CHAPTER 3 THE OCH CONCEPT

One of the biggest transportation issues facing Colombo is the lack of an orbital or outer ring road. The purpose of such a road in the CMR would be to encourage the development of current or future growth centers, to connect radial routes, and lastly to divert through traffic from the center of the city. This is in line with the stance of the Urban Development Authority (UDA) and the Sri Lankan Government to shift some of the city's core urban functions and population to the outer suburbs in order to reduce congestion and control urban sprawl. In regards to this goal, the OCH is crucial, since it connects many of the present and future growth centers that the UDA envisions in Colombo, which would attract traffic away from the center of Colombo and reduce congestion by creating a multi-core urban structure instead of a uni-core structure (see Fig.3.1).

Based on the needs of the CMR described above, one of the major functions of the OCH will be the servicing of relatively short-distance trips between existing and future growth centers and existing radial routes. Given this, it does not seem advisable for the OCH to be a fully-controlled facility like the Colombo Katunayake Expressway (CKE). On the other hand, it is crucial for the OCH to maintain relatively high speeds if it is to properly fulfill the functions mentioned above. It is suggested, therefore, that the OCH be constructed to a standard somewhere between an arterial road and an expressway.

Given the above suggestion, it is realistically unfeasible for the OCH to be a toll road, since a toll road must be a fully-controlled facility in order to collect tolls from users. A partially-controlled facility with levels of service between an arterial road and an expressway (e.g., a toll way) would have the functions needed to provide the access required together with sufficient travel speeds for the people of the CMR. Based on this, it is recommended that the physical structures of the OCH has the basic characteristics listed below:

1. Be partially-controlled: To allow for OCH access only at pre-established interchanges, with fences and bus bays at the appropriate locations.
2. Be separated by a median or green area: To secure the safety of OCH users.
3. Be grade-separated: To ensure high levels of operation and the smooth flow of traffic.
4. Be equipped with a frontage road: To ensure sufficient access to the OCH as well as maintain current road and community integrity.

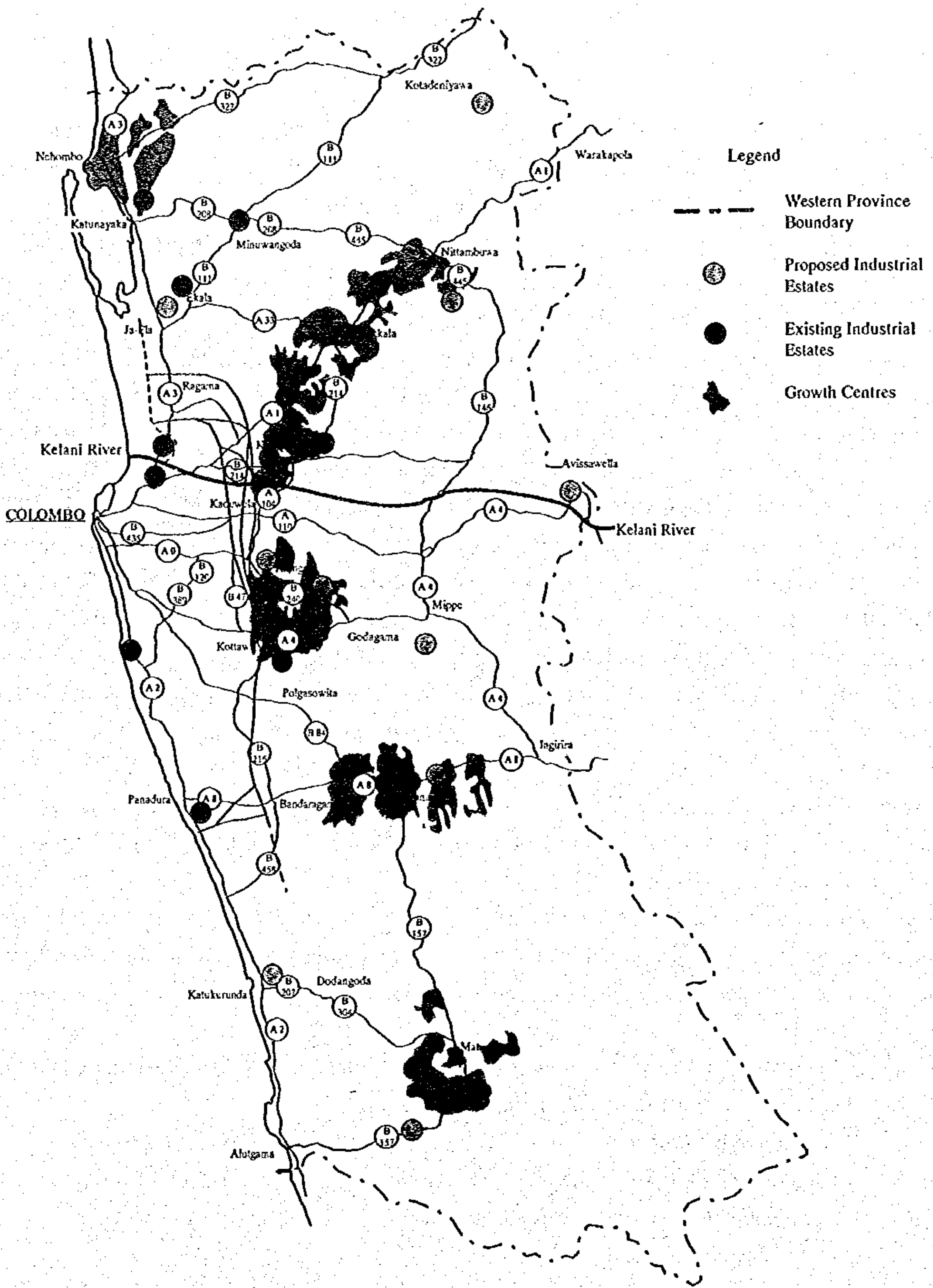


Fig. 3.1 Future Urban & Industrial Development and the OCH Alignments

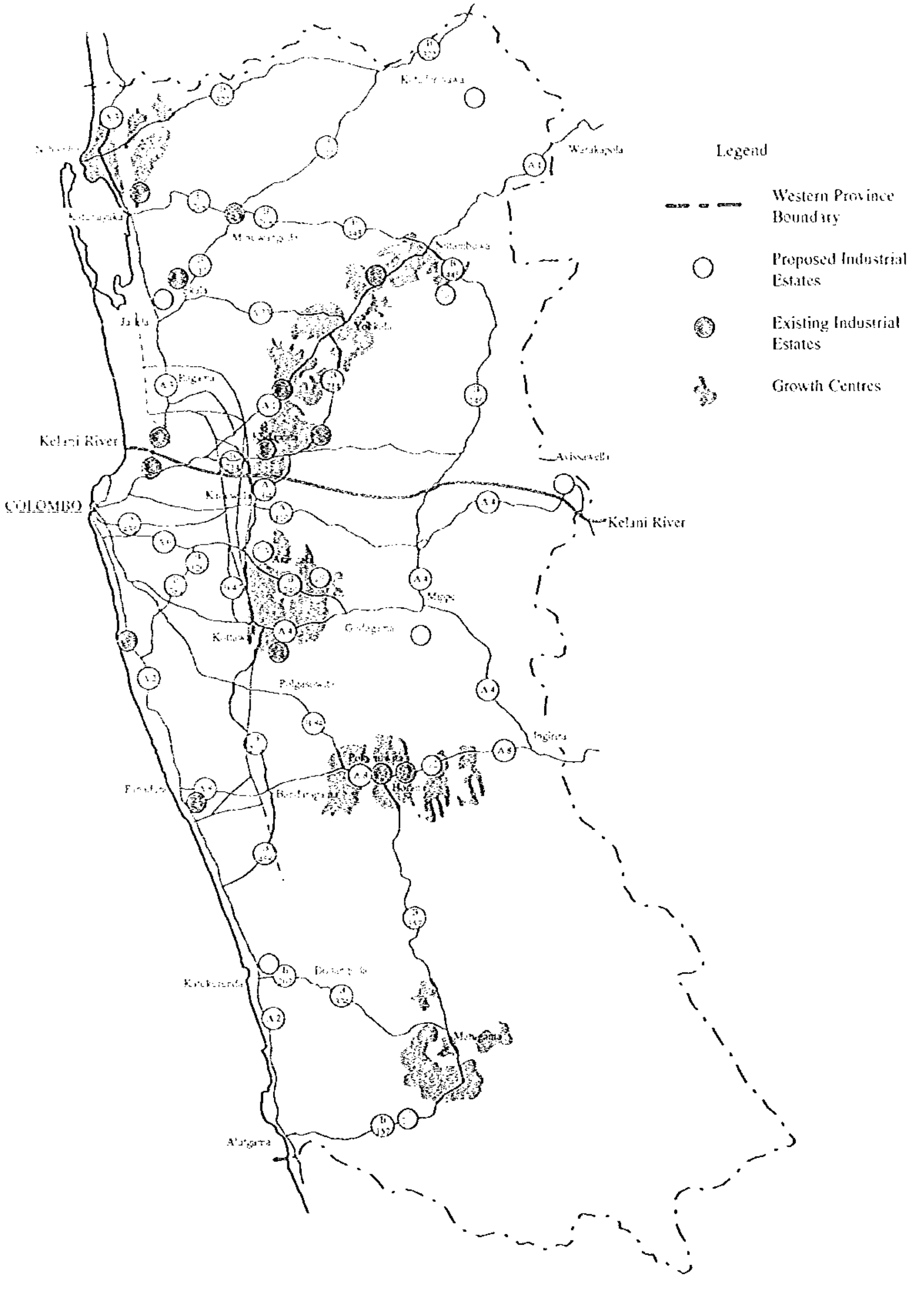


Fig. 3.1 Future Urban & Industrial Development and the OCH Alignments

CHAPTER 4 HIGHWAY ALIGNMENT AND DESIGN

4.1 Alternative Highway Alignments Method for Selecting

A flow chart illustrating the steps used to select the most appropriate highway alignment is shown Fig. 4.1 and is summarized as follows:

Step 1

Determination of Possible Highway Alignments

All possible alternative alignments for consideration are located within a 10-km wide belt . The determination is based on discussions with the RDA, from the results of previous studies, and from land acquisition requirements.

Selection of Preferred Possible Highway Alignments

Possible alignments are broken down into segments with alpha-numeric designations (e.g.,a1-c1), which are then screened for suitability based on the concept of urban sustainability. Here, urban sustainability consists of three factors : economic, social and environmental sustainability.

Step 2

Selection of Most Appropriate Highway Alignment

Alternative alignments comprised of segments are compared using a rating system. All of the parameters are broken down into major categories (e.g., engineering, cost) and assigned a performance score, with the maximum score equal to 100.

The best alternative alignment is selected based on the sum of these performance scores, taking into account a qualitative assessment of environmental impacts.

Step 3

Recommended Highway Alignment

Analyses of the economic benefits and financial return on investment are performed. If the results are acceptable, the most appropriate highway alignment is selected and a feasible implementation plan is drawn up taking into consideration the financial capabilities of the project, its appropriate phasing, and the most cost-effective work packaging and work breakdown.

4.2 Selection of Highway Alignment

Mosaic photographs produced from aerial photographs have been utilized for the evaluation of the preferred possible alignments and in the selection of the most appropriate highway alignment, which is shown in Fig.4.2.

4.3 Highway Design

A typical highway cross section for the OCH would be composed of the following elements:

- Carriageway
- Center median
- Shoulder (including stopping lane)
- Frontage road
- Green area along the road side

The typical cross section for the OCH is shown in Fig.4.3, which is a 4-lane dual carriageway after the completion of the initial stage of construction. However, traffic demand estimates for the year 2020 indicate the necessity for a 6-lane dual carriageway in the future. Taking into account the role the OCH is to play, traffic lanes are to be 3.5 meters wide and vehicle design speed 80km/h.

STEP 1

BASED ON DISCUSSION WITH RDA AND RESULTS OF
PREVIOUS STUDIES AND LAND ACQUISITION REQUIREMENTS

DETERMINATION OF POSSIBLE HIGHWAY ALIGNMENTS
CONFINED TO A BELT 10Km IN WIDTH

BASED ON
CONCEPT OF URBAN SUSTAINABILITY
LAND ACQUISITION REQUIREMENTS
ELIMINATE
OBVIOUSLY INAPPROPRIATE SEGMENTS

SELECTION OF
PREFERRED POSSIBLE HIGHWAY ALIGNMENTS

STEP 2

BASED ON
THE RDA APPROVED PARAMETERS
AN D
IMPORTANCE FACTORS
IN EACH CATEGORY
(ENGINEERING, COST, CONSTRUCTION, TRAFFIC,
SOCIO - ECONOMIC, DEVELOPMENT
AND ENVIRONMENTAL)

