section between Edapally and Palari Vattom and the PHPDT demand in the section between Lissi Junction and Madhav Pharmacy is 17555, demand in the remaining sections is in the range of 16784 to 1685 only. The planned capacity of 9000 (11430 under dense loading) is less than the PHPDT demand in twelve (twelve, with dense loading capacity) sections out of twenty two sections. With this planned PHPDT capacity, optimum utilization of Rolling Stock will be achieved and empty running of trains will be considerably reduced. However, the Rolling Stock is designed for carrying higher density loading @ 8 standee passengers per square meter and in the sections in which PHPDT capacity exceeds the planned capacity, overloading during these periods will help in reducing the demand for increased deployment of Rolling Stock. Traffic demand and train capacity for this corridor in the year 2020 is tabulated and represented on a chart enclosed as Attachment I/B.

- **Year 2025** (Refer Attachment I/C)

Train operation with **3 car Trains** with headway of **3 min** between Alwaye – Petta is planned in the year **2025** with Peak Hour Peak Direction Capacity of **12000 @ 6 persons per square meter of standee area (Capacity of 15240 @ 8 persons per square meter of standee area under dense loading conditions)**.

The maximum PHPDT demand of 21065 is in the Section between Edapally and Palari Vattom and the PHPDT demand in the section between Pathadipalam and Edapally Junction is 20623, demand in the remaining sections is in the range of 19065 to 2049 only. The planned capacity of 12000 (15240 under dense loading) is less than the PHPDT demand in thirteen (eleven, with dense loading capacity) sections out of twenty two sections. With this planned PHPDT capacity, optimum utilization of Rolling Stock will be achieved and empty running of trains will be considerably reduced. However, the Rolling Stock is designed for carrying higher density loading @ 8 standee passengers per square meter and in the sections in which PHPDT capacity exceeds the planned capacity, overloading during these periods will help in reducing the demand for increased deployment of Rolling Stock. Traffic demand and train capacity for this corridor in the year 2025 is tabulated and represented on a chart enclosed as Attachment I/C.

In case of any mismatch in the capacity provided and the actual traffic, the capacity can be moderated suitably by adjusting the Headway. The PHPDT capacity provided on this corridor in different years of operation is tabulated below:

Capacity Provided

LINE	YEAR		
Alwaye – Peta Corridor	**2015**	**2020**	**2025**
Cars/trains	**3**	**3**	**3**
Head way (Minutes)	**5**	**4**	**3**
Max. PHPDT Demand	**13681**	**17663**	**21065**
PHPDT Capacity Available	**7200 (9144*)**	**9000 (11430*)**	**12000 (15240*)**

* @ 8 persons per square meter of standee area

6.3.5 Train frequency

Alwaye –Petta Corridor

The train operation Alwaye – Petta Corridor provides for the following:

a) The train operation plan provides for **5 min.** Headway with 3 – Car train in Alwaye – Petta Corridor during peak hours and **15 min** headway during lean hours in the year 2015.
b) The train operation plan provides for **4 min.** Headway with 3 – Car train in Alwaye – Petta Corridor during peak hours and **15 min** headway during lean hours in the year 2020.
c) The train operation plan provides for **3 min.** Headway with 3 – Car train in Alwaye – Petta Corridor during peak hours and **15 min** headway during lean hours in the year 2025.
d) No services are proposed between 00.00 hrs to 5.00 hrs, which are reserved for maintenance of infrastructure and rolling stock.

6.3.6 Hourly Train Operation plan

The hourly distribution of daily transport capacity is presented in **Table 1.1, 1.2 & 1.3** for years 2015, 2020 & 2025 for Alwaye - Petta Corridor and enclosed as Attachment II. Number of train trips per direction per day is worked out as 150 in the year 2015, 178 in the year 2020 and 216 for in the year 2025. The directional split is presented in **Table 2** enclosed as Attachment III.

6.3.7 Vehicle Kilometer

Based on above planning, after considering maintenance period and assuming 340 days in service in a year, Vehicle Kilometers for Alwaye- Petta Corridor is given in **Table 3** enclosed as Attachment IV.

6.4 Year wise rake Requirement

Based on Train formation and headway as decided above to meet Peak Hour Peak Direction Traffic Demand, Rake requirement has been calculated and enclosed as Attachment V & has been tabulated below:

Corridor	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches
Alwaye – Petta Corridor	2015	5	22	3 car	66
	2020	4	27	3 car	81
	2025	3	36	3 car	108

Requirements of coaches is calculated based on following assumptions-

Assumptions -

(i) Train Composition planned as under
- 3 Car Train Composition : DMC-TC-DMC
  Train Carrying Capacity of 3 Car Train : 600 passengers

(ii) Coach requirement has been calculated based on headway during peak hours.

(iii) Traffic reserve is taken as one train to cater to failure of train on line and to make up for operational time lost.

(iv) Repair and maintenance reserve has been estimated as 8 % of total requirement (Bare +Traffic Reserve).

(v) The calculated number of rakes in fraction is rounded off to next higher number.

(vi) Schedule speed is taken as 33 KMPH.

(vii) Total Turn round time is taken as 6 min at terminal stations.

Attachment - I/A

PHPDT Demand and Capacity Chart

Kochi Metro : Alwaye - Petta Corridor

Year:	**2015**
No. of Cars per Train:	**3**
Passenger Capacity @ 6 persons/sqm of a 3-Car Train:	**600**
Passenger Capacity @ 8 persons/sqm of a 3-Car Train:	**762**
Headway (min)	**5**

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	Alwaye	Polinchodu	3780	7200	9144
2	Polinchodu	Companypady	5035	7200	9144
3	Companypady	Ambattukaru	8450	7200	9144
4	Ambattukaru	Muttom	11594	7200	9144
5	Muttom	Appolo Tyre	11594	7200	9144
6	Appolo Tyre	Jacobite Chruch	11897	7200	9144
7	Jacobite Chruch	Kalamassarey	12037	7200	9144
8	Kalamassarey	Pathadipalam	13016	7200	9144
9	Pathadipalam	Edapally Junction	13216	7200	9144
10	Edapally Junction	Edapally	13266	7200	9144
11	Edapally	Palari Vattom	11695	7200	9144
12	Palari Vattom	J.L.Nehru Stadium	12481	7200	9144
13	J.L.Nehru Stadium	Kaloor	12928	7200	9144
14	Kaloor	Lissi Junction	**13681**	7200	9144
15	Lissi Junction	Madhav Pharmacy	5247	7200	9144
16	Madhav Pharmacy	Maharaja College	3132	7200	9144
17	Maharaja College	Ernakulam South	2853	7200	9144
18	Ernakulam South	GCDA	1557	7200	9144
19	GCDA	Elamkulam	1524	7200	9144
20	Elamkulam	Vythilla	1558	7200	9144
21	Vythilla	Thaikoodam	1502	7200	9144
22	Thaikoodam	Petta	1481	7200	9144

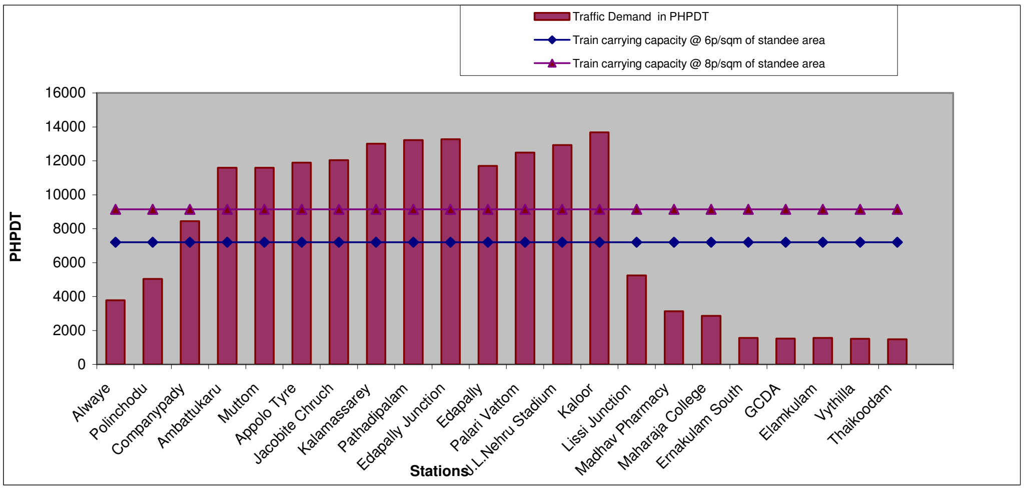


Fig 1.1

Attachment - I/B

PHPDT Demand and Capacity Chart

Kochi Metro : Alwaye - Petta Corridor

Year:	**2020**
No. of Cars per Train:	**3**
Passenger Capacity @ 6 persons/sqm of a 3-Car Train:	**600**
Passenger Capacity @ 8 persons/sqm of a 3-Car Train:	**762**
Headway (min)	**4**

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	Alwaye	Polinchodu	5783	9000	11430
2	Polinchodu	Companypady	5783	9000	11430
3	Companypady	Ambattukaru	7943	9000	11430
4	Ambattukaru	Muttom	13158	9000	11430
5	Muttom	Appolo Tyre	13158	9000	11430
6	Appolo Tyre	Jacobite Chruch	13736	9000	11430
7	Jacobite Chruch	Kalamassarey	13778	9000	11430
8	Kalamassarey	Pathadipalam	13778	9000	11430
9	Pathadipalam	Edapally Junction	14756	9000	11430
10	Edapally Junction	Edapally	14762	9000	11430
11	Edapally	Palari Vattom	**17663**	9000	11430
12	Palari Vattom	J.L.Nehru Stadium	15463	9000	11430
13	J.L.Nehru Stadium	Kaloor	16119	9000	11430
14	Kaloor	Lissi Junction	16784	9000	11430
15	Lissi Junction	Madhav Pharmacy	17555	9000	11430
16	Madhav Pharmacy	Maharaja College	7478	9000	11430
17	Maharaja College	Ernakulam South	5051	9000	11430
18	Ernakulam South	GCDA	3297	9000	11430
19	GCDA	Elamkulam	2001	9000	11430
20	Elamkulam	Vythilla	1857	9000	11430
21	Vythilla	Thaikoodam	1707	9000	11430
22	Thaikoodam	Petta	1685	9000	11430

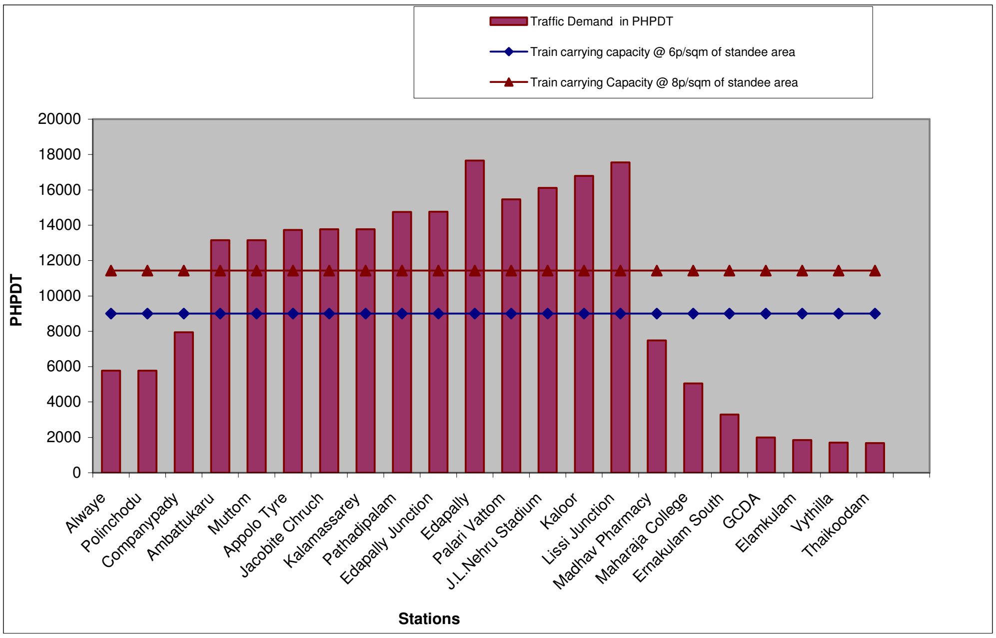


Fig 1.2

Attachment - I/C

PHPDT Demand and Capacity Chart

Kochi Metro : Alwaye - Petta Corridor

Year:	**2025**
No. of Cars per Train:	**3**
Passenger Capacity @ 6 persons/sqm of a 3-Car Train:	**600**
Passenger Capacity @ 8 persons/sqm of a 3-Car Train:	**762**
Headway (min)	**3**

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	Alwaye	Polinchodu	7359	12000	15240
2	Polinchodu	Companypady	9215	12000	15240
3	Companypady	Ambattukaru	13473	12000	15240
4	Ambattukaru	Muttom	14138	12000	15240
5	Muttom	Appolo Tyre	15726	12000	15240
6	Appolo Tyre	Jacobite Chruch	15996	12000	15240
7	Jacobite Chruch	Kalamassarey	17671	12000	15240
8	Kalamassarey	Pathadipalam	18772	12000	15240
9	Pathadipalam	Edapally Junction	20623	12000	15240
10	Edapally Junction	Edapally	19065	12000	15240
11	Edapally	Palari Vattom	**21065**	12000	15240
12	Palari Vattom	J.L.Nehru Stadium	17564	12000	15240
13	J.L.Nehru Stadium	Kaloor	17795	12000	15240
14	Kaloor	Lissi Junction	17659	12000	15240
15	Lissi Junction	Madhav Pharmacy	18418	12000	15240
16	Madhav Pharmacy	Maharaja College	11206	12000	15240
17	Maharaja College	Ernakulam South	8243	12000	15240
18	Ernakulam South	GCDA	4488	12000	15240
19	GCDA	Elamkulam	4083	12000	15240
20	Elamkulam	Vythilla	3730	12000	15240
21	Vythilla	Thaikoodam	2074	12000	15240
22	Thaikoodam	Petta	2049	12000	15240

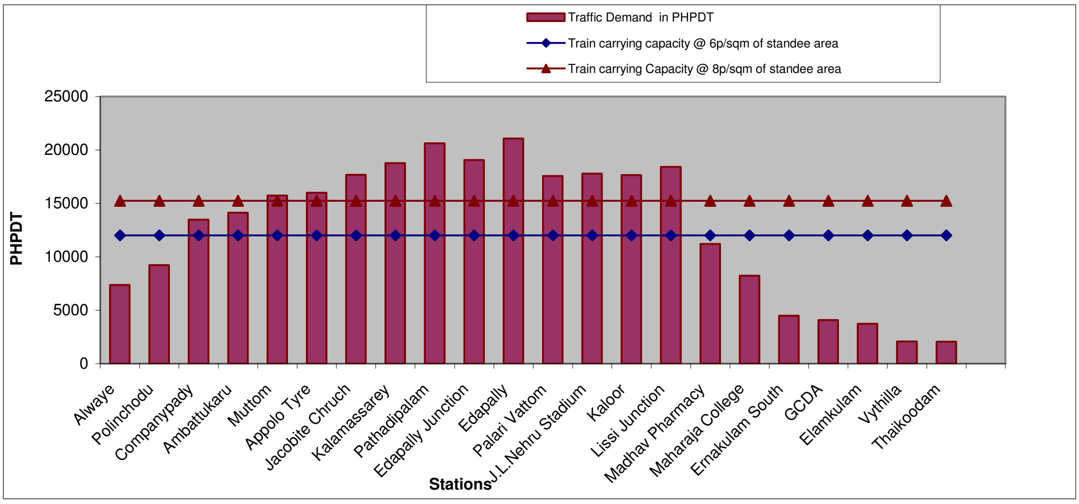


Fig 1.3

Attachment II

TABLE 1.1

Hourly Train Operation Plan for Kochi Metro : Alwaye - Petta Corridor
Year: 2015
Configuration: 3 Car
Headway(min): 5

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	12	5	5
6 to 7	10	6	6
7 to 8	8	8	7
8 to 9	**5**	**12**	**12**
9 to 10	**5**	**12**	**12**
10 to 11	**5**	**12**	**12**
11 to12	8	8	7
12 to 13	10	6	6
13 to 14	12	5	5
14 to 15	12	5	5
15 to 16	10	6	6
16 to 17	8	7	8
17 to 18	**5**	**12**	**12**
18 to 19	**5**	**12**	**12**
19 to 20	**5**	**12**	**12**
20 to 21	8	7	8
21 to 22	10	6	6
22 to 23	12	5	5
23 to 24	15	4	4
Total No. of train trips per direction per day		**150**	**150**

TABLE 1.2
Hourly Train Operation Plan for Kochi Metro : Alwaye - Petta Corridor
Year: 2020
Configuration: 3 Car
Headway(min): 4

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	12	5	5
6 to 7	10	6	6
7 to 8	6	10	10
8 to 9	**4**	**15**	**15**
9 to 10	**4**	**15**	**15**
10 to 11	**4**	**15**	**15**
11 to12	6	10	10
12 to 13	10	6	6
13 to 14	12	5	5
14 to 15	12	5	5
15 to 16	10	6	6
16 to 17	6	10	10
17 to 18	**4**	**15**	**15**
18 to 19	**4**	**15**	**15**
19 to 20	**4**	**15**	**15**
20 to 21	6	10	10
21 to 22	10	6	6
22 to 23	12	5	5
23 to 24	15	4	4
Total No. of train trips per direction per day		**178**	**178**

TABLE 1.3

Hourly Train Operation Plan for Kochi Metro : Alwaye - Petta Corridor
Year: 2025
Configuration: 3 Car
Headway(min): 3

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	12	5	5
6 to 7	10	6	6
7 to 8	5	12	12
8 to 9	**3**	**20**	**20**
9 to 10	**3**	**20**	**20**
10 to 11	**3**	**20**	**20**
11 to12	5	12	12
12 to 13	10	6	6
13 to 14	12	5	5
14 to 15	12	5	5
15 to 16	10	6	6
16 to 17	5	12	12
17 to 18	**3**	**20**	**20**
18 to 19	**3**	**20**	**20**
19 to 20	**3**	**20**	**20**
20 to 21	5	12	12
21 to 22	10	6	6
22 to 23	12	5	5
23 to 24	15	4	4
Total No. of train trips per direction per day		**216**	**216**

Attachment III

TABLE 2
Kochi Metro : Alwaye - Petta Corridor
PHPDT for the Year 2015

S.No	From Station	To Station	Maximum PHPDT	Directional Split to Petta	Directional Split to Alwaye
1	Alwaye	Polinchodu	3780	50%	50%
2	Polinchodu	Companypady	5035	50%	50%
3	Companypady	Ambattukaru	8450	50%	50%
4	Ambattukaru	Muttom	11594	50%	50%
5	Muttom	Appolo Tyre	11594	50%	50%
6	Appolo Tyre	Jacobite Chruch	11897	50%	50%
7	Jacobite Chruch	Kalamassarey	12037	50%	50%
8	Kalamassarey	Pathadipalam	13016	50%	50%
9	Pathadipalam	Edapally Junction	13216	50%	50%
10	Edapally Junction	Edapally	13266	50%	50%
11	Edapally	Palari Vattom	11695	50%	50%
12	Palari Vattom	J.L.Nehru Stadium	12481	50%	50%
13	J.L.Nehru Stadium	Kaloor	12928	50%	50%
14	Kaloor	Lissi Junction	**13681**	50%	50%
15	Lissi Junction	Madhav Pharmacy	5247	50%	50%
16	Madhav Pharmacy	Maharaja College	3132	50%	50%
17	Maharaja College	Ernakulam South	2853	50%	50%
18	Ernakulam South	GCDA	1557	50%	50%
19	GCDA	Elamkulam	1524	50%	50%
20	Elamkulam	Vythilla	1558	50%	50%
21	Vythilla	Thaikoodam	1502	50%	50%
22	Thaikoodam	Petta	1481	50%	50%

Attachment IV

TABLE 3
Vehicle Kilometer
Kochi Metro : Alwaye - Petta Corridor

Year	**2015**	**2020**	**2025**
Section Length	24.69	24.69	24.69
No of cars per Train	3	3	3
No of working Days in a year	340	340	340
Number of Trains per day each Way	150	178	216
Daily Train -KM	7407	8789	10666
Annual Train - KM (10^5)	25.18	29.88	36.26
Annual Vehicle - KM (10^5)	**75.55**	**89.65**	**108.79**

Attachment V

Rake Requirement

Kochi Metro : Alwaye - Petta Corridor, Year : 2015
Passenger Capacity @ 6 Persons/sqm in 3 Car Train: 600 **Schedule Speed in Kmph= 33**

Section	Distance (kms)	Schedule Speed in kmph	Projected PHPDT Demand	Max. PHPDT Capacity Available	Headway (min)	Rake Requirement			Total No of Rakes	No. of Cars per rake	No. of Cars
						Bare	Traffic Reserve	R&M			
Kochi Metro : Alwaye - Petta Corridor	24.69	33.0	**13681**	7200	**5**	19	1	2	22	3	**66**
Total Turn Round Time(min)	**6**										

Kochi Metro : Alwaye - Petta Corridor, Year : 2020
Passenger Capacity @ 6 Persons/sqm in 3 Car Train: 600 **Schedule Speed in Kmph= 33**

Section	Distance (kms)	Schedule Speed in kmph	Projected PHPDT Demand	Max. PHPDT Capacity Available	Headway (min)	Rake Requirement			Total No of Rakes	No. of Cars per rake	No. of Cars
						Bare	Traffic Reserve	R&M			
Kochi Metro : Alwaye - Petta Corridor	24.69	33.0	**17663**	9000	**4**	24	1	2	27	3	**81**
Total Turn Round Time(min)	**6**										

Kochi Metro : Alwaye - Petta Corridor, Year : 2025
Passenger Capacity @ 6 Persons/sqm in 3 Car Train: 600 **Schedule Speed in Kmph= 33**

Section	Distance (kms)	Schedule Speed in kmph	Projected PHPDT Demand	Max. PHPDT Capacity Available	Headway (min)	Rake Requirement			Total No of Rakes	No. of Cars per rake	No. of Cars
						Bare	Traffic Reserve	R&M			
Kochi Metro : Alwaye - Petta Corridor	24.69	33.0	**21065**	12000	**3**	32	1	3	36	3	**108**
Total Turn Round Time(min)	**6**										

Chapter 7

Power Supply

CHAPTER 7

POWER SUPPLY ARRANGEMENTS

7.1 Power Requirements

Electricity is required for operation of Metro system for running of trains, station services (e.g. lighting, lifts, escalators, signaling & telecom, fire fighting etc) and workshops, depots & other maintenance infrastructure within premises of metro system. The power requirements of a metro system are determined by peak-hour demands of power for traction and auxiliary applications. Broad estimation of auxiliary and traction power demand is made based on the following requirements:-

(i) Specific energy consumption of rolling stock – 75KWh/1000 GTKM

(ii) Regeneration by rolling stock – 30%

(iii) Elevated station load – initially 200KW, which will increase to 300 KW in the year 2025

(iv) Depot auxiliary load - initially 2000KW, which will increase to 2500 KW in the year 2025

Keeping in view of the train operation plan and demand of auxiliary and traction power, power requirements projected for the year 2015 , 2020 and 2025 are summarized in table 7.1 below:-

Table 7.1 Power Demand Estimation (MVA)

Corridor		Year 2015	2020	2025
Alwaye – Mutton - Petta Corridor [24.82 kms & 23 stations]	Traction	7.1	8.5	10.6
	Auxiliary	8.2	9.9	11.6
	Total	15.3	18.4	22.2

Detailed calculations of power demand estimation are attached at **Annexure –7.1**

7.2 Need for High Reliability of Power Supply

The proposed Section of the Kochi metro system is being designed to cater to about 21000 passengers per direction during peak hours when trains are expected to run at 3 minutes intervals in 2025. Incidences of any power interruption, apart from affecting train running, will cause congestion at stations. Interruption of power at night is likely to cause alarm and increased risk to traveling public. Lack of illumination at stations, non-visibility of appropriate signages, disruption of operation of lifts and escalators is likely to cause confusion, anxiety and ire in commuters, whose tolerance level are low on account of stress. Effect on signal and communication may affect train operation and passenger safety as well. Therefore, reliable and continuous power supply is mandatory for efficient metro operations.

