Chapter 7

ALTERNATIVE ROUTE ALIGNMENT STUDY

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By this study, alternative routes are formulated which in turn facilitates to select the optimum route for the KLORR by evaluating the alternative routes. Alternative routes study was made as described in this Chapter.

7.1 Procedure for Alternative Route Selection

In the Highway Planning process, the method of selecting an optimum alignment for the proposed road is one of the important issues. In most of the cases, an optimum route is selected from several alternative routes/alignments. Figure 7-1 shows the process of formulation of alternative routes.

In the first step, the concept of the proposed KLORR project was developed with the basic consideration of the function of the proposed road area development and network configuration. The concept building process is described in Chapter 5.

In the second step, a corridor covering the areas where the proposed road might pass were identified, taking into account the concept and terrain condition. The corridor was set with an approximate width of 10km.

In the next step, basic control points, such as geological conditions, urban area, water catchment area, forest reserves and interchanges with other highways were identified for preparation of alternative routes.

With alternative routes, all necessary control points were examined, followed by the planning of alignment for the alternatives. The control points included geology, environment, highway network, etc.

Once the alignment for alternatives were planned, these alternative routes were evaluated from the standpoint of various aspects, such as geology, environment, engineering and economic analysis.

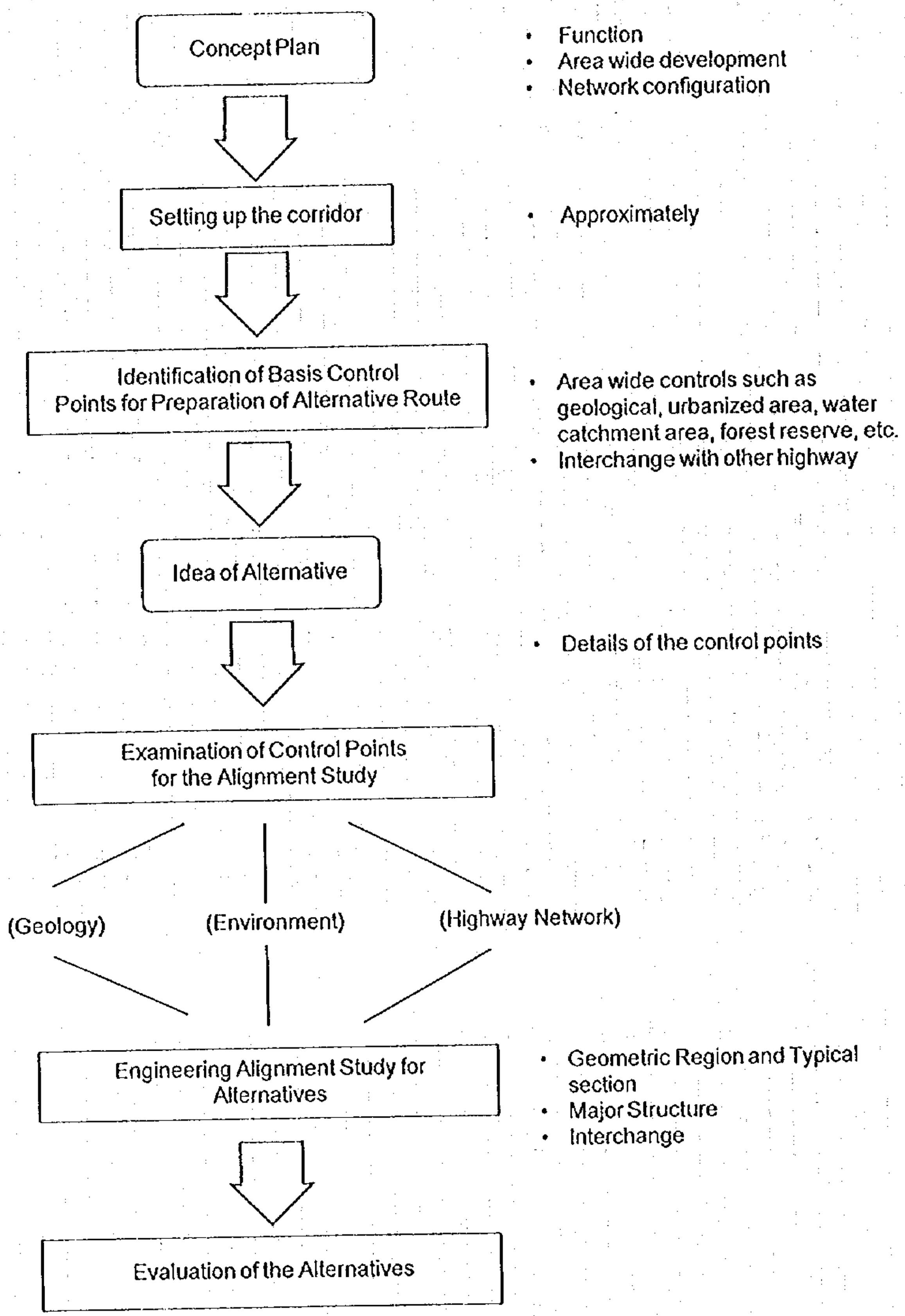

Figure 7-1 : Procedure for Route Selection

7.2 Basic Consideration

In this section, the basic control points which should be considered on the selection of the alternative routes are discussed.

For the selection of the alternative routes, the control points should be identified with area issues as shown in Figure 7-2. The corridor for KLORR has been identified from Rawang/Serendah in the north to North - South Central Link in the south, passing through the eastern area of Kuala Lumpur. This corridor can be divided into three areas: Northern, Eastern and Southern. The major issues in the three areas are represented with the key words as follows:

Northern area : Key word - "Topography, Engineering, Environment"
Eastern area : Key word - "Environment, Development, Road Network"
Southern area : Key word - "Development"

1) Northern Area

The Northern area consists of mountainous and hilly terrain, forest reserve and small built-up area. How to cross the mountainous terrain without compromising the design standard, quality and comfort of the proposed road was of great concern to highway engineers. Therefore, the topography, engineering and environmental aspects were predominant for this area.

2) Eastern Area

This area consists of hills, forest and water catchment areas which makes crossing of these areas by the road alignment difficult. Additionally, connection of the KLORR with the proposed extension of NKVE Ampang by-pass is also an important issue. The KLORR has potentiality for development in Hulu Langat and hence consideration should be made to provide access for such future development areas. As a result, aspects of topography, environment, development and road network are predominant in this area.

3) Southern Area

This area consists of many built-up areas, as well as proposed future developments. Putra Jaya is being developed as the administrative center of the country, which will involve huge development works. Thus, it is important to coordinate the KLORR and Putra Jaya Development Plan. On the other hand, there is Bangi New Town, in adjacent to the town of Kajang. How to bypass these towns and development area is a major concern. So, development is the predominant aspect in this area.

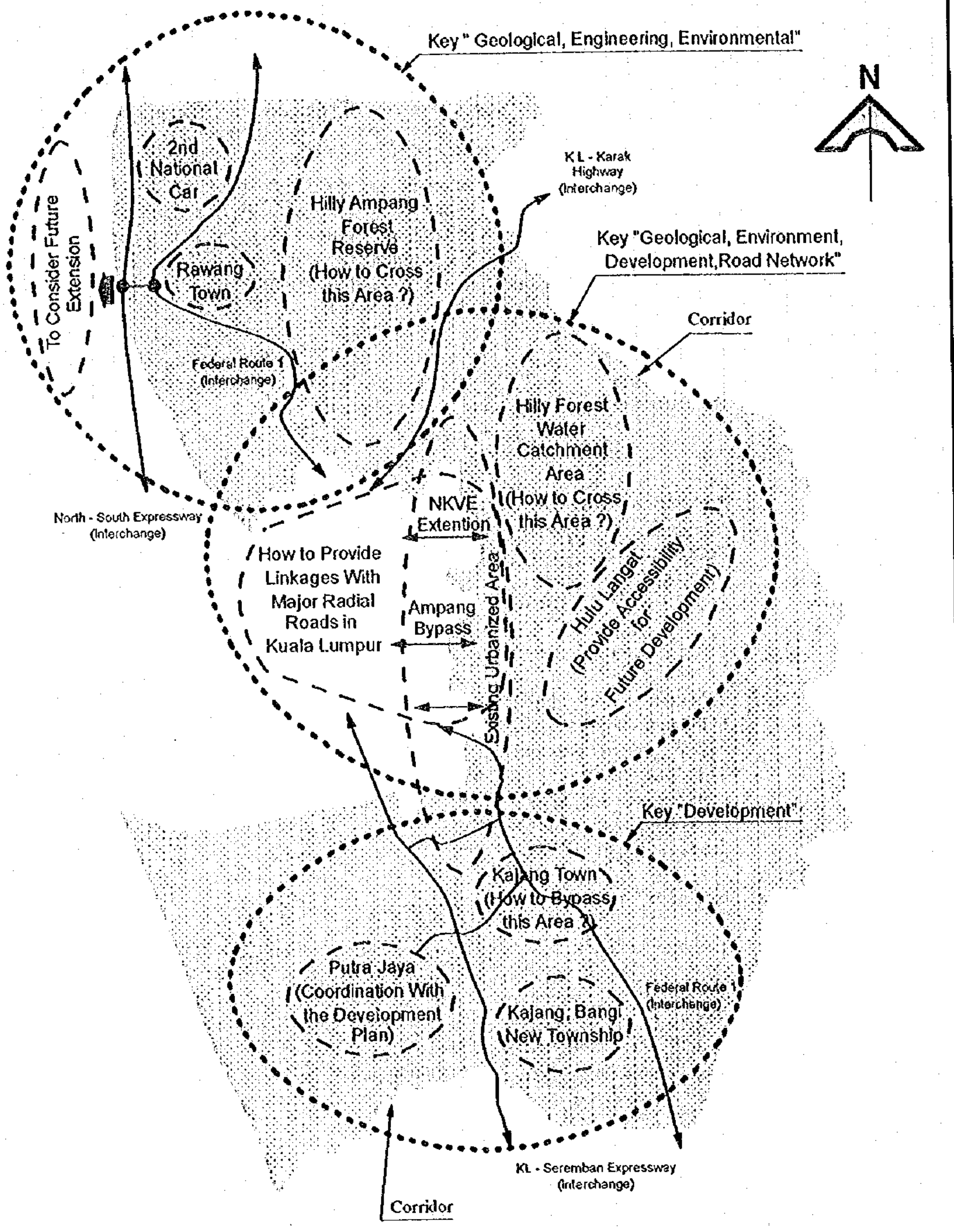

Figure 7-2 Area Wide Control Points for Alternative Routes

THE KUALA LUMPUR OUTER RING ROAD PROJECT
(Japan International Cooperation Agency)

7.3 Proposed Alternative Routes

7.3.1 Examination of Alternative Routes

The alternative routes were examined by dividing the KLORR corridor into three sections as follows:

(1) Section 1 (North) -- from N-S Expressway to Kuala Lumpur-Karak highway
(2) Section 2 (East) -- from Kuala Lumpur - Karak highway to Federal Route No.1
(3) Section 3 (South)-- from Federal Route No.1 to N-S Central Link

1) Section 1

Natural Barrier

The natural barriers in this section are the mountain ranges of Bukit Hulu Gombak (698 m), Bukit Hulu Kalong (695 m) and Bukit Lagong (575 m). Passage through these mountain ranges was one of the main concerns of designing the alternative routes. The control points were established as follows:

Control Points

a. Highway / Expressway

N-S Expressway -- Existing Rawang Interchange and a new interchange in Bt. Beruntung completed in middle of 1995.
FR No.1 -- Rawang bypass planned.

b. Railway

Malayan Railway in Rawang and Serendah.

c. Development Project

- "PERODUA" project of "KANCIL" car plant in operation in Sungai Choh
- Bt. Sentosa Industrial park in Serendah.
- Housing and Industrial developments
- Industria Estate near Rawang Interchange

d. Orang Asli

Kg. Melaka and Serendah Orang Asli settlement in Serendah town.

e. Other Facilities

- Addict rehabilitation center in Serendah

- Cemetery in the hilly area in Serendah.

f. Forest Reserves

Serendah FR, Bkt. Lagong FR, Kancing amenity FR, Wildlife Reserve at the northern part of Temper Park.

g. Water Catchment Area

Batu Dam water catchment area.

Possible Route

To pass through the mountain range, two routes are possible. One follows Sungai Serendah and climbs the mountain range as far as possible and descends at Sungai Pisang to Sungai Gombak, where Kuala Lumpur-Karak Highway runs. The other follows the valley, where Federal Route No.1 runs adjacent to the new development behind the Batu Caves. Different possible segments are considered in each section as follows:

Segment 1 starts from the N-S Expressway between Rawang and new Bt. Beruntung IC at Serendah and crosses the railway line and FR1. Then it runs eastward in the south of Serendah town. It then follows the Sungai Serendah valley and climbs by a 3% grade as far as possible before crossing the mountain range by a tunnel. From there it crosses the valley of Sungai Liam and Jalan Ulu Yam Baharu (B23). Then it traverses the valley of Sungai Gajah Mati and Sungai Pisang, one of the tributaries of the Sungai Gombak river where Kuala Lumpur-Karak highway runs.

Segment 2 starts at the southern section of the existing Rawang Interchange, as long as there is enough spacing between two interchanges from the traffic control stand point. Then it runs between FR1 and Bukit Lagong FR before crossing FR1 near Temper Park. Then it crosses hills by tunnels at the foot of Batu Dam and behind the Batu Caves, before crossing KL-Karak Highway. After crossing KL-Karak Highway, it turns south, so as not to encroach upon the International Islamic University.

2) Section 2

Natural Barrier

Natural barriers in this section are huge mountain ranges which spread at up stream of the Klang Gate Dam. The water catchment area of this dam and the quartz ridge of Klang Gate are sensitive areas for the alternatives. There are Hulu Gombak and Ampang Forest Reserves in this section. The Southern part of this section is a gently sloping hilly area at Hulu Langat which can not be natural barrier for route location. The following control points were considered for this section.

Control Points

a. Highway / Expressway
- KL- Karak Highway is widened 2-lane to 4-lane divided highway
- NKVE eastern extension
- Ampang elevated highway or the Jalan Ampang
- East-west Link Expressway

b. New Development

Sungai Long

c. Orang Asli

Pusat Pembangunan Orang Asli, Kg. Batu 16 Gombak, Kg. Perdik in Hulu Klang.

d. Forest Reserve

Hulu Gombak (Extension), Ampang Water Catchment FR, Bt. Sungai Puteh (north and south), Hulu Langat and Sungai Jeloh, Sungai Chongkak recreation park and Wildlife Reserve in the Klang Dam reservoir.

e. Water Intakes

Sungai Gombak along the Kuala Lumpur - Karak highway, Ampang Water Catchment FR and Sungai Langat.

f. Other Facility
- National Zoo
- S. Long
- Saujana Impian

Possible Route

Passage through the Klang Gate water reservoir and its water catchment area, Ampang FR water catchment area, without encroaching the development project area in Hulu Klang and Ampang, are main considerations of this section. Three possible routes are considered.

The first one detours to the mountain side crossing a water catchment area by tunnels and bridges. The second one passes under the quartz ridge by tunnel, then traverses the Ampang water catchment area by the minimum length to Hulu Langat valley. The third one also passes under the quartz ridge and crosses by tunnel, between a developed area and forest, before crossing Sungai Puteh by tunnel to reach Hulu Langat.

The segment 1 follows Sungai Rumput and traverses the catchment area of Klang Gate Dam. Then it crosses by tunnel under the mountain range near Bukit Cenuang, (820 m high) and follows Sungai Chongkak and Sungai Peredek both of them are tributaries of Sungai Hulu Langat. It then traverses the southern part of Jalan Hulu Langat in the hilly area of Sungai Long and Sungai Jeloh and turns to the west by a large radius bypassing Kajang town in the south.

The segment 2 turns south to the Bt. Batu Tabor (quartz ridge) after crossing the Kuala Lumpur - Karak Highway, not to encroach to the International Islamic University campus construction site north of the quartz ridge and a wildlife reserve near the Klang Dam reservoir. It passes by tunnel under the ridge and crosses the Taman Melawati area by viaduct. Then it runs to the mountain side of the developed area of Ampang and traverses below Ampang FR and its water catchment area by tunnel. Then it follows the valley of Sungai Semungkis to reach Hulu Langat Area. It runs southward, then merges with the segment 1.

Segment 3 starts from the segment 2 in the North Section, then crosses the quartz ridge by tunnel, as in the segment 2. It passes between the built up area on hill sides of Hulu Klang and Ampang FR, which includes Kemensah, Bukit Jerlang and Sungai Seriang. Then it turns to the east under the mountain range of Sungai Puteh by tunnel to reach Hulu Langat and traverses southward in the hilly area of Sungai Long in Cheras. It then turns to the west by a large radius, crossing the northern area of Kajang town.

3) Section 3

Natural Barrier

There are no natural conditions which prevent passage in this area, but some high hills should be detoured to avoid high cutting depth. The control points for this section are:

Control Points

a. Highways / Expressways

There are many expressway projects in this area related to Putra Jaya and KLIA project:
- Kuala Lumpur - Seremban Expressway (open to traffic)
- N-S Central Link - KLIA Expressway
- South Klang Valley Expressway
- Dedicated Highway
- Damansara Highway

b. Railway

Malayan railway, electric commuter service, KTM for Kuala Lumpur - Seremban, New Express Rail Link

c. Development

- Existing urbanized area - Kajang Town

- Putra Jaya - new administrative center
- KLIA - new international airport
- Bangi New Town

c. Forest Reserve
Air Hitam

d. Orang Asli
Kg. Bukit Baja

Possible Route

There are three possible routes in this area. The first one passes through Kajang town in the south then crosses Bangi new town and Putra Jaya. The second crosses Kajang town in the north and passes through the northern boundary of Putra Jaya. The third starts from the first one after crossing Kuala Lumpur - Seremban Expressway and merges with the second.

The segment 1 turns west, bypassing Kajang town in the south after crossing FR No.1, then it crosses Bangi New Town area and the Kuala Lumpur-Seremban Expressway. It traverses the hilly area of Dengkil and proposed Putra Jaya area. Then it runs south-west to avoid many mining ponds, where it crosses the N-S Central Link at north of Bt. Baja, which is the final point of the alignment.

The segment 2 crosses Kajang town in the north, then follows Jalan Sungai Chua and State Road B11 after crossing FR1 south of the Country Heights. Then it traverses the hilly area of Dengkil, following the northern boundary of Putra Jaya, where it turns south-west to avoid many mining ponds and finally merges with the segment 1.

The third diverts from the segment 1 after crossing the Kuala Lumpur - Seremban Expressway and merges with the segment 2 at the north boundary of Putra Jaya in Dengkil.

7.3.2 Proposed Alternative Route Alignment.

As a result of the above mentioned examinations, three alternative routes are established, namely Route A, B and C. The configuration of these alternative routes is shown in Table 7-1.

Table 7-1 : Configuration of Alternative Routes by Section

	Section 1	Section 2	Section 3
Route A	Segment 1	Segment 1	Segment 1
Route B	Segment 2	Segment 2 Segment 1	Segment 3
Route C	Segment 2	Segment 3	Segment 2

1) Alternative Route A

This is the outermost alignment which will provide good services for development projects in the outer area and will have the least social impact.

2) Alternative Route B

This is middle alignment which will have medium impact to both social and natural environments.

3) Alternative Route C

This is innermost alignment, same as the route B in section 1. This will provide good services to the inner area and affect least to natural environment.

Figure 7-3 shows the three alternative routes. A preliminary engineering study and cost estimation as well as a future traffic demand analysis were carried out for the three alternative alignments and major issues for each alternative alignment were identified as shown in Table 7-2.