EVALUTION OF
PREFERRED POSSIBLE ALIGNMENT

SELECTION OF
MOST APPROPRIATE HIGHWAY ALIGNMENT

STEP 3

PERFORM
DETAILED SITE SURVEY
PRERIMINARY DESIGN
ECONOMIC AND FINANCE STUDY

IMPLEMENTATION PLAN FOR
RECOMMENED HIGHWAY ALIGNMENT
BASED ON EIRR AND FIRR RESULTS

Fig.4.1 Flow Chart for Alignment Selection Method

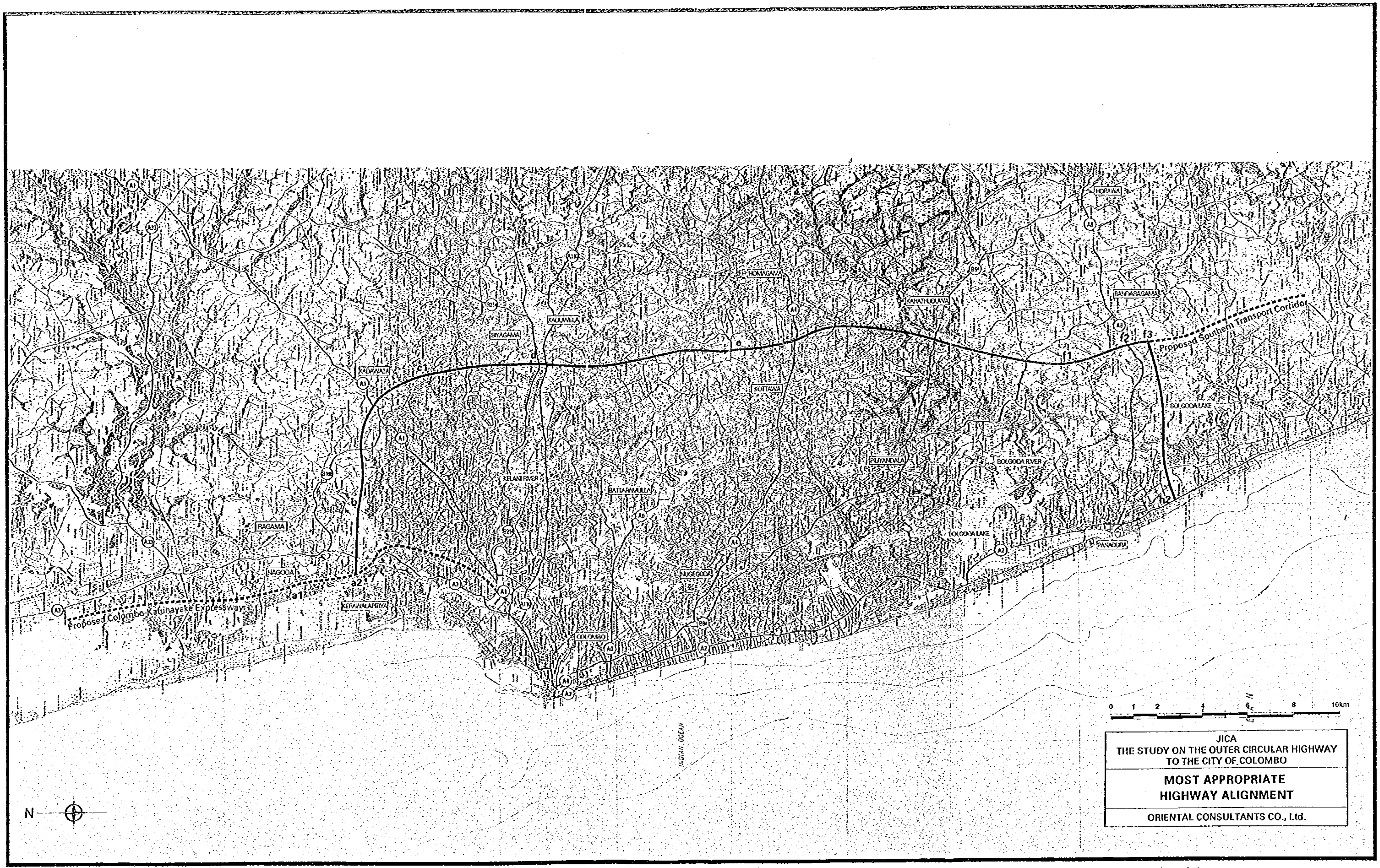
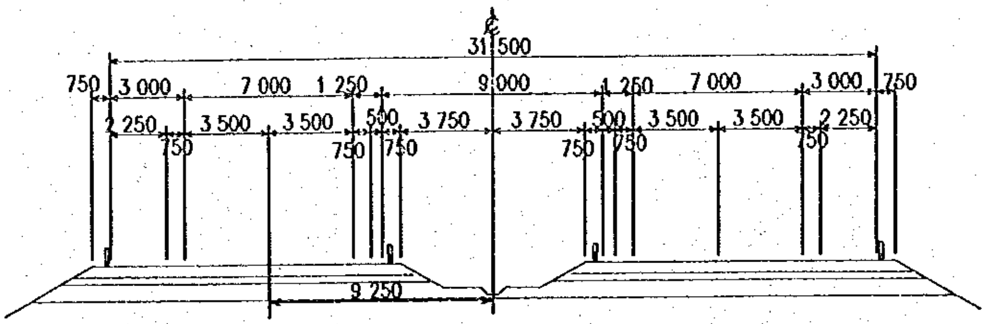


Fig.4.2 Most Appropriate Highway Alignment

(OPERATION WITH 4 TRAFFIC LANES)

TYPE-4L



(OPERATION WITH 6 TRAFFIC LANES)

TYPE-6L

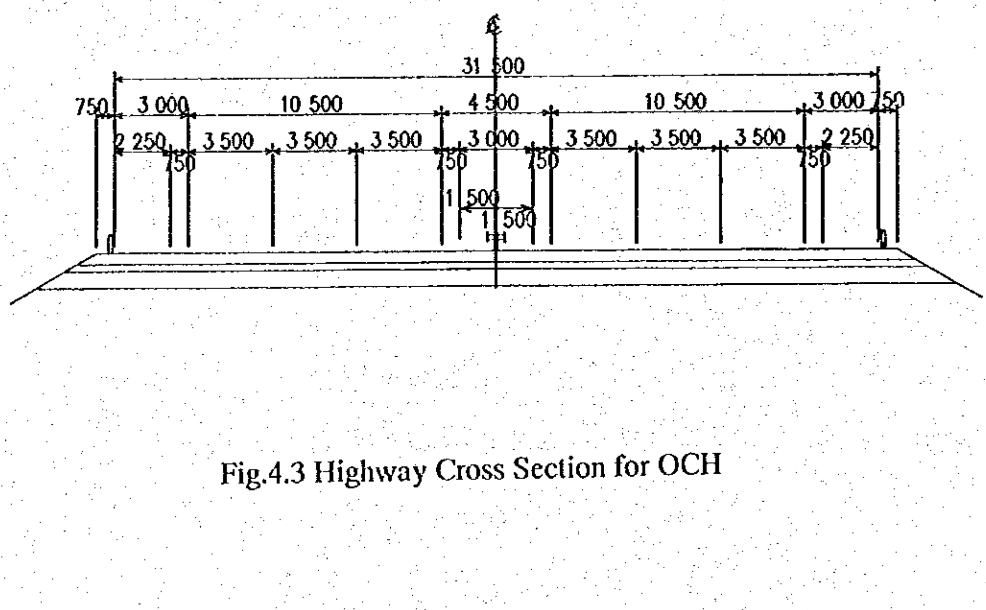


Fig.4.3 Highway Cross Section for OCH

CHAPTER 5 TRAFFIC DEMAND

5.1 Objective

The main objective of this chapter is to calculate future traffic flows via the construction of a traffic demand model for the Outer Circular Highway (OCH) using existing traffic and socio-economic data, as well as information and data collected from a traffic survey executed by the Study Team. Indices such as travel time and vehicle-kilometers, which are determined by the traffic demand model, are then used to evaluate the OCH and its impact on the Colombo Metropolitan Region (CMR) for the target years of 2010 and 2020.

The overall workflow for estimating traffic demand is shown in Fig. 5.1. The three items that are representative of the work performed are traffic survey execution, traffic demand model construction, and future traffic demand forecasting. Each of these is taken up respectively in the sections that follow in this chapter.

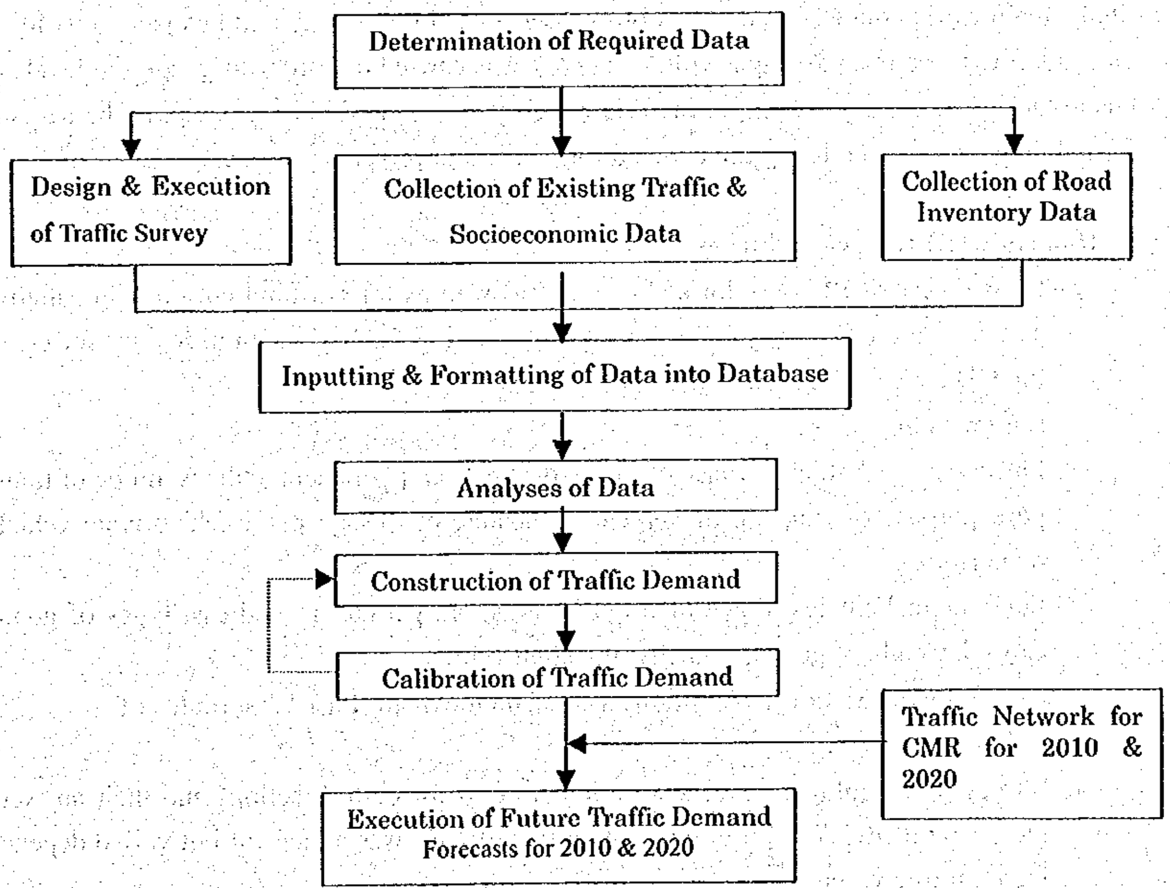


Fig. 5.1 Overall Workflow for Estimating Future Traffic Demand

5.2 Traffic Survey

The traffic survey was carried out from the beginning of January to the beginning of March 1999. The survey was first designed by the Study Team and finalized after consultations with the Road Development Authority (RDA) and Univ. of Moratuwa, in order to sufficiently account for local conditions. Engineering Consultants Limited (ECL), a local consultant selected by the Study Team via a designated JICA bidding process, was entrusted with survey execution. Enumerators, mostly from the Univ. of Moratuwa, were then recruited by ECL and trained by the university. The survey was then executed under the Study Team's supervision, with the Univ. of Moratuwa checking enumerator performance to ensure reliable data collection and quality. To convert the data into a form suitable for analysis and for the building of a traffic demand model, the data compiled by ECL was sent to the Univ. of Moratuwa and inputted and formatted in an electronic format designated by the Study Team.

In addition to the roadside OD (origin-destination) survey, traffic volume survey, turning movement survey, and travel speed survey, which were originally scheduled for execution, the Study Team carried out a supplemental bus passenger volume survey and bus passenger interview survey. The bus passenger volume survey was carried out order to gauge the levels of bus usage, while the bus passenger interview survey was carried out for grasping the demand for public transit and modeling the demand for public and private transport.

1) Roadside OD Interview Survey

- Survey Period: 12 hours for a single day, as well as for grasping current trip patterns. The roadside OD survey is important for gathering the basic data necessary for creating OD tables to be used in the traffic demand model.
- Survey Items:
  For Passenger Vehicles: Place of origin/destination, permanent address, mode of transport, purpose of trip, no. of vehicle occupants, bus usage per week, private vehicle ownership.
  For Freight Vehicles: Place of origin/destination, permanent address, types of goods carried, weight of goods, capacity of freight vehicle.
- No. of Survey Stations: 16 stations located on the major East-West routes of Colombo.
- Survey Methodology: Drivers were interviewed for both directions and their answers recorded on-site. A minimum sampling rate of 10% was aimed for but varied depending on traffic volume.

2) Traffic Volume Survey

- Survey Period: The traffic volume survey is important for grasping current vehicle flows and congestion and for providing vehicular volume data to calibrate the traffic assignment model. 24 hours over a period of 3 days.
- Measurement Intervals: 15 minutes (total of 96 observations per day).
- No. of Survey Stations: 24 stations on major East-West routes (3 stations per route) covering an urban area, suburban area, and area near the prospective Outer Circular Highway. In addition, 10 survey stations on 5 major North-South routes.
- Survey Methodology: Manual classified counts for 8 vehicle classes together with automatic traffic counts.

3) Bus Passenger Volume Survey

- Survey Period: 12 hours over a period of 3 days.
- No. of Survey Stations: Same 16 stations on the East-West routes described in the road OD interview survey.
- Bus Classification: Divided into private and public buses, intra- and inter-provincial routes, and bus size (below 20 seats, 20-29 seats, 30-39 seats, and 0ver 4 seats).
- Survey Methodology: Non-intrusive visual inspection.

4) Turning Movement Survey

The turning movement survey is important for providing details on the directional movements of traffic. The details of its execution are as follows:

- Survey Period: Morning peak and off-peak times over a period of 3 days.
- Measurement Intervals: 15 minutes.
- No. of Survey Stations: 16 stations representing major junctions in the CMR.
- Vehicle Class: 8
- Survey Methodology: Measurements were carried out for all the directions of travel (left, right, straight) by a single team of enumerators that did a 15-minute count for each

5) Travel Speed Survey

This survey is important in that it provides observed travel speed data that can be directly compared with modeled travel speeds in the calibration of the traffic demand model.