To ensure reliability of power supply, it is essential that both the sources of Supply and connected transmission & distribution networks are reliable and have adequate redundancies built in. Therefore, it is desirable to obtain power supply at high grid voltage of 220kV, 110KV or 66kV from stable grid sub-stations and further transmission & distribution is done by the Metro Authority itself.

7.3 Sources of Power Supply

The high voltage power supply network of Kochi has 220kV, 110KV and 66kV network to cater to various types of demand in vicinity of the proposed corridor. 220 KV sub-stations are generally located at outskirts of the city. 110 kV sub stations are located to the alignment of Corridors. Keeping in view the reliability requirements, two input sources of 110 kV Voltage level are normally considered for this corridor. Therefore, to achieve the desired reliability, two Receiving Sub Stations (110 / 33 /

25 kV) are proposed to be set up for this Corridor. M/s KSEB have given confirmation for supply of electricity at the following grid sub-stations at 110kV voltage vide their letter no. TCK/111/DB-1/Metro Rail/2005-06/394 dated:-27.06.2005 and letter no. T -2(b) /Misc./klmsy/metro Kochi/57,dated:-26.04.2011. (**Annexure – 7.2**).

Table 7.2 Sources of Power Supply

Corridor	Grid sub-station (with Input voltage)	Location of RSS of Metro Authority	Approx. length of cables
Alwaye - Petta Corridor	Kalamassery Grid Sub-station (110 KV)	Mutton Depot (110 / 33/25 KV)	3.5 km, 110 KV (Double Circuit Cables).
	Kaloor Grid Sub-station (110 KV)	Near JLN Stadium (110 / 33/25 KV)	1.0 km, 110 KV (Double Circuit Cables).

Since power supply to Kaloor is being fed from Kalamassery GSS itself through a single 110 KV feeder any Bus bar fault at Kalamassery may render both the sub-station out of order and hence reliability being an issue of concern. M/s KSEB is planning another alternate feeder from Brahmapuram, which will improve reliability.

M/s KSEB letter no. T -2(b) /Misc./klmsy/metro Kochi/57,dated:-26.04.2011 is enclosed, whereas they have indicated Vyttila will take time, therefore second sub-station proposed at Kaloor.

Summary of expected power demand at various sources is given in Table – 7.3.

Table 7.3 Power Demand Projection for various sources.

Corridor	Input Source / Receiving Sub Station (RSS)	Peak Demand – Normal (MVA)			Peak Demand – Emergency (MVA)		
		2015	2020	2025	2015	2020	2025
Alwaye - Petta Corridor	**Kalamassery RSS.**						
	Traction	4.5	5.2	6.3	7.1	8.5	10.6
	Auxiliary	5.0	5.9	6.8	8.2	9.9	11.6
	Total (A)	9.5	11.1	13.1	15.3	18.4	22.2
	Kaloor RSS						
	Traction	2.6	3.3	4.3	7.1	8.5	10.6
	Auxiliary	3.2	4.0	4.8	8.2	9.9	11.6
	Total (B)	5.8	7.3	9.1	15.3	18.4	22.2
	TOTAL (A + B)	**15.3**	**18.4**	**22.2**			

The 110 kV power supply will be stepped down to 25kV single phase for traction purpose at the RSS of Kochi Metro and the 25kV traction supply will be fed to the OHE at viaduct through cable feeders. For feeding the auxiliary loads, the 110 kV power supply received will be stepped down to 33 kV will be distributed along the alignment through 33kV Ring main cable network. These cables will be laid in dedicated ducts along the viaduct. If one RSS trips on fault or input supply failure, train services can be maintained from the other RSS. However, in case of total grid failure, all trains may come to a halt but station lighting & other essential services can be catered to by stand-by DG sets. Therefore, while the proposed scheme is expected to ensure adequate reliability, it would cater to emergency situations as well.

Typical High Voltage Receiving Sub-station

The 110kV cables will be laid through public pathways from Kerala state Electricity board to RSS of Metro Authority. For this corridor, each of RSS shall be provided with 2nos. (one as standby) 110/25 kV, 21 MVA single-phase traction Transformers for feeding Traction and 110/33 KV, 15 MVA three phase Transformers for feeding auxiliary loads. The capacity of transformers will be reviewed considering the load requirement/distribution of this corridor at the time of detailed design and simulation results.

Conventional Outdoor type 110 kV Switchgear is proposed for RSS's to accommodate two transformers for 25 KV traction and two transformers for 33 KV auxiliary to be located in approx. 100 X 80 m (8000 sq. mtr.) land plot. In case of difficulty in land acquisition, Gas Insulated Sub – stations (GIS) sub stations may be planned. Requirement of land for GIS will be approx. 60 X 80 m (4800 sq. m) but the cost of sub station works will increase by nearly Rs. 15 Crore per RSS.

7.4 Selection of Traction System

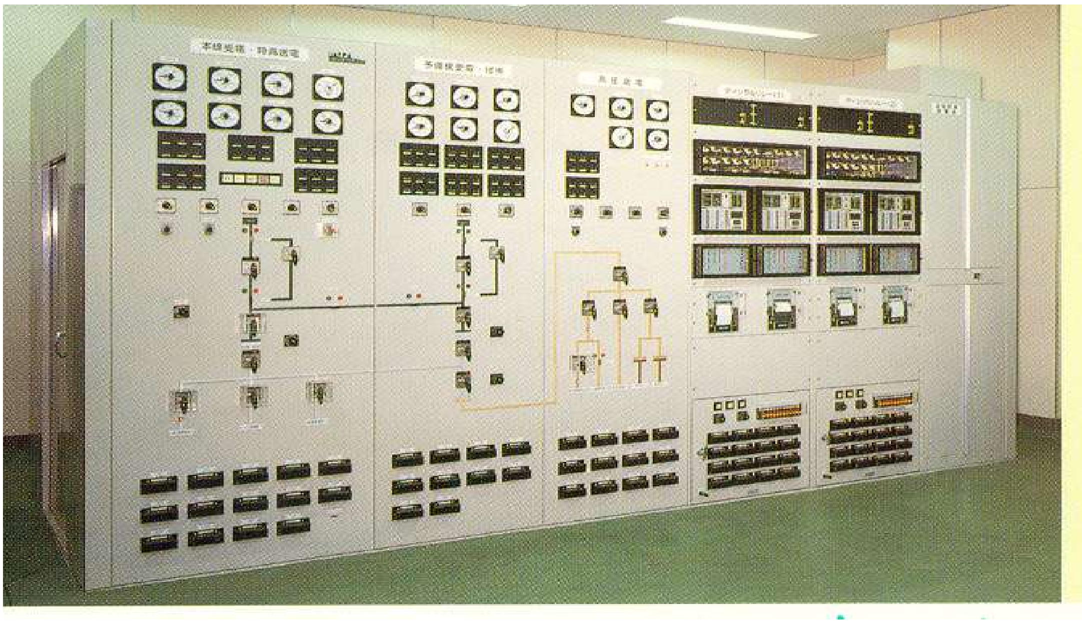
Alwaye to Petta is a stand alone line. In Earlier 2005 DPR the city aesthetics was the main consideration for recommending 750 V d. c.

On techno-economic consideration, it is recommended to adopt 25 KV single phase A.C. Traction, it in addition has the following merits.

- Lower initial cost.
- Lower operating and maintenance cost as in case of 25 KV ac traction the regeneration is up-to 30% and the line losses are around 0.5% in comparison to D.C. losses up-to 6 – 7%.
- A.C. system poses lesser Fire hazards as current levels are much lower than D.C.
- Stray current problems and hence the corrosion is controlled.

7.5 Auxiliary Supply Arrangements for Stations & Depot

Auxiliary sub-stations (ASS) are envisaged to be provided at each station (1 ASS for elevated station) for stepping down 33 kV supply to 415 V for auxiliary applications. A separate ASS is required at depot. The ASS will be located at mezzanine or platform level inside a room. The auxiliary load requirements have been assessed at 200kW for elevated / at-grade stations which is likely to increase up to 300 KW in the year 2025. In order to meet the requirement of auxiliary power two dry type cast resin transformers (33/0.415kV) of 500 kVA capacity are proposed to be installed at the elevated stations (one transformer as standby). For Property Development within the footprints of the station, a provision to add third transformer at a later date may be kept at elevated station.



Typical Indoor Auxiliary Sub-station

7.6 Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC)

25kV ac traction currents produce alternating magnetic fields that cause voltages to be induced in any conductor running along the track. Booster Transformer and Return Conductor (BT/RC) System is proposed for EMI mitigation. Concrete structures of elevated viaducts are not good electrical earths and therefore, Earthing and Bonding of the traction system shall be in accordance with the latest standards EN50122-1, IEEE80 and other relevant standards. Two earth conductors –Overhead Protection Cable (OPC) and Buried Earth Conductor (BEC) are proposed to be laid along with elevated via duct and all the metallic structures, structural reinforcement, running rails etc will be connected to these conductors to form an equiv-potential surface & a least resistance path to the fault currents. The overhead protection cable will also provide protection against lightning to the 25kV OHE and the elevated viaduct. Similar arrangements have been adopted on Delhi Metro as well.

Detailed specification of equipment e.g. power cables, transformer, switchgear, E&M equipment etc shall be framed to reduce conducted or radiated emissions as per appropriate international standards. The Metro system as a whole (trains, signaling & telecomm, traction power supply, E&M system etc) shall comply with the EMC requirements of international standards viz. EN50121, EN50123, IEC61000 series etc. A detailed EMI/EMC plan will be required to be developed during project implementation stage.

7.7 25kV Flexible Overhead Equipment (OHE) system

25kV ac flexible OHE system shall comprise 107 sqmm HD-copper contact wire and 65 sq.mm Cd-copper catenary wire. Return conductor (RC) shall be All Aluminum Conductor (AAC) of 233 sq.mm cross section. From safety considerations, Hydraulic type Anti-Tensioning Device (ATDs) are proposed on mainlines which does not require use of balance weight for tensioning of OHE conductors. Proven catenary fittings are proposed similar to DMRC system.

7.8 Rating of Major Equipment

25kV ac Overhead Equipment (OHE) shall comprise 107mm^2 HD-copper contact wire and 65 mm^2 Cd-copper catenary wire. Return conductor (RC) shall be All of OHE conductors.

Based on emergency demand expected at each RSS as shown in Table 7.3, 2 nos. 110/25kV traction transformers of 21 MVA capacity and 2 nos. 110/33 KV Auxiliary transformers of 15 MVA shall be provided at each RSS, being standard design (one to be in service and second one to serve as standby). The 110kV incoming cable shall be 3-phase single core XLPE insulated with 400 mm^2 Aluminum conductor to meet the normal & emergency loading requirements and fault level of the 110 kV supply.

33kV and 25kV switchgear shall be rated for 1250 A being standard design. 33kV cable ring network shall be adequately rated to transfer requisite auxiliary power during normal as well as emergency situations and accordingly 3 number of

Single core 300 mm^2 FRLSOH Copper conductor cable XLPE insulated 33kV cable is proposed for ring main network.

Adequate no. of cables are required for transfer of traction power from Metro's RSS to 25kV OHE. Single-phase XLPE insulated cables with 240mm^2 copper conductors are proposed for traction power. Based on current requirements, 2 cables are required for each of the two circuits to feed power to OHE.

The above capacities of transformers, switchgear, cables etc. have been worked out based on the conceptual design. Therefore, these may be required to be revised for better accuracy during design stage of project implementation.

7.9 Standby Diesel Generator (DG) Sets

In the unlikely event of simultaneous tripping of all the input power sources or grid failure, the power supply to stations as well as to trains will be interrupted. It is, therefore, proposed to provide a standby DG set of 180 KVA capacity at the elevated stations to cater to the following essential services:

(i) Essential lighting
(ii) Signaling & telecommunications
(iii) Fire fighting system
(iv) Lift operation
(v) Fare collection system

Silent type DG sets with low noise levels are proposed, which do not require a separate room for installation.

7.10 Supervisory Control and Data Acquisition (SCADA) System

The entire system of power supply (receiving, traction & auxiliary supply) shall be monitored and controlled from a centralized Operation Control Centre (OCC) through SCADA system. Modern SCADA system with intelligent remote terminal units (RTUs) shall be provided. Optical fiber provided for telecommunications will be used as communication carrier for SCADA system.

Digital Protection Control System (DPCS) is proposed for providing data acquisition, data processing, overall protection control, interlocking, inter-tripping and monitoring of the entire power supply system consisting of 33kV ac switchgear, transformers, 25kV ac switchgear and associated electrical equipment. DPCS will utilize microprocessor-based fast-acting numerical relays & Programmable Logic Controllers (PLCs) with suitable interface with SCADA system.

7.11 Energy Saving Measures

Energy charges of any metro system constitute a substantial portion of its operation & maintenance (O & M) costs. Therefore, it is imperative to incorporate energy saving measures in the system design itself. The auxiliary power consumption of metros is generally more than the traction energy consumed by train movement during initial years of operation. Subsequently, traction power consumption increases with increase in train frequency/composition in order to cater more traffic. The proposed system of Kochi Metro includes the following energy saving features:

(i) Modern rolling stock with 3-phase VVVF drive and lightweight stainless steel coaches has been proposed, which has the benefits of low specific energy consumption and almost unity power factor.

(ii) Rolling stock has regeneration features and it is expected that 30% of total traction energy will be regenerated and fed back to 25kV ac OHE to be consumed by nearby trains.

(iii) Effective utilization of natural light is proposed. In addition, the lighting system of the stations will be provided with different circuits (33%, 66% & 100%) and the relevant circuits can be switched on based on the requirements (day or night, operation or maintenance hours etc).

(iv) Machine-room less type lifts with gearless drive has been proposed with 3-phase VVVF drive. These lifts are highly energy efficient.

(v) The proposed heavy-duty public services escalators will be provided with 3-phase VVVF drive, which is energy efficient & improves the power factor. Further, the escalators will be provided with infrared sensors to automatically reduce the speed (to idling speed) when not being used by passengers.

(vi) The latest state of art and energy efficient electrical equipment (e.g. transformers, motors, light fittings etc) have been incorporated in the system design.

(vii) Efficient energy management is possible with proposed modern SCADA system by way of maximum demand (MD) and power factor control.

7.12 Electric Power Tariff

The cost of electricity is a significant part of Operation & Maintenance (O&M) charges of the Metro System, which constitutes about 25 – 35% of total annual working cost. Therefore, it is the key element for the financial viability of the project. The annual energy consumption is assessed to be about 41 million units in initial years (2015), which will increase to about 58 Million Units by year 2025 for this Corridor. In addition to ensuring optimum energy consumption, it is also necessary that the electric power tariff be kept at a minimum in order to contain the O& M costs. Therefore, the power tariff for this Corridor should be at effective rate of purchase price (at 110 kV voltage level) plus nominal administrative charges i.e. on a no profit no loss basis. This is expected to be in the range of Rs. 2.75-3.50 per unit. It is proposed that Government of Kerala takes necessary steps to fix power tariff for Kochi Metro at “No Profit No Loss” basis. Financial analysis has been carried out based on this tariff for the purpose of finalizing the DPR. Similar approach is being pursued for Delhi Metro

Chief Engineer (Transmission-South),
Vydyuthi Bhavanam, Pattom
Thiruvananthapuram-695 004

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Fax: +91-471-2514460
Email: cets@ksebnet.com

No.T2(b)/Misc./klmsy/Metro Kochi/ 57   Dated: 26-04-2011

Annexure:- 7.2

To

Sri.Sharat Sharma
Executive Director/Electrical
Delhi Metro Rail Corporation Ltd.,
Metro Bhawan,
Fire Brigade Lane,
Barakhamba Road,
New Delhi – 110 001.

Sir,

Sub:- Power requirement for proposed Kochi Metro Rail Developments – Shifting/Providing adequate clearance for the EHT road crossing feeders with metro rail between Alwaye and Petta (Tripunithura).

Ref:- (1) Discussions had at this office on 08-04-2011.
(2) Minutes forwarded by you dated 22-04-2011.

As discussed in the meeting and based on the minutes forwarded by you, I may inform the following for your information.

Power requirement

(1) For the required power you have to give request to Deputy Chief Engineer, Transmission Circle, Kalamassery in the prescribed format with necessary application fee.
(2) You have to give willingness for the remittance of the entire amount under work deposit basis for the construction of 110 kV lines / cables to your proposed 110 kV Substation at Muttam and Kaloor and for the construction of feeder bays at KSEB Substations for that.
(3) You have to identify and locate the Substation site in a joint inspection with KSEB authorities enable them to prepare the line construction estimate. Necessary advance to be remitted for the estimate preparation.
(4) At present Board can provide power from Kalamassery and Kaloor 110 kV Substations only. Alternate supply from Brahmapuram to Vyttila will take long time and that can be considered at your cost only.
(5) For arranging alternate feeding at Kaloor from Brahmapuram, that also can be considered at your cost and that too will take much time.

Providing adequate clearance – shifting EHT line

For providing adequate clearance / shifting of existing road crossing EHT line between Alwaye and Petta (Thripunithura).

KSE Board cannot undertake such work and hence Metro rail itself has to arrange that under the strict supervision and direction of KSE Board. For that Metro rail has to pay the supervision charges based on the cost of estimate for shifting. For this Metro rail has to give request to the Deputy Chief Engineer, Transmission Circle, Kalamassery with your willingness for remitting the supervision charges and a joint inspection to be conducted for deciding the tower locations and to decide the type of towers required for providing adequate clearance. Based on that Board will prepare estimate and with Boards sanction the amount to be remitted will be intimated.

The shifting works can be arranged in a phased manner as per the schedule of KSE Board as major industrial consumers and several substations are connected with these lines. Shifting / providing additional clearance with the EHT lines can be considered with out any harm to the existing alignment of the EHT lines.

Necessary PTCC clearance for the proposed EHT line shifting to be obtained by Metro railway.

For shifting the distribution transformers and lines, metro rail has to take up the matter with Chief Engineer, Distribution Central, Ernakulam for early necessary action.

Any works related to the power supply line construction / shifting :s etc. can be considered only with your proper application for requirement and receipt of necessary amount towards the work t charges and supervision charges.

Yours faithfully,

N.M.BABUKUTTAN
Chief Engineer (Transmission-South)

): 1. The Deputy Chief Engineer,
Transmission Circle,
Kalamassery - for information.
2. The Executive Engineer,
Transmission Division,\
Kalamassery - for information.
3. Sri.P.Sriram,
PD,
Delhi Metro Rail Corporation Ltd.
II[nd] Floor, GCDA Complex,
Ernakulam South Railway Station,
Eastern Entry, Kochi – 16.
4. Sri.V.R.Sudhi,
Dy.CEE,

KERALA STATE ELECTRICITY BOARD

Transmission Circle, H.M.T Colony PO, Kalamassery PIN–683 5(
Phone:0484-2555682 Fax:0484-2555682 Email: dcetkly@sancharnet.in

o.TCK/111/DB-I/Metro Rail/2005-06/d 394 Date : 27-6-2005.

rom

The Deputy Chief Engineer.

o

The Deputy Chief Electrical Engineer
Delhi Metro Rail Corporation Ltd,
N.B.C.C.Place.
Bhishma Pitamah Marg,
Pragati Vihar,
New Delhi – 110 003.

r,

Sub:- Power supply arrangements for the proposed Cochin Metro Project - Regarding.

Ref:- Letter No.DMRC/Elect/16/Cochin-M/05 dated, 17-6-2005 of that office.

Please refer to above.

In the proposed Substations, Kalamassery and Kaloor, there is ample capacity to spa e required load.