Table 7-2 : Summary on Comparison of the Three Alternative Routes

	A	B	C
1) Highway Type	Expressway with full access control		
2) Design Speed	100 km/hr	100 km/hr	100 km/hr
3) No. of Lanes	6	6	6
4) Concept of Alignment	• Outermost Alignment • Min. Social Impact • Max. Natural Environmental Impact	• Middle Alignment • Section 1: Same as C • Section 2: Middle of A and C • Section 3: Same as C	• Innermost Alignment • Max. Social Impact • Min. Natural Environment Impact
5) Total Length	93,300m	87,700m	77,000m
6) Land Use Length a) Forest b) Agriculture c) Ex Tin Mine d) Urban	 45,800 m 35,900 m 5,400 m 6,200 m	 36,400 m 42,200 m 2,000 m 7,100 m	 28,300 m 39,000 m 500 m 9,100 m
7) Structure Type Length a) Earth Work b) Bridge c) Tunnel	 55,540m 22,210m 15,600m	 58,850m 19,360m 9,580m	 43,990m 18,360m 14,640m
8) Number of Interchanges (Including Junctions)	13	13	13
9) Project Cost a) Construction Cost b) Land Acquisition Cost	 RM4,580 million RM298 million	 RM3,850 million RM335 million	 RM3,924 million RM398 million
c) Total	RM4,878 million	RM4,185 million	RM4,322 million
10) Traffic Volume (2000) Traffic Volume(2020) Total Veh-km (2020) Total Veh-hr (2020)	24,300 veh/day 79,600 veh/day 97.3 million veh.km 4373.2 thousand veh.hr	27,100 veh/day 81,000 veh/day 96.9 million veh.km 4297.5 thousand veh.hr	34,700 veh/day 84,500 veh/day 95.5 million veh.km 4292 thousand veh.hr
11) Major Issues			
Section 1	• JCT with N-S Exp. is close to Service Area • Long Slope in Section 1 • Many tunnel sections incl. 3.8km long in Sec.1 • Construction problem due to fault line	• JCT with N-S Exp. is close to Rawang IC • Close to Housing Development at the South of Batu Dam	• JCT with N-S Exp. is close to Rawang IC • Close to Housing Development at the South of Batu Dam
Section 2	• Long Span Bridge with high pier • Affect water catchment area for Klang Gate dam • Long tunnel (4.7 km) • Crossing Malay Reserve	• Tunnel under quartz ridge • Crossing Taman Melawati • Long tunnel (4.47km) • Crossing Malay Reserve	• Tunnel under quartz ridge • Crossing Taman Melawati • Affecting squatters at Ulu Kelang and Ampang • Crossing Malay Reserve • Long tunnel (3.8 km)
Section 3	• Crossing Putra Jaya • Long Viaduct on swamp area	• Long Viaduct on swamp area	• Squatter at Kajang area • Long viaduct on swamp area

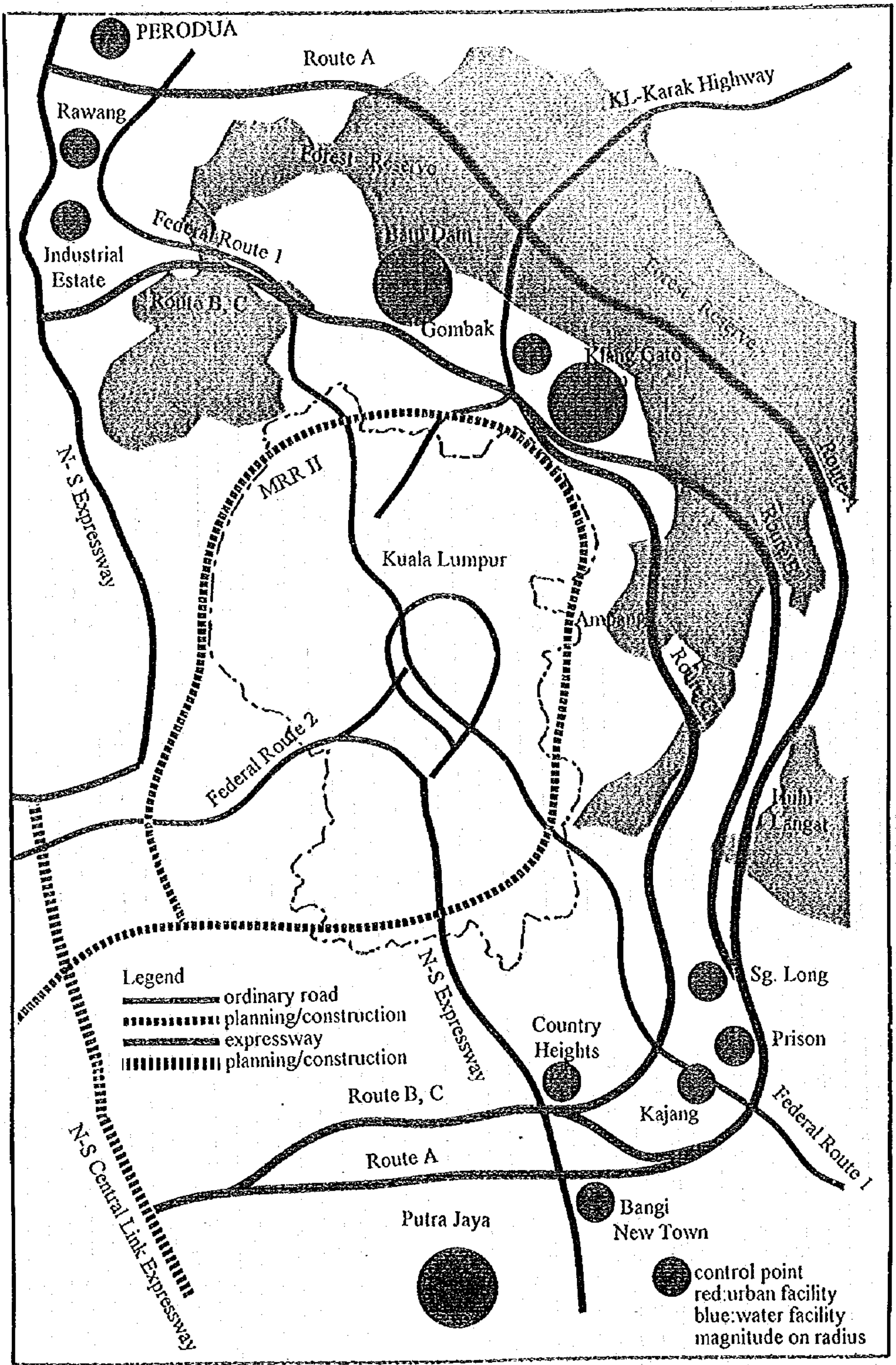

Figure 7-3 : Location of the Three Alternative Routes

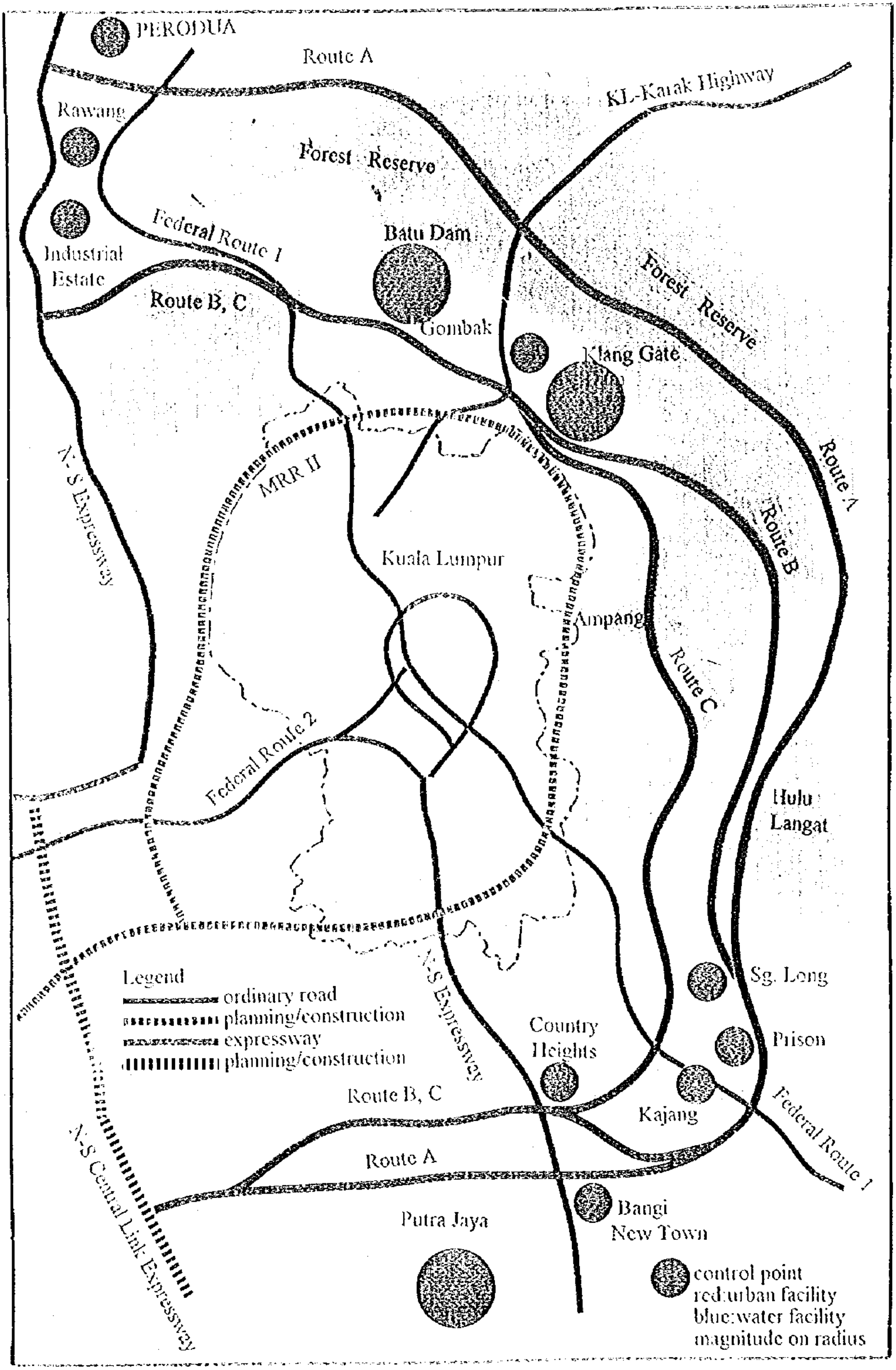

Figure 7-3 : Location of the Three Alternative Routes

7.4 Evaluation of the Alternative Route Alignments

7.4.1 Evaluation Criteria

The evaluation of the alternative routes were made from the following aspects :

1. Engineering
2. Environment
3. Economic

There are several factors within each of these aspects which are explained below.

1) Engineering

a) Geology

Geological composition, such as granite and quartzite, is very hard, whereas limestone and sandstone is not so hard. Thus, the type and hardness of rock make a significant difference in construction. Faults also make construction difficult. If the direction of the fault is parallel to the alignment, the effect will be more severe than if the fault lies across the alignment. Swamp land also makes construction difficult, demanding extra structures.

b) Topography

The existence of mountain, hills, deep valleys, ridges, rivers etc. affect the route, as the route will have steep slopes in the high mountains or valleys and long-span bridges over big rivers.

c) Construction

The construction method and level (easy or difficult) depends upon the structures, such as bridges and tunnels. In case of long tunnels and long bridges, the construction becomes more difficult since complicated methods and equipment are used.

d) Land Acquisition

If the route passes through a built up area or private lands it will be difficult to acquire the land necessary for construction of road. Also, if it passes through an urban area, the land acquisition will be more difficult than in rural areas, such as forest or agricultural land.

e) Project Cost

The project cost contains two components : construction costs and land acquisition costs. Lower project costs are preferable.

2) Environment

a) Natural Environment

The route with minimum impact to the natural environment such as forests, water catchment areas, flora and fauna is preferred.

b) Social Environment

The route shall avoid encroachment of sensitive historical, cultural, religious monuments, temples or buildings. Also it should have minimum impact to privileged settlements such as the Orang Asli settlement or the Malay Reserve. Likewise, squatter settlements are also sensitive areas.

c) Public Nuisance

Public nuisances such as air and noise pollution should be kept to a minimum during the construction phase and operation thereafter.

d) Regional Development

When a new road is constructed, new towns will be developed on the roadside or nearby, provided that land is available for such development. The regional development potential at the road side will be considered.

3) Economic Aspect

a) Traffic Demand

The volume of traffic demand on the proposed route and how it can reduce congestion on other existing roads are important in route evaluation. The higher the traffic demand the more suitable the route will be. The alternative route with small aggregated vehicle-kilo meter and vehicle-hours value of all traffic in the study area is preferable.

b) Accessibility

Easier access to the route from adjoining areas or existing roads will be an important point in the evaluation of the route.

c) Cost-benefit Analysis

Cost-benefit analysis is performed after determining the project cost. Economic indicators, such as internal rate of return (IRR), benefit cost ratio (B/C) and net present value (NPV) are important for evaluation. The alternative route alignment with the highest values of IRR and B/C ratio is preferred.

7.4.2 Evaluation of the Alternative Routes

The alternative routes were evaluated as follows. (Refer to Table 7-3)

1) Engineering

a) Geology

There are mountains of granite, and hills of schist and sandstone in section 1, in all three routes. The route A passes parallel to the faults running north-west to south-east. The hills near the Batu Caves consists of granite, through which the route B and C traverse. There are also faults in the route B and C, however, they run across the alignment, posing less difficulties in construction than in the route A. There are swamp areas in section 3 in all three routes.

b) Topography

The route A runs through steep mountain ranges and deep valleys at Hulu Gombak in section 1 in the north, causing a long climbing section. It runs through undulating hills in the east and alluvial land in the south. The routes B and C run through hilly terrain in the north, steep quartz ridges and moderate mountains in the east and undulating hills and alluvial areas in the south.

c) Construction

Due to existence of the parallel faults in the route A, the construction will be difficult and needs special precautionary measures. Also, the route A consists of maximum total length of tunnels, including the longest tunnel, with a length of 4.7 km, making construction most difficult. It also contains long span bridge with high piers at a crossing point with the Kuala Lumpur - Karak Highway. The route B has comparatively low lengths of tunnels, which makes construction easier than the other two. The route C has the minimum lengths of bridges, but the total length of tunnels is longer than the route B.

d) Land Acquisition

The route A passes through a minimum of urban land, whereas the route B passes through intermediate areas and the route C passes through the biggest length of urban land. Thus, land acquisition and compensation cost will be the highest for the route C and lowest for A, with B in the middle.

e) Project Cost

The construction cost of the route A is 4.5 billion RM and land acquisition cost is 298 million RM, the total cost is 4.8 billion RM. Similarly, the construction cost of the route B is 3.85 billion RM and land acquisition cost is 335 million RM, with the total cost of 4.1 billion RM whereas for C construction cost is 3.9 billion RM and land acquisition cost is 398 million RM resulting in total cost of 4.3 billion RM. Thus, the total project cost for B is the lowest.

	A	B	C
1. Engineering a) Geology	• Long fault line parallel to the route in the North Section	• Short fault line in the north section • Tunnel under quartz ridge	• Short fault line in the North Section • Tunnel under quartz ridge
b) Topography	• Long slope at Hulu Gombak mountain range • Deep valley at Sg Gombak • Steep mountain range Bt Cenuang	• Relatively less long slope though passing hilly area below Batu Dam and steep quartz ridge in the North and N-E section	• Relatively less long slope though passing hilly area below Batu Dam and steep quartz ridge in the North and N-E section
c) Construction	• Many tunnel and bridge sections including 4.7km long tunnel. • Long span bridge with high pier	• Less tunnel sections but including 4.5km long tunnel	• Many tunnel and bridge sections but the longest tunnel is relatively short
d) Land Acquisition	• Minimum requirement of urban land (5.8 km)	• Urban land requirement is less than C but more than A (6.2 km)	• Maximum requirement of urban land (9.1 km)
e) Project Cost	• Highest Project Cost (RM 4,878 million)	• Lowest Project Cost (RM 4,135 million)	• Intermediate Project Cost (RM 4,322 million)
2. Environment a) Natural Environment	• Affect water catchment area for Klang Gate Dam and Batu Dam	• Affect water catchment area for Klang Gate Dam but the length is shorter than A.	• Least length in water catchment area and forest reserve.
b) Social Environment	• Close to Orang Asli Settlement at Kg. Melaka and near Kg. Padang but not serious influence	• Some impact at Melawati	• Affect squatters at Ampang, Ulu Klang and Kajang, Community at Ulu Klang
c) Public Nuisance	• Minimum public nuisance	• Some at Melawati	• High public nuisance at Ampang, Kajang, Cheras
d) Regional Development	• High Impact to the means of KL - Tg. Malim corridor, Ulu Langat and Putra Jaya related project	• Same as A	• Relatively less impact particularly at Ulu Langat Area
3. Economic Aspect a) Traffic Demand	• Lowest traffic demand in 2020 (79,600 veh/day)	• Intermediate Demand (81,000 veh/day)	• Highest Traffic Demand in 2020 (84,500 veh/day)
b) Accessibility	• Good access to Serendah, Kajang, Ulu Langat, Putra Jaya through 13 Interchanges with major highways	• Good access to Rawang, Kajang, Putra Jaya etc. through 13 Interchanges with major highway	• Good access to Rawang, Kajang, Putra Jaya etc. through 13 Interchanges with major highway
c) Cost Benefit Analysis	• IRR = 14.8% • B/C = 1.39%	• IRR = 17.8% • B/C = 1.90	• IRR = 18.2% • B/C = 1.97

Table 7-3 : Comparison of Alternative Routes

2) Environment

a) Natural Environment

As the route A is located at the outermost, it will have the most significant impact to the natural environment. This is due to the longest length which passes through the forest reserve and water catchment area. On the contrary, the route C is the innermost alignment with the least length in forest reserve and water catchment area, resulting in minimum impact to the natural environment.

b) Social Environment

Among the various impacts on the social environment, the most sensitive matter is the squatters and the community. In this context, the route C is the most undesirable, since squatters at Ampang, Ulu Klang and Kajang and the community at Ulu Klang will be affected. The route A is the most preferable and the route B is second for this reason. The route A does not have much impact on communities, except on some Orang Asli settlements in the north and east. The route B has some impact on communities in Taman Melawati and also on the Malay Reserve. The route C has the large impact on communities at Kajang and the Malay Reserve.

c) Public Nuisance

As for public nuisance, the route C will have adverse effects at Ampang, Cheras and Kajang in terms of air and noise pollution, making it the most undesirable. The route B also will cause some consequence on Melawati. Thus, the route A is the best one from this standpoint.

d) Regional Development

Along the KLORR, regional development potential is found in these areas : Kuala Lumpur - Tg. Malim corridor, Hulu Langat and the adjacent areas of Putra Jaya and KLIA. Since the route C has an innermost location, merit to these regions are not so expected. On the other hand, the route A and B will be able to contribute to development of these regions.

3) Economic Analysis

a) Traffic Demand

The traffic demand for the route A is the lowest, as it passes mostly through rural areas. The route C passes through some urbanized areas and also close to a built up area, having the highest demand. But the difference is not very large. The aggregated vehicle-km and vehicle-hours of all traffic in the study area will be the highest for the route A and the lowest for the route C.

b) Accessibility

The route A will have easy access to PERODUA motor factory and the newly established towns around the factory, whereas access from Rawang town needs a long detour. The route A can also be easily accessed from Ampang and Kajang towns. The route B can be accessed from Rawang, Ampang and Kajang towns. The route C is also accessible from Rawang, Ampang and Kajang towns.

As a result, there are no significant differences among the alternatives.

c) Cost-benefit Analysis

The cost-benefit analysis indicator shows the highest values for the route C. The internal rate of return (IRR) for the route C is 18.2%, that for the route B and A are 17.9% and 14.8%, respectively. Cost-benefit ratio for the route C is 1.97, 1.9 for the route B and 1.39 for the route A. The differences in these indicators between the route B and C are not significantly large. Thus the route B or C is preferable from the standpoint of cost-benefit analysis.

<u>Scoring of Evaluation</u>

After scrutinizing each alignment from the viewpoint of above aspects, a scoring was experimentally given by each evaluation item. The details of scores for all the three alignments are given in Table 7-4.

The scoring was made based on the following considerations.

(1) If a difference of quantitative indicator for the evaluation item, among the alternatives was within or more than 20%, a positive/negative score was given according to superiority / inferiority. In cases where there is no quantitative indicator, the seriousness of the condition/impact will be assessed.

(2) A specific weight was not given to each evaluation item, since the weighting may differ depending on the individuals and the surrounding circumstances at the time of scoring.

<u>Overall Evaluation</u>

Since the route A is located at the outermost area, the impact to the natural environment will be most serious, particularly where it encroaches the water catchment area for Klang Gate Dam. In addition, many tunnel sections, including the 4.7 km long tunnel, together with long fault lines running parallel to the route will make construction difficult. As the total length of structures is the longest, the cost benefit analysis indicates it is less advantageous than other alternatives.

Table 7-4 : Scores of Evaluation of the Three Alternatives

Aspect	Alternatives			Remarks (Indicator for Scoring)
	A	B	C	
1. Engineering				
a) Geology	Bad (-1)	Fair (0)	Fair(0)	Refer to Table 7-3
b) Topography	Bad (-1)	Fair (0)	Fair (0)	Refer to Table 7-3
c) Construction	Bad (-1)	Fair(0)	Fair(0)	Refer to Table 7-3
d) Land Acquisition	Fair (0)	Fair(0)	Bad (-1)	Length of Urban Land
e) Project Cost	Fair (0)	Fair(0)	Fair (0)	Project Cost
2. Environment				
a) Natural Environment	Bad (-1)	Fair(0)	Good (+1)	Refer to Table 7-3
b) Social Environment	Good (+1)	Fair(0)	Bad (-1)	Refer to Table 7-3
c) Public Nuisance	Good (+1)	Fair(0)	Bad (-1)	Refer to Table 7-3
d) Regional Development	Good (+1)	Good (+1)	Fair (0)	Refer to Table 7-3
3. Economic Aspect				
a) Traffic Demand	Fair (0)	Fair (0)	Fair (0)	Traffic Volume in 2020
b) Accessibility	Good (+1)	Good (+1)	Good (+1)	Refer to Table 7-3
c) Cost-benefit Analysis	Fair (0)	Good (+1)	Good (+1)	IRR
Total	0	+3	0	-

Note: If indicators are noted in the column "Remarks", the above scoring criteria (1) is applied. In other cases, the above criteria (2) is applied.

Score: Good : +1, Fair : 0, Bad : -1

The route B is located at the middle, therefore, the environmental impact is not extreme, but modest, although there are some negative impacts to the natural as well as social environment. They will not be very serious if relevant countermeasures are provided. The total structure length is the least among the three alternatives. This suggests that the route is aligned with better topographic conditions, which will possibly results in relatively less construction costs than the other alternatives.

As the route C is located nearest to the urbanized area, impact to the social environment will be the most serious. Particularly, it will affect the communities and squatters at Ampang, Cheras, Kajang and Hulu Klang where public nuisance also will be expected.

As a consequence, the route B should be selected as the optimum alignment.

Table 7-4 : Scores of Evaluation of the Three Alternatives

Aspect	Alternatives			Remarks (Indicator for Scoring)
	A	B	C	
1. Engineering				
a) Geology	Bad (-1)	Fair (0)	Fair(0)	Refer to Table 7-3
b) Topography	Bad (-1)	Fair (0)	Fair (0)	Refer to Table 7-3
c) Construction	Bad (-1)	Fair(0)	Fair(0)	Refer to Table 7-3
d) Land Acquisition	Fair (0)	Fair(0)	Bad (-1)	Length of Urban Land
e) Project Cost	Fair (0)	Fair(0)	Fair (0)	Project Cost
2. Environment				
a) Natural Environment	Bad (-1)	Fair(0)	Good (+1)	Refer to Table 7-3
b) Social Environment	Good (+1)	Fair(0)	Bad (-1)	Refer to Table 7-3
c) Public Nuisance	Good (+1)	Fair(0)	Bad (-1)	Refer to Table 7-3
d) Regional Development	Good (+1)	Good (+1)	Fair (0)	Refer to Table 7-3
3. Economic Aspect				
a) Traffic Demand	Fair (0)	Fair (0)	Fair (0)	Traffic Volume in 2020
b) Accessibility	Good (+1)	Good (+1)	Good (+1)	Refer to Table 7-3
c) Cost-benefit Analysis	Fair (0)	Good (+1)	Good (+1)	IRR
Total	0	+3	0	-

Score: Good : +1, Fair : 0, Bad : -1

The route B is located at the middle, therefore, the environmental impact is not extreme, but modest, although there are some negative impacts to the natural as well as social environment. They will not be very serious if relevant countermeasures are provided. The total structure length is the least among the three alternatives. This suggests that the route is aligned with better topographic conditions, which will possibly results in relatively less construction costs than the other alternatives.