- Survey Period: Morning peak and off-peak times over a period of 3 days.
- No. of Measurements: 2 times per day for the 8 survey routes for both directions, with speeds recorded at the appropriate locations along each route.
- Survey Methodology: A test car was used and average travel speeds for the different lo-

cations along the survey routes obtained by travelling along with the traffic flow (i.e., the average car method was applied).

6) Bus Passenger Interview Survey

This survey, like the bus passenger volume survey, was a supplemental survey and not initially considered. The importance of this survey is to determine whether bus riders are captive users for modal split purposes.

- Survey Period: Depending on whether or not there was existing data, either a 6 hour survey (morning or afternoon) or an all-day survey was carried out. Also, at important bus locations, the all-day survey was done for 3 days.
- Survey Items: Access mode, egress mode, and car ownership.
- Survey Methodology: Bus passengers waiting at important bus stops and terminals were interviewed at random and their answers recorded on site.

5.3 Traffic Survey Results & Analyses

1) Roadside OD Survey

<u>Vehicle Trip Characteristics</u>

Passenger vehicle trips by purpose were categorized into 3 types: home-based work trips, home-based other trips, and non-home-based trips. As Fig. 5.2 indicates, home-based other trips accounted for the largest proportion of trips at approximately 44%, with home-based work trips being next at 33% and non-home-based trips the smallest at 23%. Note that school trips are included in home-based other trips.

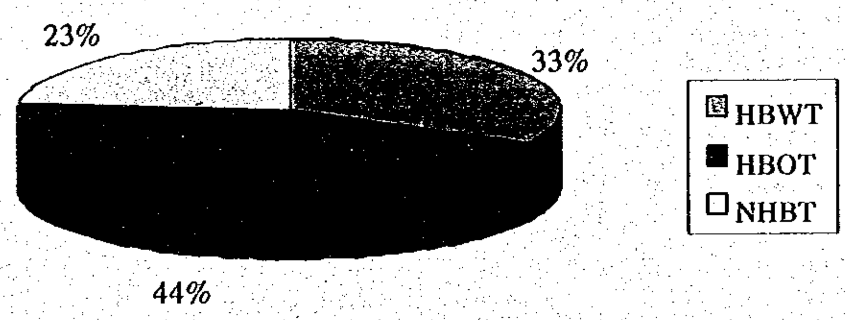


Fig. 5.2 Vehicle Trip Composition by Purpose

As for freight vehicle trips, excluding those trucks that were empty (36%), the most ferried items according to those vehicles surveyed were construction materials (18%), industrial products (17%), and processed food (12%). The proportion of vehicles that were carrying other types of commodities totaled about 17%. (See Fig. 5.3)

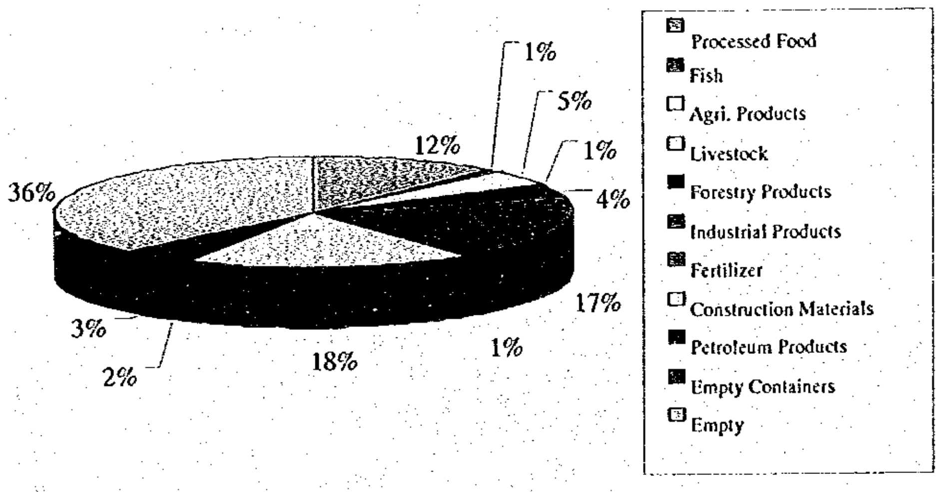


Fig. 5.3 Commodities Carried by Freight Vehicles

As for total vehicle trip movements, Fig. 5.4 indicates that the vast majority of vehicles surveyed (or 87.1%) traveled within the CMR. As for vehicle trips with one trip end outside of the CMR, these accounted for 12.6% of the vehicles surveyed, while only 0.4% of the vehicles questioned were through trips.

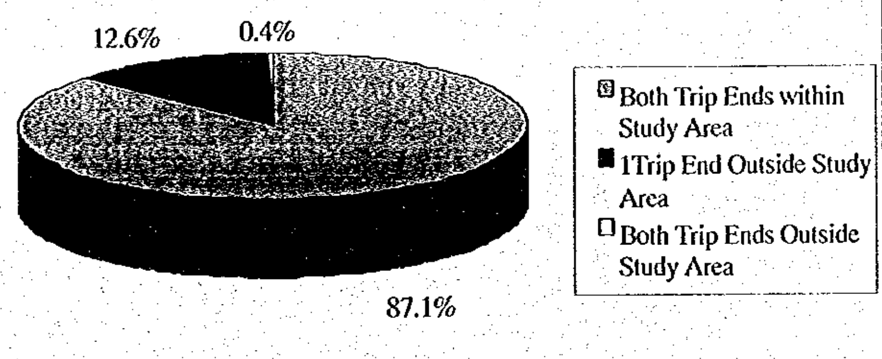


Fig.5.4 Outline of Vehicle Trip Movements

2) Traffic Volume Survey

The composition of traffic, as determined by the traffic volume and roadside OD surveys, is shown in Fig. 5.5. As the figure indicates, 58% of the vehicles on the road are private passenger vehicles (i.e., cars and motorcycles), while 22% of vehicular traffic consists of buses (regular buses and minibuses). Freight vehicles and 3-wheelers each accounts for about 10% of total traffic.

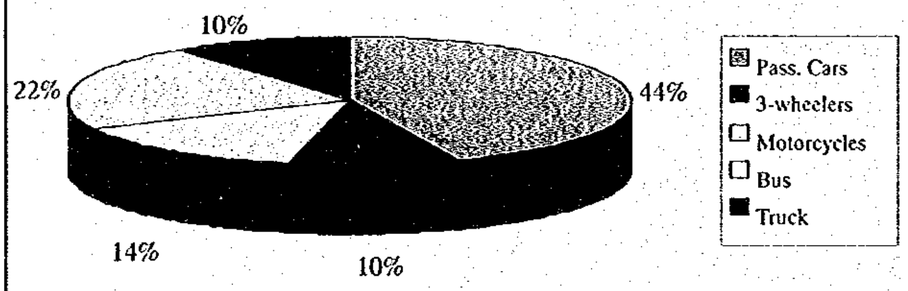


Fig. 5.5 Traffic Composition

Excluding buses and school vans, the average occupancy of the different vehicle classes is as shown in Fig. 5.6. Except for motorcycles, all the different vehicle types had an average occupancy greater than 2, with passenger cars having the largest average value of 2.69 persons per vehicle. Motorcycles had an average occupancy of 1.30.

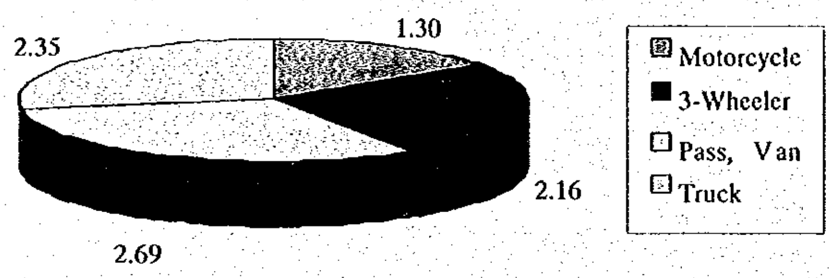


Fig. 5.6 Average Vehicle Occupancy (incl. driver)

As for the actual traffic volumes that were surveyed on site. Daily traffic flows on arterials near the center of the city are experiencing large volumes of traffic. On Route A3 at the point nearest Colombo, more than 59,000 vehicles were surveyed coming and going to the city. Of the 34 locations that were surveyed, 5 experienced traffic flows greater than 40,000 vehicles per day and 7 flows greater than 30,000. This indicates that portions of the road network are heavily used and experiencing congestion.

3) Bus Passenger Volume Survey

Three important pieces of information were derived from the bus passenger volume survey: type of bus operation (intra-provincial or inter-provincial), bus capacity, and bus usage conditions. Each of these is shown in the three figures below. (Fig. 5.7 – Fig. 5.9)

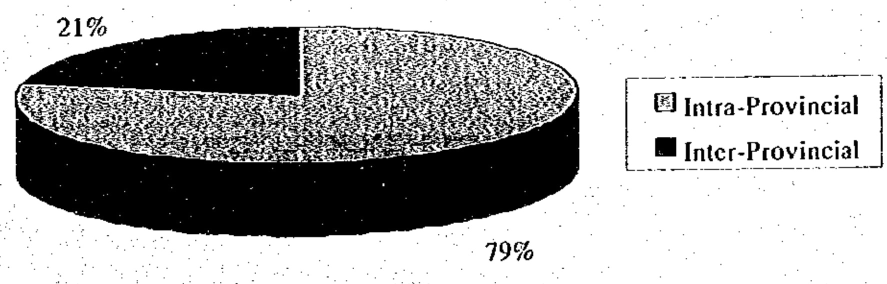


Fig.5.7 Type of Bus Operation

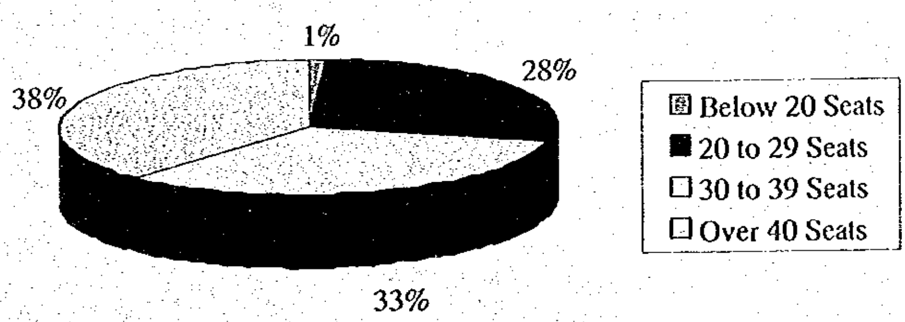


Fig.5.8 Bus Seating Capacity

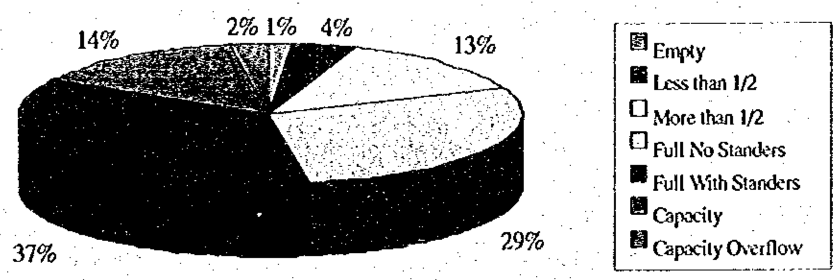


Fig. 5.9 Passenger Loads on Bus

In Fig. 5.7, it can be seen that the vast majority of buses observed (or 79%) operate within the CMR (or Western Province). Of these, only 1% had a seating capacity of less than 20 seats, while 38% had a capacity of more than 40 seats and 33% a capacity between 30 to 39 seats (see Fig. 5.8). The other 28% of the buses observed had a seating capacity between 20 to 29 seats. As Fig 5.9 indicates, buses are used rather extensively, with 53% of those observed being full with no standers or at capacity or greater. If being able to sit down is a criteria for using a bus, then 82% of the buses observed would be unattractive choices for travel.

4) Turning Movement Survey

The purpose of the turning movement survey for this study was solely for grasping the directional flows of traffic at important junctions and not for obtaining data to carry out detailed analyses of intersection design. Refer to Annex 1 for detailed information on the directional flows of intersections.

5) Travel Speed Survey

According to the travel speed survey results, average travel speed on major traffic corridors in Colombo is in the range of 30 to 35 km/h, depending on the time of day and direction. In the direction of Colombo, the morning peak has a minimum travel speed of 28 km/h, which increases to 34 km/h during the off-peak and drops back down to 31 km/h in the evening peak (see Fig.5.10). As for the direction away from Colombo, the morning peak has the highest speed of 35 km/h, indicating that many commuting trips are in the opposite direction. This drops to 30 km/h in the off-peak and rises to 33 km/h in the evening peak (see Fig.5.11).

