CHAPTER 4
TRAFFIC ASSIGNMENT OF ALTERNATIVES

CHAPTER 4 TRAFFIC ASSIGNMENT

4.1 GENERAL

4.1.1 Purpose

Traffic assignment is an important part of the network planning, which assigns future trip interchanges to a proposed road network. It can be used to estimate the volume of traffic on various links of the road network for the target year. Therefore, the traffic assignment procedure requires, as input, the complete description of the proposed road network and a matrix of interzonal trip movement (OD table). The final purpose of traffic assignment is to evaluate alternative road networks based on the estimated assigned traffic.

4.1.2 Road Network Data

The improvement plans of road network by UDA, DOH and GCEC are considered to meet the future demand arising from population and employment growth in the objective area. From the viewpoint of the traffic assignment for the future traffic volume, a suitable road network incorporated with the committed projects and the alternatives of the Project Road are set up in this study. The road network for the traffic assignment is shown in Appx. Fig. 5 to Fig. 6.

4.2 TRAFFIC ASSIGNMENT

4.2.1 Traffic Assignment Model

In order to calculate the traffic volume on the road network (including the project roads), the following traffic assignment procedure is used:

First Step

For each link of the road network to which vehicles are assigned, the relationship between traffic volume and travel time is established. In this relationship, travel time increases with the increase in traffic volume.

Second Step

It is assumed that traffic volume in each O-D pair is assigned to the road with minimum travel time. In case of a toll road, the toll is represented in terms of travel time.

Third Step

Vehicular OD traffic is equally divided into 5 parts. A 20% of the volume is first assigned to the road network and the resultant travel time is computed for each link. The next step is to assign a further 20% of the traffic volume to the network and a new set of resultant travel time is computed for all the links. This process is repeated until all the volume has been assigned and the final travel time is calculated. This procedure, which is referred to as the Q-V formula, is based on the assumption that as the volume of traffic on a link increases, so the travel time on that link increases too. Thus the speed necessary to travel on that link is reduced just as increased congestion causes speeds to be lowered in real situations. This relationship is illustrated in Fig. 4-1.

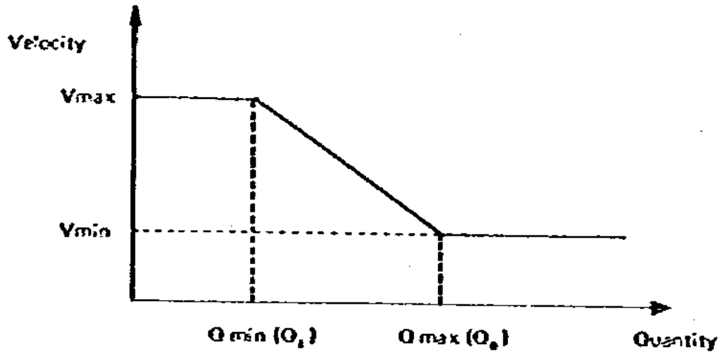


Fig. 4-1: Q-V Formula

When the traffic volume is below Q_1, the vehicle may be able to travel at the maximum speed (V max), while when the traffic volume exceeds Q_1, the travel speed decreases.

Based on the above-mentioned road network, the road type and its Q-V formula are determined in order to compute the traffic volume. These are classified using the classification of road type as shown in Table 4-1.

4.2.2 Cases for the Project Road

From the view point of preliminary engineering study (see Sections 5, 6, 7 & 8) five cases for the project road as shown in Fig. 4-2, 3 were selected to examine their feasibility.

4.3 RESULTS OF TRAFFIC ASSIGNMENT

Summarized in Table 4-2 are the estimated traffic assigned on each road section by cases. Judging from this table, the following observations can be obtained:

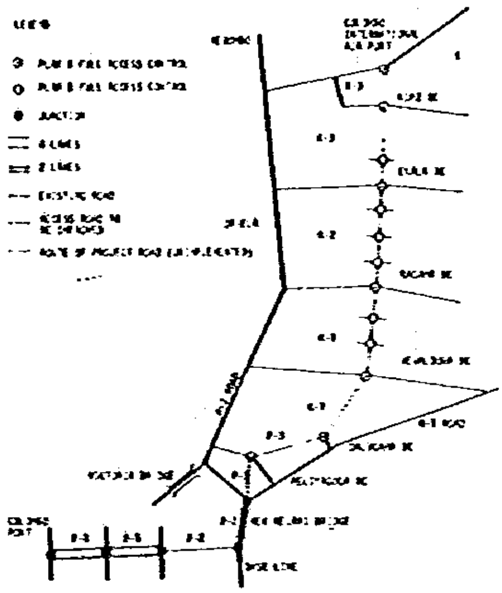
a) The assigned traffic volume on Project B is comparatively large. The daily traffic volume on each section of this road is estimated to be more than 20,000 in 1990 and 40,000 in 2000. Especially, that on the section between Perera Mawatha to Colombo

Table 4-1: The Type of Q-V Formula by Road Type

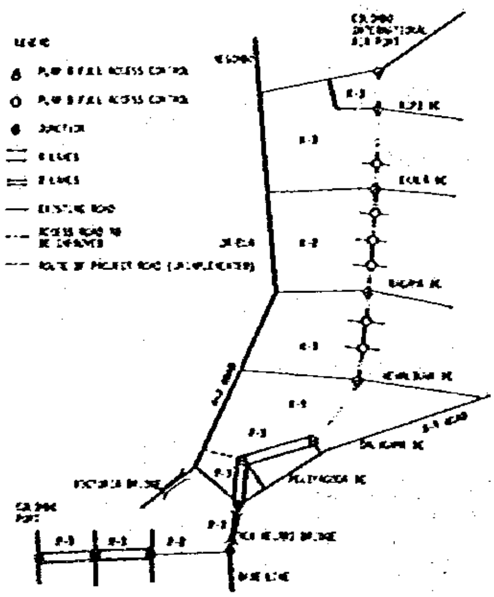
Type of Road	Q-V Code	Standard Velocity (km/h)	Standard capacity Vehicle/day	Vmax (km/h)	Vmin (km/h)	Qmax Vehicle/day	Qmin Vehicle/day
Roads within Colombo	1	10					
	2	15					
	3	20					
	4	25					
	5	30					
	6	35					
	7	40					
	8	45	*	*	*	*	*
	9	50					
	10	60					
A Class Road*	11	30					
B Class Road*	12	20					
C Class Road*	13	10					
Roads without Objective Area	14	40					
Victoria Bridge	15	40	10,000	40	4	17,500	2,500
New Kelani Bridge	16	50	40,000	50	5	70,000	10,000
A1 Roads (2-lanes)	17	50	9,000	50	5	15,750	2,250
A1 Roads (4-lanes)	18	40	38,000	40	4	66,500	9,500
A3 Roads (2-lanes)	19	50	9,000	50	5	15,750	2,250
A4 Roads (4-lanes)	20	40	38,000	40	4	66,500	9,500
Improved Access Roads	21	40	9,000	40	4	15,750	2,250
New Port Access Roads	22	60	38,000	60	6	66,500	9,500
Expressway (4-lanes)	23	80	44,000	80	8	77,000	11,000

* Since most traffic on these roads are not related to that caused by the completion of the project roads, the standard velocity is fixed according to the road congestion.

— Case 1 —



— Case 2 —



— Case 3 —

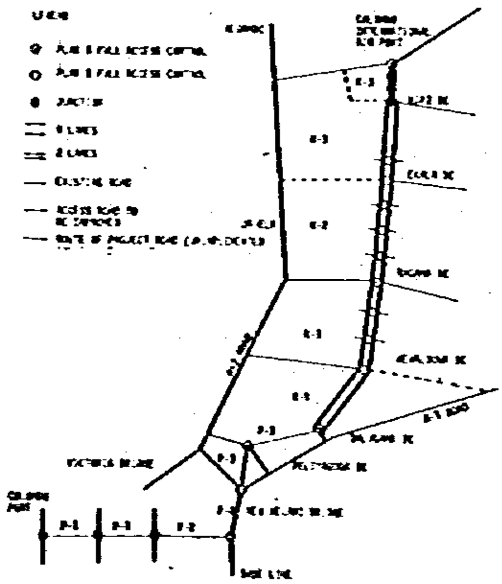


Fig. 4-2 Alternative to the Project Road (Case 1 ~ 3)

– Case 4 –

– Case 5 –

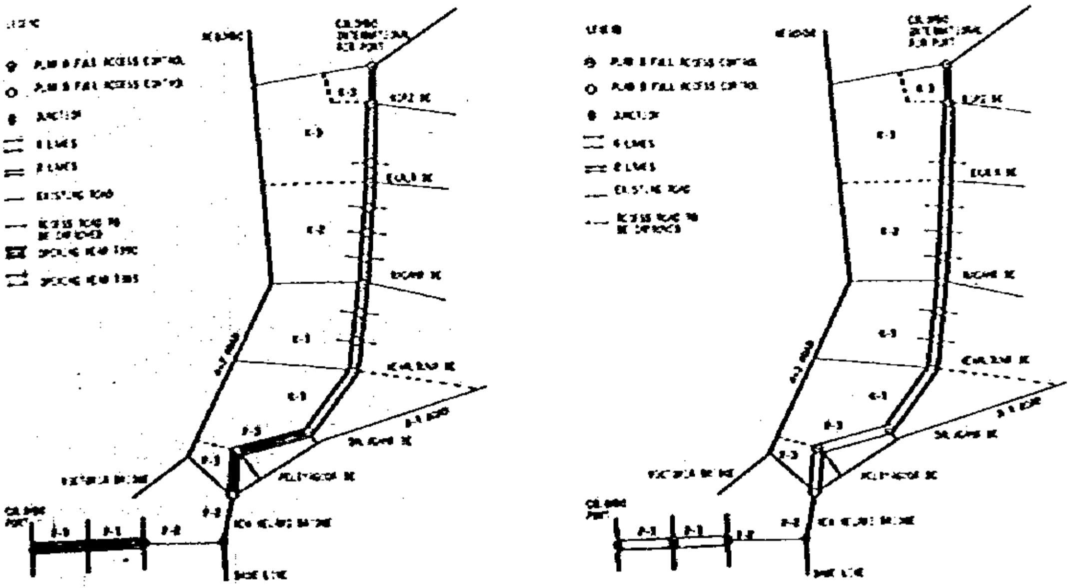


Fig. 4-3 Alternative to the Project Road (Case 4, 5)

Table 4-2: Results of Future Traffic Assignment for Cases

(Unit : Vehicle/day)

Route	Road Section	Case 1 1990	Case 1 2000	Case 2 1990	Case 2 2000	Case 3 1990	Case 3 2000	Case 4 1990	Case 4 2000	Case 5 1990	Case 5 2000
K13	AIRPORT - KIPZ					2124 2120 4244	5206 5234 10440		6545 6732 13277	2301 2201 4502	6545 6732 13277
K13	KIPZ - EKALA					5703 5337 11,040	9734 9877 19611		10572 10983 21,555	5826 5640 11466	10572 10983 21,555
K12	EKALA - RAGAMA					8555 7411 15966	16954 16325 33279		18516 17945 36461	9046 8209 17255	18516 17945 36461
K11	RAGAMA - WEWELDUWA					9417 8107 17524	18544 17,727 36271		20158 19347 39505	9908 8905 18813	20158 19347 39505
K11	WEWELDUWA - DALUGAMA					9262 7771 17,033	18208 16945 35153		25172 25105 50277	13343 12625 25968	25172 25105 50277
P13	DALUGAMA - PELIYAGODA			11,973 10052 22025	16183 16469 32652			11,973 10052 22025	20158 20165 40323	17431 15605 33036	20158 20165 40323
P13	PELIYAGODA - KANDY RD.			23542 18612 42154	31854 28678 60532			23542 18612 42154	30290 28138 58428	21992 18579 40571	30290 28138 58428
P12	KANDY RD. - BASELINE RD.	23309 18482 41,791	45023 37864 82887	23813 19303 43116	47520 39609 87129			23813 19303 43116	48692 41,791 90483	24019 19644 43683	48692 41,791 90483
P12	BASELINE RD. - PRINCE OF WALES	13516 10536 24052	23580 19821 43401	14020 11273 25293	23618 19861 43479			14020 11273 25293	24488 21679 46167	14226 11,714 25940	24488 21679 46167
P11	PRINCE OF WALES - PERERA MAWATHA	12734 10795 23529	23942 22564 46506	11,730 11,797 23527	23467 23001 46463			11,730 11,797 23527	23636 23164 45800	12734 10793 23527	23636 22164 45800
P11	PERERA MAWATHA - PORT	14863 18873 33736	27995 37129 65124	16641 17095 33736	31983 33103 65086			16641 17095 33736	27977 37109 65086	14863 18873 33736	27977 37109 65086

Note : Upper:Number of Passenger Cars (Private Cars, Taxis and Hires, Buses)
Middle:Number of Freight Cars (Vans, Medium Lorries, Heavy Lorries, Containers)
Lower :Total Number of Cars

Port is estimated to be more than 30,000 in 1990 and 60,000 in 2000.

b) The assigned traffic volume crossing the New Kelani Bridge is considerably large. In 2000, that traffic volume reaches more than 90,000 per day. On the other hand, the assigned traffic volume on the Victoria Bridge is about 30,000.

c) The assigned traffic volume on Project A will have a larger traffic volume when Project B is constructed together with the Expressway.

d) The composition of passenger cars and freight cars of the assigned traffic is almost even on each road section.

e) Compared with the basic case where the Project Road would not be constructed, traffic congestion along A-1 and A-3 Road would be considerably decreased.

Fig. 4-4 illustrates the flow of future daily traffic volume on cases for the Project Road.

4.4 RELATIONSHIP OF EXPRESSWAY AND RAILWAY

4.4.1 Existing Situation of Railway

Within the objective area, the Colombo - Puttalam Line and the Colombo - Kandy Line are in service. The northern line which serves the urban centres from Ragama to Kochchikade is a single track, while the Colombo - Ragama line is a double track. From Ragama to Negombo is also a single track. The total length of the rail links in the areas reaches 28 miles.

However, now the existing railway system is not sufficient for the commuter demands for railway, due to the shortage of passenger coaches and superannuation of the railway facilities. Therefore, the following plans are examined to improve the railway system by Sri Lanka Government Railway and National Planning Authority.

a. Double tracking Ragama - Katunayake rail and improving the rail services to serve commuter traffic

b. Electrification of the railway

4.4.2 Future Development Plan of Railway

(1) Double Tracking

The average number of passengers using the Puttalam line travelling in the direction of Colombo in March 1979 is shown in Table 4-3. (See Appx. Table 14 for the supporting data)

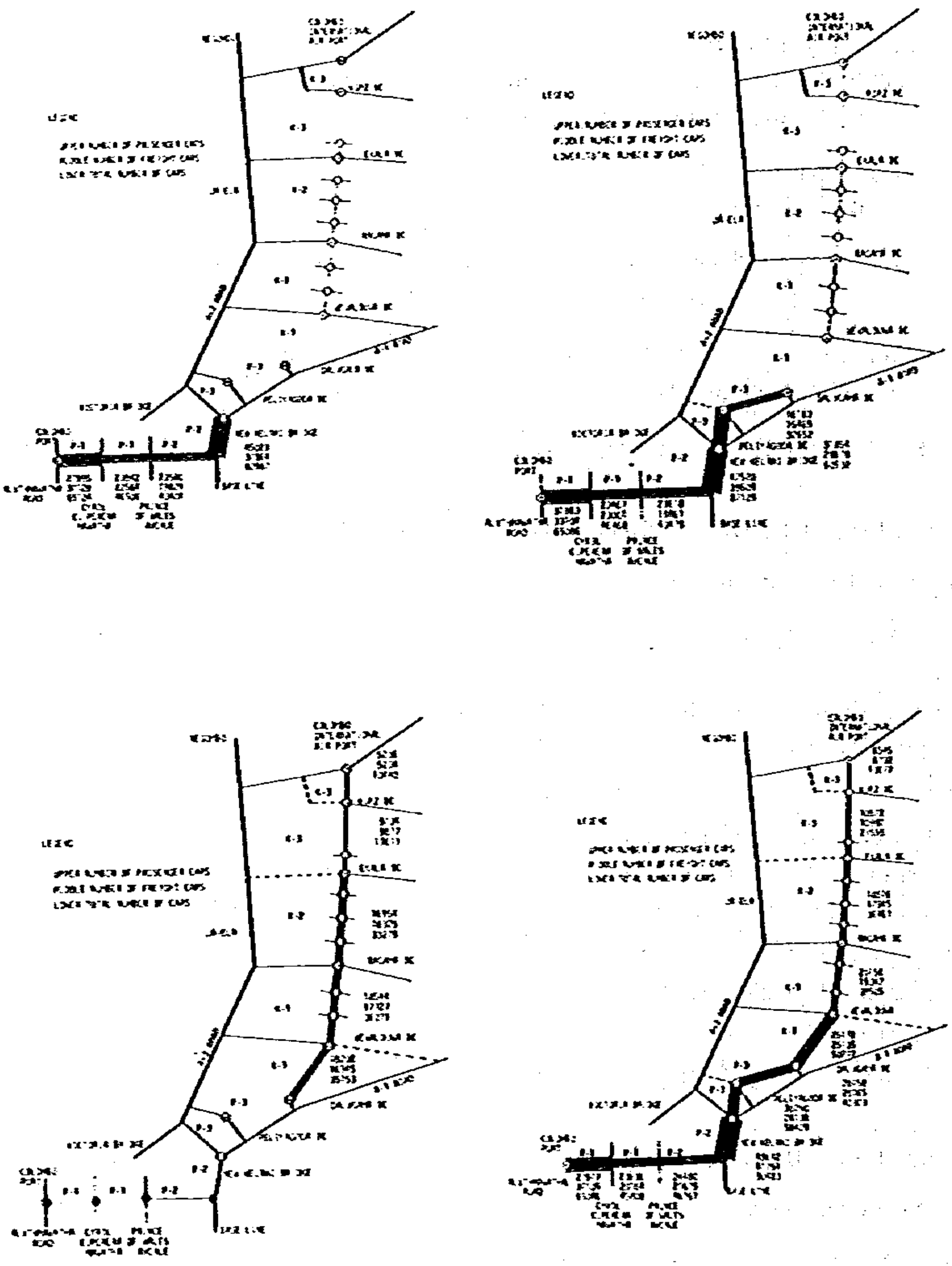


Fig. 4-4 Future Daily Traffic Volume (2000 Year) Case 1 ~ 5

Table 4-3: Daily Rail Passengers Travelling towards Colombo

Ticket Type	Negombo	Ja-Ela	Ragama
Season Ticket	2,419	6,051	9,300
Ordinary Ticket	924	1,584	1,985
Total	3,343	7,635	11,285

Judging from the existing railway frequency and capacity shown in Appx. Table 15, the rail operation would not be able to meet the passenger demand in the future, due to the full development of KIPZ, the growth of air passenger traffic, the increment of job opportunities within Colombo City and Peliyagoda and so on. (For more details, see 'Report on Transport Requirements of the GCEC Area of Authority', GCEC, October, 1980)

Therefore, double tracking from Ragama - Katunayake and the railway electrification are expected to improve the regular rail service, especially during peak hours.

(2) Electrification

The purpose of the railway electrification is to utilize the surplus of electric power generated from Mahaweli Power Stations during hours of off-peak power to carry commuters. Because from the view point of the efficient energy policy, it is desirable that the electrification could reduce wasting of crude oil.

The following is the outline of the proposed electrification of the railway:

1) Section of electrification
   - Colombo Fort – Polgahawela
   - Colombo Fort – Panadura
   - Panadura – Kalutara South
   - Ragama – Negombo
   - Ragama – Colombo International Airport

2) Operated Head (peak hours)
   4 ~ 5 minute (existing 10 ~ 15 minute)

3) Velocity
   45 km/hour (existing 20 ~ 30 km/hour)

4) Passenger Capacity
   30,000 person/hour

4.4.3 Relationship of Expressway and Railway Improvement

The following items can be pointed out:

1) Even with the improvement of railway, it is difficult to stop the trend of growing car ownership as seen experienced in many developed and developing countries.

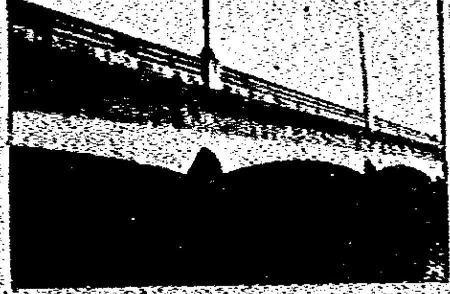
2) The power of inducement for industrialization is more reinforced by using road network (including expressway) than railway improvement alone.

3) The commodities and materials cannot be gathered from and distributed to many places smoothly without road network (including expressway) because the supply and demand places are scattered in a wide area. In other words a better door to door service can be provided by the road network.

4) On the other hand, the railway improvement will contribute to long trip passengers and long distance freight flows, and also contribute to commuting during the peak hours as a "line-transport service".

Therefore, expressway and railway will mutually supplement a portion of functions of the other, although in some aspects they would be competitive.

CHAPTER 5
PRELIMINARY ENGINEERING



CHAPTER 5 PRELIMINARY ENGINEERING

5.1 NATURAL CONDITIONS

5.1.1 Topography

The project area drained by Kelani Ganga, Ja-Ela Canal and Dandugam Oya, has a generally flat terrain gently rising to hilltops rarely exceeding 35 m above sea level. A vast extent of the land, especially in the Dandugam Oya basin is low lying and exists as either paddy fields or marshes. Some of them are below mean sea level (MSL) as observed in Peliyagoda, Horape and Ragama areas. Highland is predominately coconut estates or home gardens with assorted crops.

5.1.2 Geology

The main bed rock types present in the project area are granites, gneises and charnokites. Gravels and laterite out crops are observed in the high lands and hillocks. Sandy soils prevail elsewhere as esturine or littoral deposits closer to and along the coastal belt and as river alluminium in the interior parts. Marshes consists of peat layers often not exceeding 10 m in thickness and followed by sandy clays or sand deposits.

5.1.3 Hydrology

Hydrology of the northern parts of the project area is largely determined by Dandugam Oya and its tributaries ie. Attanagalu Oya, Kuda Oya and Kimbulapitiya Oya with a total catchment exceeding 800 km^2. Owing to frequent meanderings on the lower reaches of the main stream and due to lack of drainage, a vast area most of which is low lying lands is affected by floods and others remain inundated for long periods such as 4 to 10 days.

On the other hand, hydrology of the southern parts of the project area is affected by Kelani Ganga which has a catchment area of 1,650 km^2. Lower areas situated north of Kelani Ganga which are mostly marshes below 2 m MSL undergo inundation when the water level in the river itself rises higher. The drainage system of Colombo City consists of a canal network with limited out falls to the sea. Especially the low lands in Bloemendhal area through which the project road is planned is affected when the canal out fall into Kelani Ganga is closed when the river rises. The highest flood level recorded (in 1947) is 3.6 m MSL about 400 m upstream of Victoria Bridge.

5.1.4 Climate

Located within the wet zone, the project area receives an average annual rain fall of 2,400 mm. The monthly precipitation is high and in the range of 250 mm ~ 380 mm during months of April to June and October to November.

Climatically the project area has a mean annual temperature of 26°C during November to February and 28°C during the warmer months of April to September. The daily temperature rises to a maximum about 32°C on the average early in the afternoon and falls to a minimum about 22°C shortly before dawn.

The relative humidity varies from 70% during day to 90% or 95% at night. During months of April and May with high temperatures the absolute humidity remains high.

5.2 FIELD SURVEYS

5.2.1 General

In order to plan the project roads and the various structures required such as, bridges, interchanges, ramps, drainage and flood relief structures adequately and economically, it is essential to grasp natural conditions, especially the topography and geology of the Project Area in general. Moreover, it is necessary to clarify specifically on the subsoil conditions as a major part of the project roads pass through marshes and paddy fields and also to ascertain the availability of construction materials in adequate quantities.

