4.3 Alternative Toll Levy Systems

As mentioned in the preceeding section 4.2, the three (3) alternative implementation bodies that can be considered for the Project Roads are Government, Private Sector and Third Sector.

In the case of either the private sector or the third sector implementing the Project Roads, the business entity set up will levy a toll on the road users. Therefore, this section discusses the merits and demerits of alternative toll levy systems which may be implemented on the Project Roads.

4.3.1 Presumptions

Prior to examination on alternative toll levy systems, the following conditions are presumed in this Study:-

(1) Setting of Tollway Section along the Project Roads

Prior to discussing the alternative toll systems, it is imperative to set up the tollway sections along the Project Roads. Although it is possible to presume that the toll system will be applied to the entire length of the Project Roads, it is important that the highways be examined for special traffic characteristics beforehand. For the purpose of this Study, the toll system is presumed to be implemented on the section of Shah Alam Highway/MRR-II from KL-Seremban Expressway to NKSB and the entire length of N-S Link.

(2) Toll Charge

In the tollway mentioned above, the section of Shah Alam Highway/MRR-II between KL-Seremban Expressway to NKSB measures some 42 kilometers with 14 proposed interchanges and N-S Link measures some 34 kilometers with 6 proposed interchanges.

The existing toll tariff adopted by LLM is shown in Table 4.3.1.

Table 4.3.1: Present Level of Toll Tariff by LLM

Class	Description	Toll Charge (cents/km)
1	Passenger Cars	5.0
2	Two axles and 6 wheels excluding buses	7.5
3	Three or more axles	10.0
4	Taxi	2.5
5	Buses	5.0

Note: Management of most of the toll expressways was transferred from LLM to PLUS in 1988.

If the existing level of toll tariff on expressways in Malaysia is adopted for these two proposed highways, than the maximum tariff for passenger car may be calculated as follows:-

(a) Shah Alam Highway/MRR-II: 42km x 5 sen/km
= say M$2.00

(b) N-S Link: 34km x 5 sen/km = say M$1.75

Therefore, the toll charge on the Project Roads should be set up within the maximum tariff calculated above.

4.3.2 Existing Toll Levy System in Malaysia

Presently in Malaysia, tollways consist of the segments of North-South Highway and Kuala Lumpur-Karak Highway operated by PLUS and LLM respectively and other privatized road projects such as NKSB and Jalan Kuching Improvement (see Table 4.3.2 and Figure 4.3.1). The toll levy system of North-South Highway is basically a distance proportional tariff system under the so-called closed system. Other tollways are under the zone or flat tariff system. The PLUS closed system utilizes a magnetic ticket and classifies vehicles into five classes as indicated in Table 4.3.3.

Class 1 vehicles which comprise 2-axle with 3 or 4 wheeled vehicles are tolled at 5 sen per km. On the other hand, under the zone or flat system, toll charges vary with tollway length and as a general measure they are also calculated on the basis of 5 sen per km.

Table 4.3.2 : Existing Tollways in Malaysia

	Length	Toll Levy System	Tariff
1. LLM/PLUS			
(1) North-South Highway			
(a) Bukit Kayu Hitam - Gurun	80 km	DPT	Car: 5sen per km
(b) Changkat Jering - Ipoh	54 km	DPT	Car: 5sen per km
(c) Kuala Lumpur - Ayer Keroh	115 km	DPT	Car: 5sen per km
(d) Senai - Johor Baru	28 km	zone	Car: 50sen
(e) Penang Bridge	14 km	zone	Car: $7.00
(2) KL-Karak Highway	18 km	zone (2 tolls)	Car: $1.00; 50sen
2. Privatized Projects			
(1) North Klang Straits Bypass	15 km	zone (2 tolls)	Car: 50sen/gate Lorry: $1/gate
(2) Jalan Kuching Improvement	5 km	zone	Car: 50sen, Lorry: $1.00

Note : (i) DPT - Distance proportional tariff system
(ii) Zone - Zone tariff system

Table 4.3.3 : Classification of Vehicle Types in Closed System

Category	Type of Vehicle
Class 1	2-axle, 3 or 4 wheels
Class 2	2-axle, 5 or 6 wheels
Class 3	3-axle and above
Class 4	Taxi
Class 5	Bus

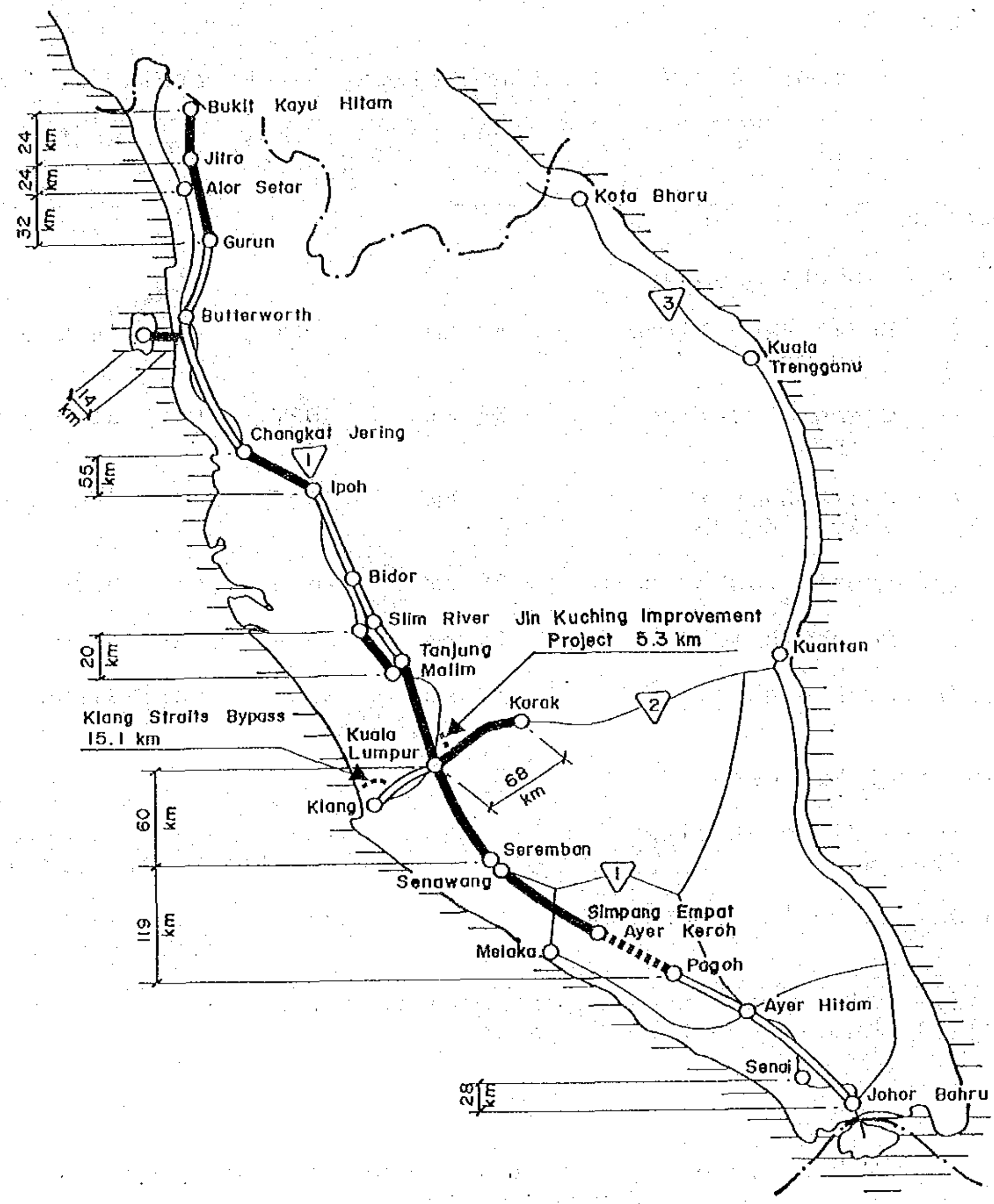

FIG. 4.3.1 : MALAYSIAN EXPRESSWAYS AND TOLL HIGHWAYS

LEGEND :

IN OPERATION

UNDER CONSTRUCTION

PLANNED

THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY

SCALE :

N

4.3.3 Classification of Toll Levy Systems

A toll levy system can be classified as either a closed or an open system depending on the operation of the toll collection. In the closed system, toll is collected from every vehicle using the tollway. As such toll gates are erected at all interchanges so that no driver escapes from paying toll. On the other hand, in the open system, some road users will be exempted from paying toll, that is, there will be no toll gate at certain locations where traffic volume is low. The resulting toll revenue in the open system may be lower than that of the closed system, but considerable savings in operation and maintenance costs can be expected. In addition, there will be less time loss at the interchanges.

There are several methods used in determining the toll payable under both closed and open systems.

The following three methods of toll levy systems may be considered, that is:-

(a) Flat tariff system
(b) Zone tariff system
(c) Distance proportional tariff system

A flat tariff system is whereby a fixed tariff is applied and to be collected at on-ramp only. A zone tariff system is defined as one in which a fixed tariff is applied and to be collected at toll barriers set up across the throughway. In a distance proportional tariff system, a driver receives a magnetic ticket on entering the tollway and pays a tariff proportional to the distance travelled on leaving the tollway.

Generally, the toll levy system for tollway inside the city in most cases is a flat tariff system for the road segment within the city central area and for the outer city area, a zone tariff system or distance proportional tariff system is usually adopted. One of the reasons for adopting a flat tariff system for the city central area is that most of the car trips using the tollway are intracity trips and their trip length is relatively short. Therefore, it is conceivable that the distance travelled on the tollway is almost uniform for most users.

Another reason for adopting a flat tariff system in this case is in order to reduce the time taken for toll collection and hence ensuring a smooth traffic flow on the tollway. The shorter the trip length, the greater is the effect of time loss incurred due to the stop at the tollgate and this could influence the utilization rate of the tollway.

Therefore, under the flat tariff system, in order to handle the large urban traffic volume, toll gates are usually located at the on-ramps only; there is no toll gate at the off-ramps thereby ensuring a smooth traffic flow and no time loss to users at the off-ramps.

Based on the principle of fairness to all users, the distance proportional tariff system should be imposed. If the application of a flat tariff system is expanded over a vast area unlimitedly, then the flat tariff charged will be seen to be unfair to some road users compared to others. Hence, it is necessary to establish an appropriately sized area for the flat tariff system. Beyond this range in the outer city area, it may be necessary to impose the distance proportional tariff system while in between, the zone tariff system may be applicable.

4.3.4 Alternative Toll Levy Systems for Shah Alam Highway/MRR-II

(1) Preparation of Alternative Toll Levy Systems

The section of Shah Alam Highway/MRR-II between the intersections with KL-Seremban Expressway and NKSB measures about 42km in length. Fourteen interchanges are proposed on this highway and the average distance between two adjacent interchanges is about 3km.

Shah Alam Highway/MRR-II is planned as a highway serving the development targetted area which lies to the south of Federal Route II. It is very important that Shah Alam Highway/MRR-II is connected to the road network in this area in an organized manner. Thus interchange locations are also selected from this viewpoint. Owing to its function as a highway, priority must be given to its service to the surrounding area.

Rapid urbanization and recent large-scale development along the corridor necessitate the urgent development of Shah Alam Highway/ MRR-II. The adoption of a tollway, thus, is assumed so as to be released from the budgetary constraint of the Government.

In planning for the most appropriate toll levy system for this highway, the following consideration is necessary:-

(a) The assignment of intra-regional traffic onto Shah Alam Highway/MRR-II and the expectation that most of these assigned trips have relatively short trip length;
(b) Road users must not be made to feel as being treated unfairly;
(c) Ensuring convenience and mobility.

Taking the abovementioned consideration into account, the following alternatives are deemed applicable for the highway:-

Alternative 1: Toll Barrier System
Alternative 2: On-ramp Toll with Toll Barrier System

On comparing both alternatives, on-ramp toll system is not adopted because road users would feel a sense of unfairness.

In case of the toll barrier system, it is necessary to determine the number of toll barrier and to select its locations. The toll tariff for passenger car at each location is assumed to be 50sen.

As for the number of toll barrier, three (3) toll barriers are proposed for Shah Alam Highway/MRR-II based on the following factors.

(a) Urban communities such as Kuala Lumpur, Petaling Jaya, Shah Alam and Klang
(b) Maximum toll charge calculated

As for the location of the three (3) toll barriers, the following factors are considered:-

(a) Urban communities along the highway
(b) Land availability for toll plazas
(c) Characteristics of Traffic Flow

Based on the factors outlined above, the following location for the proposed three toll barriers are selected.

Barrier 1 : Section between Awan Besar and Kinrara Development

Barrier 2-A: Section between Puchong-Sg.Besi Road and N-S Link

Barrier 2-B: Section between N-S Link and HICOM

Barrier 3 : Section between SKSB and Jalan Langat

In the case of on-ramp toll with toll barrier system, the following toll barrier is assumed in this Study.

Barrier 2-A: Section between Puchong Sg. Besi Road and N-S Link

Therefore, the following alternative toll levy systems are prepared in this Study as shown in Figure 4.3.2.

Alternative 1-A : Toll Barrier System (Barriers 1, 2-A and 3)

Alternative 1-B : Toll Barrier System (Barriers 1, 2-B and 3)

Alternative 2 : On-ramp Toll System with Toll Barrier System

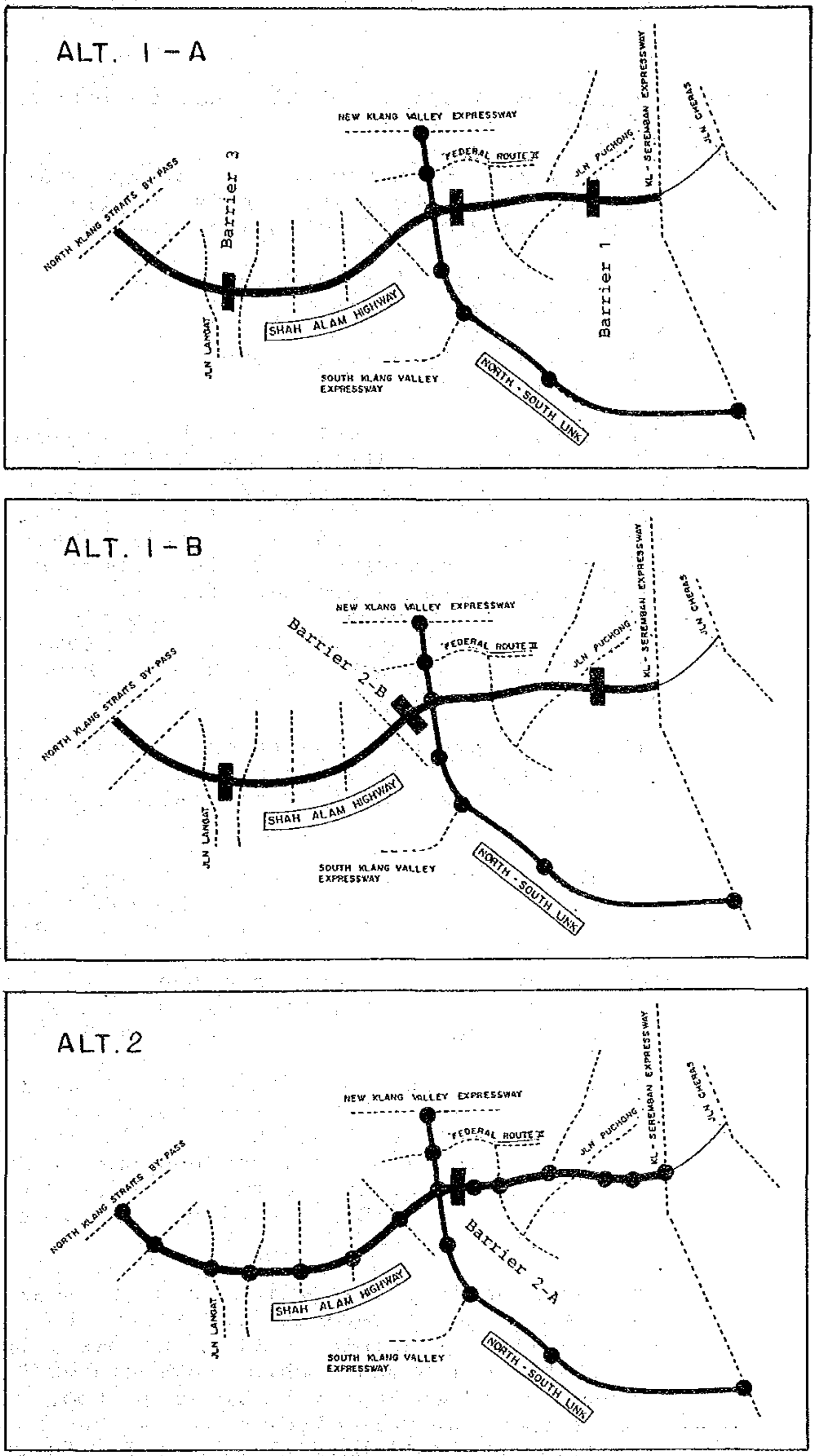

Figure 4.3.2: Alternative Toll Levy Systems

(2) Comparative Analysis of Alternative Toll Levy Systems

Table 4.3.4 shows the results of comparative analysis of the alternative toll levy systems based on the following aspects:-

* Traffic Volume for Tariff
* Toll Revenues
* Toll Facility Cost
* Road and Toll Facility Cost
* Operating Cost

The comparative analysis shows that if solely on the basis of traffic volume and hence the revenue receivable, Alternative 2 (on-ramp toll with toll barrier system) is superior to Alternatives 1-A and 1-B (toll barrier system). Alternative 1-B is superior to Alternative 1-A. However for the project evaluation purposes, the adoption of Alternative 1-A (toll barrier system) is assumed in this Study for Shah Alam Highway/ MRR-II because of the following reasons:-

(a) The initial investment cost of Alternative 2 is expected to be much higher than that of either Alternative 1-A or 1-B;

(b) At the same time, the operating cost of Alternative 2 is also much higher than that of either Alternative 1-A or 1-B;

(c) Taking into consideration of the Malaysian context, Alternative 1-A or 1-B is more popular than Alternative 2;

(d) Regarding the location of toll barrier, Alternative 1-B is expected to have a higher toll revenue than Alternative 1-A and the index of toll revenue per roadway and toll facility costs also shows that Alternative 1-B has a higher value than Alternative 1-A.

If Alternative 1-A which has a smaller estimated toll revenue is found to be financially feasible, it follows that Alternatives 1-B and 2 which have higher toll revenue would obviously be feasible too. For the purpose of this Study, it is thus safer to assume the toll barrier system for further deliberation.

Table 4.3.4: Comparative Table Between "Toll Barrier System" and "On-ramp Toll With Toll Barrier System" for Shah Alam Highway/MRR-II

		Toll Barrier System		On-Ramp With Toll Barrier
		Alt.1-A	Alt.1-B	Alt.2
Number of Toll Booths	Number	49	54	100
	Index	1.00	1.10	2.04
Traffic Volume for Tariff in 2005 (Daily)	Number ('000)	193.8	214.0	249.0
	Index	1.00	1.10	1.28
Toll Revenue in 2005 (Annual)	Amount ($'000)	38,617	42,632	62,050
	Index	1.00	1.10	1.61
Toll Facility Cost	Amount ($'000)	13,287	14,643	33,020
	Index	1.00	1.10	2.49
Roadway and Toll Facility Costs	Amount ($'000)	673,470	674,826	693,203
	Index	1.00	1.00	1.03
Operating Cost in 2005 (Annual)	Amount ($'000)	1,863.5	2,054	3,800
	Index	1.00	1.10	2.04
Toll Revenue/ Roadway and Toll Facility Costs	Index	1.00	1.10	1.56

Note: (1) All costs and revenue are based on 1988 constant prices
(2) Construction cost is based on the ultimate plan

Nevertheless, the adoption of the toll barrier system in toll levy system for Shah Alam Highway/MRR-II requires further confirmation at the detailed engineering stage.

4.3.5 Alternative Toll Levy System on N-S Link

N-S Link is planned as a segment of the expressway traversing Peninsular Malaysia, known as North-South Highway. In the future N-S Link will connect NKVE with KL-Seremban Expressway so that Bukit Kayu Hitam in the north and Johor Bharu in the south will be connected by one single expressway (Figure 4.3.3).

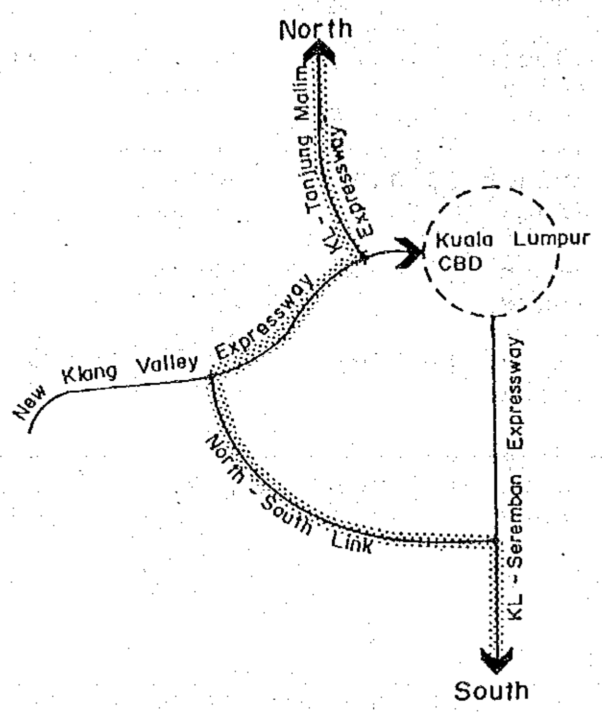

Figure 4.3.3 : Concept of N-S Link as Part of North-South Highway

Presently the toll levy system on existing segments of North-South Highway comprises both the closed system and open system. However in the future the whole length will adopt the closed system.