Fig.5.10 Average Travel Speed on Major Traffic Corridors to Colombo

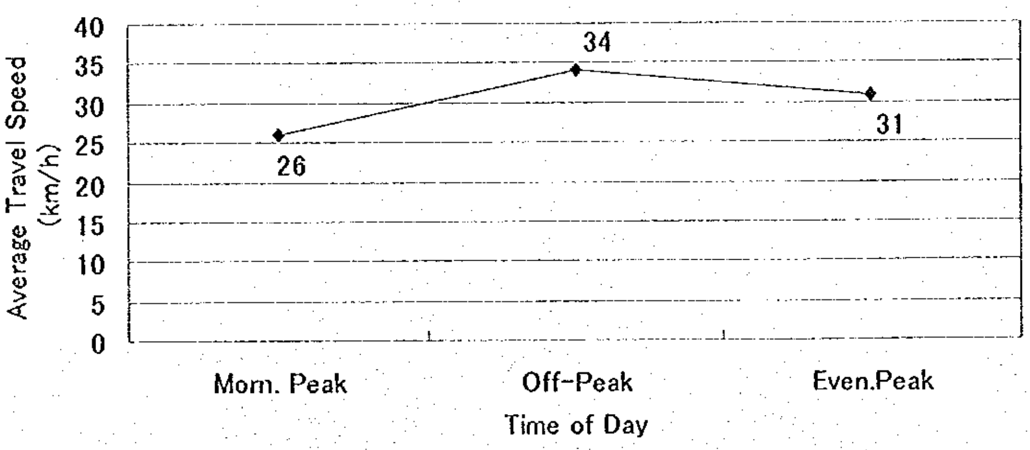
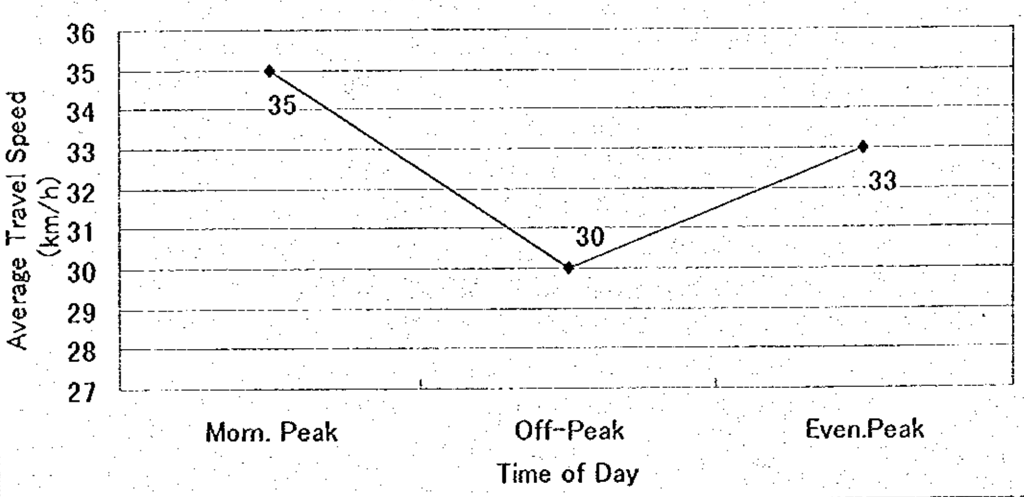


Fig.5.11 Average Travel Speed on Major Traffic Corridors from Colombo



6) Bus Passenger Interview Survey

The main results of the bus passenger interview survey are shown in figures 5.12, 5.13, 5.14, and 5.15 below. As the first two figures indicate, the mode used most often to access and egress a bus stop is walking at 50.6% and 62.4%, respectively. The mode used next most often is bus, meaning that people are perhaps riding a bus from a minor route to connect with another bus that plies a major route. Other modes, such as car and rail, as connectors to bus transport are insignificant in terms of use, indicating that the concept of park-and-ride is not being practiced. It also seems to indicate that inter-modal transport does not yet exist on any sort of large scale in Colombo. Another important result of the survey was that only 6.2% of the bus users surveyed owned a car, indicating that almost all of the people who ride buses are captive users. That is, they use the bus because they have no choice (see Fig. 5.14). For those who own a car and use a bus, they do so mainly because it is cheaper (56.6%). Only 17.7% said they use a bus because it is more convenient, while another 14.6% said they use a bus because it is faster.

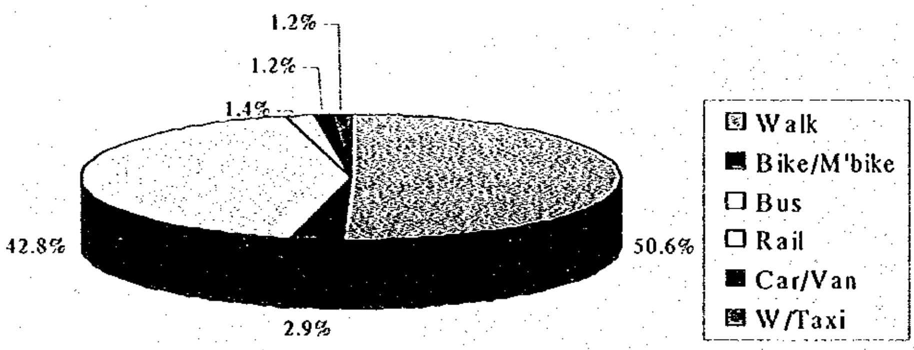


Fig.5.12 Access Mode to Bus Stops

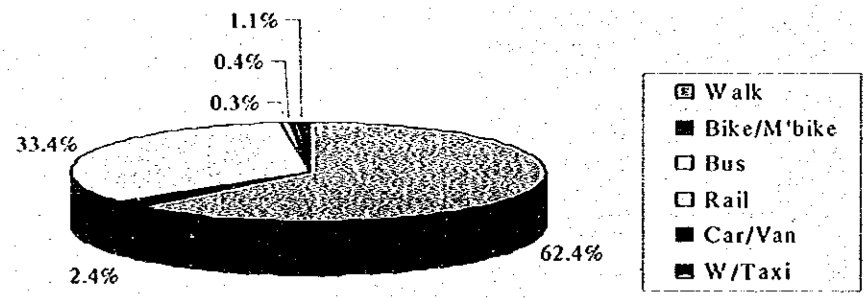


Fig.5.13 Egress Mode from Bus Stops

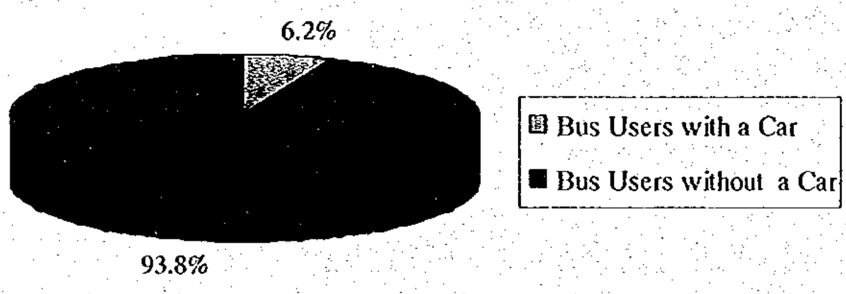


Fig.5.14 Car Ownership for Bus Users

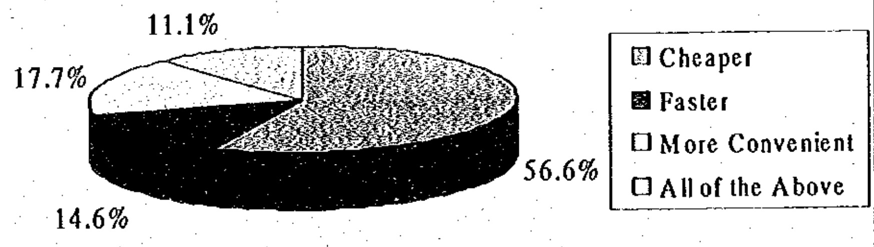


Fig.5.15 Reasons for Car Owners Using Bus

5.4 Building of Traffic Demand Model

The traffic demand model employed the traditional 4-step estimation method contained in the JICA STRADA (System for Traffic Demand Analysis) package, which consists of the steps of trip generation/attraction, trip distribution, modal split, and traffic assignment, to calculate the traffic demand for the CMR and OCH. The forecast years for this study were 2010 and 2020. An outline of the basic structure for forecasting traffic is shown in Fig. 5.16. Note that this process was applied only to the estimation of trips that occurred within the CMR. For trips that begin or end outside of the CMR, calculations were carried out using a simple projection method. As for through trips, since they were insignificant in terms of overall volume they were not taken into consideration .

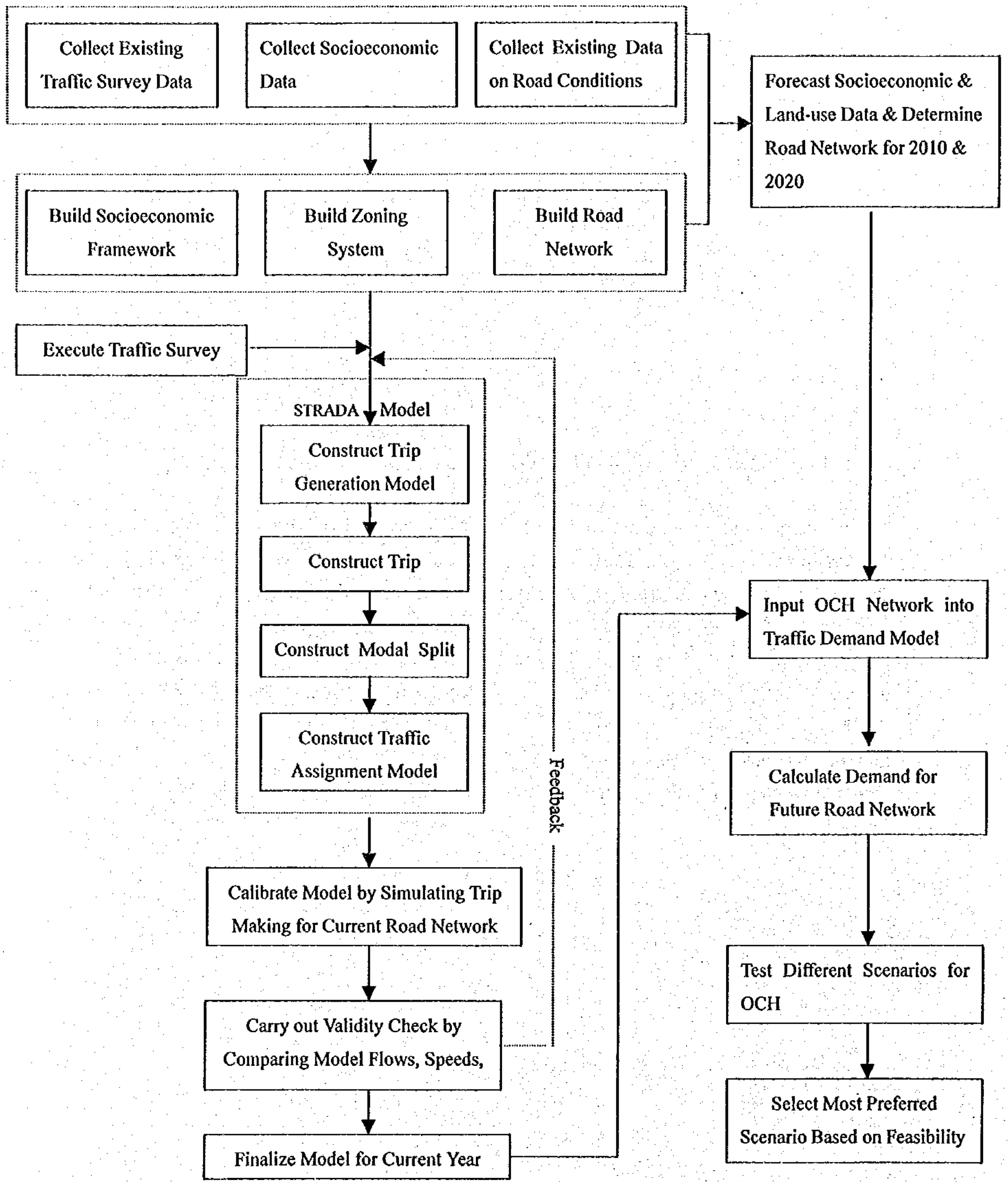


Fig. 5.16 Process for Forecasting Future Traffic Demand

5.5 Future Traffic Demand

By applying the calibrated traffic assignment model above, forecasts for 2010 and 2020 are carried out after inputting the future road network for the target years of 2010 and 2020.

5.5.1 Future Road Network Improvements

To calculate future traffic demand for the OCH, it is imperative to consider future road construction and improvements. Except for the new Kandy Expressway, the new Ratnapura Road, and the northward extension from the airport (completion to be 2020), it is assumed that all road improvements and construction schemes will be completed by the year 2010.

1) New Road Construction

The new road construction considered in the model is as follows:

(1) The Northeast Highway to Kandy: This route would improve access to the north (including Kandy) and east of the country and reduce congestion on Route A1 and A3. Its terminus in Colombo would be the northern entrance to the Baseline Road.

(2) The Southeast Highway to Ratnapura: This route would connect the southern part of the Baseline road with Ratnapura and provide more access to areas in the outer suburbs of CMR to the core of the city.

(3) The Katunayake Expressway: This alignment would be a fully-controlled toll road that would connect the City of Colombo with the city's international airport. The intention is to provide reliable, timely service for travelers going to/from the airport.

(4) The Baseline Road Extension: This would extend the Baseline Road from its current southern terminus of Kirillapone straight to Attidiya in the south (or about 5.5 km), which would then extend down to Galle Road via an existing road.

(5) The Katunayake - Padeniya Highway: This would further improve access to the airport and extends north beyond the boundary of the CMR to Padeniya in the North West Province.

2) New Road Improvements

Future road improvements for the CMR focus on improving the capacity of nine existing corridors to improve speeds to around 30-40 km/h. The total length of these corridors is 180 km and they would have as one of their main purposes the distribution of inter-regional traffic to the area of the Colombo Metropolitan Council and its suburbs. These nine corridors and the sections to be improved, as well as their length, are indicated in Tab. 5.1 below.

Tab. 5.1 High Mobility Corridors

Name of Corridor	Location of Sect. for Improvement	Length of Sect. Improvement
Route A1 (Colombo-Kandy Rd)	Up to Kadawatha interchange with North-South Highway.	18 km
Route A2 (Colombo-Galle-Hambantota-Wellawaya Rd)	Up to Panadura	28 km
Route A3 (Peliyagoda-Puttalam Road)	Up to Ja-El interchange with North-South Highway.	20 km
Route A4 (Colombo-Ratnapura-Wellawaya-Batticaloa Rd)	Up to Kottawa interchange with North-South Highway.	22 km
Route B84 (Colombo-Horana Rd)	Up to Polgasowita interchange with North-South Highway.	20 km
Route A110 (Colombo-Hanwella Rd)	Up to Kaduwela interchange with North-South Highway	15 km
Route A0 (Kollupitiya-Sri Jayawardena Pura Rd)	Up to Talangama interchange with North-South Highway.	15 km
Route A8 (Panadura-Nambapana-Ratnapura Rd)	Up to Ingiria	34 km
Baseline Road	Improved to dual 3-lane carriageway.	8 km
Total		180 km

Source: Based on data from Urban Development Authority, *Colombo Metropolitan Structural Plan*, Vol. II. 1998.