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As a consequence, the route B should be selected as the optimum alignment.

Chapter 8

PRELIMINARY ENGINEERING STUDY

CHAPTER 8 PRELIMINARY ENGINEERING STUDY

8.1 Engineering Key Issues

In the construction of a better quality highway, Highway Planning will play a significant role, which will require a more comprehensive and sufficient planning consideration.

The PEIA study was conducted to clarify the impacts of the project road to surrounding environment. The PEIA study not only selected the alignment but also provided significant issues for engineering study comprehensively and collaboratively, in terms of physical, biological and sociological aspects.

Four key issues, Topography, Environment, Development and Road Network were identified in Chapter 7. The four key issues will be translated into Engineering Key Issues based on the PEIA study and the engineering study for the alternative alignments.

The Engineering Key Issues should be examined and summarized into design concepts which will be applied to the preliminary Engineering Design. The Preliminary Engineering Design will be conducted based on the design standards and criteria, also taking into account those design concepts.

Seven major engineering key issues are identified as shown in Figure 8-1. Buffer zones and environmental harmony are for environmental preservation in developed and forest areas, respectively. Tunnels, bridges and slopes should be studied from the standpoint of topography and environment. Structures such as tunnels and bridges will minimize the destruction of nature and prevent slope failures.

Traffic safety is also considered as a main factor. Toll collection system is a big issue in terms of road users, traffic flow and efficiency which will be significant to interchange design.

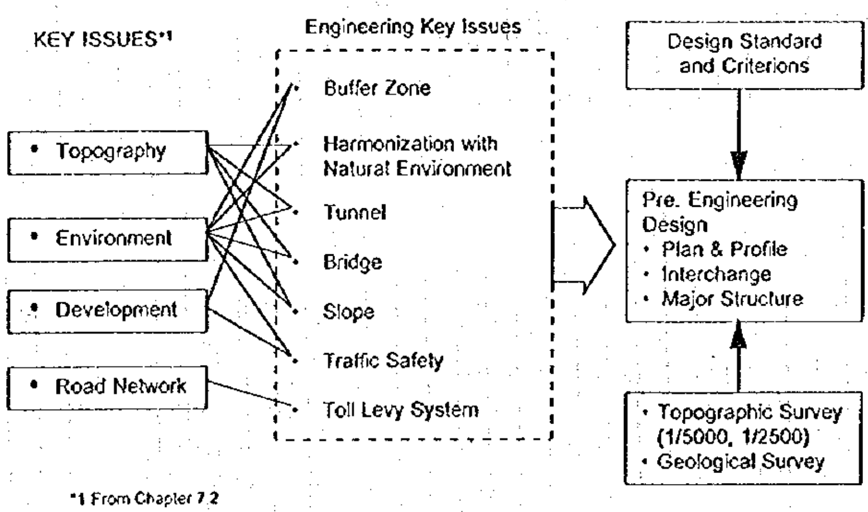

Figure 8.1 Identification of Engineering Key Issues for the Preliminary Engineering Study

Basic Data Used

Preliminary design was conducted using the following basic data and design standard.

1) Topographic Map

Topographic map of apporoximately 8,000 ha in scale of 1:5,000 was preparaed based on aerial photographs taken in May 1995. Plan, profile and structure design of ordinary section were prepared on the map.

For interchange and structural design, topographic maps of approximately 1200 ha in scale of 1:2,500 was prepared.

The results of the design are compiled in Drawings of the study Report.

2) Geological Survey

The main purpose of the geotechnical investigation was to clarify the general and detailed geotechnical conditions such as the type and quality of rocks, distribution of faults and condition of soil layers around the site area for the design of major structures on the KLORR, such as bridges, slopes, tunnels, etc.

The geotechnical investigation included a reconnaissance survey machine boring and laboratory tests.

Boring Points	: 30 locations
SPT (Standard Penetration Test)	: every 1 meter of boring
Bulk Soil Sampling	: 10 location
Laboratry Testing	
- Natural water content	
- Specific gravity	
- Grain size analysis	
- Alterberg limit	
CBR test	
Compaction Test	

8.2 Design Standard

8.2.1 Geometric Design Standard

JKR and MHA have prepared the following geometric design guides and standards:

- "A Guide on Geometric Design of Roads" issued in 1986 (JKR);
- "A Guide to the Design of At-Grade Intersections" issued in 1987 (JKR);
- "A Guide to the Design of Interchanges" issued in 1987 (JKR);
- "Design Standard for Interurban Toll Expressway System of Malaysia" (MHA).

The recommended geometric design standards for the KLORR are mainly derived from these guides and standards, supplementing some necessary items. Main design elements for the KLORR, comparing the guide and standards are shown in Table 8-1.

1) Through Carriageway

(1) Road Classification

The KLORR will pass through a forest area and some residential areas in the north and east sections. In the southern section, it will pass through urbanized areas or proposed development areas. It will serve inter-city and intra-city mixed traffic. It will be an expressway, and considering its nature and functions it will be classified as R6 and U6 in the southern section.

(2) Design Speed

The design speed of the KLORR is decided at 100km/h. A design speed higher than this will not be necessary, considering the function of the KLORR. Long and high speed trips will not be predominant, as in the inter-city expressway. But, a design speed of 80km/h might be necessary for the sections of the KLORR passing through mountainous and hilly areas.

(3) Lane Width

Careful consideration of lane width is important to road planning. It reflects the speed and nature of traffic, which the road should serve. For the KLORR, a lane width of 3.65m is adopted. The KLORR will not be expressway like inter-urban expressways, which have a lane width of 3.75m serving high speed, long inter-city trips. But, to serve development projects in the suburbs, a lane width of 3.50m will not be enough.

(4) Shoulders

A shoulder width of 3.00m is adopted following the existing standards. But, for the tunnel and long span bridge sections, the shoulder is reduced by 1.00m to cut construction cost.

(5) Medians

A median of 4.00m is adopted following the existing standards.

(6) Maximum Superelevation and Minimum Radius

The maximum superelevation and minimum radius together with the design speed are closely related to each other. The relation between radius and superelevation is obtained from the following equation:-

$$R = V^2 / 127(i+f)$$

Where,

R : Radius
V : Design Speed (km/h)
i : Superelevation (m/m)
f : Lateral Friction Factor

Table 8-1: Geometric Design Standard for the Outer Ring Road
Road Categories : Expressway

				J.K.R (Jabatan Kerja Raya)						M.H.A (Malaysian Highway Authority)				JICA (KL Outer Ring Road Project)	
Design Control & Criteria	1	Design Standard		RURAL R6			URBAN U6								
	2	Access Control	-	FULL						FULL				FULL	
	3	Area Type		F	R	M	I	II	III					F	R.M.
	4	Design Speed	km/hr	120	100	80	100	80	60	140	120	100	80	100	80
Cross Section Elements	5	Lane Width	m	3.50			3.50			375				3.65	
	6	Shoulder Width	m	3.0	3.0	2.6	3.0	3.0	2.5	3.00				3.00	
	7	*1 (Structure >100m)	m	1.0			1.0			0.50				1.00	
	8	Median Width (Minimum)	m	6.0	5.0	4.0	4.0	3.5	3.0	4.0				4.00	
	9	Median Width (Desirable)	m	18.0	12.5	8.0	12.0	9.0	6.0	6.0				-	
	10	Marginal Strip Width	m	0.50			0.50			0.20				0.50	
	11	Minimum Reserve WIDTH	m	60			60			-				60	
Elements of Design	12	Stopping Sight Distance	m	285	205	140	205	140	85	325	225	150	100	225	150
	13	Passing Sight Distance	m	Not Applicable			Not Applicable			Not Applicable				Not Applicable	
	14	Minimum Radius	m	570	375	230	465	280	150	1000	650	450	240	500	230
	15	Minimum Length of Spiral	m	See Table			See Table			See Table				See Table	
	16	Maximum Superelavation	Ratio	0.10			0.06			0.07				0.10	
	17	Maximum Grade (Desirable)	%	2	3	4	3	4	5	-	-	-	-	3	4
	18	Maximum Grade	%	5	6	7	6	8	8	3	4	5	6	5	6
	19	Crest Vertical Curve (K)	-	120	60	30	60	30	15	(R) 27000	12,000	6,000	3,000	(R) 12,000	6,000
	20	Sug Vertical Curve (K)	-	60	40	28	40	28	15	(R) 8,000	5,000	3,000	1,800	(R) 5,000	3,000
Overhead Clearance			m	5.10 (5.00 + 0.10)						5.40 (5.20 + 0.20)				5.40 (5.20 + 0.20)	
Remark															

(7) Maximum and Minimum Grade

Maximum gradient are normally determined based on the condition that fully loaded trucks can climb slope maintaining speed of at least half the design speed. The gradient of 3% for design speed of 100 km/h, are adopted respectively as a desirable maximum grade. At slope where steeper grade than desirable grade are needed, critical length of grade should be considered.

(8) Vertical Curve

Vertical curves have effect in smoothening the vertical alignment between tangent grade in crest or sag. This should result in a design that is safe, comfortable in operation, pleasing in appearance and adequate for drainage.

A standard cross section for the KLORR is shown in Figure 8-2 and Geometric Design Standards are shown in Table 8-1.

2) Interchanges

(1) Design elements of through highway

The geometric design standard of through highway at an interchange area should be higher than that of a normal section of highway to facilitate diverging, merging and weaving, and to provide longer sight distance.

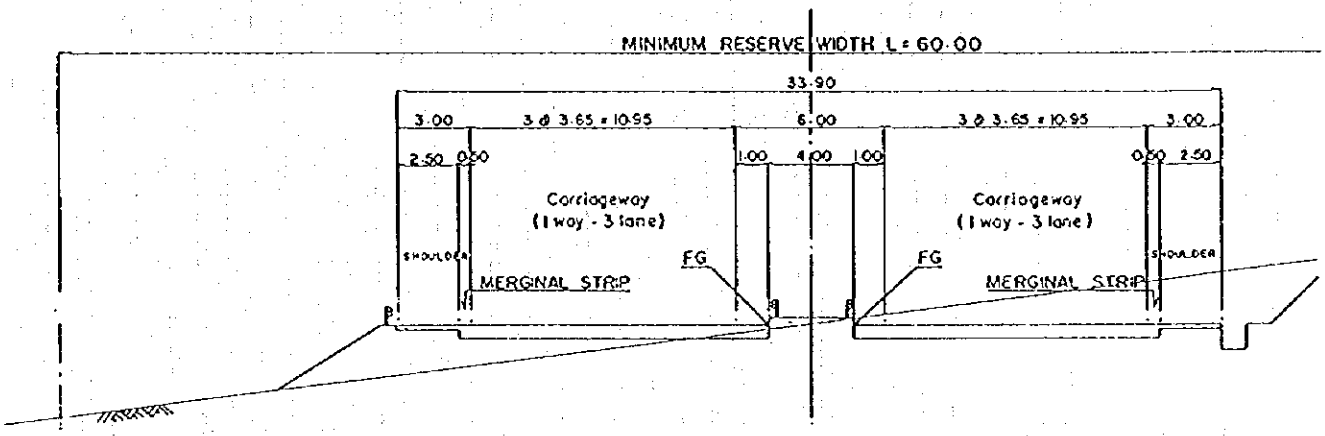

Figure 8-2 : Standard Cross Section

(7) Maximum and Minimum Grade

Maximum gradient are normally determined based on the condition that fully loaded trucks can climb slope maintaining speed of at least half the design speed. The gradient of 3% for design speed of 100 km/h, are adopted respectively as a desirable maximum grade. At slope where steeper grade than desirable grade are needed, critical length of grade should be considered.

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2) Interchanges

(1) Design elements of through highway

The geometric design standard of through highway at an interchange area should be higher than that of a normal section of highway to facilitate diverging, merging and weaving, and to provide longer sight distance.

(2) Design Speed in Interchange Ramp

"A Guide to the Design of Interchanges" prescribes the table for the ramps design speed as shown in Table 8-2.

Table 8-2 : Ramp Design Speed

Highway Design Speed (km/h)	Ramp Design Speed (km/h)		
	upper	middle	lower
120	90, 80	70	60 (50)
100	80, 70	60	50
80	70, 60	50	40
60	50	40	30
50	40	30	25

( ) is applicable only for loops

4) Capacity

To determine the required number of lanes, the capacity of the KLORR is analyzed. The concept and methodology used for the analysis is based on the Highway Capacity Manual of the Highway Research Board, USA. Some adjustments are made to reflect local conditions based on the results of "A Guide on Geometric Design of Roads of Malaysia", as shown in Table 8-3.

Table 8-3 : Capacity of the KLORR

Description		Throughway		Rampway	
				Semi-Direction	Loops and Diagonal
Design Speed (km/h)		100	80	60	40
Terrain or Grade		Flat	Rolling	4%	5%
Basic Capacity (PCU/Hour/Lane)		2000	1900	1900	1900
Service Level		C	C	C	C
Coefficient of Service Level		0.75	0.75	0.75	0.75
Service Volume (PCU/Hour/Lane)		1500	1400	1400	1400
Lane Width (m)		3.65	3.65	3.50	3.50
Lateral Clearance (m)	Shoulder side	3.00	3.00	2.50	2.50
	Median	1.00	1.00	0.75	0.75
Heavy Vehicle	Ratio of H.V.(%)	20	20	20	20
	Composite PCE	1.44	1.44	1.60	1.60
Coefficient	Width of Lane	1.00	1.00	1.00	1.00
	Lateral Clearance	1.00	1.00	0.97	0.97
	Heavy Vehicle	0.69	0.69	0.63	0.63
	Total	0.69	0.69	0.61	0.61
Design Service Volume (Veh/Hr/Lane)		1035	990	850	850
PHF(%)		8	8	10	10
DDR (%)		60	60	60	60
Design Daily Capacity (Veh/Day/Lane)		10800	10300	7080	7080

8.2.2 Bridge Design Standard

1) Standard to be used

Prevailing bridge standard specifications and other structural design guidelines in Malaysia, summarized below, are adopted for the study.

- Guideline Book for Bridge Design (Buku Panduan Rekabentuk Jambatan).
- Concrete Bridge Design Guidelines - published by the Design and Research Section in the Public Works Department (JKR) in November 1985.
- Inter-urban Toll Expressway System of Malaysia, Design Standard, Comprehensive Design Standard of Interurban Toll Expressway System - published by the Malaysian Highway Authority in November 1986.

For supplementary purposes, the following standards are used as guidelines:

- Specifications of Highway Bridges published by the Japan Road Association.
- Design Manual published by the Japan Road Authority.
- Standard Specifications for Highway Bridges published by the American Association of State Highway Officials (AASHTO).
- Series of Specifications and Codes published by the British Standards Institution (BSI).

2) Major Design Load

Major design loading criteria adopted in this study are as follows:

(1) Dead Load

Structural Steel	7.85 ton / cu.m
Reinforced Concrete	2.5 ton / cu.m
Portland Cement Concrete	2.3 ton / cu.m
Asphalt Cement Concrete	2.35 ton / cu.m
Backfill Material	1.8 ton / cu.m
Embankment Material	1.8 ton / cu.m

(2) Live Load

a) Type HA Load (Normal Loading)

This load approximately represents the effect of three vehicles, each 22 tons in weight, closely spaced, in each of two carriageway lanes, followed by 10 tons and 5 tons vehicles. A 25% allowance for impact is included. Type HA load consists of three components:

(i) HA-udl load, uniformly distributed load

(ii) HA-kel load, knife edge load, acting across the width of lane
(iii) HA-wheel load

HA-udl and HA-kel loads are given in charts and diagrams in conjunction with design lane width and loaded length. Standard cross-sectional loading is shown in Figure 8-3. The loaded length is usually the base length of the positive or negative portion, as the case may be, of the influence line diagram for the member under consideration.

As for continuous construction, where the positive or negative portion of the influence line appears in a complicated shape, the maximum effect for the member under consideration is to be studied, taking into account any possible combination of the separate loaded length. In such case, the loaded length is the sum of the separate loaded lengths. Figure 8-5 and 8-6 show the example of influence line loading on 2-5 span and 4-5 span continuous structures.

b) Type HB Load (Abnormal Loading)

This load caters for safe passage of a single abnormally heavy vehicle (16 wheels, four axles) up to 180 tons, and would be used when specified by the appropriate authority. The HB vehicle is shown in Fig 8-4.

The full HB load per axle is 450 kN (approximately 45 tons). Type HB load is often expressed in Units (1 unit = 10 kN, approximately 1 ton) per axle. The full type HB load is often referred to as 45 units.

As the case may be, 37.5 units or 30 units are adopted for design. No allowance for HB load impact is made.

(iii) Loads Due to Centrifugal Force

Where the bridge carriageway is curved, a load for centrifugal action of the vehicles (Fc) is considered in designing the members. Fc is given as follows:

$$Fc = \frac{30,000}{r + 150} \text{ kN}$$

where, r = radius of lane (m)

This load is imposed on up to two lanes and any numbers anywhere every 50m in longitudinal direction.

(iv) Breaking Loads (Longitudinal Load)

This load represent the traction and breaking force of vehicles. The one force for width of bridges shall be applied over an area 3.0m wide by 9.0m long, or the length of the bridge, whichever is less. The force shall be loaded at the level of the carriageway surface in longitudinal direction so as to cause the worst effect on the member under consideration. In conjunction with the span length the force ranges from 100kN (approximately 10 tons) to 253 kN (approximately 25.3 tons).

(v) Seismic Loads

No seismic force is taken into consideration.

(vi) Wind Loads

Wind forces, though rarely significant in small-span and medium-span bridgework, can be critical in bridges like the suspension type where the span is large. Generally, any structure which is sensitive to stability problems will inevitably tend to be more sensitive to wind loading.

(vii) Load Due to Shrinkage, Temperature and Creep

These are horizontal loads due to forces generated in the beams / slabs caused by shrinkage, temperature and creep in the material.

3) Material and Allowable Stress

The use of major materials and required strength of each of them are shown in the following tables.

Table 8-4(a) : Design Compressive Strength of Concrete

Class	Design Compressive Strength at 28 days	Use
A	400 kg / cm²	Prestressed Concrete Structure Casting on Site.
B	300 kg / cm²	Steel Reinforced Superstructure
C	300 kg / cm²	Steel Reinforced Substructure
D	200 kg / cm²	Non Reinforced Substructure

Table 8-4(b) : Tensile Strength of Reinforcing Steel

Type	Tensile Strength	Yield Strength
Round Bar	1400 kg / cm²	24 kg / mm²
Deformed Bar	1800 kg / cm²	30 kg / mm²

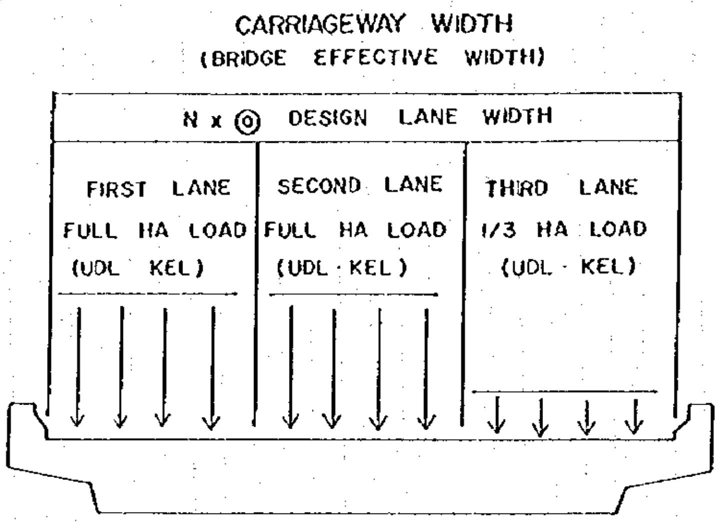


Figure 8-3 : Type HA Loading

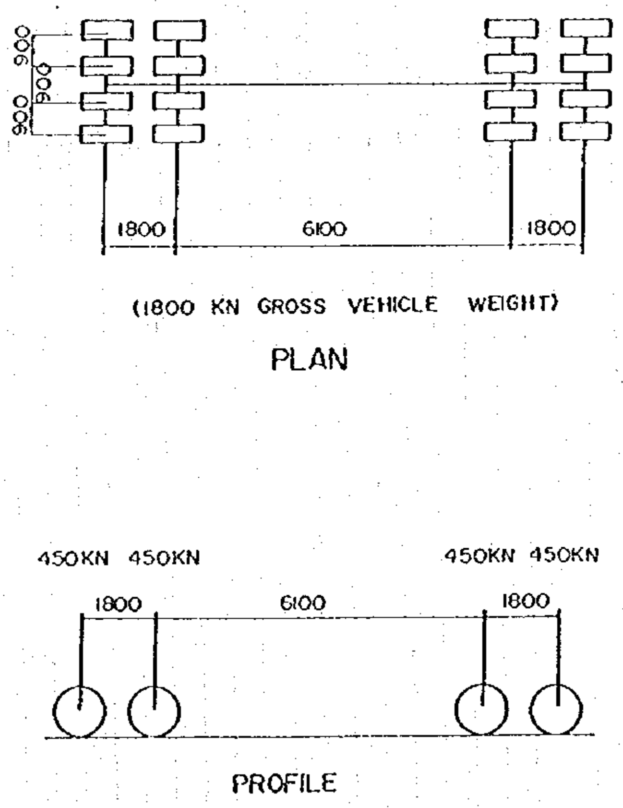


Figure 8-4 : The HB Vehicle

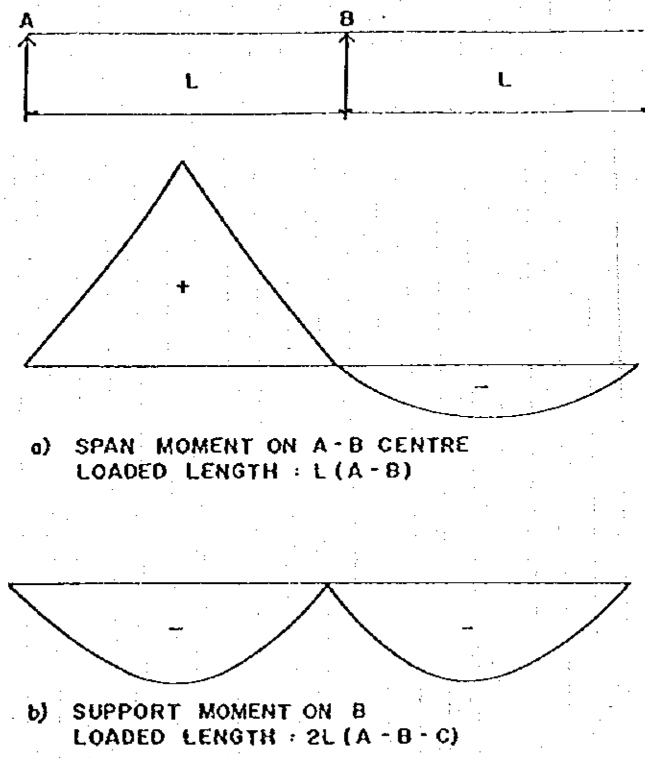


Figure 8-5: Influence Lines For 2-Span Continuous Structure

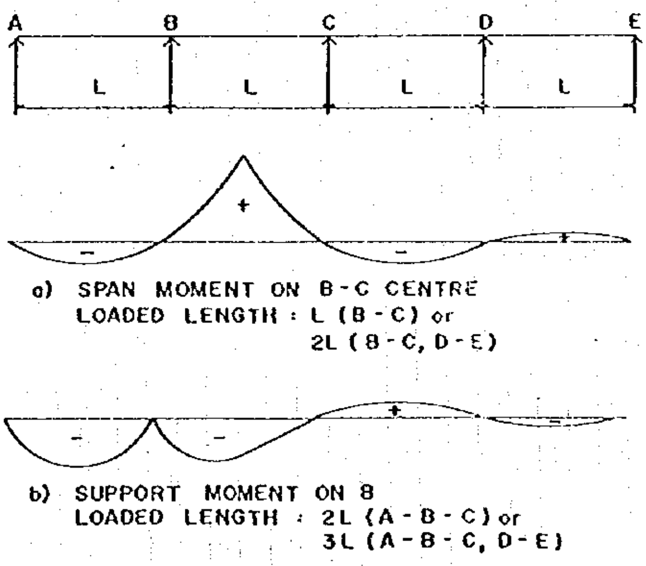


Figure 8-6 : Influence Lines For 4-Span Continuous Structure

Table 8-5 : Strength of Prestressing Steel (SWRP 7A T12.4 and SBPC 125)

Name	Yield Strength	Breaking Strength
PC7-Wire Strand	150 kg / mm²	175 kg / mm²
PC-Bar	110 kg / mm²	125 kg / mm²

8.2.3 Pavement Design Standard

1) General

Pavements can be broadly classified into flexible and rigid types.