The 110 kV bays are to be constructed for giving the outlets and it is feasible to exten 110 kV bus in both Substations. Please note that the expenditure on this account has to b rne by you.

urs faithfully,

PUTY CHIEF ENGINEER

27/6

y submitted to the Chief Engineer (Transmission South), KSEB, Vaidyuthibhavanam, ruvananthapuram.

y to the Executive Engineer. Transmission Division. Kalamassery/ Master Plan Division

ENERGY REQUIREMENTS

	Alwaye to Petta					
	Year 2015		Year 2020		Year 2025	
Traction power requirements						
No of cars	**3**	(2DMC+1 TC)	**3**	(2DMC+1 TC)	**3**	(2DMC+1 TC)
passenger weight	39.0	T	39.0	T	39.0	T
Train Tare weight	103.0	T	103.0	T	103.0	T
Total train weight	142.0	T	142.0	T	142.0	T
Section length	24.82	KM	24.82	KM	24.82	KM
Specific Energy consumption with 30% regeneration	53	KWhr/1000 GTKM	53	KWhr/1000 GTKM	53	KWhr/1000 GTKM
No. of train trips per direction in a day*	150		178		216	
Yearly Traction Energy consumption with 365 days working with 30% regen	**20.26**	**million units**	**24.04**	**million units**	**29.18**	**million units**
Station aux power requirements						
Elevated/at-grade station--power consumption	0.20	MW	0.25	MW	0.30	MW
Underground station--power consumption	2.00	MW	2.25	MW	2.25	MW
No. of elevated/at-grade stations	23		23		23	
No. of Underground stations	0		0		0	
Total Station Aux Power requirement	4.6	MW	5.8	MW	6.9	MW
Depot Aux power requirement	2.0	MW	2.3	MW	2.5	MW
Total Aux Power requirement	6.6	MW	8.1	MW	9.4	MW
Total aux power requirement (MVA) assuming 5% energy losses and .85 pf for aux loads	**8.2**	MVA	**9.9**	MVA	**11.6**	MVA
Diversity factor of aux loads	0.4		0.4		0.4	
Yearly Aux Energy consumption 20 hrs/day and 365 days working (million units)	**20.24**	**million units**	**24.68**	**million units**	**28.82**	**million units**
Total traction & aux power requirement (MVA)	**40.5**	**million units**	**48.7**	**million units**	**58.0**	**million units**

Note:-

The requirement of PD load is not considering in estimation of power calculation.

Annexuer-7.1

POWER REQUIREMENTS

	Alwaye to Petta					
	Year 2015		Year 2020		Year 2025	
Traction power requirements						
No of cars	**3**	(2DMC+1 TC)	**3**	(2DMC+1 TC)	**3**	(2DMC+1 TC)
passenger weight	39.0	T	39.0	T	39.0	T
Train Tare weight	103.0	T	103.0	T	103.0	T
Total train weight	142.0	T	142.0	T	142.0	T
Section length	24.82	KM	24.82	KM	24.82	KM
Headway	**5**	mts	**4**	mts	**3**	mts
Specific Energy consumption	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM
No. of trains/hr in both directions	24		30		40	
Peak traction power requirement	6.3	MW	7.9	MW	10.6	MW
Less Regeneration @ 30%	1.9	MW	2.4	MW	3.2	MW
Depot power requirements	2.0	MW	2.1	MW	2.2	MW
Total traction power requirement	6.4	MW	7.7	MW	9.6	MW
Total traction power requirement (MVA) assuming 5% energy losses and .95 pf	**7.1**	MVA	**8.5**	MVA	**10.6**	MVA
Station aux power requirements						
Elevated/at-grade station--power consumption	0.20	MW	0.25	MW	0.30	MW
Underground station--power consumption	2.00	MW	2.25	MW	2.25	MW
No. of elevated/at-grade stations	23		23		23	
No. of Underground stations	0		0		0	
Total Station Aux Power requirement	4.6	MW	5.8	MW	6.9	MW
Depot Aux power requirement	2.0	MW	2.3	MW	2.5	MW
Total Aux Power requirement	6.6	MW	8.1	MW	9.4	MW
Total aux power requirement (MVA) assuming 5% energy losses and .85 pf for aux loads	**8.2**	MVA	**9.9**	MVA	**11.6**	MVA
Total traction & aux power requirement (MVA)	**15.3**	MVA	**18.4**	MVA	**22.2**	MVA

Note:-

The requirement of PD load is not considering in estimation of power calculation.

Chapter 8

Maintenance Depot

8.1 INTRODUCTION

The Kochi Metro Project comprises of following corridor:

Corridor	Gauge (mm)	Route Length (KMs)
Alwaye-Peta	1435	25.612

8.2 It is proposed to establish a depot- cum- workshop at Muttom. The Depot planning is based on following assumptions:

(i) Enough space is available at Muttom for establishment of a Depot- Cum- workshop.
(ii) All inspection, workshop lines and stabling lines are designed to accommodate two trainsets of 3- car each.
(iii) All stabling lines are planned in the proposed depot-cum-workshop assuming adequate space availability. In case of space constraints, if any, stabling facilities may need to be created at terminal stations or elsewhere to cater to the required stability facilities.

In broad terms, based on the planned Rolling Stock requirements, this chapter covers conceptual design on following aspects and will work as a guide for detailed design later:

- Layout of Stabling-shed, Inspection-shed, minor repairs and heavy repair overhauling workshop and cleaning of Rolling Stock.
- Operational and functional safety requirements.
- Ancillary buildings for other maintenance facilities.
- Electrical & Mechanical Services, power supply and distribution system.
- Water Supplies, Drainage & Sewerage.

8.3 MAINTENANCE PHILOSOPHY

➢ Monitoring of the performance of equipment by condition monitoring of key parameters. The concept is to evolve the need based maintenance regime, which can be suitably configured in the form of schedules like daily check, “A” checks, “B” type checks, “IOH” and “POH”.

- Labour intensive procedures are kept to the minimum. Automation with state of the art machinery to ensure quality with reliability.
- Multi skilling of the Maintenance staff to ensure quality and productivity in their performance.
- Energy conservation is given due attention.

8.4 ROLLING STOCK MAINTENANCE NEEDS

8.4.1 Maintenance Schedule

The following maintenance schedule has been envisaged for conceptual design of depots assuming approx. 300 kms running per train per day, taking in consideration the passenger load of 2015, 2020 and 2025 respectively.

Type of Schedule	Interval	Work Content	Locations
Daily	Daily	Check on the train condition and function at every daily service completion. Interval cleaning/mopping of floor and walls with vacuum cleaner.	Stabling Lines
"A" Service Check	5,000 Km (approx. 15 days)	Detailed inspection and testing of sub - systems, under frame, replacement/ topping up of oils & lubricants.	Inspection Bays
"B" Service Check	15,000 Km (approx. 45 days)	Detailed Inspection of 'A' type tasks plus items at multiples of 15,000 Km ('B' type tasks)	Inspection Bays
Intermediate Overhaul (IOH)	420,000 Km, (3 and half Years approx.)	Check and testing of all sub-assemblies (Electrical + Mechanical). Overhaul of pneumatic valves, Compressor. Condition based maintenance of sub-systems to bring them to original condition. Replacement of parts and rectification, trial run.	Workshop
Periodical Overhaul (POH)	840,000 Km, (7 Years approx.)	Dismantling of all sub-assemblies, bogies suspension system, traction motor, gear, control equipment, air-conditioning units etc. Overhauling to bring them to original condition. Checking repair and replacement as necessary. Inspection and trial.	Workshop
Heavy Repairs	-	Changing of heavy item such as bogies, traction motor, axles, gear cases & axle boxes etc.	Workshop

The above Schedule may need slight revision based on the actual earned kilometers per train and the specific maintenance requirements of Rolling Stock finally procured.

8.4.2 Washing Needs of Rolling Stock

Cleanliness of the trains is essential. Following schedules are recommended for Indian environment:

S.N.	Kind Inspection	Maint. Cycle	Time	Maintenance Place

1.	Outside cleaning (wet washing on automatic washing plant)	3 Days	10 mins.	Single Pass through Automatic washing plant of Depot
2.	Outside heavy Cleaning (wet washing on automatic washing plant and Front Face, Vestibule/Buffer area. Floor, walls inside/outside of cars and roof. Manually)	30 days	2 – 3 hrs.	Automatic washing plant & cleaning & washing shed

8.5 Year-wise planning of maintenance facility setup at depot cum workshop based on planned Rolling Stock requirement in TOP is tabulated below:

(i) Planned rakes as per TOP:

Year	Headway in minutes	No. of Rakes	No. of coaches
2015	5	22	66
2020	4	27	81
2025	3	36	108

(ii) Average earning/day/rake based on TOP:

Year		Remarks
2015	336	• 'A' inspection frequency after every 15 days • 'B' inspection after every 45 days
2020	325	
2025	296	

(iii) Requirement of Stabling Lines (SBL),Inspection Lines (IBL) and Workshop Lines(WSL) in the Depot

Year	No. of Trains	SBLs	IBLs	WSLs
2015	22	11 lines x two 3-car	3 lines x one bay of 3 lines with two trains of 3-cars each in each line	3 lines x one bay of 3 lines with two trains of 3-cars each in each line
2020	27	13 lines x two 3-car	3 lines x one bay of 3 lines with two trains of 3-cars each in each line	-do-
2025	36	17 lines x two 3-car	6 lines x one bay of 3 lines with two trains of 3-cars each in each line	-do-

-

- All lines shall be suitable for placement of two 3-car trains on each line.
- Provision of space shall be made for additional 8 stabling lines x two 3- car (total 25 lines x two 3-car)

8.6 Requirement of maintenance / Inspection lines for depot-cum-workshop:

Schedule	**Maintenance Requirement (No. of Cars)**	**Lines Needed**
i) Year 2015 - Maximum no. of rake holding is 22 TS x3 (= 66 Cars)		
'A' Checks (5000 km) approx. 15 days	(22X3) Cars = 66 Cars	1 Line x two 3- cars (with Sunken Floor)
'B' Checks (15000 km) approx. 45 days	(22X3) Cars = 66 Cars	1 Line x two 3- cars (with Sunken Floor)
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	1 Line x two 3- cars (with sunken Floor)
Requirement		1 bay of 3 lines with provision of space for additional bay of 3 lines for work load in 2025
ii) Year 2020 - Maximum no. of rake holding is (27 TS x3 = 81 Cars)		
'A' Checks (5000 km) approx. 15 days	(27X3) Cars = 81 Cars	1 Lines X two 3- Cars (with sunken floor)
'B' Checks (15000 km) approx. 45 days	(27X3) Cars = 81 Cars	1 Lines X two 3- Cars (with sunken floor)
Unscheduled line & adjustment lines	For minor repairs, testing & adjustments post major repairs / IOH & POH	1 Line X two 3- Cars (with sunken floor)
Requirement		1 bay of 3 lines with provision of space for additional bay of 3 lines for work load in 2025

iii) Year 2025 -Maximum no. of rake holding is (36x3 = 108 Cars)		
'A' Checks (5000 km) 15 days	(36 X 3) Cars = 108 Cars	2 Lines X two 3- Cars (with sunken floor)
'B' Checks (15000 km) 45 days	(36 X 3) Cars = 108 Cars	2 Lines X two 3- Cars (with sunken floor)
Unscheduled line & adjustment lines	For minor repairs, testing & adjustments post major repairs / IOH & POH	1 Line X two 3- Cars (with sunken floor)
Requirement		2 bays of 3 lines each

All lines shall be suitable for placement of two 3-car trains on same line.

8.7 Inspection requirements at depot:

Facilities for carrying out inspection activitities shall be provided in the inspection bay for following Systems / Equipments of a train:

- Electronics; PA/PIS
- Mechanical components, couplers etc
- Batteries
- Air conditioner
- Brake modules
- Bogie
- Traction Motor
- Vehicle doors, windows and internal fittings
- Power system including converter, circuit breaker etc.

These activities shall be grouped into “A” checks and “B” checks. The minor scheduled inspections (“A” checks) shall be carried out during the day off peak and night. Since “B” checks take longer time, these cannot be completed in the off peak times. Certain inspection lines will be nominated for “A” checks. For “B” checks, separate line will be nominated where the rakes may be kept for long time.

One dedicated line in the shed will be used for minor repairs and for adjustment and testing after the IOH and POH. There shall be a spare line in inspection bay for this purpose.

8.8 Design of Depot- cum- Workshop Facilities.

8.8.1 Stabling lines at depot:

As per advised dimensions of the Rolling Stock, the length of 3-Car train would be Approx.56.5 mts. For the design of the stabling lines in the depot and terminal stations or elsewhere (as may be required), following approximates lengths have been taken in consideration:

(i) Length of one 3- car rake= 56.5 m

(ii) Gap between two 3-car rakes = 10m

(iii) Free length at outer ends of two 3- car rakes (for cross pathway, Signal and Friction buffers)= 10m each side

(iv) Total length of Stabling lines = (iii)+(i)+(ii)+(i)+(iii)= 10+ 56.5+ 10+ 56.5+ 10= 143m ≈ 145m

Looking to the car width of 2700 on SG, 5m "Track Centre" is proposed for all the stabling lines. Thus, space between stabling shall be sufficient to include 1 mt. wide pathway to be constructed between tracks to provide access for internal train cleaning and undercarriage inspection with provision of following facilities:

a) Each Stabling line to have water connection facility so that local cleaning, if required, is facilitated.

b) Platforms at suitable points at each end of stabling lines to enable train operators to board or de- board conveniently.

8.8.2 Inspection Bay at depot-cum-workshop

The length of Inspection shed is computed as below:

(i) Length of a 3-car rake= 56.5 m.

(ii) Gap between two 3- car rakes= 10 m

(iii) Cross- path at each end= 10 m

(iv) Length of Inspection line= (iii)+ (i)+(ii)+ (i)+ (iii) = 10+ 56.5+ 10+ 56.5+ 10= 143m ≈ 145m

The width of the Inspection bay in computed as below:

(i) Centre – to- centre spacing between the three lines= 7.5 m

(ii) Centre line of outer lines to column of Shed= 3m

(iii) Width of a 3 line Inspection Bay= (ii)+(i)+(i)+(ii)= 3+ 7.5+ 7.5+ 3= 21 m

a) There shall be one inspection bay of 145 m X 21 m size each with provision of accommodating three inspection lines each having sunken floor and overhead roof inspection platforms at each of the depot. The floor will be sunken by 1100mm. The track spacing between the adjacent IBLs shall be 7.5 m. This bay of 145m X 21m covering 3 lines is planned for inspection load 36 to 44 trainsets during 2014 to 2020. For rake requirements in 2025 and beyond, there shall be provision of space for extension by one bay of three lines to cater the workload of inspection in future.

b) Roof Inspection platforms and walkways for roof inspection supported on the columns shall be provided. There would be lighting below the rail level to facilitate the under frame inspection. Ramps of 1:8 slopes, 3 meter wide should be provided with sunken floor system for movement of material for the cars. Further, 10m cross pathways are left at each end for movement of material by fork lifter/Leister/Hand trolley. 415V 3 phase 50 Hz, 230V 1 phase 50 Hz AC supply and Pneumatic supply shall also be made available on each inspection shed columns. Air-circulators shall be provided on each column. The inspection bay shall be provided with EOT crane of 1.5 T to facilitate lifting of equipment.

Roof and walls shall be of such design that optimum natural air ventilation occurs all the time and sufficient natural light is also available. Each Inspection bay will also have arrangement close by for cleaning of HVAC filter under high pressure water jet.

8.8.3 Workshop Shed:

Requirement of workshop lines is planned as under:

Year	IOH & POH	Wheel / Bogie storage	Unschedule repairs /lifting	Total	Remarks
2015	1	1 line of 3-car and free space of 3-car length for storage of other equipments	1 line x two 3-car	3-lines	The size of workshop shall be the same as inspection bay i.e. 145X21 m with one working bay comprising of two lines capable of accommodating two 3-car rakes with Bogie turning facility, one line of 3- car rake length with free space of 3-car rake length for storage of wheel/ bogie/ equipments etc.
2020	1	-do-	1	3-lines	
2025	1	-do-	1	3-lines	

(a) There shall be one bay comprising of three lines each (as detailed in 'Remarks' above). Size of the workshop bay is proposed to be 145m x 21m.The unscheduled lifting and heavy repair line shall be fitted with jack system capable to lift the 3-Car unit simultaneously for quick change of bogie, thereby saving down time of Rolling Stock. The arrangement of jack system shall be such that lifting of any coach in train formation for replacement of bogie/equipments is also individually possible. One line shall be available for stocking of Bogies and wheels. These lines are to be provided with pits at regular intervals for inspection of undercarriage with turn tables. Each workshop bay shall be equipped with two 15T and 3T overhead cranes, each spanning the entire length of the workshop bay.

(b) There shall be provided space for repairs of HVAC, Door, and Traction motor etc. repairs. Distinct spaces shall be earmarked for dismantling/repairs/ assembling and testing of each of these equipments. Related machinery for Overhauling / Repairs & testing activities of every equipment are also to be housed in the space earmarked.

(c) There shall be washing and cleaning equipments on the workshop floor. Bogie test stand shall be provided in the workshop. Other heavy machinery shall also be suitably installed on the workshop floor. Air-circulators, lights, Powers supply points and compressed air supply line shall be provided on each workshop column.

(d) Workshop lines shall be inter-linked through turn tables, each suitable for movement of a train in AWo (unloaded) condition and shall also be capable to rotate with a fully loaded bogie on it. Repair of heavy equipments such as air conditioners shall be so located so that it does not affect the movement inside workshop.

(e) There shall be walkways on columns for roof inspections, along the workshop lines. These walkways shall not infringe with cars being lifted/ lowered by means of mobile jacks. Suitable space between the nearest exterior of a car and farthest edge of the walkway has to be ensured to avoid conflict in lifting and lowering of cars.

(f) The small component, bogie painting and battery maintenance cells will be located in the workshop with arrangement that fumes are extracted by suitable exhaust systems.

(g) Workshop will have service building with array of rooms along its length. Total size is proposed to be 145 x 8m. These can be made by column and beam structure and architecture made of brick works. These shall cater for overhauling sections, offices, costly store item, locker rooms, toilets etc. Two opposite sides widthwise shall be open to facilitate natural air circulation and cross ventilation besides the egress & ingress for coaches. The sidewalls shall also have sufficient width of louvers for providing adequate ventilation.

(h) There shall be space for bogie/ axle repair shop with necessary infrastructure for disassembly, overhead, assembly and testing of mechanical components of bogies/ axle. The repair shop shall be easily approachable from with the workshop for transportation of components.

Following equipment repair/overhaul facilities are planned in the workshop and wheel repairs shop at the workshops:

1. Body furnishing
2. Bogie
3. Wheels
4. Traction Motors
5. Axle Box and Axle Bearing
6. Pantographs
7. Transformer, converter/inverter, circuit breaker
8. Battery
9. Air Compressor
10. Air-conditioner
11. Brake Equipment
12. Door actuators
13. Control and measuring equipments
14. Pneumatic equipment
15. Dampers and Springs
16. Couplers/Gangways

17. Coach Painting (Applicable only for Aluminum coaches, if any)

8.9 Car Delivery Area

There shall be rail connectivity between the Depot-cum- Workshop and mainline and all trains due for scheduled/ unscheduled works shall reach the depot-cum- Workshop by rail.

However in case of newly procured coaches, which are transported by road, these shall reach the Depot-cum Workshop by the road on trailers. To unload the coaches and bring them to the track, provision of space, along the side of shunting neck, has to be made for unloading of cars and other heavy materials. This area shall have an insulated track embedded in the floor facilitating the movement of road trawler, which brings in the cars. The length of the track embedded area shall be about 40m long. There should be enough space available for movement of heavy cranes for lifting of coaches. The unloading area should be easily accessible for heavy duty hydraulic trailers.

8.10 Operational Features

The rake induction and withdrawal to main line will be primarily from the stabling shed. Further, provisions are there for direct rake induction and withdrawal to main line from Inspection Shed/workshop area. Movement from depot to the main line is so planned that the headway of main line is not affected. Simultaneous receipt and dispatch of trains from depot to main line is feasible in the present site scenario. Both of these activities will be done effectively without effecting the train operation on the main line. The stabling lines would be interlocked with the main line thereby induction of train from the stabling would be safe and without loss of time. The proposition for a transfer track on the incoming line as well as on the outgoing line to facilitate the movement of rake in the depot by Operation Control Centre (OCC) even though the further path inside the depot is not clear shall be explored in the detailed design stage depending on the actual availability of land.

An emergency line is also provided from which an emergency rescue vehicle may be dispatched to main line in the event of emergency if necessary.

8.11 Infrastructure Facilities

I. Inspection and Workshop facilities:

As indicated in 8.8.2 & 11.8.3 above.

II. Stabling Lines in Depot:

a) The requirement of lines shall be in accordance with the details indicated in para 8.8.1 above. A part of the stabling siding in the depot shall be covered with a roof in order to facilitate testing of air conditioning of trains and their pre-cooling under controlled condition of temperature.

b) Separate toilets adjustment to stabling lines shall be provided with small room for keeping cleaning aids and for utilization by the working staff.

III. Automatic Coach Washing Plant (AWP)

Provision to be made for Rolling Stock exterior surfaces to be washed using a fully automated Train Washing System, with a throughput capacity of approximately ten trains per hour. The AWP shall be situated at such a convenient point on the incoming route so that incoming trains can be washed before entry to the depot and undesirable movement/shunting over ingress and egress routes within the depot is avoided. Additional space for plant room for AWP system shall be earmarked alongside the washing apron as indicated at S. No. 6 of Annexure I.

IV. Train Operators Booking Office

Suitable office facility adjacent to the stabling lines at each depot should be provided so that train operators reporting 'On' duty or going 'Off' duty can obtain updates regarding 'Special Notices', 'Safety Circulars' and other technical updates/information in vogue. These offices should have an attached a cycle/scooter/car stand facility for convenience of the train operating staff.