5.5.2 Traffic Demand Forecasts for 2010 & 2020

In addition to the future road improvements and construction mentioned in the previous section, 9 different possible alignments for the OCH were examined for possible incorporation into the future road network, which were decided in consultation with the RDA. Here, only the traffic demand forecast for the alignment that was selected as the most preferred route is taken up and examined for the future years of 2010 and 2020 in comparison to the case of no OCH being built. A comparison of the present situation with and without the existence of the OCH is also carried out for the purposes of reference.

In Tab.5.2 to 5.4, the traffic indices of vehicle-kilometers, vehicle-hours, average area congestion, and average area speed are used to assess the impact of the OCH on the CMR.

Tab. 5.2 Comparison Traffic Impact with and without the OCH for 1999

	Daily Veh-km For CMR (mil)	Daily Veh-hrs for CMR (mil)	Daily Average VCR	Daily Average Speed
Without OCH	8.99	0.26	0.47	32.7
With OCH	8.92	0.26	0.41	34.7
Ratio of with/without	0.99	1.00	0.87	1.06

Tab. 5.3 Comparison Traffic Impact with and without the OCH for 2010

	Daily Veh-km for CMR (mil)	Daily Veh-hrs for CMR (mil)	Daily Average VCR	Daily Average Speed
Without OCH	19.69	0.71	0.83	27.7
With OCH	19.57	0.65	0.73	30.3
Ratio of with/without	0.99	0.92	0.88	1.09

Tab. 5.4 Comparison Traffic Impact with and without the OCH for 2020

	Daily Veh-km for CMR (mil)	Daily Veh-hrs for CMR (mil)	Daily Average VCR	Daily Average Speed
Without OCH	30.11	1.20	1.06	25.2
With OCH	29.40	1.04	0.92	28.4
Ratio of with/without	0.98	0.87	0.87	1.13

The conclusions that can be drawn from the construction of the OCH based on the above tables are as follows:

1) The impact of the OCH becomes larger as time passes by. In the year 2020, the construction of the OCH would result in daily area speeds being 1.13 times faster as compared to only 1.06 times faster if the OCH was in existence today. In the year 2010, the construction of the OCH would result in average area travel speeds being 1.09 times faster.
2) The reduction in distance traveled on the road network with the introduction of the OCH is slight. In the year 2010 it is a small 1% and would reach 2.4% in the year 2020, indicating an increase in the number of orbital trips. On the other hand, vehicle-hours would be 11% and 13% less in the years 2010 and 2020, respectively, as compared to the case of there being no OCH.

3) The difference in actual area travel speeds with and without the OCH is 2.7 km/h in 2010 and 3.2 km/h in 2020. These are substantial differences in speed for an urban area.
4) Area wide congestion with the OCH would be about 12% less as compared to without.

The above clearly indicates that the OCH would be a feasible proposition from the perspective of the impact that it would have on area-wide traffic. As for the traffic demand on the OCH itself, estimates by this study indicate that the OCH would be a highly traveled facility. For example, in the year 2010, a daily total of about 91,000 vehicles would use the OCH, while in 2020 this total would be about 142,000 vehicles per day. The average traffic flow for a section of road on the OCH would be about 37,000 pcus in 2010 and 45,100 pcus in 2020. Given these traffic volumes, it is suggested that the OCH be constructed initially as a 4-lane facility. The most congested parts of the OCH would be located in the middle of this ring road and the least congested parts at the tail ends. However, the northern tail end would have a much higher traffic volume (34,500 pcus) as compared to the southern tail end (19,200 pcus).

In the year 2020, pcus flows indicate that the entire middle portion of the OCH is over capacity. Although a 4-lane OCH facility is sufficient to handle the required traffic flows in the year 2010, improvements to the OCH will be necessary to handle the traffic generated in the year 2020. Except for the southern tail end of the OCH, it is suggested that the OCH be made into a 6-lane facility for the year 2020. Although traffic on the northern tail end and on the section between A8 and the Southern Highway can be handled by a 4-lane structure, it would be better from a network point of view to make these 2 sections into 6-lane structures as well. That is, because the northern tail end would connect the important CKE with the 6-lane portion of the OCH, which intersects the busy Kadawata area, it would be in the long run strategically better for the northern tail end to become a 6-lane facility. In the case of the OCH portion between A8 and the Southern Highway, it is quite short in length (less than 1 km) and it would be rather pointless to only retain this section of the OCH straightaway as a 4-lane structure. As for the southern tail end of the OCH, its traffic demand of 28,200 pcus requires that it remain as a 4-lane structure.

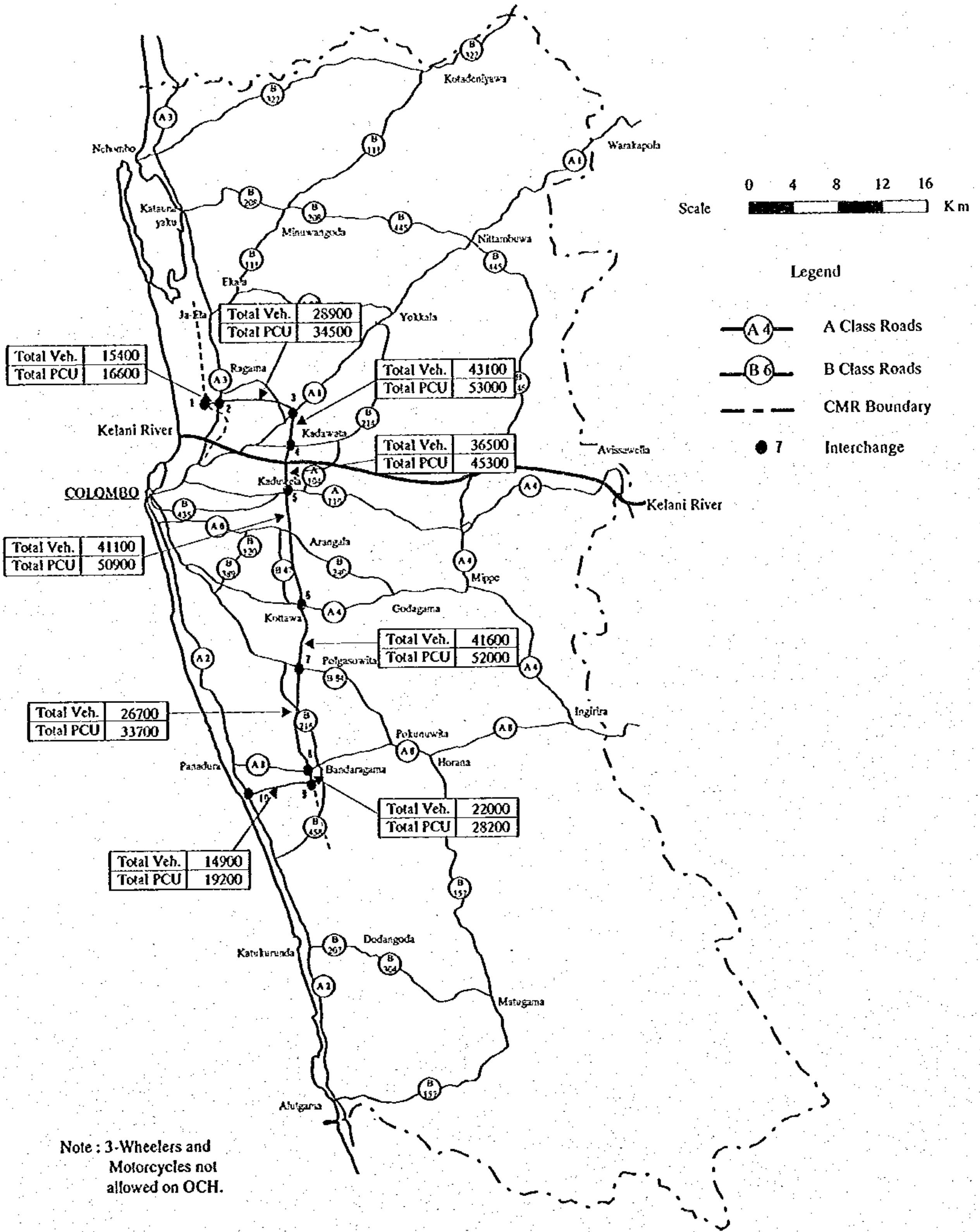


Fig.5.17 Traffic Volume (both directions) for Road Links of Outer Circular Highway for 2010 for Most Appropriate Alignment

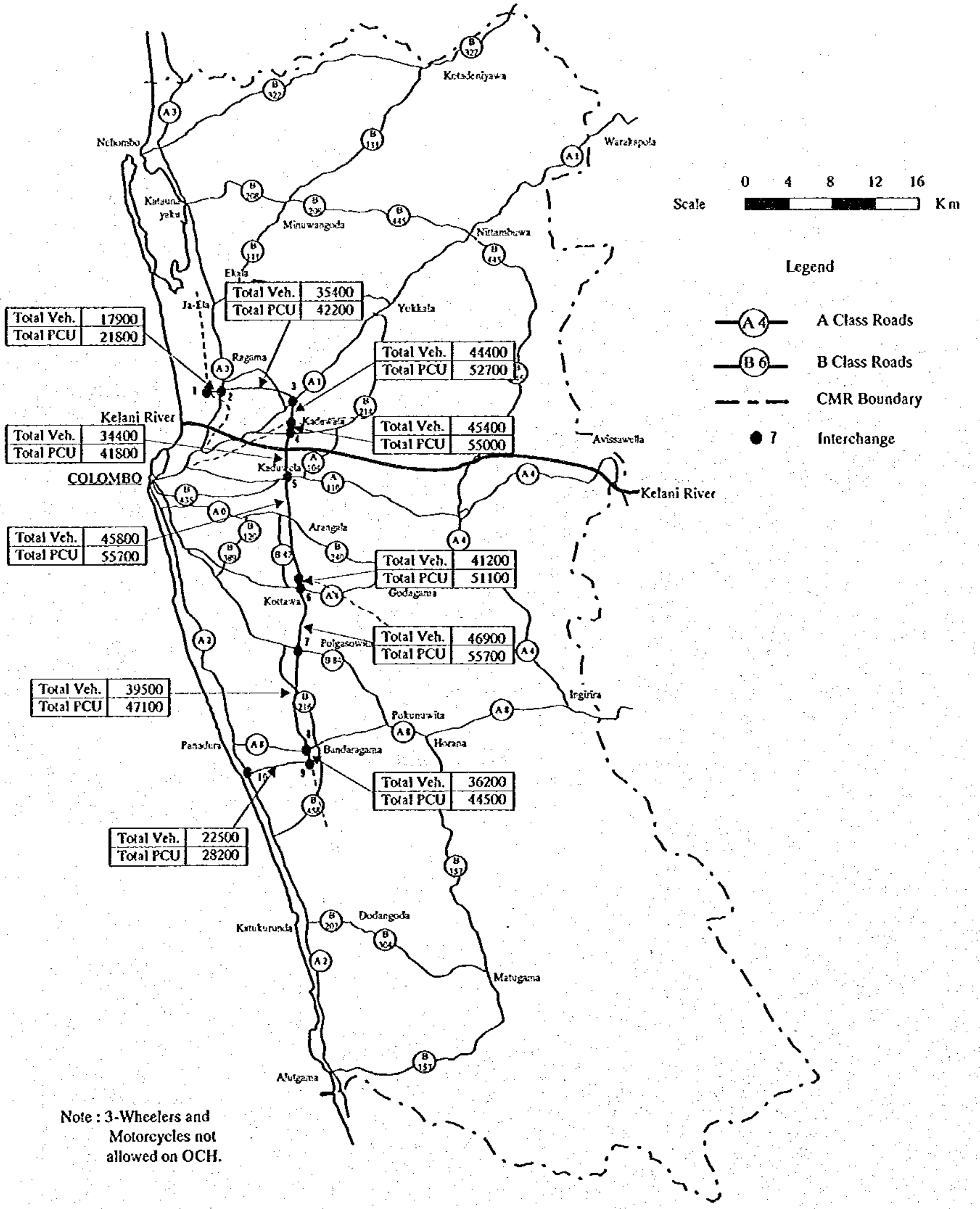


Fig.5.18 Traffic Volume (both directions) for Road Links of Outer Circular Highway for 2020 for Most Appropriate Alignment

CHAPTER 6 ENGINEERING STUDY AND PROJECT COST ESTIMATION

6.1 Engineering Study

6.1.1 Geometric Features of Outer Circular Highway

The geometric design criteria for the Study adopted Japanese standards, taking into consideration AASHTO and RDA highway design standards as well. The standards applied to the Outer Circular Highway (OCH), which should be reviewed in the detailed design stage, are as follows:

① Annotation and Application of the Road Structure Ordinance, February 1983 (Japan Road Association, JRO).

② Geometric Design Standard of High Standard Arterial Expressways, Japanese Ministry of Construction, September 1989.

6.1.2 Geometric Design Standards for Outer Circular Highway

The geometric design stands for the main line of the OCH are based on the Japanese road standards for type 1 class 3 roads in Japan, which possess characteristics needed by the OCH to fulfill its functional requirements. As for the OCH interchange design standard, this is based on the Japanese Interchange class 1 standard.