In selecting the type of pavement for each road, the following features of each pavement type are taken into consideration :

(a) Ease of construction and maintenance
(b) Resistance to rot and wear
(c) Stage construction
(d) Materials used
(e) Skid resistance
(f) Initial investment
(g) Difficulty in repair

Considering the climatic and environmental conditions, physical properties and condition of the roadbed soils and the heavy traffic volume in the Klang Valley, the most reasonable design procedure was selected from procedures as described in the Road Note 29 and 31, and Japan Road Association Standards.

2) Optimum Design of Flexible Pavement Structures

Flexible pavement is recommended for throughways, ramps, frontage roads and bridges. The optimum design of flexible pavement structure for the project road is discussed in subsection 8.5.4 pavement.

3) Optimum Design of Rigid Pavement Structure

Rigid pavement with slab thickness of 30cm is recommended in the toll plaza area for all road segments.

8.3 Basic Design Policy

8.3.1 Buffer Zone

A buffer zone between carriageways and adjacent properties is an important countermeasure for environmental preservation, especially traffic nuisances such as noise, air pollution and vibration. The type of buffer zone is determined from the land use of roadside areas.

Table 8-6 and Figure 8-7 show the type of buffer zones by land use. Five types of buffer zones are proposed for different land uses and road side conditions. The widths of the buffer zone are examined based not only on the influence of traffic nuisances, but also on urban landscaping, with reference to the National Landscape Guideline - JPBD.

Table 8-6 : Roadside Land Use and Buffer Zone Type

• Residential Area

Type of Urban Areas	Roadside Conditions	Type of* Crossing Section	Right of way and (one side width of BZ) (m)
Existing Urban Area	General Types	A	80 (23.05)
	Crossing Urban Area (with service road)	B	100 (21.05)
Approved Urban Area (Structure Plan / Local Plan)	With Service Road	B	100 (21.05)
	High Level Environmental Residential Area	C	120 (31.05)
Future Developed Area	With Service Road	B	100 (21.05)

• Industrial Area (Commercial Area)

Type of Urban Areas	Roadside Conditions	Type of* Crossing Section	Right of way and (one side width of BZ) (m)
Existing Urban Area	General Type	D	60 (13.05)
Approved Urban Area (Structure Plan / Local Plan)	With Service Road	E	80 (11.05)
Future Developed Area	With Service Road	E	80 (11.05)

• Open Space Area

Type of Urban Areas	Roadside Conditions	Type of* Crossing Section	Right of way and (one side width of BZ) (m)
Open Space	-	D	60 (13.05)

Note : * Reference to Figure 8-7

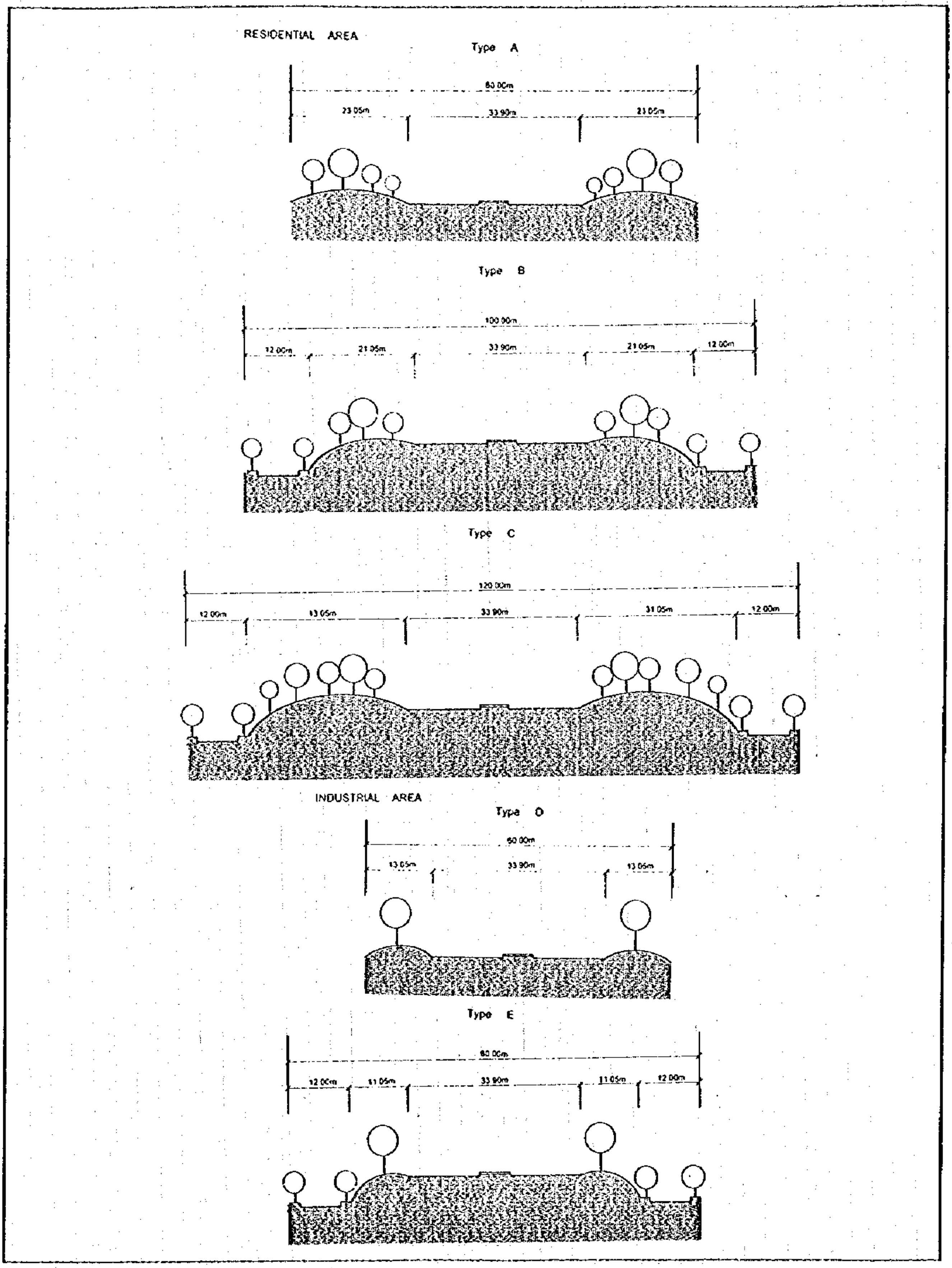


Figure 8-7 : Types of the Buffer Zones

To decide the type of buffer zone for the KLORR, roadside areas of the project are examined from the standpoint of density of buildings, land use type, condition of infrastructure development and so on, as mentioned in Table 8-7.

Based on the analysis, eleven sections are proposed to be provided with buffer zones. The locations and type are shown in Figure 8-8.

Table 8-7 : Roadside Conditions and Buffer Zones for the KLORR

Section *1		Density of Building		Land Use Pattern				Infrastructure Development		Land use on the Development Plan *2					Distance from Interchange		Area Classification *3	Bufferzone Type *3
		High	Low	Residential	Commercial	Industrial	Others	Sufficient	In Sufficient	Residential	Commercial	Industrial	Others	Not Available	Close	Far		
1	In	•		•				•		•					•		a-1-1	C
	Out	•		•				•		•					•		a-1-1	C
2	In		•	•					•					•		•	a-2	A
	Out		•	•					•					•		•	a-2	A
3	In	•		•				•		•						•	a-1-1	C
	Out	•		•				•		•						•	a-1-1	C
4	In		•	•					•			O		•	•		c-1	E
	Out		•	•					•			O		•	•		c-1	E
5	In		•				•	•				O		•	•		c-1	E
	Out		•				•	•				O		•	•		c-1	E
6	In		•	•				•	•	O				•		•	a-1-1	B
	Out		•				•		•	O				•		•	c-2	B
7	In		•				•		•	O				•		•	c-2	B
	Out	•		•				•		O				•		•	a-1-1	B
8	In		•	•					•	•						•	a-1-1	B
	Out		•	•					•	•						•	a-1-1	B
9	In		•				•		•					•	•		a-2	D
	Out	•					•	•					•		•		a-1-1	A
10	In		•				•		•					•	•		a-2	D
	Out	•					•	•					•		•		a-1-1	A
11	In		•				•		•					•			b-4	D
	Out		•				•		•					•			b-4	D

*1 See Figure 0.0
*2 • Existing Situation
O Proposed by the Study Team
*3 See Table 0.0

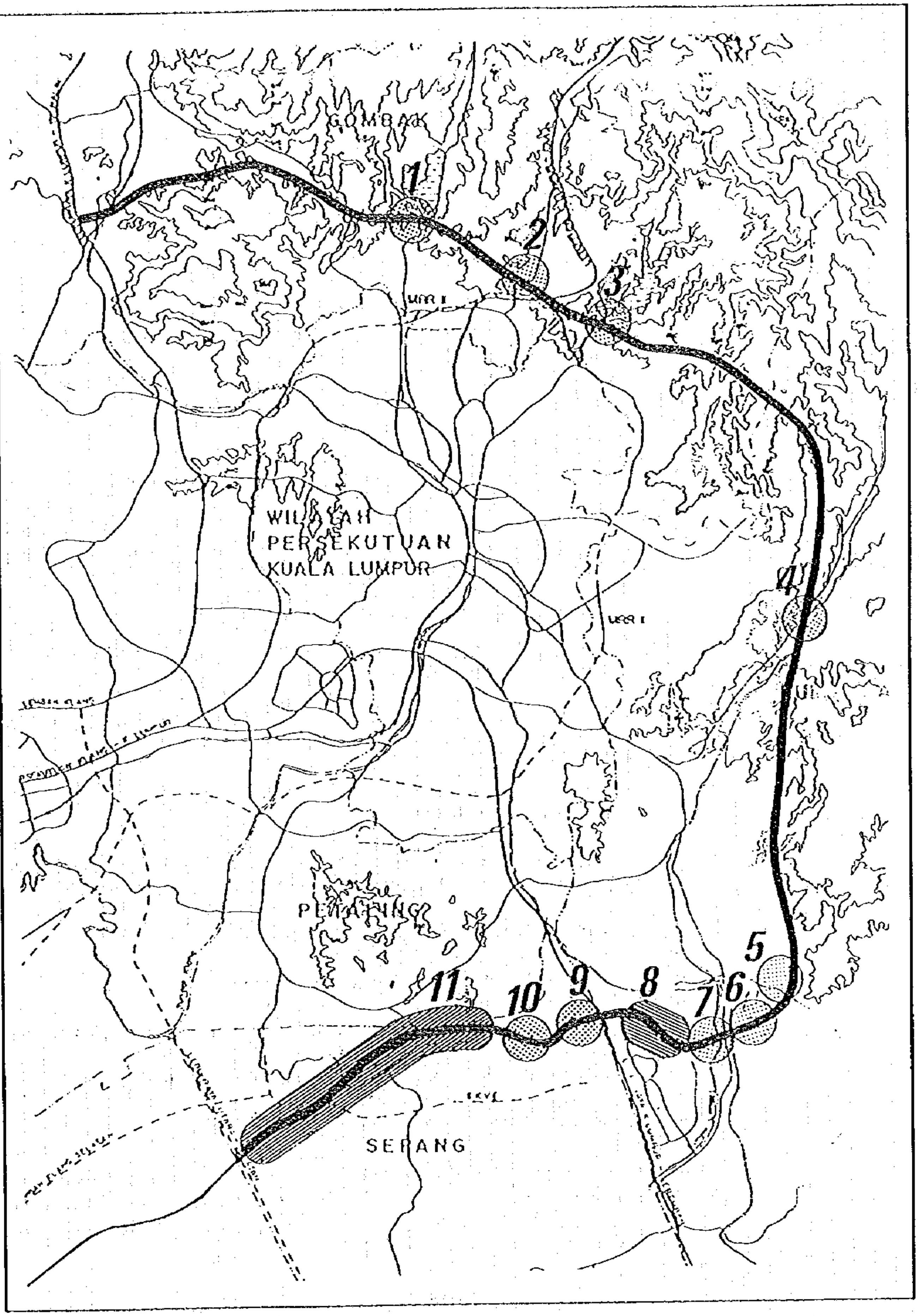


Figure 8-8 : Analysis Section for the Position of Buffer Zones

8.3.2 Harmonization with Natural Environment

1) Conservation of the Environment through Planting

Although highways are artificial facilities, they can be harmonized with the background natural environment by carefully deliberated mitigation measures. In case where the project road will affect landscape and wildlife, it is important to consider a planning application to preserve them.

To mitigate the impact caused by the development of the project road, the planning application can be by planting trees, and it can be effective for landscaping too. The planting for landscaping, in fact, can be effective to the wildlife conservation in the vicinity of the project road, and also contribute to a reduction of public nuisance such as air pollution.

(1) Landscape Planting for the Improvement of the Living Environment

Where the project road pass near schools, hospitals and residential places in a suburban area, planting trees in ROW for landscaping will improve the living environment.

In determining the pattern and size of landscape planting, the type and number of buildings alongside the road, environmental quality, and land use pattern should be taken into consideration.

The model pattern will be a multi-storied planting with evergreen trees as the core zone, surrounded by a mixture of tall, medium and low deciduous and other soil improving trees.

(2) Landscape Planting Technique

The landscape planting technique has not yet been well established and remains debatable. However, the following points can be taken into consideration:

(a) Planting of native species.
(b) Transplanting useful existing trees.
(c) Conservation of scientifically important plants.
(d) Conservation and recycling of the top soil.
(e) Protection by planting along the edge of forest, using sleeve and mantle communities.
(f) Planting trees and plants which provide food for birds.

2) Landscape Planting for Wildlife Conservation

The development of the project road will affect wildlife environment during construction as well as operation phases. In order to minimize the disturbance, the continuity of wildlife habitat with regard to topography, vegetation, soils and other factors should be secured in the design and construction of the road.

Various species of wildlife inhabit natural, wide and continuous forests. The road development may often divide wildlife habitat linearly and causes detrimental effects to wildlife.

The followings three mitigation measures are considered. Figure 8-9 demonstrates some examples of them.

(1) Mammal Trail with Planting

This is a way to connect both sides of forest habitats which are divided by the highway. There are two methods: One is a tunnel by box culvert under the highway. The other is an overhead bridge above the highway.

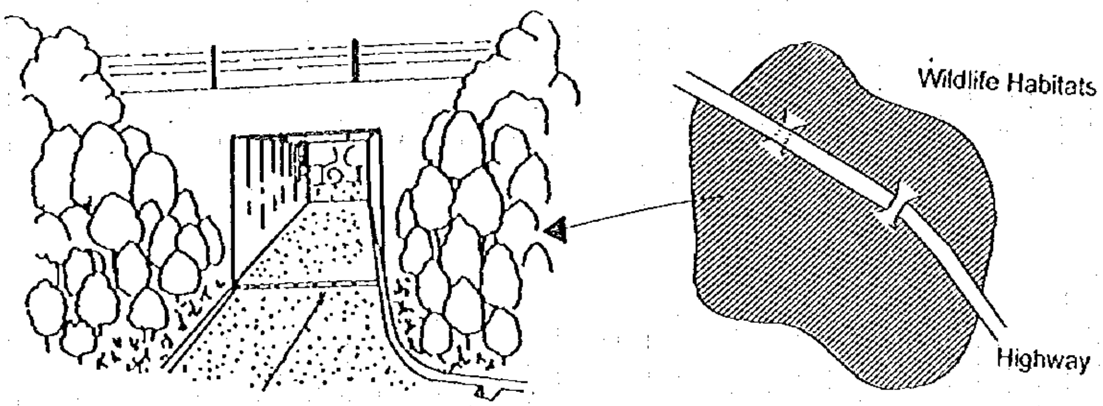
In either method, vegetation should be planted near the facilities for hiding wildlife refuge. The fence along the highway will prevent wildlife from crossing the road, thus encountering accidents.

(2) Forest Cut Edge Recovering with Planting

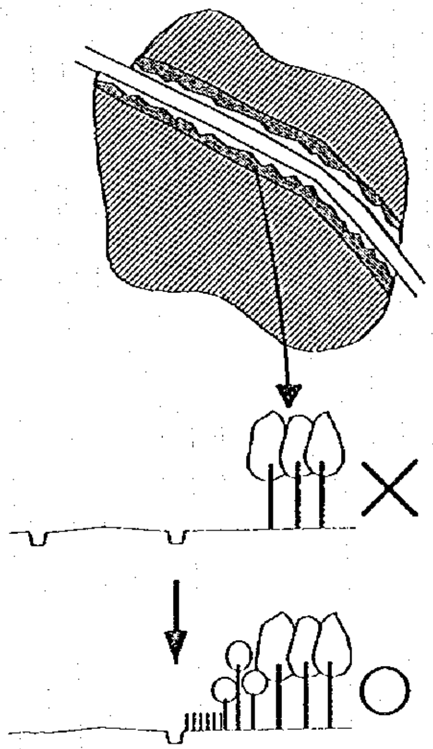
Highway construction in forest area not only divides habitats but also endanger flying wildlife, especially birds by traffic flow. Trees planted artificially near by the road will help them to fly over the road safely.

(3) Wildlife Corridor with Planting

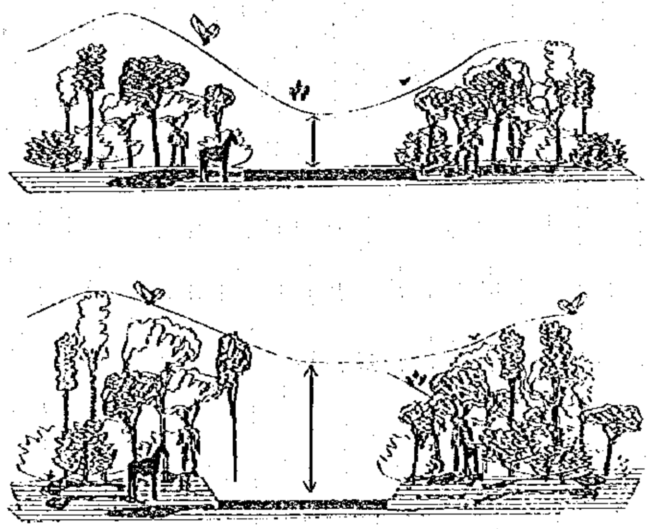
It is useful for wildlife conservation to connect the separated forest habitats by a vegetation corridor. In the vegetation corridor, wildlife can hide themselves and use the corridor safely.



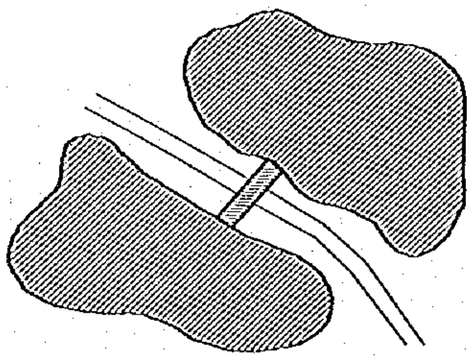
● Mammals Trails



● Edge Recovering with Planting



● Measures for Birds And Flying Insects



● Wildlife Corridor with Planting

Figure 8-9 : Mitigation Measures for Wildlife

8.3.3 Traffic Safety

Traffic safety was considered in designing the project road, based on drivers' concern and feeling to the existing highways and expressways. A drivers' interview survey was conducted on the Karak highway and the N-S expressway to collect information regarding awareness and concern of the drivers. The method, questionnaire and detailed analysis, including cross statistical analysis are included in Technical Report.