V. Test Track

A test track of 1000 mts. in length covered & fenced should be provided beside workshop in the depot. It shall be equipped with signaling equipments (ATP/ATO). It shall be used for the commissioning of the new trains, their trials and testing of the trains after the IOH and POH. Entry into the test track shall be planned for a 3-car train. In compliance to safety norms, the boundary of the track shall be completely fenced to prevent unauthorized trespassing across or along the track.

VI. Heavy Cleaning Shed

Monthly heavy cleaning of interior walls, floors, seats, windows glasses etc, outside heavy cleaning, Front/rear Face, Vestibule/ Buffer area, outside walls and roof shall be done manually in the interior cleaning plant designed for cleaning of one at a time. A line adjacent to inspection shed should be so provided that placement of rakes is possible from workshop or inspection lines & vice – versa conveniently and with ease.

VII. Power Supply

Auxiliary substations are planned for catering to the power supply requirement of the whole depot and workshop. Details of connected load feeder shall be worked out. Taking diversity factor of 0.5 the maximum demands shall be computed. Two Auxiliary substations are proposed, as the demand by machines in Workshop area would be very large. The standby power supply is proposed through DG set with AMF panel. The capacity of DG set will be adequate to supply all essential loads without over loading.

VIII. Compressed Air Supply

Silent type compressor units shall be suitably installed inside the depots at convenient location for the supply of compressed air to workshop and Inspection sheds. Thus, the pneumatic pipeline shall run within the workshop and inspection bays as to have compressed air supply line at all convenient points.

IX. Water Supply, Sewerage and Drainage Works

In house facilities shall be developed for the water supply of each depot. Sewerage, storm water drainage shall be given due care while designing the depots for efficient system functioning. Past records of Municipal Corporation shall be used to design the drainage system. Rainwater harvesting would be given due emphases to charge the under ground reserves.

X. Ancillary Workshop

This workshop will have a line at floor level with provision of pits. Arrangement for repairs of Shunters, Rail Road Vehicles and other ancillary vehicles will be provided. These vehicles will also be housed here itself. Heavy lifting works can be carried out in main workshop.

Ancillary workshop will be used for storing OHE/rigid OHE parts and their maintenance/ repair for restoration of 25 kV feed system.

XI. Watch Towers

There shall be provision of adequate number of watchtowers for the vigilance of depot boundary.

XII. Administrative Building

An administrative building close to the main entrance is planned. It can be suitably sized and architecturally designed at the detailed design stage. A time and security office is also provided close to main entrance. It shall be equipped with suitable Access control system for all the staff working in the complex.

XIII. Parking Facilities

a) Ample parking space shall be provided for the two wheelers and four wheelers at the following points.
   - i) Close to the depot entry.
   - ii) Close to the stabling lines.
   - iii) Close to the Workshop/IBL.

b) Space for parking of road and re-railing equipments

   Enough space for parking of road vehicle/ trailers/ trucks etc. Enough space will also have to be earmarked adjacent to workshops. Similarly, provision of space for parking of re-railing equipments will have to be made close to the main exit gate of the Depot.

XIV. Shed and Buildings

The shed and buildings normally provided in the depot with their sizes and brief functions are indicated in Annexure-I. At the detailed design stage depending upon the land availability, the decision to locate these buildings can be taken. These can then be architecturally and functionally grouped.

XV. Plant and Machinery

a) A separate building is planned for housing pit wheel lathe (PWL), approachable from workshop, inspection bay and stabling lines through rail and road for placement of cars for re- profiling of wheels within the depot along with space for depot of scrap.

b) Requirement of buildings and major plants and machinery, is given in Annexure-I & II.

8.11.1 Following Safety features should be incorporated in the design of the Maintenance Depot-cum-Workshop:

a) 1.5 EOT cranes in the inspection bay should be interlocked with 25 kV ac OHE in such a way that, the cranes become operational only when the OHE is isolated and grounded.

b) Red flasher lights should be installed along the inspection lines at conspicuous location to indicate the OHE is ‘Live’.

c) Multi level wheel and TM stacking arrangement should be an inbuilt feature at the end of Workshop Lines.

d) Pillars in the inspection bay & workshop should have provision for power sockets.

e) Placement of rakes from inspection/workshop lines on to washing lines for interior cleaning on their own power should be possible. Linking of OHE and its isolation at the cleaning area should be provided. Necessary requirements of safety should be kept in view.

f) The roof inspection platform should have open-able doors to facilitate staff to go up the roof for cleaning of roof. Suitable safety interlock should be provided to ensure maintenance staff are enabled to climb on the roof inspection platform only after the OHE is isolated.

g) Control Centre, PPIO & store depot must be close to Workshop.

h) Width of the doors of the sections wherein repairs of equipments are done should be at least 2 meters wide to allow free passage of equipment through them.

i) Provision of water hydrants should be done in workshops & stabling yards also.

j) Compressed air points along with water taps should be available in interior of buildings for cleaning.

k) Ventilation arrangement inside the inspection shed and workshop should be ensured. Arrangement for natural cross ventilation from one side to another of inspection & workshop bays to be incorporated along with optimum availability of natural light at floor level.

Annexure-I

List of Buildings at Depot at Kochi

Depot-cum-workshop:

S.No	Name of Building	Size	Remarks
1.	Inspection Shed	145m x 21m • One bay of 3 lines (2 trains of 3-cars in each line)	Servicing of Cars for 15 days & 45 days inspection. This shed will have scope of expansion by 3 lines (1 additional bay of 3 lines for future requirement).
	Workshop Shed	145m x 21m	Major repair & overhaul of rolling stocks, diesel shunters, electric tractors, tower wagons. All heavy lifting jobs.
	Associated Sections	145m x 8m	Rooms for carrying out the inspection & workshop activity.
	Stabling line shed	145m x 57m (11 lines of 3-cars in each line for 22 trains)	Stabling lines will have a scope of expansion by 14 lines (2 trains of 3-car of each lines).
2.	Stores Depot & Offices including Goods Platform with Ramp	45m x 45m	i. Stocking of spares for regular & emergency requirement including consumable items. ii. This store caters for the requirement of depot for rolling stock & other disciplines. iii. To be provided with computerized inventory control. iv. Loading/Unloading of material received by road.
3.	Elect. Substation & DG set room	20m x 15m	To cater for normal and emergency power supply for depot, workshop, service and all other ancillary buildings, essential power supply for essential loads and security light.
4.	Traction repair depot and E &M repair shop	80m x 30m (partly double storey)	Stabling and routine maintenance of shunting engine etc. & Traction maintenance depot. For maintenance of lifts/escalators and other General service works.
5.	Cycle / Scooter / Car Parking	100m x 6m 60m x 6m	i. Close to the depot entry. ii. Close to the stabling lines.
6.	Auto coach washing plant	40m x 10m	For automatic washing of coaches. Provision of Washing apron for collection of dripping water and its proper drainage to be ensured.
7.	Washing apron for Interior Cleaning	145m x 6.5m	Heavy wet washing of rakes from inside, under frame, roof at 30 days interval.
8.	P-way office, store & Workshop including Welding plant	80m x 20m	i. For track maintenance of section and depot. ii. To weld rails for construction period only.

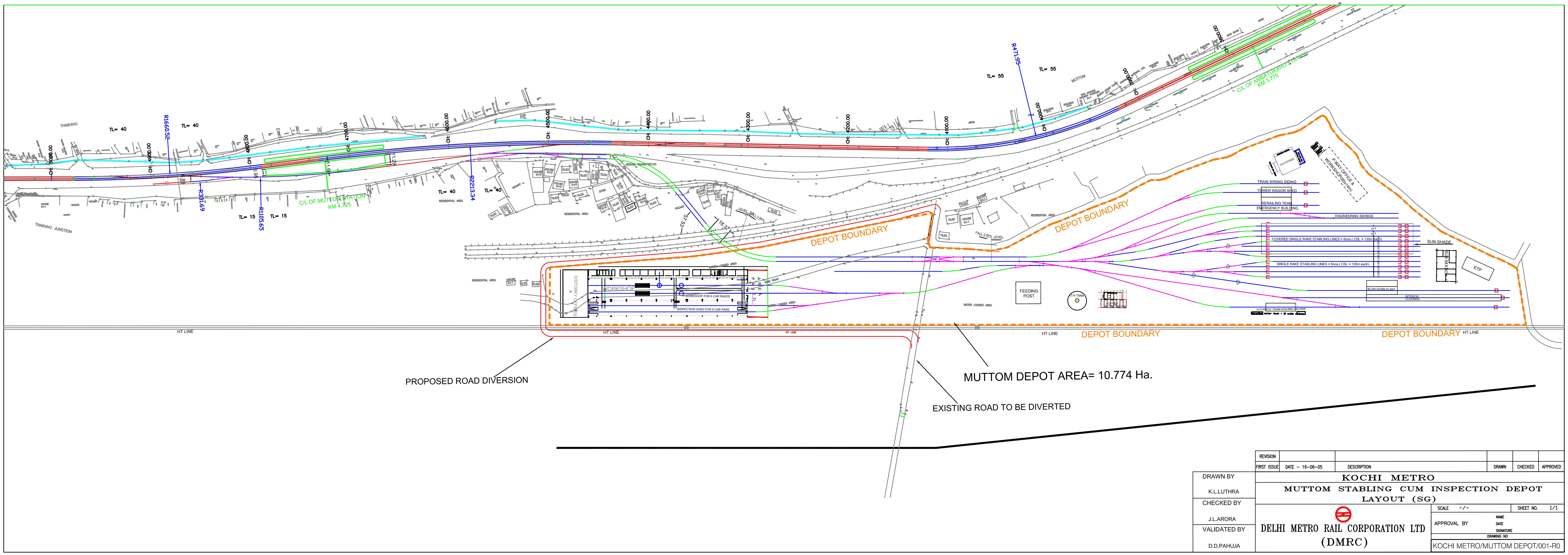
			iii. To stable track Tamping machine.
9.	Security office & Time Office Garages (4 Nos.)	15m x 8m	For security personnel. For time punching For parking vehicle jeep, truck etc.
10.	Check Post (2 Nos.)	5m x 3m	For security check of incoming/outgoing staff material and coaches.
11.	Watch Tower (4 Nos.)	3.6m x2.5 m	For security of the depot especially during night time.
12.	Depot control centre & Crew booking centre	25mx20m (double storey)	To control movement of trains in and out of the depot and for crew booking.
13.	O.H raw water Tank	1,00,000 Ltrs. Capacity	For Storage of water.
14.	Pump house Bore well	7.3mx5.4m (200 mm bore)	Submersible type pump planned with 200 mm diameter bore well.
15.	Dangerous goods Store	15m x 10m	For Storage of paints, inflammables & Lubricants
16.	a)Traction 25/33kV/66kV sub station b) Feeding Post	a)120m x 80m b) 15m x30m	Traction Power Supply
17.	Waste Collection Bin	10m x 10m	Garbage dumping
18.	Repair shops for S & T	40m x 20m	For the AFC gates, Signaling and telecom equipment.
19.	Work shop Manager Office	30m x 20m	Office of Depot in charge
20.	ATP & ATO Room	10m x 8m	To keep equipments of ATP/ATO
21.	Waste Water Treatment Plant	12m x 6m	For treating the discharge waters of the depot and remove the oil, acids etc. before discharging into the river, with U/G tank.
22.	Canteen	200 sqm.	To cater staff of depot and workshop. Should be in a separate building with modern kitchen ware and facilities. Obligatory as per statutory requirements.
23.	Toilets -Gents -Ladies	10m x 7m 10m x 7m	These toilets shall be approachable both from workshop as well as from inspection bay and ladies toilets shall be completely insulated from gent's toilet.

Annexure - II

List of Plants & Equipments at Depot-cum-Workshop

S. No.	Equipment	Qty.	Unit
1.	Under floor Pit wheel lathe, Chip crusher and conveyor for lathe on pit, Electric tractor for movement over under floor wheel lathe	1	No.
2.	Under floor lifting systems for 3-car unit for replacement of bogie	1	Set
3.	Mobile jacks 15T for lifting cars (set of 12 jacks)	1	No.
4.	Rerailing equipment consisting of rail cum road vehicle and associated jack system etc.	1	Set
5.	Run through type Automatic Washing plant for Metro cars.	1	No.
6.	Rail fed Bogie wash plant	1	No.
7.	Bogie test stand	1	No.
8.	Work lift platform	4	No.
9.	Electric bogie tractor for pulling cars and bogies inside workshop	1	No.
10.	Chemical cleaning tanks, ultrasonic cleaning tanks, etc	1	Set
11.	Compressor for Inspection shed & shop air supply	2	No.
12.	(i) Travelling O/H crane Workshop 15T/3 T (ii) 1.5T Capacity (IBL):- 4 Nos.	2 4	No. No.
13.	Mobile jib crane	2	No.
14.	Mobile lifting table	4	No.
15.	Carbody stands	24	No.
16.	Bogie turn tables	2	No.
17.	Underframe & Bogie blowing plant & small parts/equipment	2	No.
18.	AC filter cleaning machine	1	No.
19.	Portable cleaning plant for rolling stock	1	No.
20.	High-pressure washing pump for front and rear end cleaning of car	2	No.
21.	Industrial furniture (Work Test Benches)	1	L.s.
22.	Minor diagnostic equipment and collective tools	-	Set
23.	Induction heater	1	No.
24.	Oven for the motors	1	No.
25.	EMU battery charger	2	No.
26.	Welding equipments (Mobile welding, oxyacetylene, fixed arc welding)	2	Set
27.	Electric and pneumatic tools	-	Set
28.	Measuring and testing equipment	-	Set
29.	Tool Kits	-	Set
30.	Mobile safety steps	12	No.
31.	Fork lift tractor	2	No.
32.	Pallet trucks	6	No.
33.	RRV	1	
34.	Road vehicles (pickup van/ truck)	1	Set
35.	Miscellaneous office equipments	-	Set
36.	Vertical Boring Mainline for wheel discs	1	No.
37.	Press for removal and pressing of the wheel on axles	1	No.

38.	Axle journal turning and burnishing lathe	1	No.
39.	Special jigs and fixtures and test benches for Rolling Stock	1	set
40.	Stackers (1T for DCOS)	2	No.
41.	Storage Racks (W/shop & DCOS stores)	1	Set
42.	Test benches	1	Set
43.	Auto panto strip thickness meter		-
44.	Vehicle mounted crane		-
45.	Impulse Tester for TMs		-
46.	Bearing puller		-



DEPOT BOUNDARY
MUTTOM DEPOT AREA= 10.774 Ha.
EXISTING ROAD TO BE DIVERTED
PROPOSED ROAD DIVERSION
HT LINE
FEEDING POST
WORKSHOP
WORKSHOP FOR 6 CAR RAKES
INSPECTION SHED FOR 6 CAR RAKE
D/STOREY OFFICES
TRAIN WIRING SIDING
TOWER WAGON SHED
RERAILING TEAM
EMERGENCY BUILDING
ENGINEERING SIDINGS
SUN SHADE
ETP
P. WAY OFFICE & WORKSHOP
C/L OF MUTTOM STATION
KM 4.705
R471.95
R2213.34
R1105.65
R331.69
R1660.52
TL= 55
TL= 40
TL= 15
MUTTOM
THAKAVU
THAKAVU JUNCTION
RESIDENTIAL AREA
WATER LOGGED AREA
DRAWN BY
K.L.LUTHRA
CHECKED BY
J.L.ARORA
VALIDATED BY
D.D.PAHUJA
REVISION
FIRST ISSUE
DATE - 16-06-05
DESCRIPTION
DRAWN
CHECKED
APPROVED
KOCHI METRO
MUTTOM STABLING CUM INSPECTION DEPOT
LAYOUT (SG)
SCALE -/-
SHEET NO. 1/1
APPROVAL BY
NAME
DATE
SIGNATURE
DRAWING NO
DELHI METRO RAIL CORPORATION LTD
(DMRC)
KOCHI METRO/MUTTOM DEPOT/001-R0

Chapter 9

EIA

9.1 ENVIRONMENTAL BASELINE DATA

The main aim of the EIA study is to ascertain the existing baseline conditions and to assess the impacts of all the factors as a result of the proposed corridor during its construction and operation phases. The changes likely to occur in different components of the environment. Environment includes water, land, air, ecology, noise, socio-economic issues, etc. The information presented in this section stems from various sources such as reports, field surveys and environment monitoring. Majority of data on water quality, vegetation, air and noise quality was collected during field studies in April-May 2005. This data has been utilized to assess incremental impact, if any, due to the project. Collection and compilation of environmental baseline data is essential to assess the impact on environment due to the project.

9.1.1 Location and Physiography

Kochi is located at latitude 9^{o} $42'$ $38''$ North and longitude 76^{o} $12'$ East with an average elevation of 1.2 m above mean sea level. The proposed project route is level terrain with little undulation.

The meteorological condition prevailing at the project route is given below.

Temperature

Highest	:	$34.8^{o}C$
Lowest	:	$19.4^{o}C$
Average high	:	$33.2^{o}C$
Average low	:	$20.6^{o}C$

Rainfall

Annual total	: 2636.5 mm
Monthly Maximum	: 578.2 mm

Wind

Mean : 10.7 km / h

Predominant wind direction: West, Southwest and North West

9.1.2 WATER AND SOIL

The water samples were collected from dug wells in households / institutions to understand the water quality along the proposed project route. The surface water in the crossings of the main backwater inlets were also monitored. Water analysis was done for the physico-chemical and biological parameters as per standard methods. The results are presented in Tables 9.1 and 9.2.

Table 9.1
Analytical results of ground water samples

S. No.	Test Parameters	Requirement (Desirable limit)	Sampling stations															
			Alwaye		Kalamassery		Edappally		Palarivattom		Ekm. North		Ekm. South		Vyttila		Thripunithura	
	Unit	IS-10500, 1993	GW 1	GW 2	GW 1	GW 2	GW 1	GW 2	GW 1	GW 2	GW 1	GW 2	GW 1	GW 2	GW 1	GW 2	GW 1	GW 2
1	pH	6.5 – 8.5	6.8	5.2	4.4	6.4	7.9	7.8	7.5	7.6	7.1	6.6	6.9	6.8	7.2	6.7	6.8	6.7
2	Turbidity NTU	5 (Max)	0.9	0.2	0.1	0.4	0.3	0	0	4.2	98	0.6	2.8	1	1.3	11	0.9	1.4
3	Hardness as CaCO3 mg/L	300 (Max)	75	48.5	29	122.5	200	186	176.7	237.1	232.5	176.7	204.7	269.7	119	29	141	193
4	Chlorides mg/L	250 (Max)	8.86	18.6	28.3	15	3.54	28.3	46	37.2	77.7	37.7	35.3	28.2	7.54	11.3	18.8	58.4
5	Total dissolved solids mg/L	500 (Max)	93	120	153	196	60	52	57	76	99	59	59	49	44	10	6	39
6	Sulfates mg/L	200 (Max)	10.5	25	30	34	6.5	10.5	7.5	10	5.5	7.5	25	9.5	20.5	1	8.5	38
7	Nitrate mg/L	45(Max)	3	2.5	3.6	3.1	3	0.8	0.9	1.8	1	,9	0.8	2	0.9	0.4	0.9	0.3
8	Iron as Fe mg/L	0.30 (Max)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9	Copper as Cu mg/L	0.05 (Max)	0.01	0.02	0.02	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.03
10	Zinc as Zn mg/L	5 (Max)	0.1	0.09	0.05	0.03	0.05	0.05	0.02	0.04	ND	ND	ND	ND	ND	ND	ND	ND
11	Manganese as Mn mg/L	0.1 (Max)	ND	0.57	0.01	ND	0.02	ND	0.02	0.17	0.23	0.03	ND	ND	ND	ND	ND	0.05
12	Total hromium as Cr mg/L	0.05 (Max)	ND	0.01	0.01	0.02	0.03	0.03	0.03	0.03	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
13	Cadmium as Cd mg/L	0.01(Max)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
14	Magnesium mg/L	30(Max)	2.16	1.53	2.06	1.54	3.75	2.81	5.22	7.71	7.69	4.18	6.31	2.68	3.22	1.01	5.21	3.76
15	Selinium mg/L	0.01(Max)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
16	Arsenic as As mg/L	0.05 (Max)	0.02	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.01	0.01	0.01	0.01	0.01	ND	ND	ND
17	Mercury mg/L	0.001(Max)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
18	Total Coliforms MPN/100 ml	10	460	43	1100+	21	1100+	93	1100+	240	43	150	1100+	1100	460	1100+	7	93
19	Fecal Coliforms MPN/100 ml	0	290	15	460	11	460	9	1100	11	21	28	150	35	290	1100	4	23
20	Salmonella ---	0	Present	Present	Present	Present	Absent	Absent	Present	Present	Absent	Present	Present	Present	Present	Present	Absent	Present

The quality of the well water was inferred in comparison with the National Standards of Drinking Water Quality (IS: 10500, 1992). All the well water samples were colourless, odourless and with agreeable taste. One sample had high turbidity and 2 samples showed low pH. The chemical characteristics such as total hardness, chlorides, dissolved solids, sulphates and nitrates were within limits. Among the metals analysed iron, copper, zinc, chromium, magnesium, cadmium, selenium, mercury and arsenic were not detected or were within stipulated limits. The level of manganese exceeded the limits in 3 wells. The bacteriological quality of the ground water was found to be poor. All the wells had coliform bacteria to varying extent. The ICMR standard for drinking water stipulates that in individual or small community supplies the coliform should not exceed 10 per 100 mL. In this survey only one well conforms to this level. Salmonella a reported pathogen is present in 12 out of 16 wells.

The quality of the surface water is compared to the Class SW V waters for Navigation and controlled waste disposal. The results are given in Table 9.2. The pH and Dissolved oxygen are within the stipulated limits of navigational waters. There is no floating scum in the water surface.

Table 9.2

Analytical results of surface water samples

Parameter	observation
PH	6.23
Dissolved oxygen	3.93 mg/L
Colour and Odour	Negligible
Sludge deposit	Nil
Solid refuse	Negligible
Floating solids	Occasional
Oil & grease	Not detected
Scum	Nil

The proposed metro corridor generally runs through commercial area and a few patches have residential areas. Hence there is very little exposed soil along the route. However, soil samples were collected and analysed and the results are presented in Table 9.3.