(1) Geometric Standards

Road standard (JRO)				Japanese Type 1, class 3 Road		Remarks
Design speed				Road 80km/ h		
Design value				Standard	Exceptional	
Horizontal alignment (Maximum)	Radius of curve		m	400 (7%)	230 (10%)	()Superelevation
	Min. curve length	θ ≥ 7	m	140	-	θ : Inter Angle
		θ < 7	m	1000/θ	140	
	Transition curve length		m	70	-	
	Radius of curve which allows omission of transition curve		m	2000	-	
Longitudinal alignment	Maximum vertical gradient		%	4	7	
	Min. vertical curve	Crest	m	4500	3000	
		Sag	m	3000	2000	
	Min. curve length		m	70	-	
Standard crossfall			%	2.5	-	RDA Standard
Max Superelevetion			%	7	10	
Max Composite Gradient			%	10.5	-	

Source: the Geometric Design Standard of High Standard Arterial Expressway, Septembe1989, Japanese Ministry of Construction

(2) Interchange

Ramp standard Interchange standard				Japanese Class 1 Interchange		Remarks
Design speed				V = 40 km/ h		
Elements				Reference value		
				Standard	Exceptional	
Horizontal alignment	Minimum radius of curvature		m	50 (9%)	40 (10%)	( )Superelevation
	Min. parameter of clothoid curve		m	35	-	
	Radius of curvature which allows omission of transition curve		m	140	-	
	Min. parameter at off ramp rose		m	60	50	
	Radius of curve at off ramp rose		m	170	-	
	Allowable radius of curve of the inverted superelevation		m	800	-	
Longitudinal alignment	Maximum vertical gradient *1		%	6	Up slope 7 Down slope 8	
	Min. radius of vertical curve	Crest	m	900	450	
		Sag	m	900	450	
	Min. vertical curve length		m	40	35	
	Min. vertical curve near the nose	Crest	m	1600	800	
		Sag	m	1400	700	
		Curve length	m	60	40	
Standard crossfall			%	2.5	-	RDA Standard
Max. Superelevetion			%	9	10	
Max, Composite Gradient			%	11.0	-	

*1. Source: The setting of the maximum vertical gradient for ramps (including the loop portion) must be less than the maximum composite gradient.

*2. Source: Geometric Design Standard of High Standard Arterial Expressway, September 1989, Japanese Ministry of construction.

6.1.3 Design Speed

Route name	Road standard applied	Design speed
Outer Circular Highway	Class 1, type3 for Japanese roads	80 km/ h
OCH Interchange	Class 1 Japanese interchange	40 km/ h

*Annotations and Application of the Road Structure Ordinance, February 1983 (JRO)Geometric Design Standard of High Standard Arterial Expressways, Japanese Ministry of Construction September 1989.

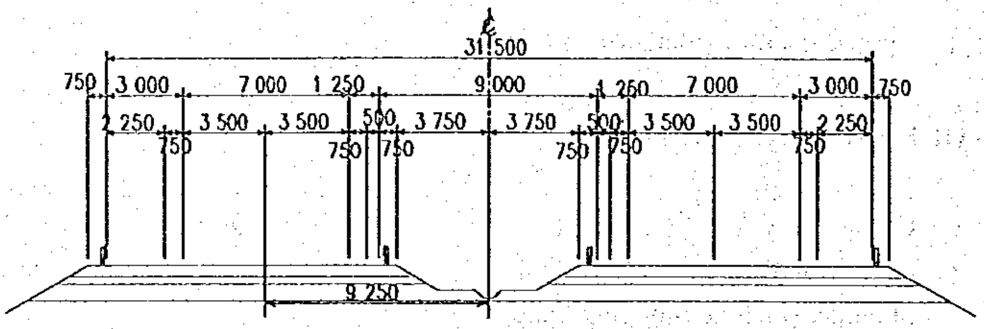
6.1.4 Cross Section Elements

(1) OCH Cross Section Elements

- Carriageway
- Center Median
- Shoulder (include Stopping Lane)
- Frontage Road (for pedestrian & bicycle use also)
- Green Area

The cross section elements for the OCH shown in Fig.6.1 apply to the scenario that will have four lanes temporarily and six lanes when completed.

(OPERATION WITH 4 TRAFFIC LANES)
TYPE-4L



(OPERATION WITH 6 TRAFFIC LANES)
TYPE-6L

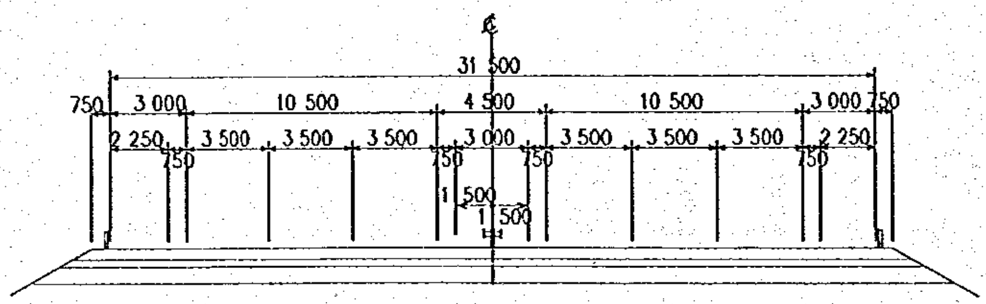


Fig. 6.1 Standard Cross Section

(2) Frontage Road

The OCH frontage road is provided in order to play the following two major functional roles.

- *To provide access along the OCH route from the proposed interchanges to the residential, commercial, industrial, and planned development areas (such as a free-trade zone or other growth center).*
- *To provide access to residents whose previous travel route or property has been severed by the OCH.*

Any vehicle can use the frontage road instead of the main carriageway, which restricts 3-wheelers and motorcycles under 250cc from entering. Frontage roads will be built on either side to enhance access. However, the length shall be minimized via the use of existing roads whenever possible in order to reduce costs. The design standard for the frontage road is shown in Fig.6.2.

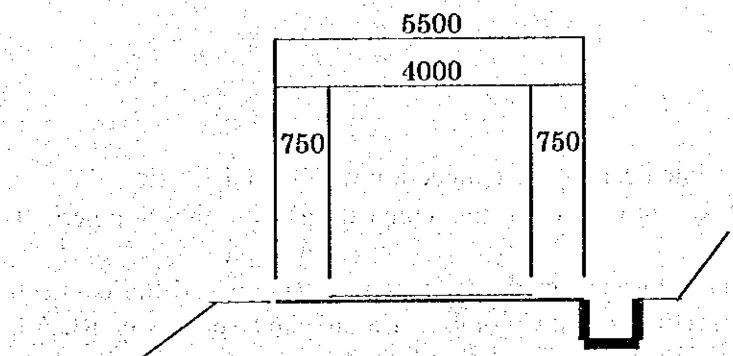


Fig. 6.2 Cross Section of Frontage Road

6.1.5 Earthwork

The slope ratio for a cut and embankment are as follows.

Standard embankment slope ratio : 1:1.8
Standard for Cut slope ratio : 1:1.0

6.1.6 Pavement

Design CBR: 6% (Subgrade)
Design Method: AASHTO
Design Period: 10 years
Heavy Vehicle Traffic: % of heavy vehicle traffic

Pavement: Asphalt concrete pavement or concrete pavement

The thickness of the left shoulder was reduced by 4 cm by eliminating the surface course in view of saving construction cost.

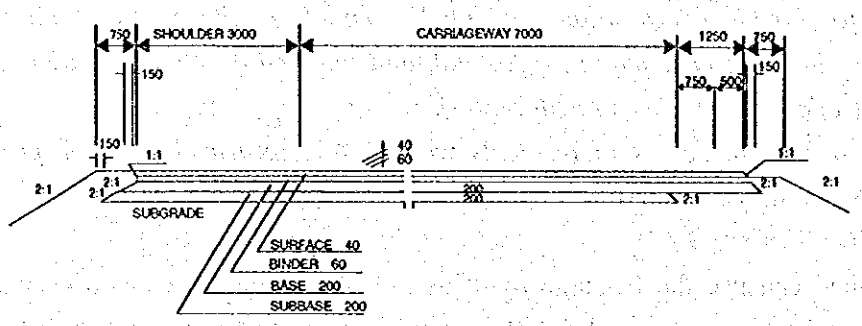


Fig. 6.3 Pavement Structure

6.1.7 Alignment Setting

(1) Horizontal Alignment

<Basic concept>

- The alignment must take into account the connection with the CKE
- The alignment must take into account the connection with the Southern Transport Corridor.
- The alignment must take into account the type of intersection and the connection with each arterial road. (Intersecting roads: Colombo - Katunayke Expressway, Rt. A3, Rt. A1, Rt. B214, Rt. A11, Rt. A4, Rt. B84, Rt. A8, Southern Transport Corridor, Rt. A2)
- Due care must be taken to minimize the effects on structures and houses along the route by having the OCH pass through non-inhabited areas.
- The alignment must be such that the amount of cut is increased to compensate for projected shortage of fill for embankment work.

(2) Vertical Alignment

<Basic concept>

- As the amount of cutting is small and borrowed material will have to be used, a low (2 – 3 m) embankment should be employed.
- Considering past flooding levels, embankment height near rivers is to be increased by 1 m above the existing height.
- The clearance for intersecting arterial roads and railways is 5.25 m and 5.50m, respectively.
- The clearance for intersections with agricultural and community roads is 4.5 m
- The minimum OCH gradient is 0.3%

6.1.8 Structure Design

The following structures shall be proposed in order to construct the OCH.

(a) Bridges for crossing rivers
(b) Viaducts for crossing existing major roads
(c) Viaducts for crossing existing minor roads
(d) Viaducts for crossing railways
(e) Overpasses for crossing over the OCH
(f) Culverts for crossing under the OCH

(1) Bridge Design Standard

The RDA drew up a Bridge Design Manual in 1997. The purpose of this Manual is essentially to introduce basic bridge design concepts and to present technical guidelines for the bridge design of highway bridges.

The design of bridges and other related structures in Sri Lanka is mainly carried out in accordance with the British Standard (BS) 5400. In this Study BS 5400 is basically adopted, while referring to Japanese and US standards as well.

(2) Basic Design Conditions

1) Cross section of Bridges

The substructure of cross sections for OCH bridges are designed in this Study so as to be able to accommodate to 6 lanes in the future.

2) Load

The following loads (which are described in BS5400 part 2) are considered in the design of bridges in accordance with the RDA Bridge Design Manual (RDA1997).

a) Dead Loads
b) Earth Pressure
c) Live Loads
d) Braking & Traction of Vehicles
e) Water Current
f) Floating Debris & Impact

g) Wind
h) Temperature
i) Shrinkage

Crossing Condition

Crossings at rivers (i.e., bridges roads) and railways (i.e , viaducts) are considered in the design of the OCH for this study and are described below.

① River Crossing

For designing bridges, the following design items are required:

a) Width and cross section of river
b) Highest water level
c) Maximum velocity of river current and maximum volume of flood discharge
d) Location or plan for shore protection

These data have been obtained from field surveys, existing data, and hearings on residents living near rivers.

However, in Sri Lanka, it is only required that the abutment and pier bearing level have a 1.0 m clearance above the highest flood level.

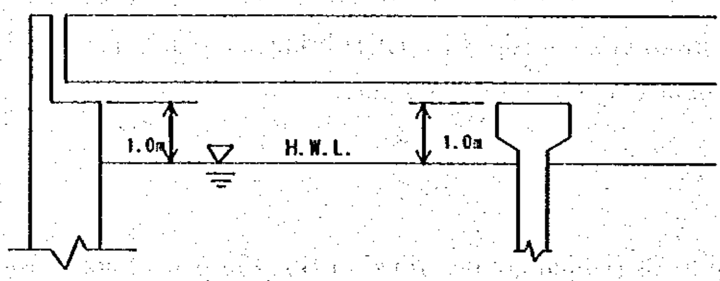


Fig.6.4 Clearance between Bearing Level and H.W.L. (SLS)

②Road Crossing

For designing viaducts for crossing highways, the following design items are required :

a) Minimum vertical clearance:5.25 m (Bridge Design Manual)
b) Road width :Existing road width or planning width

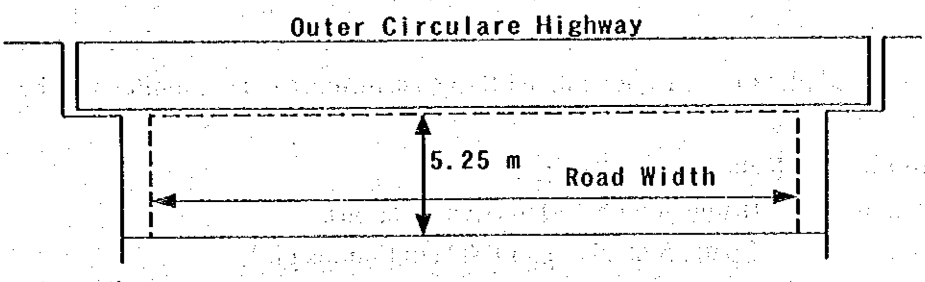


Fig. 6.5 Vertical Road Clearance

③ Railway Crossing

There are two locations where the OCH for this Study crosses a railway: the Colombo - Kandy Line with a triple-track at Horape near Halanduruwa marsh and the Colombo - Avissawella Line with a single track at Malapalla near Rt. A4.

For designing viaduct crossings over a railway, the following items are required:

a) Minimum vertical clearance:18' = 5.50 m
b) Structure gauge

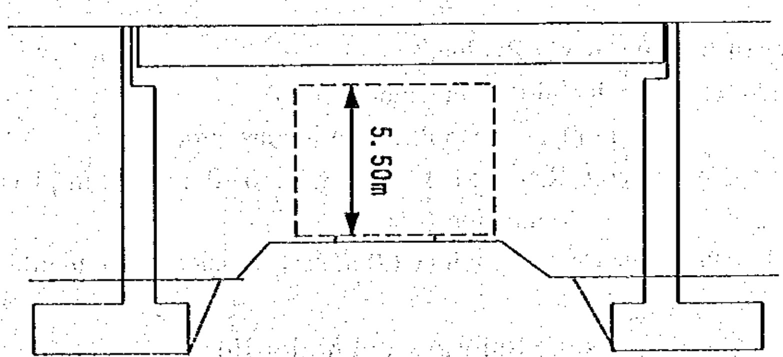


Fig. 6.6 Crossing over Railway

(3) Bridge and Viaduct Planning

1) Kelani River Bridge

The river width at the crossover point for the Kelani River is about 120 m and the Biyagama Road (B214) is about 60 m from the right river bank. It may be possible to have a three-span bridge cross both Rt. B214 and the river. Spans will be 25m in length and consist of connected girders using pre-tensioning PSC beams to realize a continuous structure without expansion joints at each support, excluding abutments, in order to ensure improved driving comfort.