Some of the results are reflected in the KLORR design. Suggestions for the KLORR design are made as follows, from the standpoint of traffic safety.

(1) Elimination of drivers' anxiety

It is normal and natural that the high percentage of drivers felt anxiety in the heavy rain in running below high cutting section. 50% of drivers pointed out their anxiety while driving on the mountain side sections of high cutting even though they are designed according to the design standard of N-S expressway.

It is recommended that the length and height of road side slopes on the KLORR should be as short and low as possible.

(2) Keeping constant speed

It is important to keep a constant speeds not only for accident prevention but also for comfortable driving. Changing speed is one of the causes of accidents.

A gentle vertical alignment should be reconsidered. 5% is the steepest gradient recommended for the KLORR.

(3) Facilitate steering

In order to keep a constant speed, it is noted that the curved section after the straight section should be designed smoothly.

70% to 90% of drivers on the Karak and N-S Expressway pointed out that steering their vehicles on sharp curves on downward slopes was most difficult. The sharp curve between the long and straight sections should be well treated.

(4) Pay more attention to tunnel design

Number of tunnels including one with length more than 3KM are planned in the KLORR. The tunnels in the KLORR will be designed with higher standerd than Genting Tunnel in the KL - Karak Highway.

Several aspects were pointed out in the tunnel driving survey, such as visibility, air ventilation and emergency systems. According to the survey results, the following items should be considered in design:

- Design of tunnel entrance : Usually, speed is reduced just before the tunnel entrance. There are many reasons, but anxiety and feelings of oppression are some. The design of tunnel entrance should be well considered.

- Gentle vertical alignment : The vertical alignment is recommended to be designed at less than 2%, if possible around 1%, to make traffic floor smooth and to minimize the speed difference, especially with lorries.

- Provision of Emergency Refuge : It is required to provide emergency refuge for broken down vehicles in a tunnel. The interval of space should be at least 1,000 m.

8.3.4 Toll System

1) General

Toll system will be an important part of operational issue of the KLORR if it will be constructed and managed by privatized scheme. To ensure smooth traffic flow and fair toll system, the Study proposed that toll system of the KLORR be a close system and integrated among toll expressways and highways in Malaysia. As there is an increasing tendency of the number of concession companies to construct expressway, it is necessary to establish the method to manage toll system.

Such a system is also considered to render good service of expressway to user and to reduce emission of pollutant by avoiding stop and go operation at toll booth. If the toll booth is installed at the entrance of every different managing body of expressways, the problem of inconvenience to driver will increase, especially at the connecting interchanges. If the KLORR is to be constructed by plural concession companies, this problem would happen in the KLORR itself. To make stops of drivers minimum some technical method is proposed.

2) Examination of Toll System

There are many toll expressways and highways already open to traffic in Malaysia. Two systems to collect toll, i.e. close toll system and open toll system are commonly used in the country. Their application are compared as follows.

(1) Open toll system

Toll barriers on main lane are needed to be installed dividing the KLORR into several sections. In this system there are some trips which are not covered by this toll barrier installation. It means there are some trips which will use the KLORR without paying toll. To prevent them some more toll barrier will be needed to be installed resulting more frequent stop.

At system interchanges with existing toll expressways, toll plazas are needed to be installed. For long distance traveller nuisance to stop at toll plazas and toll barriers will be troublesome even though there are some trips not covered by this system.

(2) Close toll system

Toll plazas are installed at entrance and exit of service interchanges. Users will get a ticket at entrance toll plaza encoded interchange name, vehicle type, date and time. The user will have to pay toll fee at exit toll plaza proportional to the travel distance on the expressway. As the KLORR will cover 88 km long section, toll charge should be fair for every user.

4) Integration of toll system with the existing toll expressway

For the traveller through the existing toll expressway and the KLORR, the same principle will be applied. They get ticket at entrance toll plaza and they will pay toll fee at the exit toll plaza. The toll charges are calculated according to the trip length of both expressway multiplied by their unit toll rate. Even if the trip is made over the section of different managing bodies the method is basically the same.

Toll plaza will not be needed to be installed at the interchange of the KLORR with other expressway, thus, it will be able to ensure smooth traffic flow at interchanges.

But, toll plaza should be installed at interchange with open toll road for each direction of traffic. A fixed toll fee can be charged at toll plaza. For the directional flow, toll will be charged as follows.

i) Open toll road to the KLORR
fixed toll fee will be collected and ticket will be issue for the KLORR at toll plaza

ii) The KLORR to open toll road
toll fee will be collected for the KLORR and open toll road depending on the direction.

5) Management of toll collection

To manage toll collection system toll managing center should be established. At the center all traffic information of the system is transmitted and stored. Amount of toll fee which should be collected is calculated immediately based on the traffic data.

The due shares of collected toll fee for concession companies are also calculated. And the balance between due share and the actual collected amount will be transacted among concession companies for a certain unit of time say a month.

Contract among the concession companies should be made regarding the exchange of traffic information and transaction of collected toll fee.

6) Network Types

There are two types of network:

(i) "tree network" -- a single route for every interchange pair

(ii) "mesh network" -- plural route for a certain interchange pair

Toll charge will be simple for the tree network which will appear at stage construction period. However, collection of toll will be complicated in case of mesh network. For mesh network that will appear at the completion of ring road, the route which a user traveled should be clarified to charge toll at exit toll plaza. For the purpose, some equipment will be needed to be installed at some strategic points on the KLORR to clarify the traveled route.

(1) Check booth
Check booth will be installed to encode the points on the ticket.

(2) Vehicle identifier without stopping
Road side facility to identify the individual vehicle by radio wave emitter and receiver with on board device. Such a facility will be realized by the year of completion of the KLORR

(3) Traffic counting station
Installation of precise traffic counter and to calculate the traffic volume separating the traffic with single route and plural route .

8.4 Design of Plan and Profile

8.4.1 Design of Alignment

The alignment designed on a 1:5,000 map is contained in the separate volume of drawings. In this section the outline of final alignment is discussed.

1) Section 1

This section is from the interchange with the North-South Expressway to the Interchange with the KL-Karak Highway.

(i)	length	22.830 meter
(ii)	interchanges	4 numbers
(iii)	tunnels	3 numbers, length 3,560 meter
(iv)	bridge	22 numbers, length 6,050 meter

(1) North - South Expressway to FR No.1

It starts at the intersection with the North-South Expressway, at north of Kuang town. The type of interchange is a combination of loops and directional ramps. Service to Kuang town is added to the interchange.

Then, it turns to north eastward along the Malayan Railway, then turns eastward to Kanching forest. The main structure of this hilly area is cut and fill but bridges are designed at the crossing points of the railway and some rivers.

Then, it passes under the mountain range and Bukit Lagong forest reserve (FR) by a tunnel of 1,320 meters to the valley where Federal Route No.1 runs. The highest elevation of this area is 145 meters and the lowest is 60 meters. A 3% gradient is used to climb to the tunnel section.

From there, it passes through the valley south of FR No.1 with the elevation around 100 meters, then intersects it. Almost all radii of horizontal curves are around 1,500 meters but in some sections radius of 800 meters are used.

(2) FR No.1 to Karak Highway

It passes through a mountain range behind newly developed area by a tunnel of 1,800 meters, then it passes near the residential area of Taman Jasa Utama and intersects State Road B 23 below the Batu Dam. The highest elevation is 150 meters and lowest is 78 meters.

It runs eastward to the mountain area north of Taman Sri Gombak with a short tunnel of 400 meters long, with cut and fill method to Sungai Gombak and KL-Karak Highway. The interchange with the Highway is designed along the west bank of Sg. Gombak.

The highest elevation is 130 meters and lowest is 80 meters in the section along Sg. Gombak. The steepest gradient of 4 % is used only in a short section. The rest of the section contains a gradient of less than 3%.

Radii of horizontal alignments are around 1,000 meters or more, except for one section crossing FR No.1.

2) Section 2

This section covers the section from the KL-Karak Highway to Federal Route No.1 (Jalan Cheras), it passes through a mountain range and Ulu Langat Malay Reserve.

(i)	length	37.580 meter
(ii)	interchanges	3 numbers
(iii)	tunnels	3 numbers, length 5,730 meter
(iv)	bridge	38 numbers, length 9,270 meter

(1) The KL-Karak Highway to Jalan Ulu Langat (State Road B52)

After crossing the Karak Highway it passes under the quartz ridge by a tunnel of 1790 meters long. Then by a viaduct it passes through Taman Melawati. Then it passes through the foot of the quartz ridge by cut and fill and bridge where filling depth deemed too high. Then it climbs a mountain range from 100 meters to 220 meters with a 4% grade for 2,800 meters long.

It passes under the top of the mountain and Ampang water catchment and forest reserve by a tunnel of 3,170 meters long. Then, it turns southward descending the mountain range by gradient 4% and 2% to the lowland along Sg. Ulu Langat, where the height is around 60 meters.

It forms interchange with the proposed Ampang Elevated Highway extension in the area. Then it forms interchange with Jalan Ulu Langat (State Road B 52). The design speed of this section is 80 km/h.

A radius of 800 meters is used to climb the mountain when winding through the range. But, in lowland along Sg. Ulu Langat larger radii are used.

(2) Jalan Ulu Langat to Federal Route No.1 (Jalan Cheras)

It forms Interchange with the proposed West East Link extension after the Interchange with Jalan Ulu Langat. Then it turns to a hilly and mountainous area in the east of Cheras and Kajang town in order to avoid the newly developed area of Sg. Long and the Prison. By radius of 1,500 meters it turns west to the south of Kajang Town.

The main structure in the area is cut and fill, but a short tunnel of 750 meters is planned, also bridges are designed in the valleys where filling with culverts become too difficult. The highest elevation is 95 meters and the lowest is 61 meters.

The steepest gradient is 3% near the tunnel and hilly area. Horizontal alignment will have also sharp curves in the hilly area where a radius of 800 meter is frequently used, like the one at the corner of the Prison.

3) Section 3

This section covers the section from the crossing point with Federal Route No.1 to the ending point at North-South Central Link.

(i)	length	28,500 meters
(ii)	interchanges	6 numbers
(iii)	bridges	19 numbers, length 6,110 meters

(1) FR No.1 to KL-Seremban Expressway

After crossing FR No.1, it forms interchange with FR No.1 which is system class B double trumpet type. Then it passes westward north of a golf course and crosses the Malayan Railway, from where it crosses the residential area of Bangi New town.

Then it turns north west to State Road B 11. By a viaduct type structure it passes on B 11 to the Kajang interchange. At the Kajang interchange, a system class A interchange is planned without disturbing present functions of the service Interchange.

The steepest gradient is less than 3 %, reflecting the flat terrain. The sharpest curve of 800 meters is used to fit and avoid control points.

(2) The KL-Seremban Expressway to N-S Central Link

It passes through the north of B11 until it connects the Damansara-Puchong Road. It forms Interchange with the Urban Motorway in Putra Jaya. The main structure is cut and fills and bridges where filling depth becomes very high.

It crosses the Dedicated Highway and forms interchange with the Damansara- Puchong Road. Then it runs to low land of less than 20 meters except one hill where cutting heights will be high. The main structure is filling but bridges are planned at crossing points of rivers. One service interchange of trumpet type is planned to serve the Putra Jaya privatized zone.

At the ending point it crosses the N-S Central Link and forms an interchange. The type of interchange will be a combination of loops and direct connection ramps.

Almost all of the gradient is less than 3% reflecting flat terrain condition and curves are larger than 800 meters.

8.4.2 Horizontal Alignment

Table 8-8 shows the results of the horizontal alignment by frequencies of usage of horizontal radius by its class. The nature of the KLORR which passes through hilly suburban area and that it is designed by expressway design standards is strongly reflected in the result.

In Section 1 and Section 3 tendency of usage of radius is almost the same, around 40% of radius are of 1,000 to 2,500 m and around 50% are more than 5,000 m. Whereas in Section 2, reflecting steep mountain conditions, the usage of small radius less than 1,000 becomes larger than in other two sections.

Table 8-8 : Frequency of Radius

Class of Radius	Section 1		Section 2		Section 3	
	Length (m)	%	Length (m)	%	Length (m)	%
Less than 1,000m	998	4.4	6,077	16.2	1,530	5.3
1,000 to 2,500m	8,877	38.9	6,630	17.6	11,633	40.7
2,500 to 5,000m	1,509	6.6	2,065	5.5	2,017	7.1
More than 5,000m	11,446	50.1	22,808	60.7	13,320	46.9
Total	22,830	100.0	37,580	100.0	28,500	100.0

8.4.3 Vertical Alignment

Table 8-9 shows frequency of gradient of the vertical alignment. This results also depicts the nature of the KLORR. In Section 1, reflecting hilly terrain and to reduce cutting and filling depth gradient of 1.5 to 3.0% are most frequently used. In Section 2, usage of gradient is scattered for all range of percentage, and because of mountainous terrain, the usage of gradient more than 3% is 16.5% which is higher than in the other sections. In Section 3, because of gentle hilly terrain condition, 86% of length are designed with gradient of less than 1.5%.

Table 8-9 : Frequency of Gradient

Class of Gradient	Section 1		Section 2		Section 3	
	Length (m)	%	Length (m)	%	Length (m)	%
Less than 0.5%	3,100	13.6	8,300	22.0	8,600	30.2
0.5% to 1.5%	0	0.0	9,300	24.7	15,900	55.8
1.5% to 3.0%	19,130	83.8	13,780	36.8	4,000	14.0
More than 3.0%	600	2.6	6,200	16.5	0	0.0
Total	22,830	100.0	37,580	100.0	28,500	100.0

8.5 Design of Road Facilities

8.5.1 Geological Condition in the Study Area

The geological map of the Study Area is shown in Figure 8-11. The general geology of the Study Area comprises various lithology of igneous, sedimentary and metamorphic rocks. The main mountain range consists of extensive masses of granite where original sedimentary cover has been removed by weathering and erosion. The low-lying areas mark the margin between granite and stratified rocks.

The area along the proposed corridor is temporarily divided into the following 3 areas from north to south.

1) Hilly area .... the area along mountain and foothill area, including the middle stream reaches of Sungai Gombak, Sungai Klang, Sungai Langat and Sungai Semenyih.
2) Alluvial area .... the area downstream of the above rivers.
3) Mining pond area .... the area of Ex-Mining ponds, which exist widely.

Each of these subdivided areas are studied geologically and geotechnically with regards to the engineering control points for the rough alignment study.

1) Hilly Areas

Hilly areas are composed of phyllite, schist, limestone granitic rocks and some quartz dykes and veins.

The surface of these rocks is overlaid with thick residual soil layers due to heavy weathering under the tropical circumstances. The geological condition in the hilly areas is shown in Figure 8-11.

The geotechnical conditions along hilly areas are preferable to the alluvial low areas.

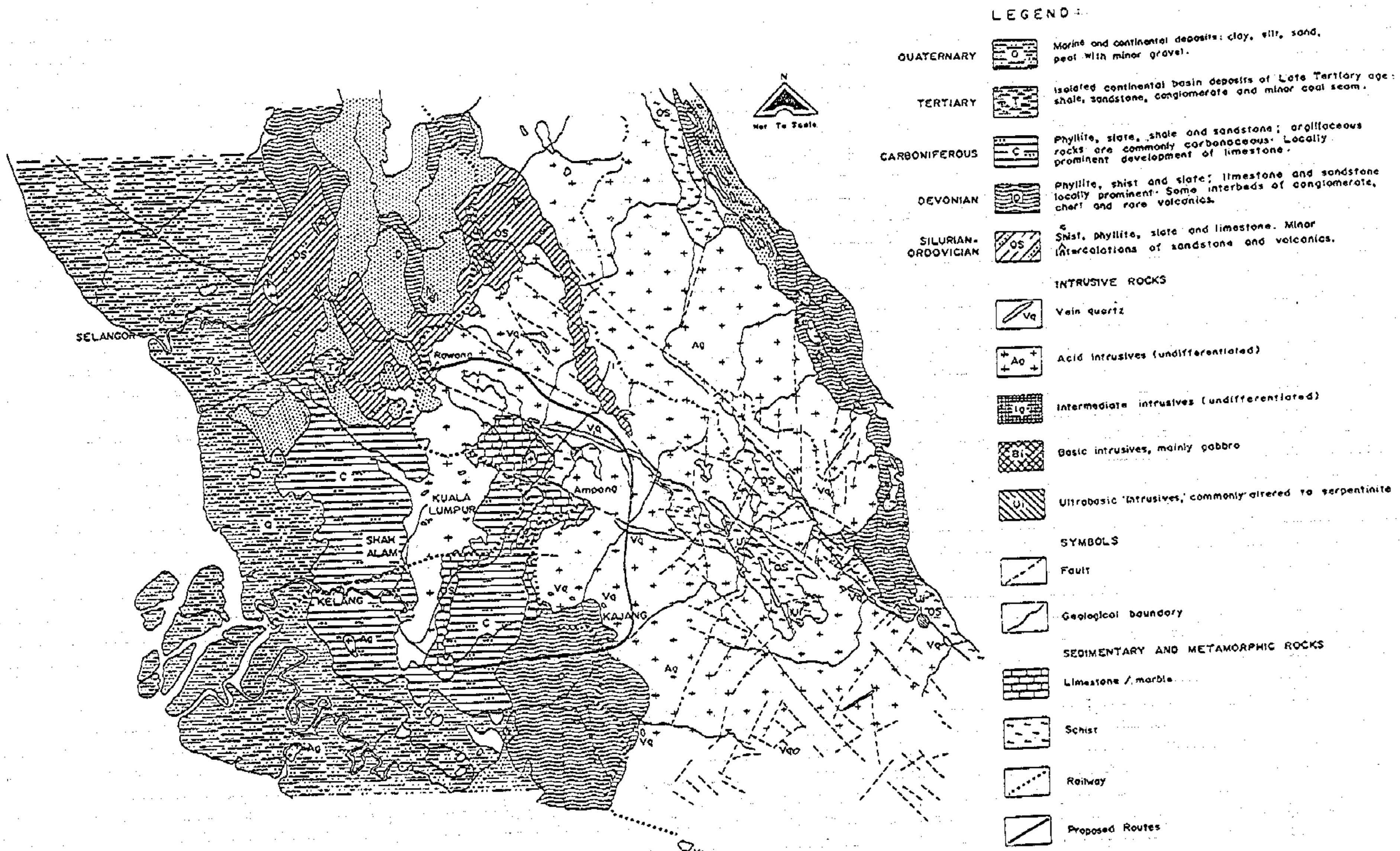
The main proposed structures which pass along hilly areas are tunnels, bridges, open cut slopes and high embankments.

2) Alluvial Area

The basic formation around site area is composed of two types of rocks, Kuala Lumpur Limestone and Quartz Vein. Thick alluvial deposits overlaying these two rocks are divided into upper alluvial deposits and lower alluvial deposits. The thickness of each deposit varies abruptly, reflecting the circumstances of deposition.

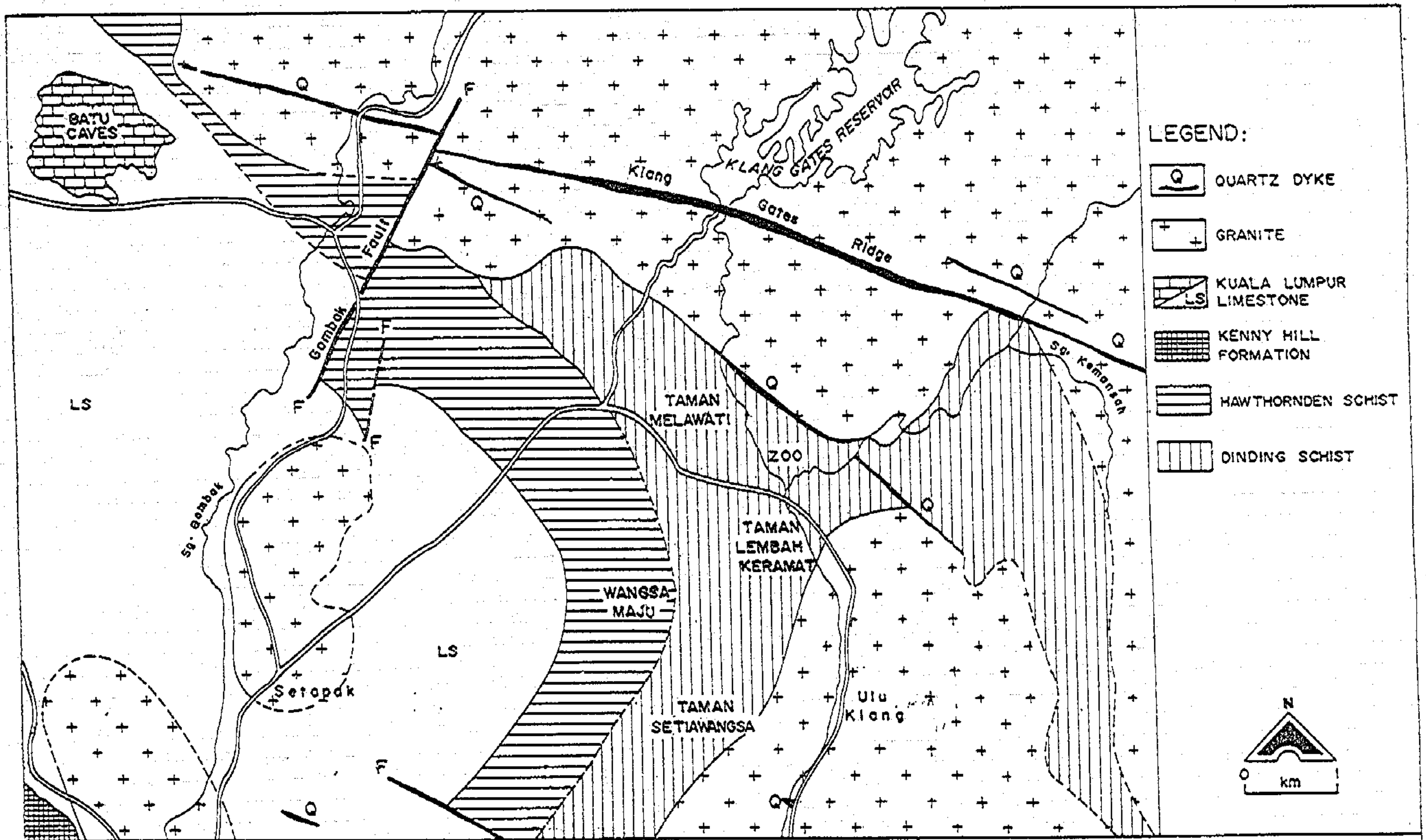
Quartz veins have intruded into the limestone during the Mesozoic period of earlier probably after the intrusion of the granite. They are composed of almost pure white quartz and some feldspar, but are considerably weathered into fine to coarse sand.