Therefore following field surveys were conducted to obtain these necessary information on topography, geology and subsoil conditions.

5.2.2 Geotechnical and Material Investigations

(1) Geotechnical Investigations

Geotechnical Investigations were conducted at a total of 21 locations as shown in Fig. 5-1. The survey points were selected after carefully study of aerial photo maps and field inspection.

Rotary type mechanical boring method was employed in the investigations. Standard Penetration Tests were conducted to confirm the bearing stratum for structure planning, the thickness of soft weak layers for settlement analysis and the depth of rock. Results of field surveys are summarized in Fig. 5-1.

Soil samples were extracted from the bore holes for laboratory soil testing. Physical tests for natural moisture content, consistency, specific gravity and the mechanical tests for unconfined and triaxial compressive strength, and consolidation characteristics were performed. Undisturbed peat samples were extracted from a pit dug in Bloemendhal area in order to grasp the general consolidation characteristics of peat widely encountered along the Project Roads.

Summarized in the Table of Fig. 5-1 is the purpose and the number of test conducted.

(2) Investigations for Construction Materials

As a large quantity of construction materials is required for the Project it is necessary to confirm their availability in adequate quantities in close proximity to the project.

1) Filling Materials : Soil

The project roads pass mostly through low lying areas and relatively lowrise hillocks. As a result, a large quantity, 440,000 m^3 in Project A and 320,000 m^3 in Project B, of earth should be brought from the borrow pits. Two hillocks, one of which is about 30 m in height located north of Ragama and the other located east of the Airport are earmarked as the borrow areas for Project A. Both these are along the Project road.

As there are no suitable borrow areas along or close to the route of Project B, earth has to be hauled a distance of about 7 ~ 10 km from Biyagama Area.

The material in all these borrow areas is gravelly lateritic soil which is of sufficient quality as an embankment material.

Location of the proposed borrow areas is shown in Fig. 5-2. Compaction tests and CBR tests were conducted in the laboratory with soil samples collected to confirm the suitability of the material as an embankment material.

2) Fine Aggregates : Sand

The quality sand required for the sand piles can be extracted from Kelani Ganga close to the river mouth. The quantity required is about 15,000 m^3 and this is adequately available.

About 220,000 m^3 of sand required for the sand mats can be met even with the sea sand which satisfies the requirement in both quality and quantity.

3) Course Aggregates : Crushed Stones

The large quantity of crushed stones required mainly as the aggregates for pavement can be sufficiently made available from the rocks widely distributed over Biyagama Area. These rocks are of granites and gneisses in origin. The volume of aggregates required only for the pavement works is about 280,000 tons, Los Angeles Abrasion tests were conducted with the rock samples to confirm the quality of the crushed stones.

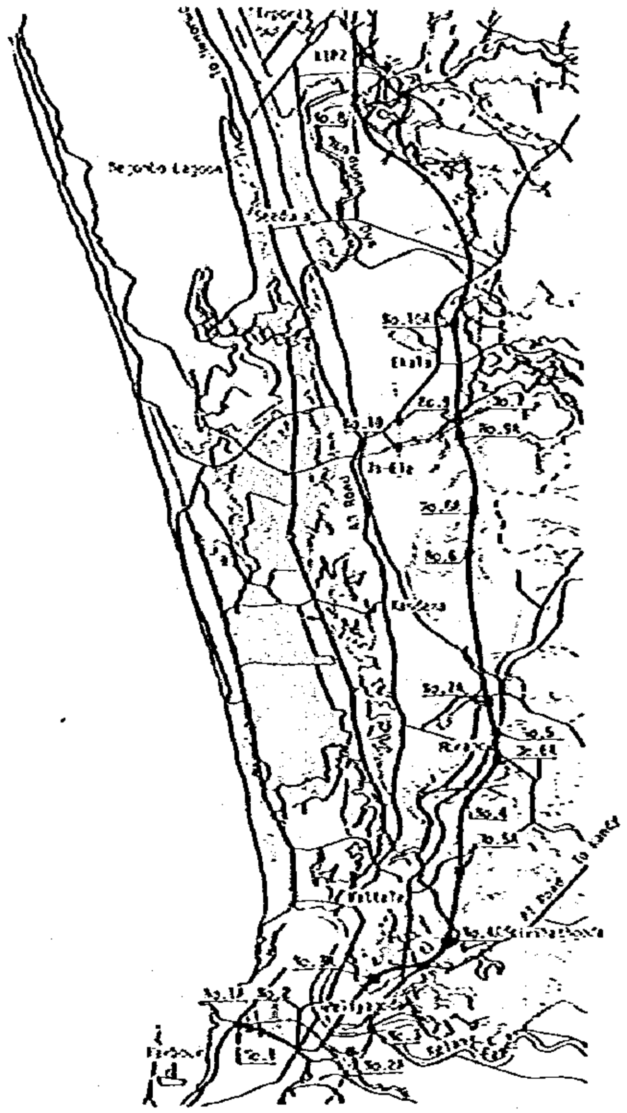
5.2.3 Topographical Survey

The following surveys were carried out for this feasibility study:

(1) Preparation of Uncontrolled Photo Mossaics

Since a suitable topographical map covering the entire project area was not available to carry out this study, a 1 : 10,000 scale uncontrolled photo mossaic map which was prepared using the available photo mossaics and supplemented with ground control data obtained from a field survey, was used in the route selection.

Locations and Results of Geological Survey



Legend

- ● Mechanical boring points
- ■ Penetration points in marsh

◯ Marshy areas

—— Project Roads

Notes: ○ : Test Done

- BD : Bulk Density
- WC : Natural Moisture Content
- ATT : Atterberg's Limits
- SG : Specific Gravity
- GSD : Grain Size Distribution
- TCS : Triaxial Compression Strength
- UCS : Unconfined Compression Strength
- CON : Consolidation Test
- LAA : Los Angeles Abrasion Test
- CMP : Compaction Test
- CBR : California Bearing Ratio

( ) : Tests for the design of road embankment

No. & Location of Field Test	Depth (m)	Ground Level (m MSL)	Purpose	Laboratory Test										
				BD	WC	ATT	SG	GSD	TCS	UCS	CON	LAA	CMP	CBR
No.1 Port Entrance Structure	6.4?		To confirm bearing strata for foundations of structures		○	○	○		○	○				
No.2 Peliyagoda Bridge	21.31				○	○	○							
No.3 Peliyagoda Bridge	21.33				○	○	○		○	○				
No.5 Horape Railway Crossing	7.65	1.25			○	○	○							
No.7 Ja-Ela River Bridge (A)	29.81				○	○	○							
No.8 Dandugam Oya Bridge	15.52				○	○	○							
No.9 Ja-Ela River Bridge (B)	15.00	13.85			○	○	○				○			
No.6 Kandana West	24.95	17.75	Cutting		○	○	○							
No.[illegible] Ja-Ela	13.77				○	○	○		○	○				
No.2 [illegible]	15.00	1.55			○	○	○		○	○				
No.4 Horape Marsh	10.20	0.80			○	○				○				
No.1A [illegible]	9.00	0.65	To confirm thickness and properties of soft layers for embankment in marshes		○									
No.1A [illegible]	9.00	0.65			○									
No.3A Peliyagoda	13.72	0.25			○	○			○					
No.4A Kiribathgoda	9.25	0.20			○									
No.5A Hunupitiya East	9.25	0.20			○									
No.6A Horape South	13.93	1.20			○	○								
No.7A Ragama West	15.05	1.37			○	○	○							
No.8A Kandana South East	12.25	0.55			○									
No.9A Ja-Ela River South	13.00	0.75			○									
No.10A Ekala East	13.00	0.7?			○									
No.11A Kandana East	15.00				○	○								
Total Number of Tests Done				[illegible] (12)	13 (12)	33 (3)	17 (7)	23 (12)			5 (3)	3	8	7

Boring Logs

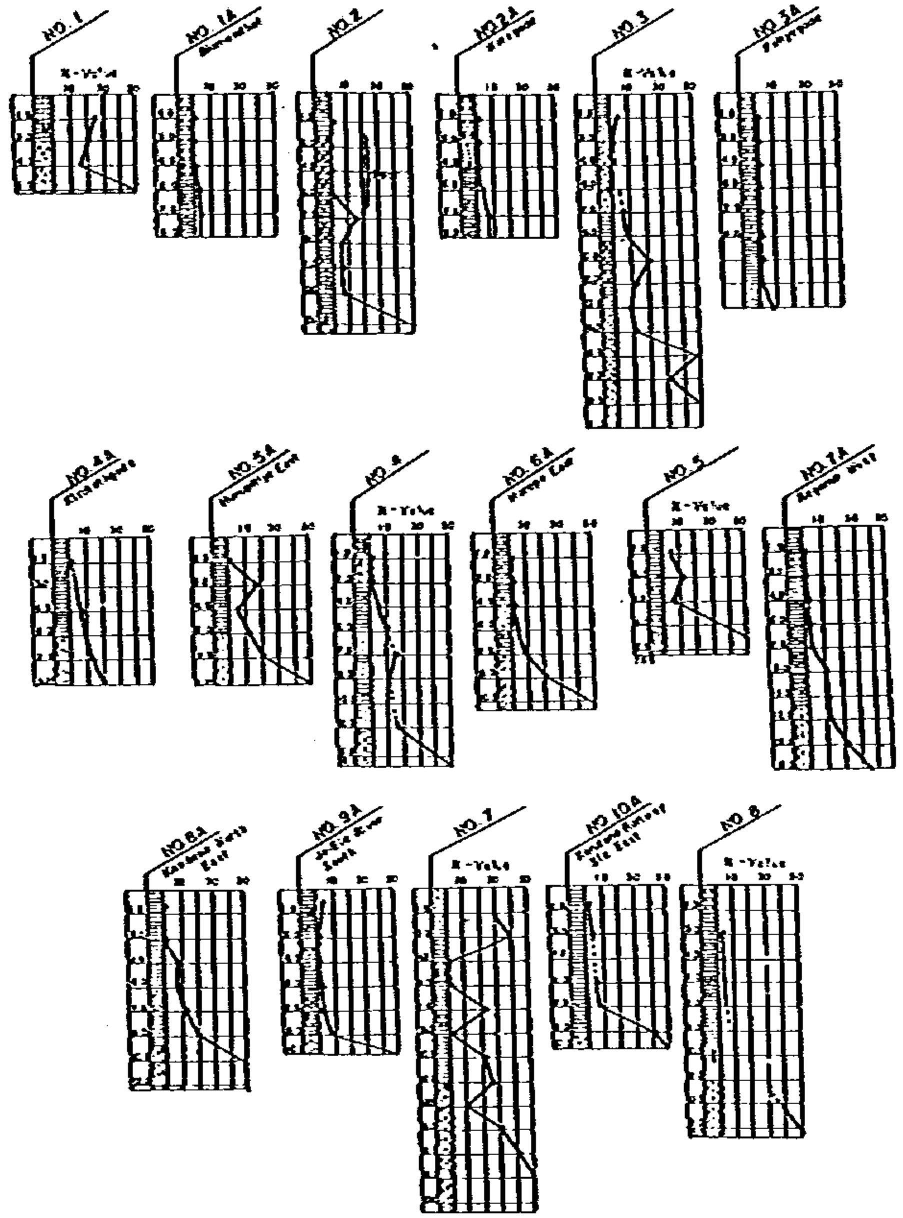


Fig. 5-1 Locations and Items of Geological Survey and Boring Logs of the Project Area

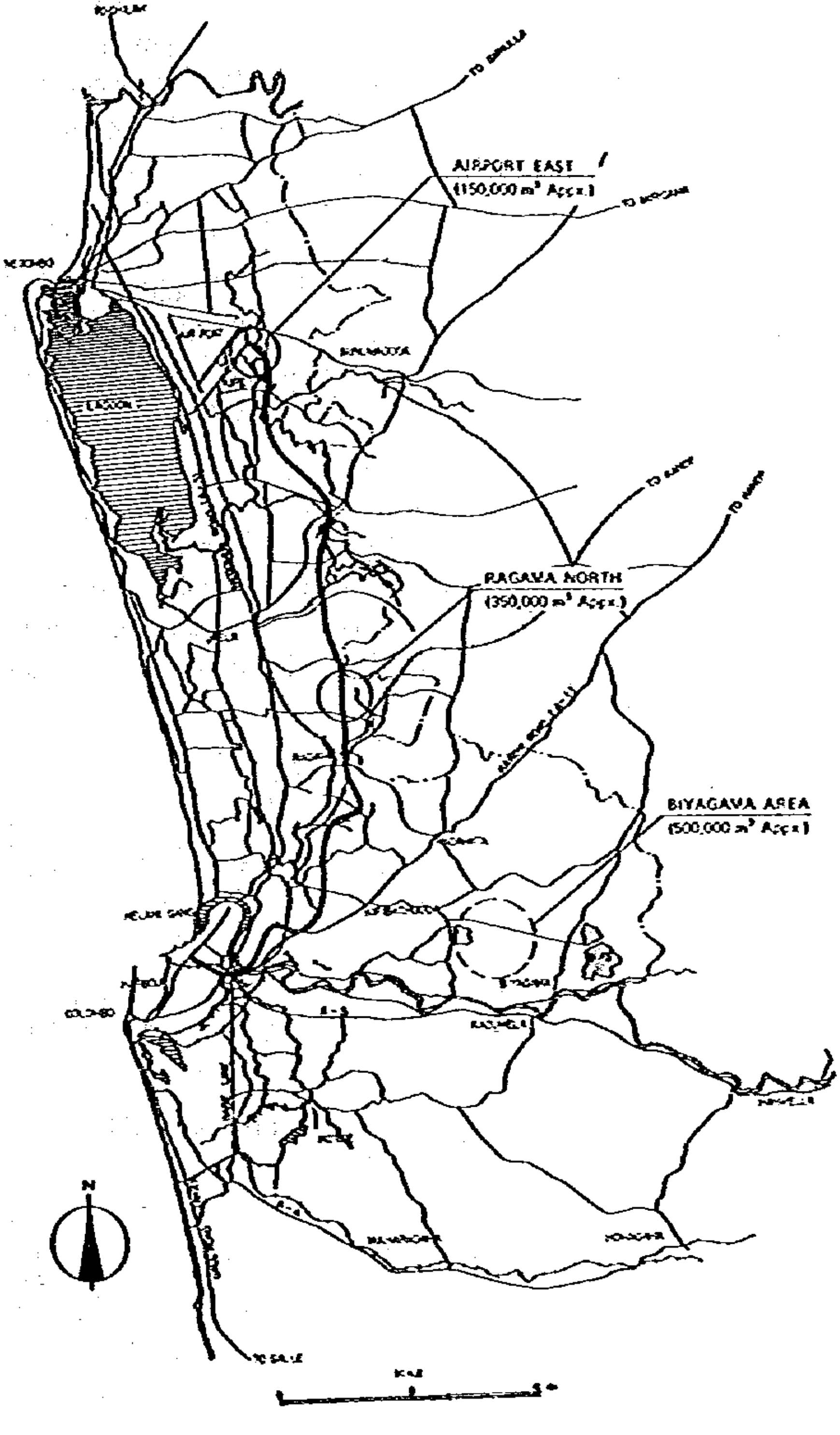


Fig. 5-2 Location Map of Borrow PITS

(2) Preparation of Contour Photo-Maps (1/10,000)

For fine adjustments on the selected route and for the study of alternatives, a contour photo map was prepared by marking contour lines and spot heights by the photogrammetric method. Contours were drawn at 5 m intervals in general and at 2.5 m on the flat areas.

(3) Route Survey

With the aim of upgrading the accuracy of cost calculations in the road planning studies, longitudinal profile and cross sections of the selected route were plotted after conducting longitudinal survey and cross sectional survey at 200 m intervals on the average. Topographical maps were prepared for the sites where structures are planned.

1) Alignment Calculations

From the data derived from the photo-mossaics, contour photo map and the supplementary surveys, the road alignment was studied and confirmed after discussions between the GCEC and the Study Team. From this confirmed alignment, the co-ordinates of main points and the centre points at 10 m intervals along the route were calculated.

2) Setting of Centre Survey Pegs

Although co-ordinates were calculated at 10 m intervals along the centre line, survey pegs were set at centre points at 200 m intervals on the average and at the main points of the alignment curves.

3) Longitudinal Survey

Ground heights of main points, centre points and critical points were surveyed and connected to the bench marks of the national grid.

The longitudinal profile of the route was prepared through this survey.

4) Cross Sectional Survey

Cross sectional survey was done up to a perpendicular distance of approximately 35 m from the centre line on its both sides and the cross sections were plotted at 1:200 scale.

5) Detailed Topographical Survey

Topographical maps were prepared for sites where major structures are proposed. This was done by enlarging the aerial photographs to the required scale and plotting the results of levelling done on a mesh form.

5.3 CHARACTERISTICS OF THE PROJECT ROAD

5.3.1 General

(1) Project Road

The route of the Project Road is described below (See Summary Fig. 2).

1) This Project Road has its starting point near the road bridge on Aluthmawatha Road over the railway line leading to Colombo Port and cuts across through the middle of the marsh well co-ordinating with the Bloemendhal Development Project to connect with the intersection at Prince of Wales Road. This section of the road hitherto had been referred to as the Port Access Road.

2) The Project Road further extends along the Access Road to New Kelani Bridge and after passing the intersection at Baseline Road crosses over Kelani Ganga to Peliyagoda over the New Kelani Bridge.

3) Keeping in co-ordination with the Peliyagoda Integrated Urban Development Project, which is already in progress in Peliyagoda area, the Project Road passes through the existing flyover on the railway leading to Ragama to connect with Kandy Road at a point near Dalugama.

   Described above is the Project B and the Project A (Expressway) described below takes over from this point.

4) With its starting point on Kandy Road near Dalugama and after crossing the railway twice at Horape and Ragama, the Project Road passes Ekala and after crossing over a bridge on Dandugam Oya runs along the eastern periphery of KIPZ to reach Colombo International Airport.

(2) General Land Use

A mixed land use pattern with primary residential areas, commercial areas and marsh areas prevails along Project B.

Between Peliyagoda to Ragama, primary residential areas, hillocks and paddy fields cover a major portion of the land and considerably large marshes are encountered near Ragama. Beyond Ragama area, the project road passes through the hillocks and marshes alternately and the plateau in the Ekala Industrial Development area before reaching the Colombo International Airport.

(3) Plans Related to This Project

The major projects relevant to this Project are listed below with a brief account of progress as of September 1983.

1) Plans Relevant to Project A

a. Negombo Urban Area – Road Improvements and Surface Drainage Project
Plans completed. Awaiting contract, implementation of a part of road improvement was done.

b. Negombo Urban Area – Slum Clearance
Upgrading and Rehabilitation Project: Planning stage.

c. Negombo Metropolitan Area – Katana New Town Project
Planning stage, awaiting release of funds.

d. Katunayake – Seeduwa New Town Housing and Commercial Complex
Planning stage, awaiting release of funds.

e. Seeduwa Regional Hospital
Concept

f. Seeduwa & Biyagama International School
Concept

g. Kadalkelle (Negombo West) Township
On-going

h. Katunayake Airport Expansion Project
Finance of contract, implementation

i. Negombo Metropolitan Area Water Supply Project
Concept, awaiting release of funds, plans completed.

j. Raddoluwa Housing Scheme
Completed.

k. Stratanwyk: Industrial Estate at Ekala – 2¼ acres. (opposite wireless station near Industrial Estate Ekala) light and medium industries – 19 blocks of 1 acre each.
Plans completed. Awaiting contract implementation.

l. Kadolkelle: (Seeduwa Township) Near Seeduwa junction fronting the lagoon – land reserved for tourist activities.
(Investors awaited) Awaiting release of funds, plans completed. .

2) Plans Relevant to Project B

a. Colombo Port Container Yard Construction Project:
Under construction

b. Bloemendhal Development Project:
Concept

c. Peliyagoda Integrated Development Project:
On-going

d. Railway Containerization Project:
On-going, a part of project (c)

e. Orgodawatta Food Stores Project:
Implementation

Out of the above, specially (b) and (c) are projects which are important in the route selection for Project B. Therefore in selecting the route sufficient attention was taken to co-ordinate with their planning.

5.3.2 Characteristics of the Project Road

The main objective of the Project Road is to smoothly connect the traffic strongholds of Colombo Port and Colombo International Airport which are also the main gateways of Sri Lanka with the GCEC Area of Authority and its surrounding region for the promotion of industry and economy and the smoothening and integration of communication and administration not only of the GCEC Area of Authority and its surrounding region but of the country as a whole.

As such, the project road is expected to possess the following characteristics.

1) This project road should be an industrial road designed to promote industry, agriculture, tourism etc., including KIPZ and the third IPZ in the economically highly potential GCEC Area of Authority neighbouring the Colombo Metropolitan Area.

2) With the traffic strongholds of Colombo Port and Colombo International Airport on its principal axis, the project road should be a fundamental transport mode that contributes to the promotion of import alternative and export industries and the growth of national economy by facilitating smooth flow of men and materials.

3) By smooth connection of the Colombo International Airport and the City of Colombo with the expressway, the project road should function as a road which promotes tourism and efficiency of administration and at the same time should serve as a road to improve the image of the country.

4) As a national trunk road which will play a role as a part of the North-South motorway in future, the project road will help to relieve traffic congestion when connected to an arterial by pass evading the congested areas of Colombo City and will

also serve as a development road which will promote the development of the belt east of Colombo city and extending southwards.

5) Especially in the case of Port Access Road by avoiding the containers and heavy trucks mixing with the ordinary traffic, the project road should contribute to relieve the intra-city traffic congestion in Colombo, to reduce traffic cost and traffic accidents, and to protect the environment of the residential and commercial areas from the public nuisances caused by heavy vehicles.

6) The project road should contribute to the convenience and comfort of travel, for example, by the introduction of Expressway Buses etc., when the commuting distances gradually increase in the future.

5.4 DESIGN STANDARDS

5.4.1 Road Design Standards

(1) General

Since the application of the Japanese Standards in this Project has been agreed between the Preliminary Survey Team and the GCEC on the Feasibility Study of this Project, road planning and design were done in accordance with these standards.

(2) Project A (Expressway)

1) Geometric Design of the Expressway

Design Standards of the project roads for design speeds between 60 km/hr to 100 km/hr can be summarized as in Table 5-1.

Since the minimum radius of curvature R used in this Project is R = 400 m (near the ending point at Colombo International Airport) and the maximum grade is 3.0%, this design can sufficiently meet a design speed of 100 km/hr.

2) Typical Cross Section

The typical cross section adopted in the Expressway is close to the type 1 Class 3 of the Japanese Standards for expressway design and has a carriageway width of 6.5 m in each direction consisting of 2 lanes of 3.25 m carriageway per lane. A shoulder width of 1.75 m is taken reserving 0.75 m for protective shoulder or as the width needed for the installation of road signs. Therefore, vehicles that need to stop in emergency can be accommodated along the shoulder side without hindering the through traffic. Width of the median is taken as 4.0 m. The vertical clearance is 5.0 m and the horizontal clearance is 8.75 m. (= 0.5 m clearance for the median + 6.50 m carriageway + 1.75 shoulder).

Approximately 1.7 km long section of the Expressway between KIPZ Interchange and the exit at the Airport is planned as a 2 way 2 lane road possessing a demian. This was planned so after considering the most economical number of lanes required for the future traffic demand (A.D.T. 13,300 vehicles/day in 2000) and the function of the approach road to the Airport as an approach ramp in the future when the Expressway is extended in Negombo East direction as the future North South Motorway.

The composition of Typical Cross Sections is shown in Fig. 5-3.