As for the bridge foundation open caissons will be used for river sections. For the abutment and pier on the right bank, ø1.0 m cast-in-place concrete piles will be used.

Summary of Kelani River Bridge:
Superstructure: Bridge length 150 m (river section),
Span 25 m, six-span PSC continuous girder
Substructure: Abutment: Reversed T type with ø1.0 m cast-in-place concrete piles foundation
Pier: Elliptical column pier with open caisson foundation

2) Bolgoda River Crossing

The pile bent type (ø1.0 m cast-in-place concrete piles with steel casing provided at the top of a pile), which is superior in workability and cost-effectiveness, will be used. As for a superstructure appropriate for such a substructure, connected pre-tensioning girders will be used. Span length is 17m x 6 spans and bridge length 102 m, with the road intersecting diagonally with the river. The abutment foundation will be ø1.0 m cast-in-place concrete piles for river sections.

Summary of Bolgoda River Bridge:
Superstructure: Bridge length 102 m (river section),
Span 17 m, six-span PSC continuous girder
Substructure: Abutment: Reversed T type with ø1.0 m cast-in-place concrete pile foundation
Pier: Pile Bent Pier with ø1.0 m cast-in-place concrete pile foundation

3) Viaducts for Crossing Existing Railways and Major Roads

① Railway Crossing

Viaduct length was determined on the condition that the excavation line of the substructure would not enter the inside of the railway ballast line. For foundation piles, ø1.0 m cast-in-place concrete piles will be used to prevent adverse effects from vibration during work on the railway.

② Viaducts for Major Road Crossings and Interchanges

The type of superstructure for viaducts at major road crossings or interchanges is either a pre-tensioned or post-tensioned type, depending on viaduct length. On the basis of boring data contained in the geological survey report, pile foundations will be used for all viaducts except for the crossing at Rt. A1.

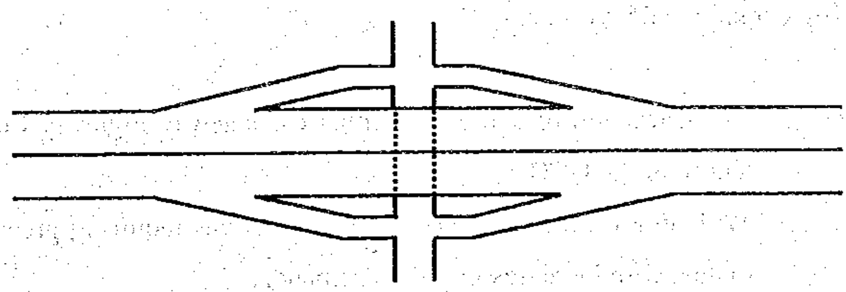
③ **Overpass**

Overpasses are planned to provide access to residents whose previous travel routes or property have been severed by the OCH. After taking into account a 4.5 m median for 6-lane operation in the future, piers will be constructed in the middle of the median. The superstructure will consist of post-tensioned T-type girders. However, the bridge span should be determined taking into account local conditions. As for the substructure, abutments will be an inverted T type and piers a T type. Since the height of most abutments will be as high as 10 – 12 m, ø1.0 m cast-in-place concrete piles will be used for the foundation, as is the case for the major OCH bridges. This type of foundation will also be applied to piers.

6.1.9 Junction and Interchange Planning

(1) Interchange Configuration

The basic OCH interchange configuration is planned to be a diamond type. Since the OCH on/off ramps would intersect with a local road at-grade for this type of configuration, the appropriateness of this design is finalized by comparing traffic capacity with forecasted traffic volumes.



Diamond Type Interchange

Based on the results of the comparison described above, the following types of junctions and interchanges where the OCH will cross a major arterial are to be employed.

(1)	CKE	:	Double trumpet type JCT
(2)	A3	:	Half trumpet
(3)	A1	:	Diamond type IC
(4)	B214Road	:	Half diamond type IC
(5)	A110Road	:	Half diamond type IC
(6)	A4 Road	:	Basic: Half clover type IC
		:	Alternative: Double trumpet type IC
(7)	B84 Road	:	Diamond type IC
(8)	A8 Road	:	Diamond type IC
(9)	STC	:	Y type JCT
(10)	A2 Road		Composite diamond (Level Crossing)

6.2 Construction Plan

6.2.1 Staged Construction Plan

(1) Staged Construction

The construction of the OCH in this Study is planned to be implemented in two stages in order to optimize traffic demand and investment:

Initial Stage : Construction of a four-lane dual carriageway highway for the entire length of the OCH.

Final Stage : Widening from four to six lanes for sections requiring greater capacity to deal with increases in traffic demand.

(2) Framework for Construction Execution

The framework for construction, which consists of a construction execution strategy, has four parts and is as shown below.

Part No.	Part	Construction Phase
1	Bandaragama – Kottawa	Initial Stage→FinalStage
2	Kottawa – Kadawata	ditto
3	Kadawata – CKE (Kelawarapitiya)	ditto
4	Bandaragama - Panadura	Final Stage(Four lane)

6.2.2 Construction Method

(1) Earthworks

Tab.6.1 shows the outline for OCH earthworks, as well as the sources for embankment materials for construction.

Tab. 6.1 Outline for OCH Earthwork

Part No.	Location	Outline of Earthworks
1	Bandaragama - A4(Kottawa)	The proposed highway runs through paddy and lowland area. Low embankment less than 2 meters in height are mostly anticipated. Borrow pits shall be situated in the neighboring hills around Kottawa for suppling embankment materials. Countermeasures for scouring by the Bologoda River shall be considered during/after embankment construction.
2	A4 (Kottawa) – A110(Kadawata)	The topography is a combination of rolling and flat land in this section. Where the flat terrain consists of paddy fields, a low embankment less than 2 meters in height will be constructed. Materials for embankment will be obtained from the borrow situated in the neighboring hills of Biyagama and from the Kelani River (river sand).
3	A110(Kadawata) – CKE(Kelawarapitiya)	The proposed highway runs through rolling and flat terrain in this section. Approximately 2 kms of the proposed highway will be located in a marsh area lying south of the Matara navy camp. A detailed soil investigation shall be carried out to research the peat layer to determine embankment settlement, which has a direct impact on construction costs. Also, the IC for CKE is constructed near a swampy area a soil investigation shall be carried out there to clarify soft soil areas as well. Embankment materials will be obtained from a borrow pit neighboring hills, of either Nugegoda, or Biyagama.
4	Bandaragama – A2(Panadura)	The proposed highway runs above the northern side of the Bolgoda River. Materials to be obtained from the neighboring hills of Bandaragama, Bolgoda and existing rivers (sandy gravel) for roadway improvement.

(2) Paving Work

Flexible pavement, such as asphalt / concrete, was selected for OCH earthworks sections and for structural sections such as bridges, overpasses and culverts.

(3) Bridge and Viaduct Construction

Continuous PC girder bridges are to be built for the two major river crossings at the Kelani and Bolgoda, rivers. Abutments and piers are assumed to use pile foundations to ensure bearing capacity. Minor bridges are assumed to use slab/PC girder bridges.

① Construction of Kelani River Bridge

Construction of the Kelani River Bridge will require the following construction methods:

- An open caisson will be required for substructure construction.
- Cast-in-place concrete piling will be executed by a reverse-circulation-drill method.
- PSC-girders will be erected by means of conventional crane erection method or erection girder method.

Superstructure Erection Methods

(a) Erection with a crane- equipped barge
(b) Erection with a truck crane
(c) Erection via temporary girders

② Construction of Bolgoda River Bridge

The merits and demerits of bridge construction methods are the same as for the Kelani river Bridge, except that Method (b) must be set at the central portion of the abutment and pier (median strip of the superstructure).

③ Overpass and Interchange Structures

Work will not take place over the water. Therefore, superstructure will normally be erected with a conventional crane.

④ **Railway Crossing**

The construction of railway crossings shall be carefully executed to avoid interfering with railway operation. Surveying shall be carried out to determine existing obstacles such as power lines, traffic lights and telecommunications. Then, methods to protect these facilities during construction will be examined. Sufficient discussions shall be held with the client on the construction procedures as well.

⑤ **Box-culverts**

Confirming the bearing capacity of the foundation is extremely important, since a box-culvert normally applies a spread foundation. Therefore, a foundation test shall be carried out before excavation.

(4) Cross Drainage/ Side ditch/ Kerb

The size and number of pipe culverts have been established based on hydrology calculations. The side ditches, pipe culverts under the center median and kerb are considered in the carriageway design shown in the typical cross section. These quantities are included in the earthworks.

(5) Cross and Side Road Treatment

It is necessary to consider how local roads, which shall either be terminated or connected to the OCH frontage road, will be dealt with in relation to the new highway profile.

(6) Other accessories

Streetlights, traffic signs, road markings, traffic control units, traffic signals and other traffic control facilities will be employed for the OCH.

6.2.3 Land Acquisition and Resettlements

(1) Establishment of Right-of-Way

The right-of-way shall be defined as an area necessary to accommodate all the necessary road structures and facilities for OCH, which has been set out in accordance with the following terms:

a) The RDA shall reserve the right of way for the operation of the OCH
b) Land, such as temporary construction yards, required outside of the designated right of way shall be provided under the contractor's obligation.

The right-of-way for the OCH is given in Fig. 6.7. and will include the installation of utilities for electricity and water for highway use in the road shoulders. Utilities for the purposes will not be installed within the right of way. The dotted lines shown in the figure distinguish the following categories:

- Road boundary: A boundary for defining operation, and which is normally categorized as the right-of-way. The border of the road boundary for the OCH at the edge of the slope drainage.
- Building line: This is the architectural gauge for buildings. Any building will not be allowed to be constructed beyond this line.
- Control line: This line defines an area for use by temporary construction yards. The yard should be 10 to 15 meters from the road boundary in order to accommodate temporary road and drainage facilities.

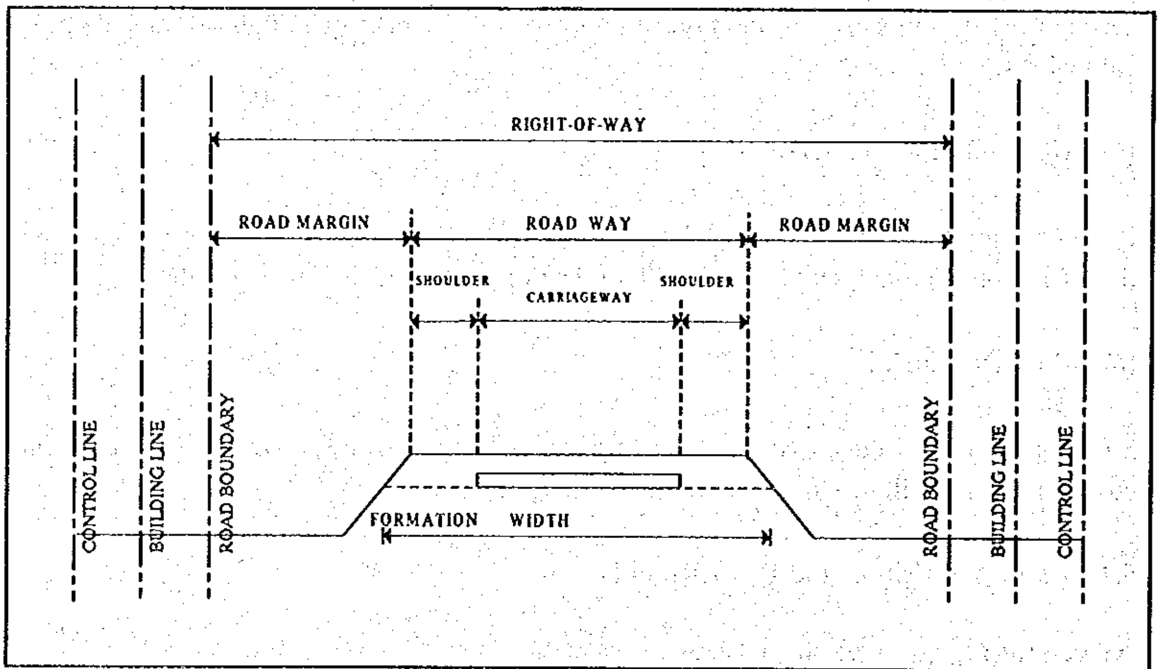


Fig.6.7 Right-of-Way , Building Line , Control Line

(2) Utility Relocation

Utilities requiring relocation have been identified by the Study Team via on-site inspection. There are high-tension towers and local electricity distribution facilities, water supply and telecommunications facilities etc. The number of high-tension towers requiring relocation has been worked out during the preliminary design and the relocation cost estimated by Ceylon Electricity Board.

6.2.4 Construction Time Schedule

(1) Conditions for Scheduling

① Critical Construction Period

The aim is to open the entire OCH to public by 2010. The construction period of each part will be a maximum of 2.5 years, and work to upgrade operation will be completed by 2020.

② Weather Conditions

According to rainfall data, the number of work days for earthworks and the construction of pavement are estimated as shown in Table 6.2.