The natural out-crops of quartz veins are found only in a limited area along the Klang Gates Ridge, situated about 13 km northeast of Kuala Lumpur.



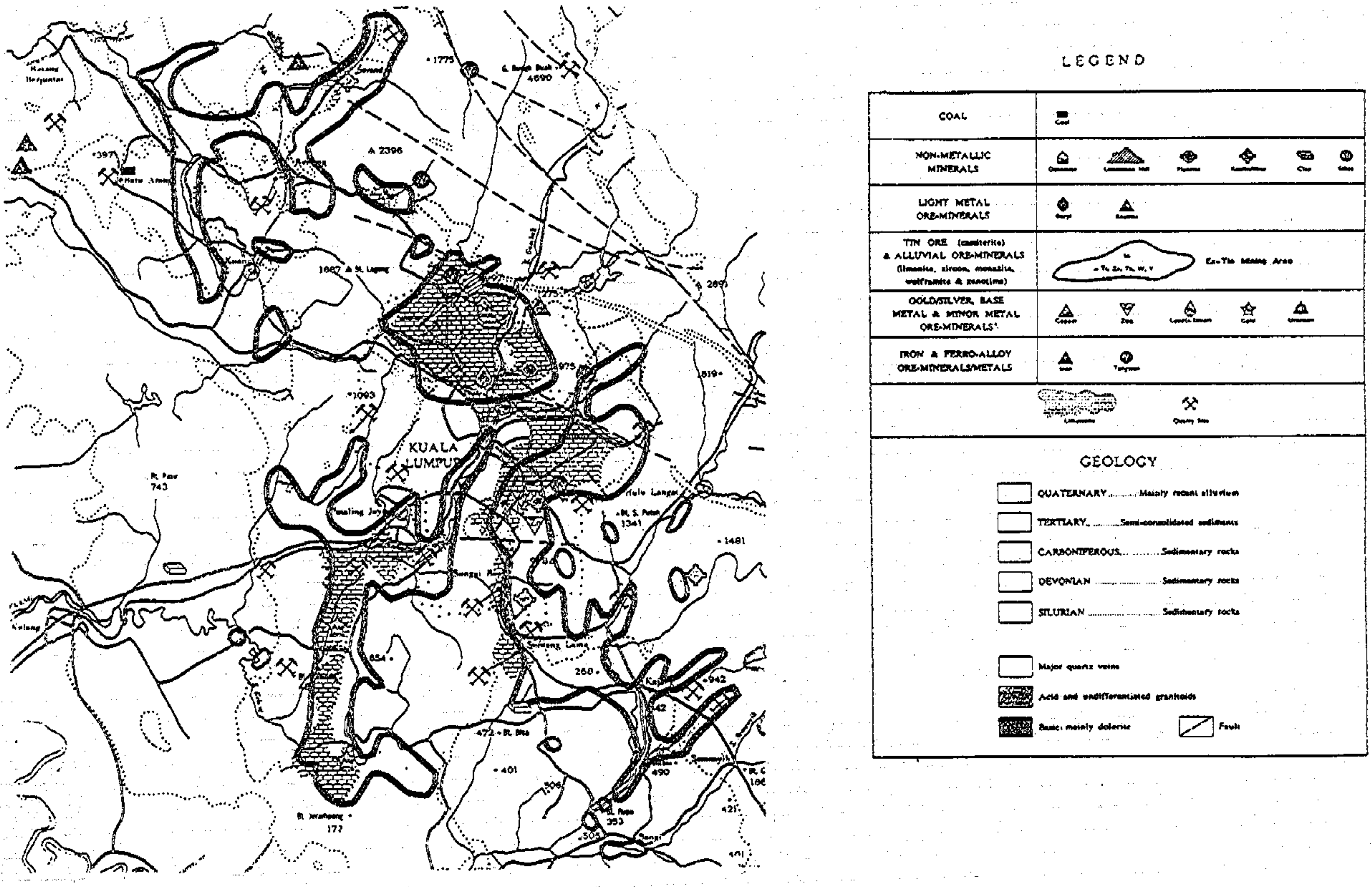
Source: Geological Survey of Malaysia, 1983

Figure 8-10 : Geological Map Around Site Area



THE KUALA LUMPUR OUTER RING ROAD PROJECT
(Japan International Cooperation Agency)

Figure 8-11 : Geology of Hulu Kelang Area
(from Gobbet, 1964)



THE KUALA LUMPUR OUTER RING ROAD PROJECT
(Japan International Cooperation Agency)

Figure 8-12 : Ex-Tin Mining Areas and Mineral Resources Map Around Selangor

Source : Geological Survey, Malaysia 1982

3) Mining Pond Area

Numerous mining ponds were excavated and so left mine tailing deposits in the alluvial plains around Kuala Lumpur as shown in Figure 8-13. Many parts of these mining ponds have already been refilled by various kinds of materials, such as domestic wastes and spoiled soils.

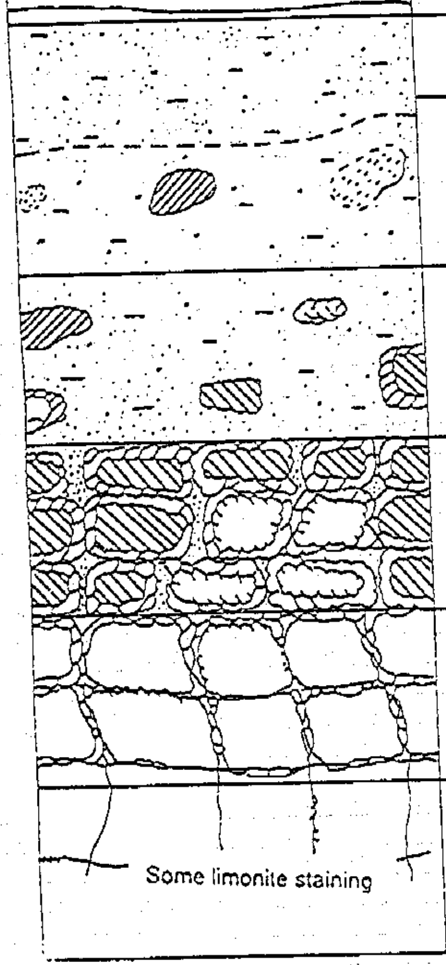
These reclaimed mining grounds show the complicated geotechnical condition in the deposited soil layer. Therefore a detailed foundation study is indispensable for these mining pond areas.

For the road construction, geological and geotechnical consideration should be studied for each of the works to be accomplished. Such work items to be expected at this proposed routes are described as follows:-

- Embankment .... Settlement and Slope Stability Analysis
- Bridge .... Type of Foundation
- Cut Slope .... Study of Slope Failure
- Tunnel .... Selection of Construction Method

Each consideration for the anticipated problems from the results of site survey are summarized hereinafter. Rock weathering and engineering judgements for construction methods are shown in Table 8-10 - Table 8-11.

Table 8-10 : Rock Weathering Grade of Granite



Grade / Zone	Degree of Decomposition	Field Recognition
VI	Soil	No recognisable rock texture, surface layer contains humus and plant roots. Average thickness 2 ~ 4 m±
V	Completely weathered (Fine-sand)	Rock Completely decomposed by weathering in place but texture still recognisable. Fine sandy materials are dominant (⌀ <1mm) and even quartz particles can be crushed by fingers.
IV	Highly weathered (Very coarse sand)	Rock so weakened by weathering that fairly large pieces can be broken and crumbled in the hands. It is composed of very coarse sandy material (⌀ >3mm) with onion weathering structure.
III	Moderately weathered (Transitional Zone)	Considerably weathered throughout. Transitional zone from mixing very coarse material and boulders to big blocks and masses.
II	Slightly weathered	Distinctly weathered through much of the rock fabric with slight limonite staining on many cracks and joints.
I	Fresh Rock	Almost fresh and intact rock

Table 8-11 : Provisional Classification of Altered Granitic and Metasedimentary Rocks

Grade	Description	Field Identification	Engineering Properties	Examples
I	Very Strong	Hammer blow - rings	Foundation - suitable for major concrete structures; embankments Grout - low take, locally moderate. Tunnel support - nil or few rock bolts where joint slightly open. Construction material - good aggregate and filter material.	Fresh granite, Quartzite and Fresh crystalline schists
II	Strong	Hammer blow - dull note	Foundation - usually suitable for major concrete structures, embankments. Grout - low to moderate take. Tunnel support - nil to pattern rock bolting depending on joint spacing and tightness. Excavation - explosives Construction material - satisfactory rockfill, unsuitable for aggregate.	Slightly altered granite, Fresh crystalline schists (mica schists)
III	Fairly Strong	Hammer blow - drummy sound. Core NX size - cannot be broken by hand	Foundation - may be suitable for low concrete structures, embankments. Grout - moderate to high take. Tunnel support - light steel sets. Excavation - difficult mechanically, explosives possibly more economic . Construction material - poor rockfill.,	Moderately altered granite, Slightly altered crystalline schists. Fresh sandstone
IV	Weak	Hammer blow - penetrates surface. Core NX size can be broken and crushed by hand. Soaked in water does not disintegrate.	Foundation - embankments. Grout - often ineffective. Tunnel support - steel sets partial lagging. Excavation - rippable. Construction material - semi-impervious fill.	Highly altered granite. Highly altered crystalline schists. Fresh to slightly altered sandstone
V	Soft - no rock strength	Coring not possible by ordinary rotary methods. Soaked in water disintegrates.	Foundation - earth fill. Tunnel support - heavy steel sets complete lagging. Excavation - by hand or mechanically. Construction material - impervious or semi - pervious fill.	Completely altered granite. Completely altered crystalline schists. Highly altered sandstone.
VI	Residual Soil	No rock textures, silty clay composition	Foundations - generally unsuitable construction material - impervious fill	Red latosols

Notes : 1 Tunnel support - Shotcrete could be used as alternative in Grades I and II, and in combination with listed items for lower grades.
2. Aggregate (Grade I) subject to alkali reactivity tests.

8.5.2 Bridge

1) General

In general, bridge constructions in Malaysia along hilly areas are rather familiar. This is easily observed as such the Karak Highway, the expressway to Ipoh and many Federal Highways passing through hilly areas. However, the most of the constructed bridges are T or I girder reinforced and prestressed concrete bridges. Whereas continuous, long span, balanced, cantilevered, girder and prestressed concrete bridges are rare.

Anyway in mountainous areas, a lot of long span high pier bridges are planned in this project. For a long span high pier bridge construction, the applyication of Dywidag post tensioning method (balanced cantilever construction method) would be the most suitable.

Therefore, generally, for short span (20 ~ 35 m girder length) and low pier (10m H) bridge construction, I or T girder prestressed concrete method is adopted, and for long span (60 ~ 100 m span) and high pier (15m H) bridge construction, the Dywidag post tensioning method is employed.

The bridges to be employed in this project are divided into four types according to their utilization. They are: bridges for crossing a small stream or a narrow path of the embankment area of the highway, a medium stream or developed area, a steep-walled valley, the project road and the loop line bridges inside the interchange.

2) Overpass of Small Stream or Narrow Path

For crossing small streams and the narrow path, box culverts or pipe culverts are to be utilized for economical reasons and to fit any cross section.

3) Overpass of Stream or Developed Area

Concerning the overpass for the stream or the developed area, there is no need to use the long span girder. Normal I or T girder prestressed concrete bridges are to be used. However, on the overpass for the developed area, in order to keep easy clearance, the Gerber hinge would be used if there is another road under the project road as shown in Figure 8-13.

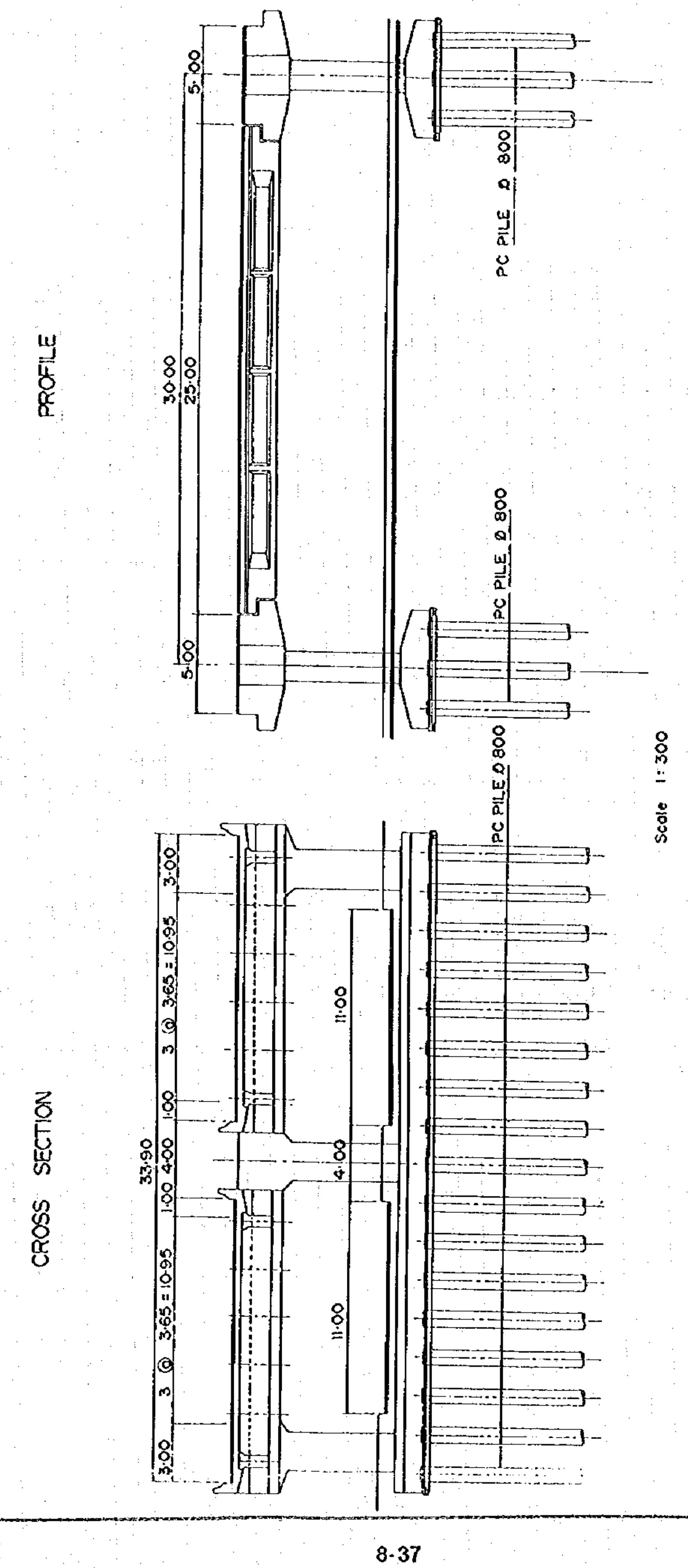


Figure 8-13 : Viaduct of City Area

4) Overpass of Steep-walled Valley

A lot of long span high pier bridges are to be constructed. Considering the advantage of the Dywidag post tensioning method, the system would be applied into the project as shown in Figure 8-14 (a).

The superstructure is divided into small sections and the concrete is poured section by section, or some blocks are made and stacked on the sections gradually from the constructed pier toward the next left and right side piers, balancing the weight of the left and right of the superstructure.

The method is widely applied in the world utilizing the above advantages into the construction procedure. The predominant characteristic of the method is keeping the volume of scaffolding to a minimum. Material transportation routes through piers are fixed from beginning to end of the construction period. The superstructure is temporarily stressed to bring forth the flexibility of the correspondence to the overburdened load related to fabrication and erection.

Taking the above factors into consideration, it can be concluded that this method is suitable for the construction of long span concrete bridges which pass over deep valleys.

Dywidag post tensioning method is a patented method for tensioning and anchoring the tendons, which are used for construction of superstructure of post tensioning prestressed concrete bridges.

Because of the difficulty in handling, the length of high-strength steel bars may have to be further limited. But sleeve couplers are available to splice the bars to any desired length.

5) Flyover

The most important aspects of the throughway crossing flyover is that the foundations of the flyover should not obstruct the sight distance of drivers in the section of the curve line.

6) Loop Line Bridges inside Interchange

For selecting an easy process of making the looped girder of the bridges, box continuity uniform height girder bridges are to be used as shown in Figure 8-14 (b).

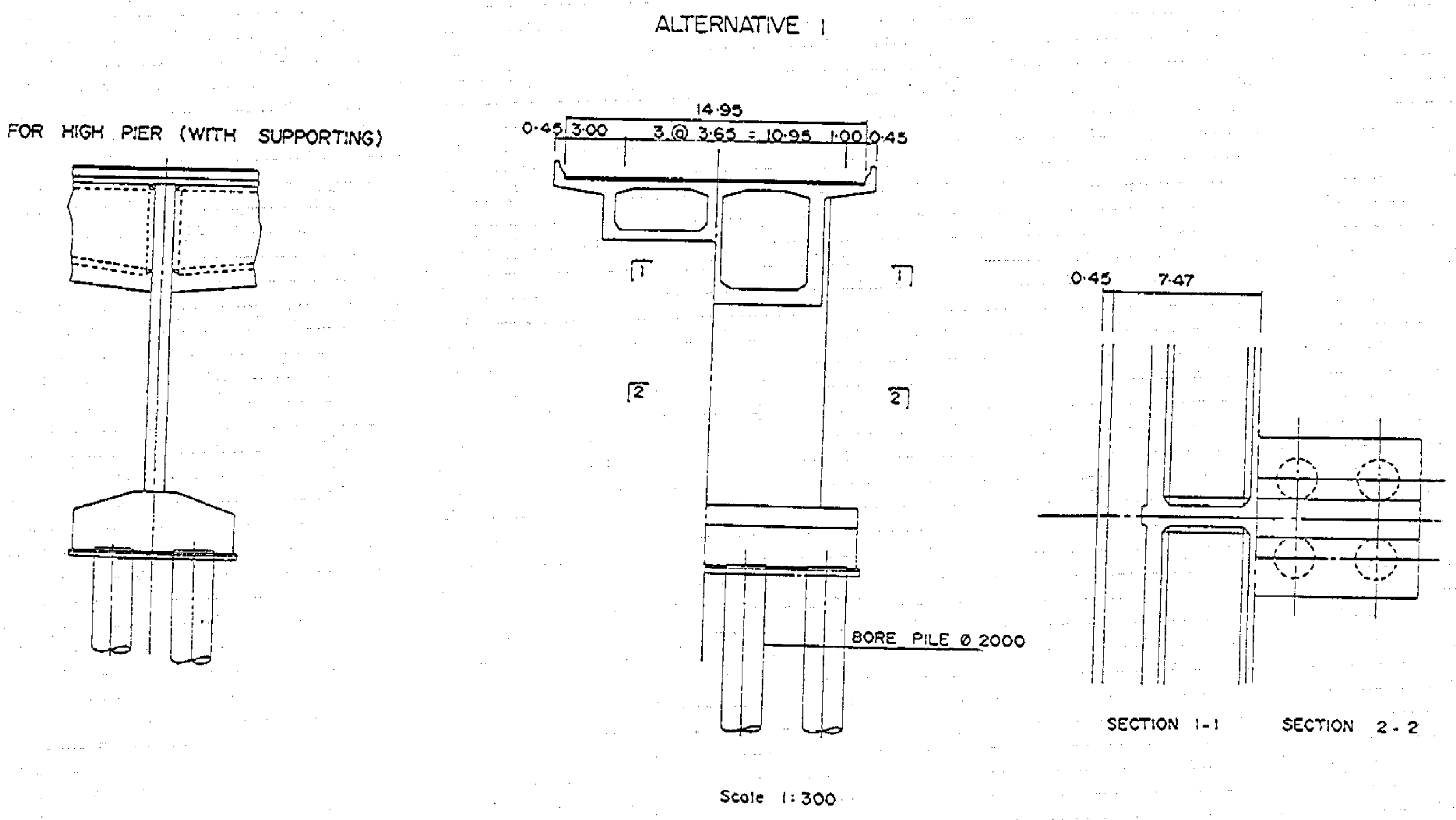


Figure 8-14 (a) : High Pier for Balanced Cantilever Bridge - Alternative 1

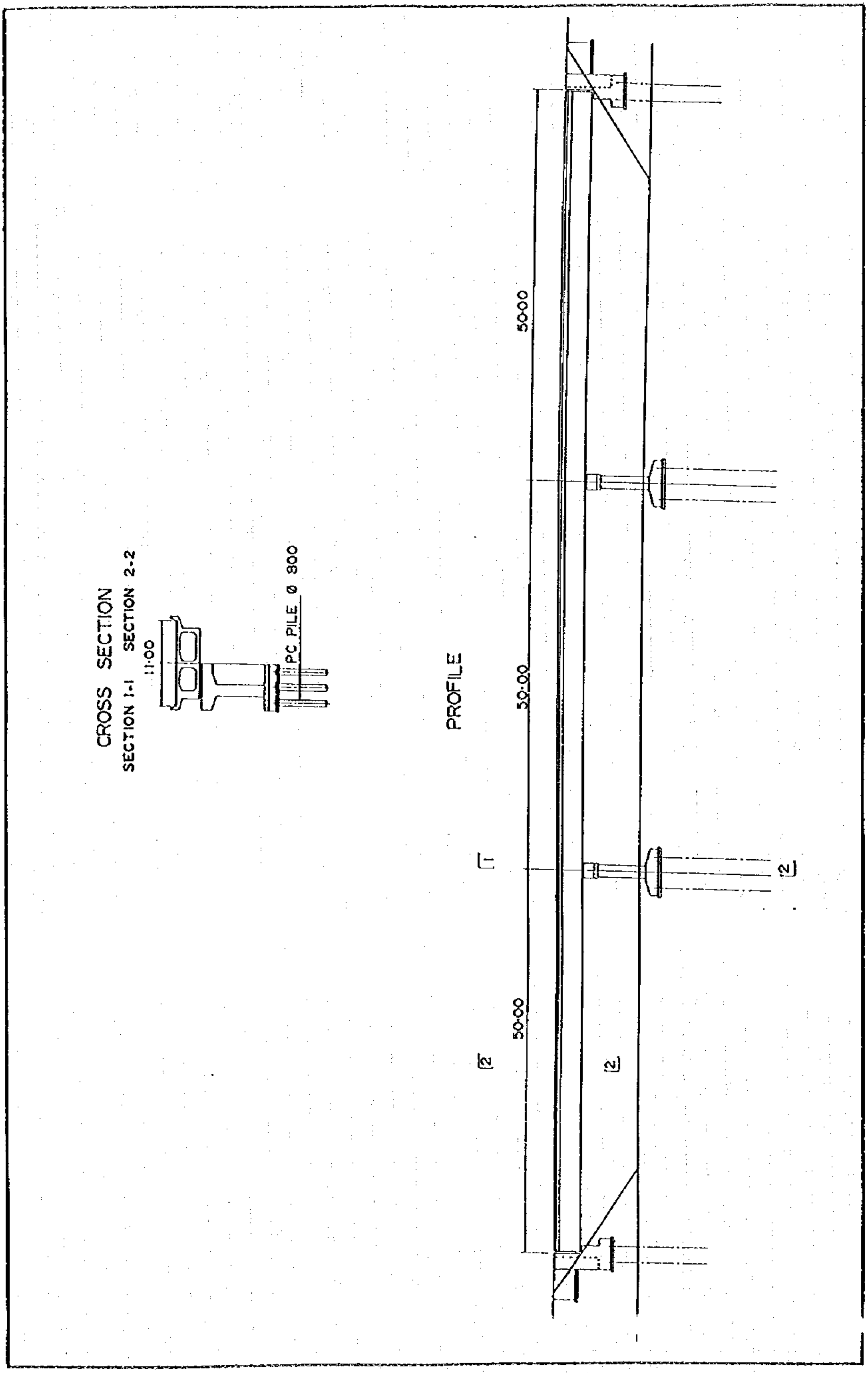


Figure 8-14 (b) : Looped Girder Bridge

7) Special Consideration of Piles

According to the result of soil investigation, the pile use area can be divided into three typical zones:

(1) Hilly or Mountainous Area

In this area, soil conditions are rather favorable to the alluvial low areas, and there are no special problems posed to piling work, as long as the piles are not too long.