Table 5-1: Design Standard of Alignment

Design Speed (Km/h)	100	80	60
Radius of Curve (m)			
Desirable Minimum	700	400	200
Absolute Minimum	380	230	120
Minimum Curve Length (m)			
Desirable	1200/θ	1000/θ	700/θ
Minimum	170	140	100
Minimum Length of Transition Curve (m)	85	70	50
Minimum Radius to Omit Transition Curve (m)			
Desirable	3 000	2000	1000
Minimum	1 500	900	500
Maximum Grade (%)			
Desirable	3	4	5
Absolute Minimum	6	7	8
Minimum Vertical Curve Radius			
Crest (m)			
Desirable	10.000	4 500	2000
Absolute Minimum	6500	3 000	1400
Sag (m)			
Desirable	4500	3000	1500
Absolute Minimum	3000	2000	1000
Minimum Length of Vertical Curve (m)	85	70	50
Maximum Compound Grade (%)	10.0	10.5	10.5
Minimum Sight Distance			
Stopping Sight Distance(m)	160	110	75
Passing Sight Distance (m)			
Desirable	700	550	350
Minimum	500	350	250

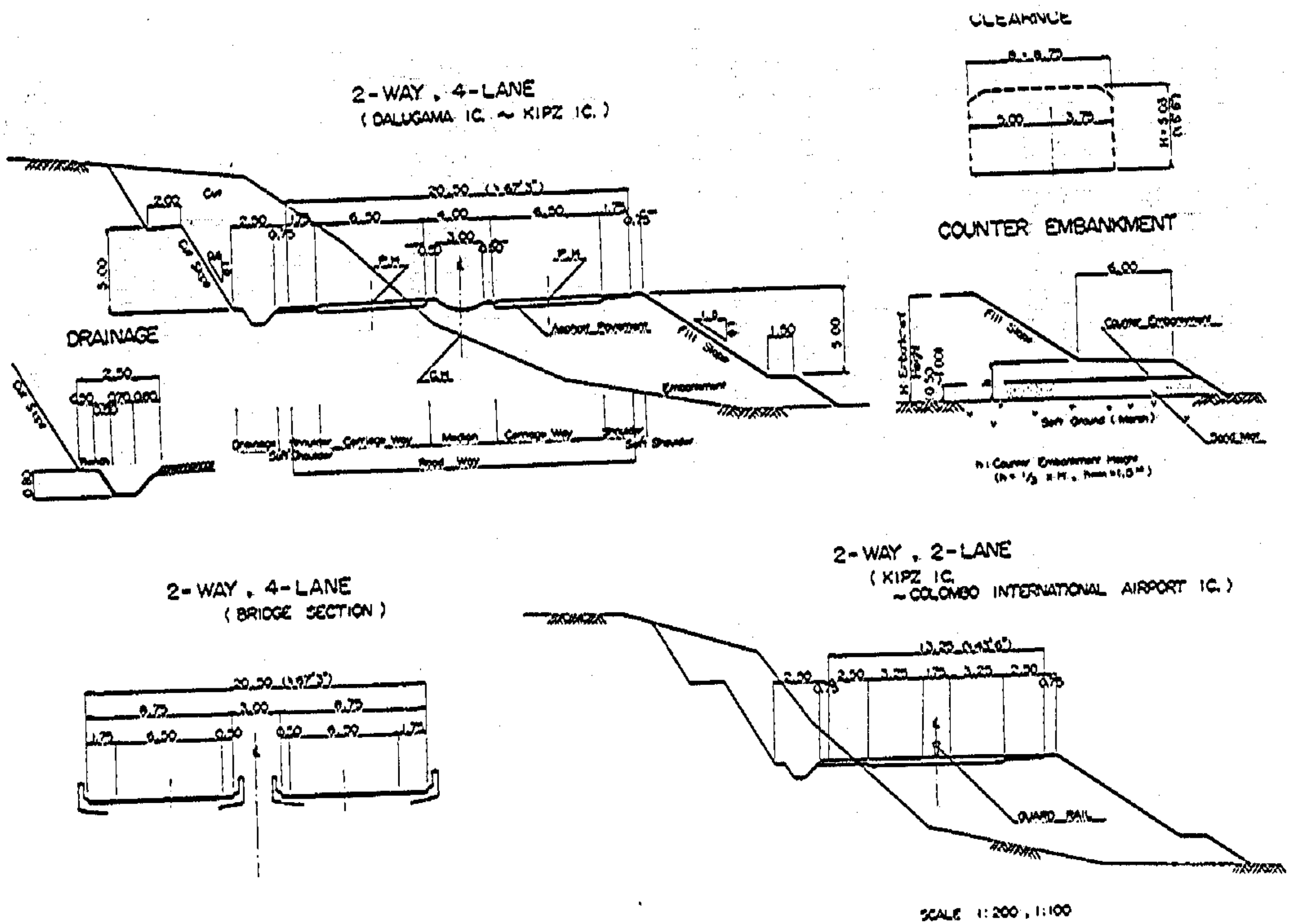


Fig. 5-3 Typical Cross Section of Expressway

(3) Project B

1) Geometric Design of the Road

This road has fundamentally the characteristics of an urban arterial road and at grade intersections are allowed at (6 ~ 8 places) the major crossings. Therefore the design speed is taken as 60 km/hr. However, in Section P-3 which connects with the Expressway the design speed was taken as 80 km/hr considering the function of this section as a speed transition section.

The minimum curvature adopted is R = 400 m where the design speed V = 80 km/hr and R = 150 m where V = 60 km/hr and the respective absolute minimums of R = 230 m, 120 m are satisfied.

2) Typical Cross Section

The width of carriageway was placed with 3.25 m x 2 = 6.50 m in each direction as in the case of the Expressway. The width of shoulder was taken in the range 0.50 m ~ 2.40 m depending on the roadside conditions and demand for parking, width of existing structures (e.g. Flyover across Railway) and the present width of road (in Section P-2) etc. With a 2.0 m wide Median (inclusive of the Marginal Strip) this road was planned as an urban road. The typical cross section is shown in Fig. 5-4.

5.4.2 Structure Design Standards

(1) General

The design standards used in this project are basically the Japanese Standards, but with modifications where necessary to suit the local conditions. However, local precast products already designed on the British Standards may also be used after studying their applicability based on the Japanese standards.

(2) Design Standards

Only the major items relevant to the project are given below:

1) Load

Dead Load	:	reinforced concrete	2.5 tf/m^3 = 156 lb/ft^3
		backfill material	1.9 tf/m^3 = 119 lb/ft^3
Live Load	:	TL-20, TT-43 Loading	

A comparison of the above loadings and HA loading in the British Standards is given in Appx. Fig. 9.

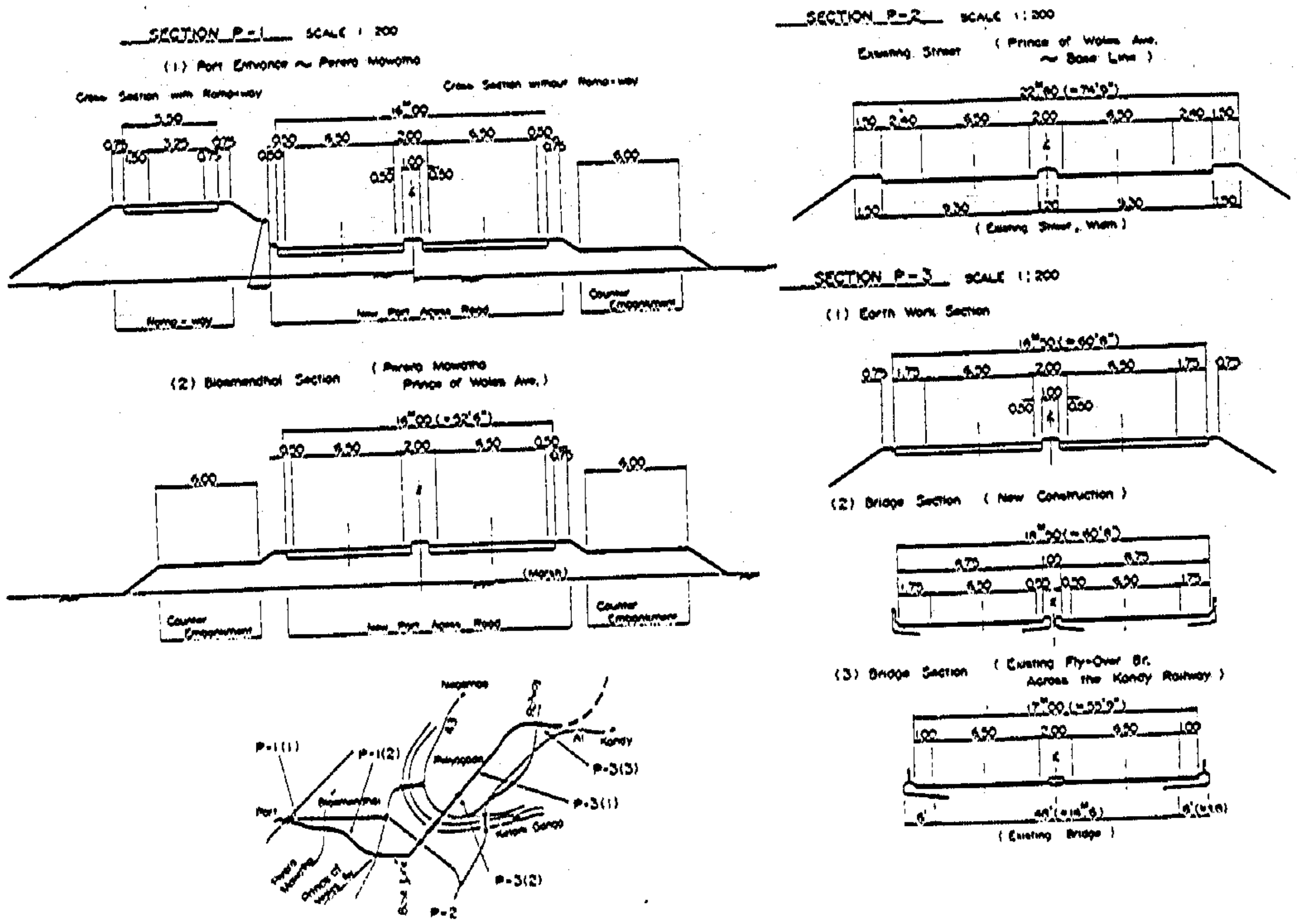


Fig. 5-4 Typical Cross Sectin of New Port Access Road

Earth Pressure = Coulomb's Formula

Seismic Load = Not considered. (Generally not considered in designs in Sri Lanka. Also according to the zone classification in the 'Indian Standard Criteria for Earthquake Resistance Design of Structures' consideration of seismic loads is judged not necessary. Sri Lanka falls in the Zone E which is the lowest zone classified).

2) Properties and permissible stress of materials

a. Concrete

Strength (kgf/cm²)	Permissible Compression Stress (kgf/cm²)	Maximum Size of Aggregates (mm)	Application
260	86.7	20	Precast reinforced concrete piles
210	70	25	Reinforced concrete
180	60	40	Gravity type of structures

b. Reinforcement

Material	Yield Stress (kgf/cm²)	Permissible Stress (kgf/cm²)	Equivalent BS Standards
SR 24	2,400	1,400	BS 4,449
SD 30	3,000	1,800	BS 4,461

3) Clearance

All criteria shown below have been adopted in Sri Lanka.

i) Existing road

- Vertical clearance:

  Road Classes A B C & D 16'6" = 5.03 m
  Others (Class E) 14' = 4.27 m

- Horizontal clearance:

  Class A : 1.2m (Sidewalk) + 6.5m (2 lanes) + 2.0 (Median) + 6.5 + 12m = 17.4m

  Class B : 1.2m (Sidewalk) + 6.5m (2 way 2 lanes) + 1.2 = 8.9m

  Class C
  D : 1.2m + 5.5m + 1.2m = 7.9m
  E

ii) Railway

The construction gauge of the railway is shown in Appx. Fig. 10. Future development plans are as follows:

- Colombo-Ragama : Present 2 track to be increased to 4 tracks with one new track on either side of existing tracks
- Ragama-Negombo : Present single track to be converted to a double track with the new track on the west side of the existing track.

4) Free Board

in heavy log debris areas	1.5m
in other areas	1.0m

5) Road Width (on bridges)

Four alternative cross sections are proposed as shown in Table 5-2.

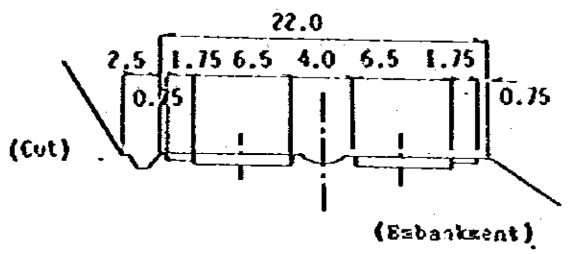
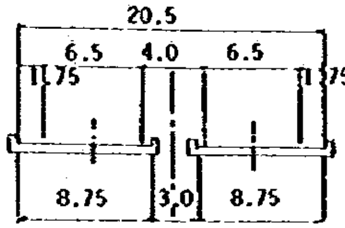
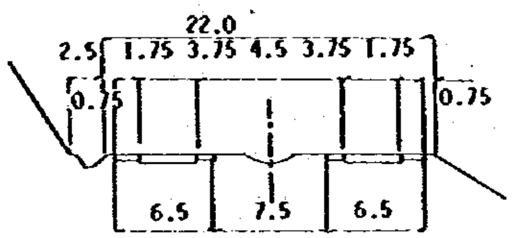
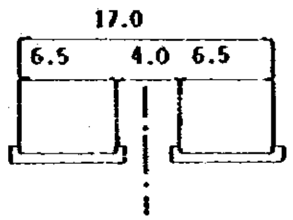
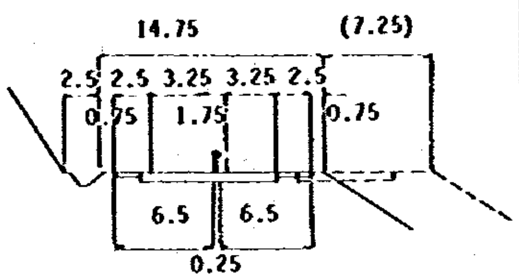
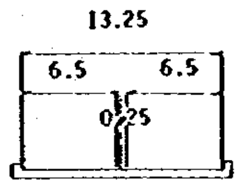
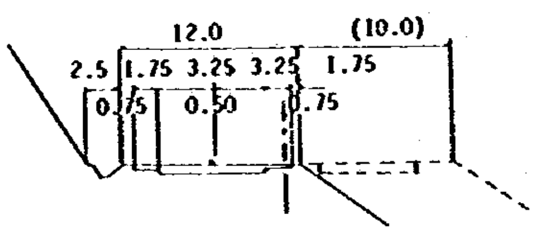
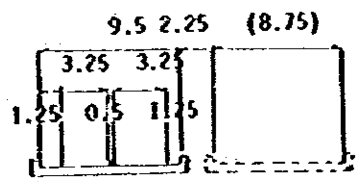
5.4.3 Pavement Design Standards

(1) General

If a Macadam type base course is adopted in the pavement structure of the Expressway, its construction must be executed mainly by manual labour and difficulties will arise in controlling the construction schedule. Therefore, in the design of pavement, it was decided to use, the "Manual for Design and Construction of Asphalt pavement – 1980" of the Japan Road Association as a manual applicable to mechanized construction of pavement.

Table 5-2: Comparison of Cross Section

Note (*-1) Final Phase = 100
(*-2) Full Control of Access
(*-3) Partial Control of Access

		CROSS SECTION: EARTH WORK SECTION (UNIT M)	CROSS SECTION: BRIDGE SECTION (UNIT M)	Economy (Construction Cost)	Travelling Performance (Comfort & Safety)	Ease of Construction (Expansion works)	Total Evaluation	Evaluation
FINAL PHASE (2-Way, 4-Lane)	4			Ratio of Unit Construction Quantities (*-1) (M3/M) 100 / (M2/M) 100 / (M2/M) 100	Possible Capacity (Vehicles/Day) Approx. 56,000 (*-2)		Most desirable type for the expressway; but construction cost is high	
DIVIDED ROAD (2-Way, 2-Lane)	2-A			Earthwork 100 / Pavement 58 / Bridge 74 *Cost of earthwork is almost the same as for completing the 4 lanes. *Initial saving in paving cost is remarkable.	Approx. 25,000 (*-3) *Safety and comfort of travelling can be sufficiently maintained	*Future expansion to 4 lanes is easy. *Narrow width of bridges will remain as it is.	*Safety and comfort of travelling can be maintained by complete separation of carriageways. Overtaking or passing of vehicles stopped on emergencies can be done using part of the shoulder. *Future construction of 4 lanes is easy since earthwork is completed. *Initial investment is larger compared to (2-C)	
	2-B			Earthwork 80 / Pavement 69 / Bridge 76 * Construction cost is about the same as (2-A)	Approx. 22,000 (*-3) *Comfort of travelling is less than in (2-A)	*Future expansion to 4 lanes is difficult. *Narrow width of bridges will remain as it is.	*Safety of travelling is maintained (by separation of carriageways with the installation of guard rails along center-line). *Overtaking is possible as in (2-A) *Initial investment is about the same as in (2-A) but face a lot of problems at the time of expanding to 4 lanes.	
UNDIVIDED ROAD (2-Way, 2-Lane)	2-C			Earthwork 72 / Pavement 54 / Bridge 54 *Initial investment of construction cost is about 70% at the minimum.	Approx. 16,000 (*-3) *Since overtaking should be done by crossing the center-line the danger of head on collisions is extremely high.	*Future expansion to 4 lanes is easy.	*Since undivided, safety of travelling cannot be maintained and from this sense, cannot be called an expressway. * An alternative plan to minimise construction cost.	

(2) Design Standards

The design standards of pavement structure in Sri Lanka were generally based on the following:

TRRL (Transport and Road Research Laboratory) standards of UK:

Category 1 – stage construction of macadam road by experienced method, upto 100 of heavy vehicles per day.

Category 2 – pavement design by *Road Note 31 of TRRL*, 'A guide to the structural design of bitumen surface roads in tropical and sub-tropical countries'. Average of 100 ~ 1500 heavy vehicles per day are applicable.

Category 3 – pavement design by Road *Note 29 of TRRL*, 'A guide to the structural design of pavement for new road', applicable for over 1,500 of heavy vehicles per day.

The above standard pavement structure is for the Macadam base course and rolled asphalt surface course.

On the other hand, JICA Study Team will, in this study, propose the standard method of Japan Road Association from the view point that it is more widely applicable to the number of heavy vehicles per day which is forecasted to be more than 1,500 per day in one direction in the case of project roads.

However, with the aim of providing a better understanding of the Japanese standards, the basic concepts are compared between AASHTO and Japanese Standards in Table 5-3, since the basic concept of TRRL has been brought from AASHTO Interim Guide.

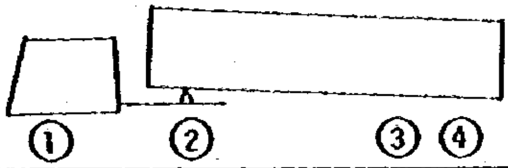
(3) Consideration of Special Container Loads

The design loads for pavement structure shall be decided considering the special container loads such as in the range of 20 ton ~ 40 ton. Data on the distribution of wheel load were obtained, through the SLPA, from the detail design report of 'Colombo Port Expansion Project' as follows:

Table 5-3: Pavement Design Concept Comparison Table

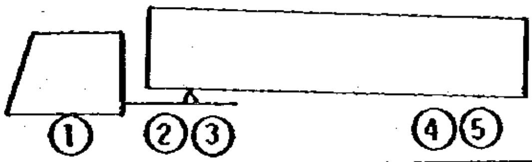
Item	AASHTO & TRRL	Japan Road Association
Denominator of Traffic	18-Kip (8,200 kg.) single-axle loads	5 ton wheel load
Classification of Pavement	Serviceability Index Pt:2.0 & 2.5	L.A.B.C.D. based on Number of Heavy Traffic
Soil Support Value	Emphirical soil support scale (from 1 to 10) of road bed	4 days soaked CBR value of subgrade
Term to represent thickness of pavement	Structural number (SN)	Thickness of Asphalt (TA)
Layer coefficient		
Asphaltic concrete surface	0.44	1.00
Crushed stone base course	0.14	0.35
Sandy gravel sub-base course	0.11	0.25
Recommended pavement types		
Surface course	Road Note 31 : Single layer Bituminous dressing Road Note 29 : Rolled asphalt 20 mm - 40 mm	Plantmixed Asphalt concrete more than 50 mm
Base course	Road Note 31 : Crushed gravel or rock 150 mm Road Note 29 : Rolled asphalt or dense bitumen macadam 60 mm	Asphalt treated crushed gravel or crushed rock
Sub base course	Road Note 31 : Naturally occurring gravel or gravel sand clay CBR more than 30	Crusherrun sand CBR more than 30

1) For 20 ton containers



Classification	1	2	3	4	
With Empty Containers	1.8	1.4	0.68	0.68	t/wheel
With Laden Containers	1.85	5.05	3.83	3.83	

2) For 40 ton containers



Classification	1	2	3	4	5	
With Empty Containers	1.57	0.56	0.56	0.76	0.76	t/wheel
With Laden Containers	2.14	2.97	2.97	5.90	5.90	

5.5 STUDY OF ALTERNATIVE ROUTES

5.5.1 Policy on Route Location

In selecting the route for the Project Road it is very important to make clear the basic policy towards the selection of a route which enables to achieve the objectives of this project rationally and smoothly and to decide on the most appropriate route after a comprehensive evaluation of the results of studies and decisions made from the view points of economic, technical and financial aspects and environmental consideration.

The basic policy towards the route selection is described below:

1) The optimum route is selected for a road that not only smoothly connects the strategic points of traffic such as Colombo Port, Colombo International Airport etc., but also promotes proper and efficient development of the GCEC area and the neighboring areas, fully taking into consideration of the correlation of future North South motorway.

2) This Project Road is a so called expressway and its characteristics differ from those of an ordinary road. Considering the necessities to smoothen the through traffic flow and to promote the development of so far undeveloped areas as a result of the introduction of this project, care is taken to avoid the built up areas as far as possible.

   Further, in order to avoid community separation by the project road and to eliminate ill effects due to inundation etc., bridges and other suitable structures are provided appropriately where necessary for vehicle crossing, pedestrian crossing, drainage and flood relief etc. -

3) The most economical route with the minimal social problems is selected taking into account of the factors such as earth balance, problems like the division of residential and agricultural lands etc.

4) With the aim of putting the marshes and other presently unutilized lands, where ground conditions are not bad, into effective use, a route which can utilize such lands for the benefit of project road and relevant facilities is selected taking sufficient consideration of the conditions of the region.

5) For this project to display its effects fully, a route which help to create an appropriate road network inclusive of the project road itself is selected considering the relationship between the Project Road and the existing roads, especially the connection with feeder roads and the relation of Negombo Road.

5.5.2 Proposed Route Alternatives

(1) Project A (Colombo-Katunayake Expressway, Length = 25.4 km)

At the first stage, following four alternatives were considered –

Alternative A – based on the original route proposed by GCEC the stretch from Kiribathgoda to Ragama was modified from a conceptual route to a practical route. This route passes through a comparatively narrow corridor already built up and occupied by existing Negombo Road and the Railway. Partition of developed towns by the expressway is inevitable.

Alternative B – after passing the same route as Alternative A from Kiribathgoda to Ja-Ela, this route joins with the route in Alternatives C & D at Ekala. This route was proposed considering the possibilities of stage-wise construction and to avoid passing through the built up Ja-Ela Town.

Alternative C – this route is basically the same as Alternative D but includes a future plan for extensions up to Negombo in the north and up to Kelani River in the south.

Alternative D – from Kiribathgoda to Ragama this follows the same route as Alternative A, but from Ragama to Katunayake IPZ it passes through the under-populated area near the east boundary of GCEC Area.

Alternative B is not attractive from the point of view that, in a stage-wise construction, this modern expressway shall be constructed starting from near the International Airport as a state symbol of a fast developing country, where as, in an effort to ease traffic congestion on A-3 Road south of Ja-Ela, the priority should be given to the construction of road section south of Ja-Ela.