Table 9.3

Physico-Chemical Characteristics of Soil

S.No.	Parameter	Value
1	pH	4.8
2	**Texture**	
	Sand (%)	60
	Silt (%)	22
	Clay (%)	18
3	Electrical conductivity	0.11 mmhos/cm
4	Bulk density	1.23 gm/cc
5	**Exchangeable cations**	
	Calcium (meq/100gm)	0.09
	Magnesium (")	0.06
	Sodium (")	11.6
	Potassium (")	52.2

9.1.3 GREEN COVER

Tree survey was carried out along the proposed alignment. The trees that could be affected by the implementation of the project were enumerated within 10 m(5m on either side from the center of the alignment). The tree volume and biomass were determined according to the standard methods of forest mensuration. The results are indicated in Table 9.4.

Table 9.4

Species richness of trees from Alwaye to Petta within 10 m of the Metro rail alignment

S. No.	Botanical Name	Vernacular Name	No. of Trees
1	Samanea Saman	Rain tree	53
2	Macaranga indica	Vatta	7
3	Nyctanthes arbotristis	Pavizha Mulla	6
4	Alstonia scholaris	Ezhilam Pala	9
5	Cocos nucifera	Coconut	132
6	Artocarpus integrifolia	Jack tree	23
7	Polyalthia longifolia	Arana maram	4
8	Azadirachta indica	Veppu	5
9	Tectona grandis	Teak	10
10	Mangifera indica	Mango tree	46
11	Cassia fistula	Kani Konna	1
12	Cinnamomum zeylanicum	Karuva	1
13	Areca catechu	Kamuku	12
14	Delonix regia	Gulmohur	12
15	Erythrina indica	Mullu murikku	2
16	Tamarindus indica	Valan puli	4
17	Lagerstroemia lanceolata	Venthekku	6
18	Ficus bengalensis	Peraal	3
19	Terminalia catappa	Thallithenga	13
20	Thespesia populnea	Poovarash	4
21	Glyrrhizidia maculata	Sheema Konna	8
22	Peltaphorum ferrugineum	-	97
23	Bombax ceiba	Panjimaram	1
24	Psidium guajava	Pera	3
25	Pongamia glabra	Ungu	3
26	Palm	Pana	1
27	Casuarina equisetifolia	Kattady	4
28	Acacia auriculiformis	Acacia	5
29	Hydnocarpus laurifolia	Marotti	1
30	Cerbera odollam	Othalam	1
		Total	**477**

The trees along the sides of the proposed alignment are mostly planted for shade purpose and a few are fruit bearing trees or coconut trees in private holdings.

The major tree species are Coconu*t,* Peltaphorum ferrugineum, Samanea saman, Mangifera indica and Artocarpus integrifolia. Tectona grandis is the only commercially valued tree in the locality which falls under the definition of The Kerala Preservation of Trees Act, 1986. It is observed that majority of the trees have been planted on the sides, which need to be cut. Most of the trees have girth greater than 70 cm. About 477 trees exist on the proposed alignment. No rare or endangered species of trees were noticed during field studies. No forest area exists along the alignment. The estimated biomass of 477 individuals is 97 tonnes.

9.1.4 AIR QUALITY

As part of the study, ambient air quality monitoring has been carried out by setting up ambient air quality monitoring stations at 8 locations for the parameters SPM, RPM, SO_2 and NOx. The ambient air quality stations were selected taking into the view of traffic flow and strategic locations on the proposed metro rail route. The locations are given in Table 9.5.

Table 9.5

Location of Ambient Air Monitoring Stations

S. No.	Monitoring Location
1	Alwaye
2	Kalamassery
3	Edappally
4	Palarivattam
5	Ernakulam North
6	Ernakulam South
7	Vyttila
8	Thripunithura

Sampling was done during April - May 2005 at the 8 locations along the proposed alignment from Alwaye to Petta.

As there is no provision for commercial / traffic related standards for the ambient air quality in National Air Quality Standards (NAAQS) for the parameters under study, the standards related to the residential / others in the NAAQS has been taken for evaluating the results from the present study. The NAAQ standards are presented as Table 9.6. The discussions are also based on Air Quality Index (AQI), a popular way of representing the air quality on an international scale. The categorization of the air quality as per the air quality index with the colour codes is presented in Table 9.7.

Table 9.6

National Ambient Air Quality Standards (NAAQS)

Pollutant	Time-weighted average	Concentration in ambient air			Method of measurement
		Sensitive area	Industrial area	Residential/ rural/ other areas	
Sulphur dioxide	Annual average	15	80	60	Improved West and Geake method
	24 h	30	120	80	Ultraviolet fluorescence
Oxides of nitrogen	Annual	15	80	60	Jacob and Hochheiser modified
	24 h	30	120	80	Gas phase chemiluminoscence
SPM	Annual	70	360	140	High volume sampling
	24 h	100	500	200	
RPM	Annual	50	120	60	RPM sampler
	24 h	75	150	100	
Lead	Annual	0.5	1.0	0.75	ASS method
	24 h	0.75	1.5	1.0	
CO	8 h	1	5	2	Nondispersive infrared spectroscopy
	1h	2	10	4	

All values except those for CO are in μg/m^3. CO values are in mg/m^3

Table 9.7

Air Quality Index (AQI) and Colour Codes

Air Quality Index (AQI) values	Levels of health concern	Colour
When AQI is in this range:	Air quality conditions are	Symbolized by the colour
0 to 50	Good	Green
51 to 100	Moderate	Yellow
101 to 150	Unhealthy for sensitive groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very unhealthy	Purple
301 to 500	Hazardous	Maroon

9.1.5 Air Quality Status of Kochi

The station wise monitoring results for each parameter are presented in Table 9.9. The review of the results in general shows that the RPM values have exceeded the NAAQS limits at a few stations. The concentration of NO_x exceeded the limit at two locations. SO_2 and SPM concentrations were found to be well within the NAAQS limits at all the stations. The overall air quality index is in the range of moderate to unhealthy in the study region. The day-wise AQI values for each station is presented in Table 9.8.

Table 9.8

Ambient Air Quality Index and Categorization of the Monitoring Stations

S. No.	Monitoring Station	Days	AQI value	Category
1	Alwaye	Day 1	92	Moderate
2		Day 2	93	Moderate
3		Day 3	93	Moderate
4	Kalamassery	Day 1	93	Moderate
5		Day 2	63	Moderate

S. No.	Monitoring Station	Days	AQI value	Category
6		Day 3	102	Unhealthy for sensitive groups
7	Edappally	Day 1	237	Very unhealthy
8		Day 2	240	Very unhealthy
9		Day 3	96	Moderate
10	Palarivattam	Day 1	167	Unhealthy
11		Day 2	89	Moderate
12		Day 3	54	Moderate
13	Ernakulam North	Day 1	141	Unhealthy for sensitive groups
14		Day 2	76	Moderate
15		Day 3	99	Moderate
16	Ernakulam South	Day 1	152	Unhealthy
17		Day 2	164	Unhealthy
18		Day 3	165	Unhealthy
19	Vyttila	Day 1	161	Unhealthy
20		Day 2	126	Unhealthy for sensitive groups
21		Day 3	132	Unhealthy for sensitive groups
22	Tripunithura	Day 1	163	Unhealthy
23		Day 2	154	Unhealthy
24		Day 3	194	Unhealthy

Table 9.9
Ambient Air Quality Monitoring Data

Alwaye			Kalamassery			Edappally			Palarivattom			Ernakulam North			Ernakulam South			Vyttila			Tripunithura		
1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
75.5	76.5	76.6	60.4	50.2	74.9	104.9	86.0	77.9	74.6	72.0	51.3	96.6	61.6	79.8	102.1	114.4	115.2	110.8	90.2	93.1	113.4	104.1	144.5
81.3	82.5	81.3	62.5	52.5	78.1	110.7	94.1	85.2	87.2	86.0	64.0	99.0	61.6	79.8	11.7	125.0	131.7	116.0	96.9	94.3	120.2	114.4	151.3
44.9	53.2	57.2	57.4	42.3	60.7	178.2	184.6	53.8	93.6	55.0	38.5	31.3	40.7	40.7	52.9	46.6	44.1	36.0	41.5	44.9	60.0	63.1	90.2
14.6	12.8	12.5	28.3	17.9	11.4	17.8	29.5	11.9	15.7	11.8	ND	53.5	nd	18.3	20.7	21.9	14.4	24.8	28.4	43.1	21.8	23.5	11.7

***ALL VALUES ARE 24 HOUR AVERAGE BASIS**

9.1.6 Air Quality Index (AQI)

The AQI in an index for reporting daily air quality. It tells how clean or polluted air is, and what associated health concerns one should be aware of. Air quality is measured by networks of monitors that record the concentrations of the major pollutants. These raw measurements are then converted in air quality index (**AQI**) values using standard formulas developed by US EPA.

$$\mathbf{AQI} = \frac{I_{HI} - I_{LO}}{BP_{HI} - BP_{LO}} \times (Conc - BP_{LO}) + I_{LO}$$

I_{LO} = index value at the lower limit of the AQI category
I_{HI} = index value at the upper limit of the AQI category
BP_{HI} = breakpoint concentration at the upper limit of AQI category
BP_{LO} = breakpoint concentration at lower limit of AQI category
Conc = pollutant concentration

An AQI value is calculated for each of the individual pollutants in an area. Finally the highest of the AQI values for the individual pollutants become the AQI value for that day. For example, if on a particular day, certain area had AQI values 120 for sulphur dioxide and 142 for RPM, the AQI value would be 142 for the pollutant RPM on that day. Each category corresponds to a different level of health concern.

(i) **Moderate:** If the AQI for a locality is between 51 and 100, air quality is acceptable. However, for some pollutants there may be a moderate health concern for a very small number of individuals.

(ii) **Unhealthy for sensitive groups**: Certain groups of people are particularly sensitive to the harmful effects of particular pollutants, which means that they are likely to be affected at lower levels than the general public. For example, children and adults who are active outdoors and people with respiratory diseases are at greater risk from exposure to ozone. When AQI values are between 101 and 150, members of sensitive groups may experience health effects. However, the general public is not likely to be affected when the AQI is in this range.

(iii) **Unhealthy**: If AQI values are between 151 and 200, everyone may begin to experience health effects. Members of sensitive groups may experience more serious health effects.

(iv) **Very Unhealthy**: When AQI values are between 201 and 300 health alert should be issued, meaning everyone may experience more serious health effects.

(v) **Hazardous**: or Critical AQI values over 300 trigger health warnings of emergency conditions. The entire population is more likely to be affected.

9.1.7 SEISMICITY

The project area falls in Zone III of Seismic Zoning Map of India. The India Meteorological Department (IMD) has considered seismic factor of 0.07 g to be adequate for design purpose for civil engineering structures.

9.1.8 NOISE

The noise levels were measured at 8 locations along the project alignment at 2.0 m away from the source as per standard practice. The noise levels so recorded as hourly Leq values are presented in Annexure I. The noise level ranges are summarized in Table 9.10. It could be concluded that the noise levels recorded at various stations are generally higher than the permissible levels of 65 dBA (day) and 55 dBA (night) for commercial areas and 55 dBA (day) and 45 dBA (night) for residential areas. The Ambient air quality standards in respect of noise are given in Annexure II.

Table 9.10
Summary of Noise Monitoring Data

S. No.	Station	day	night	day	night	day	night
1.	**Alwaye**	52.4-69.8 (63.3)	40.8-61.7 (46.3)	60.6-70.1 (65.6)	42.3-55.6 (48.1)	56.5-67.6 (64.9)	44.6-52.8 (47.8)
2.	**Kalamassery**	66.3-75.5 (70.9)	61.4-75.6 (65.4)	67.3-76.6 (71.4)	60.9-70.5 (66.2)	68.6-76.5 (72.0)	65.6-69.4 (66.9)
3.	**Edappally**	64.9-74.9 (70.3)	48.4-69.1 (60.2)	64.2-73.5 (70.1)	54.3-71.2 (62.0)	68.5-74.4 (71.8)	65.5-68.7 (66.9)
4.	**Palarivattom**	62.8-78.9 (72.7)	52.4-71.2 (61.1)	72.1-76.3 (74.0)	54.7-70.1 (61.2)	70.3-76.3 (73.6)	59.6-71.8 (64.6)
5.	**Ernakulam North**	66.4-78.1 (71.8)	54.5-68.7 (62.3)	67.8-6.8 (71.2)	52.9-65.8 (59.3)	70.7-74.6 (72.9)	54.8-68.4 (61.5)
6.	**Ernakulam South**	64.6-80.4 (75.5)	55.8-72.6 (64.7)	64.5-78.8 (74.4)	58.7-74.8 (64.3)	74.8-77.2 (76.4)	58.5-67.7 (61.8)
7.	**Vyttila**	68.9-80.1 (75.0)	55.9-72.5 (64.1)	66.8-77.9 (73.7)	59.7-69.5 (64.4)	68.9-75.4 (73.1)	61.7-65.8 (63.7)
8.	**Thripunithura**	66.6-80.2 (74.9)	51.2-73.2 (57.0)	67.7-77.2 (74.2)	50.5-64.8 (58.0)	71.3-79.5 (76.0)	46.3-63.7 (54.7)

All values are expressed in dB (A) the upper line in each column represents the range of values and the value in bracket represents the average noise level.

9.2 SOCIO-ECONOMICS

Impact of socio-economic environment would involve the demographic structure of the area, provision of basic amenities, health status of the people, socio-economic pattern of life in general and the aesthetic environment.

The Average literacy rate in Ernakulam district is 92.35 %. The literacy rate is high among men (95.46 %) compared to that among women (82.27 %). There are about 950 educational institutions in the district.

The public health facilities in the area are excellent which include primary health centers, govern-ment hospitals, private clinics and private nursing homes as well as super specialty hospitals. The other infrastructure facilities are also excellent. A number of post offices, banks, cooperative societies, etc adequately serve the public. The project activity is taking place in an urban area with a large number of major, medium and small-scale industries. They include fertilizer units, petrochemical units, cable units, milk units, tire manufacturing units, small and medium scale engineering units and miscellaneous units.

There are no important historical monuments along the proposed metro corridor.

9.2.1 Dislocation due to proposed project

In order to keep minimum acquisition of private land and Governmental properties, the project has been planned in such a way that mostly it runs along the median of existing roads. However, for station entry/exit, traffic integration, maintenance depot and construction depots, some acquisitions are required, the details of which are given in Chapter 5.

9.2.2 Sampling Design

In order to collect the primary data, a detailed questionnaire was used in the field. The sample surveys have been carried out at most of the households and shops, which are likely to be affected directly by the implementation of this project.

9.2.3 Socio-Economic Profile of the PAP's

As an initial survey, data was collected from the households / shops in Alwaye – Pulinchod area which is at the northern end of the Metro project and is analysed for different parameters and is tabulated below in different tables which shows the Family pattern (Table 9.12), Religious groups (Table 9.13), Caste distribution

(Table 9.14), Age-wise distribution (Table 9.15), Literacy Level (Table 9.16), Occupation (Table 9.17), Source of Income (Table 9.18), Annual Income (Table 9.19), Details of Structures (Table 9.20), Construction of Structure (Table 9.21), Ownership of Structure (Table 9.22), and Period of Construction (Table 9.23).

Table 9.12

Family Pattern of PAP

area	Joint		Nuclear		Individual		Total	
Alwaye to Pulinchodu	F	%	F	%	F	%	F	%
	14	28	15	30	21	42	50	100

Table 9.13

Religious Group of PAPs

Area	Hindu		Muslim		Christian		Total	
Alwaye to Pulinchodu	F	%	F	%	F	%	F	%
	25	50	9	18	16	32	50	100

Table 9.14
Caste distribution of PAPs

Area	SC/ST		OBC		General		Total	
Alwaye to Pulinchodu	F	%	F	%`	F	%	F	%
	0	0	14	28	36	72	50	100

Table 9.15
Age-wise distribution of PAPs

Area	1-14		15-35		36-60		>60		Total	
Alwaye to Pulinchodu	F	%	F	%	F	%	F	%	F	%
	32	20	43	26	60	37	27	17	162	100

Table 9.16
Literacy among PAPs of loosing land

Area	Literate		Illiterate		Primary		Middle		High school		College		Profess-ional		Total	
Alwaye to Pulinchodu	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%
	2	1.2	1	0.6	18	11.1	18	11.1	53	32.7	46	28.4	24	14.8	162	100

Table 9.17
Occupation of PAPs

Area	Labor		Business		Service		Unempl-oyed		Retired		Others		Total	
Alwaye to Pulinchodu	F	%	F	%	F	%	F	%	F	%	F	%	F	%
	14	9	23	14.2	17	10.5	74	46	13	8	21	13	162	100

Table 9.18
Source of Income of PAPs

Area	Agriculture		Wages		Self Employed		Service		Nil		Others		Total	
Alwaye to Pulinchodu	F	%	F	%	F	%	F	%	F	%	F	%	F	%
	1	0.6	21	13	10	6	16	10	75	46.4	39	24	162	100

Table 9.19
Annual Income of PAPs in Lakhs

Area	< 0.25		0.25-05		0.5-1.0		1.0-2.0		Not revealed		Nil		Total	
Alwaye to Pulinchodu	F	%	F	%	F	%	F	%	F	%	F	%	F	%
	2	1.2	1	0.6	64	39.3	12	7.5	8	5	75	46.4	162	100

Table 9.20
Details of structure

Area	House		Shop		House and shop		Factory		Others		Total	
Alwaye to Pulinchodu	F	%	F	%	F	%	F	%	F	%	F	%
	38	76	8	16	0	0	0	0	4	8	50	100

Table 9.21
Construction details of structure

Area	Kutcha		Semi-pucca		Pucca		Total	
Alwaye to Pulinchodu	F	%	F	%	F	%	F	%
	4	8	27	54	19	38	50	100

Table 9.22
Nature of ownership

Area	Owned		Rented		Others		Total	
Alwaye to Pulinchodu	F	%	F	%	F	%	F	%
	41	82	6	12	3	6	50	100

Table 9.23
Period of construction (years)

Area	<5		5-10		11-20		21-40		>40		Not recordab le		Total	
Alwaye to Pulinchodu	F	%	F	%	F	%	F	%	F	%	F	%	F	%
	4	8	1	2	17	34	11	22	7	14	10	20	50	100

The following conclusions can be drawn from the analysis of socio-economic scenario.

1. Percentage of joint and nuclear families are almost same in the study area
2. Hindu families are much more than any other religious group.
3. Percentage of general caste is predominant in all the areas,
4. The people of age group between 36 – 60 are predominant,
5. Most of the people are educated up to High School Level and above,
6. Though unemployed are more business is the main activity.
7. Wage earners and those in various services are predominant compared to self-employed.

8. Level of annual income is in between Rs 50,000/- and 1,00,000 /- for more than 1/3rd of the population
9. Houses form majority of the structures
10. Most of the structures are semi-pucca followed by pucca houses
11. Owned structures form the majority.
12. Mostly the structures are less than 20 years old and 20 % are in between 20 – 30 years.
13. Sources of drinking water are municipal supply and dug wells.
14. Septic tank is the predominant method of sanitation
15. Solid waste removal is mostly by Municipal help and is regular.

9.3 POSITIVE ENVIRONMENTAL IMPACTS

Based on the project particulars and existing environmental conditions potential impacts have been identified that are likely to result from the proposed metro rail project. The positive environmental impacts are as follows;

Reduction in traffic congestion
Quick service and safety
Less fuel consumption
Reduction in air pollution
Reduction of noise level
Better roads
Employment opportunities

9.4 NEGATIVE ENVIRONMENTAL IMPACTS

Negative impacts have been identified and listed under the following headings:
Impacts due to project location
Impact due to construction works
Impacts due to project operation

9.5 Impact due to project location

9.5.1 Change of land use pattern: The alignment is so selected that the change of land use pattern is minimum. The change of land use is expected to be about 16 hectares.

9.5.2 Loss of trees: About 477 trees exist along the alignment and are likely to be lost. Total cost of these trees lost is about Rs 3.5 lakhs. There will be no encroachment into natural reserves as the project area is in the urban center.

9.5.3 Loss of historical and cultural monuments: No historical or cultural monuments will be affected as a result of the proposed project.

9.5.4 Soil erosion and health risk at construction site: Runoff from unprotected excavated areas can result in excessive soil erosion especially when erodibility of soil is high. Mitigation measures include careful planning, timing of cut-and-fill operations and revegetation. Problems could arise from dumping of construction spoils, waste materials (from contractor's camp), etc. causing surface and groundwater pollution. Hence, it is proposed to have mix concrete directly from batching plant for use at site. Batching plants should be located away from the densely populated areas. Health risks during construction activity include hazards to workers due to lack of sanitary facilities like safe disposal of garbage and clearance and disposal facility. In order to avoid such a situation, proper mitigation measures should be incorporated, which should include proper water supply, sanitation, drainage, healthcare and human waste disposal facilities in labour camps. In addition reduced contaminated water spillage and adoption of disease control measures should be adopted to reduce health risks.

9.5.5 Traffic diversions and risk to existing buildings: During construction, traffic diversions on roads will be essentially required. As most of the construction activities will be confined to the centre of the road (in the elevated alignment) and most of the roads are narrow, it will be appropriate that one-way traffic with diversion of traffic to nearby road for smooth progress of construction activities be adopted. Advanced information on communication systems will be an advantage to users of any particular road. As elevated portion is to be located in the middle of the road and the deck width being much less than the existing road width, risk to the existing buildings all along the route will be practically negligible.