KL-Seremban Expressway is already under the closed system. The on-going and committed segments of NKVE and KL-Tanjung Malim Expressway are also expected to be under the closed system when put into operation.

The closed system is an effective toll levy system in order to ensure high mobility on the expressway. From the viewpoints of mobility and safety, the installation of toll barriers under the open system should be strongly avoided because of problems which will result in the deterioration of expressway function.

On the other hand, in the case of the closed system, toll plazas must be erected at each interchange and this may give rise to contentions for rejecting the closed system on grounds of high operation and maintenance costs.

Nevertheless, while in the interim an open system may be applied to N-S Link, in the future it should be necessary to attain the planning efforts to have a single completed expressway running from north to south of Peninsular Malaysia. Therefore, it is important to introduce the closed system in order to ensure high mobility and safety on N-S Link.

4.3.6 Proposed Toll Levy System on Project Roads

In this Study the alternatives for toll levy system have been evaluated by the Study Team based on the overall consideration of project implementation, toll levy system operations and functionality of the Project Roads.

It is proposed that for sake of conformity the final type of toll levy system on N-S Link will be similar to that used on North-South Highway, i.e. a closed system by distance proportional tariff.

In the case of Shah Alam Highway/MRR-II, it is proposed that an open system by zone tariff be implemented with three toll barriers; one located between Kuala Lumpur and Subang-Puchong area, the second one is located between Subang-Puchong area and Shah Alam while the third one is located between Shah Alam and Klang, that is, only inter-urban centre traffic will be tolled.

Figure 4.3.4 shows the proposed toll levy system on the Project Roads and the location of toll barriers on Shah Alam Highway.

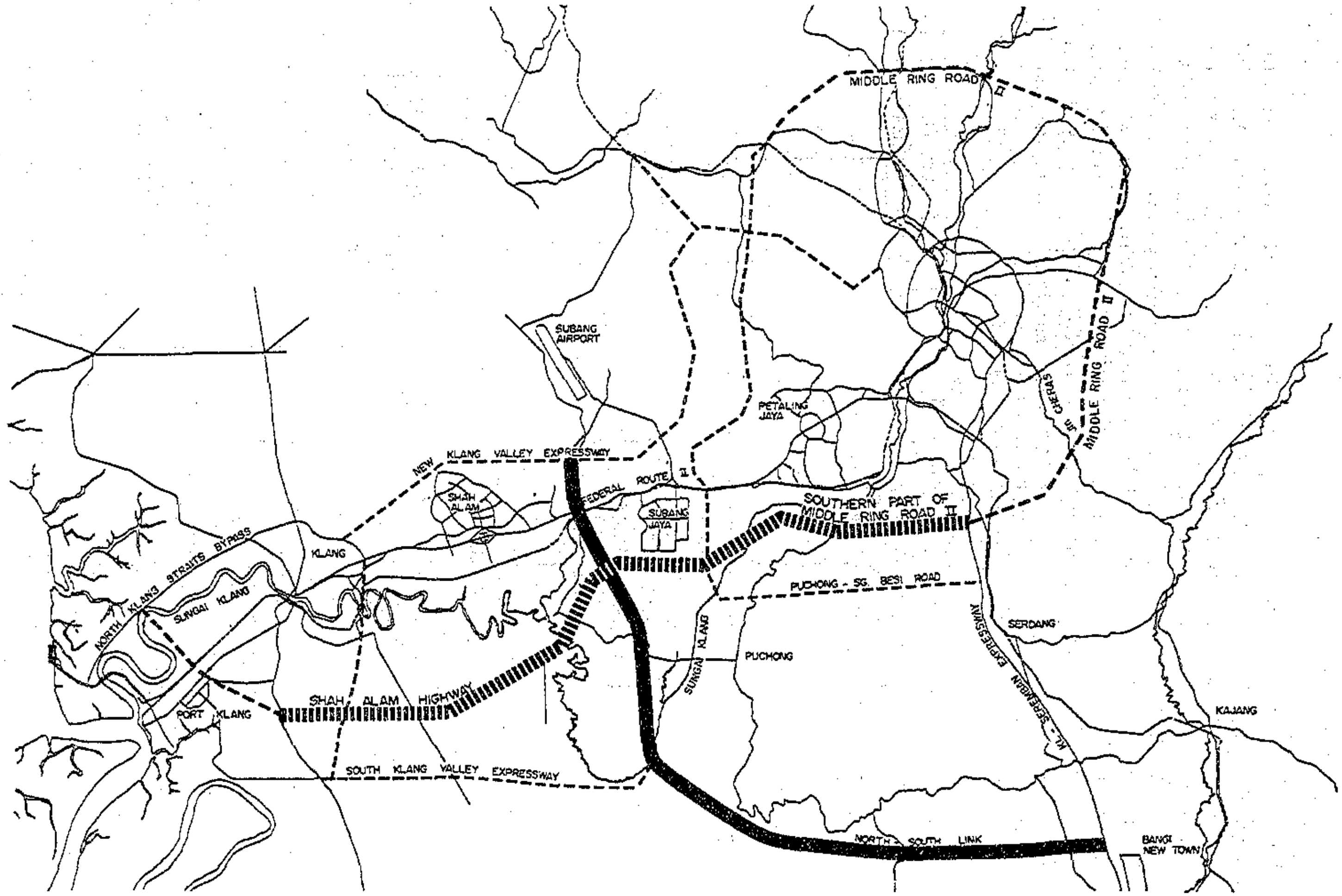

Fig.4.3.4 PROPOSED TOLL TARIFF SYSTEM ON STUDY ROADS

LEGEND:
- CLOSED SYSTEM BY DISTANCE PROPORTIONAL TARIFF
- OPENED SYSTEM BY ZONE TARIFF

SCALE: 0 1 2 5 10 km

N

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4.4 Alternative Interchange Plans

4.4.1 Study Approach

Figure 4.4.1 shows the procedure to determine the number of interchanges and their location on the Project Roads. In order to determine the optimum number of interchanges, firstly all the possible interchange location will be identified. Then, based on the possible interchange location, alternative interchange plans are prepared and evaluated in this Study. And finally, based on the result of the evaluations made, the optimum interchange plan is selected.

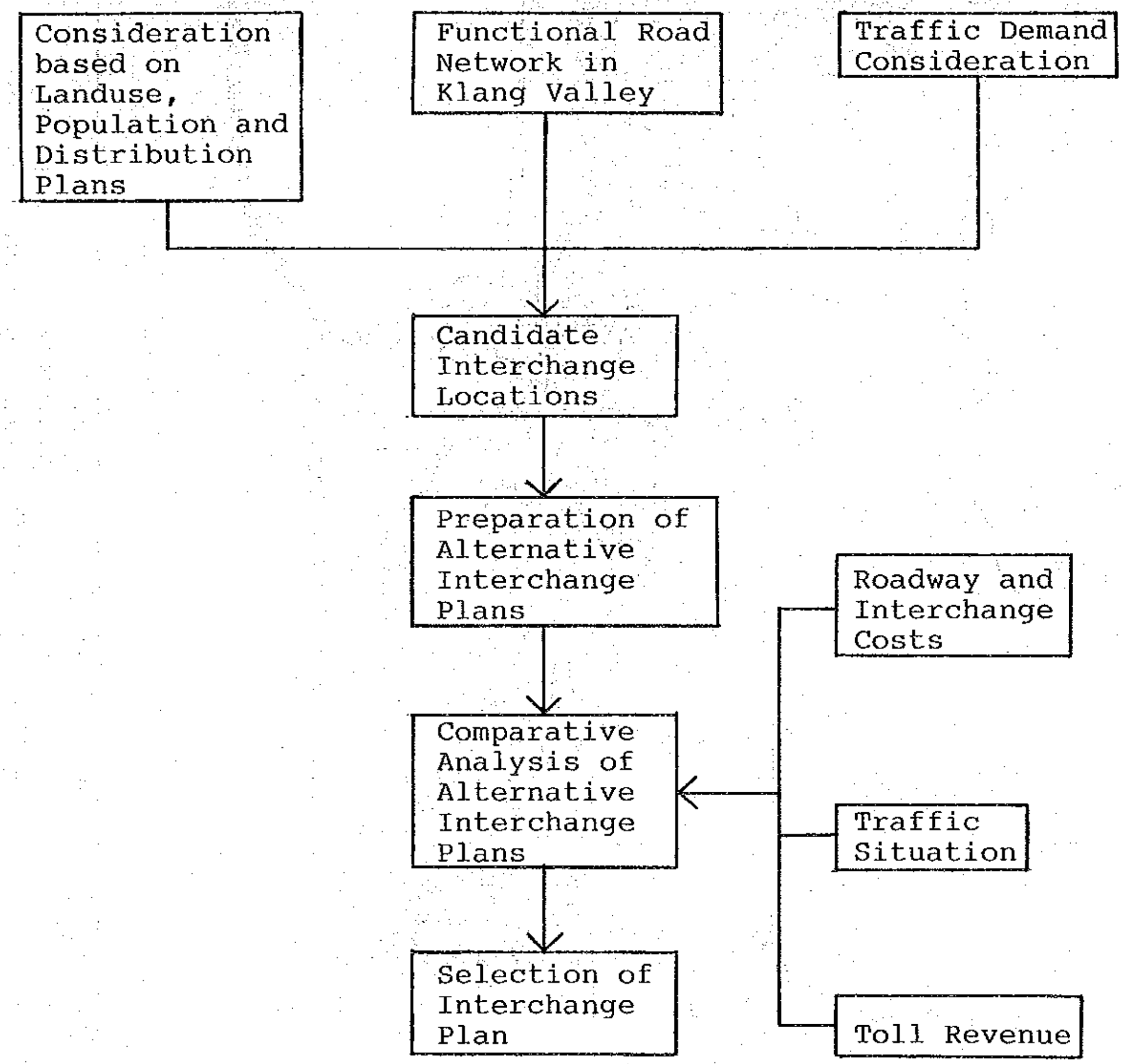


Figure 4.4.1: Procedure for Selection of Interchange Plan

4.4.2 Preparation of Alternative Interchange Plans

Interchange location is principally selected based on the following aspects:-

(a) Landuse consideration
(b) Population and employment distribution plans
(c) Functional road network in Klang Valley
(d) Traffic demand consideration

Based on the abovementioned aspects, the number and location of interchanges are tentatively selected as shown in Figure 4.4.2. 16 interchanges on Shah Alam Highway/MRR-II are selected while 7 interchanges on N-S Link are selected (Subang South IC has been counted twice).

These selected interchanges are classified into the following three (3) ranks in order to prepare the alternative plans.

(1) Interchanges of the first rank have the vital necessity to be operative at the same time as the opening of the Project Roads so they are to be constructed simultaneously. However, the construction of interchanges with a planned road can be delayed until the planned intersecting road is implemented.

(2) Interchanges of the second rank have the function to increase the efficiency of the Project Roads considerably by mostly connecting the highway with other medium standard roads.

(3) Interchanges of the third rank have the purpose of increasing the service level of the Project Roads. The construction of some interchanges of this rank can be delayed until the adjacent development projects are implemented.

Based on the abovementioned basic considerations, the implementation ranking of interchanges on Shah Alam Highway/MRR-II and N-S Link are presented in Figures 4.4.3 through 4.4.5.

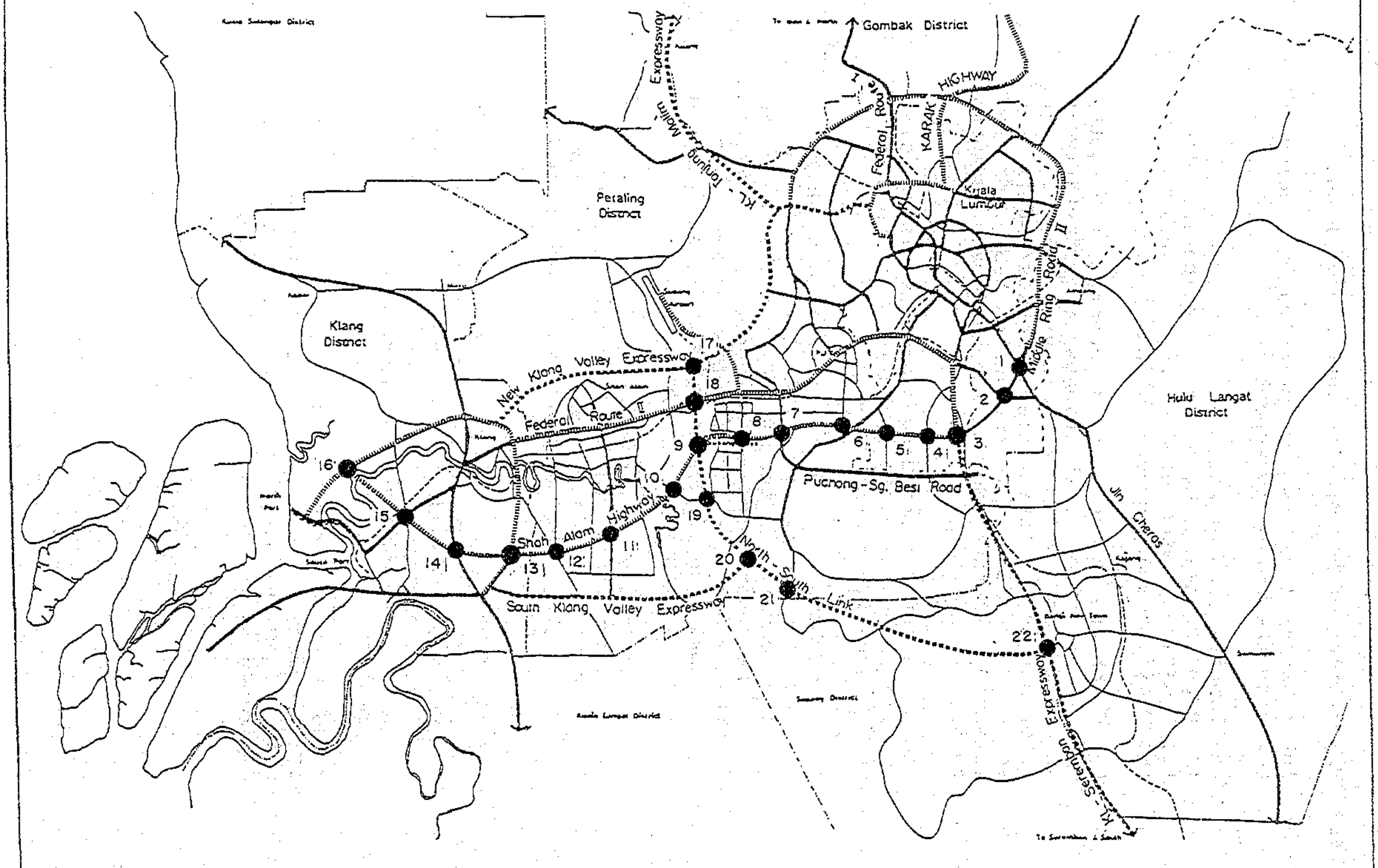


Figure 4.4.2: Location of Interchanges on Project Roads

LEGEND:

SCALE:

0 1 2 5 10 km

N

THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY

1st RANK

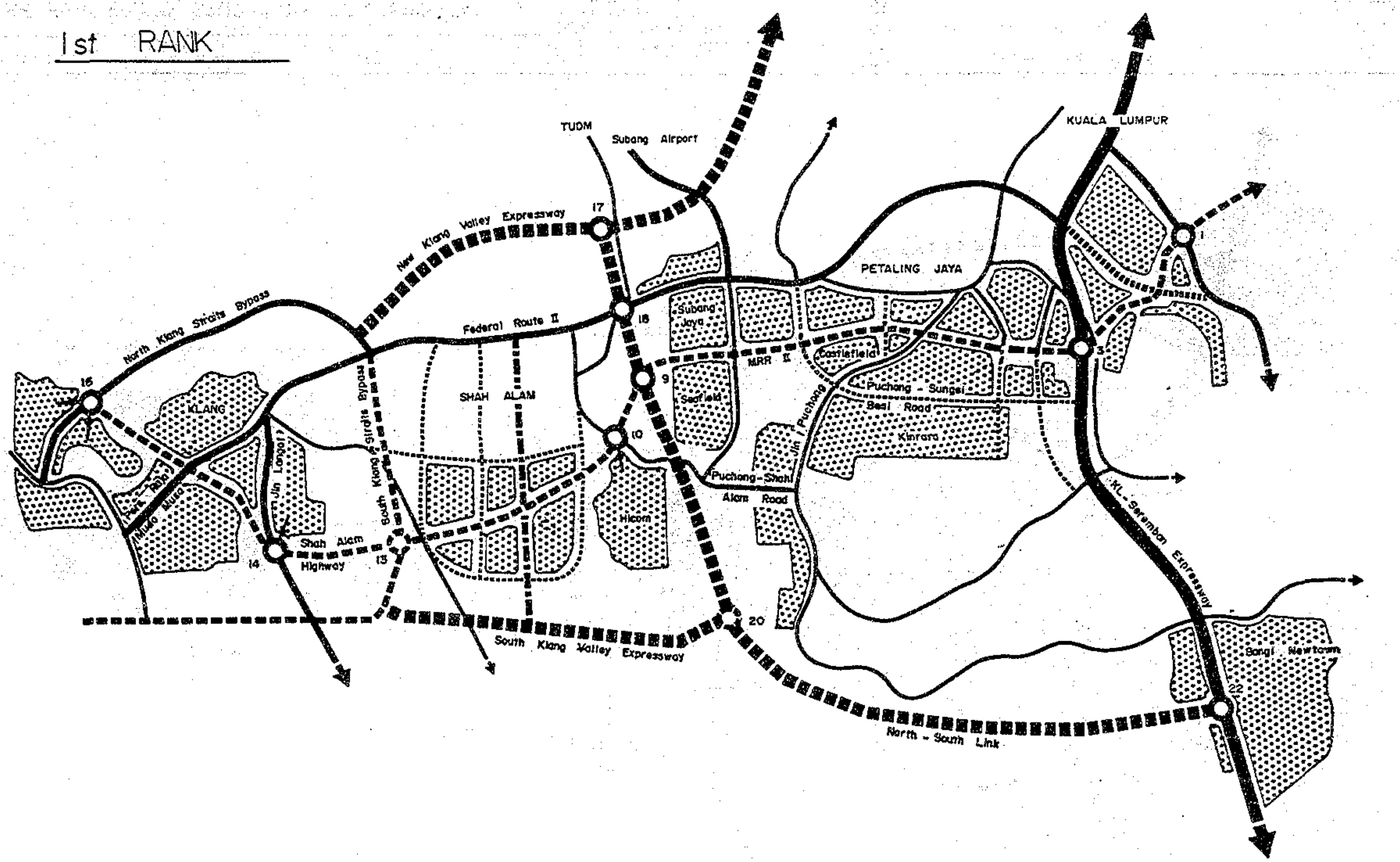


Figure 4.4.3: Implementation Priority of Interchange 1st Rank

THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY

LEGEND:
EXPRESSWAY (FUTURE)
EXPRESSWAY (EXISTING)
HIGHWAY (FUTURE)
HIGHWAY (EXISTING)
PRIMARY (FUTURE)
PRIMARY (EXISTING)
IC WITH EXISTING ROAD
IC WITH PLANNED ROAD
MAJOR ARTERIAL
MINOR ARTERIAL

SCALE:

N

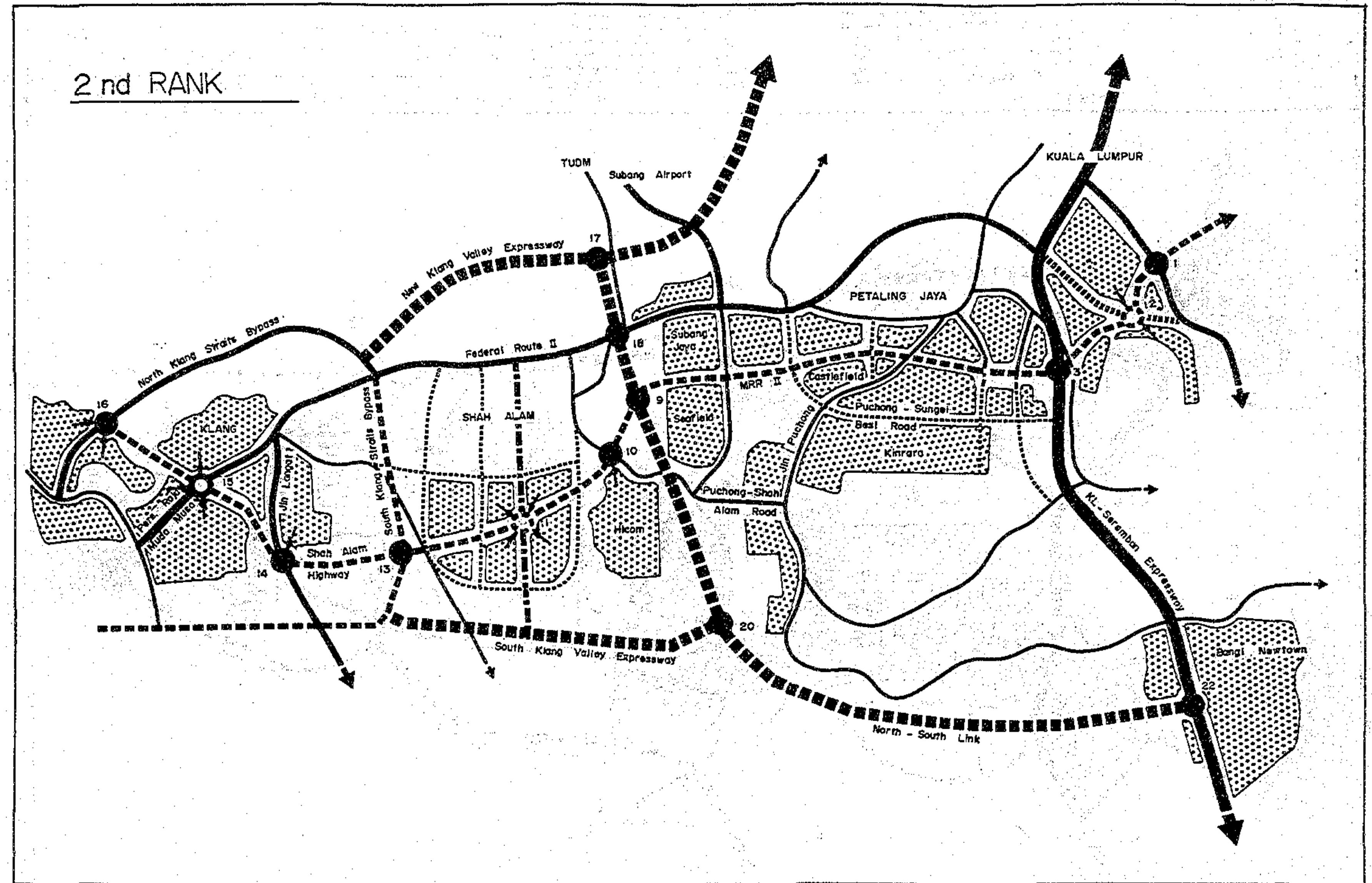


Figure 4.4.4: Implementation Priority of Interchange 2nd Rank

THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY

LEGEND:
- EXPRESSWAY (FUTURE)
- EXPRESSWAY (EXISTING)
- HIGHWAY (FUTURE)
- HIGHWAY (EXISTING)
- PRIMARY (FUTURE)
- PRIMARY (EXISTING)
- IC WITH EXISTING ROAD
- IC WITH PLANNED ROAD
- CONSTRUCTED
- MAJOR ARTERIAL
- MINOR ARTERIAL

SCALE :

N

3rd RANK

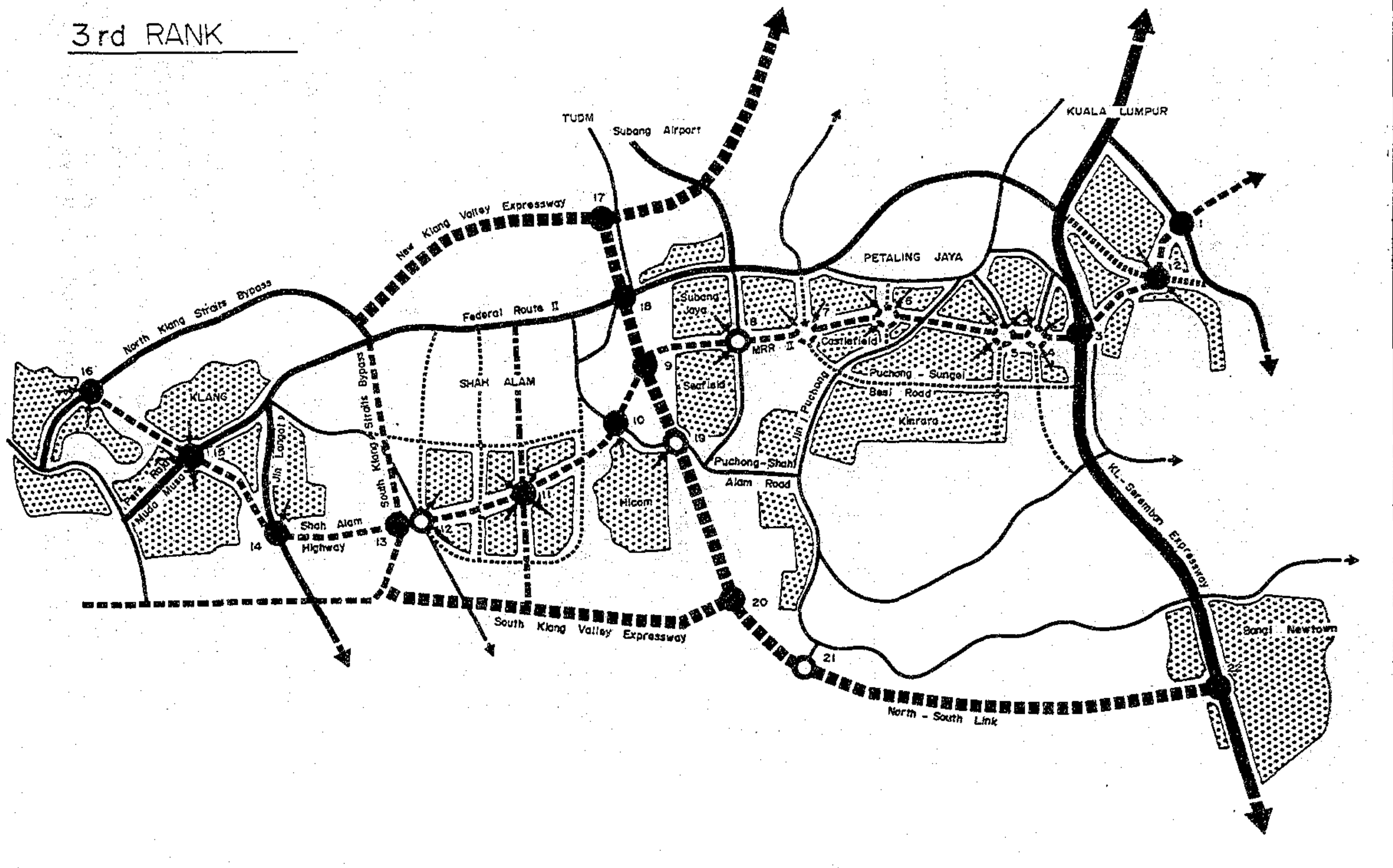


Figure 4.4.5: Implementation Priority of Interchange
3rd Rank

THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY

LEGEND:
- EXPRESSWAY (FUTURE)
- EXPRESSWAY (EXISTING)
- HIGHWAY (FUTURE)
- HIGHWAY (EXISTING)
- PRIMARY (FUTURE)
- PRIMARY (EXISTING)
- IC WITH EXISTING ROAD
- IC WITH PLANNED ROAD
- CONSTRUCTED
- MAJOR ARTERIAL
- MINOR ARTERIAL

SCALE:

N

From the abovementioned classification of interchange ranking and landuse consideration, the following three (3) alternative interchange plans are prepared in this Study:-

Plan 1 .. 11 Interchanges
Plan 2 .. 17 Interchanges
Plan 3 .. 22 Interchanges

Figure 4.4.6 illustrates these alternative interchange plans.

4.4.3 Comparative Analysis of Alternative Interchange Plans

A comparative analysis of the alternative interchange plans is made based on the following aspects:-

* Traffic Volume on the Project Roads
* Toll Revenues
* Roadway and Interchange Construction Costs
* Index of Toll Revenues/Construction Costs
* Average Interchange Interval at the Existing Expressway and Highway

The results of a comparative analysis of the proposed alternative interchange plans are summarized as follows:-

(a) Table 4.4.1 reveals that increase in toll revenue overwhelms the construction cost in the case of Plan 3 compared with Plan 1.

This implies that additional construction cost of interchanges will bring about preferable financial returns.

(b) Table 4.4.2 compares the average interchange interval between existing expressway and highways with the Project Roads.

The average interchange interval at Shah Alam Highway/MRR-II and N-S Link under Plan 3 is 3km and 5km respectively. These intervals are rather modest as compared with the existing expressway and highways. Considering the average interchange interval of the existing expressway and highways, Plan 3 can thus be justified.

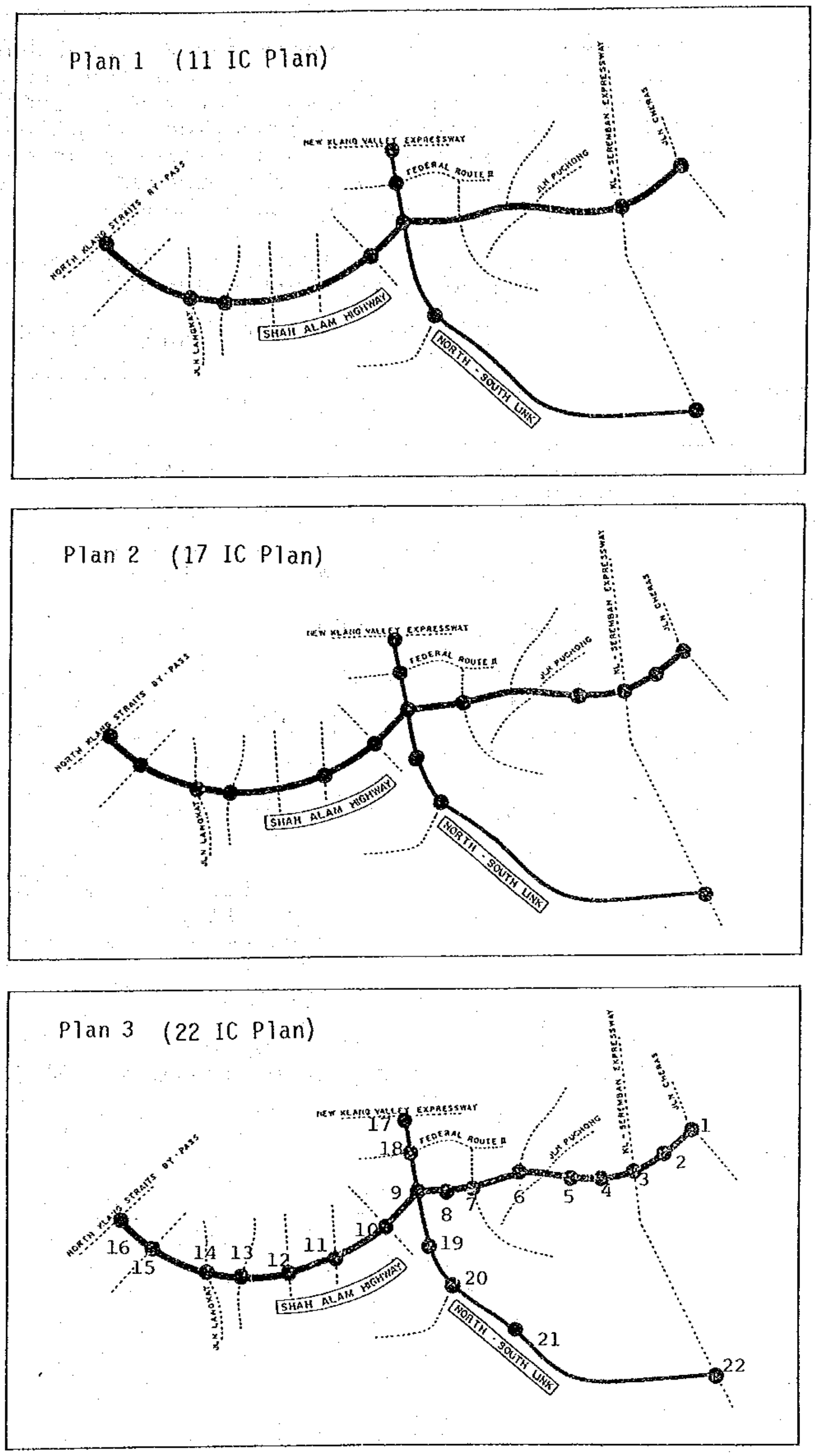


Figure 4.4.6: Alternative Interchange Plans

Therefore, Plan 3 which has 22 interchanges on the Project roads is assumed to be employed in this Study. Moreover, once the land area at the intersection location is reserved, stage-wise construction plan can be applied in pace with the process of urban development around the interchanges.

Table 4.4.1: Comparative Analysis of Alternative Interchange Plans (Entire Project Roads)

		IC Plan 1	IC Plan 2	IC Plan 3
Number of Interchanges	Number	11	17	22
	Index	1.00	1.55	2.00
Traffic Volume in 2005	Number ('000 veh)	278.2	374.4	480.8
	Index	1.00	1.35	1.73
Toll Revenue in 2005	Amount (M$million)	48.4	55.2	67.0
	Index	1.00	1.14	1.38
Construction Cost (Road-way & Inter-change Costs)	Amount (M$million)	1,001.5	1,019.4	1,032.1
	Index	1.00	1.02	1.03
Toll Revenue/cost	Index	1.00	1.12	1.34

Notes: (1) Toll revenue on the Project Roads is calculated using 1988 tariff basis
(2) Construction cost is based on the ultimate plan
(3) It is assumed the following toll levy systems will be implemented:-
Shah Alam Highway/MRR-II..Toll Barrier System
N-S Link..Distance Proportional Tariff System

Table 4.4.2: Average Interval of Interchanges on Existing Expressways/Highways

	Average Interval of ICs
Kuala Lumpur-Seremban Expressway (Salak to Bangi)	3 km
Federal Route II (Kuala Lumpur to Shah Alam)	1.5 km
Shah Alam Highway/MRR-II	
Plan 1 (7 IC)	6.8 km
Plan 2 (12 IC)	4.0 km
Plan 2 (16 IC)	3.0 km
N-S Link	
Plan 1 (5 IC)	6.7 km
Plan 2 (6 IC)	5.6 km
Plan 2 (7 IC)	4.8 km

4.5 Stage Implementation Plans

4.5.1 General

In the construction of huge highway projects such as in the case of Project Roads, it is possible to introduce stage construction method so as to reduce initial capital outlay. Herein, the preferable implementation plan is determined by the evaluation of utilization rate of the Project Roads under various stage implementation plans.

4.5.2 Possible Stage Implementation Plan

Three cases of the traffic assignment are examined for the stage implementation plans illustrated in Figure 2.4.2. Alt.1 consists of implementing the 4-lane sections of Shah Alam Highway/MRR-II from KL-Seremban Expressway to HICOM and N-S Link from NKVE to Shah Alam Highway. Alt.2 consists of implementing a 6-lane section of Shah Alam Highway/MRR-II from KL-Seremban Expressway to SKSB and a 4-lane section of SKSB to Jalan Langat. Alt.3 consists of implementing a 4-lane section of Shah Alam Highway/MRR-II from KL-Seremban Expressway to HICOM, a 6-lane section of N-S Link from NKVE to Shah Alam Highway and a 4-lane section from Shah Alam Highway to KL-Seremban Expressway at Bangi.

4.5.3 Comparative Analysis of Stage Implementation Plans

As mentioned earlier, the effectiveness of each possible stage implementation plan is measured by the utilization rate of the Project Roads. This in turn is measured by comparing the assigned road capacity. A higher utilization rate reflects on the appropriateness of the design capacity to meet the expected traffic demand.

Figure 4.5.1 shows the results of the assigned traffic demand on the project roads in 1995 under the formulated three possible stage implementation plans described in the previous section.

In Alt.1, it is shown that daily traffic volume on Shah Alam Highway/MRR-II ranges from 31,000 to 83,000 PCU while that on N-S Link ranges from 45,000 to 64,000 PCU. The road capacity on both roads can be sufficiently provided by 4-lane sections. In Alt.2, the daily traffic volume ranges from 32,000 to 121,000 PCU when Shah Alam Highway/MRR-II is extended from HICOM to Jalan Langat compared to Alt.1. In this case, the road capacity on certain sections will need at least 6 lanes to cope with the high traffic volume.

In Alt.3 however, the daily traffic volume on Shah Alam Highway/MRR-II ranges from 15,000 to 77,000 PCU while that on N-S Link ranges from 27,000 to 65,000 PCU, indicating rather unbalanced utilization rate for different road sections.

The evaluation of the three possible stage implementation plans can thus be made by comparing the traffic statistics on the Project Roads as shown in Table 4.5.1. Accordingly, Alt.1 is found to be superior to the other plans in terms of utilization rate of the Project Roads followed by Alt.2.

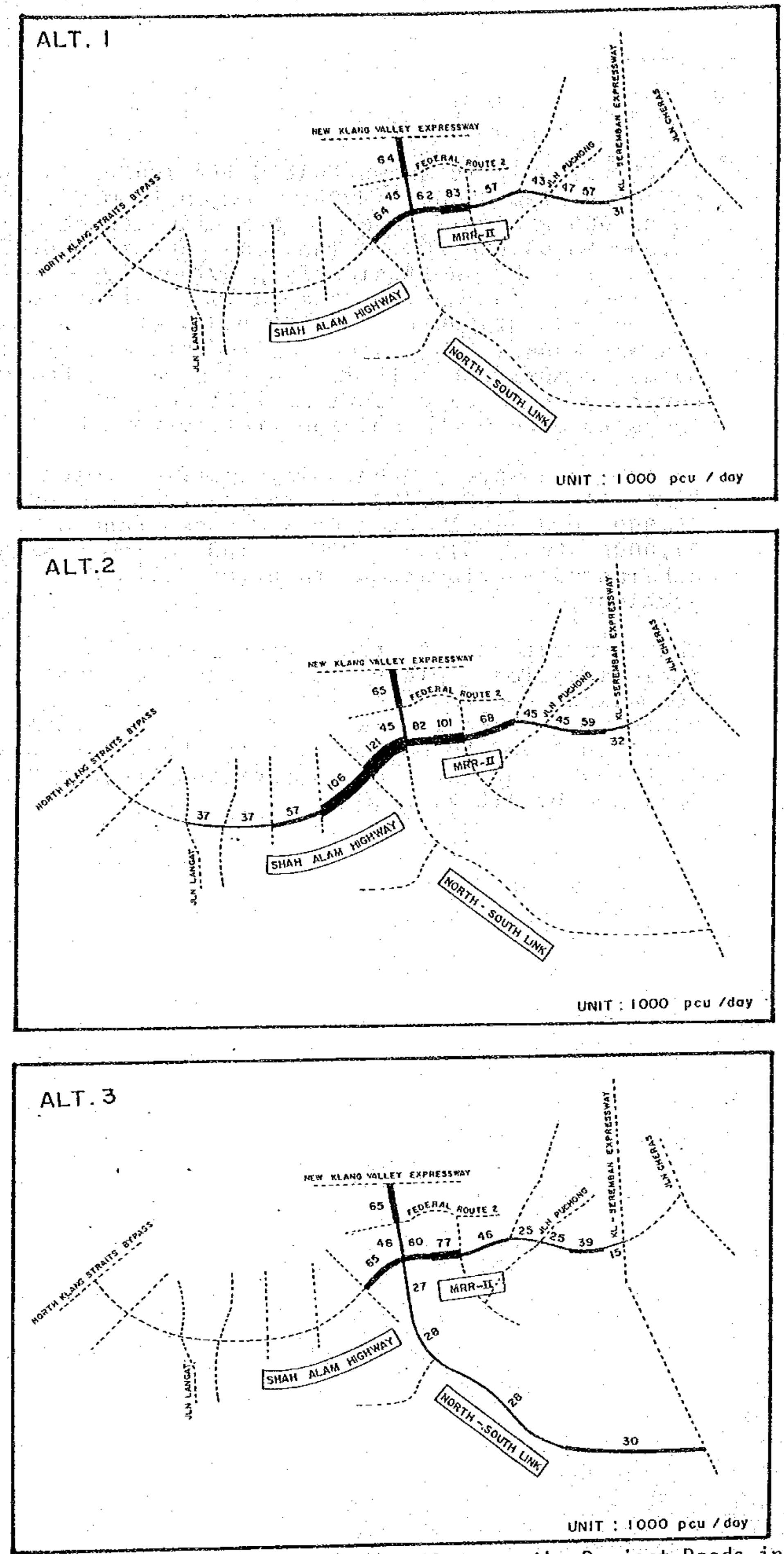


Figure 4.5.1: Assigned Traffic Volume on the Project Roads in 1995 under Stage Implementation Plans

Table 4.5.1 : Traffic Statistics on the Project Roads by Stage Implementation Plans in 1995

	Alt.1 *1 (A)	Alt.2 *2 (B)	Alt.3 *3 (C)	Comparison (B/A)	(C/A)
Traffic Volume ('000 veh)	140.7	188.7	154.6	1.34	1.10
Vehicle Kilometers ('000 veh.km)	1,159	2,338	1,921	2.02	1.66
Capacity Kilometers ('000 veh.km)	1,370	2,956	3,631	2.16	2.65
Veh.km/Capacity.km	0.85	0.79	0.53	0.93	0.62

Notes:*1 Shah Alam Highway: KL-Seremban Expressway to HICOM, 4-lane
N-S Link: NKVE to Shah Alam Highway, 4-lane

*2 Shah Alam Highway: KL-Seremban Expressway to SKSB, 6-lane
SKSB to Jalan Langat, 4-lane
N-S Link: NKVE to Shah Alam Highway, 4-lane

*3 Shah Alam Highway: KL-Seremban Expressway to HICOM, 4-lane
N-S Link: NKVE to Shah Alam Highway 6-lane
Shah Alam Highway to KL-Seremban Expressway, 4-lane

CHAPTER 5 : PRELIMINARY ENGINEERING STUDY

5.1 Basic Data

5.1.1 Aerial Photographs

Aerial photographs of the corridor flown in December 1982 to a scale of 1:40,000 were used in the initial stage of route location study.