Tab. 6.2 Construction Working Cycle-time(Dry Season/Rainy Season)

Item	Dry Season Jul.- Sep. Dec.- Mar (8 months)	Rainy Season Apr.- Jun. Oct.-Nov. (4 months)	Annual
Number of rainy days	10.1 days/month	14.0 days/month	145days
Working efficiency on a rainy day	65%	35%	52.5%
Number of holidays	5.0 days/month	4.3 days/month	60 days
Number of working days	21.5days/month	16.6 days/month	229 days
Working efficiency	72%	55%	63%

(2) Construction Schedule

A construction schedule has been prepared for each OCH section for the initial and final construction stages of the OCH. The detailed design for a four lane OCH will begin in early 2002 for a 1.5 year period, and construction will be executed in 2.0 - 2.5 years from the beginning or middle of 2003. Widening to a six-lane structure is dependent on traffic demand and the policy for optimizing investment by the government.

Fig.6.8 Construction Time Schedule for Initial Stage

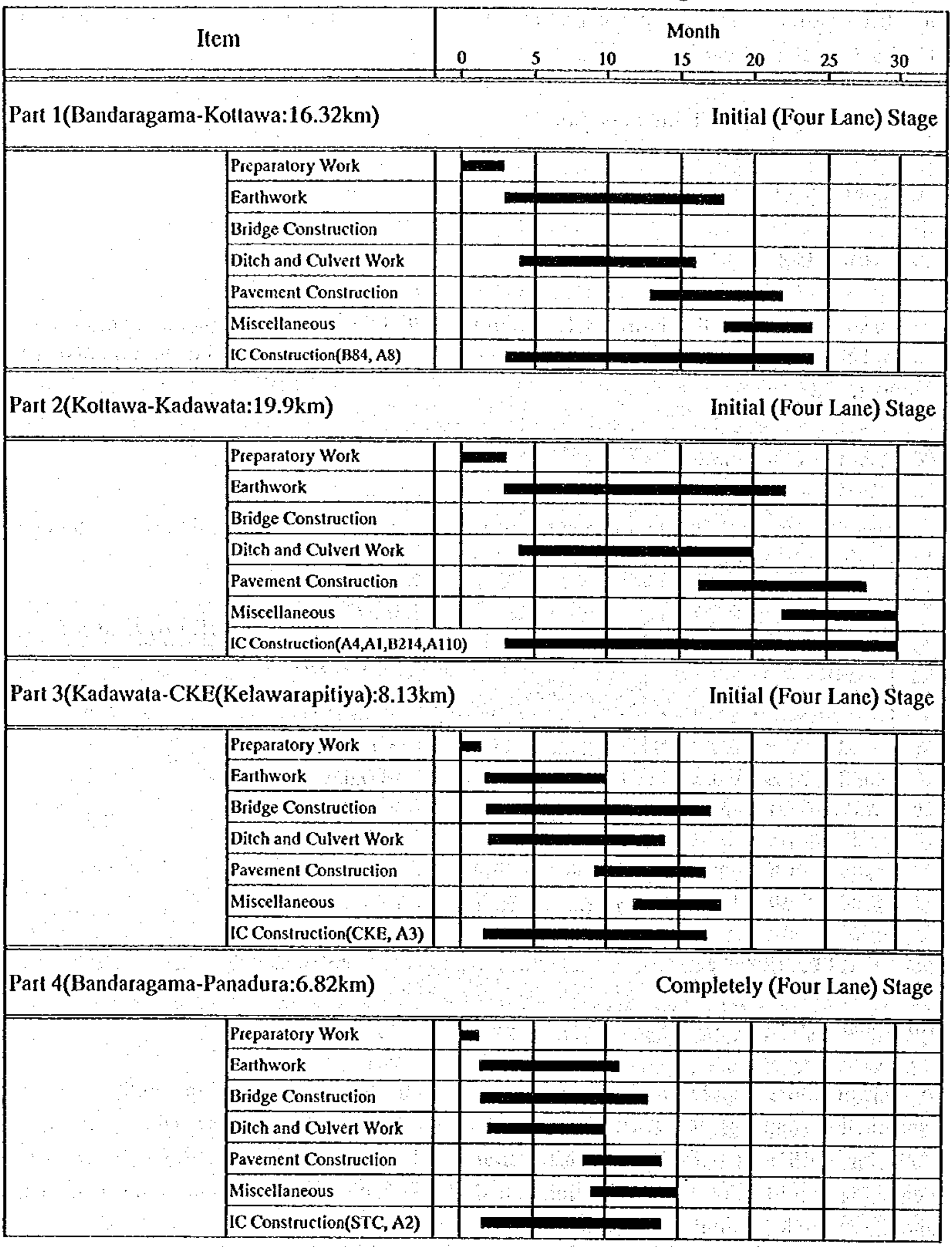
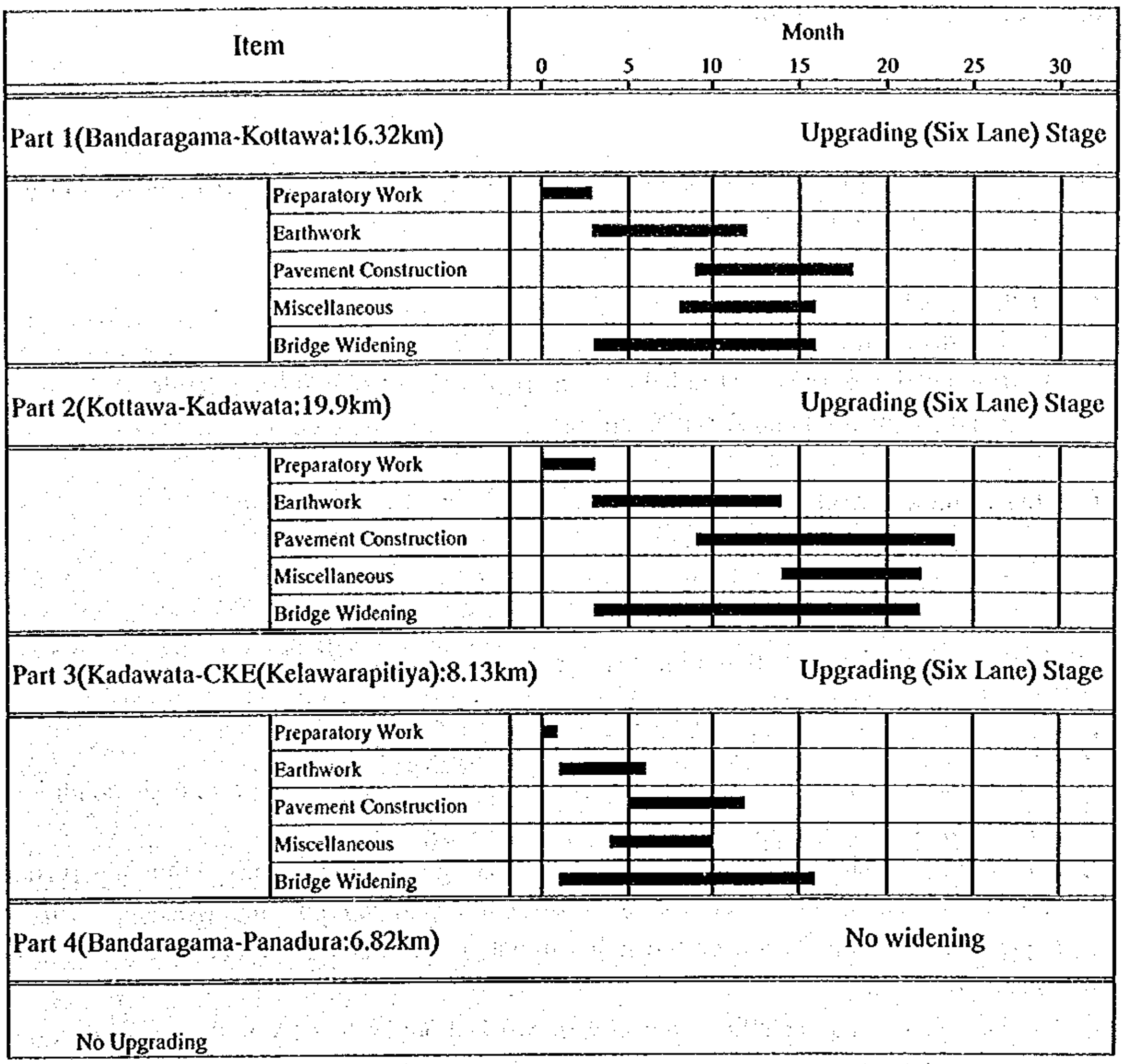


Fig.6.9 Construction Time Schedule for Final Stage



6.3 Project Cost Estimation

6.3.1 General

Project cost was estimated applying the results of the preliminary engineering design. Project cost in this chapter consists of the following items:

- Project Cost
  - Construction
  - Engineering Services (Detailed Design/ Tender assist/ Supervision Services)
  - Land Acquisition and Resettlement
- Operation and Maintenance cost
  - Utility: Electricity, Water Supply
  - Overlay.

The basic premises in estimating project cost are as follows:

1) All construction work will be executed by private contractor(s).
2) The unit cost of each cost component was determined based on the economic conditions prevailing in 1999 (Rs 1.0 = 1.6 Yen).
3) Engineering services consist of detailed engineering design and construction supervision and have been estimated at 8% of construction cost. Tendering assistance will be required at the time of tender and it is estimated that this will be equivalent to 2% of construction cost.
4) Land acquisition and resettlement cost were worked out in the EIA on the basis of market prices estimated by a land assessor.
5) Physical contingency is estimated to be 10% for the total of construction cost, land acquisition and resettlement cost, engineering services cost (including supervisory services).
6) Currency
   Exchange Rate: RS. 1= 1.6 YEN (December 1999)
7) Taxation

(a) Civil Works:	
- GST	12.50%
- Defense levy on imports	6.00%
- Tax on civil works (GST/ CD/ DL)	18.90%
(b) Consulting Services GST only	12.50%

6.3.2 Unit Costs of Construction Works

The unit costs of construction for chief work items are estimated based on labor costs, material costs, equipment costs, overhead, and profit. The estimated unit cost is compared with current bid prices and adjusted as required to obtain the most realistic prices. Overhead and profit are estimated as 10% of the sum for road works and 15% of the sum for structural work.

6.3.3 Estimated Construction Cost

A summary of the estimated construction and engineering costs for each part of the OCH and for each construction stage are shown in Tab. 6.3 and Tab.6.4.

Tab.6.3 Summary of Estimated Construction Cost (including contingency) in 1999 Prices (million Rs.)

	Part	Initial (4 lanes)			Final (6 lanes)		
		Construction	Tax & Duty	Total	Construction	Tax & Duty	Total
Portion of Southern Hwy Project	1	3,814.2	1,054.0	4,868.2	4,060.1	1,121.5	5,181.6
OCH Project	2	4,198.2	1,161.2	5,359.4	4,481.4	1,239.1	5,720.5
	3	2,674.1	722.2	3,396.3	2,813.3	760.3	3,573.6
	4 *	1,707.1	462.2	2,169.3	1,707.1	462.2	2,169.3
	Total	8,579.4	2,345.6	10,925.0	9,001.8	2,461.6	11,463.4

* 4 lanes for final stage

Tab.6.4 Summary of Estimated E/S Cost (including contingency) in 1999 Prices (million Rs.)

	Part	Initial (4 lanes)			Final (6 lanes)		
		E/S	Tax & Duty	Total	E/S	Tax & Duty	Total
Portion of Southern Hwy Project	1	381.4	79.2	460.6	406.0	84.3	490.3
OCH Project	2	419.8	87.3	507.1	448.1	93.1	541.1
	3	267.4	54.0	321.4	281.3	56.8	338.1
	4 *	170.7	34.6	205.3	170.7	34.6	205.3
	Total	857.9	175.9	1,033.8	900.1	184.5	1,084.6

* 4 lanes for final stage

6.3.4 Land Acquisition and Resettlement Cost

Tab.6.5 Summary of Estimated Land Acquisition and Resettlement Costs (million Rs.)

Description	Part 1 (Southern Highway) Project	OCH Project			
		Part 2	Part 3	Part 4	Total
(1)Demolition	244.7	299.7	121.9	102.3	523.9
(2)Land Acquisition	218.2	267.2	108.7	91.2	467.1
(3)Resettlement	54.1	66.2	26.9	22.6	115.7
(4)Removal of High Tension tower	55.0	18.3	18.3	18.3	55.0
Total	572.0	651.4	275.8	234.4	1,161.6

6.3.5 Estimated Project Cost

(1) Estimated Project Cost in the Initial and Final Improvement Stages

The summary of the project cost in 1999 prices is shown in Tab. 6.6 together with the foreign and local currency portions. Project cost is expressed in terms of financial cost and is divided into the investment cost in the initial and final stages for each part of the OCH project.

Tab.6.6 Summary of Project Cost of Foreign and Local Currency in 1999 Prices (million Rs.)

	Part	Stage	Foreign	Local	Total
Southern Highway	1	Initial Stage	2,969.4	2,931.5	5,900.8
		Final Stage	3,156.6	3,087.3	6,243.9
Project Cost	2	Initial Stage	3,277.6	3,240.4	6,518.0
		Final Stage	3,495.0	3,418.3	6,913.3
	3	Initial Stage	1,932.3	2,061.2	3,993.5
		Final Stage	2,037.6	2,150.0	4,187.6
	4	Initial Stage	1,244.3	1,364.7	2,609.0
		Final Stage	1,244.3	1,364.7	2,609.0
	Total	Initial Stage	6,454.2	6,666.3	13,120.5
		Final Stage	6,776.9	6,933.0	13,709.9

(2) Operation and Maintenance Cost

Tab. 6.7 is a summary of the operation and maintenance cost for each OCH section. Additional investment costs consist of the operational cost of utilities such as electricity, water and the cost of pavement overlay, which is to take place every 10 years after the completion of construction.

Tab.6.7 Summary of Operation and Maintenance Cost (2005~2039) (million Rs.)

	Southern Highway Project	OCH Project			
	Part1	Part2	Part3	Part4	Total
Length (km)	16.32	19.99	8.13	6.82	34.94
Cost	1,190.0	1,440.0	570.0	378.0	2,388.0