9.5.6 Impact on water quality: Construction activities may have impact on water bodies due to disposal of wastes. The waste could be due to spillage of construction materials, oil and greases, and labour camp wastes. However, care needs to be taken to provide adequate sanitary facilities and drainage in the temporary colonies of the construction workers. Provision of adequate washing and toilet facilities with septic tanks and appropriate refuse collection and disposal system should be made obligatory. Contamination of groundwater can take place, if the dump containing above substances gets leached and percolate into the groundwater table. This is not the case with the present project as the activity does not involve usage of any harmful ingredients. Moreover activities are of short duration. Hence no impact on either ground or surface water quality is anticipated in the present project.

9.6 Impacts due to Project Operation

9.6.1 Water Pollution: Pollution due to oil spillage is very likely during the service and maintenance of the rolling stock in the depot cum workshop. The common oil spillage occurs during cleaning and repair process, patchwork, painting as well as greasing and change of lubricants. An effluent treatment plant consisting of an oil separation unit may be set up in the depot premises for water pollution control. The extruded / spilled oil will be collected in special grit chambers to settle suspended matters. The trapped / collected oil may be auctioned or disposed after proper treatment. The treated water could be used for developing a green belt around the depot.

9.6.2 Noise: The main sources of noise include construction and fabrication activities during construction phase and during operational phase noises like Engine noise, cooling fan noise, Wheel rail interaction, Electric generator noise and miscellaneous noise like due to service and maintenance in the service depot, passenger's chatting etc. However these noises during operational stage is expected to be below the 80-dBA threshold levels. However, due to the implementation of metro rail project the reduction in road traffic will bring about a reduction of 10 to 15 % in ambient noise levels.

9.6.3 Accident Hazards: Internationally accepted on-site and off-site emergency measures recommended and accepted by metro rail systems has to be implemented to tackle the accident hazards due to failure of systems and operation as well as possible terrorist sabotages. Proper disaster management options will be formulated to tackle disruptions caused by natural calamities such as tidal waves associated with tsunamis or cyclones.

9.6.4 Water Supply and Sanitation: Central Public Health Environmental Engineering Organisation (CPHEEO) has recommended 45-litres/day of water supply to persons working at railway stations. All the stations are in urban area. Water requirement at stations has various components, viz, personal use of staff, fire demand, make up water for air conditioning and ventilation and wastage. The water demand at each station would be about 100 m^3 per day. The water requirement for fire fighting could be met from the municipal water supply system. It is also proposed to implement rainwater harvesting systems at stations. This will conserve considerable quantity of water, which in turn will reduce the load on the municipal water supply system.

The refuse from metro station includes; garbage, rubbish, and floor sweepings. The total refuse generated at each station will be about 100 kg/day on the assumption that only about 25 % of the passengers visiting various stations will be producing refuse. For the maintenance of adequate sanitary facilities, containers/collection bins not exceeding 120 litres and equipped with side handles will be appropriately designed and installed at stations and platforms. Awareness messages in the station premises will help greatly to reduce the generation of refuse.

9.7 CHECKLIST OF IMPACTS

A typical checklist identifying anticipated environmental impacts is shown below Table. 9.24.

Table 9.24
Checklist of Impacts

	Parameter	Negative impact	Positive impact	No impact
A	**Impacts due to Project Location**			
I	Change of landuse	*		
ii	Loss of trees	*		
iii	Loss of historical / cultural monuments			*
B	**Impact due to Project Construction**			
i	Soil erosion, pollution and health risk at construction site	*		
ii	Traffic diversions and risk to existing buildings	*		
iii	Impact on water quality			*
C	**Impact due to Project Operation**			
i	Oil pollution			*
ii	Noise and vibration	*		
iii	Accidental hazards			*
iv	Water supply			*
v	Metro station refuse			*
vi	Visual impacts			*
D	**Positive impacts**			
i	Traffic congestion reduction		*	

	Parameter	Negative impact	Positive impact	No impact
ii	Quick service and safety		*	
iii	Less fuel consumption		*	
iv	Better roads		*	
v	Reduction in air pollution		*	
vi	Employment opportunities		*	

9.8 ENVIRONMENTAL MANAGEMENT PLAN

Based on the environmental baseline conditions, planned project activities and its impact assessed, the set of measures to be taken during implementation and operation to avoid, offset adverse environmental impacts or to reduce them to acceptable levels, together with the action which needs to be taken to implemented are given in this section.

9.8.1 Mitigation Measures: Based on the project description, environmental baseline data and environmental impacts, it is proposed to prepare the environmental management plan for the following:

a) Compensation for loss of land

b) Compensation for loss of trees

c) Compensatory afforestation and fencing

d) Compensation for relocation / resettlement

e) Water supply and sanitation

f) Noise control

g) Vibration control

a) Compensation for loss of land: The cost of land for compensation is taken under the project cost.

b) **Compensation for loss of trees**: There are about 477 trees on the proposed route, which are required to be uprooted. The compensation for loss of trees works out to Rs.3.5 lakhs.

c) **Compensatory afforestation:** According to survey, about 477 trees are likely to be lost due to the project along the alignment. Ten times the number of trees is to be planted as done by the Delhi Metro Rail Corporation (DMRC) for Delhi metro rail project. Hence about 4770 plants are required to be planted in the project area in an area of 2 ha at a total cost of Rs. 1 lakh. It is presumed that government land will be provided for afforestation; hence no land cost will be involved. Compensatory afforestation should also be done as a green belt for the Muttom Dock Yard with the help of any local environmental NGO. The effluent from the dock yard discharged through the proposed ETP can be used to water these trees so that it will filter out the excess nutrients and other chemical ions and prevent ground water pollution. The recommended plant species for afforestation include Alstonia scholaris, Polyalthia longifolia, Pongamia glabra, Mimusops elengi, Sweitenia mahogany, Hydnocarpus laurifolia, Hopea parviflora, Strychnos nuxvomica, Cassia fistula and Casuarina equisetifolia.

d) **Compensation for relocation/resettlement:** The project involves relocation of shops, commercial cum residential buildings along the alignment. Which need to be paid compensation as per Government policy.

e) **Water supply and sanitation**: The public health facilities such as water supply sanitation and toilets are much needed at project location. Water should be treated before use upto WHO standards. In addition, water will be required for contractors's camps during construction for which additional arrangements have to be made in consultation with the Corporation of Kochi and Kerala Water Authority. The collection and safe disposal of human wastes are among the most important problems of environmental health. During the operation phase, adequate water supply and sanitation facilities would be made available at all the stations. Properly designed rain water harvesting systems will be installed at all stations to conserve water. Effluent treatment plant has to be put up at the Muttom Dock yard.

f) **Noise**: There will be an increase in noise level in ambient air due to construction and operation of metro rail. However, noise level in the city will go down. The increase in levels is marginal, hence local population will not be adversely affected. However, the exposure of workers to high noise levels especially near engine, vent shaft, etc. need to be minimized. This can be achieved by job rotation, automation, protective devices, noise barriers, and soundproof compartments, control rooms, etc. The workers employed in high noise level area could be employed in low noise level areas and vice versa from time to time. Automation of equipment and machineries, wherever possible should be done to avoid continuous exposure of workers to noise. At work places, where automation of machineries is not possible or feasible, the workers exposed to noise should be provided with protective devices. Special acoustic enclosures should be provided for individual noie generating equipments, wherever possible.

g) **Vibration control**: Vibration emanates from rail-wheel interaction and the same can be reduced by minimizing surface irregularities of wheel and rail, improving track geometry, providing elastic fastenings, and separation of rail seat assembly from the concrete plinth with insertion of resilient and shock absorbing pad.

9.9 ENVIRONMENTAL MONITORING PLAN

The environmental monitoring will be required for the construction and operational phases. The parameters to be monitored are water quality, air quality and noise level.

a) **Water quality**: Water quality parameters can be monitored one year before the construction, during the construction phase and also for one year after the completion of the project. Monitoring shall be carried out at least four times a year to cover seasonal variations. The parameters for monitoring will be pH, total dissolved solids, chlorides, nitrates, sulphates, total suspended solids, calcium, iron, fluoride, total alkalinity, oil and grease, etc. Locations for monitoring can be decided after the construction phase. The cost of water quality analysis for four locations works out to be Rs 4.00 lakhs.

b) **Air quality and noise level:** Ambient air quality and noise level should be monitored one year before the construction, during the construction phase, and for one year after the completion of the project. The proposed monitoring programme for field monitoring and laboratory analysis of air and noise is given in Table 24. The cost of ambient air quality and noise level monitoring works out to be Rs 15.20 lakhs.

Table 9.25

Proposed monitoring programme air and noise quality

Monitoring	Monitoring parameters	Number of proposed sites	Sampling duration	Frequency	Cost (Rs lakhs)
Ambient air quality	4	4	Twice a week	Four times a year	15.00
Noise levels	dB(A)	4	Once a week	Seasonal	0.20
				Total cost	**15.20**

9.10 ENVIRONMENTAL MANAGEMENT SYSTEM

The environmental management system constitutes provision of an environmental division, which should be staffed by an environmental engineer/officer, an environmental assistant and two other assistants. The task assigned should include supervision and coordination of monitoring and implementation of environmental mitigation measures. An environmental advisor shall review progress of the division every year.

ANNEXURE I

Location of Monitoring Station: Alwaye

Date of Monitoring: 16-17 April, 2005

Time, hours	Hourly Leq, dB(A)
16.00	67
17.00	66
18.00	66
19.00	65
20.00	64
21.00	57
22.00	57
23.00	50
24.00	42
1.00	42
2.00	41
3.00	43
4.00	44
5.00	45
6.00	51
7.00	59
8.00	61
9.00	64
10.00	62
11.00	58
12.00	68
13.00	61
14.00	65
15.00	62

Location of Monitoring Station: Kalamassery

Date of Monitoring: 20-21 April, 2005

Time, hours	Hourly Leq, dB(A)
14.00	74
15.00	72
16.00	75
17.00	67
18.00	72
19.00	70
20.00	73
21.00	70
22.00	67
23.00	67
24.00	69
1.00	64
2.00	62
3.00	67
4.00	62
5.00	64
6.00	69
7.00	71
8.00	72
9.00	72
10.00	70
11.00	69
12.00	69
13.00	69

Location of Monitoring Station: Edappally

Date of Monitoring: 5-6 May, 2005

Time, hours	Hourly Leq, dB(A)
13.00	72
14.00	72
15.00	71
16.00	71
17.00	70
18.00	69
19.00	71
20.00	68
21.00	67
22.00	66
23.00	62
24.00	56
1.00	53
2.00	58
3.00	54
4.00	60
5.00	62
6.00	69
7.00	67
8.00	72
9.00	69
10.00	69
11.00	70
12.00	71

Location of Monitoring Station: Palarivattam

Date of Monitoring: 9-10 May, 2005

Time, hours	Hourly Leq, dB(A)
13.00	72
14.00	69
15.00	74
16.00	74
17.00	77
18.00	73
19.00	72
20.00	72
21.00	69
22.00	71
23.00	67
24.00	58
1.00	58
2.00	56
3.00	54
4.00	55
5.00	60
6.00	67
7.00	72
8.00	73
9.00	73
10.00	75
11.00	73
12.00	71

Location of Monitoring Station: Ernakulam North

Date of Monitoring: 13-14 May, 2005

Time, hours	Hourly Leq, dB(A)
12.00	73
13.00	73
14.00	74
15.00	71
16.00	71
17.00	71
18.00	76
19.00	73
20.00	72
21.00	69
22.00	67
23.00	65
24.00	66
1.00	62
2.00	61
3.00	58
4.00	60
5.00	58
6.00	61
7.00	67
8.00	69
9.00	69
10.00	72
11.00	74

Location of Monitoring Station: Ernakulam South

Date of Monitoring: 17-18 MAY, 2005

Time, hours	Hourly Leq, dB(A)
14.00	79
15.00	77
16.00	77
17.00	77
18.00	76
19.00	76
20.00	74
21.00	72
22.00	67
23.00	71
24.00	62
1.00	64
2.00	61
3.00	57
4.00	61
5.00	67
6.00	65
7.00	71
8.00	76
9.00	76
10.00	77
11.00	76
12.00	77
13.00	77

Location of Monitoring Station: Vyttila

Date of Monitoring: 20-21may, 2005

Time, hours	Hourly Leq, dB(A)
17.00	79
18.00	77
19.00	78
20.00	78
21.00	79
22.00	69
23.00	67
24.00	63
1.00	59
2.00	56
3.00	63
4.00	64
5.00	64
6.00	71
7.00	73
8.00	73
9.00	74
10.00	75
11.00	73
12.00	77
13.00	75
14.00	69
15.00	72
16.00	76

Location of Monitoring Station: Tripunithura

Date of Monitoring: 25-26 May, 2005

Time, hours	Hourly Leq, dB(A)
15.00	78
16.00	77
17.00	77
18.00	75
19.00	74
20.00	70
21.00	71
22.00	65
23.00	59
24.00	61
1.00	58
2.00	46
3.00	44
4.00	52
5.00	55
6.00	68
7.00	69
8.00	74
9.00	77
10.00	79
11.00	73
12.00	76
13.00	77
14.00	77

ANNEXURE II

Noise pollution (regulation and control) rules, 2000

Schedule [see rule 3(1) and 4(1)]

Ambient air quality standards in respect of noise

Area code	Category of area/zone	Limits in dB(A) Leq	
		Day time	Night time
A	Industrial area	75	70
B	Commercial area	65	55
C	Residential area	55	45
D	Silence zone	50	40

Note:

1. Day time shall mean 6.00 am to 10.00 pm.
2. Night time shall mean from 10.00 pm to 6.00 am.
3. Silence zone is defined as an area comprising not less than 100 m around hospitals, educational institutions and courts. The silence zones are zones which are declared as such by the competent authority.
4. Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority.

dB(A) Leq denotes the time weighted average of the level of sound in decibels on scale a which is related to human hearing. Leq is an energy mean of the noise level over a specified period.

Chapter 10

Cost Estimates

10.1 INTRODUCTION

Detailed cost estimates for Alwaye - Petta corridor have been prepared covering civil, electrical, signalling and telecommunications works, rolling stock, environmental protection, rehabilitation, etc. considering 25 KV OHE Traction at August, 2011 price level.

While preparing the capital cost estimates, various items have generally been grouped under three major heads on the basis of (i) route km length of alignment, (ii) number of units of that item, and (iii) item being an independent entity. All items related with alignment, whether elevated or at-grade construction, permanent way, traction, Signalling & telecommunication, whether in main lines or in maintenance depot, have been estimated at rate per route km basis. Cost of station structures, other electrical services at these stations including Lifts & Escalators and automatic fare collection (AFC) installations at all stations have been assessed in terms of each station as a unit. Similarly Rolling stock costs have been estimated in terms of number of units required. In remaining items, viz. land, utility diversions, rehabilitation, etc. the costs have been assessed on the basis of each item, taken as an independent entity.

In order to arrive at realistic cost of various items, costs have been assessed on the basis of accepted rates in various contracts of Phase II by DMRC and escalated to August 2011 price level except stations where the rates have been reduced due the smaller length of the stations (3 coach only). However the details of taxes and duties are worked out separately.

The capital cost has been worked out for Alwaye - Petta corridor with Depot at Muttom.

The overall capital cost for Alwaye – Petta corridor, at August , 2011 price level, works out to Rs. 3733 crores, excluding taxes and duties, but including general charges @ 7% on all items except land and 3% contingencies on all items. The abstract capital cost estimates are shown at **Table 10.1.**

TABLE10.1

CAPITAL COST ESTIMATE					
ALWAYE-PETTA					
Total Length(Dead End to Dead End) : 25.612Km, Ramp = 1.000 Km. UG : 0 Km, Elevated (Including ramp approach depot) = 26.612 Km, Depot At Grade : 1.175 Km					
Total Station =23, Elevated : 23					
S. No.	**Item**	**Unit**	**Rate as per Price level AUG-2011 (INR In Crores)**	**Qty.**	**Amount (INR in Cr.) (Cost Without Taxes & Duties) as per Price level AUG-2011**
1.0	**Land (INCLUDING R&R COSTS)**				
1.6	Permament	LS			604.00
	Sub Total (1)	LS			**604.00**
2.0	**Alignment and Formation**				
2.1	Elevated viaduct section	R. km.	30.142	25.612	771.98
2.2	At Grade	R. km.	21.099	1.000	21.10
	Sub Total (2)				**793.08**
3.0	**Station Buildings**				
3.1	Elevated stations (including finishes)				
a	Type (A) way side Civil works	Each	13.973	16.000	223.56
b	Type (A) way side E&Mworks	Each	2.254	16.000	36.06
c	Type (B) Way side with signaling civil works	Each	15.134	6.000	90.80
d	Type (B) Way side with signaling E&M works	Each	2.438	6.000	14.63
e	Type (C), Terminal station	Each	17.469	1.000	17.47
f	Type (C) Way side with signaling E&M works	Each	2.818	1.000	2.82
	Sub total (3)				**385.34**
4.0	**Depot**				
4.1	Muttom				
a	Civil works	LS			59.93
b	E&M	LS			82.02
	Sub total (4)				**141.95**

5.0	**P Way**				
5.1	Ballastless track for elevated alignment including ramp	R. km.	6.738	26.612	179.31
5.2	Ballastted track at grade	R. km.	6.738	1.175	7.92
	Sub total (5)				**187.23**
6.0	**Traction & power**				
	Traction & power supply incl. OHE, ASS etc.				
6.1	Elevated section	R. km.	8.560	27.787	237.86
6.2	Escalatoe at Elevated Section	R. km.	1.001	46.000	46.02
	Sub total (8)				**283.88**
7.0	**Signalling and Telecom.**				
7.1	Signalling & Telecom	R. km.	12.000	26.612	319.34
7.2	Automatic fare collection	Each Stn	3.079	23.000	70.82
	Sub Total (7)				**390.16**
8.0	**R & R incl. Hutments etc. (NO COST AS IT IS INCLUDED IN LAND COST)**	LS			0.00
	Sub Total (10)				**0.00**
9.0	**Misc. Utilities, other civil works such as median, road signages etc.**				
9.1	Civil works + E&M works	R. km.	2.500	26.612	66.53
	Sub Total (9)				**66.53**
10.0	**Rolling Stock (SG)**	Each	8.400	66	554.40
	Sub Total (10)				**554.40**
11.0	**CISF BARRACKS ETC.**	LS			20.00
	Sub Total (11)				**20.00**
12.0	**Total of all items except Land**				**2822.57**
13.0	**General Charges incl. Design charge @7% on all items except land**				**197.58**
14.0	**Total of all items including General charges except land**				**3020.15**
15.0	**Contingencies @ 3 %**				**90.60**
16.0	**Gross Total**				**3110.75**
COST WITHOUT LAND					**3111**
	Total of cost inclusive of land cost				**3733**

10.2 CIVIL ENGINEERING WORKS

10.2.1 Land

i) Land requirements have been kept to the barest minimum & worked out on area basis. For elevated viaduct, no land is proposed to be acquired permanently since piers are located mostly on central median of roads. Land is proposed to be acquired permanently in small areas for locating entry/exit structures, traffic integration, etc. at stations, for at-grade stretch near Alwaye for car maintenance & construction depots and for the stretch where alignment is off the road.

ii) Total land requirements have been worked out to 9.3787 ha. of govt. land and 15.9559 ha. private land including 12.8096 ha. for car maintenance depot at Muttom and construction depots, is also proposed to be acquired. Total requirement of Government land and Private land put together comes to 25.3347 ha.

10.2.2 Formation & Alignment

Rates are based on accepted rates for on going works of Delhi Metro, duly updated to Aug, 2011 price level and duly corrected for the systems proposed for Kochi Metro. Cost of viaduct length for station has been included in elevated section.

10.2.3 Station Buildings

Estimated rate is based on accepted rates for stations for Phase II Corridors of Delhi Metro and modified for 3 coach length platforms. The cost includes the general services at the stations but excludes the cost of viaduct, escalators, which have been considered separately under, respective items.

10.2.4 Permanent Way

For elevated section, ballastless track and for at-grade section and Depot ballasted track has been planned. Rates adopted are based on accepted rates of Delhi Metro which covers both ballastless & ballasted tracks.

10.3 DEPOT

Car Maintenance Depot-cum-Workshop has been proposed at Muttom. The depot is planned at ground level. Costs have been worked out for various items of building, elevated structures, tracks, boundary wall & plants machinery etc.

10.4 UTILITY DIVERSIONS

The costs of utility diversions involved in the stretch have been considered separately and provided for in the estimate. In addition to sewer/drainage/water pipelines other important utilities works considered are road diversions, road restoration etc. Cost provision has been made on route km basis based on experience of Delhi Metro.

10.5 ENVIRONMENTAL IMPACT ASSESSMENT

Provision for environmental impacts of Alwaye –Petta Metro corridor has been made to cover various protection works, additional compensatory measures, compensation for loss of trees, compensatory afforestation and fencing, monitoring of water quality, air/noise pollution during construction, establishment of Environmental Division.

10.6 REHABILITATION & RESETTLEMENT

Provision towards compensation/rehabilitation of structure likely to be affected has been assessed. This provision has been included in land cost item

10.7 TRACTION & POWER SUPPLY

Provisions have been made to cover following subheads:

- 25 Kv OHE.
- Receiving-cum-Traction Sub-stations including cables.
- ASS for elevated and at-grade stations.
- Service connection charges for Receiving Sub-stations.
- Scada augmentation.
- Miscellaneous items e.g. illumination, lifting T&P, etc.

The rates adopted for various items are based on the completion rates of Phase II.

10.8 ELECTRICAL SERVICES AT STATIONS

These are included in estimated E & M costs of stations. Cost of escalators for elevated stations has been taken separately under the cost item head of Traction and Power supply.

10.9 SIGNALLING & TELECOMMUNICATION WORKS

The rates adopted are based on assessment done considering rates of similar sub-system on Delhi Metro. These rates include escalation during manufacture & supply of equipment and their installation at site, but exclude CD and WT.

10.10 AUTOMATIC FARE COLLECTION

Adopted rates are based on assessment done considering rates accepted on Delhi Metro. These rates exclude CD & WT, but include escalation during the period of equipment manufacture and their supply, including installation.

10.11 ROLLING STOCK

Cost of the coach has been taken as adopted for the estimate of Phase III of Delhi Metro.