5.1.2 Topographical Maps

Topographical maps to a scale of 1:10,000 published by Directorate of National Mapping which were compiled by photogrammetry (ploted in 1969 and field completion in 1975 to 1981) were used for the route location study.

Topographical maps to a scale of 1:25,000 and a scale of 1:63,360 were also used for hydrological study.

Photogrammetric ploting from 1982 aerial photographs and supplementary field completion in June 1988 are done by the JICA Study Team.

Topographical maps to a scale of 1:5,000 based on the photogrammetry with field completion are used for route identification and preliminary engineering study for throughway.

Topographical maps to a scale of 1:1,000 are produced based on the ground survey for the following six (6) locations of large-scale interchanges.

(1) Klang West Interchange (No.16)
- North Klang Straits Bypass/Shah Alam Highway

(2) Kim Chuan Interchange (No.15)
- Persiaran Raja Muda Musa/Shah Alam Highway

(3) Sri Petaling East Interchange (No.3)
- Kuala Lumpur-Seremban Expressway/MRR-II

(4) Cendekiawan Interchange (No.2)
- Jalan Cendekiawan/MRR-II

(5) New Klang Valley Interchange (No.17)
- New Klang Valley Expressway/N-S Link

(6) Bangi West Interchange (No.22)
- Kuala Lumpur-Seremban Expressway/N-S Link

5.1.3 Standard Sheets

Standard sheets at a scale of 1:6,336 are obtained from Selangor State and the City Hall of Kuala Lumpur and are used to present future development plans.

The proposed right-of-way of project roads is shown on the relevant standard sheets and the land availability is confirmed by each planning authority.

5.2 Right-of-way Situation (R.O.W)

The available R.O.W width for the project roads is summarized in Table 5.2.1.

These R.O.Ws are set in principle as a typical section between interchanges.

The proposed R.O.W for an interchange, ON/OFF ramp and a toll barrier is referred to the Planning Control Maps.

Table 5.2.1: Proposed Right-of-Way (R.O.W)

Project Road	Section	Proposed R.O.W.(m)
Shah Alam Highway	Klang West IC - CH. 0+600	50
	CH. 0+600 - CH. 6+000	40
	CH. 6+000 - Shah Alam West IC	60
	Shah Alam West IC - Shah Alam East IC	80 a)
	Shah Alam East IC - Sunway IC	60
Middle Ring Road II	Sunway IC - Sri Petaling West IC	60 c)
	Sri Petaling West IC - Sri Petaling East IC	80 b)
	Sri Petaling East IC - Cheras IC	40 d)
North-South Expressway Link	New Klang Valley IC - CH. 3+700	80 b)
	CH. 3+700 - Bangi West IC	60
	Direct Access to Bangi Town Centre	40

Notes: a) 60m wide road reserve for throughway and 20m for frontage road which is provided by developers of land fronting the existing Jalan Bukit Kemuning.

b) 60m wide road reserve for throughway and 20m for frontage road which is used to maintain the function of existing roads.

c) 60m wide road reserve includes a 10m wide frontage road wherever necessary.

d) 40m wide road reserve includes a 10m wide frontage road but R.O.W is reduced to 30m in HAR Holding, Rumah Tulin and Taman Taynton area.

5.3 Geological Analysis and Soil Survey

5.3.1 General Geology

The project sites are located in a very wide area which covers the Federal Territory and Selangor as shown in Figure 5.3.1.

For a better understanding of ground conditions at the sites, geological features of this area is briefly described in this section. The geological map of the area shown in Figure 5.3.1 was prepared based on the map published by Geological Survey of Malaysia in 1985. As shown in Figure 5.3.1, the area is mainly composed of Kuala Lumpur limestone, Kenny Hill formation, granitic rocks and quaternary deposits. The general profile of the sites are shown in Figure 5.3.2.

Their main features are described below:-

(1) Kuala Lumpur Limestone

The Kuala Lumpur limestone is considered to have been sedimented in the seabed during the middle to upper Silurian period which occured 400 million years ago. The limestone body was later uplifted by crustal movements and the surface was worn and cut by the water. The easily eroded nature of the limestone produced the unique karstic features of the area such as caves, underground channels, pinnacles, steep slopes and depressions with sinkholes. The topographic features of this limestone area will present numerous engineering problems for foundation construction.

The Kuala Lumpur limestone is generally covered by thick quatenary alluvial deposits which yield placer tin ore. Limestone outcrop is only found at the northern end of Kuala Lumpur valley where it forms "Batu Caves" in Gombak and tin mining area in Sungei Besi respectively.

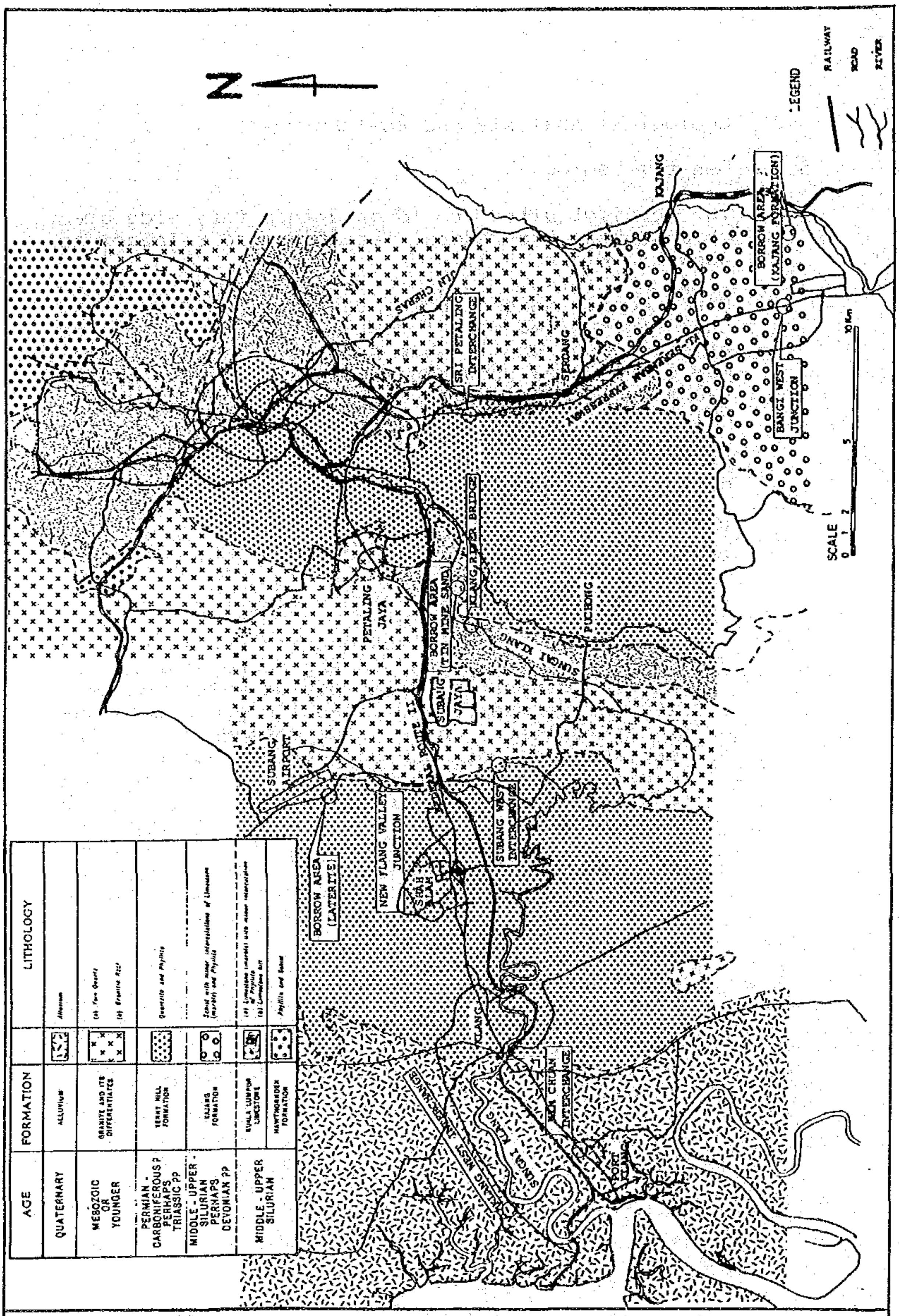


Figure 5.3.1 Geological Map of the Sites and their Surrounding Area

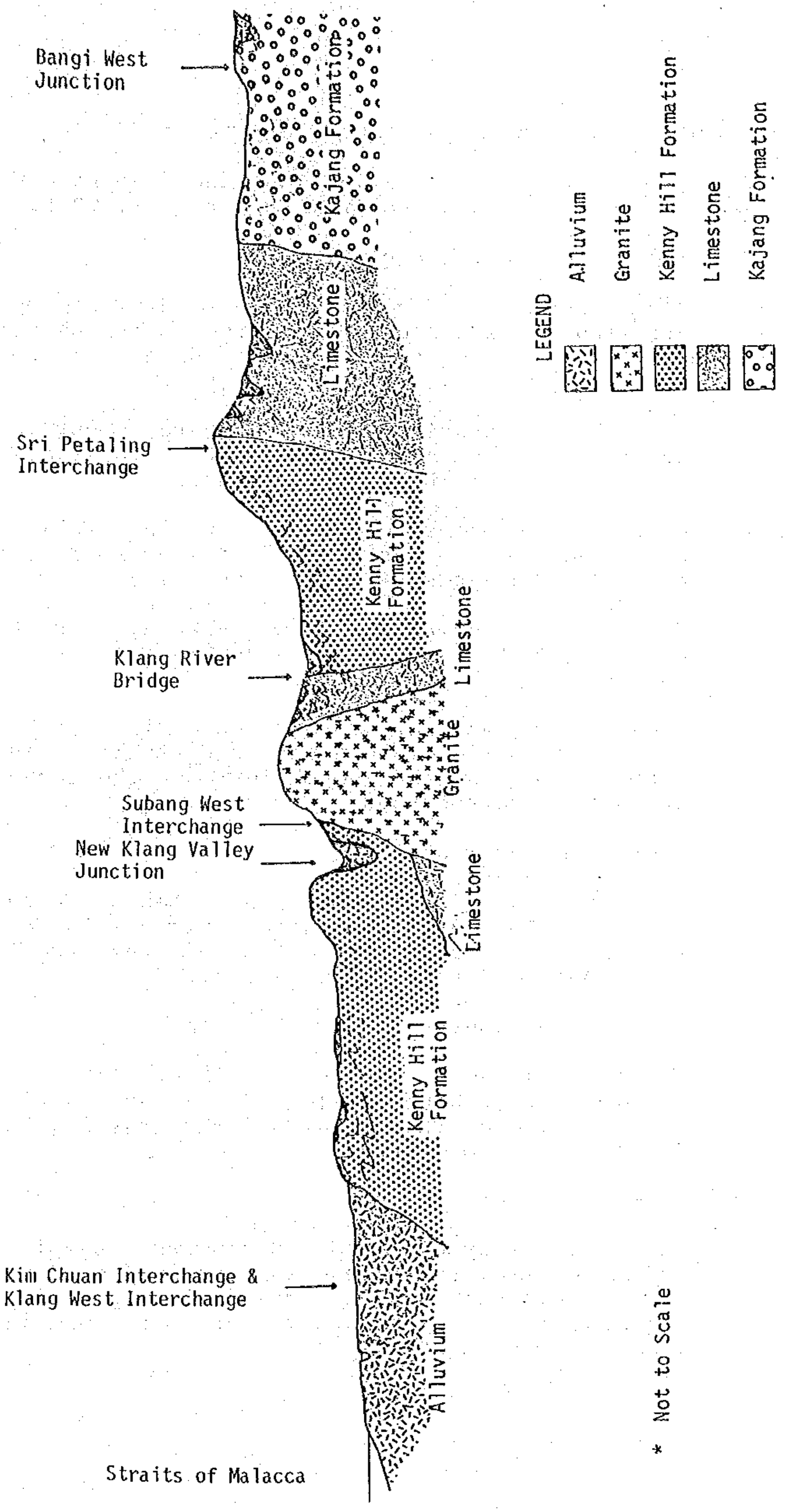


Figure 5.3.2 Generalise Profile of the Sites

5.3.2 Field Investigation and Laboratory Tests

A series of field investigation and laboratory soil tests were conducted from June to July 1988.

(1) Exploratory Drillings

Subsurface ground conditions were explored by drilling 15 boreholes at selected locations at seven major structure sites using three rotary-type rigs.

Standard Penetration Tests were carried out in accordance with ASTM D1586-84 at 1m intervals in the boreholes to obtain N-values.

Disturbed samples collected in the split-barrel during the tests were examined so as to classify the types of soil at the site.

Undisturbed samples were taken in soft cohesive soil layers using a stationary piston sampler with thin-walled tube.

Rock coring was performed using triple tube core barrel with diamond bit whenever rock was encountered in the boreholes and the core recovery were recorded.

(2) Pressuremeter Tests

A total of 17 pressuremeter tests were performed to study deformation characteristics and lateral subgrade reaction of the soil using Menard G-type pressuremeter.

(3) Sampling of Construction Materials

Three bulk soil samples comprising laterite sample from Subang, Kajang formation sample from Bangi and tin mining sand and gravel from Puchong were collected.

(4) Laboratory Soil Tests

Both undisturbed and disturbed samples obtained from the boreholes were subjected to both physical and mechanical property determination in laboratory tests performed in accordance with ASTM.

(5) Laboratory Tests on Construction Material

The three bulk soil samples collected from Subang, Bangi and Puchong were subjected to the following tests :-

(a) Specific Gravity Test
(b) Absorption Test
(c) Sieve Analysis
(d) Los Angeles Abrasion
(e) Modified CBR Test and
(f) Design CBR Test

The tests were carried out in accordance with ASTM except the modified CBR test which was carried out in a method presented in Manual for Design and Construction of Asphalt Pavement published by Japan Road Association.

5.3.3 Ground Conditions of Each Site

From the exploratory drillings the profiles of ground condition at the following six (6) sites of major structures are elucidated:-

(1) Sri Petaling East Interchange
(2) Klang River Bridge
(3) Subang West Interchange
(4) Bangi West Interchange
(5) Klang West Interchange
(6) New Klang Valley Interchange

The load bearing stratum has been found to varry from 10m below ground level at Klang River Bridge site to 40m at Klang West Interchange site. A depth of 20m to 30m is found elsewhere (see Figures 5.3.3 and 5.3.4).

More information and data are given in Appendix 5.2.1.

Results from pressuremeter tests giving the earth pressure at rest, creep pressure, limit pressure and modulus of deformation at the six (6) sites are summarized in Table 5.3.1.