In Alternative C, the extensions beyond Katunayake and Kiribathgoda are judged to be too early for consideration, for one reason, it is beyond the scope of this Project and these extensions can be done without much difficulty in future if planning is properly done at this stage to accommodate them.

Accordingly, alternatives A and D shown in Fig. 5-5 were studied in further detail and are compared in Table 5-4.

Alternative D was finally selected as the most suitable route considering its role as a part of the future North-South Motorway from the view point of future regional development effect, construction cost and other comprehensive aspects.

On the presumption that an Expressway is chosen for Project A we recommend Alternative D for the following advantages and disadvantages of the two Alternatives A & D.

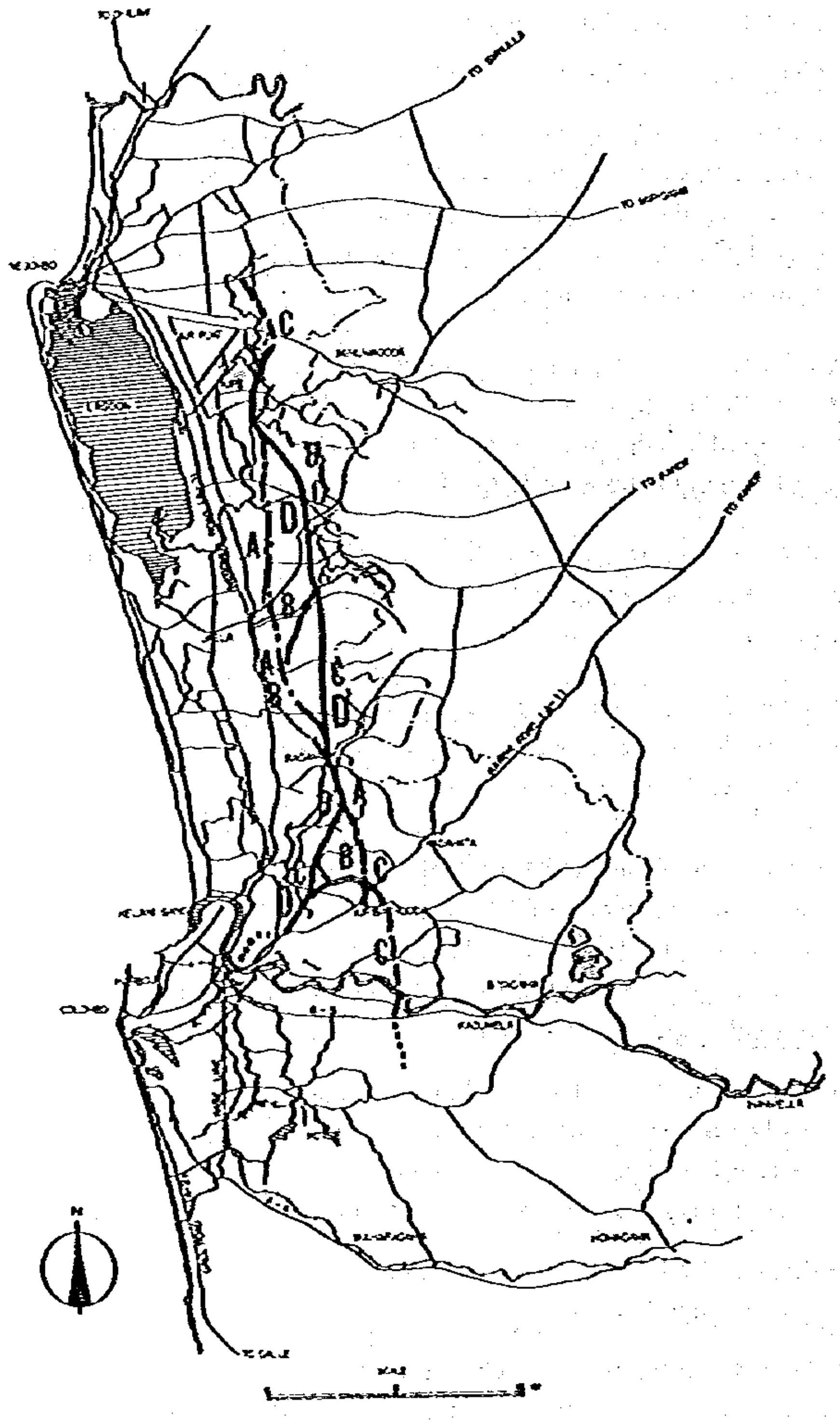
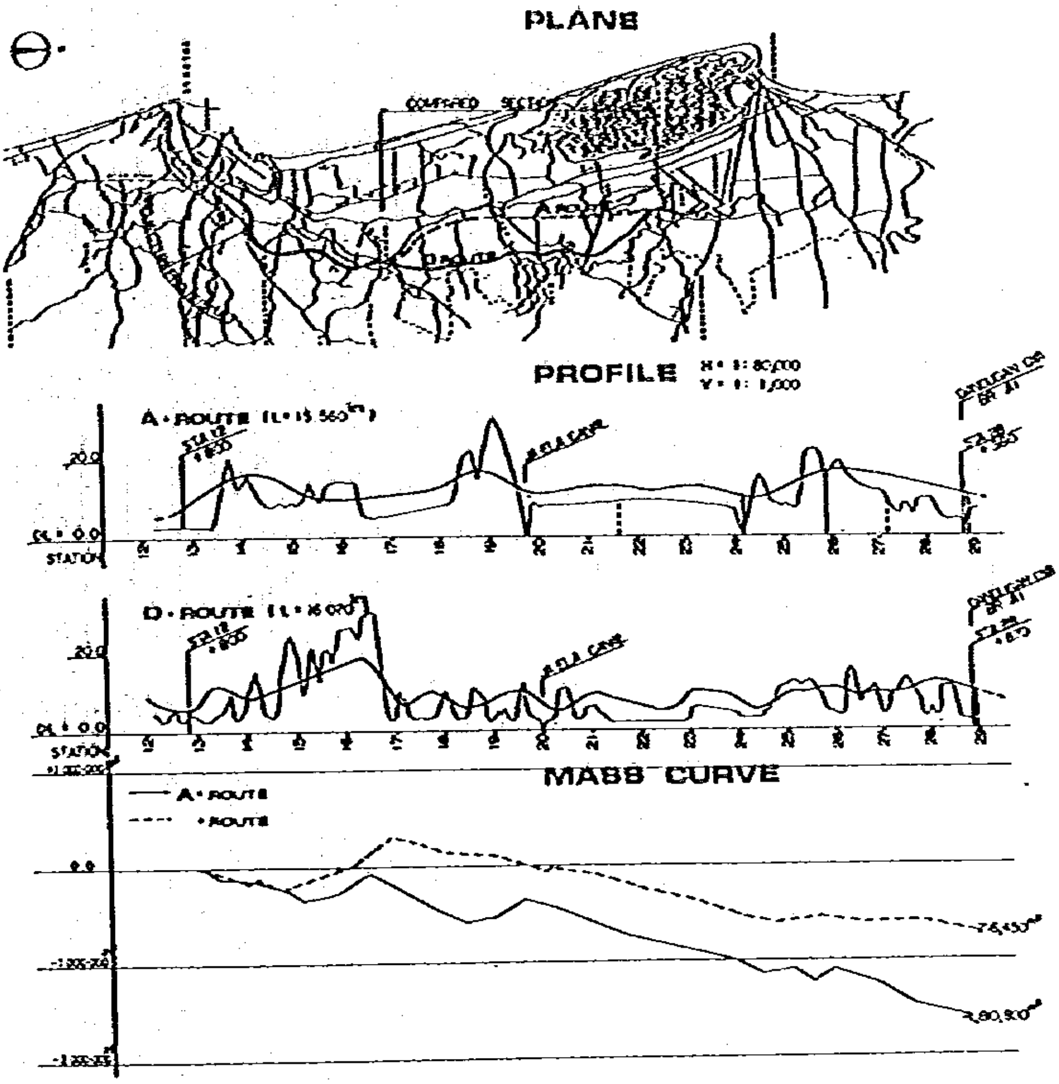


Fig. 5-5 Project A Route Alternatives

Table 5-4: Comparison of A-Route & D-Route (under 4-Lane)



(Unit: 10^3 Rs)

ITEM	A - ROUTE	D - ROUTE	REMARK
① EARTH WORK	237,766	137,166	
② PAVING WORK	183,194	166,777	
③ MISCELLANEOUS WORK	38,044	32,779	
④ BRIDGE	55,168	47,715	
⑤ CONSTRUCTION COST	459,172	384,437	①+②+③+④
⑥ LAND ACQUISITION	139,469	85,782	
⑦ CONTINGENCY	94,296	70,333	(⑤+⑥) x 15%
⑧ ENGINEERING FEE etc.	45,917	38,444	⑤ x 10%
TOTAL COST	771,854	579,196	⑤+⑥+⑦+⑧

Table 5-5: Reasons for the Selection of Alternative D

ALTERNATIVE A	ALTERNATIVE D
• Buildings and other facilities are already densely built up along alternative Route A than on Route D and the possibilities of future expansion of development are therefore low. • Traffic nuisances due to noise and exhaust gases will affect these dwellings and other facilities. Precautional measures of environmental protection will be costly. • When partial access control is adopted, function of the proposed road as an expressway will be hindered considerably due to the frequent crossings at heavily built up areas. • In contrast to Alternative D, there is a comparatively large number of problems due to high costs of acquisition and compensation in the areas densely built up with houses and other facilities, or where relocation of facilities may become bottleneck in the progress of project implementation. It may be mentioned here that relocation of houses and other facilities in the residential area had been once done from end of 1974 to middle of 1976 for road widening and a repitition of such action is considered difficult. • Crossings are mainly grade separations and require high embankment. Rough cost of construction is higher than that of Route D (Refer to Alternative D). • From the angle of accessibility, circumstances are as same as in Route D since factories and other facilities situated along Route A become freely inaccessible due to access control. • The area surrounded by Route A and Dandugam Oya becomes isolated and the effective use of land will be hindered. Further, since this route runs parallel to the railway, effective use of the land enclosed by the railway and route A will be hampered due to isolation. • 60 m x 9 km land area is planned as the right of way of road west of Ekala. Acquisition of land is not made at all so far and it remains at planning stage. Therefore, at the feasibilty study state it is not desirable to have a feeling as if the route is entirely decided. • It is more desirable to use Route A as an internal road (approach road or service road for industries and other facilities) upon the materialization of Route D as an expressway. • Since Routes A and A-3 (Colombo - Negombo) Road are too close to each other, their areas of influence overlap and as a result, development potentialities will lie low.	• When partial access control is adopted, all the arterial roads crossing the expressway will have free access and the people living in the surrounding areas get the privilege to use the expressway. • Since the selected route runs through the inland, earthworks of cut and embankment balance well and also the transport distance becomes short. The cost of construction is lower than that of Route A. Construction cost of Route A : Rs. 772 million Route D : Rs. 579 million Ratio of construction cost (D/A) : 0.75 The above cost is the construction cost of Routes A and D respectively for the stretch between their bifucation near Ragama and the point where they meet again near Dandugam Oya. • Since there is a higher possibility for land use development than in the case of Route A, development will first begin near the interchanges and on and off ramps and gradually spread to the surrounding areas with the construction of access roads. • Hilly lands around the interchanges will be converted into flat lands with the aim of multipurpose usage of flat lands including the securing of earth volume for filling purposes. As a result, development of industrial complexes and housing complexes etc., will be enhanced and it will be possible to put the idling lands into better use. • Since Route D passes mainly through the under/undeveloped rural areas, the impact of pollution due to noise and exhause gases etc., will be low and suitable environmental protection measures can be taken with less cost. • Route D can be made also to function as the 'North-South Motorway' which is merely a concept at this stage but aimed at the linking of North and South regions by passing the heavily congested Colombo City. By extending upto Negombo from the terminal at Colombo International Airport, e.g. by improving the existing roads, and upto Kotte from the southern terminal at Kiribathgoda by crossing Kelani Ganga, this Expressway could be made to substitute the North South Motorway. It is needless to say that selection of Alternative D for the Expressway which has higher possibilities of materialisation is more desirable than depending on the conceptual North South Motorway. (Please see Fig. 5-8). Relationship between the Proposed Expressway and the North South Motorway). • Route D will have a direct impact on Gampaha District not only in the fields of food production, plantation industry and agricultural development, but also in housing development as a residential area for people commuting to Colombo or the IPZs. Higher future potentiality for development can be expected by employing a lateral street construction between existing A-3 Road and the new Expressway to form the 'Stepladder' network, which will benefit not only the Industrial Areas but also the underpopulated areas in the boundary of GCEC Area. Further, when considering the aim of 'Stepladder' System of Roads mentioned in the Scheme Plan for the GCEC by UN Consultants in August 1980, being too close to each other, the two roads will lose their function as the 'Spines'.

(2) Project B – (Port Access Road (p-1) + (p-2) + (p-3), Length = 5.7 km)

Following four alternative routes were considered – (See Fig. 5-6)

Alternative A – This is the route originally proposed mainly from the view point of minimizing construction cost. This route is proposed to utilize the railway track through Bloemendhal and existing roads leading to existing New Kelani Bridge.

Alternative B – This route runs along the railway across Bloemendhal marsh and crosses Kelani River over a new bridge that will replace the existing Victoria Bridge, which is already overcongested.

Alternative C – This route passes through Bloemendhal marsh in compliance with the development plans and runs along the existing road from Prince of Wales Avenue to Baseline Road and thereafter crossing Kelani River at a point about 2.5 km upstream of New Kelani Bridge. This route is proposed with a wider view to resolve the traffic problems also in the east of Colombo using a shorter by-pass to Kotte Administration Area.

Alternative D – This route is proposed to accommodate all existing schemes planned by the UDA. It is the same route as Alternative C upto the Baseline Road.

After investigating briefly on the durability, Victoria Bridge was judged to be structurally stable except for some minor parts which need repairs and maintenance, so that Alternative B was withdrawn.

Alternative C which is considered an excellent route in contributing to traffic distribution in Kotte Area, however, is not recommendable exclusively as a port access road.

Therefore, the remaining alternatives A and D were studied in detail. Alternative D was strongly supported by the UDA and was adapted as the most suitable route.

5.5.3 Considering of North-South Motorway

According to the road network plan of UDA and GCEC the concept is to build the network structure as a 'Stepladder' system along the developed west coast corridor. Negombo Road (A3) passing through the already built up urban area along the coast line is one axle and the other axle is planned towards inland parallel to this road. This second

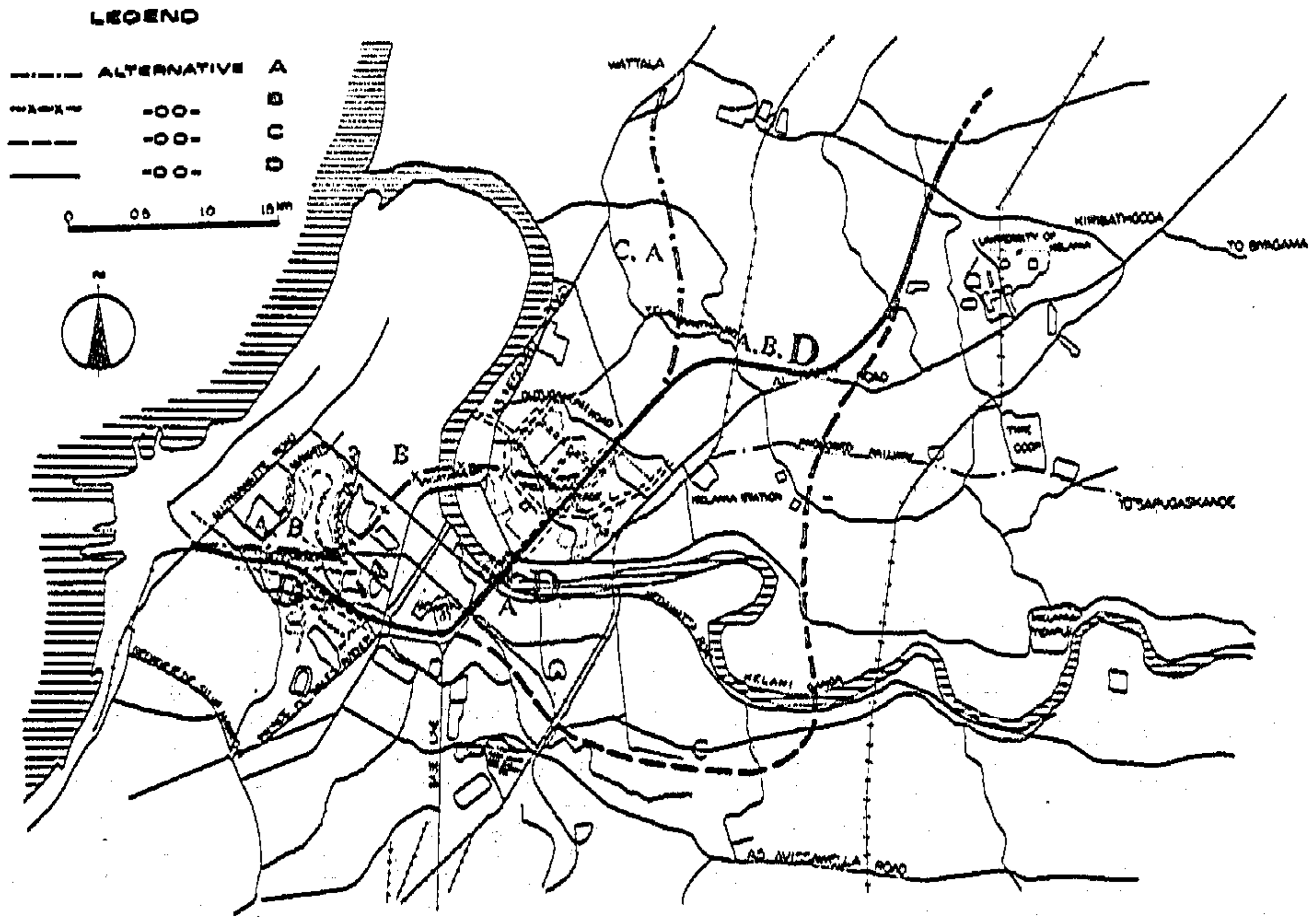


Fig. 5-6 Project B Route Alternatives

axle seems to be the 'North-South Motorway' planned by the UDA or the Colombo-Katunayake Expressway of the present study. (See Fig. 5-8)

A series of existing east-west routes crossing these axles will make the 'Steps' in a grid pattern.

The route of second axle should be best located at the eastward fringe of residential zone in the future urbanized land use, so that it will avoid cutting through the residential areas and stop urbanization expanding from the coastal area towards inland thereby protecting the agricultural land use areas developing east side of this route.

The North-South Motorway is planned not only for the Colombo-Metropolitan Region but for the nation as a whole. Whereas the Colombo-Katunayake Expressway has the specific function of linking the two regions of Colombo and Katunayake. However, it can be considered that Colombo-Katunayake Expressway should be able to incorporate that portion of North-South Motorway within the GCEC Area. In short, it is needless to construct two main motorways parallel and close to each other in the CMR even in the future.

5.5.4 Relationship between the Proposed Expressway and the North-South Motorway

(1) Forward

In the selection of route for the proposed expressway, it is a matter of course that due consideration shall be given to the existing road network and the future road development plans. The relation of North-South Motorway with the proposed expressway project which we consider needs clarification is discussed here. (See Fig. 5-7)

(2) North-South Motorway

1) North-South Motorway which is conceptually planned on the east side of proposed expressway is a road identified or recognized to be included in the long term plan after year 2000, which will contribute to the smooth flow of vehicles in North-South direction by avoiding traffic congestion within Colombo City.

2) So far this North-South Motorway remains merely a concept and the exact location, road structure (standard cross section, geometrical structure etc.) and the nature of road are still not made clear except for its conceptual trace towards the eastern periphery of GCEC Area.

3) There is hardly any regional centers or Urban Areas Centers along this North-South Motorway and the Motorway is not identified even as a road which should promote industrial and economic development of the region by connecting the 'nuclei' in the outskirts with each other.

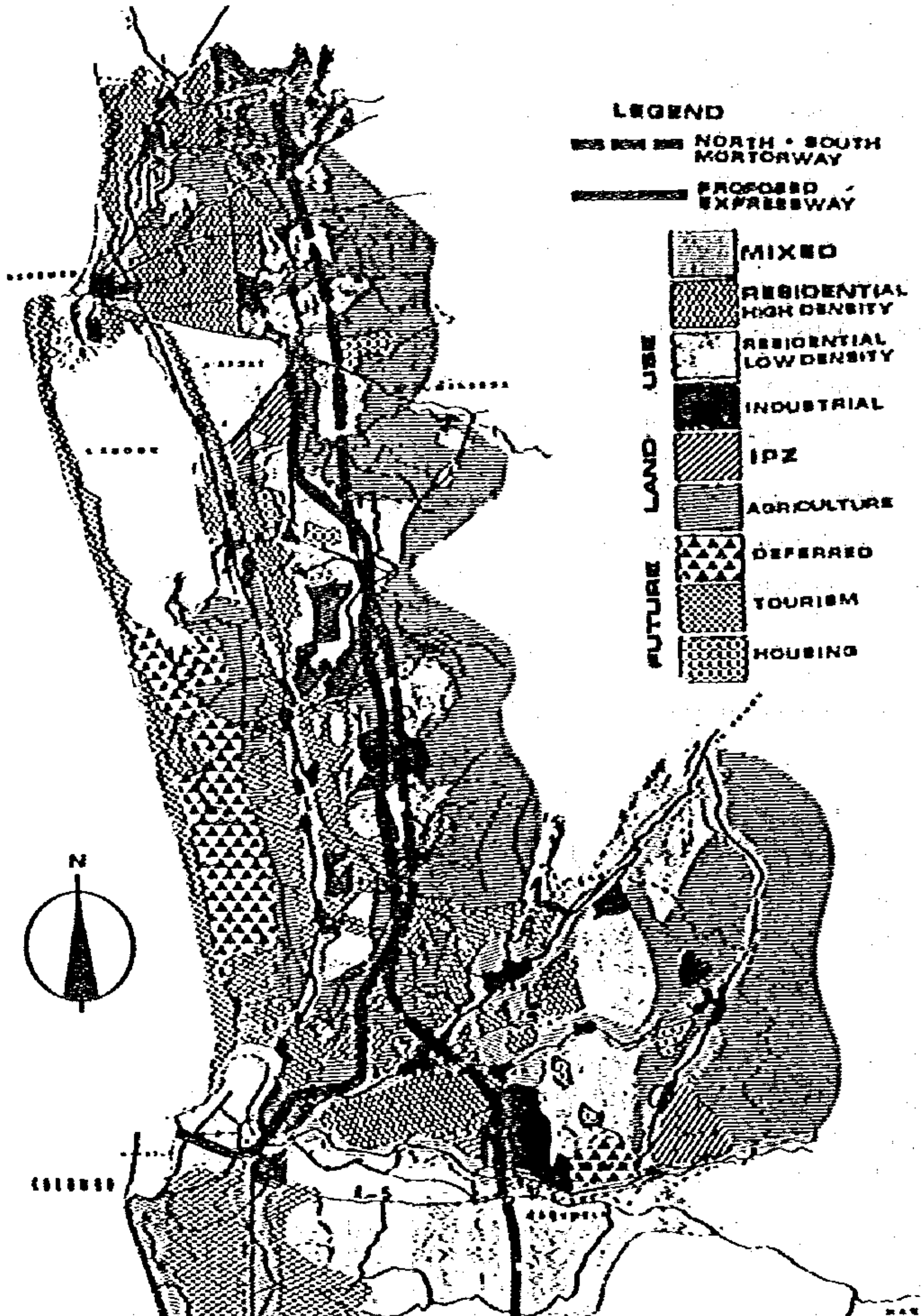


Fig. 5-7 Relationship between the Proposed Expressway and the North-South Motorway