However, the overall problem of soil condition of this area exists. The surface of the structural supporting layer is not horizontal, but steeply inclined. Also thickness of the soft soil covered layer is varied.

(2) Alluvial Area

The site is almost flat. According to the data of subsurface investigation, thick alluvial deposits are divided into upper alluvial deposits and lower alluvial deposits. Upper alluvial deposits are further divided into fine coarse sand, organic clay and sandy silt layers. Lower alluvial deposits are divided into loose sand, medium sand, dense sand and silt layers.

The thickness of each deposit varies abruptly, reflecting the circumstance of deposition. To support the structural loads adequately, the pile length must be 30m or more.

(3) Mining Pond Area

Numerous mining ponds were excavated and left mine tailing deposits in the alluvial plains around Kuala Lumpur. Many parts of these mining ponds have already been refilled by various kinds of materials, such as domestic waste and spoiled soils.

These reclaimed mining grounds show the complicated geotechnical condition in the deposited soil layers. Therefore, a detailed foundation study is indispensable for these mining pond areas.

These facts show us the difficulties in mining pond areas. Propoer consolidation procedures should be done to determine how to best deal with problems, such as ground settlement.

8.5.3 Tunnel

1) General

A fundamental rule of the tunnel work, no matter what type of timbering would be used, is always performed to take account of the circumstances, situations and conditions of the work ground. Also when the different interpretation of the circumstances between planned and actual situation arises, proper steps should be taken from time to time to make the working method fit for the actual circumstances.

From this point of view, New Austrian Tunneling Method (NATM) has a clear advantage judging from the fact that the method is the most flexible to the alteration of the plan or design due to the changing of the circumstances, such changing as area of the cross section, size or interval of the timbering, thickness or kind of lining material etc. Thus, in this project, as this method is used worldwide, the method would be used.

(1) New Austrian Tunneling Method

New Austrian Tunneling Method (NATM) is a way of tunnel excavation. One of advantages of using this system is to be able to utilize the natural ground strength effectively.

For bringing forth the maximum utilization of the natural ground strength, rock bolts are to be inserted in place of steel timbering from tunnel excavated surface to inner of the overburdened ground at regular intervals, expecting a very small amount of ground surface displacement toward the center of the tunnel by which it would form the ground arch reaction depending on the ground strength.

Even if the quantity of the rock bolts to be used is estimated in the design stage, it will be adjustable in the construction stage in conformity with the changes of the situation of the ground conditions or behavior.

(2) Lining Method

Usually the tunnel surface lining work which would be executed just after certain length of tunnel excavation is divided into two stages.

Mainly the first stage lining work consists of shotcrete work (lining thickness: 5 ~ 25 cm), occasionally, additional material, such as steel nets, rock bolts and frame squares would be adopted coupling with the work. However, during this period, for the purpose of not obstructing the tunnel displacement convergence, the lining would not be made to be too stiff.

Whereas it is said that an intention of the second stage lining work, which will be executed after tunnel displacement has been settled, is restoration of the first stage lining work. Therefore, the lining structure is not necessary to be strengthened. Yet taking the safety of the tunnel into account, the thickness of the lining of the tunnel shall be more than 30 cm.

2) Concept of Tunnel Design

The geological features of the tunnel construction area are composed of phyllite, schist, limestone, granitic rocks and some quartz dykes and veins. The main mountain range consists of extensive of granite masses where the original sedimentary cover has been removed by weathering and erosion.

Limestone is not strong against water movement. It is unevenly eroded away by water penetration. Sometimes this erosion causes sinkhole problems. Even though the limestone is a crystallized rock mass, there is the possibility of erosion.

Also, some active fault zones are scattered over the northern part of the planning area of the KLORR. The direction of the active-fault lines is approximately 120 degrees south - east.

The rock mass, mostly granitic rocks around the Kuala Lumpur area, has already suffered from heavy weathering under the severe tropical climates. Surface layers are almost changed to soil and even the remaining rock has many open cracks and joints.

-Selection of Tunnel Route

Taking the above geological conditions into consideration, the following examination criteria for tunnel routing were established.

(1) Avoid places where eccentric loading would be generated, select the tunnel route symmetrically with the lay of the land to the tunnel centerline so as to bear uniform loads.

(2) The route of the tunnel should have sufficient length from the heavy weathered rock, the tunnel route should have enough distance from the foot line of the mountain to prevent serious tunnel deformation, settlement or collapse. (Weathered rock zones would be 25~50m from the ground surface.)

(3) In principle, the tunnel route should be free from active faults. If the route cannot avoid active faults, the route should not be run parallel to the active fault lines located near or inside the tunnel, for the active faults, apt to include rock crushed strata, sometimes bring about serious water spouts from the ground.

(4) The route center line should be perpendicular to the contour line of the topography, close to the entrance/exit of the tunnel to prevent the collapse of tunnel mouth.

(5) The route should not pass through limestone areas to prevent circumstances that lead to sinkhole problems.

(6) The slope of the tunnel longitudinal line should be gentle because a steep slope in the tunnel longitudinal line would reduce traffic capacity of the highway and interfere with smooth traffic flow. Also, emission of car fumes inside the tunnel would increase. However, taking the water drainage slop into consideration, it should be 0.5 ~ 2 (especial 3) %.

3) Design of Tunnel

(1) Design of Tunnel Cross Section

New Austrian Tunneling Method (NATM) is recommended to construct three lane tunnel as shown in Figure 8-16. One of advantage of using this method is to be able to utilize the natural ground strength effectively.

(2) Length of Proposed Tunnel

The length of the proposed tunnel at Section 1 and 2 is shown in Table 8-12 and Table 8-13.

Table 8-12 : The length of Proposed Tunnel at Section 1

Station (km)	Length (m)
6+550-7+870	1320
13+310-15+110	1800
16+930-17+350	420

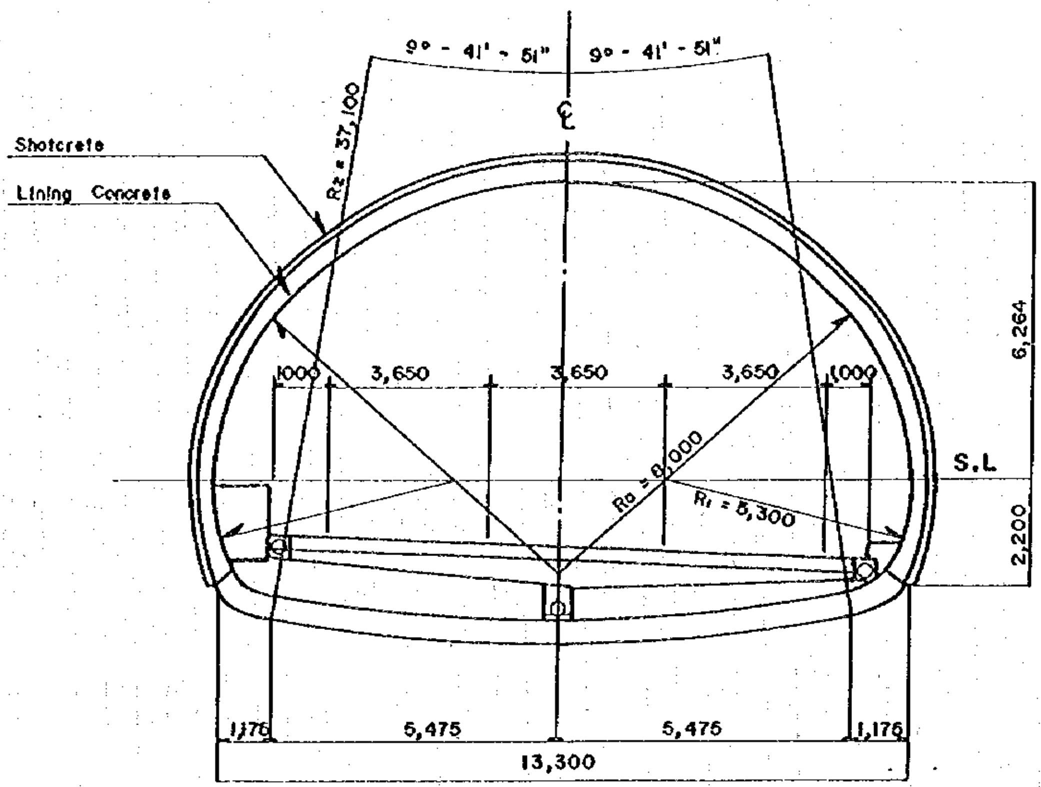


Figure 8-15 : Tunnel Cross Section

Table 8-13 : The length of Proposed Tunnel at Section 2

Station (km)	Length (m)
0+260-2+050 9+400-12+560 29+270-30+050	1790 3160 780

(3) Auxiliary Facilities

For ensuring smooth traffic, safety and comfortableness in the tunnel for both vehicles and pedestrians, a ventilation, lighting and emergency measure system would be used.

(a) Ventilation System

The ventilation system is divided into two systems. One is natural ventilation system and the other is mechanical ventilation system.

Which system to be used depends on the following formula.

$$LN \geq 2000 \quad \text{or} \quad LN < 2000$$

Where, L : Tunnel Length (km),
N : Traffic Volume (N/h) :

If $LN \geq 2{,}000$, then the mechanical ventilation system would be used. Whereas, if $LN < 2{,}000$, the natural ventilation system would be used. The mechanical ventilation system is classified into three groups depending upon their ventilating flow direction of the exhausting gas. They are parallel flow ventilation system, partial lateral flow ventilation system and lateral flow ventilation system. Figure 8-17 and Figure 8-17 show different types of ventillation systems.

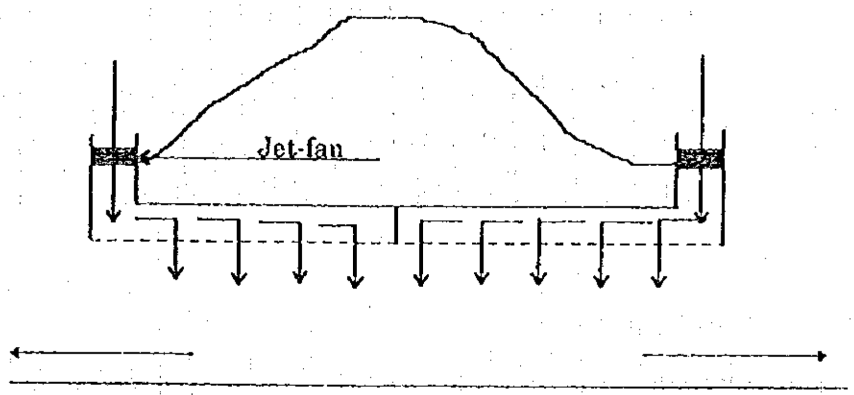


Figure 8-16 : Parallel Flow Ventilation System

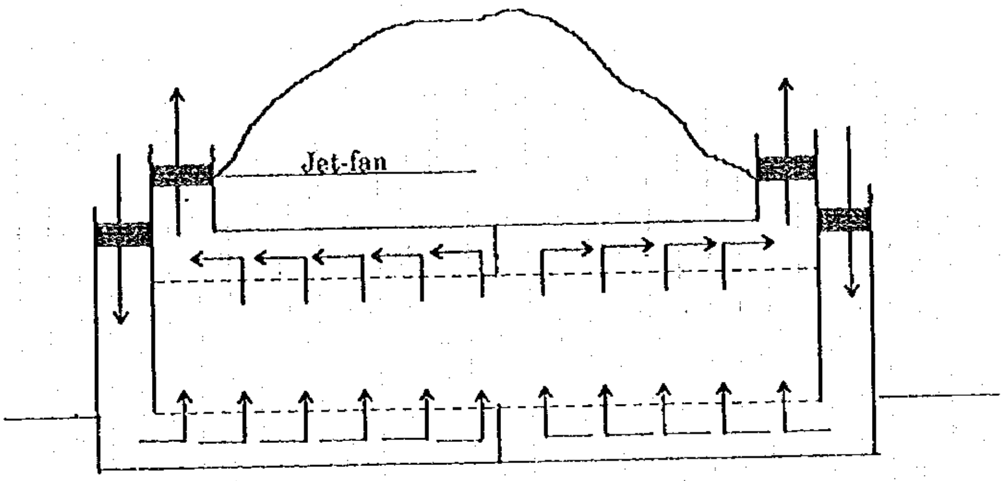


Figure 8-17 : Lateral Flow Ventilation System

Selection of Ventilation System

When the ventilation system is selected, the lay of the land, environment, adaptability of the traffic congestion and the calamity as well as the tunnel length and the traffic conditions should be taken into consideration for each alternative.

For reference, in general the following types of ventilation are selected depending upon the length of the tunnel.

Table 8-14 : Selection of Type of Ventilation

Parallel Flow Ventilation	L < 1,500m
Partial Lateral Flow Ventilation	L < 3,000m
Lateral Flow Ventilation	L > 2,000m

(b) Lighting

(i) Normal Lighting Section

In this section, the intensity of illumination depends on the visible distance of the obstacles in the tunnel, driving comfortableness and traveling speed (design speed) of vehicles.

(ii) Entrance Lighting Section

The function of this lighting system is to have the vehicle driver recognize the tunnel entrance. Without its help, the driver would perceive the tunnel entrance as a flat black hole and can not see the inside of the tunnel when the driver approaches it.

Another important function of this system is to be a help of having the driver adapt the tunnel environment just after enters it.

(iii) Exit Lighting Section

For prevention of a lowering of vision of the driver when he goes out the tunnel, the intensity of illumination near the tunnel exit would be adjusted suitably.

(c) Emergency Measure System

For prevention of spreading of the fire in the tunnel and minimizing the damage of the fire, several kind of emergency measure facilities are to be installed in the tunnel.

The emergency measure facilities, could be listed as follows.

(1) Communication Facility
(2) Emergency Alarm Device
(3) Fire Extinguisher
(4) Smoke Extraction Apparatus
(5) Refuge Guidance System
(6) Observation Facility

In addition to the above, fixing of the drainage facility and the interior finishing work for tunnel would be needed.

8.5.4 Pavement

1) Design Conditions

The pavement layers and their thickness should be determined based on the following factors governing the design (flexible pavement design):

-Traffic;
-Strength of subgrade;and
-Construction materials adopted to the pavement layers.

In most of the prevailing pavement design guides, traffic is expected in terms of the cumulative single axle loads of 8,200 kg (18-kip), over the design life of the road. The number of commercial vehicles, in particular, heavy vehicles such as buses and trucks.

The truck factor per vehicle computed from the equivalent single axle is assumed to be 2.5 on average.

The strength of subgrade will govern the thickness design of pavement. Commonly the strength is expressed by California Bearing Ratio (CBR) value determined by laboratory testing. A CBR value of 4.0 to 6.0 % is adopted in the computation of pavement thickness.

2) Design Features

Based on the above discussion, Road Notes 29 and 31, and Japan Road Association standards have been used to design the thickness of the pavement layers. The design condition is indicated as follows:

-Design life	:	20yrs
-Truck factor	:	2.5
-Bus factor	:	0.7

-CBR of Subgrade : 4-6%

The result of the computation indicates that the pavement thicknss is required as shown in Figure 8-18.

8.5.5 Embankment

1) General

Maximum embankment height is examined by two different aspects namely, slope stability analysis and consolidation settlement analysis.

Slope stability is evaluated by safety factors against landslides along assumed arc in road cross-section. Among others, the Swedish method has been used for the analysis, in which embankment characteristics and subsoil conditions given by soil investigation are taken into account. The required safety factor is generally 1.2.

Consolidation settlement at the middle of the embankment base is given by a sum of each consolidation settlement of particular clayey subsoil layer against the considered embankment shape and weight. The degree of consolidation settlement progress is also studied.

Assumed embankment characteristics would be as follows:

Embankment Slope Gradient	1 : 1.5
Embankment Unit Weight	1.8 ton / cu.m
Cohesion of Soil	3.0 ton / sq.m
Internal friction angle	10 degrees

In accordance with the estimation of the work of this project, maximum height of the embankment would be 20 to 25 m. Thus, when selecting materials, non-settling and stable material should be chosen for embankment work.

2) Method

To prevent earth and sand flowing out from the slope of the embankment, slope protection measures are adopted. There are many kinds of slope protection methods. In this project, the turfing method will be adopted. (gradient : 1 : 1.5), a horizontal space would be made every 5 ~ 7 m in the slope. Furthermore, perfect drainage of the road should be planned in the detailed design stage.

8.5.6 Excavation

1) General

The maximum cutting height of this project would be 100 m. However, this scale of excavation work can be seen anywhere in Malaysia.

Therefore, it is very important to analyze rockfall and landslide problems of the cutting area, due to heavy ground weathering and siltation.

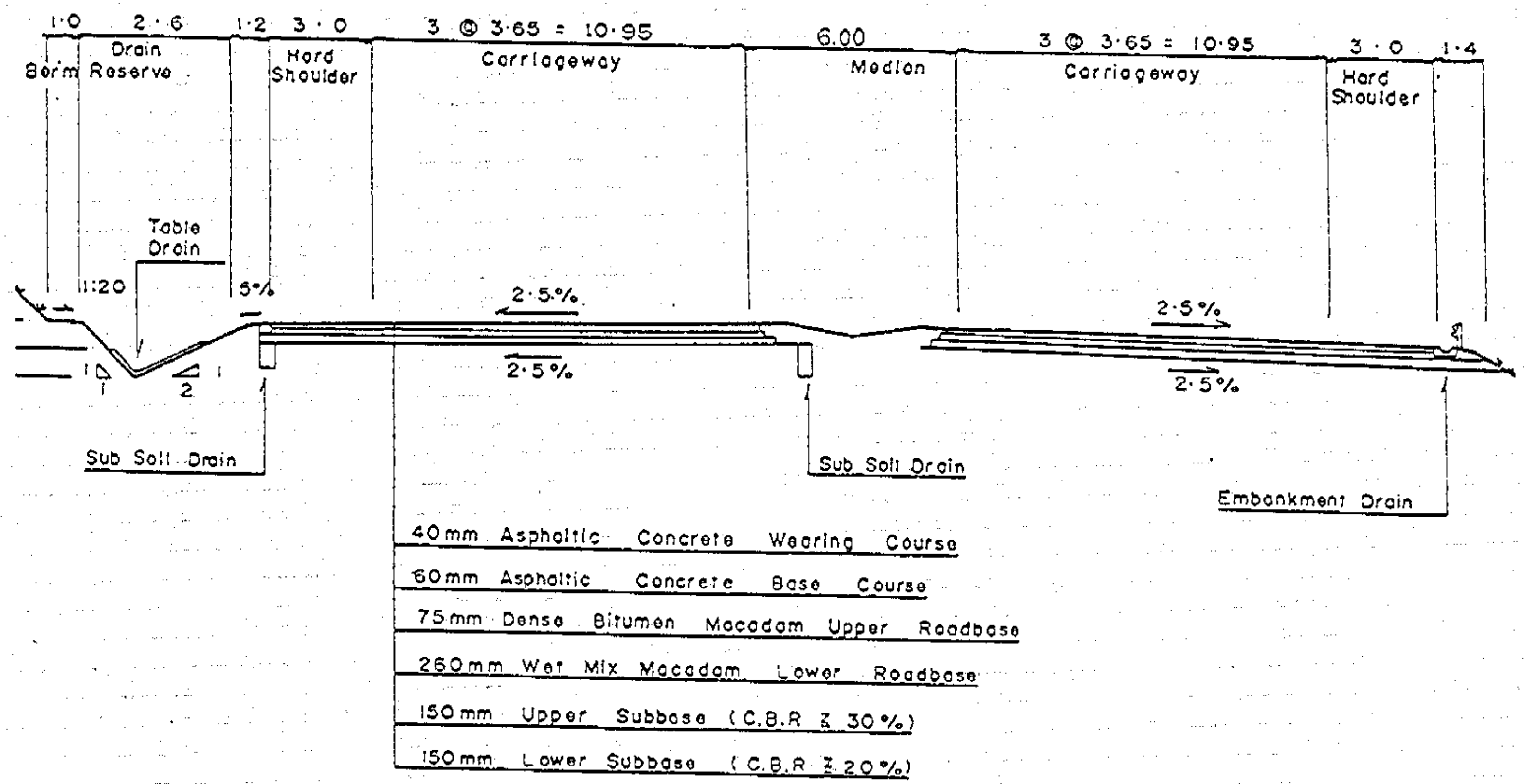


Figure 8-18 : Flexible Pavement Structure

2) Geotechnical Conditions

Due to the unusually rapid pace of development for housing and industrial estates, the cut slopes at hilly areas are often faced with the problems of rockfalls and landslides.