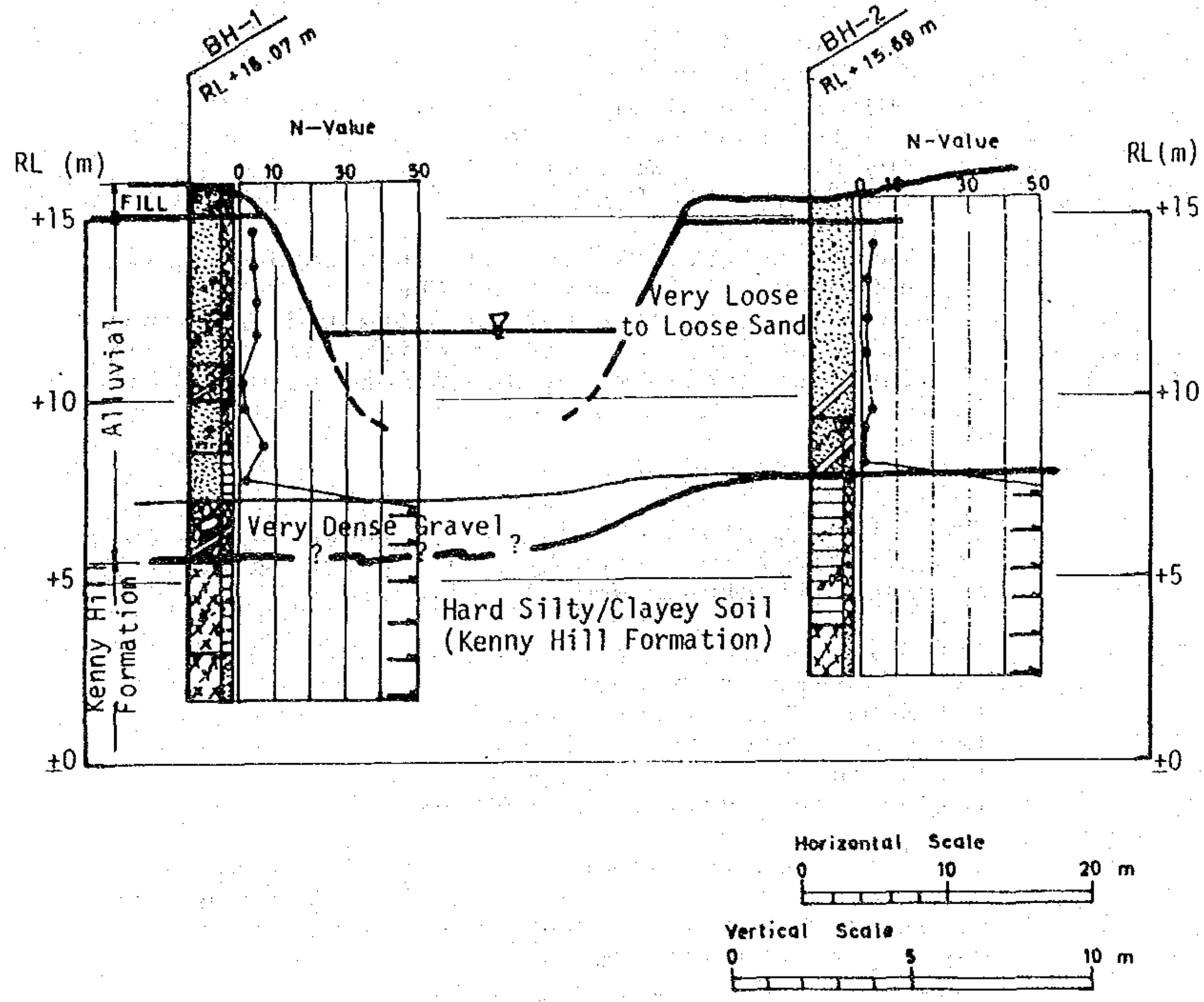


Figure 5.3.3: Soil Profile at Klang River Bridge Site

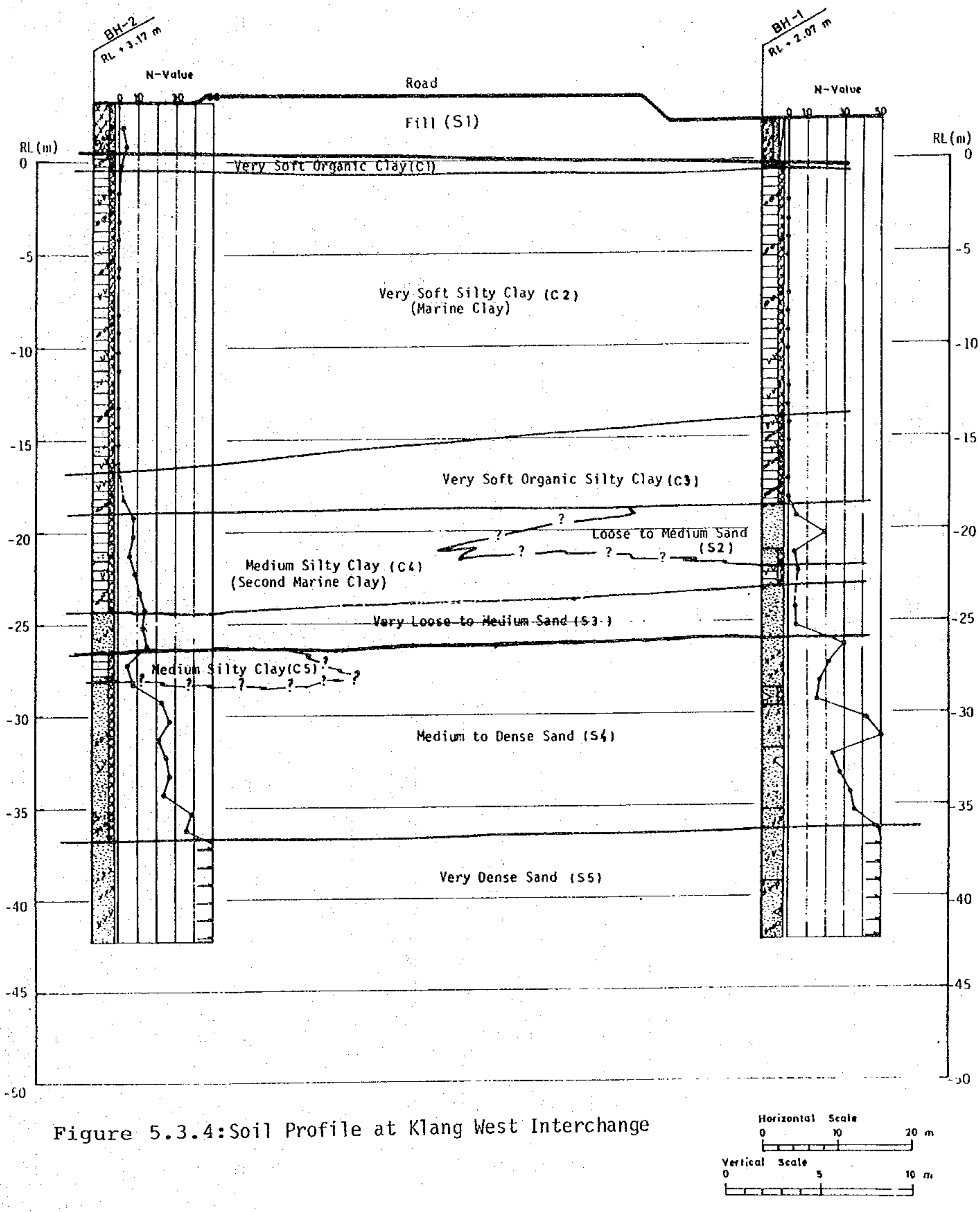


Figure 5.3.4:Soil Profile at Klang West Interchange

Table 5.3.1 : Summary of Pressuremeter Tests Results

Location	Formation	Strata	Depth (m) (BH)	Po (kg/sq.cm)	Pf (kg/sq.cm)	Pl (kg/sq.cm)	Ep (kg/sq.cm)
SRI PETALING EAST I.C.	Fill	-	3.00 (BH-2)	0.56	1.50	>1.66	12
	Kenny Hill Forma-tion	Medium to Stiff Sandy Silt	4.00 (BH-1)	2.60	9.32	>12.22	156
		Medium to Stiff Silty Clay	5.00	0.68	1.60	>2.49	21
KLANG RIVER BR.	Alluvial	Very loose to loose	5.00 (BH-1)	0.54	1.40	>1.68	12.50
			5.00	0.52	1.51	>1.72	12.50
SUBANG WEST I.C.	Granite (Residual Soil)	Medium to Stiff Clay/ Silt	4.00 (BH-2)	1.70	3.70	>6.45	62.6
	Kenny Hill Forma-tion	Medium to Stiff/ Silty Soil	3.00 (BH-3)	0.19	0.72	>1.02	11.7
		Hard Silty Soil	4.00 (BH-1)	2.90	18.05	- (Blow out)	781
		Very Dense Soil	6.00 (BH-1)	3.60	7.45	>10.85	199
BANGI WEST I.C.	Alluvial	Medium Silty Clay	4.50 (BH-1)	0.24	0.97	>1.28	8
	Kajang Forma-tion	Stiff Silty	4.00 (BH-2)	1.28	4.75	>5.89	136
KLANG WEST I.C.		Very Soft Clayey Soil (Cl)	4.0 (BH-2)	0.37	1.19	>1.34	12.3
			8.0 (BH-2)	0.21	0.95	>1.49	26
NEW KLANG VALLEY I.C.	Alluvial	Very Soft Clay	5.0 (BH-2)	0.22	0.68	>0.92	9.4
		Very Loose to Loose Sand	5.0 (BH-1)	0.24	0.59	>0.80	10
KIM CHUAN I.C.	Alluvial	Very Soft Silty Clay	5.0 (BH-1)	0.27	0.89	>1.31	15.3
			7.5	0.18	0.40	>0.75	11.0

Po : Earth Pressure at Rest
Pf : Creep Pressure
Pl : Limit Pressure
Ep : Modulus of Deformation

5.3.4 Engineering Properties of Construction Materials

The results obtained from a series of laboratory test performed on three bulk soil samples to determine their engineering properties are summarized in Tables 5.3.2 and 5.3.3.

The detailed description is presented in Appendix 5.2.2.

Table 5.3.2 : Summary of the Soil Properties of Construction Material

	Laterite Soil	Kajang Formation	Tin Mining Sand	Tin Mining Gravel
Natural Water Content (%)	17.5	30.1	-	-
Specific Gravity	2.679	2.722	2.659	2.65
Liquid Limit (%)	49	67	-	-
Plastic Limit (%)	20	33	-	-
Gravel Content (%)	1	1	15	-
Sand Content (%)	52	12	79	-
Silt Content (%)	11	40		-
Clay Content (%)	36	47	6	-
* Maximum Dry Density (mg/cu.m)	1.899	1.72	1.787	-
* Optimum Moisture Content (%)	12.7	18.7	10.0	-
Water Absorption (%)	-	-	-	0.23
Percentage of Wear (%) by Los Angeles Abrasion Test	-	-	-	49.6

Compaction Test, 92 blows/layer
Modified Proctor, 3 layers x 92 blows/layer

Table 5.3.3 : Summary of the Modified and Design CBR Test Results of the Construction Material

Sample and Location	Number of Blows	Swelling Ratio	CBR (%)
Laterite	92	3.395	8
Soil	42	2.82	5
(Subang)	17	2.71	2
	67*	0.112 - 0.20	2 - 4
Kajang	92	2.43	14
Formation	42	2.56	7
(Bangi)	17	3.02	1 (0.5)
	67*	-0.3 - 0.02	2
Tin Mining	92	-0.40	29
Sand (Puchong)	42	-0.08	25
(Puchong)	17	-0.103	8

* Design CBR at natural moisture content, 3 layers x 67 blows/layers
Energy: 4.5kg rammer x 45 cm height

5.4 Geometric Design

5.4.1 Geometric Design Policies

The design policies applied to the project roads are established after careful study of the surrounding conditions and experience on geometric design. The design policies are described as follows:-

- Careless use of the maximum or minimum values from the design standard should be avoided because these figures are considered as limits rather than desirable figures;

- To form the project road section that will be truly efficient and safe in operation the aim should be to produce a carefully tailor-made design for each section;

- Sudden changes in geometric design standard which would result in problems for drivers on the road should be avoided providing there is no significant violation of the right-of-way limit provided by Selangor State and the city of Kuala Lumpur;

- Where vertical and horizontal curves occur in combination or in close proximity to each other, consideration should be given to designing a flowing alignment by providing good coordination of these curves;

- Considering ease of construction the alignments should be designed to be as simple as possible wherever the design standard allows; and

- The right-of-way area to be required for the construction of the project roads should be kept at the absolute minimum.

5.4.2 Geometric Design Standard

(1) General

Since the geometric design standards of each classified road must reflect the desired goals identified by the Department of Public Works (JKR) and Malaysia Highway Authority (MHA), it is possible to apply uniformed standards.

JKR and MHA have already prepared the following geometric design standards, i.e.:-

- 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);
- A Guide to the Design of Cycle Track issued in 1986 (JKR); and
- Design Standard for Interurban Toll Expressway System of Malaysia (MHA).

(2) Recommended Design Standards

The recommended geometric design standards for the project roads are mainly derived from the abovementioned guides. Some necessary supplements are made. Table 5.4.1 tabulates the recommended design standards.

The backgrond of each criteria is described in Appendix 5.3.

(3) Other Elements of Design

(a) Medians

A standard median of 12.5m wide for N-S Link and 11.5m wide for Shah Alam Highway/ MRR-II respectively are recommended considering future additional lanes. After providing for future lanes, a standard median of 5.0m wide with 4.0m being raised for N-S Link and 4m wide with 3m being raised for Shah Alam Highway/MRR-II will be maintained.

Table 5.4.1 Design Control and Element of Roads

Items	Road	Throughway			Ramp		
		Southern Part of Middle Ring Road II	Shah Alam Highway	North-South Link	Semi-Direction	Loops and Diagonal	Loops and Diagonal
Design Control	Design Standard	Arterial (U5)	Arterial (U5)	Expressway (R6)	-	-	-
	Design Vehicle	Truck Combination (WB-50)	Truck Combination (WB-50)	Truck Combination (WB-50)	Truck Combination (WB-50)	Truck Combination (WB-50)	Truck Combination (WB-50)
	Design Speed (km/h)	80	80	120	60	50	40
	Design Daily Capacity (veh/day/Lane)	11,700	9,400	8,800	7,200	7,500	7,500
Element of Design	Sight Distance (m)	140	140	285	85	65	45
	Lane Width (m)	3.50	3.50	3.75	3.50	3.50	3.50
	Outer Shoulder Width (m)	3.00 (1.50)	3.00 (1.50)	3.00 (1.50)	3.00 (1 Lane) 0.75 (2 Lanes)	3.00 0.75	3.00 0.75
	Inner Shoulder Width (m)	0.75	0.75	0.75	0.75	0.75	0.75
	Crossfall of Travelled Way (%)	2.5	2.5	2.5	2.5	2.5	2.5
	Crossfall of Outer Shoulder (%)	4	4	4	4 (1 Lane) 2.5 (2 Lanes)	4 2.5	4 2.5
	Type of Pavement	Asphalt Concrete	Asphalt Concrete	Asphalt Concrete	Asphalt Concrete	Asphalt Concrete	Asphalt Concrete
	Maximum Superelevation (%)	10	10	7	7	7	10
	Minimum Radius (m) Max.Grade(%) (Desirable) (Absolute)	230 4 7	230 4 7	650 2 5	125 5 8	85 6 8	50 7 10
Remarks		( ) Value for bridge and viaduct section, of length more than 100m					

(b) Outer Separation, Borders and Frontage Roads

Frontage roads are often required to maintain local service and to collect and distribute ramp traffic entering and leaving the access controlled highway/ expressway. The outer separation or border provides space for sideslopes, drainage, guardrails, lighting standards, signs, planting space, access control faces, retaining wall or stone masonry, cycle tracks, ramps and toll gates, if any. The outer separation or border may also provide space for installing noise abatement measures in sensitive areas.

In Shah Alam area, an outer separation of 15m wide is recommended as buffer zone between the highway and the adjacent area and to accomodate a high standard of ramp design and toll gates, if necessary.

(c) Horizontal and Vertical Clearances

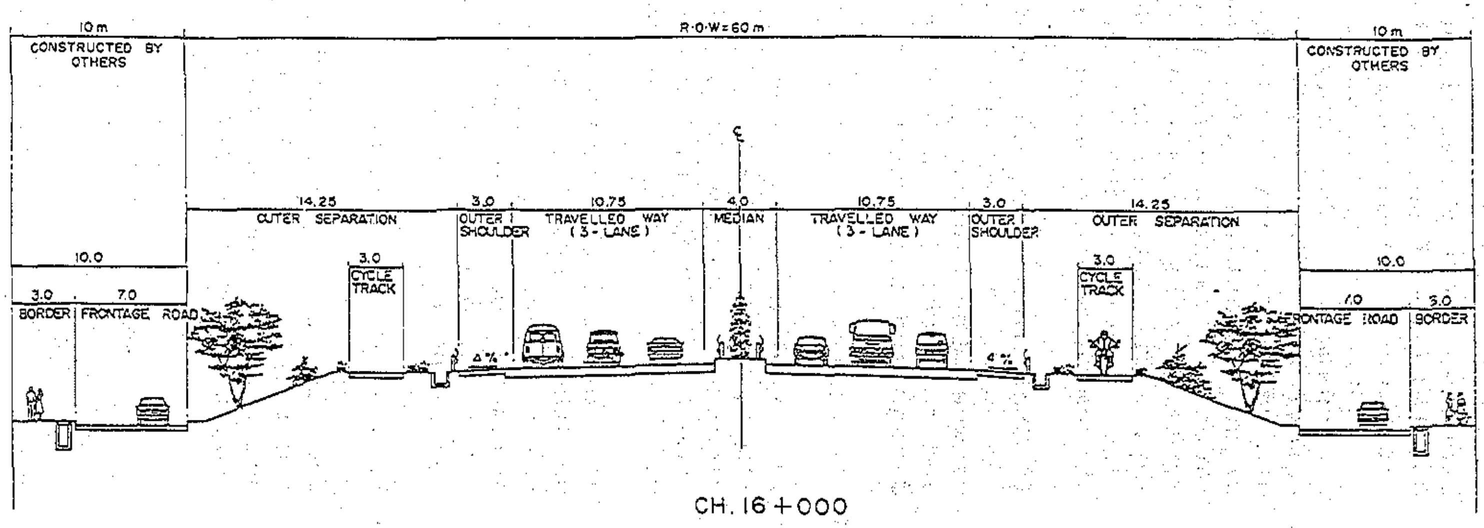
In the case of horizontal clearance limit, at least 0.25m additional clearance beyond the outer edge of the shoulder, except in the case where a 3.0m width outer shoulder, is to be provided.

As for vertical clearance limit, a 5.3m headroom including space for future resurfacings is applicable for high standard roads. The minimum clearance at electrified railway crossing is 6.5m high above the railway level.

(d) Typical Cross Section

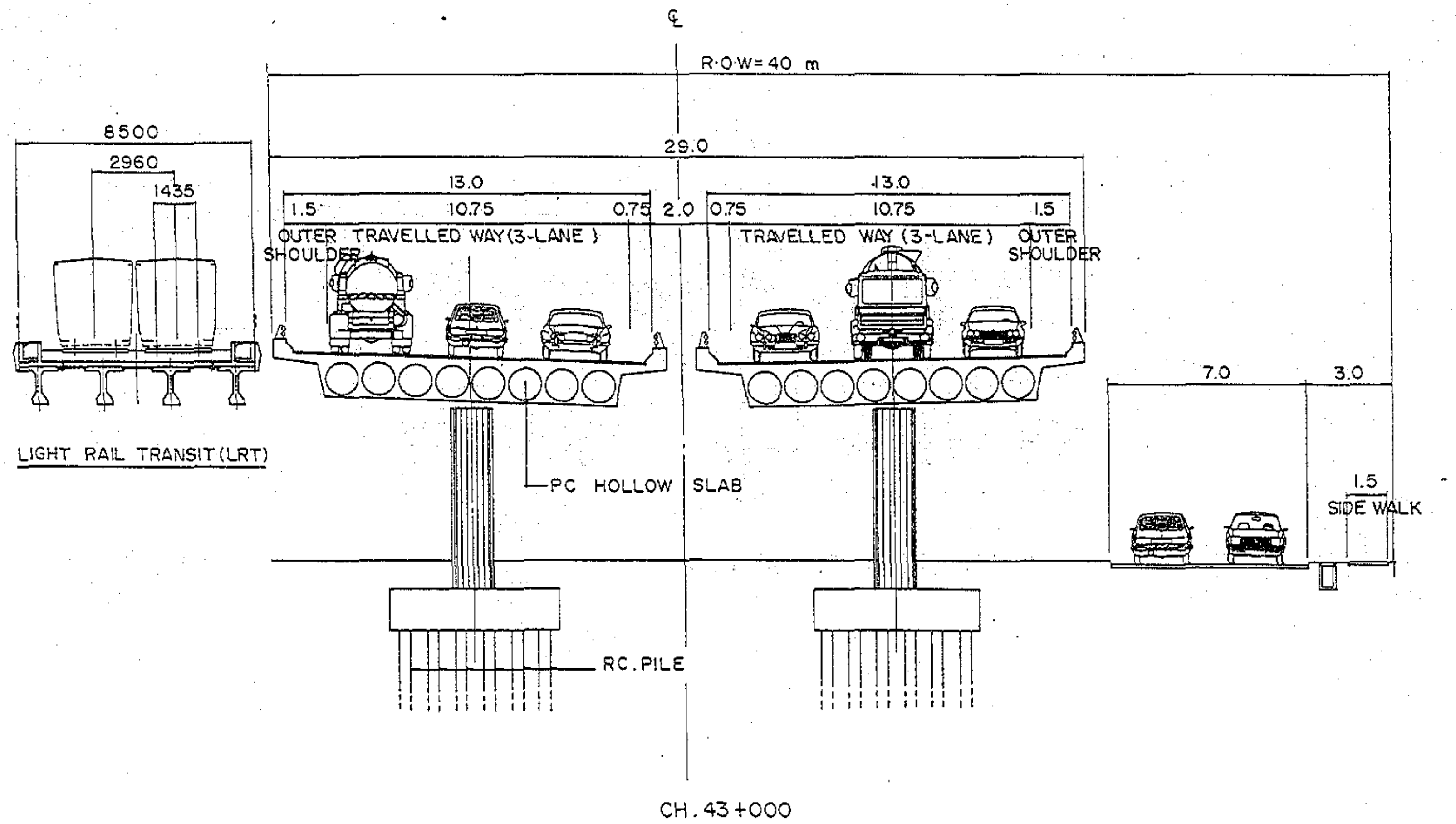
The typical cross sections shown in Figures 5.4.1 to 5.4.4 are proposed based on the recommended design standard and proposed right-of-way.

SHAH ALAM HIGHWAY



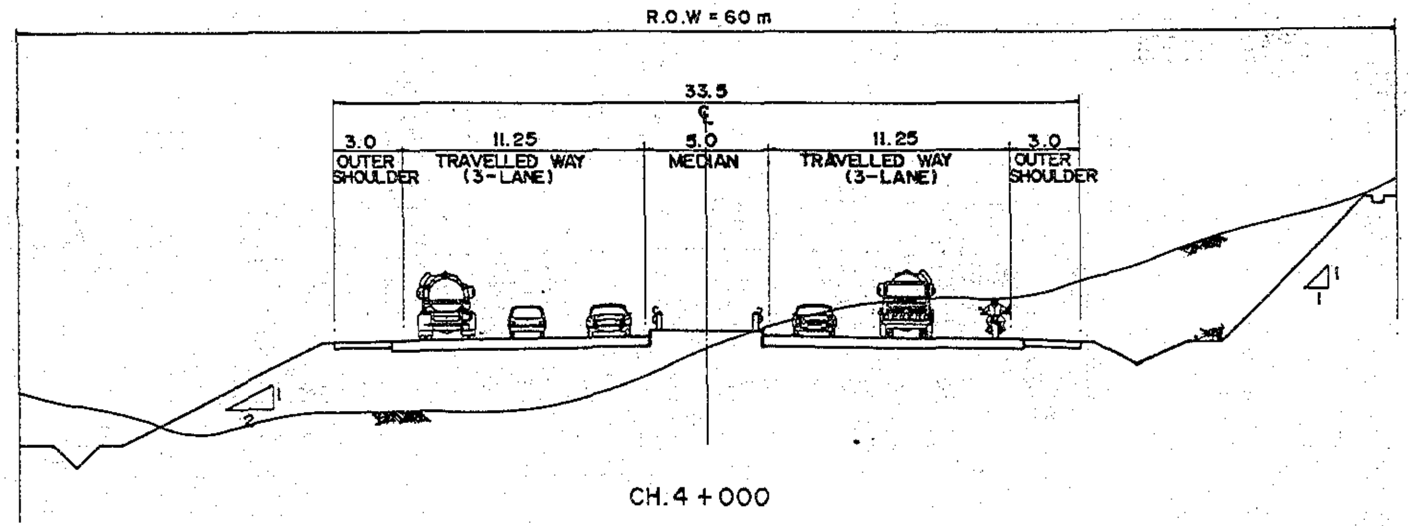
HIGHWAY PROJECT	SCALE: 4 2 0 2 4 6 metres	THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY
Fig.5.4.1 : Typical Cross-section for Shah Alam Highway	DRAWING NO: / DATE:	JAPAN INTERNATIONAL COOPERATION AGENCY

MIDDLE RING ROAD II



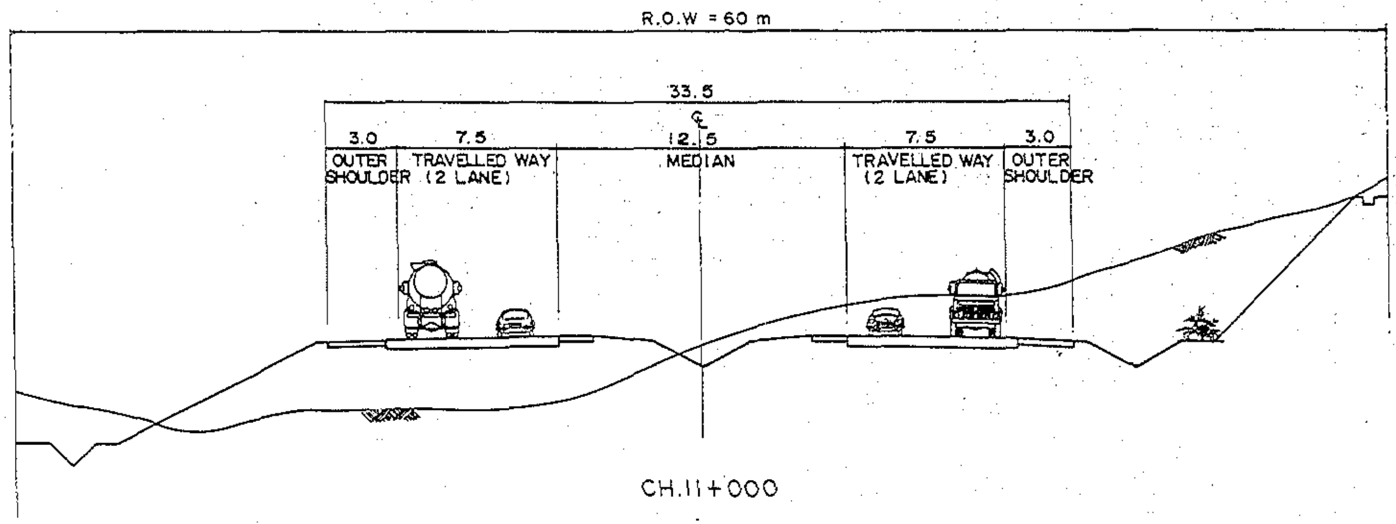
HIGHWAY PROJECT	SCALE : 2 1 0 2 metres 4		THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY
Fig.5.4.2 : Typical Cross-section for Middle Ring Road II	DRAWING NO :	DATE :	JAPAN INTERNATIONAL COOPERATION AGENCY

NORTH-SOUTH LINK



HIGHWAY PROJECT	SCALE: 2 1 0 2 4 6 metres	THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY
Fig 5.4.3 : Typical Cross-section for N-S Link (6-lane)	DRAWING NO: 18 / DATE:	JAPAN INTERNATIONAL COOPERATION AGENCY

NORTH-SOUTH LINK



HIGHWAY PROJECT	SCALE : 2 1 0 2 4 6 metres	THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY
Fig 5.4.4 : Typical Cross-section for N-S Link (4-lane)	DRAWING NO : / DATE :	JAPAN INTERNATIONAL COOPERATION AGENCY

5.4.3 Design Section of Each Road

When designing a roadway, due consideration must be given in providing adequate capacity to meet traffic demand as well as attaining economic and financial viabilities.