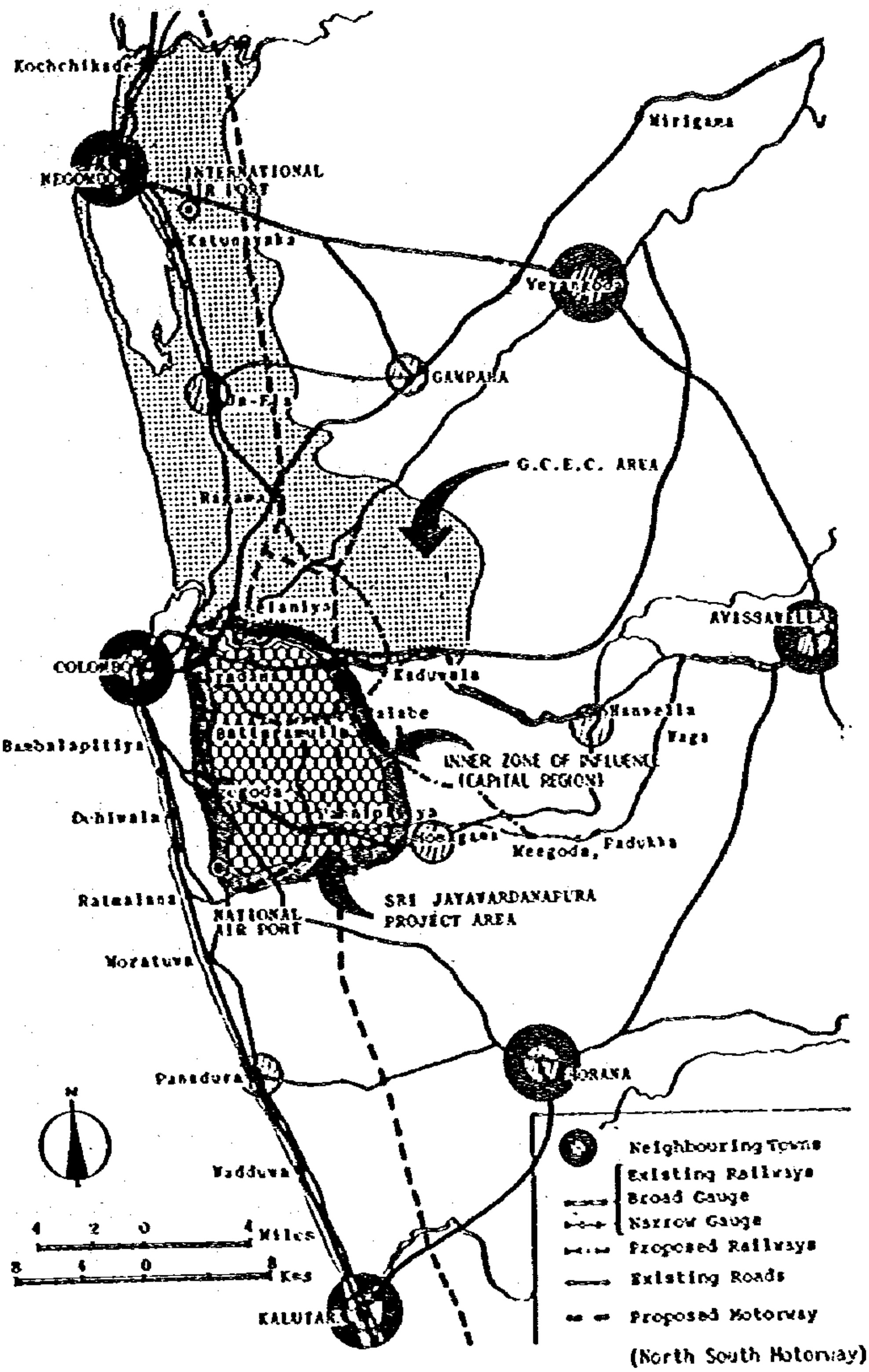


Fig. 5-8 Concept Plan of North-South Motorway

4) GCEC also has the intention of bringing the proposed expressway to function as a North-South Motorway in future by considering the possibility of extending it. On the otherhand, since the North-South Motorway is identified by the UDA as a road to be included in the long term plan after year 2000 and remains a concept only at the moment, it is almost impossible or therefore considered not necessary to coordinate with the UDA on the relationship of this motorway with this project.

5.5.5 Role of North-South Motorway in the Route Selection of Proposed Expressway

1) As clear from above, North-South Motorway is only a concept for the present and it is questionable to decide on route location of the proposed expressway taking into account of North-South Motorway of which the location, nature and the possibilities of implementation are still not clearly ascertained. From the point of road planning we clearly understand the necessity to include North-South Motorway among the pre-requisites in the route selection of proposed expressway. However, from a more realistic view point where a more efficient road has to be materialised within an extremely limited road construction budget, North-South Motorway is no longer a decisive factor in the route selection for the proposed expressway.

2) When considering the circumstances under which the request was made to study this project, the main objectives of the project are to smoothen the transport of passengers and goods, promote the growth of investment promotion zones, smoothen tourist traffic, materialize a vestibular road which functionally connects Colombo International Airport and Colombo City and to relieve existing A3 road from traffic congestion by constructing a road with its main axis connecting the traffic origins of Colombo Port and Colombo International Airport which are the Gateways to the country. Accordingly, Colombo International Airport and Colombo Port are the terminals of this project and therefore, only the intermediate area between the starting point and the ending point is left for route selection. One may consider the possibility of shifting the route of proposed expressway towards east so as to serve as the North-South Motorway. But in this case, since the road which has predetermined starting and ending points should take a longer 'arc' shape path making it inconvenient for traffic and also involving high construction costs, shifting of route to the east cannot be considered as an advisable measure.

3) At present, urbanization is gradually spreading outwards from the Colombo Metropolitan Area, while the progress of urbanization is being controlled to some extent as it moves towards the inland areas from the coastal area where urbanization takes place along a North-South belt. Leaving aside the roads for the development of underdeveloped areas, usually the development of road network is done accordingly with the progress of urbanization. Therefore, the first step should be to plan a road through the study area where land use plans such as the development plans for IPZ, housing complexes are more clear and certain than in the inland area and then to proceed with the future planning of North-South Motorway, which is only a concept so far, considering the characteristics, location and standards etc., of the proposed expressway as pre-requisites in planning.

4) Even if the North-South Motorway is extended towards North beyond Katunayake, there is no suitable ending point in the North and just extending it makes no sense. The Northern end of proposed expressway is Colombo International Airport and if it is necessary to extend the expressway so as to play the role of a North-South Motorway, it is recommendable to extend upto Negombo in the North and close to Kotte connecting to A2 road in the South. However, it is desirable that planning of such extension be carefully studied after the planning of the proposed expressway taking into account of the transport network in the Greater Colombo Area.

5.5.6 Screening of Alternative Route

Based on the basic policy of route selection discussed in 5.5.1, the advantages and disadvantages of each alternative were discussed in 5.5.2 with respect to 4 alternatives A, B, C & D for Project A and 4 alternatives A, B, C & D also for Project B.

Specially, the reasons for the selection of Alternative D for the Expressway are given in Table 5-5.

Further, the relationship between the Expressway and the North-South Motorway and the role of this Motorway on the route selection of the Expressway are discussed in 5.5.3 ~ 5.5.5.

After careful study and evaluation as discussed above, Alternative D was selected for Project A and Alternative D again, through road sections (P-1) – (P-2) – (P-3) was selected for Project B.

5.6 STUDY OF ALTERNATIVE TYPES

5.6.1 General

Since alternatives can be considered not only with respect to the routes, but also, with respect to the number of interchanges or on or off ramps to be provided, the vertical alignment, for example, whether a high embankment or a low embankment to be used, their advantages and disadvantages and the characteristics will be carefully compared from various aspects and we hope to recommend the optimum proposal after the final evaluation.

5.6.2 Study of Alternative Types

(1) Full Control of Access and Partial Control of Access

Full and Partial Control of Access as defined in 'the Highway Capacity Manual' or in the Text 'The Highway Engineering' are as follows:

Expressway – Divided arterial highway for through traffic with full or partial control of access and generally with grade separation at major intersections, where, *Full Control of Access* means that the authority of control of access is exercised to give preference to through traffic by providing access connections with selected public roads only and by prohibiting crossings at grade or direct private driveway connections and, *Partial Control of Access* means that the authority to control access is exercised to give preference to through traffic to a degree that in addition to access connections with selected public roads, there may be some crossing at grade and some private driveway connections.

Since the application of Partial Control of Access in this project, allowing at-grade intersections as in the above definition, is not desirable for the reasons given below, alternatives are proposed basically for a fully access controlled Expressway with several accesses through interchanges or On-Off ramps.

1) On the Partial Control of Access

a. The existing Negombo Road (A3 Road) has the characteristics of a Community Road and the construction of a partially access controlled road, which allows at-grade intersections and has similar characteristics, parallel to Negombo Road will be a duplication of investment for the same purpose and moreover it is not desirable from the effectiveness of this project as an expressway intended to smoothly facilitate the major traffic origins of Colombo International Airport, Colombo Port, KIPZ and Colombo City in order to maintain comfort of travel and reduction of travel time.

b. In Sri Lanka where an expressway is to be introduced for the first time, the drivers need sufficient time to gain experience in high speed travelling on the expressway and moreover, allowing at-grade crossings against high speed traffic flow in the 80 km/h ~ 100 km/h range could be disastrous as serious traffic accidents can occur at these at-grade intersections by the passage of men, cattle etc. and intermittent crossing of vehicles.

For these reasons, a partially access controlled road is not desirable, however much it is going to be convenient for the people of the region.

2) Alternatives for Full Control of Access

For the reason discussed above, a fully access controlled road is considered here for which the following alternative plans are proposed.

a. Plan A. An Expressway with all the intersections fully grade-separated along its total length of about 25.4 km, and provided with Diamond Type interchanges at 3 locations namely: Weweldurwa IC, Ragama IC and Ekala IC, a partial Interchange (only an on-off ramp) to connect with the KIPZ and the entrance and exit facilities at Kandy Road and Colombo International Airport. (See Fig. 5-9)..

b. Plan B. This again is an expressway with all the intersections fully grade separated, but provided with 6 Partial Interchanges in addition to those in Plan A. 2 of them located between Dalugama IC and Ragama IC, 3 of them between Ragama IC and Ekala IC and the remaining one between Ekala IC and the partial interchange at KIPZ. (See Fig. 5-9).

i) Characteristics of Plan A

This alternative gives priority to the through traffic and the vehicles have access only at the 3 interchanges and the 3 entrance and exit facilities. Therefore, it is convenient for the relatively long distance traffic such as from the Colombo International Airport to the city, but on the other hand, since there is no access to the expressway from some of the feeder roads which are presently bus routes, the people of the region will find it difficult to use the expressway.

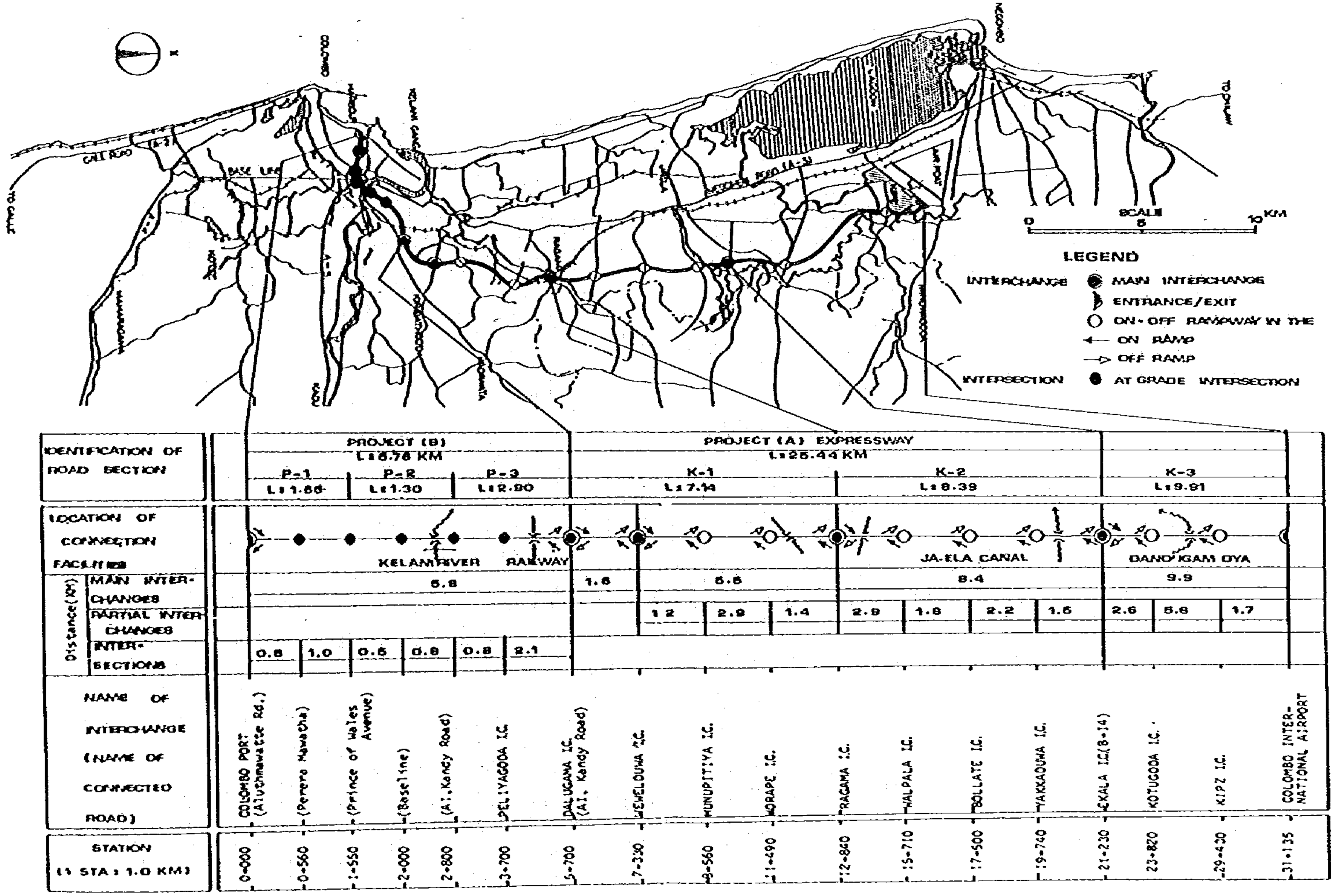


Fig. 5-9 Location of Interchange and Service Level

ii) Characteristics of Plan B

Since there are 6 additional on-off ramps compared to Plan A, the travelling comfort and travelling speed of long tripped through traffic will tend to drop somewhat near the entry ramps as attention need to be paid on the vehicles entering. However, the expressway becomes more convenient to the people who use the feeder roads and moreover, development in the GCEC area of authority becomes easy with the formation of a 'Stepladder System' of road network with the Expressway and Negombo Road as the two spines.

iii) Comparison of Plan A and Plan B

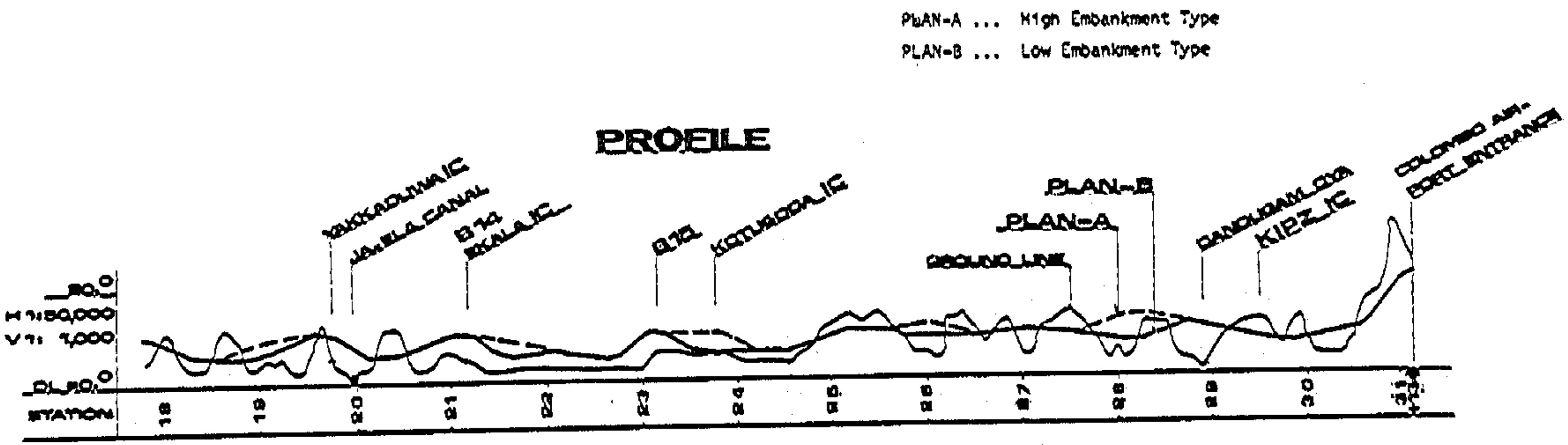
When comparing Plan A with Plan B, Plan B is considered more desirable for the reasons given below. (See Fig. 5-10).

a) In order to satisfy the two objectives of contributing to a through traffic and promoting development in the GCEC Area parallely and simultaneously, Plan B which allows access from the Feeder Roads is desirable.

b) The Feeder Roads in the Project Area are not well developed and take long winding routes with barely sufficient road width for two buses to pass each other and some of them are unpaved and often undergo inundation during floods. If the major feeder roads are not given access to the expressway, the traffic generated or attracted around these feeder roads will inevitably have to take a relatively long detouring routes to reach the main interchanges such as at Ragama, Ekala, or even if the traffic is generated or attracted close to the Expressway such traffic will be forced to use the Negombo Road. In this case although the Expressway brings in benefits for the through traffic, it can only yield negative benefits to the traffic which must take detours in using the interchanges.

   Therefore, it is necessary to select the type of access to the Expressway from the point of view of national economy so that the total benefit as the difference between 'With Expressway' and 'Without Expressway' reaches the maximum. Judging from the present undeveloped status of feeder roads around the Expressway, specially of those running in north-south direction, Plan B is expected to yeild enhanced benefits.

c) With the present undeveloped condition of the feeder roads, Plan A will make it difficult for development to take place beyond the areas adjacent to the interchanges thus creating a concentrated pattern of development. Therefore, Plan B is desirable in order to promote a



(Cost: million Rs.)

Item	Unit	PLAN-A High Embankment Type		PLAN-B Low Embankment Type		Cost Ratio B/A
		Quantity	Cost	Quantity	Cost	
Earth Work						
Cutting and Filling	M^3	923,000		985,000		
Borrow Filling	M^3	678,000	110.9	281,000	88.1	0.79
Others	LS	1	38.7	1	36.1	0.98
Sub Total			149.6		124.2	0.83
Paving Work	LS	1	122.4	1	124.3	1.00
Miscellaneous Work	LS	1	44.3	1	55.3	1.25
Bridge Work	LS	1	86.3	1	86.1	1.00
Construction Total			402.6		389.9	0.97

Note : Quantity and Cost are estimated in Section K-2 and K-3.

Fig. 5-10 Comparison between Plan A and Plan B sprawling development in the areas surrounding the Expressway.

d) With the future expansion of Colombo Metropolitan Area, industrial, commercial and residential areas are expected to be gradually developed within the GCEC area and as a result of this, travel between these areas and Colombo City for work, schooling and business etc. is expected to increase. What is important here is the efficient operation of buses, which are the common mode of mass transportation. The buses which now use the winding feeder roads with bad road surface conditions will be able to transport smoothly a large number of passengers by the efficient operation of Expressway Buses once the expressway is opened. Therefore also from the stand of passenger transport, Plan B which has comparatively better capacity for the operation of Expressway Buses is desirable.

e) For a long distance expressway, for example, one exceeding 300 km, it is desirable to have through traffic priority type on-off ramps and interchanges placed at long intervals. But in the present Expressway which is merely 25.4 km in total length, its total effectiveness cannot be improved by trying to reduce travel time and neglecting the convenience of the people of the region to use the Expressway. Therefore, Plan B which offers local inhabitants the convenience to use the Expressway and leaves lesser possibilities for the occurrance of social problems is desirable.

(2) Alternatives for Section P-3

1) General

Along the Section P-3, part of the Peliyagoda Integrated Development Project is now being implemented by the UDA. Existing in this section are 4 structures, namely a flyover structure situated immediately north of New Kelani Bridge, 2 box culverts along Section P-3, and a flyover structure at the intersection of railway leading to Ragama, constructed by the DOH 15 years ago and left unused since then.

The route of the project road is selected exactly along the line extended through these structures. Whether to adopt a High Embankment Type road which utilizes these existing structures or a Low Embankment Type road which necessitates their demolition for this section is a matter which require careful judgement.

Therefore, the optimum alternative will be selected here after careful comparative study of the two alternatives taking into consideration of the intentions of the relevant authorities.

2) High Embankment Type P-3(H)

This alternative, as shown in Fig. 5-11, proposes for a road with grade separated intersections on an embankment with a maximum height of about 8.0 m along a stretch of about 1.5 km utilizing the existing structures.

When this High Embankment Type alternative is adopted, it becomes necessary to widen the New Kelani Bridge at its right bank end by an area of about 46.7 m x 3 m in order to accommodate the entry and exit ramps. Further in order to allow the flow of traffic from New Kelani Bridge to Kandy direction and from Victoria Bridge and Wattala to Kandy direction under this high embankment, it will be necessary to construct a new structure north of the existing structure. (See Fig. 5-12)

3) Low Embankment Type P-3 (L)

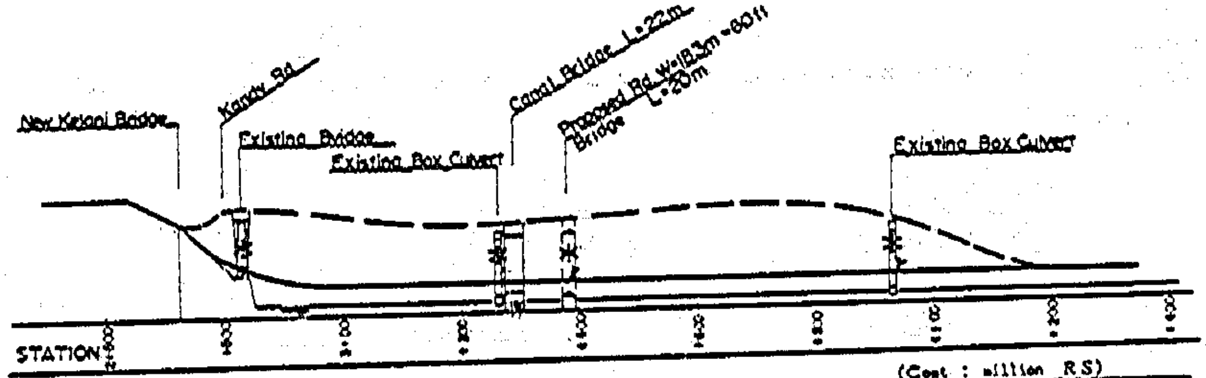
This alternative, as shown in Fig. 5-11, proposes for the demolition of the existing structures and to traverse the Peliyagoda Marsh over a low embankment with a height of 1.5 m or 3.5 m. In this alternative, the intersection at the right bank end of New Kelani Bridge will be an at grade intersection and the only new structure here will be a grade intersection for the main road in Peliyagoda Integrated Development Project, to cross the Project Road.

The existing flyover structure over the Colombo-Ragama Railway will be utilized in both the above alternatives.