10.12 TAXES AND DUTIES

The component of Import Duty, Excise Duty, Sales Tax and works Tax is not included in the Capital cost estimated. The estimated taxes and duties work out to Rs. 616 crores (Table 10.2)

Table 10.2
Details of Taxes and Duties (Alwaye -Petta Corridor, Kochi)

	Customs duty =	20.9464	%					
	Excise duty =	10.3	%					
	Sale tax =	6.25	%					
	Works tax =	6.25	%					
	VAT =	12.5	%					
			Taxes and duties					
S. No.	**Description**	**Total cost without Taxes & duties (Cr.)**	**customs duty (Cr.)**	**excise duty (Cr.)**	**sale tax (Cr.)**	**works tax (Cr.)**	**VAT (Cr.)**	**Total taxes & duties (Cr.)**
1	**Alignment & Formation**							
	Elevated, at grade & entry to Depot	793.08		81.69	49.57	49.57	99.14	**180.82**
2	**Station Buildings**							
	Elevated station - civil works	385.34		39.69	24.08	24.08	48.17	**87.86**
3	**Depot**							
	Civil works	59.93	3.77	1.85	1.12	1.12	2.25	**7.87**
	EM works	82.02	3.44	6.76	4.10	4.10	8.20	**18.40**
4	**P-Way**	187.23	31.37	3.86	2.34	2.34	4.68	**39.91**
5	**Traction & power supply**							
	Traction and power supply	237.86	19.93	14.70	8.92	8.92	17.84	**52.47**
	Esclators	46.02	9.64					**9.64**
6	**S and T Works**							
	S & T	319.34	53.51	6.58	4.40	4.40	8.81	**68.90**
	AFC	70.82	11.13	1.82	1.22	1.22	2.44	**15.39**
7	**R & R hutments**	40.00				2.50	2.50	**2.50**
8	**Misc.**							
	Civil works & E&M	66.53		6.85	4.16	4.16	8.32	**15.17**
9	**Rolling stock**	554.40	102.19	6.85	0.43	0.43	0.86	**109.90**
10	**CISF**							
	Civil works	20.00		2.06	2.58	2.58	5.15	**7.21**
	Total	**2862.57**	**234.97**	**172.71**	**102.92**	**105.42**	**208.34**	**616.03**
	Total taxes & Duties					**SAY**		**616**

Chapter 11

Financing

CHAPTER 11

FINANCING OPTIONS, FARE STRUCTURE AND FINANCIAL VIABILITY

11.1 INTRODUCTION

The Kochi Metro covering a route length of 25.612 KMs is proposed to be constructed with an estimated cost of Rs 3733 Crore at August 2011 price level without taxes and duties but including land cost of Rs. 622 crore. The estimated cost with central taxes is Rs. 4141 crore.

The estimated cost at August-2011 price level includes an amount of Rs.20 Crore as one-time charges of security personal towards cost of weapons, barricades, hand held and door detector machine etc. However, the recurring cost towards salary and allowances of security personal have not taken into account in FIRR calculation.

11.2 Costs

11.2.1 Investment Cost

11.2.1.1 For the purpose of calculating the Financial Internal Rate of Return (FIRR), the completion cost with central taxes have been calculated by taking escalation factor @5% PA. It has been assumed that Government of Kerala will exempt local taxes or reimburse the same. The impact of proposed Goods & Service Tax Act (GST) has not been considered in the calculation.

The project will be taken up for construction in April-2012 and expected to be completed on 31.03.2016 and Revenue Opening Date (ROD) has been assumed as 01.04.2016. The total completion costs duly escalated and shown in the table 11.1 have been taken as the initial investment. The cash flow of investments separately is placed in Table –11.1 as below.

Table 11.1 Corridor-wise & Year wise Investment-With Central Taxes

Figs in Rs. Cr.

Financial Year	Estimated Cost	Completion Cost
2012-13	436.00	392.00
2013-14	602.00	602.00
2014-15	942.00	1039.00
2015-16	831.00	1048.00
2016-17	666.00	882.00
2017-18	332.00	462.00
2018-19	332.00	485.00
Total	4141.00	4910.00

11.2.1.2 Although the construction is expected to get over by 31st March 2016, the cash flow spills up to March 2019 on account of payment normally required to be made to the various contractors up to that period necessitated by contractual clauses.

11.2.1.3 The land cost is divided in initial three years during which it is expected that the land acquisition work would be over and related payments would have to be released.

11.1.4 The escalation factor used is 5% p.a. including on land cost. The land cost including escalation @5% worked out to Rs.672 crore.

11.2.2 Additional Investment

Total investment provided in the FIRR calculation towards requirement of additional rolling stock duly escalated @5% PA is placed in table 11.2 as under: -

Table 11.2 Additional Investment towards Rolling Stock (Rs/Crore)

With Taxes & Duties			
2020-21		2025-26	
No of Cars	Amount	No of Cars	Amount
15	234.00	27	538.00

11.2.3 Operation & Maintenance (O&M) Costs

11.2.3.1 The Operation & Maintenance costs can be divided into three major parts: -

(i) Staff costs

(ii) Maintenance cost which include expenditure towards upkeep and maintenance of the system and consumables

(iii) Energy costs

The staff is assumed to be provided @ 35 persons per kilometre. The escalation factor used for staff costs is 9% per annum to provide for both escalation and growth in salaries.

The cost of other expenses is based on the actual O & M unit cost for the Delhi Metro Phase-2 project. The rate of electricity assumed in the Delhi Metro study is about Rs. 3.20 per unit whereas at present in Kochi the applicable rate is Rs. 4.00 per unit. The latter has been used for all calculations. The O&M cost (excluding staff cost) has been obtained by providing an escalation of 5% per annum towards energy cost, 5% towards Maintenance cost.

11.2.3.4 The total O&M cost of both the corridors have been tabulated in Table 11.3 as below:

Table 11.3 Operation and Maintenance Costs

Figs in Rs. Cr.

YEAR			Staff	Maintenance Expenses	Energy	Total
2016	-	2017	62.39	25.61	20.68	108.68
2017	-	2018	68.01	26.89	21.71	116.61
2018	-	2019	74.13	28.24	22.80	125.16
2019	-	2020	80.80	29.65	23.93	134.38
2020	-	2021	88.07	31.13	30.22	149.42
2021	-	2022	95.99	32.69	31.73	160.41
2022	-	2023	104.63	34.32	33.32	172.27
2023	-	2024	114.05	36.04	34.98	185.07
2024	-	2025	124.32	37.84	36.73	198.89
2025	-	2026	135.50	39.73	45.93	221.17
2026	-	2027	147.70	41.72	48.23	237.65
2027	-	2028	160.99	43.80	50.64	255.44
2028	-	2029	175.48	45.99	53.17	274.65
2029	-	2030	191.28	48.29	55.83	295.40
2030	-	2031	208.49	50.71	58.63	317.82
2031	-	2032	227.25	53.24	61.56	342.05
2032	-	2033	247.71	55.90	64.63	368.25
2033	-	2034	270.00	58.70	67.87	396.57
2034	-	2035	294.30	61.63	71.26	427.19
2035	-	2036	320.79	64.72	74.82	460.33
2036	-	2037	349.66	67.95	78.56	496.17
2037	-	2038	381.13	71.35	82.49	534.97
2038	-	2039	415.43	74.92	86.62	576.96
2039	-	2040	452.82	78.66	90.95	622.43
2040	-	2041	493.57	82.59	95.49	671.66
2041	-	2042	537.99	86.72	100.27	724.99

11.2.4 Depreciation

Although depreciation does not enter the FIRR calculation (not being a cash outflow) unless a specific depreciation reserve fund has been provided, in the present calculation, depreciation calculations are placed for purpose of record.

11.2.5 Replacement Cost

The replacement costs are provided for meeting the cost on account of replacement of equipment due to wear and tear. With the nature of equipment proposed to be provided, it is expected that only 50% of the Signalling and Telecom and 25% of electrical works would require replacement after 20 years. Further, 50% of the Signalling and Telecom and 25% of electrical works would require replacement after 30 years. These costs have been provided duly escalated @ 5% per annum.

11.3 Revenues

The Revenue of Kochi metro mainly consists of fare box collection and other incomes from property development, advertisement, parking etc.

11.3.1 Fare box

The Fare box collection is the product of projected ridership per day and applicable fare structure based on trip distribution at different distance zones.

11.3.2 Traffic

11.3.1.1 a. The projected ridership figures years are as indicated in table 11.4 as below: -

Table 11.4 Projected Ridership

Year	Trips per day (lakhs)
2016-17	3.82
2020-21	4.68
2025-26	5.39
2030-31	6.01

11.3.1.1 b. The growth rate for traffic is assumed at 4% Per Annum upto 2019-20, @ 3% from 2020-21 to 2024-25 and @2% thereafter.

11.3.1.2 Trip Distribution

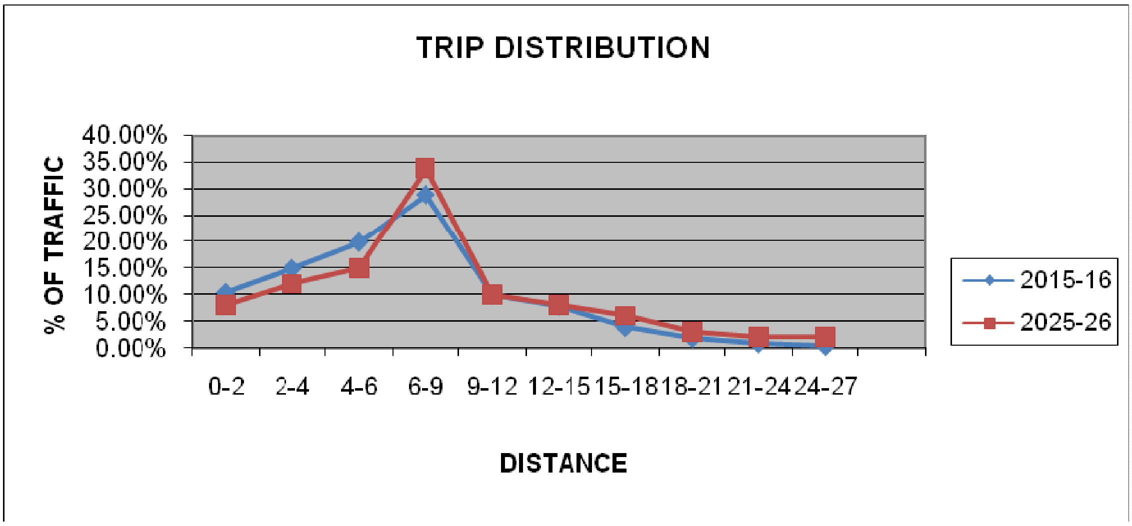
The trip distribution has been worked out is placed in Table 11.5 below: -

Table 11.5 Trip Distribution

Distance in kms.	Percent distribution	
	2016-17 (With an average Lead of 7.33 KMS)	2025-26 (With an average Lead of 8.46 KMs)
0-2	10.50%	8.00%
2-4	15.00%	12.00%
4-6	20.00%	15.00%
6-9	29.00%	34.00%
9-12	10.00%	10.00%
12-15	8.00%	8.00%
15-18	4.00%	6.00%
18-21	2.00%	3.00%
21-24	1.00%	2.00%
24-27	0.50%	2.00%
Total	100.00%	100.00%

The graphic presentation of the same is placed below in Figure-11.1.

Figure 11.1 –Trip Distribution



Fare Structure

The Delhi Metro Fares structures as fixed by a fare fixation committee in 2009 have been assumed, which have been duly escalated @7.50% for every two years with effect from 2009, which is placed in table 11.6.

Table 11.6 Fare Structure in 2016-17

Distance in kms.	DMRC's existing fare from 2009 (Rs.)	Proposed fare for Kochi Metro (Rs.)
0-2	8.00	10.00
2-4	10.00	13.00
4-6	12.00	15.00
6-9	15.00	19.00
9-12	16.00	21.00
12-15	18.00	23.00
15-18	19.00	24.00
18-21	21.00	27.00
21-24	22.00	28.00
24-27	23.00	30.00

11.3.2 Other sources of revenues

Other revenues from Property Development and advertisement have been estimated at 15% of the fare box revenues during operations. Apart from development of property on metro stations and depot it is possible to raise resources through leasing of parking rights at stations, advertisement on trains and tickets, advertisements within stations and parking lots, advertisements on viaducts, columns and other metro structures, co-branding rights to corporate, film shootings and special events on metro premises.

11.4 Financial Internal Rate of Return (FIRR)

The FIRR with Central taxes only is produced in Table 11.7.

Table 11.7 FIRR:

Particulars	Completion Cost With Central Taxes
FIRR (%)	**3.04 %**

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Chapter 12

Economic Analysis

12.1 INTRODUCTION

12.1.1 The purpose of undertaking an economic evaluation is to provide an overall picture of the contributions of the METRO system to broadly defined social goals thereby justifying its implementation. The economic viability is commonly expressed in terms of Economic Internal Rate of Return (EIRR).

12.2 ECONOMIC ANALYSIS APPROACH

12.2.1 The economic appraisal of METRO Corridor from Alwaye to Petta in Cochin has been carried out within the broad framework of Social Cost –Benefit Analysis Technique. It is based on the incremental costs and benefits and involves comparison of project costs and benefits in economic terms under the “with” and “without” project scenario. In the analysis, the cost and benefit streams arising under the above project scenarios have been estimated in terms of market prices and economic values have been computed by converting the former using appropriate shadow prices. This has been done to iron out distortions due to externalities and anomalies arising in real world pricing systems. The annual streams of project costs and benefit have been compared over the analysis period of 36 years to estimate the net cost/ benefit and to calculate the economic viability of the project in terms of EIRR.

12.2.2 The Economic Internal Rate of Return (EIRR) for the project has then been arrived using Discounted Cash Flow technique to the net benefit stream at economic prices.

12.3 EVALUATION ASSUMPTIONS

The key evaluation assumptions used in the economic evaluation are listed in **Table 12.1**

Table 12.1 KEY EVALUATION ASSUMPTIONS

PARAMETER	ASSUMPTION
Price Level	AUG 2011
First year of operation	2016
Construction period	4 years (2012-2015)
Daily to annual factor	340

12.4 ESTIMATION OF COSTS

12.4.1 The project cost comprises capital cost, operation and maintenance cost.

Cost components considered for the purpose of this exercise include:

- Capital cost of infrastructure (civil engineering, land, track, power supply, traction system, signaling and telecommunications, etc.) and rolling stock.
- Operating cost of METRO

Table 12.2 summarizes the estimated cost (Rs. in Crores) to economy for Alwaye-Petta Corridor of Cochin METRO. The construction cost is estimated at Rs. 3733 Cr.

TABLE 12.2
ESTIMATED COST TO ECONOMY FOR ALWAYE-PETTA CORRIDOR OF KOCHI METRO IN 2011

SYSTEM	COST	Rs. In Crores
METRO	Construction Cost	3733
	Operating Cost	108.68

12.5 ESTIMATION OF BENEFITS

12.5.1The Alwaye-Petta corridor of Cochin METRO will yield tangible and non-tangible savings due to equivalent reduction in road traffic and certain socio-economic benefits. Introduction of METRO will result in reduction in number of buses, usage of private vehicles, air pollution and increase the speed of road-based vehicles. This, in turn, will result in significant social benefits due to reduction in fuel consumption, vehicle operating cost and travel time of passengers. Reduction in accidents, pollution and road maintenance costs are the other benefits to the society in general.

12.5.2. The benefit stream that has been evaluated and quantified includes:

- Capital and operating cost (on present congestion norms) of carrying the total volume of passenger traffic by existing bus system and private vehicles in case METRO project is not taken up.
- Savings in operating costs of all buses and other vehicles due to de-congestion including those that would continue to use the existing transport network even after the METRO is introduced.
- Savings in time of commuters using the METRO over the existing transport modes because of faster speed of METRO.
- Savings in time of those passengers continuing on existing modes, because of reduced congestion on roads.
- Savings on account of prevention of accidents and pollution with introduction of METRO.
- Savings in road infrastructure and development costs that would be required to cater to increase in traffic, in case METRO is not introduced.
- Savings in fuel consumption on account of less number of vehicles on road and decongestion effect with introduction of METRO are included in those of vehicle operating cost.

The values used for various parameters used for the analysis are given in Annexure-1.

12.5.3 Quantification of some of the social benefits has not been attempted because universally acceptable norms do not exist to facilitate such an exercise. However, it has been considered appropriate to highlight the same, as given below:

- Reduced road stress
- Better accessibility to facilities in the influence area
- Economic stimulation in the micro region of the infrastructure
- Increased business opportunities
- Overall increased mobility
- Facilitating better planning and up-gradation of influence area.
- Improving the image of the city.

12.6 TRANSPORT DEMAND ON METRO CORRIDOR

12.6.1 At present mostly buses operated by private operators, Ferries and railway services are meeting the transport demand in the study area. Part of the demand is also met by auto modes and private modes. As explained in Chapter 2, the transport demand for various years is given in **Table 12.3.**

TABLE 12.3
TRANSPORT DEMAND FORECAST ON ALWAYE-PETTACORRIDOR OF KOCHI METRO

I T E M	2016	2021	2026
Total Trips (Lakh)	22.00	24.70	26.40
Trips on METRO (Lakh)	3.82	4.68	5.39
Trips by other modes (Lakh)	18.18	20.02	21.01

12.7 REDUCTION IN TRAFFIC CONGESTION AND FUEL CONSUMPTION

12.7.1 The traffic on METRO will come from the shift from buses, ferry, train, auto, car and two wheeler. The major shifting of traffic would be from buses, two wheeler and car modes considering the comfort and convenience factor. It has been estimated that the number of buses and other IPT modes are likely to decrease with the introduction of this METRO corridor..

12.8 PASSENGER TIME SAVING

12.8.1 With the introduction of Cochin METRO, there will be reduction in traffic congestion on the roads and correspondingly, there will be saving in time of commuters travelling by various modes of road transport. Similarly, METRO System itself being faster than conventional road transport modes, will also lead to considerable saving in time of commuters travelling on METRO.

12.9 SAFETY

12.9.1The reduction in traffic volumes on roads brought about by modal transfer to METRO is expected to reduce number of accidents. Any reduction in number of accidents will involve savings from damage to vehicles and savings towards medical and insurance expenses to persons involved in accidents.

12.10 REDUCED AIR POLLUTION

12.10.1The benefits because of saving in cost of prevention of vehicular pollution, with the implementation of proposed Kochi METRO.

12.11 SAVINGS IN ROAD INFRASTRUCTURE

12.1.1The METRO corridor may bring savings in investment in road infrastructure because shifting of passengers to METRO and withdrawal of vehicles in the project area. Since no local data is available concerning the road infrastructure investment on this account, this saving has not been incorporated into economic evaluation.

12.12 SHADOW PRICING

The value of Project cost and benefits have been expressed in terms of market prices. These prices, however, do not reflect the real resource cost and value of benefits derived from the project to the economy. The market prices are distorted due to variety of factors. These factors could be controlled/administered prices of inputs, monopolistic market of inputs, tax structure etc. The factors used for converting project inputs and output to economic costs are given in following **Table 12.4**

S. No.	ITEM	FACTOR
1	CAPITAL COST	0.85
2	OPERATIONS & MAINTENANCE COST	0.80
3	SAVINGS IN OPERATING COST	1.10
4	SAVINGS IN PASSENGER TIME	1.0
5	SAVINGS IN ACCIDENT COSTS	1.0
6	SAVINGS IN POLLUTION COSTS	1.0

12.13 RESULT OF ECONOMIC ANALYSIS

12.13.1 The cost and benefit streams for 29 year period in the economic prices have been worked out and presented in **Tables 12.5** for Alwaye-Petta corridor of Cochin METRO. The residual value of METRO facilities (e.g. Metro and Rail corridors, equipment for power supply and tele-communication, rolling stock, etc.) in last year has not been taken into account as benefit in these tables. The total cost worked out on the above basis is then subtracted from the total benefits to estimate the net benefit of the project. This flow is then subjected to the process of discounting to work out the internal rate of return on the project, to examine the viability of the Project in Economic terms. Thereafter, the Project EIRR in economic terms has been arrived by using shadow prices.