Each project road must be examined for its various design sections where different design standards may be applied to achieve the abovementioned objective. Nevertheless, it is desirable to use the same standard on a continuous roadway as far as possible from the viewpoints of traffic safety and implications of design on actual construction.

MRR-II and Shah Alam Highway will be divided into the following three design sections:-

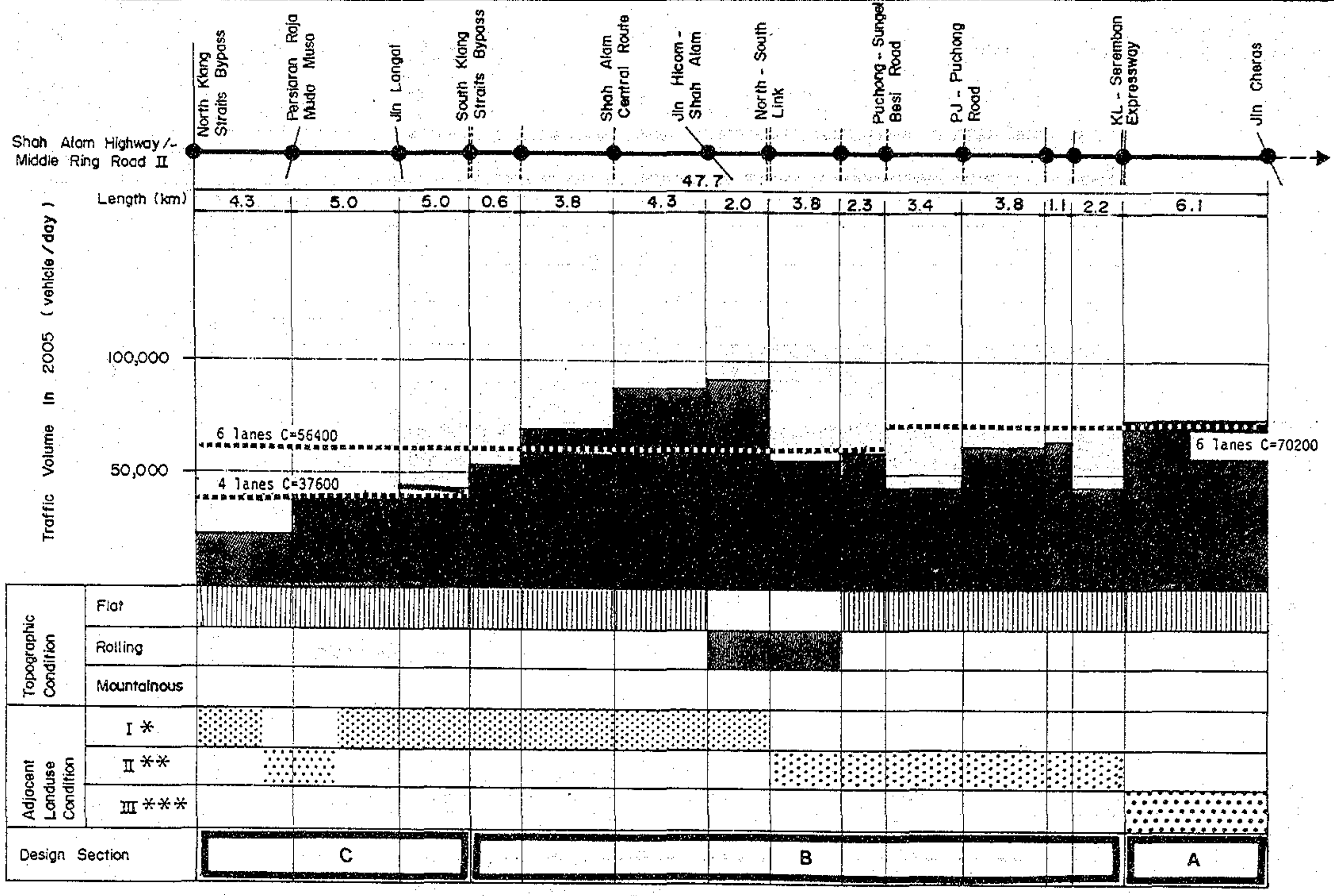
(a) Jalan Cheras to Kuala Lumpur-Seremban Expressway: 6-lane major arterial
(b) Kuala Lumpur-Seremban Expressway to South Klang Straits Bypass: 6-lane highway with exclusive cycle track
(c) South Klang Straits Bypass to North Klang Straits Bypass: 4-lane highway

Figure 5.4.5 shows traffic demand in 2005 and topographic condition and adjacent landuse conditions on the study route.

N-S Link will be divided into two (2) sections:-

(a) New Klang Valley Expressway to Shah Alam Highway: 6-lane expressway
(b) Shah Alam Highway to Kuala Lumpur-Seremban Expressway: 4-lane expressway

Figure 5.4.6 shows traffic demand in 2005 and topographic and adjacent landuse condition of the study route.

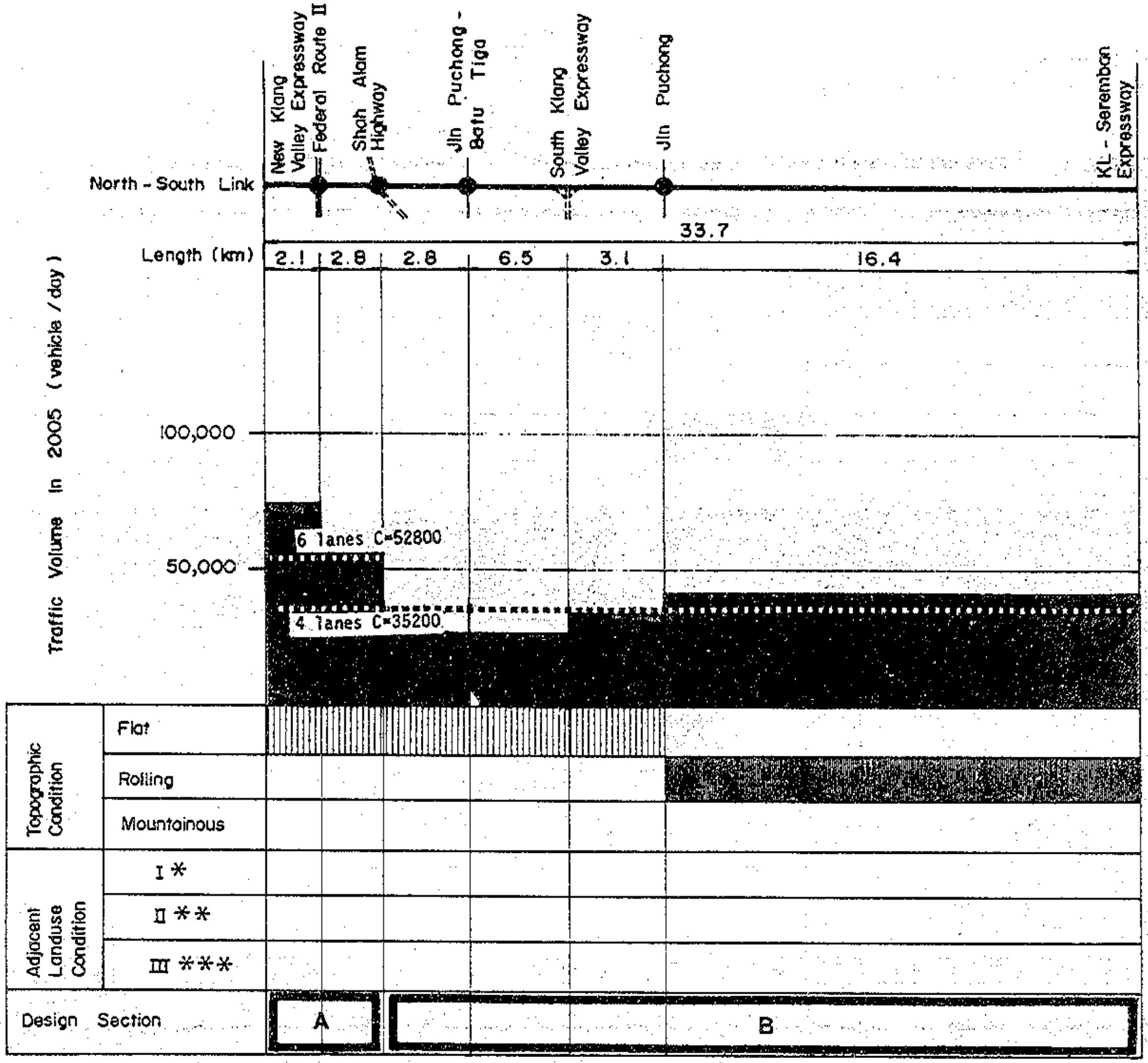


Note: * Type I - Relatively free in road location with very little problems as regards land acquisition, affected buildings or other socially sensitive areas.

** Type II - Intermediate between I and III

*** Type III - Very restrictive in road location with problems as regards land acquisition, affected buildings and other sensitive areas.

Figure: 5.4.5 : Design Section on MRR II/- Shah Alam Highway



Note: * Type I - Relatively free in road location with very little problems as regards land acquisition, affected buildings or other socially sensitive areas.

** Type II - Intermediate between I and III

*** Type III - Very restrictive in road location with problems as regards land acquisition, affected buildings and other sensitive areas.

Figure: 5.4.6 : Design Section on North-South Link

5.5 Interchange Plan and Design

5.5.1 General

(1) Study Approach

The ability to accomodate high volumes of traffic safely and efficiently through intersections depend on what arrangement is provided for handling intersecting traffic. An interchange is a system of interconnecting roadways in conjunction with one or more grade separations that provides for the movement of traffic between two or more roadways on different levels.

An interchange may be warranted as shown in the following items:-

(a) Design designation
(b) Elimination of bottlenecks spot congestion
(c) Elimination of hazards
(d) Site topography
(e) Road Users' benefits
(f) Traffic volume warrant

The type of interchange, along with its design, is influenced by many factors, such as road classification, character or composition of traffic, design speed and degree of access control. Moreover, on toll roads, the toll revenue system must be taken into consideration.

The basic design concept upon which alternative interchange types are formulated is based on a classification of interchanges by function and considerations from the aspects of toll levy system, traffic manoeuvre scheme and uniformity of interchange pattern. Some practical types of interchange design for consideration on the study roads are identified.

The adopted study methodology for determination of interchange type and its preliminary engineering design is given in Appendix 5.4.1.

(2) Basic Design Concept

The basic design concept of interchange plan is to determine the location and configuration of interchanges on Shah Alam Highway/MRR-II and N-S Link. The various considerations are taken to determine the optimum number of interchanges.

The following points are selected and proposed in the previous sections:-

(a) Both Shah Alam Highway/MRR-II and N-S Link are operated as a tollway
(b) Zone tariff by toll barrier for Shah Alam Highway/MRR-II and distance proportional tariff for N-S Link
(c) Interchange Plan-3 (22 interchange plan).

From the engineering viewpoints, the proposed interchange Plan-3 has the following advantages.

(a) Plan-3 which consists of 8 system interchanges and 14 service interchanges is the desirable maximum case, while Plan-1 (10 interchange plan) is the practical minimum one.

    The average interchange interval of Shah Alam Highway/MRR-II and N-S Link is 3km and 5km respectively. These interval is rather modest as compared with the existing expressway and highway (cf. Federal Route 2 from KL-Shah Alam is 1.5km; KL-Seremban Expressway for Salak-Bangi is 3.3km interval). Moreover, a good serviceability can be attained.

(b) Table 4.4.1 reveals that the increase of toll revenue will overwhelm that of construction cost as compared Plan-3 with Plan-1. This implies that the additional cost for the construction of interchanges will bring about preferable financial returns.

(c) Once the land area at the interchange location is reserved, stage-wise construction can be applied.

5.5.2 Interchange Location

The location of twenty-two (22) interchanges on the study roads as shown in Figure 5.5.1 are studied. Possible interchange location has been prepared based on a functional road network system in Klang Valley. The three study roads categorized as expressway and highway/arterial are expected to provide a high degree of mobility for the longer trip length.

Whether this expected function can be accomplished may be reflected in its consistency in the intra-city of town road network system. Therfore, interchange locations and area of influence are studied within the context of the planned road network system as shown in Figures 5.5.2 to 5.5.7.

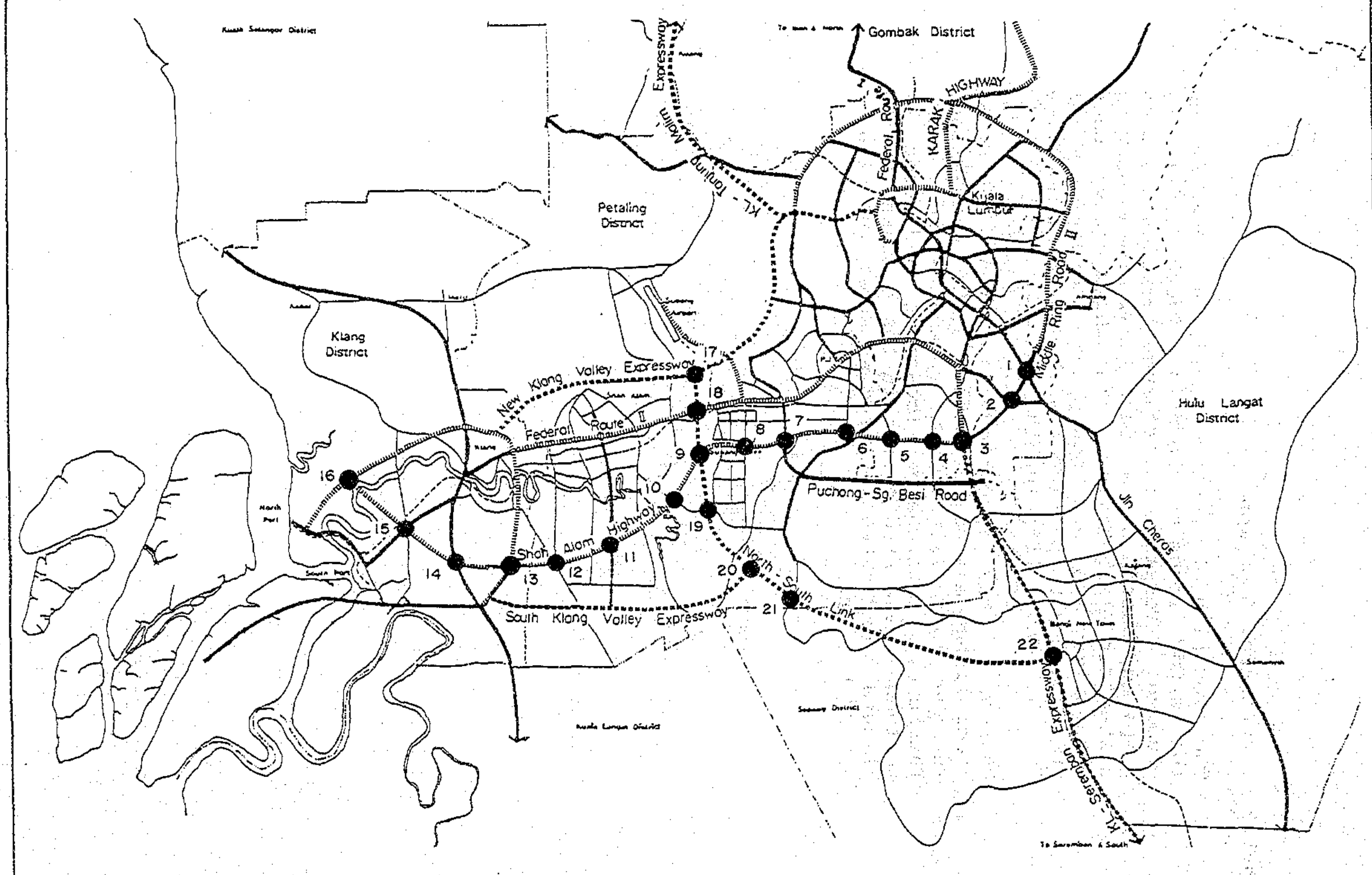


Fig.5.5.1 : Location of Interchanges on Study Roads

THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY

LEGEND:

SCALE:

0 1 2 5 10km

N

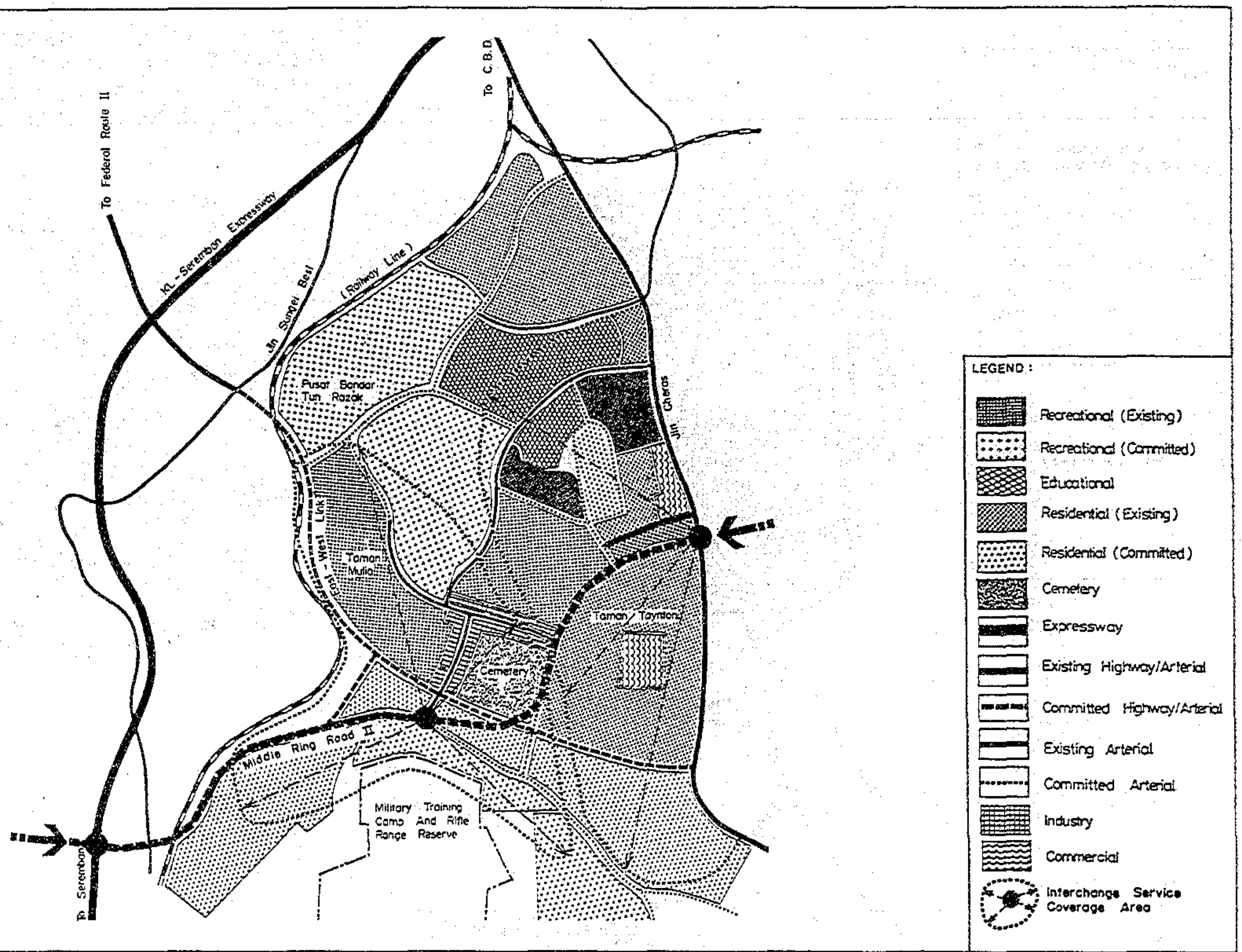


Fig.5.5.2 : Road Network Configuration in Kuala Lumpur-Taman Midah Area

LEGEND:

THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY

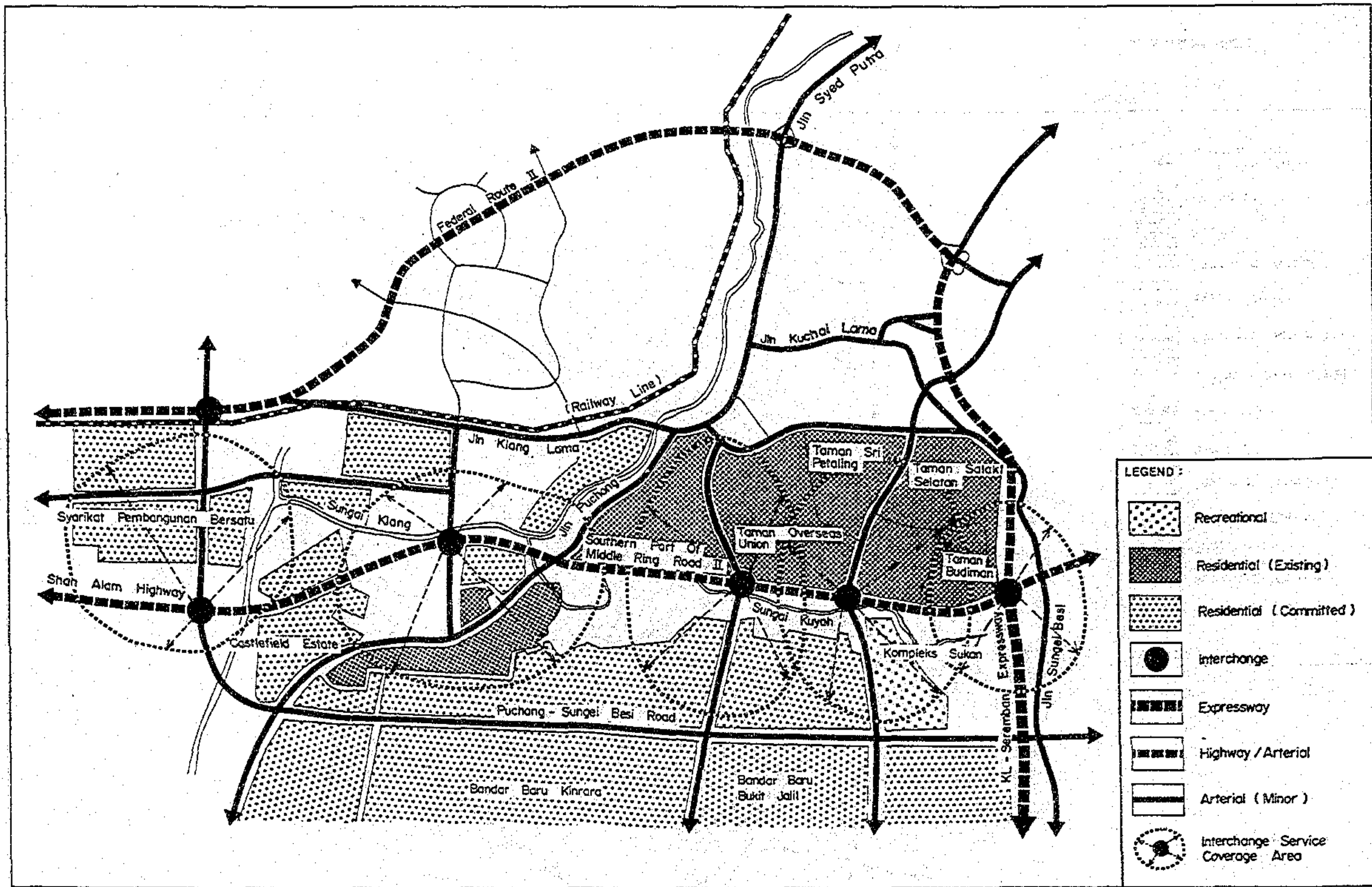


Figure 5.5.3 : Road Network Configuration in Kuala Lumpur - Puchong Area

LEGEND:

SCALE : 0 0.5 1 km

N

THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY

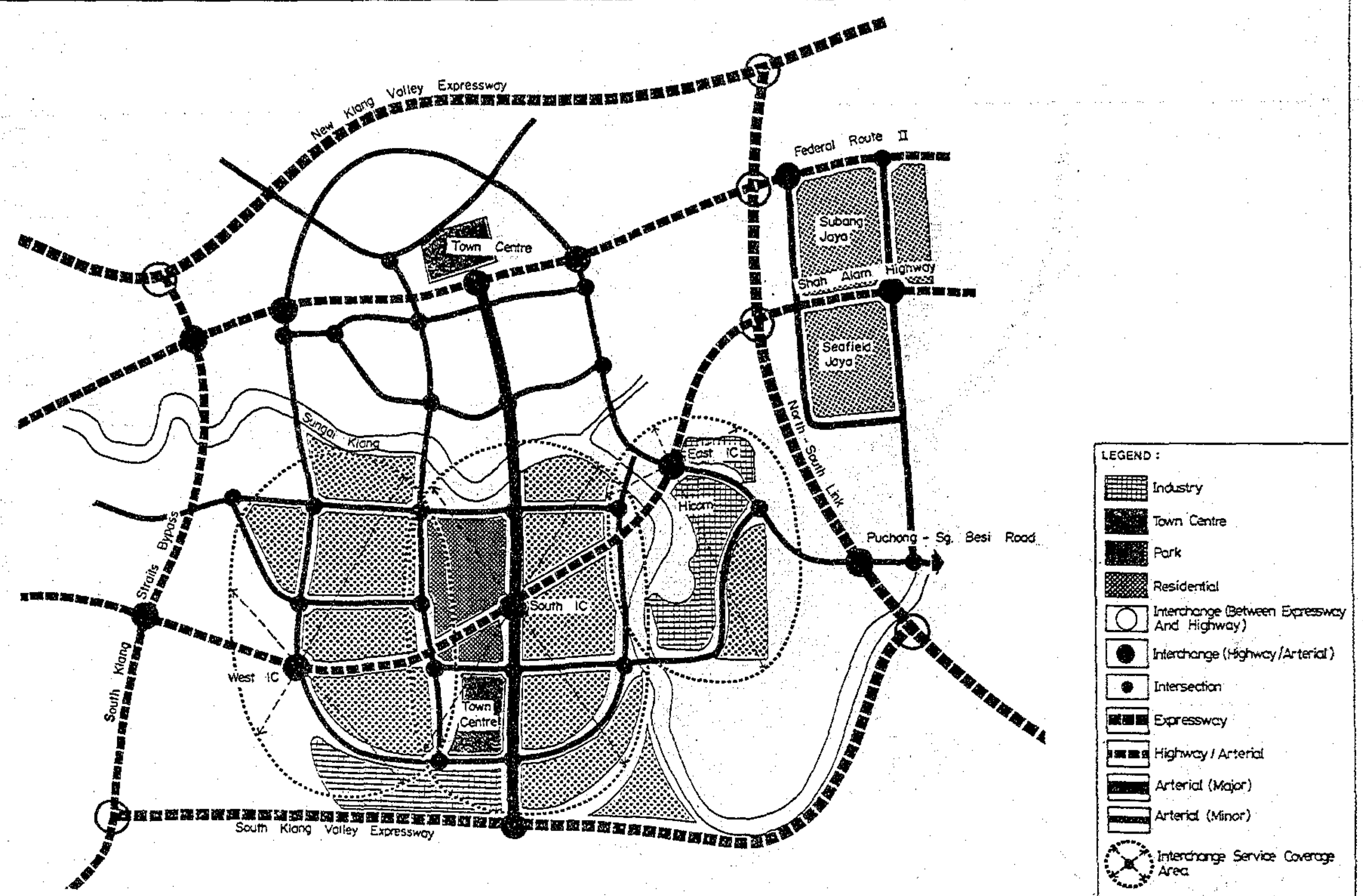


Figure 5.5.4 : Road Network Configuration in Shah Alam

LEGEND:

THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY

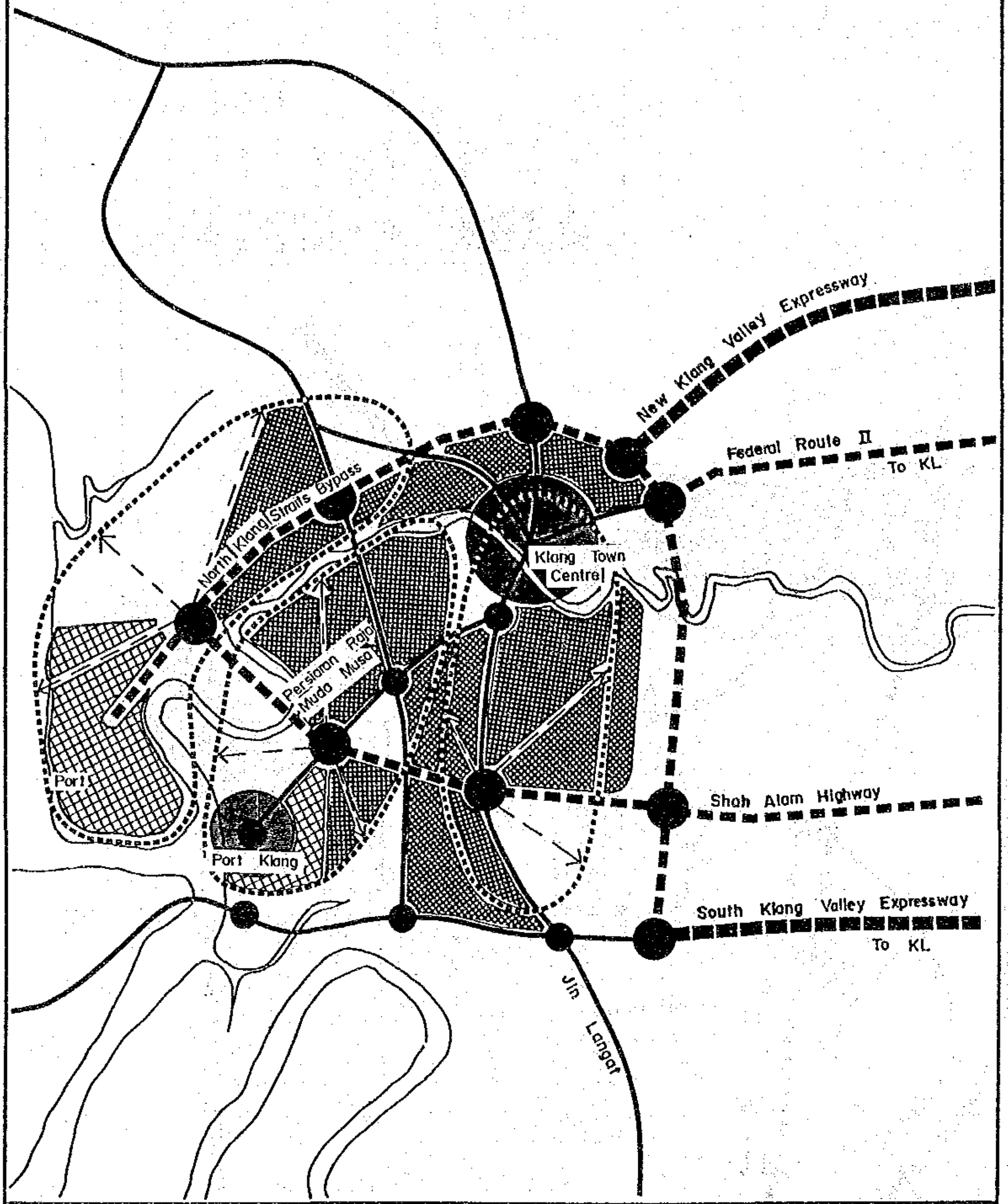


Figure 5.5.5 : Road Network Configuration in Klang District

LEGEND :

- Residential
- Town Centre
- Industry
- Interchange/Junction
- Interchange
- Expressway
- Highway/Arterial
- Primary Road/Arterial
- Interchange Service Coverage Area

THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY

SCALE :

0 1 2 5 km

N

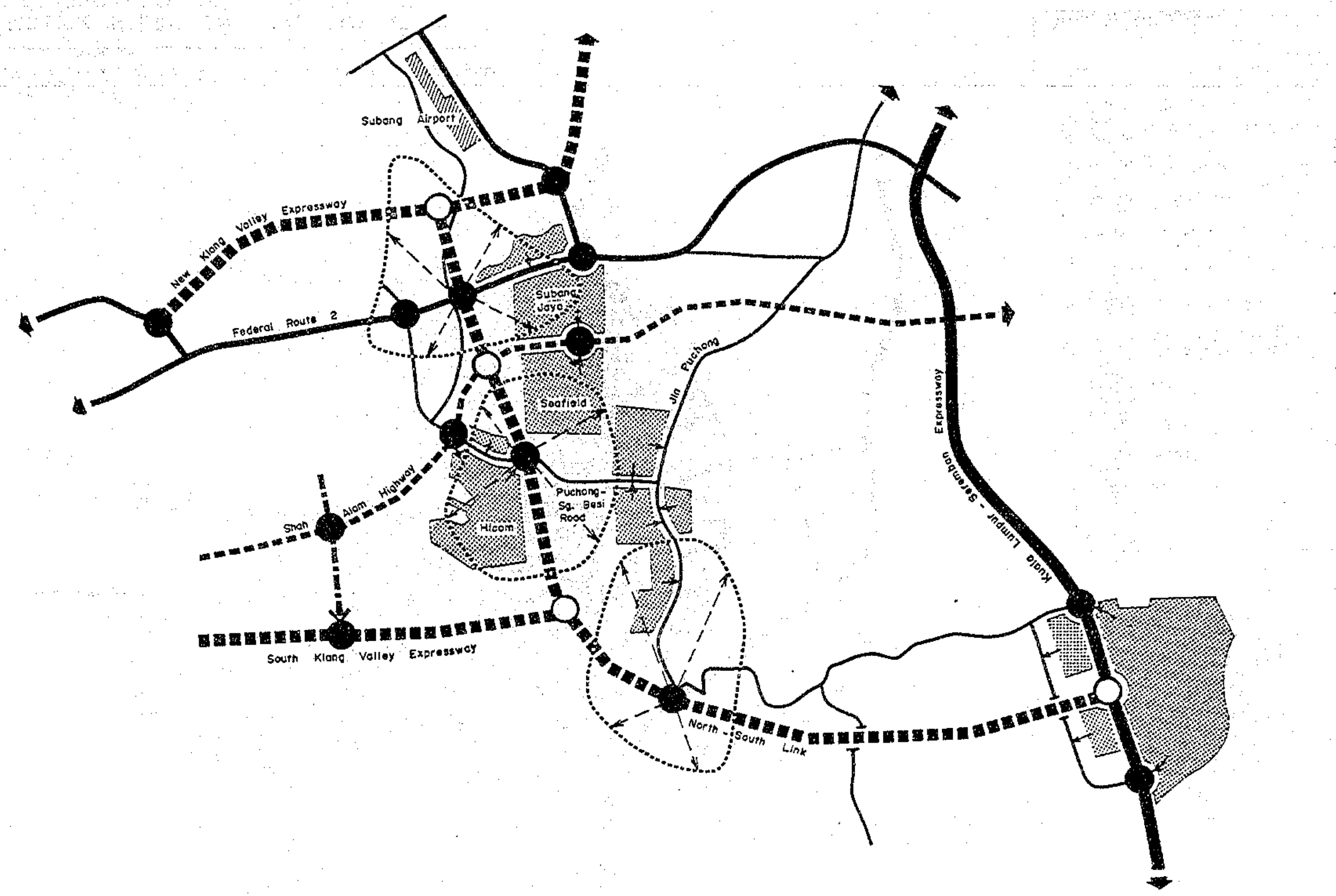


Fig.5.5.6 : Road Network Configuration in North-South Link Corridor

THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY

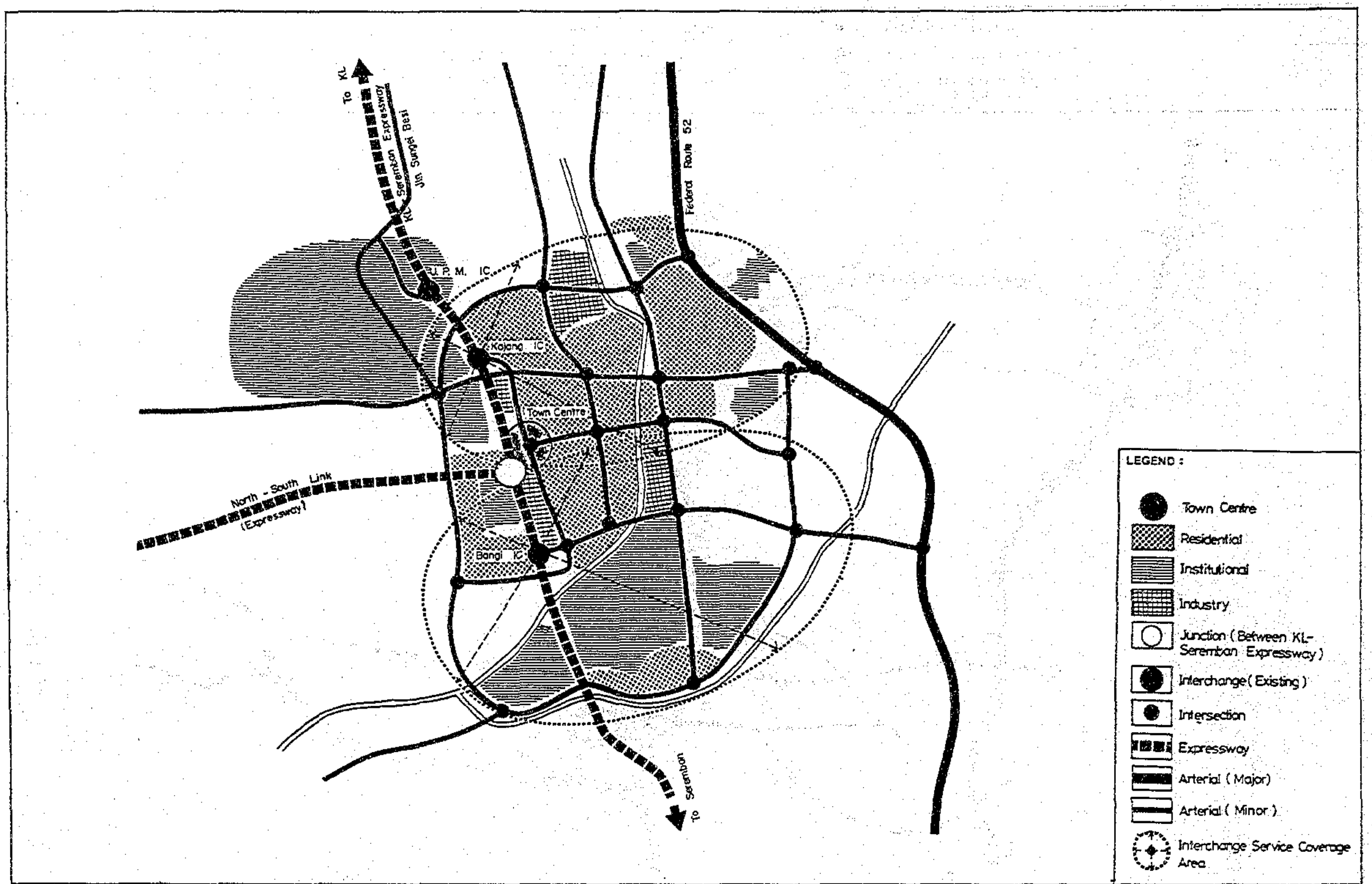


Figure 5.5.7 : Road Network Configuration in Bangi Newtown

LEGEND:

THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY

5.5.3 Traffic Manoeuvre Scheme and Uniformity of Interchange Pattern

Two other major factors in the determination of interchange types are traffic manoeuvre scheme at the interchange and the uniformity of interchange pattern.

At times, the complexity of traffic manoeuvre scheme in a group of successive interchanges warrant the adoption of a specific interchange type at a certain location or explains why the capacity of certain intersections can be suppressed. This is most applicable when the location of two interchanges are too close to each other such that the functions may be shared or delegated among them. There are six locations on the study roads where traffic manoeuvre scheme at the interchange becomes the deciding factor in determining interchange type.

When a series of interchanges is being designed, attention must be given to the group as well as to each individually. Considering the need for high capacity, appropriate level of service and maximum safety in conjunction with expressway or highway operations, it is desirable to provide uniformity in exit and entrance patterns.

In this study all traffic movements will enter or leave from left only using a semi-directional ramp. If there is no physical constraint, an 'A'-type interchange, that is, traffic entering from near side of structure exit ramp will be adopted; if a 'B'-type interchange (that is, traffic entering from the far side) has to be adopted from viewpoint of major turn volume, then considerations for good sighting distance and visibility become important.

A third consideration on uniformity is to design for all turning movements to get off from a single point as a principle.

In addition to the extent practicable all interchanges along an expressway should be reasonably uniform in geometric layout and general appearance.

5.5.4 Selection of Interchange Types

(1) Classification of Interchange by Function

Interchange types can be divided into two categories, namely, system interchange which connects an expressway or access control road to another access control road and service interchange which connects an access control road to lesser facilities (such as primary, secondary or local roads).

System interchanges can be further subdivided into two classes, that is, system interchange - Class A which connects an expressway to another expressway and system interchange - Class B which connects an expressway to highway/arterial or a highway to another highway.

For service interchange, an interchange type costing lesser and requiring smaller land area such as a diamond type is usually preferred to cloverleaf type.