4) Comparison of High Embankment Type and Low Embankment Type

a. The cost of construction, excluding pavement works, of the approximately 1.5 km long stretch in Peliyagoda is Rs. 184 million (cost of high embankment and widening of New Kelani Bridge) in the case of High Embankment Type and is 1.7 times high when compared with the cost of Rs. 110 million (cost of low embankment + flyover) in the case of Low Embankment Type showing a difference in cost of about Rs. 74 million. Therefore High Embankment Type is not desirable from the point of view of economic evaluation as well as in saving construction cost.

b. Along the route of this project road, Peliyagoda and Bloemendhal are areas where problems arise due to marshes. Out of them, marsh in Peliyagoda is extremely weak consisting of soft organic soils with N values around 2 extending up to depths of 12.0 m or 14.0 m. It is generally understood that these peaty layers often undergo settlements exceeding one third their thickness even under moderate fill loads. Therefore in the case of a fairly high embankment large volumes of earth will be necessary to compensate not only for the



(Cost : million RS)

ITEM	Unit	PLAN-A (High Embankment Type) Quantity	PLAN-A Cost	PLAN-B (Low Embankment Type) Quantity	PLAN-B Cost	Cost Ratio (B/A)
Earth Work						
Borrow Filling	m³	360,000	28.4	38,000	6.9	0.24
Soft Ground Work	Ls	1	28.8	1	17.1	0.59
Others	Ls	1	7.1	1	7.1	1.00
Sub Total		-	64.3	-	31.1	0.48
Paving Work	Ls	1	20.0	1	20.0	1.00
Miscellaneous Work	Ls	1	13.1	1	14.0	1.07
Bridge Work						
Highway Bridge	Ls	1	9.6	1	3.9	0.61
Over Bridge	Ls	1	-	1		
Others	Ls	1	1.7 ※1	1	1.2 ※2	0.71
Sub Total		-	11.3	-	7.1	0.63
Construction Cost			184.3		110.4	0.60

※1 Widening of New Kelani Bridge
※2 Demolish Work of The Existing Structures

Fig. 5-11 Peliyagoda Section

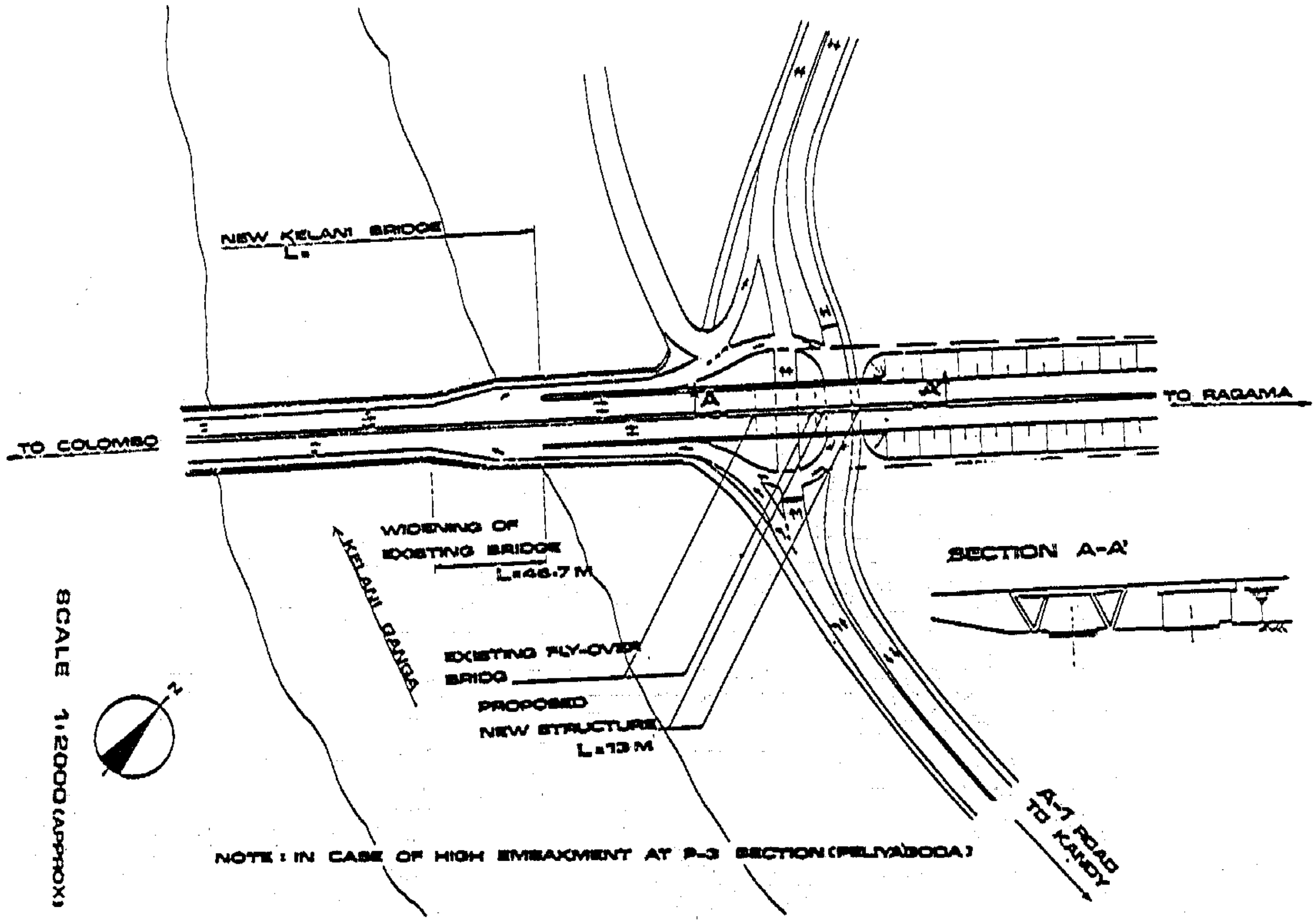


Fig. 5-12 Plan of Grade Separation at A-1 Road

heavy settlement directly under the embankment, but also for the lateral flow. Moreover, it may take several decades for the stabilization of road embankment due to prolonged ground settlement and therefore the High Embankment Type poses problems from the view points of both economy and road maintenance.

c. In the case of High Embankment Type, it is necessary to widen the New Kelani Bridge on the right bank side at two places on upstream and downstream sides by 46.7 m x 3 m area to accommodate the entry and exit ramps. This work not only require additional cost of Rs. 1.7 million approximately but will cause traffic congestion due to obstructions to traffic during construction. Since this is a strategic point of traffic in the Colombo Metropolitan Area, traffic congestion here may lead to a social problem if the construction work takes a long period.

d. Since the existing structures are to be used in the High Embankment Type, a new structure will be required adjacent to the existing structure and the combination of old and new structures is not clear-cut from the aspects of structural planning.

   Further, since the visibility will be obstructed by the structures at the intersection, vehicles will be forced to suddenly cross the opposite lane from a lane with poor visibility, and this coupled with the complex flow of traffic at this point, will cause hindrance to the smooth flow of traffic making it undesirable from the point of traffic engineering.

e. The grade intersection at the right bank end of New Kelani Bridge will be effective in its own way in giving priority to the through traffic. However, when the capacity of at-grade intersections becomes insufficient with the future increase in traffic demand, this single grade intersection will not be effective any more in maintaining smooth flow of traffic in future unless the other intersections en route such as at Baseline Road, Prince of Wales Avenue etc., are also grade separated in continuation.

f. By complete grade separation in Section P-3 with a high embankment it is possible to attain high speeds of 80 km/hr or 100 km/hr common to expressways. But since the vehicles used to high speeds on the expressways will have to suddenly slow down at New Kelani Bridge, there will be high possibilities for the occurrance of traffic accidents due to this sudden slow down of speed coupled with the traffic entering from the ordinary roads at this point.

In any case it is desirable to have a transition section when connecting the expressway with the ordinary roads in order to adjust the travelling speed. Therefore it is necessary to make Section P-3 play the role of a transition section by allowing at-grade intersections partly in this road section.

g. The curb to curb width of the existing structures vary between 40'(12.2 m) to 60'(18.3 m) whereas the width required for the 4 lanes is 8.75 m x 2 = 17.5 m at the structures and 18.5 m without curbs at the embankment. Therefore, in the case of utilizing the existing structures it will be necessary to widen them. But the widening of existing flyover structure over the railway require lateral prestressing of the existing girders which is difficult.

   Therefore, if the use of this structure with the present width of 14.5 m becomes inevitable, it is feared that the smooth flow of traffic at this strategic point in Peliyagoda will be hindered.

h. The location of the existing Box Culverts does not conform with the road network planned under the Peliyagoda Integrated Urban Development Project. If these box culverts are to be utilized in the project road, it will be necessary to make adjustments in the above road network and to construct new bridges to cross the canal. As such the utilizing of existing structures cannot be considered necessarily beneficial as its merits could be far exceeded by the demerits owing to the problems such as, increase in expenditure, lack of conformity with existing plans.

i. When the Low Embankment Type is adopted, although grade intersections in Peliyagoda Area becomes a problem this can be solved by the construction of over-bridges etc., where necessary, with the gradual implementation of Peliyagoda Integrated Development Project or by providing at-grade intersections as the alternative depending on the circumstances.

   Details of these alternatives will anyhow be studied at the Stage of Detailed Engineering.

j. It is feared that the demolition of existing structures which were constructed 15 years ago would lead to social and political problems. The Survey Team wishes to keep the social and political judgements regarding this problem beyond their responsibilities. However, the Survey Team recommends the Low Embankment Type from the engineering and economic points of view.

   Nevertheless, it is desirable that the judgement whether to demolish the existing structure or not be made only after a careful study including the social and political aspects.

5.7 PRELIMINARY DESIGN

5.7.1 General

The preliminary design of the Project Road was started with site reconnaissance and collection of data. With the use of the 1:10,000 scale photo map, several alternatives for each type were basically selected. With the aid of 1:10,000 scale contour map, the quantities and rough costs for each alternative were also estimated and compared. Using this map, horizontal and vertical alignments were studied in more detail and a favourable route was recommended. Longitudinal and cross-section survey of the recommended route was made to upgrade the accuracy.

The procedure for preliminary design, indicating the maps used, and the contents and results of study is shown in the flow chart of Fig. 5-13.

5.7.2 Alignment

(1) Horizontal Alignment

The horizontal alignment was selected on the photo map (scale 1:10,000) for several alternatives and the most favourable one was studied using the photo contour map (scale 1:10,000) to determine a more detailed alignment.

Special attention was given to the following items in designing the horizontal alignment:

1) General items

a. The Radius Curvature, a main factor in the horizontal alignment, was set to satisfy the standard values for each design speed (V = 100 km/h for Project A, V = 60 ~ 80 km/h for Project B) selected for the project roads.

b. In order to assure comfortability of driving along a harmonious and smooth alignment, Clothoid Curves were used in the transition sections.

c. The alignment was determined in such a way to minimize the distance through which the Project roads have to pass through marshy areas.

d. To minimize the inconveniences to the people in the area by division of communities and blocking of access to schools, places of worship and public facilities are avoided as far as possible.

2) Adjustment with existing development plans

To adjust fully with existing development plans, confirmations were done when necessary with the Local Government Agencies regarding the progress of the plans concerned and the position of the route alignment.

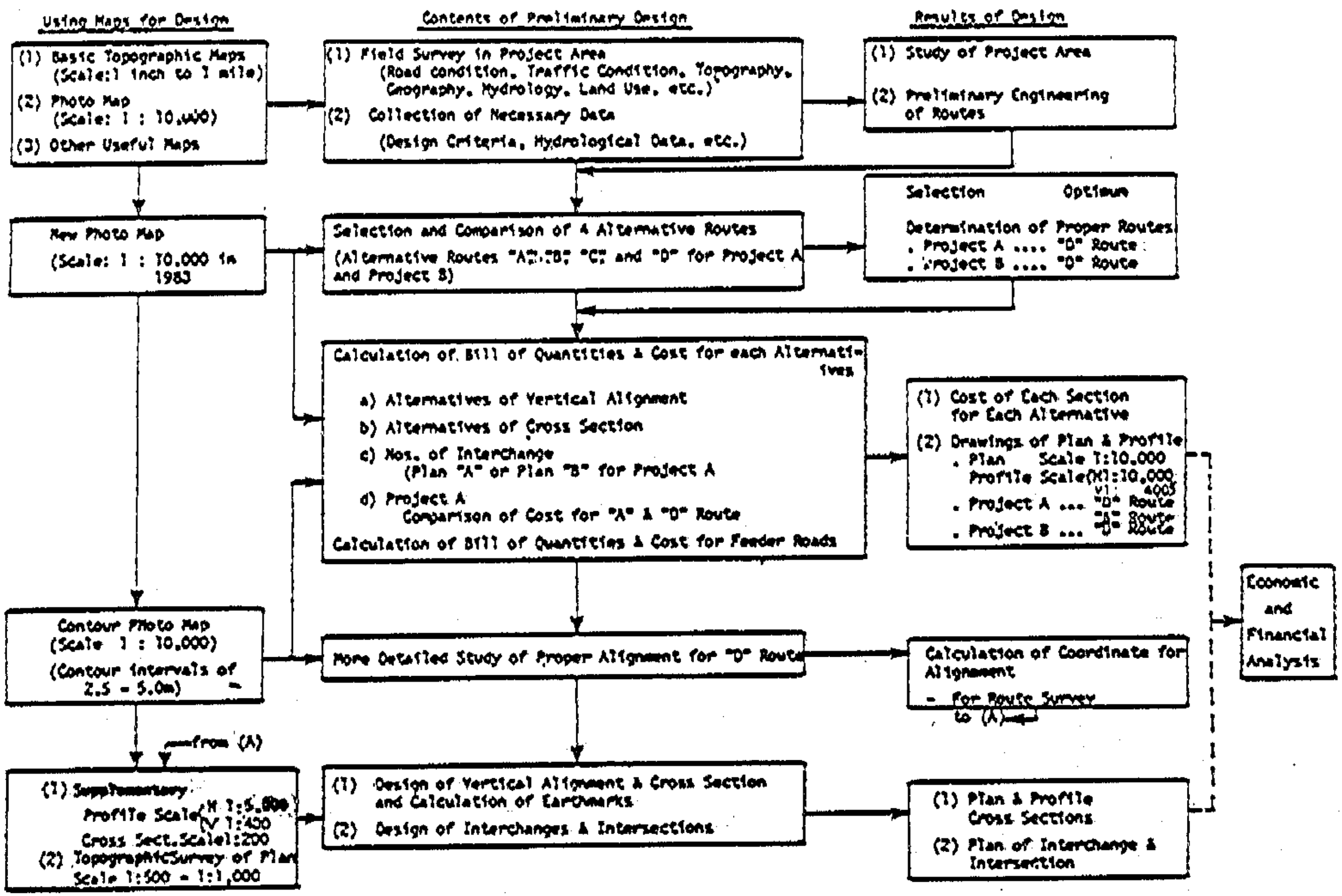


Fig. 5-13 Flow Chart of Preliminary Design of Road

a. Colombo Port Entrance (Beginning point of Project B Road)
Adjustments were made with the intra-port road plan.

b. Bloemendhal Development Project (See Appx. Fig. 11)
Adjustments were made with the street lines of planned trunk road.

c. Peliyagoda Integrated Urban Development Project (Phase I) (See Appx. Fig. 11)
Adjustments were made with the street lines of the planned trunk road.

d. Existing Structure (Flyover across the Colombo-Ragama Railway)
Direction and position of bridge was adjusted.

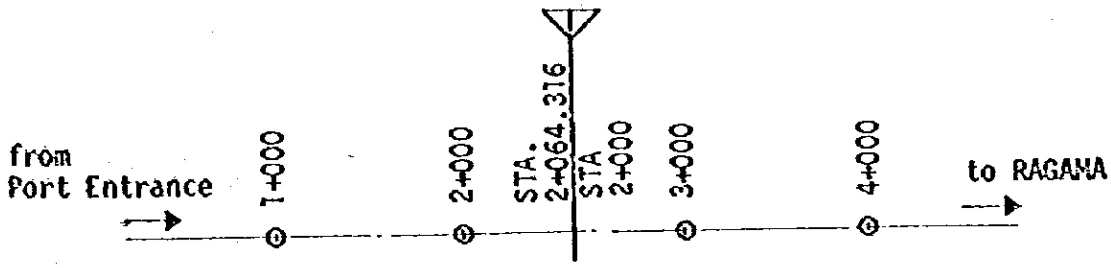
e. KIPZ (Phase III)
The areas where construction is already in progress is avoided.

3) Supplementary items

a. The interval between two consecutive stations along the road is taken as 1 km (= 0.62 mile).

b. Coordinate calculation of the recommended horizontal alignment was done using the electronic computer.

c. As the stations along route beyond Baseline Road Junction is renumbered starting with Station 2 + 000 m, there is a lap of 64.313 m.



L = + 64.313M

d. The alignment of centre line was set in more detail through coordinate calculations and concrete pegs were anchored in the field at about 200 m intervals along the recommended route.

However, it is very important to note that this centre line was studied on a plan of a scale only 1:10,000 and therefore, later in the detailed design stage, corrections are recommended to determine the best alignment through more detailed surveys and maps.

(2) Vertical Alignment

The vertical alignment was planned using a photo contour map (scale 1:10,000), and its accuracy was improved by using the results of longitudinal surveys conducted along the recommended route.

Special attention is given to the following items in designing the vertical alignments:

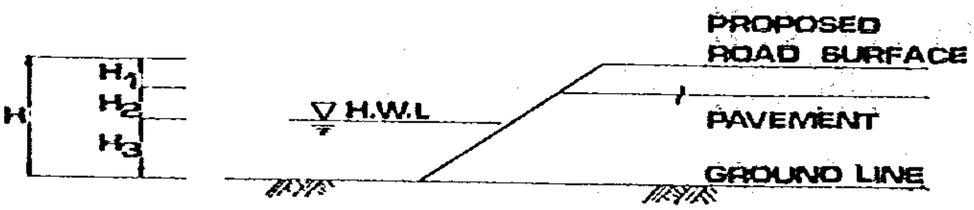
a. The maximum gradient which greatly affects the driveability of vehicles in general and especially of heavy vehicles, is taken at I = 3% for Project A and I = 4% for Project B.

b. Due to problems in road drainage, the minimum slope is taken as I = 0.3%. For that section of road passing through the continuous flat marshes of Bloemendhal and Peliyagoda in the Project B area, I = 0.25% is applied. However, where existing roads are used in Project B, the design adopts the present gradient of the existing road.

c. The minimum vertical clearance as adopted is 5.03 m (=6'6")

d. The structural clearance of the railway for the two crossings of the railway (Colombo-Ragama Line and Ragama-Negombo Line) will conform with the present standards. (See Appx. Fig. 10)

e. The minimum embankment height in the flood prone areas, is taken over 2.5 m ~ 2.8 m taking into account of the Highest Water Level (HWL) experienced in the past. (See Fig. 5-14)



H_1 = 0.8 m (Pavement, Slope of Surface)

H_2 = 0.5 m (Clearance)

H_3 = 1.2 ~ 1.5 m (Depth of inundation)

Total H = $(H_1 + H_2 + H_3)$ = 2.5 ~ 2.8 m

Fig. 5-14 The Minimum Embankment Height in the Flood Prone Areas

f. At crossings with rivers and canals, a free board is provided. The clearance under the bridges for medium and small rivers/canals is 1.00 m and 1.50 m for large rivers/canals (Ja-Ela Canal, Dandugam Oya).

g. Extremely deep earth cutting presents problems in construction and slope protection. Therefore, the height of major earth cutting at Ragama North is kept below 15 m (with 3 berms).

5.7.3 Cross Section

The components of cross section, with respect to width is explained among the items in Chapter 5.4.1. The basic thinking in the selection of cross section and other related items are briefly discussed here. (See Fig. 5-3 and Fig. 5-4)

(1) General (Components of cross section)

1) Basic planning policy

Japanese Road Standards are basically used in determining the components of cross section, but in the actual design, present traffic conditions in Sri Lanka are taken into consideration also aiming at the economization of the road construction.

2) Width of carriageway

3.25 m is alloted to each lane. There are many examples of expressways with 3.50 m or even 3.75 m wide lanes in Japan and some other countries. However, taking into consideration of economy and lane width of existing A-Class roads in Sri Lanka, a lane width of 3.25 m is used in this Project. The design capacity in this case is 56,000 vehicles/day, which is sufficient to satisfy the projected future traffic volume.

3) Shoulder width

a. Project A (Expressway)
A width of 1.75 m is provided for the left side shoulder of the entire expressway. This width is not necessarily adequate for emergency parking, but light vehicles will still have 2 lanes to pass even when a heavy vehicle is parked.

b. Project B
Left side shoulders of Section P-3 which connected with Project A (Expressway), is taken as 1.75 m, the same as in the Expressway. The left side shoulders of Section P-1 is reduced to 0.50 m.

4) Median

In Project A (Expressway) the median strip is set at 3.00 meters, which is sufficient for planting trees, and 0.50 m marginal strips are provided on each side of the median strip.

The standard median strip of width 1.00 m used for urban roads is provided in Project B and guard rails or fences are erected along this strip. Marginal strips of width 0.50 m are also provided on each side of the median.

(2) Cross Section Type

1) Gradient of cut slopes

The gradient of cutting is set at 1:0.6. This was concluded after considering the characteristics of laterite, and especially the conditions of existing roads (actually the gradient of cutting of many local roads is much steeper than 1:0.6, e.g. New Biyagama Road is constructed at 1:0.5).

2) Drainage in cut sections

To lower the costs, open ditches are used for drainage in the cut sections. To prevent errosion, the ditches are lined with concrete. This method is adopted from local design practice considering easy maintenance.

3) Gradient of embankment slopes

The gradient of embankment slopes is set at 1:1.5. There are no high embankments in this Project and this gradient is considered sufficient.

4) Berms

Berms for both cutting and embankment are provided at 5.0 m intervals of height. The width of berm in embankments is 1.50 m and 2.00 m for cutting.

5) Counter embankment method

The counter embankment method is actively used on soft soil. This provides not only stability of the embankment but since it can be used also as a service road in the future, the width of the counter embankment is taken as 6.00 m.

(3) Comparison of Cross Section

There are 4 main types of cross section alternatives in Project A (Expressway). The 4 types are called (4), (2A), (2B), (2C) and details of the cross section components and characteristics are shown on Table 5-2. Alternative (4) is recommended in this project.

1) Alternative (4) – Divided 2 way 4 lane
This is a favourable type for an expressway, and is recommended in this study.

2) Alternative (2-A) – Divided 2 way 2 lane
In the first stage, only one lane in each direction is paved to minimize initial investment.

3) Alternative (2-B) – Divided 2 way lane.
This section is designed to further cut down the initial investment than in the Alternative (2-A) by using a narrower embankment cross section. However, expansion into 4 lanes in future will be extremely difficult.

4) Alternative (2-C) – Undivided 2 way 2 lane
This alternative section requires the lowest initial investment of all the alternatives, but there is a large danger of severe traffic accidents owing to opposite traffic as the road in undivided. By definition this cross section is beyond the category of the expressway. It is technically, relatively easy to expand to 4 lanes, but when considering the additional costs that will be incurred, in the event of expansion, the total cost cannot be necessarily said to be cheaper than in Alternative (4).

5.7.4 Design of Interchanges and Intersections

(1) General

Project A is a fully access controlled road and all access to this road from existing roads is by interchanges. 2 types of interchanges are planned with 3 main interchanges and 7 on-off rampways. Other than these, there is a main interchange at the connecting point with Project B and entrance/exit is provided at Colombo International Air port, the terminal point of the Expressway. The main interchanges are diamond types and have rampways in both the Colombo and Air Port directions, but the half diamond type on-off ramps have rampways only in the Colombo direction.

Project B is an urban arterial road and is designed to connect to the major existing roads at intersections. There are 5 intersections, and traffic signalling systems are recommended for traffic control.