12.13.2 The EIRR in economic terms works out to 14.2% for Alwaye-Petta Corridor of Cochin METRO.

12.14 SENSITIVITY ANALYSIS

12.14.1 A sensitivity analysis of the EIRR with 10% cost overrun and 10% reduction in traffic materialisation (separately) has been carried out. The EIRR under these scenarios are given in **Table 12.6.**

TABLE 12.6
EIRR - SENSITIVITY ANALYSIS

SENSITIVITY	EIRR
Basic EIRR	**14.2%**
With increase in cost by 10%	13.0%
With reduction in traffic materialization by 10%	12.9%
With 10% reduction in traffic and increase in cost by 10%	**11.8%**

Annexure I

Vehicle Occupancy		Rs/Km	Rs/Hr
Veh_Typ	**Occupancy**	**VOC**	**VOT**
Car	2.27	2.2	55
2-Whlr	1.25	1.4	30
Auto	1.8	1.84	35
Bus	41.82	5.36	15

Emission Factors (Gms/Veh-Km)						
Veh_Typ	**TSP**	**SO2**	**NOX**	**CO**	**HC**	**Pb**
Car	0.1483	0.2800	1.9000	9.5000	1.5000	0.0106
2-Whlr	0.0323	0.0800	0.3900	8.3000	0.7200	0.0023
Auto	0.1030	0.5000	0.1000	12.2500	7.6500	0.0073
Bus	2.5000	2.0000	21.0000	12.7000	2.1000	0.0000

Health Cost of Emissions 15.79394 Rs. (Crore)/Ton/Day

APPENDIX II

Cost and Benefit Stream : Normal Scenario Rs. IN Cr.					
YEAR	**CAPITAL**	**Operation & Maintenance Cost**	**TOTAL COSTS**	**TOTAL SAVINGS**	**NET CASH FLOW**
2012	-634.61	0.00	-634.61	0.00	-635
2013	-634.61	0.00	-634.61	0.00	-635
2014	-951.92	0.00	-951.92	0.00	-952
2015	-951.92	-86.94	-1038.86	0.00	-1039
2016	0.00	-86.94	-86.94	455.46	369
2017	0.00	-86.94	-86.94	498.00	411
2018	0.00	-86.94	-86.94	541.74	455
2019	0.00	-86.94	-86.94	586.64	500
2020	0.00	-86.94	-86.94	632.75	546
2021	0.00	-86.94	-86.94	648.79	562
2022	0.00	-86.94	-86.94	665.19	578
2023	0.00	-86.94	-86.94	681.94	595
2024	0.00	-86.94	-86.94	699.06	612
2025	0.00	-86.94	-86.94	713.33	626
2026	0.00	-86.94	-86.94	732.71	646
2027	0.00	-86.94	-86.94	752.65	666
2028	0.00	-86.94	-86.94	773.17	686
2029	0.00	-86.94	-86.94	794.29	707
2030	0.00	-86.94	-86.94	816.03	729
2031	0.00	-86.94	-86.94	838.39	751
2032	0.00	-86.94	-86.94	861.40	774
2033	0.00	-86.94	-86.94	885.08	798
2034	0.00	-86.94	-86.94	909.45	823
2035	0.00	-86.94	-86.94	934.51	848
2036	0.00	-86.94	-86.94	960.31	873
2037	0.00	-86.94	-86.94	986.84	900
2038	0.00	-86.94	-86.94	1014.15	927
2039	0.00	-86.94	-86.94	1042.24	955
2040	0.00	-86.94	-86.94	1071.14	984
2041	0.00	-86.94	-86.94	1100.70	1014
2042	0.00	-86.94	-86.94	1131.08	1044
2043	0.00	-86.94	-86.94	1162.30	1075
2044	0.00	-86.94	-86.94	1194.38	1107
2045	0.00	-86.94	-86.94	1227.34	1140
Total	**-3173.05**	**-2695.26**	**-5868.31**	**25311.07**	**19442.75**
				IRR %	**14.2%**
ENPV (Rs. in crores @ 12% discount rate)					**577.9**

Cost and Benefit Stream						
Sensitivity I: 10% increase in cost						
Units: Rs in Crores						
YEAR	CAPITAL	RUNNING EXPENSE OF MRTS	TOTAL COSTS	TOTAL SAVINGS	NET CASH FLOW Rs. IN Cr.	IRR
2012	-698.07	0.00	-698.07	0.00	-698	
2013	-698.07	0.00	-698.07	0.00	-698	
2014	-1047.11	0.00	-1047.11	0.00	-1047	
2015	-1047.11	-95.64	-1142.74	0.00	-1143	
2016	0.00	-95.64	-95.64	455.46	360	
2017	0.00	-95.64	-95.64	498.00	402	
2018	0.00	-95.64	-95.64	541.74	446	
2019	0.00	-95.64	-95.64	586.64	491	
2020	0.00	-95.64	-95.64	632.75	537	
2021	0.00	-95.64	-95.64	648.79	553	
2022	0.00	-95.64	-95.64	665.19	570	
2023	0.00	-95.64	-95.64	681.94	586	
2024	0.00	-95.64	-95.64	699.06	603	
2025	0.00	-95.64	-95.64	713.33	618	
2026	0.00	-95.64	-95.64	732.71	637	
2027	0.00	-95.64	-95.64	752.65	657	
2028	0.00	-95.64	-95.64	773.17	678	
2029	0.00	-95.64	-95.64	794.29	699	
2030	0.00	-95.64	-95.64	816.03	720	
2031	0.00	-95.64	-95.64	838.39	743	
2032	0.00	-95.64	-95.64	861.40	766	
2033	0.00	-95.64	-95.64	885.08	789	
2034	0.00	-95.64	-95.64	909.45	814	
2035	0.00	-95.64	-95.64	934.51	839	
2036	0.00	-95.64	-95.64	960.31	865	
2037	0.00	-95.64	-95.64	986.84	891	
2038	0.00	-95.64	-95.64	1014.15	919	
2039	0.00	-95.64	-95.64	1042.24	947	
2040	0.00	-95.64	-95.64	1071.14	976	
2041	0.00	-95.64	-95.64	1100.70	1005	
2042	0.00	-95.64	-95.64	1131.08	1035	
2043	0.00	-95.64	-95.64	1162.30	1067	
2044	0.00	-95.64	-95.64	1194.38	1099	
2045	0.00	-95.64	-95.64	1227.34	1132	
Total	-3490.36	-2964.79	-6455.15	25311.07	18855.92	
				EIRR %	13.03%	
				ENPV (Rs. in crores @ 12% discount rate)	292.40	

Cost and Benefit Stream Units: Rs in Crores Sensitivity II: 10% reduction in benefits						
YEAR	CAPITAL	RUNNING EXPENSE OF MRTS	TOTAL COSTS	TOTAL SAVINGS	NET CASH FLOW Rs. IN Cr.	
2012	-634.61	0.00	-634.61	0.00	-635	
2013	-634.61	0.00	-634.61	0.00	-635	
2014	-951.92	0.00	-951.92	0.00	-952	
2015	-951.92	-86.94	-1038.86	0.00	-1039	
2016	0.00	-86.94	-86.94	409.91	323	
2017	0.00	-86.94	-86.94	448.20	361	
2018	0.00	-86.94	-86.94	487.57	401	
2019	0.00	-86.94	-86.94	527.98	441	
2020	0.00	-86.94	-86.94	569.48	483	
2021	0.00	-86.94	-86.94	583.91	497	
2022	0.00	-86.94	-86.94	598.67	512	
2023	0.00	-86.94	-86.94	613.75	527	
2024	0.00	-86.94	-86.94	629.15	542	
2025	0.00	-86.94	-86.94	642.00	555	
2026	0.00	-86.94	-86.94	659.44	572	
2027	0.00	-86.94	-86.94	677.39	590	
2028	0.00	-86.94	-86.94	695.85	609	
2029	0.00	-86.94	-86.94	714.86	628	
2030	0.00	-86.94	-86.94	734.43	647	
2031	0.00	-86.94	-86.94	754.55	668	
2032	0.00	-86.94	-86.94	775.26	688	
2033	0.00	-86.94	-86.94	796.57	710	
2034	0.00	-86.94	-86.94	818.51	732	
2035	0.00	-86.94	-86.94	841.06	754	
2036	0.00	-86.94	-86.94	864.28	777	
2037	0.00	-86.94	-86.94	888.16	801	
2038	0.00	-86.94	-86.94	912.74	826	
2039	0.00	-86.94	-86.94	938.02	851	
2040	0.00	-86.94	-86.94	964.03	877	
2041	0.00	-86.94	-86.94	990.63	904	
2042	0.00	-86.94	-86.94	1017.97	931	
2043	0.00	-86.94	-86.94	1046.07	959	
2044	0.00	-86.94	-86.94	1074.94	988	
2045	0.00	-86.94	-86.94	1104.61	1018	
Total	-3173.05	-2695.26	-5868.31	22779.96	16911.65	
				EIRR %	12.92%	
				ENPV (Rs. in crores @ 12% discount rate)	234.61	

Cost and Benefit Stream						
Sensitivity III: 10% increase in cost and 10% reduction in Benefits						
Units: Rs in Crores						
YEAR	CAPITAL	RUNNING EXPENSE OF MRTS	TOTAL COSTS	TOTAL SAVINGS	NET CASH FLOW Rs. IN Cr.	IRR
2012	-698.07	0.00	-698.07	0.00	-698	
2013	-698.07	0.00	-698.07	0.00	-698	
2014	-1047.11	0.00	-1047.11	0.00	-1047	
2015	-1047.11	-95.64	-1142.74	0.00	-1143	
2016	0.00	-95.64	-95.64	409.91	314	
2017	0.00	-95.64	-95.64	448.20	353	
2018	0.00	-95.64	-95.64	487.57	392	
2019	0.00	-95.64	-95.64	527.98	432	
2020	0.00	-95.64	-95.64	569.48	474	
2021	0.00	-95.64	-95.64	583.91	488	
2022	0.00	-95.64	-95.64	598.67	503	
2023	0.00	-95.64	-95.64	613.75	518	
2024	0.00	-95.64	-95.64	629.15	534	
2025	0.00	-95.64	-95.64	642.00	546	
2026	0.00	-95.64	-95.64	659.44	564	
2027	0.00	-95.64	-95.64	677.39	582	
2028	0.00	-95.64	-95.64	695.85	600	
2029	0.00	-95.64	-95.64	714.86	619	
2030	0.00	-95.64	-95.64	734.43	639	
2031	0.00	-95.64	-95.64	754.55	659	
2032	0.00	-95.64	-95.64	775.26	680	
2033	0.00	-95.64	-95.64	796.57	701	
2034	0.00	-95.64	-95.64	818.51	723	
2035	0.00	-95.64	-95.64	841.06	745	
2036	0.00	-95.64	-95.64	864.28	769	
2037	0.00	-95.64	-95.64	888.16	793	
2038	0.00	-95.64	-95.64	912.74	817	
2039	0.00	-95.64	-95.64	938.02	842	
2040	0.00	-95.64	-95.64	964.03	868	
2041	0.00	-95.64	-95.64	990.63	895	
2042	0.00	-95.64	-95.64	1017.97	922	
2043	0.00	-95.64	-95.64	1046.07	950	
2044	0.00	-95.64	-95.64	1074.94	979	
2045	0.00	-95.64	-95.64	1104.61	1009	
Total	**-3490.36**	**-2964.79**	**-6455.15**	**22779.96**	**16324.82**	
				EIRR %	**11.81%**	
				ENPV (Rs. in crores @ 12% discount rate)	**-50.93**	

Chapter 13

Implementation Plan

13.1 GENERAL

Kochi Metro Project will be the biggest urban Project undertaken in Kerala state. The Project has to be implemented through densely populated area along highly congested routes. In spite of all efforts taken to mitigate inconveniences and hardships to the public, certain sensitive land acquisitions and certain disruptions in the city are unavoidable. If the Project has to go through fast, a visible positive support to the Project from the Government, City Corporation and GCDA should be available. Each day's delay in completing this Project will hike up the cost of the Project by 15 lakhs. If the Project implementation is delayed, the city will become more and more crowded and it will be practically impossible to carry out construction activities later on. Therefore, a carefully drawn up strategy is necessary for implementing this Project.

Government of Kerala has already approved earlier Detailed Projct Report submitted in July, 2005 for Kochi Project. Decision has also been taken by the Govt. of Kerala vide their G.O.No.32/2011/Tran dated 18.06.2011 that a Special Purpose Vehicle (SPV) named as Kochi Metro Limited shall be formed under the provisions of Company Act, 1956 with an Authorized Capital of Rs. 2000 Crores. The composition of Board of Directors for the SPV has also been decided vide the above G.O . Managing Director is named and already in position. On receipt of updated DPR, it may be put up to State Government once again for the information and approval of updated cost.

13.2 INSTITUTIONAL ARRANGEMENTS

To enable Kochi Metro project to be implemented without any loss of time and cost over-run, effective institutional arrangements would need to be set up. Details of these arrangements are explained below:

13.2.1 SPECIAL PURPOSE VEHICLE

As above ,the SPV with the name as Kochi Metro Limited should immediately be formed and organization thin but effective to be put in place under the leadership of MD already posted for this work. In order to avoid delays usually associated with bureaucratic process of decision-making, the Board of Directors (BOD) of KML should be vested with full powers needed to implement the project. The BOD, in turn, should delegate adequate powers to the Managing Director to take all decisions in day-to-day matters. MD, Kochi Metro should also be assisted by few functional directors for taking important decisions. Two options of implementing the project are given in Finance viability chapter, However, DMRC recommends the implementation pattern of DMRC. Once the project is commissioned, there are two ways of operation and maintenance ie. either by SPV itself or through the concessionaire. The decision on this important issue has to be taken by The GoK.

13.3 IMPLEMENTATION THROUGH SPV

In the case of O & M through Concessionaire, the SPV's role is limited to that of a regulatory authority. Thus KML would monitor the implementation of the project and its commissioning, performing task such as laying down the passengers fares, targets for minimum number of services to be run by Concessionaire, their frequency, punctuality, liability, safety etc. There cannot be any compromise on these matters and penalty for not achieving these target have to be set up in advance. KML in this option will have to enter into an agreement with the Concessionaire, clearly listing out the obligations and rights of the concessionaire and the client (i.e. KML). Terms and conditions for appointing the concessionaire for O & M, are to be finalized

As the project is already delayed by 5 years, now the prompt action has to be taken by GoK to implement the Metro Project. The proposed commissioning of the Alwaye-Petta Corridor with suggested dates of important milestones are given in **Table 13.1**.

Table 13.1
Implementation Schedule through SPV

S. No.	Item of Work	Completion Date
1	Obtain Central Government Clearances	30.11.2011
2	Finalisation of Major Contracts	29.02.2012
3	Execution of works and Procurement of equipments, coaches and installations	01.04.2012 – 31.12.2015

4	Testing and Commissioning	01.01.2016 – 31.03.2016
5	Revenue Operation	31.03.2016

13.4 ORGANISATION SET-UP OF KML

The KML Organisation, as stated above, should be very lean but effective. It will consist of a Managing Director with full Executive Powers and three Functional Directors including Director (Finance). All the three Functional Directors will be full members of the Management Board. The Directors will be assisted by Heads of Departments in each of the major disciplines and they in turn will have supporting staff. The organisation should be basically officer-oriented with only Personal Assistants and Technical Assistants attached to senior officers by eliminating unproductive layers of staff such as Peons, Clerks, etc. We strongly recommend that the total organisational strength is limited to 45 to 50 eliminating too many tiers to enable faster decision-making.

It is necessary for the KML officers to get exposed to the Metro technology and Metro culture through study tours of some of the selected foreign Metros and Delhi/Calcutta/ Chennai Metros.

13.4.1 Implementing a metro project in a congested metropolis is indeed a challenge. In sheer size, magnitude and technical complexity there are few parallels to metro projects. Further, these projects are to be carried out in difficult urban environment without dislocating city life, while at the same time preserving the environment. The project involves integration of a number of complex technical systems – some of the technologies used in these systems are new to the country – each one of which is a major project by itself. Whereas actual construction work in the field will be the responsibility of the Concessionaire, its supervision for quality control and monitoring the construction schedule to achieve the laid down targets will have to be done by KML. Interfacing various system contracts is a difficult and highly skilled exercise.

Clearances from the local authorities have to be taken to cut trees. Arrangements for diversion of utilities, management of road traffic, etc., all of which will call for an efficient and competent project implementing agency will also be the responsibility of KML.

Metro projects cannot be executed the way Government agencies execute projects in this country. Timely completion is very important to safeguard their financial viability. Being a rail-based project, for most of the systems such as rolling stock, signalling, telecommunication, traction power supply, etc., persons with railway background would be necessary.

Since KML will not have the required expertise and experienced manpower to check and monitor the Concessionaire's work it may be necessary to engage

General Consultants, from the very start who will do this job on behalf of KML or it should be got implemented on deposit terms from any agency having the experience of construction of Metro and also O & M.

13.5 HIGH POWER COMMITTEE

During the implementation of the project several problems with regard to acquisition of land, diversion of utilities, shifting of structures falling on the project alignment, rehabilitation of project affected persons, etc. are likely to arise. For expeditious resolution of these problems, an institutional mechanism needs to be set up at the State Government level. Towards this end, it is recommended that a High Power Committee under the chairmanship of Chief Secretary, Kerala should be set up. Other members of this Committee should be Secretaries of the concerned Departments of the State Government and Heads of civic bodies who will be connected in one way or the other with the implementation of the project. This Committee should meet once a month and sort out all problems brought before it by KML. For Delhi Metro also such a High Power Committee was set up and it proved very useful in smooth implementation of the Delhi Metro rail project.

13.6 CONTRACTS

Number and type of contracts required to implement the project may be decided taking advantage of experience of implementing Delhi Metro.

13.7 LEGAL FRAMEWORK

Government of India has passed metro act named as “The Metro Railways (Amendment) Act 2009” which may readily be used for implementing the Kochi Metro

13.8 CONCESSIONS FROM GOVERNMENT

Metro rail projects need very heavy investment. Loans have invariably to be taken to fund a part of the capital cost of the projects. These projects yield low financial internal rate of return though their economic internal rate of return is very high. With reasonable fair level, servicing of these loans often pose problems. To make the project financially viable, therefore, the fares need to be substantially increased to socially un-acceptable levels. This results in the ridership coming down significantly, as it is sensitive to increases in the fare level. Thus the very objective of constructing the metro rail system to provide an affordable mode of mass travel for public is defeated. It, therefore, becomes necessary to keep the initial capital cost of a metro project as low as possible so that the fare level of the metro system can be kept at reasonable level.

13.8.1 Experience of Delhi Metro project has shown that the taxes and duties constitute about 16 – 18% of the project cost. Following are the taxes and duties, which have to be borne by a metro project:

- Custom Duty on all imported rolling stock and other equipment needed for the project.
- Excise Duty on all indigenously manufactured rolling stock and other indigenously finished goods required for the project.
- Sales Tax on all purchases made for implementation of the project whether directly by the project implementation authority or by the contractors executing the project.
- Sales Tax on works contracts to be executed for the implementation of the - project.
- Tax on electricity required for operation and maintenance of the metro system.
- Municipal Taxes.

13.8.2 In the case of Delhi Metro project, the Union Government has granted exemption from payment of Custom Duty and Excise Duty while the Delhi Government has agreed to give exemption from payment of Sales Tax and Sales Tax on works contracts. Delhi Metro Rail Corporation is also pursuing with the Government for exemption from tax on electricity being consumed by Delhi Metro for its operation and maintenance.

13.8.3 It is recommended that similar exemptions from taxes and duties be granted by the Central Government/Kerala Government for Kochi Metro. In this connection it may be mentioned that the Central Government has been encouraging infrastructure projects in the country through fiscal and non-fiscal concessions Cities have emerged as the engines of growth and mass transport systems today are one of the most important pre-requisites for the balanced growth of the city. The Government can demonstrate the importance it attaches to this sector by granting the above concessions which would not only help reduce the initial cost of the project so that Kochi Metro remains commercially viable during its operation phase but also send strong signals to the effect that it is committed to a safer and pollution free city. Moreover, public transport is employment-friendly and favours social balance in a sustainable way since it allows access to jobs and services to all.

13.9 Meanwhile the State Government should freeze all further developments along the proposed route of Kochi Metro to avoid infructuous expenditure and take necessary steps for completion of the ROBs/Flyovers under execution or planning. Widening of roads from Vytilla to Petta should also be completed which is necessary for the project to take off.

Chapter 14

Conclusions

14.1 Kochi is the commercial capital of Kerala as well as a center for higher education. Cochin Port has emerged as one of the most important ports in the country. Rapid urbanization in the recent past has put the city's travel infrastructure to stress. With Vellarpadam Container Terminal, Goshree Island Development project and industrial activities centred around Cochin Shipyard, Cochin Refinery, Cochin Fertilizer Plant, etc., traffic in the city is expected to shoot up. Being thickly populated area and with narrow roads, Kochi's traffic needs cannot be met by any road-based system.

On account of the intense developments, waterways, low-lying areas and heavy type of constructions, provision of a rail based mass transit system cannot be delayed any further. Studies have brought out that a Light Metro with carrying capacity of about 25,000 phpdt will be adequate to meet not only the traffic needs for the present but for the rest 30 to 35 years also. A Light Metro System from Alwaye to Petta (25.612 km), at an estimated completion cost of Rs. 5146 crores (Including Central Taxes but excluding state taxes) to be made operational by the year 2016 has accordingly been recommended.

14.2 A detailed Environmental Impact Assessment Study has been carried out for the project. As a part of this Study, comprehensive environmental baseline data was collected, and both positive and negative impacts of the project were assessed in detail. The project has many positive environmental impacts like reduction in traffic congestion, saving in travel time, reduction in air and noise pollution, lesser fuel consumption, lesser road accidents etc, with a few negative impacts (especially during implementation phase of the project) for which Environmental Management Plan has been suggested.

14.3 The fare structure has been estimated based on Delhi Metro fares duly escalating the same for year 2009. Subsequently, for the purpose of assessing returns form the project, the fares have been revised every second year with an escalation of 7.5%.

14.3 In Kochi Metro there is not much scope of property development along the corridor as land is not available for the same. However, there is scope to permit additional FSI for all properties falling in the belt of 500 meters on either side of the metro alignment. This additional FSI will have to be purchased by the land owner/developers at a predetermined premium per FSI sq. m which can be reviewed periodically.

14.4 As in the case of Delhi Metro, the State and the Central Governments should exempt Kochi Metro from the following taxes and duties:

- Custom Duty on all imported rolling stock and other equipment needed for the project.
- Excise Duty on all indigenously manufactured rolling stock and other indigenously finished goods required for the project.
- Sales Tax on all purchases made for implementation of the project whether directly by the project implementation authority or by the contractors executing the project.
- Sales Tax on works contracts to be executed for the implementation of the - project.
- Tax on electricity required for operation and maintenance of the metro system.
- Municipal Taxes.

14.5 While the Financial Internal Rate of Return (FIRR) for the project has been assessed as 3.04%, the Economic Internal Rate of Return (EIRR) works out to 14.2%.

14.6 To avoid delays in processing the clearance for the Project, It is suggested that immediately on receipt of the DPR, the State Government should approve it 'in principle' and forward the DPR to the Secretary, Ministry of Urban Development, Government of India, advising the GOI of the State Government's intention to take up the Project on BOT basis and requesting for the latter's "in principle" clearance to go ahead with the Project.

14.7 Meanwhile the State Government should freeze all future developments along the proposed route of Kochi Metro to avoid infructuous expenditure and take early action for completion of the ROBs/Flyovers under execution or planning. Widening of the road from Vytilla to Petta should also be completed, which is necessary for the project in this stretch to take off.

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