As mentioned before, the rock mass around Kuala Lumpur area has already suffered from heavy weathering under the severe tropical climate. Surface layers have almost changed to soil and even the remaining rock has many open cracks and joints. This is aggregated by rain seeping into the rock, so rockfalls and landslides often occur.

Hence, a suitable treatment plan should be prepared while the structures in this area are designed.

3) Selection of Cutting Areas

Similar to as tunnel route evaluation, the following evaluation criteria for fixing alignment, takes into consideration the suitable cutting area in conformity with the present soil conditions, where established.

- Avoid excavation in steep and heavily weathered places.
- Avoid excavation in weathered sedimentation areas.
- Select the cutting places where water drains well.
- Avoid the cutting in active fault zones.
- Perpendicularly interesect the road route and the contor line of the topography.

4) Special Considerations

Severe rockfalls and landslides are present around Kuala Lumpur. The observed causes of these tragic disasters can be classified into two reasons. One is an artificial reason and the other is an inherent reason.

Excessive and rapid development of land around Kuala Lumpur, either for housing or industrial used quickly extends the cutting areas wider and wider, and the collapse of cut slopes can be seen anywhere in developing zones. This is the reason for the increase of rockfalls and landslides.

These factors also have a high potential to harm the slopes. Taking the above reasons into consideration, as long as the developers are deliberate in coping with the execution of the cutting area near land sliding, many of the disasters would be effectively prevented.

We cannot prevent the weathering of rocks, but we can utilize the fact that the rocks need time for weathering. In other words, it is useless to make cutting slopes gentle, because all the rocks will be weathered and loosened evetually. They can be steepened but we have to consider the results of weathering.

5) Character of Geotechnical

As mentioned previously, the rock mass mainly consists of granitic rocks around the Kuala Lumpur area and has already suffered from heavy weathering under the severe tropical circumstances. Surface layers have almost changed to soil and even the remaining rock has many open cracks and joints.

Because of this, rain water easily penetrates into the base rock and this accelerates weathering, which encourages landslides.

6) Prevention of Rockfalls and Landslides

The measures to prevent rockfalls and landslides are as follows:

If the rock layer surface is parallel to the excavated rock surface or inclined downward, then rock anchor cables or bolts, chain-link or torpedo netting are used.

If the rock layer surface is perpendicular to the excavated rock surface or inclined upward, then chain-link or torpedo netting is used to prevent small scale rockfall.

In both cases, a drainage is ditched along the top edge of the rock to seperate rainwater from the surface of the base rock. Drain pipes can be inserted into the rock slope to take seepage water away from the rock mass.

However, if the route couldn't avoid large scale disaster areas, then there is a possibility of large scale landslides. Disaster prevention shelters should be installed for safety of passing cars.

If these measures are applied to the plan after detailed investigation and the plan is executed in conformity with these ideas, they would surely prevent landslide disaster.

7) Cutting Slopes

The incline of the cutting surface slope should be 1:0.7 to 1:1, on account of the degree of weathering, direction of the layer surface and the kind of materials included between the layers of rock or soil.

In addition to detailed soil investigations, analysis of the landslide for slope should be executed in the detailed design stage to ensure the safety of the structure.

8.5.7 Other Facilities

(1) Road Drainage

1) Road Surface Drainage

The existing rivers, channels and drains run parallel with the planned roads in most of the project area and are therefore suitable for outlets from the roads drainage systems. Under these conditions the principle of keeping the planned road drainage completely separate from that of the frontage road may be costly and impractical.

It is therefore proposed that generally the systems are kept separate, however at outlets, a combined system may be used to avoid expensive duplication, as shown in Figure 8-18 The combined drainage facility will be maintained by the relevant authorities after maintenance limits have been decided.

(i) The sag point on the road profile

(ii) The crossing point of existing drainage structures

(iii) Points accessible to existing drainage

The proposed typical road surface drainage system are shown in Figure 8-18 and are described as follows:

* Outer shoulder which was 4% crossfall and 3.0m wide will be utilized for the location of road gullies;

* Catch-basins with grid covers will be placed at intervals of not more than 50m; and

* Concrete pipes not less than 40m diameter will be set longitudinally under the shoulder to connect to the basins.

2) Road side Drainage

Road side drains which have enough discharge capacity to give protection from floods should be planned at the outside of the side strips and connected to the existing main drain, canal or river.

(2) Toll Collection Facilities

1) Roof Structure

A roof structure to cover the toll booths and collection area is needed for protection from the weather. The roof and supporting pillars for the roof structure will be made of permanent construction materials.

2) Refuge Island

The refuge island is needed to provide a foundation for the toll booth and protection from approaching vehicles. Drawpit and air ducts are installed to provide the air condition system for each toll booth.

3) Toll Booth

The toll booth is used as a space for toll collection. The booth structure will be prefabricated unit.

4) Toll Building

The toll building is provided mainly for the supervision of the toll collecting operation and consists of the following floor plants:

-Control room with supporting office spaces;
-Security and lobby;
-Security van;
-Service and cafeteria;
-Locker rooms; and
-Emergency generator room

5) Equipments and Devices in Toll Plaze

The following equipments and devices will be provided in the toll plaza:

-Signal system for traffic lane control in the toll plaze area;
-Toll collection devices such as voucher issue equipment, fare display and vehicle

detector, all provided in the toll booth;
-Vehicle weighting devices in the barrier type toll gate;
-Local data processing unit in the toll building; and
-Interphone system.

(3) Lighting

1) General

The objective of the provision of lighting facilities is to reduce the number of traffic accident occurrences during the night time. By providing lighting, it will also make the toll ways more attractive to potential users.

2) Scope

The provision of the lighting installations in this project covers the following locations and facilities;

-Thoughways of long bridge section;
-Interchanges including ramps and through lanes and at-grade intersections;
-On-off ramps including toll plazas;
-Toll building interior lighting; and
-Emergency power units for the toll buildings and other facilities.

3) Standards

-Informational guide for roadway lighting, American Association of State Highway and Transportation Officials (AASHTO); and
-Design standard for road lighting facilities, Ministry of Construction, Japan.

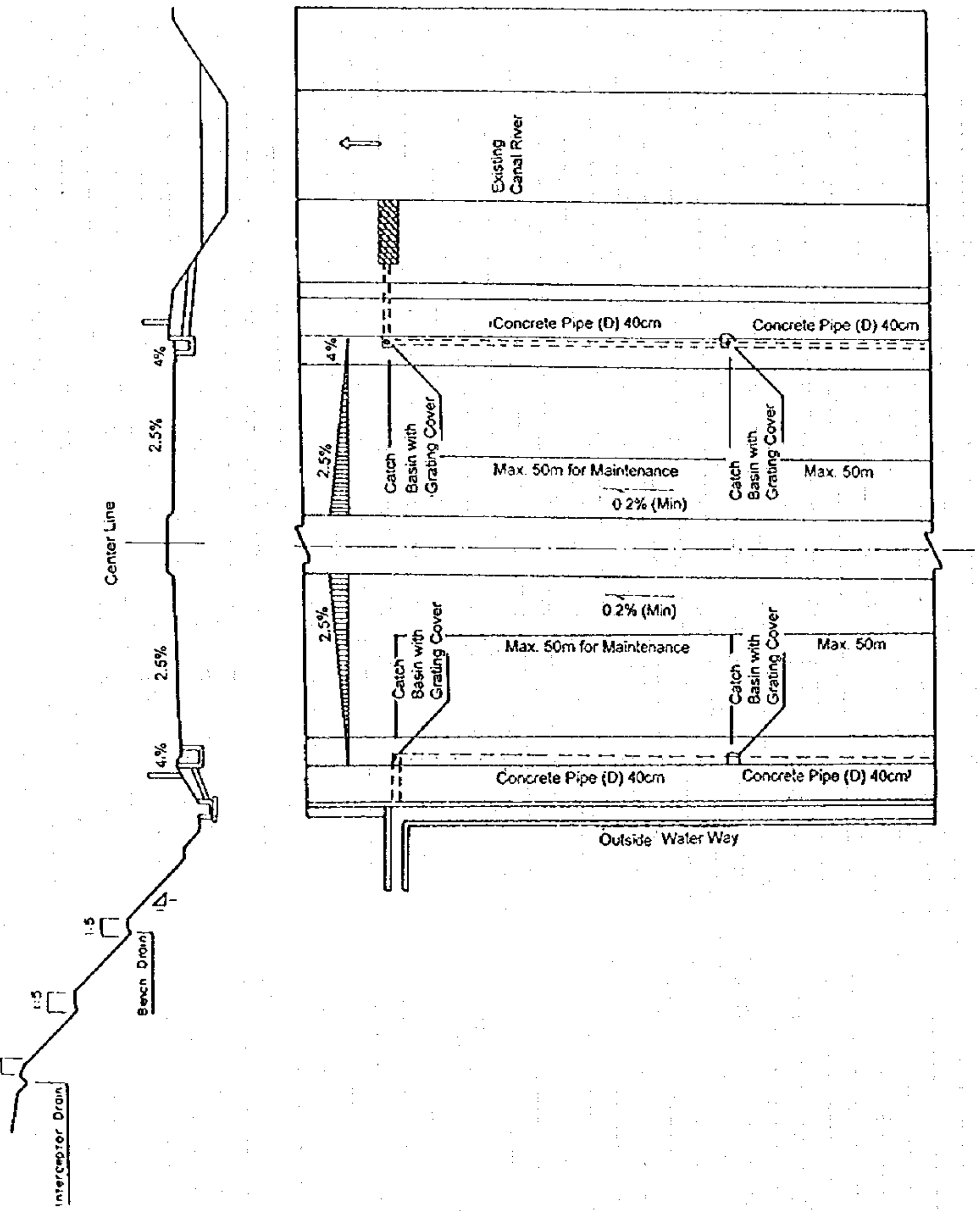


Figure 8-19 : Proposed Typical Road Surface Drainage System

8.6 Interchange Plan and Design

8.6.1 Proposed Interchanges on the KLORR

Interchanges of the KLORR with other roads are studied and thirteen interchanges are planned based on the future highway network configuration. Table 8-15 show the proposed interchanges with the classification.

8.6.2 Examination of Interchange Location and Configuration

Interchange locations are determined predominantly by the alignment of the proposed expressway, but sometimes they are determined due to the limited land availability for interchanges, constraints from nearby existing or committed interchanges, difficult terrains conditions and so on. Figure 8-20 shows interchange location and configuration.

For example, the location and type of interchange with the North-South Expressway or the KL-Seremban Expressway are planned and designed taking into account existing and committed interchanges, which are located within short intervals. For those interchanges, several alternative interchange plans are prepared and evaluated for comparison.

The KLORR will be a privatized project with toll charged to users. A toll collection system is an important factor to confirm interchange locations and types. In order to provide smooth traffic flows on the Expressway network, and to make the toll fee fair for all users, a closed toll system is recommended. Even if several privatized companies are involved in the operation of the network, the introduction of a common ticketing system with other expressways is recommended. This will provide free traffic flow without stopping at toll gates, especially on system interchange class A.

Table 8-15 : Proposed Interchanges and their Classification

IC No.	Location	Connecting Road	Classification of the Connecting Road	Classification of Interchange
1	Rawang	North - South Expressway	Expressway	System (A)
2	Templer Park	Federal Route 1 (Jln. Ipoh)	Highway	System (B)
3	Batu Dam	State Road B23 (Jln. Ulu Yam)	Primary	Service
4	Gombak	KL - Karak Highway	Highway	System (B)
5	Ulu Langat	Ampang Elevated Highway Extension	Highway	System (B)
6	Ulu Langat	State Road B52 (Jln. Ulu Langat)	Primary	Service
7	Ulu Langat	East - West Link Extension	Highway	System (B)
8	Kajang	Federal Route 1 (Jln. Semenyih)	Highway	System (B)
9	Kajang	KL - Seremban Expressway	Expressway	System (A)
10	Putra Jaya	Putra Jaya Urban Motorway	Urban Motorway	System (B)
11	Putra Jaya	Damansara Puchong Road	Primary	Service
12	Putra Jaya	Putra Jaya Service Road	Primary	Service
13	Kuala Langat	North-South Central Link Expressway	Expressway	System (A)

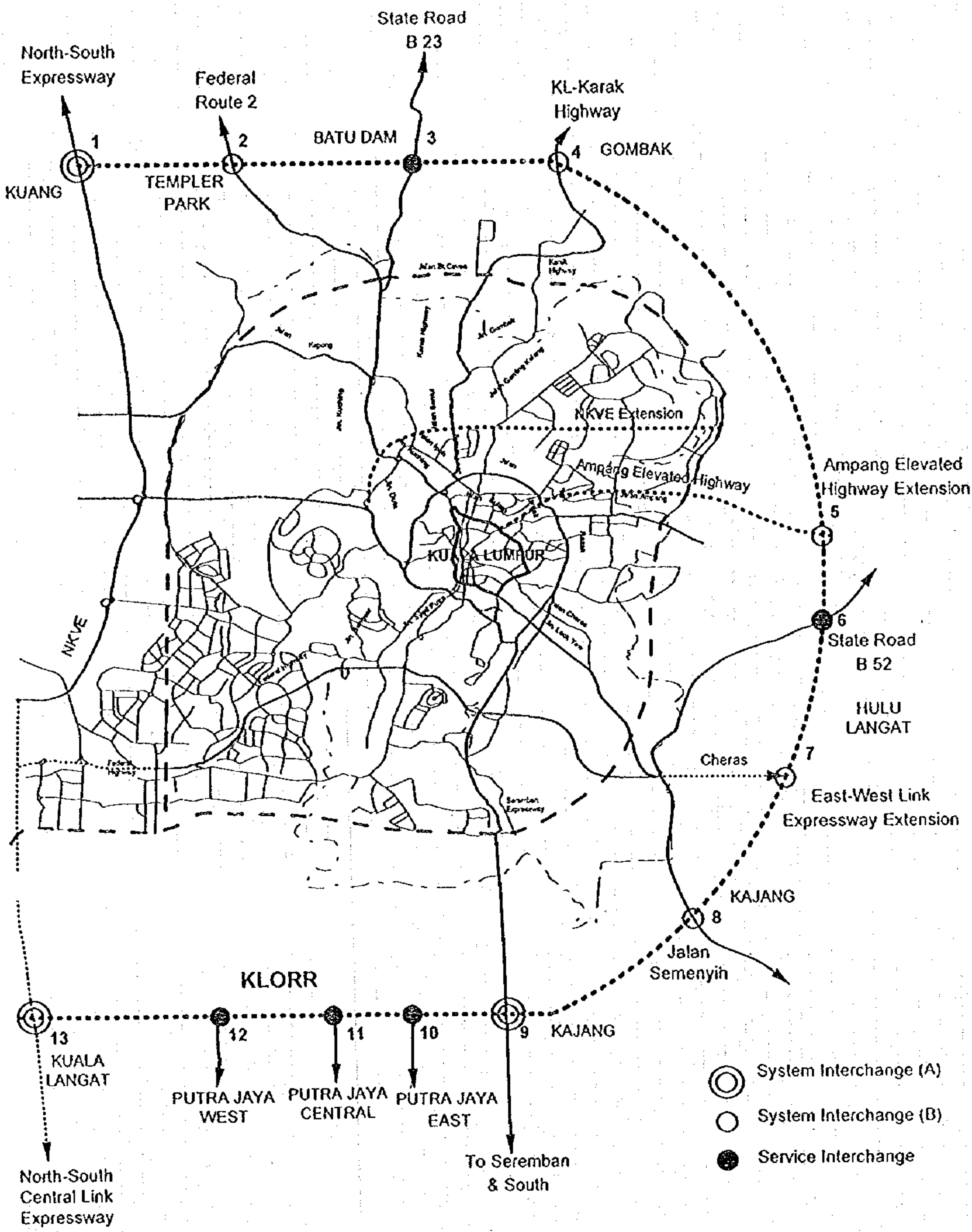


Figure 8-20 : Interchange Location and Configuration

The comparative evaluation and major planning considerations for the each of the proposed interchanges are discussed below.

<u>System Interchanges class A</u>

(1) The North-South Expressway (IC No.1)

The interchange with the North-South Expressway which is an origin point of the KLORR is planned in the nearby area of Rawang and Serendah. In the area, the Rawang Interchange was constructed and two new interchanges are planned. One is at Bukit Beruntung, the other is in Kg. Sungai Choh, approximately 5 km north from Rawang IC. Furthermore, there is a service area already open in between. The other interchange is planned in Kuang, approximately 4 km south from Rawang IC. These interchanges and facilities are major constraints for the planning of interchanges of the KLORR.

From the standpoint of future traffic demand, the northern location of Rawang IC is preferable for the KLORR interchange. However, spaces between the interchanges and service areas are not sufficient to construct a new interchange. In addition, committed development projects along the North-South Expressway and the Federal Highway also put constraints on the alignment of the KLORR, even if the interchange with the KLORR could be integrated with the proposed new Sungai Choh IC.

The interchange, therefore, should be planned in the south of Rawang IC. However, a new service interchange in Kuang is planned. It is difficult to construct a new interchange between two interchanges. Subsequently, two alternatives using either existing Rawang IC or new Kuang IC are considered. The function of the both alternatives are Service IC as well as a System IC.

(2) The KL-Seremban Expressway (IC No.9)

The physical condition of the KL-Seremban Expressway in the Kajang area is similar to the one in the Rawang area mentioned above. There are three interchanges with short intervals, namely UPM IC, Kajang IC and Bangi IC.

Considering the KLORR alignment, there are two alternatives. Using the existing Kajang IC or constructing a new interchange. Alternative 1 means new interchange construction and alternative 2 means to integrate with the existing Kajang IC.

Alternative 1 : An interchange should be located at a sufficient distance from the existing interchanges. The interchange, therefore will be located in the west of the Bangi new town center, meaning the KLORR crosses the town centre. This location is the same as the interchange of the South Klang Valley Expressway with the KL-Seremban Expressway proposed by the Putra Jaya Development Plan.

Alternative 2 : This is selected to add the interchange onto the existing Kajang IC (Service Interchange) which avoids the construction of a new interchange in the section of the KL-Seremban Expressway.

In Alternative 1, the KLORR will cross Bangi New Town Center, creating four successive interchanges. Subsequently, alternative 2 is selected in spite of the complicated ramp way configuration. Provision of sufficient traffic information system for the proposed interchange is recommended.

(3) The North-South Central Link Expressway (No.13)

The interchange with the North-South Central Link Expressway should be planned as a System Interchange class A, a combination of directional and loop interchange. The location of the interchange is based on the Putra Jaya development plan.

System interchange class B and service interchange

(4) The KL-Karak Highway (IC No.4)

Major constraints on the planning of the interchange with the KL-Karak Highway include topographical conditions and existing villages along Jalan Gombak. Also the Islamic University and the KL-Karak Highway widening project including construction of a new toll gate, which is under construction.

The new toll gate and the university are located south and north of the criss-crossing point with the KL-Karak Highway. To minimize the influence to the existing villages, the proposed interchange is planned outside the village. The interchange will be designed as a System Interchange class B.

(5) Federal route 1 (IC No.2)

The crossing point of Federal Route 1 with the KLORR is in mountainous terrain. The KLORR will pass through the area with tunnels and bridges as well as high cut slope. Federal Route 1 passes through the valley area with steep gradient.

A double trumpet type interchange is proposed as a service interchange. The planning of the ramp way should be examined carefully according to the structures and alignments of both expressway and highway.

(6) State Road B52 (IC No.3)

The planning of the interchange with State Road B52 faces the same constraints as the interchange with Federal Route 1. The merging point and diverging point of the ramp way should be selected carefully.

(7) Extension of Ampang Bypass (IC No.5)

The location for this interchange will be determined based on the alignment of both the KLORR and Ampang Bypass extension. The location should be chosen in an area with less mountainous terrain.

(8) Jalan Ulu Langat (IC No.6)

This interchange will be designed as a Service Interchange. Minimizing the destruction of the community along Jalan Ulu Langat is the most important issue in the design of this interchange.

(9) Extension of East-West Link (IC No.7)

This interchange is proposed as a three-leg trumpet type. Since both highways have been planned recently, it is possible to identify the location for the interchange where there are fewer constraints.

(10) Federal Route 1 (Jalan Semenyih) (IC No.8)

The connection with Federal route 1 in Kajang is designed as a service interchange. A major issue is how to avoid existing and approved development projects in the alignment.

(11) Urban Motorway in Putra Jaya (IC No.10)

According to the Putra Jaya development plan, three interchanges are planned in the area. This Study will design the interchanges in line with the development plan. The alignment of the KLORR is differed from the one proposed in the development plan.

The location of the No. 10 interchange, therefore, is decided according to the KLORR alignment. The Urban Motorway in Putra Jaya will connect to the interchange. Considering land availability and topographical condition, the interchange will be designed as a three leg semi-directional.

(12) Damansara - Puchong Road (IC No.11)

By the negotiation with Putra Jaya this interchange was decided to connect Damansara - Puchong Road. The type is basically double trumpet, but considering topographical conditions, the shape is somewhat changed.

(13) Putra Jaya Ring Road (IC No.13)

This interchange will connect to the Putra Jaya Ring Road which will serve the privatized zone of the Putra Jaya. This is a trumpet type interchange.