Besides these intersections, are the abovementioned interchange at the connection with Project A and an on-off rampway palnned at the entrance to Colombo Port to connect with Aluthmawatha Road.

Locations of each interchange and intersection are shown in Fig. 5-9. A typical plan for a diamond type interchange is shown in Appx. Fig. 12. The typical general plans for interchanges and intersections are given in the Drawing in a separate volume.

(2) Design Standards

1) Design speed of rampway

The design speed of rampways, which is a basic standard for the design of rampways of the interchanges is taken at V = 50 ~ 40 km/h. (See Table 5-6)

Table 5-6: Design Speed of Rampway

(Unit km/hr)

Project	Design Speed of Mainway	Design Speed of Rampway
Project A	100	50
Project B	80	40
Project B	60	40

2) Typical cross section

The carriage way is 1 lane with a width of 3.25 m. The width of the roadway is 5.5 m, and this allows the passing of a semi-trailer even when a light vehicle is parked on the side. (See Fig. 5-15)

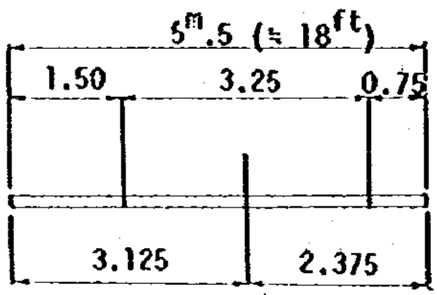
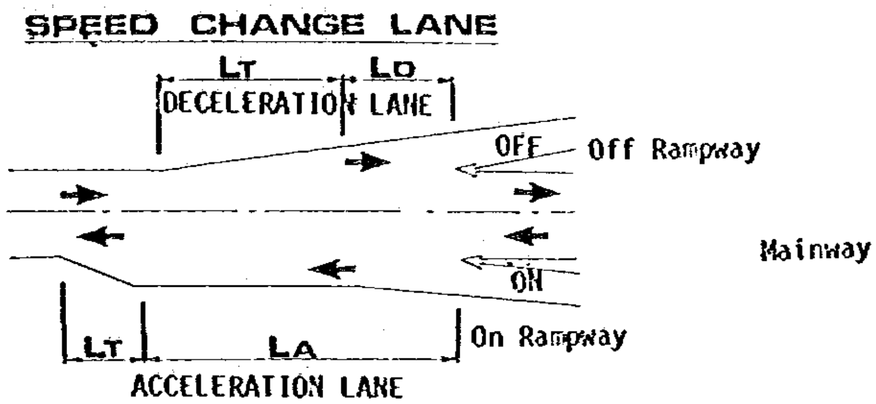


Fig. 5-15 Typical Cross Section of Rampway

3) Speed change lane

Speed change lanes are provided so that vehicles entering the mainway from the ramps at intersections do not disturb the through traffic flow. The design speed change lanes in relation to the design speed of the mainway is shown in Fig. 5-16.

Speed Change Lane



Note LT : Taper

Main Road Design Speed (km/h)	Acceleration Lane		Deceleration	
	LA (m)	LT (m)	LO (m)	LT (m)
100	180	60	90	80
80	160	50	80	70
60	120	45	70	60

Fig. 5-16 Speed Change Lane Standards

5.7.5 Design in Soft Sub-soil Conditions

(1) General

Marshes and soft grounds are widely distributed in the area along the project roads. Nearly 7 km of the total road length of 26.4 km in Project A and about 4 km out of a total 5.7 km in Project B pass through soft grounds. As nearly 35% of the project roads is on soft grounds it is necessary to study carefully on the possible problems of ground settlement, embankment failure and their counter measures etc. Also it is important to study the necessity and the technical feasibility of soil stabilization methods or soft ground improvement methods and to estimate such costs among the construction cost for economic analysis.

The soft grounds in the project area are classified into 8 areas as follows. The representative bore hole numbers are also given.

Along Project A

Area 1 : Kiribathgoda West Area (No. 4A)

2 : Hunupitiya East Area (No. 5A)

3 : Horape-Ragama Area (No. 4, 6A, 7A)

4 : Kandana North East Area (No. 8A)

5 : Ja-Ela Canal Area (No. 7, 9A)

6 : Dandugam Oya Area (No. 8)

Along Project B

7 : Bloemendhal Area (No. 1A, 2)

8 : Peliyagoda Area (No. 3A)

The thickness of soft strata is 6 ~ 7 m in Area 5 and 6 with 2 ~ 3 m in other areas of Project A in Project B, Bloemendhal marsh has a 7.5 m thick peat layer while in Peliyagoda area has the thickest soft ground with 12.0 m of organic clay.

(2) Estimation of Settlement of Soft Ground

For the above 8 soft ground areas, the consolidation settlement under the imposed loads of embankment is estimated to study the methods of soft ground treatment.

1) Estimation of consolidation settlement

Consolidation settlement is estimated using consolidation test results obtained from the test pit at No. 2 boring and compression index (see Fig. 5-17) presumed from the values of moisture content.

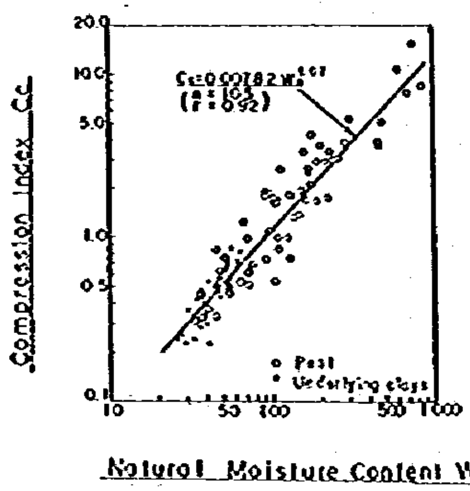


Fig. 5-17. Moisture Content – Compression Index

Ground conditions are shown in Appx. Fig. 13.
From the results of calculations, relationship between final consolidation settlement and embankment height for each area can be summarized as in Fig. 5-18.

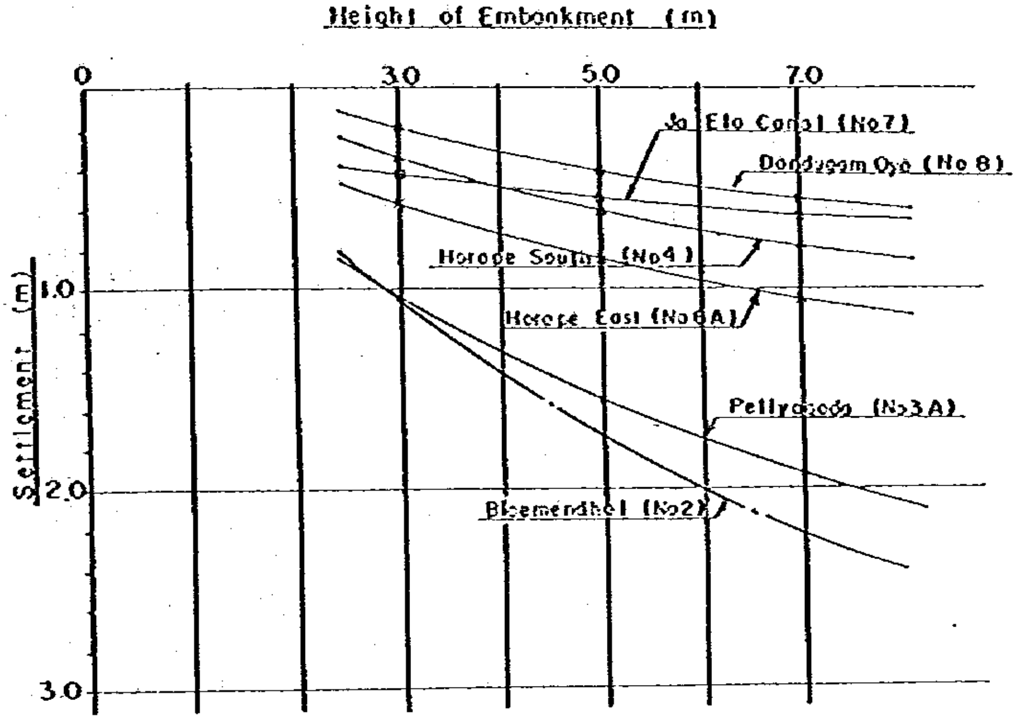


Fig. 5-18 Consolidation Settlement Related to the Height of Embankment

From this figure the following approximate relationship can be drawn;

a. Bloemendhal and Peliyagoda Area : $Sc \fallingdotseq H/3$
b. Other Soft Ground Areas (Areas 1~6) : $Sc \fallingdotseq H/6$

Where, Sc : consolidation settlement (m)
H : embankment height (m)

2) Estimation of settlement time

Prediction of settlement time is essential for judging whether soft ground treatment is necessary or not.

Soft grounds in Project A have only 2 ~ 3 m thick strata of consolidation, therefore the final consolidation settlement is small as 50 ~ 100 cm.

However, soft grounds of Bloemendhal and Peliyagoda areas along project B are 7.5 ~ 12 m in thickness, and therefore the amount of settlement itself is large and take long time for the completion of consolidation settlement.

According to the results of the calculations, it will take about 10 years for the completion of 90% of the consolidation in soft ground strata of Bloemendhal and about 30 years in Peliyagoda area.

Therefore, it will be necessary to improve ground conditions and to accelerate settlement with a suitable method.

(3) Design of Soft Sub-soil Treatment

As for Bloemendhal and Peliyagoda Areas, it will take more than 10 years to finish consolidation settlement because of their thick soft soil strata. It is necessary to improve the ground for accelerating consolidation settlement if embankment is constructed on these soft sub-soil.

1) Selection of the treatment method

In the preliminary designs from the view points of ground conditions, objectives of improvement, cost & method of construction and materials available, sand drain and sand compaction methods were judged to be suitable for the improvement of soft grounds in Project B. As the data on peaty soils of Sri Lanka are extremely limited, design samples of pealy grounds in Japan were also referred.

2) Design of sand drains

Arrangements of sand drains are decided according to consolidation settlement time as shown in Appx. Fig. 14.

The intervals of sand drains were decided at 2 m to achieve a progress of 90% of the ultimate settlement within two years. This was increased to 3 m in the counter embankment zone.

3) Stability against embankment sliding

According to existing survey results the shear strength of soft grounds in Bloemendhal and Peliyagoda Areas estimated from cone penetration resistance is about 0.1 kg/cm^2.

The results of the calculation of safety factor against sliding of slope are shown in Table 5-7.

According to these results, safety against sliding is maintained only upto a height of embankment of 4 m even after the use of sand drains.

In the case of an embankment height more than 5 m, it was decided to use both sand drains and sand compaction piles for increasing shear strength of the ground.

Table 5-7: Safety Factor against Sliding of Embankment

Embankment Height (m)	Primary Filling (H = 1.5 m)	Secondary Filling	
		Before Improvement	After Improvement
3.0	3.2	1.2 *	1.7
4.0	2.8	0.9 *	1.3
5.0	1.9	0.7 *	1.1 *
6.0	1.5	0.6 *	0.9 *

Note : * Unsatisfactory with safety factor less than 1.25

5.7.6 Pavement Design

(1) Premises for Design

1) Design standards

The Manual for Design and Construction of Asphalt Pavement 1980 (Japan Road Association) is used as the standards for the design of pavement of high-standard roads. For details of those standards see section 5.4.3 Pavement Design Standards.

2) Design traffic volume

When the opening year is set as 1990, the average daily traffic (A.D.T.) is shown in Table 5-8 based on the traffic forecast analysis.

Table 5-8: Daily Traffic Volume

Section	1990	2000
K-3	11,500	21,600
K-2	17,300	36,500
K-1	26,000	50,300
P-3	40,600	58,400
(P-2)	(43,700)	(90,500)
P-1	33,700	65,100

Note : ( ) : Section using an existing road.

3) Vehicle composition

According to the traffic survey and traffic forecast studies, the composition of heavy vehicles (buses and lorries) is about 40% ~ 60% as shown in Table 5-9

Table 5-9: Ratio of Vehicles*

Section	Light Vehicle	Heavy Vehicle Lorry **	Bus	Sub Total	Total
K-1	60	20	20	40	100
K-2	51	22	27	49	100
K-3	53	21	26	47	100
P-3	57	19	24	43	100
P-1	39	61	0	61	100

Note * : Results from the Traffic Survey in Feb. 1983
** : Containers included

4) Design life

The design life of Asphalt Concrete Pavement is considered to be 10 years.

5) Surface course

In this project, only the binder course will be used for the first five years after the opening and the surface course will be constructed at the end of this period. This is in order to reduce the initial costs as well as to cope with the differential settlement in soft ground.

6) Base course materials

Inclusive of the base course materials, a large quantity, about 300,000 tons of crushed stones is required. For Ja-Ela and Katunayake areas ie, in Sections K-2 and K-3, where supply of crushed stones is rather difficult, application of soil cement method is considered.

(2) Study of Pavement Thickness

1) The composition of pavement

The composition of pavement with the thickness of each course is shown in Fig. 5-19.

Pavement/Section	Project A			Project B	
	K-3	K-2	K-1	P-3	P-1
1) Surface Course *	–	–	–	–	–
2) Binder Course	10	10	10	15	15
3) Base Course					
Bituminous Stabilization	7	9	10	10	10
Mechanical Stabilization	15	15	20	15	20
4) Sub-Base Course					
Gravel and Crushed Stone	–	–	20	20	20
Soil Cement	15	15	–	–	–
Total Thickness	47	49	60	60	65

(Unit: cm)

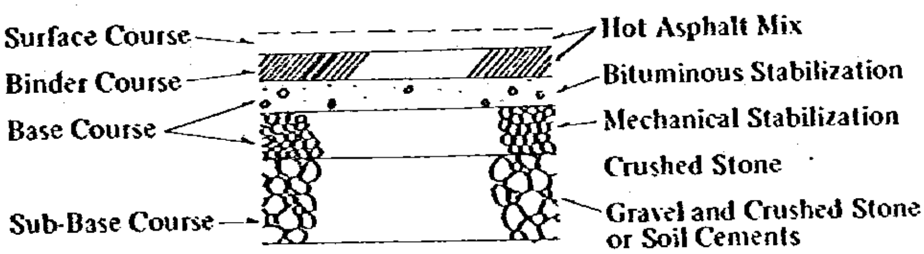


Fig. 5-19 Thickness and Cross Section of Pavement

2) Thickness of T_A and H

Thickness T_A and H are determined from the following formula.

$$T_A = \frac{3.84 \times N^{0.16}}{CBR^{0.3}}$$

$$H = \frac{28.0 \times N^{0.2}}{CBR^{0.6}}$$

Where,

TA = The design thickness, (i.e. the required thickness of a full depth hot mix asphalt pavement having an equivalent strength).

H = The pavement thickness

N = The number of equivalent 5-ton wheel-loads in one direction to be expected during the 10-year period following construction.

3) Design CBR

The gravelly lateritic soils has a high strength and according to the soil tests the CBR value is about 50.

In the design of pavement, the design CBR is selected as in Table 5-10 considering a safety factor and taking into account of the actual conditions of construction (of each embankment section).

Table 5-10: Design CBR

CBR/Section	K-3	K-2	K-1	P-3	P-1
CBR	8	8	6	6	4

4) Overlay of pavement

Overlaying of the surface is planned in 5 years and 15 years after the opening year. The thickness of overlay is given in Table 5-11.

Table 5-11: Thickness of Surface

(Unit: cm)

Year/Section	K-3	K-2	K-1	P-3	P-1
After 5	5	7	8	8	9
After 15	5	5	6	6	7

5) Calculations

The calculations of the pavement design is given in the Technical Report.

5.8 PRELIMINARY DESIGN OF STRUCTURES

5.8.1 Study of Structures

(1) Introduction

In Phase I of this study fundamental information and data required for the planning of structure were collected. This was followed with the investigation of locally available materials and technology, investigation of cross roads and railway crossing the project roads for the planning of structures, field investigations of flood areas and related existing structures.

In the Phase II stage, based on the results of the above investigations and survey, the basic policy of the structural planning was decided upon sufficiently considering the local conditions and the design standards were also set up.

The basic policy of structure planning are summarized as follows:

1) Local technology and materials should be used as much as possible.

2) Rationality of planning the structures is considered by establishing the standard designs.

3) Flood relief and drainage structures are planned practically and realistically in consideration of the flood records and the conditions of existing nearby structures.

Standard designs were prepared for planning the large number of structures along the project roads adequately and rationally.

Structures required along the project roads are listed below and the number and scale of them are shown as Table 5-12.

a. Structures for road crossing.
b. Flood relief and drainage structures.
c. Overbridges
d. Railway flyovers.

Their locations, types and scale are shown in Appx. Fig. 16 ~ 19.

Table 5-12: Details of Structures Along the Proposed Expressway and New Port Access Road

	Bridges (L = length)		Overbridges (L= length)		Box Culvert (O=dimension)		Pipe Culverts (Ø = diameter)	
Project (A) K-1, K-2, K-3	L = 10^m - 15^m	14	L = 28^m	1	O = 8^m x 5^m	3	Ø = 1.8^m	4
	L = 15^m - 35^m	6	L = 2x14 = 28^m	12	O = 3^m x 3^m	16	Ø = 1.5^m	5
	L = 35^m - 80^m	2	L = 2x28 = 56^m	1	O = 2^m x 2^m	27	Ø = 0.9^m - 1.2^m	6
	Total	22	Total	14	Total	46	Total	15
Project (B) P-1, P-3	L = 10^m - 15^m	2	L = 28^m	1	O = 8^m x 5^m (twin)	1	Ø = 1.8^m	1
	L = 15^m - 35^m	2					Ø = 1.5^m	4
	L = 35^m - 80^m	-					Ø = 0.9^m - 1.2^m	-
	Total	4	Total	1	Total	1	Total	5

(2) Investigations

1) Rainfall

For the planning of flood relief and drainage structures, data of the maximum annual daily rainfall during the past 30 years observed at the Colombo Observatory, which is the nearest to the Project Area, were collected from the Department of Meteorology.

The average annual rainfall within this area is in the range of 1900 mm – 2500 mm, and the rainfall during the period from May to October affected by the south west monsoon is considerably high.

2) Investigation of waterways

The project road along its course cuts across a few major waterways whose length and catchment area are given in Table 5-13.

Table 5-13: Major Waterways Crossed by the Project Road

Name of Waterway	Length L (km)	Catchment Area A (km^2)
Kelani Ganga	80	2,000
Ja-Ela Canal	30	150
Dandugam Oya	40	600

Kelani Ganga is one of the major rivers in Sri Lanka and makes the northern boundary of Colombo City. A flood gauge is available near the point where the project road crosses the river and the flood stage has been recorded for the past 40 years. The highest flood level was recorded at 3.9 m above mean sea level. Except for a short stretch, Ja-Ela Canal flows gently through paddy fields and enters Negombo Lagoon at Ja-Ela. No data of observation is available with respect to flood levels.

Dandugam Oya, after flowing through Attanagalla and Gampaha areas also enters Negombo Lagoon. River stage has been observed for two years near Seeduwa Road. The highest flood level was recorded 1.4 m above mean sea level.

3) Soil investigation

Soil investigation were conducted by mechanical boring at the following 7 locations (see Table 5-14) where major structures are expected. Standard penetration tests using the bore holes and laboratory soil tests using the extracted samples were also performed.

Table 5-14: Location of Soil Investigations for Major Structures

Boring Hole No.	Location
No. 1	Port Entrance (Aluthmawatte Rd.)
No. 2	Bloemendhal
No. 3	Peliyagoda Bridge
No. 4	Horape Marsh, Railway Flyover
No. 5	Proposed Railway Flyover at Ragama
No. 7, No. 9	Proposed Ja-Ela Canal Bridge
No. 8	Proposed Dandugam Oya Bridge

4) Evaluation of existing structures

In order to gain information for the selection of routes for the project roads, the existing structures of Victoria Bridge, New Kelani Bridge and the abandoned road structures in Peliyagoda were evaluated. Since there were no data available with regards to the Victoria Bridge, actual measurements were taken in the field and the condition of maintenance was examined. From these investigations it was evaluated that the Victoria Bridge can sufficiently accommodate the ordinary vehicles excluding the heavy lorries (corresponding to Load TT-43) for sometime into the future.

Since all the remaining structures were designed about 15 years ago based on the HA Loading of the British Standards, it is judged that if these structures are to be used as a part of the project roads, only simple modifications and strengthening will be necessary. (See Appx. Fig. 15)

5) Other projects related to the project roads

a. Canal improvement projects
The New Capital City Drainage Project and the Peliyagoda Integrated Urban Development Project provide improvement plans for the drainage canals along the proposed routes of project roads within Colombo City and Peliyagoda areas.

The location and the planned cross sections of canals related to this project are shown in Appx. Fig. 20.

b. Road projects of the Peliyagoda Integrated Urban Development Project
As a part of the above mentioned Peliyagoda Integrated Urban Development Project, a road is proposed within that project area whose location and width are shown in Appx. Fig. 11.

c. Improvement projects of existing roads
Ekala-Gampaha Road for which an interchange is planned at Ekala is presently classified as a class–B road but is proposed to be graded up to class–A road (Department of Highways).

d. Strengthening track project of the railway
The project roads are expected to cross the railway at a few points. Future development plan of the railway, construction gauge and the frequency of train passage etc., were discussed with the Sri Lanka Government Railway.

The results of the discussions are as follows:

- As a future plan, it is proposed that the present 2 track stretch between Colombo and Ragama be increased to 4 tracks, and the present single track between Ragama and Negombo be increased to a double track system.
- There is an electrification plan for each route.
- The clearance is shown in Appx. Fig. 10.

6) Local technology

a. Specifications and standards

The "Specifications for Highway Bridge Construction" prepared by Messrs Kampsax International A/S, advisors from the World Bank is proposed to be used as the specifications for the construction of highway structures.

As the code of practice in design, "British Standards" are basically used although the "Indian Code of Practice" which is sometimes adopted for loads used in the design of minor structures.

"Sri Lanka Standards" are partly available for materials and material testing and the locally manufactured materials such as cement and steel bars are in accordance with these standards. In general, British Standards or the USA Standards, ASTM, are in use for material testing.

b. Standard design

The following three types of standard designs are being used at the Department of Highways:

Bridge Superstructures (PC)	: Pre-tensioned slab type L = 7 ~ 16 m
- do -	: Post-tensioned girder type L = 20 ~ 35 m
Pipe culverts (spun RC pipe)	: ϕ = 0.6 ~ 1.8 m
Retaining walls (gravity type retaining walls with plum mixed concrete)	: H = 2 ~ 7 m

c. Structure types

For the superstructure of bridges, the above-mentioned standard designs are mainly used and S.D.C.C. (State Development & Construction Corporation) produces precast PC slabs for spans longer than 3 m in the factory. Almost all the abutments are of gravity type constructed of plums mixed concrete.

As for foundations, piles and wells are mainly used. Piles are locally manufactured as precast reinforced concrete products with a square cross section of 350 mm x 350 mm and used in lengths up to maximum 10 m per pile. Well foundations in most cases are of a circular cross section and used often in the depth range of 10 ~ 12 m. The cylindrical wells generally used have a diameter of 3.3 m and the reinforced concrete cutting edges are available as precast products.

d. Materials

i) Cement

The demand of cement in Sri Lanka, though significantly affected by the major construction projects, is estimated around 100 million tons/year of which 60 ~ 80% is met by the locally manufactures cement. 100% self sufficiency is expected soon after the newly constructed plant of the Ceylon Cement Corporation goes into full operation. However, recently the quality of products varies largely as the plant is still new, and althogh imported cement is mainly used in the structures, a switch over to local cement is generally expected once the quality stabilizes.

ii) Reinforcement steel

Ordinary round bars and Tor-steel (cold twisted and ribbed) manufactured by Ceylon Steel Corporation using imported billets are generally used.

7) Investigation of flood prone areas

Since the proposed route of the expressway runs through areas submerged during the rainy season, flood prone areas were investigated as this was necessary in the planning of structures, and the results of investigation are given in Appx. Table 18. In carrying out this investigation, information of the flow conditions during floods were gathered by interviewing the inhabitants of the locality and by examining the actual state of railway and road structures in the vicinity.

8) Investigation of cross roads

Since the project roads cross the existing roads, structures become necessary to provide grade separations to some of them.

Therefore, the roads crossing the route of project roads were investigated both in the field and on the contour maps of 1:10,000 scale. The results are summarized in Appx. Table 19.

(3) Planning of Major Structures

Major structures listed below are taken into special consideration due to specific conditions among many structures along the proposed routes. Outline is as follows:

1) Structure at the Colombo Port entrance (See Fig. 5-20)

a. Planning

In planning this structure, the following conditions were considered and reinforced concrete box culvert were proposed:

- It is necessary to consider special construction methods and sequences so as to maintain existing traffic during construction since Aluthmawatha Road is indispensable for regional service and there is no other road for detour.
- Railway structures exist adjacent to the planned structure.
- Connection with the roads proposed within port area should be taken into account.
- It is better to avoid the buried oil pipelines.

b. Construction method (See Fig. 5-21)

Temporary structure should be proposed to satisfy the above mentioned necessary conditions. Construction sequences are as follows:

- Constructing temporary structure
- Excavating under the temporary structure
- Constructing of the structure at port entrance
- Backfilling
- Removing temporary structure
- Rehabilitating Aluthmawatha Road damaged by construction

2) Horape Railway Flyover (See Fig. 5-22)

The expressway intersects the railway line (Colombo-Ragama) about 8 m from the 8¼ mile post at a sharp skew angle of 40 degrees.

The flyover is planned taking into consideration the following:

a. There is a future plan to increase the existing two tracks with each new track on either side of the existing tracks.

b. The skew angle of the structure is eased to 60 degrees in order to avoid technical problems caused by the sharp skew angle.

c. A minimum clearance of 1.5 m is kept between the walls of the substructure and the construction gauge of the railway.

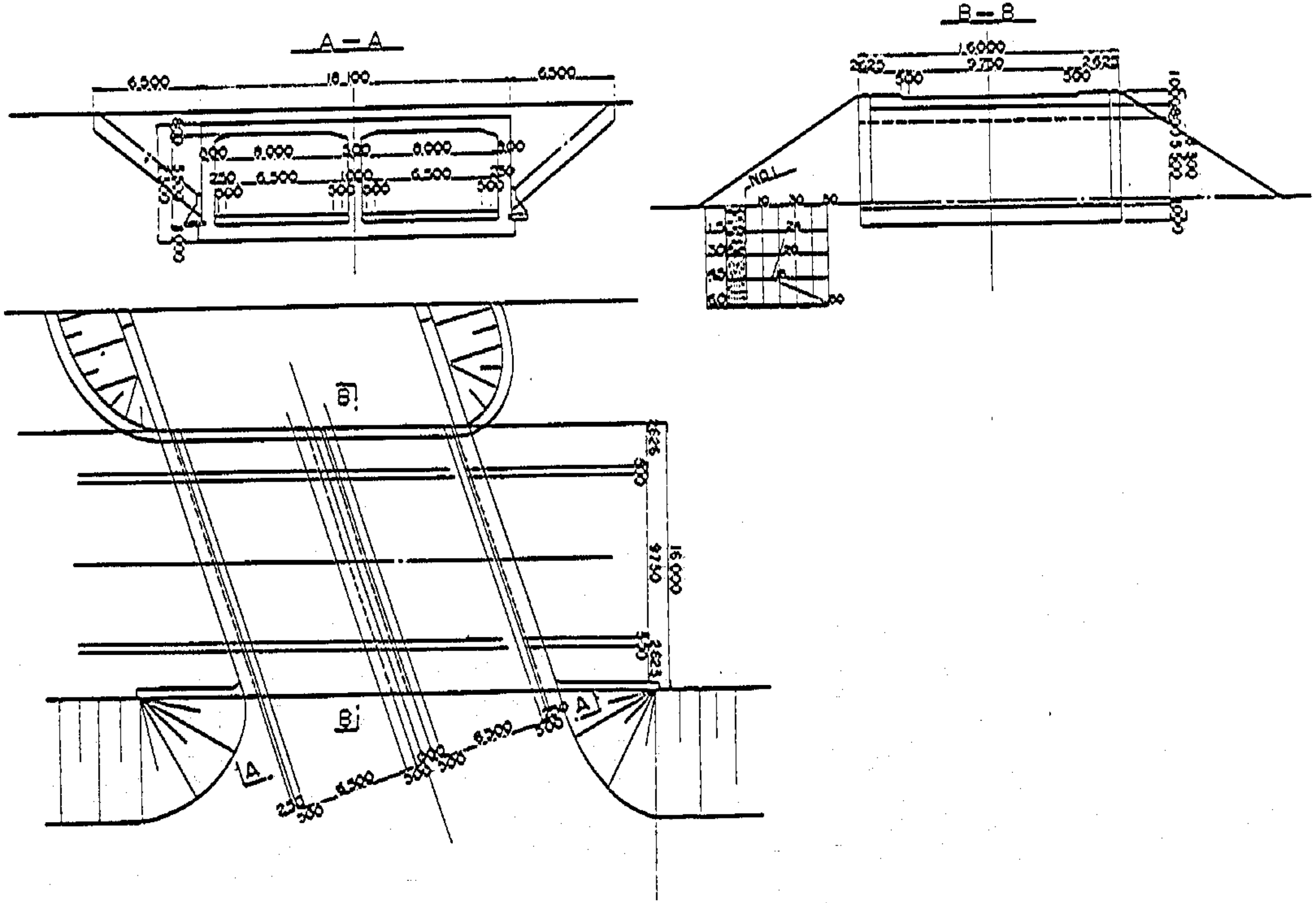


Fig. 5-20 Box Culvert at the Port Entrance

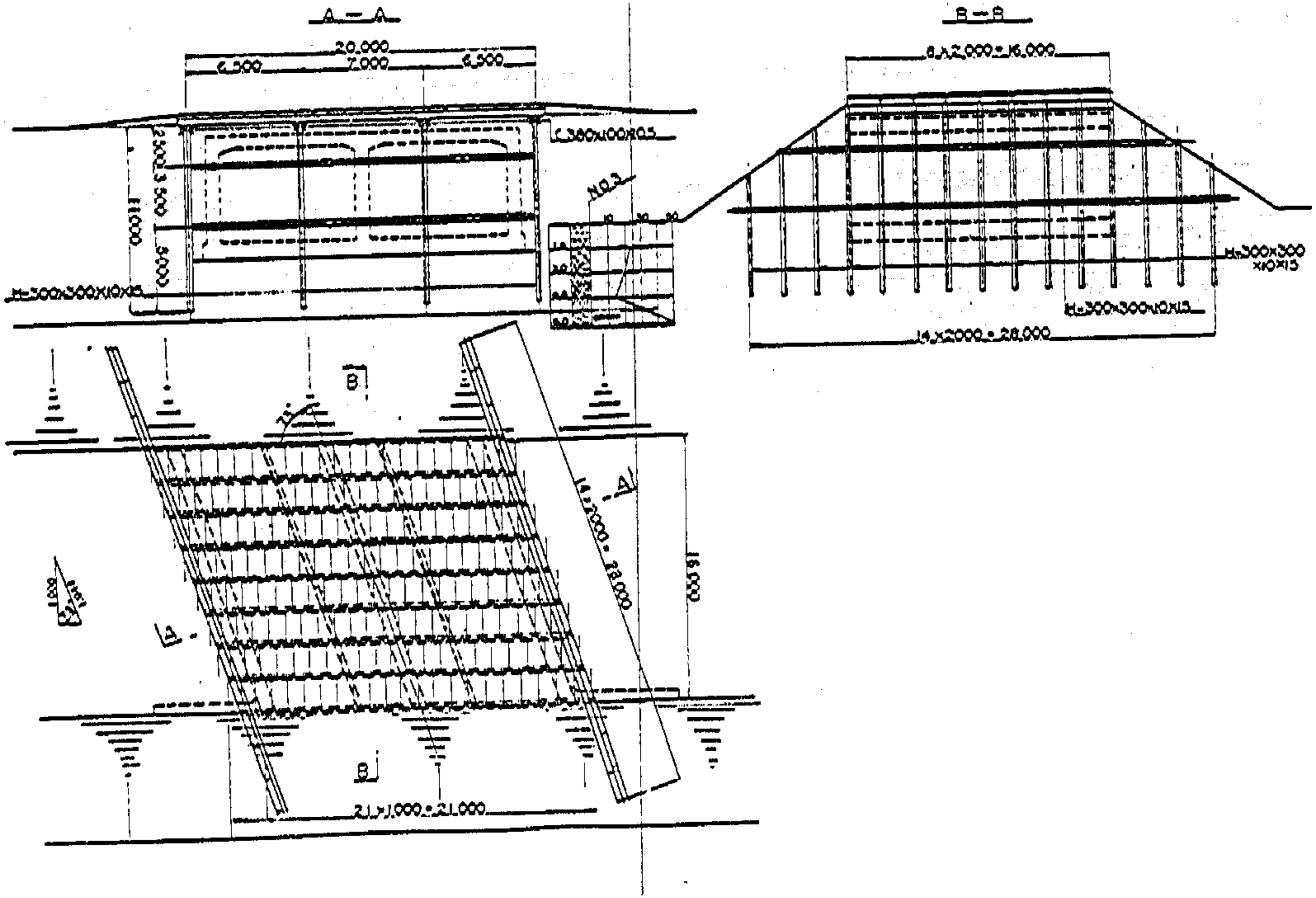
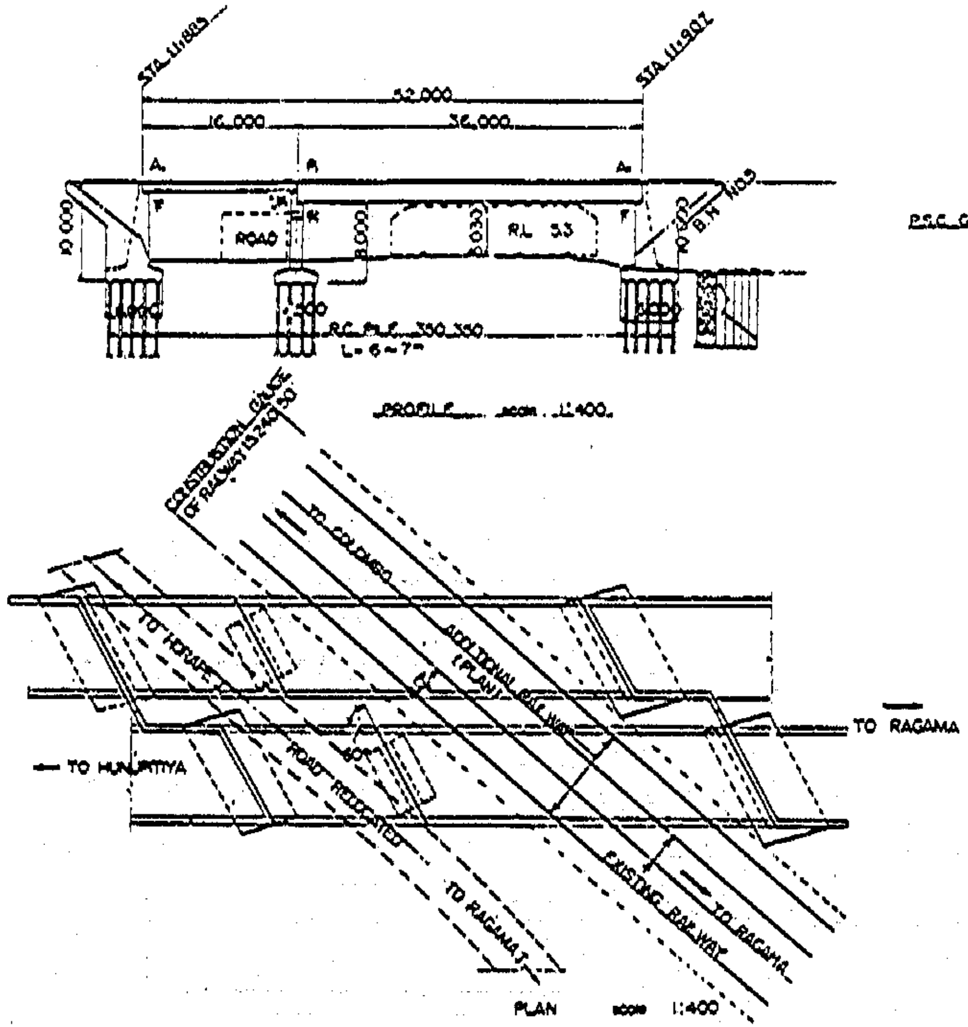
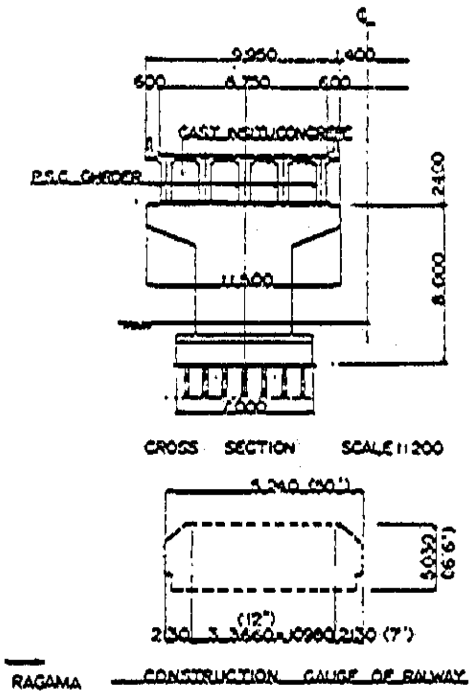


Fig. 5-21 Alutmawatta 2Cont. Box Culvert





ESTIMATE OF QUANTITIES PER ONE WAY

ITEM		UNIT	QUANTITIES	REMARKS
Superstructure	L=36m	M	315	
	L=16m	M	140	P110 AF 170
Substructure	CONCRETE	M^3	685	
	FORM	M^2	740	
	REINFORCEMENT	Kg	54,800	
PILE		M	830	

Fig. 5-22 General Plan (Railway Flyover Near Horape St.)

Considering the above conditions and referring to soil survey results, 52 m span bridge (36 m post tensioned PC beam + 16 m pretensioned PC beam) with a substructure of pile foundation (6 ~ 7 m precast pile) is proposed.

3) Dandugam Oya bridge (See Fig. 5-23)

Dandugam Oya having a wide catchment area flow through the low hillocks and flat marshy terrain with frequent meanderings and inundating a vast area of low lying lands during floods. As there is no data on the conditions during floods, taking into consideration the information obtained by interviewing local inhabitants in the "Investigation of flood areas" (Appx. Table 18), the topography and the length of existing Dandugam Oya Bridge (4 spans x 19.3 m = 77.2) on A-3 road down stream, this bridge is planned with a length of 80 m (25 m x 2 PC girder + 30 PC girder).

The following are taken into consideration in planning the bridge:

a. Avoiding of construction work in deep water.
b. Minimizing interference of piers to flow as much as possible.
c. Minimizing the depth of expected scouring which may depend on the water depth during flood period.

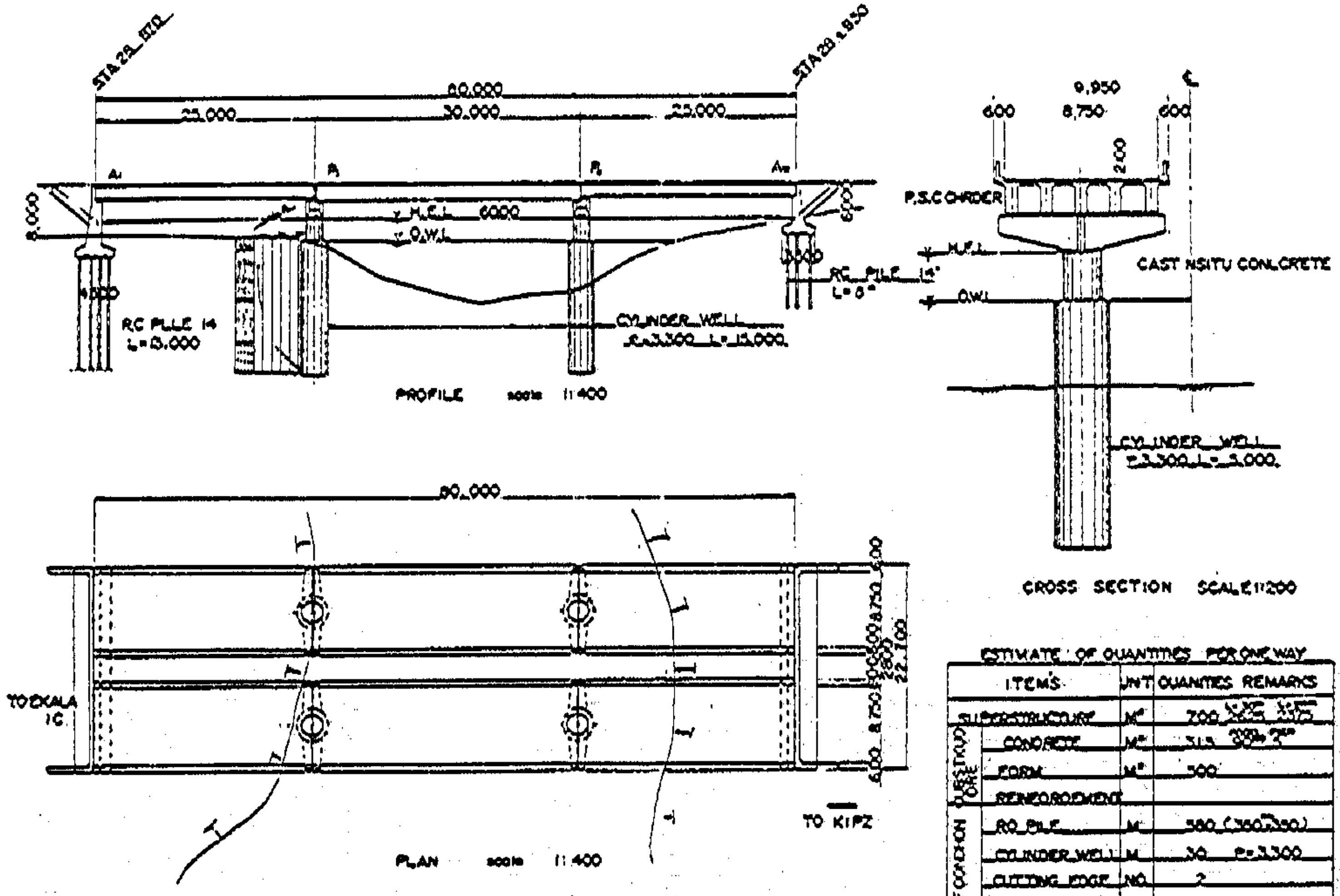
The bore hole data (No. 8) at the site show that there is a layer of relatively soft sandy silt up to 9 m below the ground surface and that the underlying soft rock is highly weathered in the upper 5 m. Therefore, it is recommendable to plan the foundation on the rock below 15 m from the ground surface. Regarding the type of foundation, a cylindrical well foundation and a pile foundation are planned for the piers and abutments respectively.

(4) Planning of Minor Structures

There are many structures to be planned along the project roads.

The following standard designs of structures were prepared for planning these structures adequately and rationally. These were applied in planning according to site, topographical and regional conditions.

• Pretensioned PC Slab Bridges	Span L = 10, 13, 16 m
• Post tensioned PC Beam Bridges	Span L = 19, 23, 28, 35 m
• Over Bridges	Span L = 18, 56 m
• Abutments (Spread footings and pile foundations)	Height H = 4, 6, 8 m
• Box Culverts	Dimension V = 5 m x 5 m ~ 8 m x 5 m
• Pipe Culverts	Diameter ϕ = 0.9 ~ 1.8 m
• Retaining Walls	Height H = 2 ~ 7 m



ESTIMATE OF QUANTITIES FOR ONE WAY

ITEMS		UNIT	QUANTITIES	REMARKS
SUPERSTRUCTURE		M	200	[illegible]
SUBSTRUCTURE	CONCRETE	M	315	[illegible]
	FORM	M	300	
	REINFORCEMENT			
FOUNDATION	RC PILE	M	380	(380 [illegible])
	CYLINDER WELL	M	30	Φ=3300
	CUTTING EDGE	NO	2	
	FORMING ISLAND	NO	2	[illegible]
EXCAVATION		M	400	

Fig. 5-23 General Plan (Dandugam Oya Bridge)

In planning structures for existing road intersections, it is a principle that box culverts are utilized if the width of the crossing roads are less than 8 m, otherwise pre-tensioned or posttensioned PC bridges are planned. Cast-in-situ RC bridges are not planned in consideration of difficulties in detouring the traffic for long periods during construction. The overbridges are planned to be minimized, which are to be erected by truck cranes in consideration of construction simplification.

5.8.2 Study of Flood Relief Opening and Drainage Structures

(1) Flood Relief Openings and Drainage Structures of Project (A)

1) Planning of flood relief openings

The areas near the Vidyalankara University, Horape, near Ma-Eliya on the up-stream of Ja-Ela Canal, and the Dandugam Oya catchment are the flood prone areas along the route where flood relief openings are considered necessary. In general, drainage in this area is poor due to lack of outlets and for the available outlets being narrow. Storm water often causes these areas to remain inundated for long periods such a 4 to 10 days. Therefore, it is difficult to decide the flood relief openings with a theoretical analysis of flood detention for the locality alone without considering the drainage conditions for the whole catchment area. In the absence of such a drainage plan, we are compelled to plan these structures based on the results of runoff analysis (Appx. Table 18) mentioned below and the Inventory of Flood Areas (Appx. Table 18) in which the condition around the nearby existing structures during floods was investigated and recorded specially for this study. But there is at least 700 km² wide area which is common to both Ja-Ela Canal and Dandugam Oya catchments, since the available data are insufficient, it was decided to plan these structures as follows based on the above Inventory and considering the topography and conditions of existing drainage channels.

a. Dandugam Oya

HFL	MSL + 6.0 m
Bridge length	80 m

b. Ja-Ela Canal

HFL	MSL + 4.8 m
Bridge length	30 m

2) Planning of drainage structure

Drainage structures were planned based on the following items.

a. Basically, for runoff volume of less than 4 m^3/sec pipe culvert is planned, for between 4 m^3/sec and 20 m^3/sec box culvert, and for more than 20 m^3/sec bridge is planned.

b. When there is a structure near by, its type and size will be considered in the planning.

c. The above mentioned planning was reconfirmed on site.

The fundamental conditions for analysis are as follows:

- Rainfall data – Annual maximum daily rainfall recorded for the past 30 years at Colombo Observatory
- Design storm frequency – Bridge 50 yrs.
  Box Culverts 25 yrs.
  Pipe Culverts 10 yrs.
- Rainfall analysis – Iwai's Method and Sherman's Formula
- Maps – 1:10,000 contour map and 1:63,360 topographical map
- Runoff calculation – Rational Equation
- Time of concentration (min) –

$$T_c = \frac{L^{1.15}}{51\,H^{0.38}}$$

L = Length of Stream (m)
H = Gradient Height (m)

(2) Flood Relief Openings and Drainage Structures of Project

Improvement plans are recommended for implementation in the New Capital City Drainage Project for almost all the drainage channels around the route within Colombo City area while drainage channels are already being constructed in the Peliyagoda Integrated Urban Development Project Area. The typical cross sections of the drainage channels which are relevant to this project are given in Appx. Fig. 20 and the structures will be planned so as to maintain these channel sections.

(3) Free Board for Bridge

The rivers with high flood discharge and abundance of floating logs were distinguished from the others and the bridges are planned using the following free board values:–

Ja-Ela, Dandugam Oya	1.5 m
Others	1.0 m