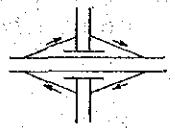
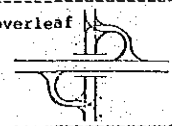
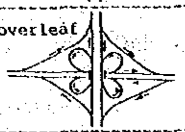
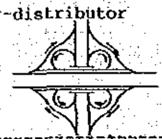
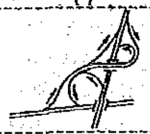
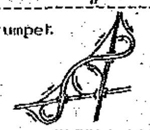
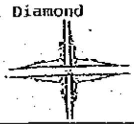
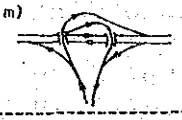
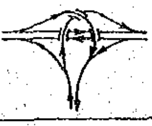
The detailed description is presented in Appendix 5.4.2.

(2) General Types of Interchanges

Among the many types of interchange configurations, ten (10) basic types considered to be practical for application to the study roads are shown in Table 5.5.1. A general comparison of their salient features, construction cost index and land area requirement is also summarized in Table 5.5.1. The cost index gives the relative cost of interchange types using a diamond type as base for system interchange - Class B and service interchange on one hand and a single structure trumpet for system interchange - Class A on the other hand.

The detailed description is presented in Appendix 5.4.3.

Table 5.5.1: Typical Configuration of Some Practical Types of Interchanges and Their Characteristics

	Layout Configuration	Salient Features	(1) Construction Cost Index	(2) Land Area (ha)
SERVICE IC AND SYSTEM IC - CLASS B (4 LEGS)	1. Diamond 	Turning movements on minor road may be controlled by signals. Traffic detour distance is shortest	1.00	4.0
	2. Half Cloverleaf 	Its two loop ramps configuration is readily adaptable to allow free movement in predominant direction. Turning movements on minor road may be controlled by signals	1.05	5.1
	3. Full Cloverleaf 	Its four loop ramps configuration allows free movement in all directions. There are two entrances and two exits on throughway. Weaving occurs between loop ramps	1.29	6.8
	4. Full Cloverleaf with collector-distributor roads 	Free movement in all directions through four loop ramps. There is only one entrance and one exit on throughway. No weaving	1.79	9.0
	5. Trumpet 	Loop ramp occurs at one point. Turning movement on minor road may be controlled by signals. Favourable configuration if there is great difference between traffic volume by direction. Toll gates can be located at a single point	1.56	7.5
	6. Double Trumpet 	Loop ramps occur at two points. All turning movements pass through one point. There is weaving traffic but toll gates can be located at a single point. No signalisation is necessary	1.89	10.5
	7. Three-level Diamond 	Allows free movement for through traffic of crossing roads. Can increase interchange capacity efficiently in an area with limited space	3.27	4.0
SYSTEM IC - CLASS A (3 LEGS)	8. Single Structure Trumpet (R = 125m) 	A simple structure commonly used for 3-leg intersection. Requires a large area which is influenced by the minimum curve radius due to design speed	1.00	15.4
	9. Two Structures Trumpet (R = 125 m) 	Separate roadways are provided for each right turning movement with two 2-level structures separating the ramps from through traffic	1.01	14.8
	10. Three Structures Trumpet (R = 125m) 	Two double jug-handle configuration usually applies where the crossing road is of considerable importance too. Requires the use of three structures thereby reducing land area	1.06	10.6

Note : (1) In the case of service interchange and system interchange - Class B, cost index is the relative cost of other interchange types when compared to diamond type taken as 1.00; in the case of system interchange - Class A, the cost of other interchange type is compared to that of single structure trumpet (R = 125m) when the later's cost index is taken to be 1.00.

(2) All interchanges are compared on equal basis with regards to all factors influencing the construction of the interchanges on flat terrain.

(3) Evaluation Criteria

The comparison and evaluation of alternatives will be made based on the following criteria:-

(a) Land Availability
(b) Function of Interchanges
(c) Construction Cost
(d) Traffic Safety and Users' Benefits
(e) Future Traffic Demand

These criteria will be analyzed comprehensively. Initially, the desirable type of interchange might be considered in terms of design concept derived from function, traffic volume, traffic safety and users benefits, etc. However, land availability and construction cost, sometimes, might warrant the second best alternative. In principle, system interchanges take a higher priority to the criteria of function and future traffic demand while service interchanges must also give higher consideration to land availability and construction cost.

Forecasted turning traffic demand at each interchange is given in Appendix 5.4.4.

(4) Proposed Interchange Type

The foremost purpose of this study on interchange plan and design is to determine the location and configuration of interchanges on Shah Alam Highway/MRR-II and N-S Link.

Land area at the location must be reserved based on the proposed interchange type. Eventhough some of the proposed interchanges can be constructed stage-wise, it is necessary to reserve sufficient land area for the construction of the ultimate interchange configuration.

In conclusion, the proposed ultimate interchange type for Shah Alam Highway and N-S Link are presented in Figures 5.5.8 and 5.5.9.

The detailed process of evaluation is described in Appendix 5.4.5.

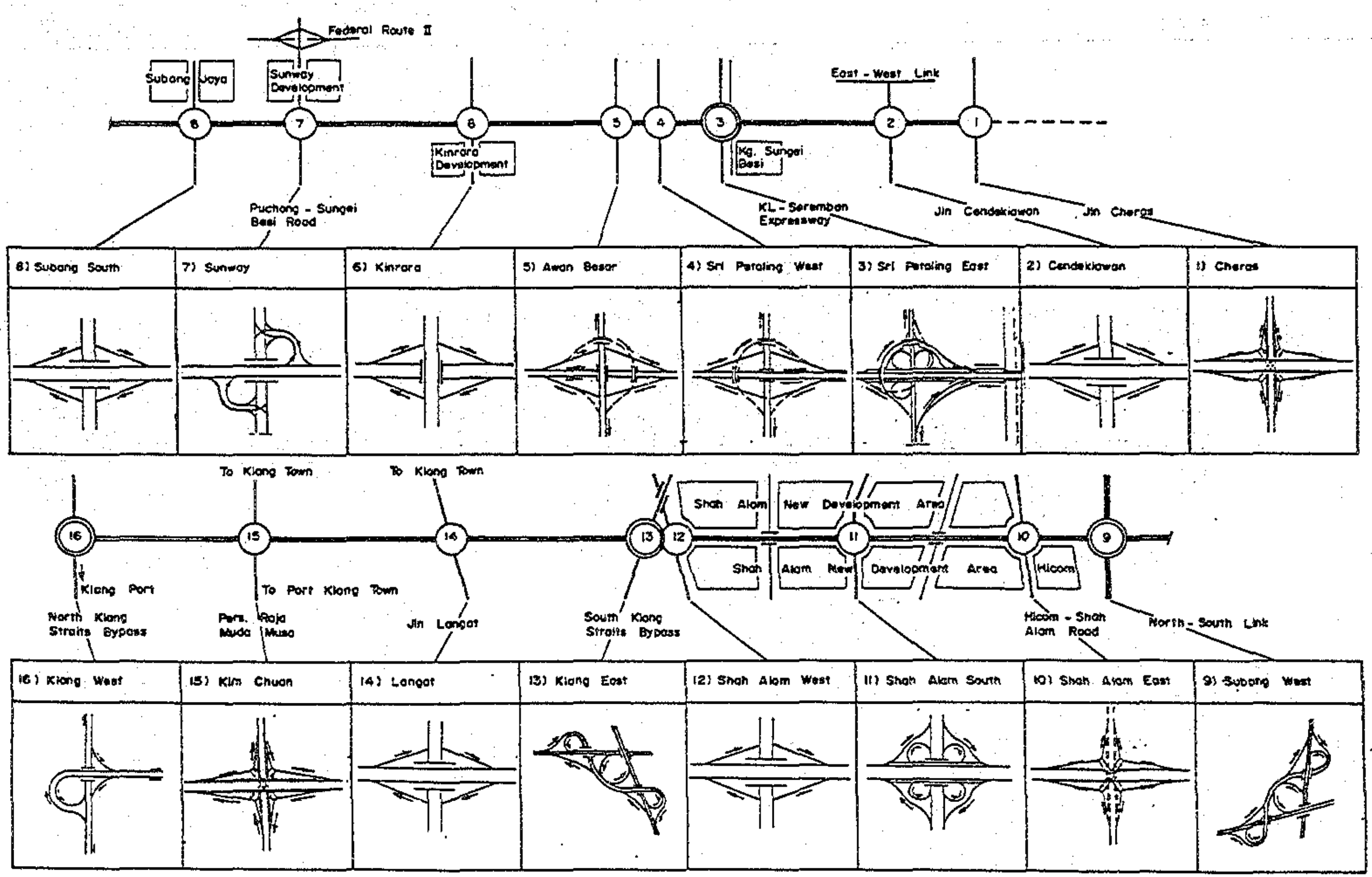


Fig.5.5.8 : Proposed Interchange Type for Shah Alam Highway/MRR-II

THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY

LEGEND:

- SYSTEM INTERCHANGE B
- SERVICE INTERCHANGE

SCALE:

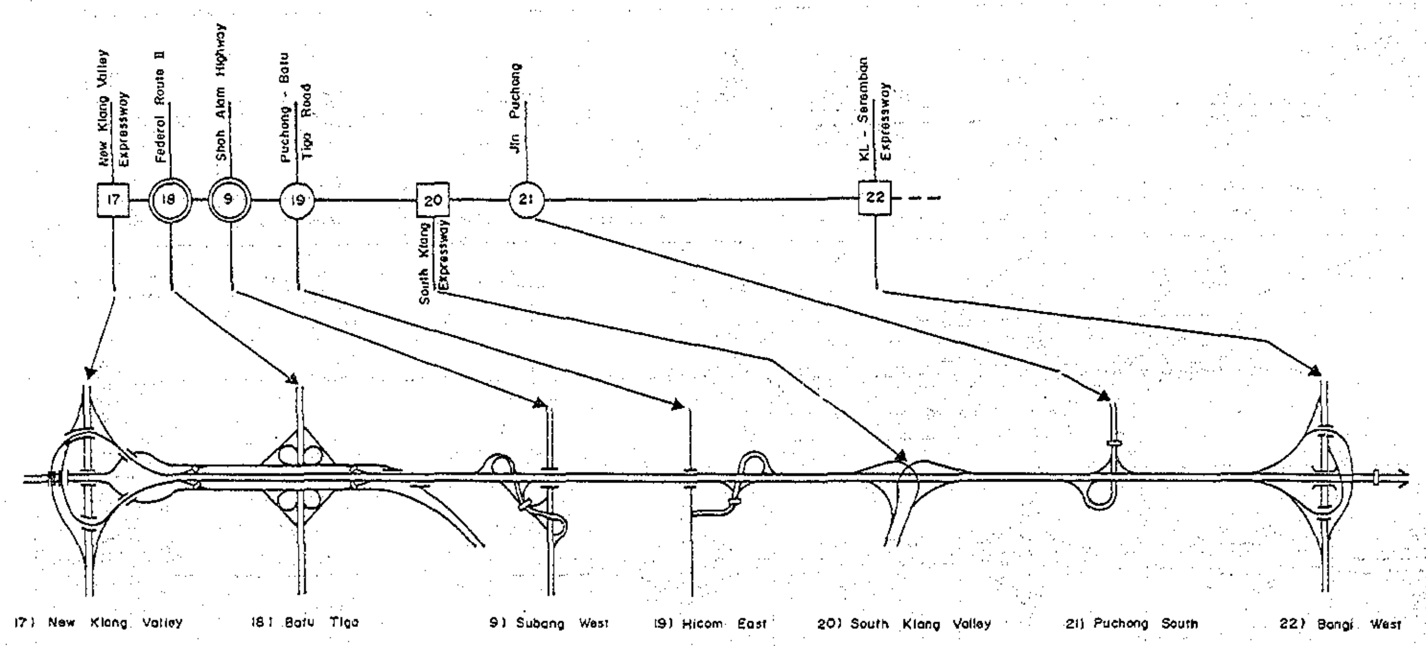


Fig.5.5.9 : Proposed Interchange Type for North-South Link

THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY

LEGEND:

- SYSTEM INTERCHANGE A
- SYSTEM INTERCHANGE B
- SERVICE INTERCHANGE
- TOLL PLAZA

SCALE :

5.6 Design of Bridges and Other Structures

5.6.1 General

Major structures in this Study include four bridges across Sungai Klang with waterways width ranging from 60m to 260m, bridges over other rivers, interchange bridges, viaducts, flyovers, box culverts and retaining walls.

Selection of bridge type and dimensions is done taking into account not only construction, and maintenance economy but also many other aspects, some being unquantifiable in nature. Safety is the most important factor. Other factors include durability, aesthetics, consistency, environmental quality and performance, ease of construction, rider's comfort, ease of reconstruction and dismantling and ease of widening, etc.

5.6.2 Preparatory Study

After the preliminary selection of bridge location on maps and photos, field reconnaissance of site topography, adjacent existing structures, existing river and streams, road, railways and housing development, etc., and soil investigation were conducted.

Visits to JKR Headquarters (Road Section and Bridge Section), Malaysia Highway Authority, Standard Industrial and Research Institute of Malaysia and Statistics Department were made for data collection, interviews and discussion on institutional design conditions, technical standards, design guidelines, etc.

Practical information on supply of construction equipment and materials were also collected through interviews with local contractors, heavy equipment manufactures, lease companies, concrete product's manufacturers, fresh concrete suppliers, steel factories, etc.

5.6.3 Design Standard of Bridges and Structures

(1) General

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 guideline published by the Design and Research section in the Public Works Department (JKR) in November 1985

- Interurban 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 purpose, 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)

The adopted design standard is presented in Appendix 5.5.1.

(2) Standard Cross Sections of Bridge

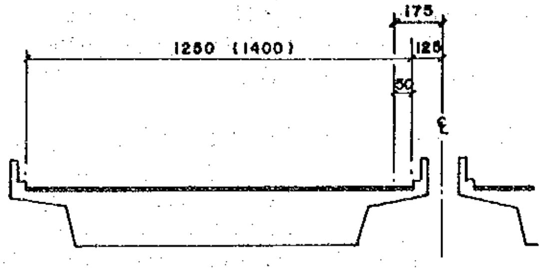
Standard cross sections of bridge shown in Figure 5.6.1 comprises features such as:-

(a) On a 3-lane carriageway, the middle lane of the three lanes has a wider width of 3.75m to lessen wheel concentration and to increase driver's comfort.

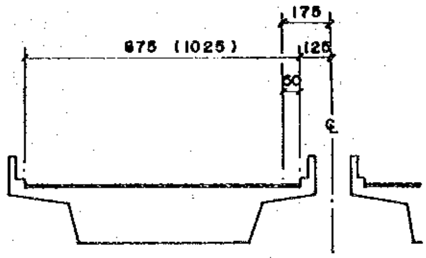
(b) In throughway, for viaducts and bridges of length more than 100m, reduced outer shoulder width of 1.5m is taken.

(1) THROUGHWAY BRIDGE

6-LANE (2 x 3 LANES)

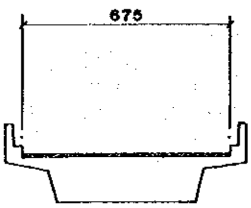


4-LANE (2 x 2 LANES)

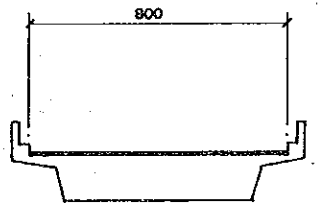


(2) RAMP BRIDGE

1-LANE



2-LANE



Figures in ( ) show the width where total length of bridge is less than 100 m

FIG.5.6.1: STANDARD CROSS SECTIONS OF BRIDGES

LEGEND :

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SCALE :

N

(3) Other Elements for Bridges and Structures Design

In addition to basic data and design standards described above, the following major design factors are considered in selecting bridge and structure types.

(a) Requirements for Obstacles Being Crossed

Design factors for bridges and structures crossing waterways are adopted from the hydraulic study results obtained from the Master Drainage Plan prepared by the Drainage and Irrigation Department of the Ministry of Agriculture in 1978 and the Study on the Flood Mitigation of the Klang River Basin being conducted by another JICA Study Team.

Items of design factors are as follows:-

- High water level
- Required bridge waterways
- Required navigation clearance
- Required clearance under superstructure: freeboard
- Required pier to pier length
- Flood area
- River reserve area
- Plan and profile of river improvement

Overpass structures on roads and railways should be designed in accordance with standards established and applied to the affected road and railway in their common practice.

Items of design factors are as follows:-

- Construction limit
- Allowance of sight distance
- Allowance of drainage
- Allowance of collision protection facilities
- Allowance of safety facilities
- Allowance of guide signs
- Protection for existing utilities

(b) Environmental Aspect

Continuous viaduct structures may be adopted at existing town centres where land acquisition is difficult and maintenance of existing street are required. Adjoining retaining walls are also to be considered so as to minimize total road width and to keep proper buffer zones against developed areas.

Major environmental factors to be considered are:-
- Aesthetic
- Noise
- Vibration
- Air Pollution
- Water Pollution
- Land Settlement
- Smell/Odour

(c) Abandoned Tin Mining Site Area

In the abandoned tin mining site area, excavated sandy soil which has usually been stockpiled nearby can be used as fill material with quite a short hauling distance.

In this Study, it is assumed that half a length of such ponds should be backfilled with sandy material which can be obtained near the sites.

5.6.4 Bridge Superstructures

(1) General

Figure 5.6.2 presents common bridge types by span and its typical characteristics.

Among these common bridge types, six practical bridge types are selected for the purpose of cost comparison.

The unit cost comparison by bridge type, span and foundation type are given in Figure 5.6.3.

The following points are suggested by the unit cost comparison:-

(a) PC inverted T-beam type has outstanding advantage of construction cost
(b) PC Hollow slab type is also advantageous
(c) PC Box Girder type is inferior to other types in the aspect of construction cost
(d) Steel Plate Girder is superior in case of large span range as well as deep braring stratum

(2) Selection of Standard Superstructure Span and Types

(i) Small River Bridges

Standard Span : 20m

PC pre-tensioned inverted T-beam type is selected.

The JKR standard PC inverted T-beams are widely employed on small bridges and have proved to be economical.

(ii) Medium River Bridges

Standard Span : 40m

PC post-tensioned I-beam type is selected due to its total economy, easy erection and maintenance.

(iii) Road Bridges, Railway Bridges and Over Bridges

Standard Span : 20m

PC pre-tensioned inverted T-beam type is selected due to its outstanding economy and ease of construction.

(iv) Rampway Bridges

Standard Span : 20m

Rampway bridges are required to be flexible to both horizontal and longitudinal curves.

PC continuous hollow slab type is selected. This type is superior in the aspect of aesthetics, economy and flexibility for sharp curve.

(v) Viaduct

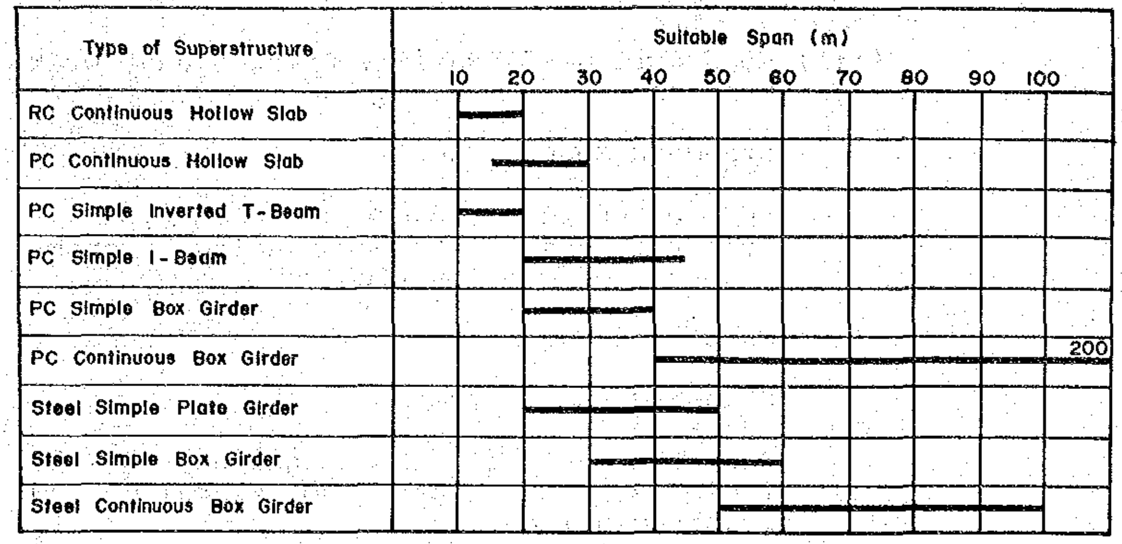
Standard Span : 20m

PC pre-tensioned inverted T-beam is selected due to its outstanding economy and ease of construction.

(vi) Flyover of Existing Expressway and Highway

Long span PC Simple I-beam or steel plate girder is selected to avoid the disturbance or diversion of existing heavy traffic.

(1) COMMON BRIDGE TYPE BY SPAN



(2) TYPICAL CHARACTERISTICS

		Aesthetics		Execution Maintenance							Application to Special Types of Bridge			
	Riders Comfort	Side Elevation	Underside Appearance	Availability of Materials	Reliability of Quality	Construction Period	Preservation of Existing Traffic	Ease of Construction	Stage Construction	Maintenance	Curved Bridge with Small Radius	Variable Width Bridge	Economy (including sub-structure)	Preference
RC Continuous Hollow Slab	A	A	A	A	B	B	C	B	B	A	O	O	A	Viaduct
PC Continuous Hollow Slab	A	A	A	B	B	B	C	B	C	A	O	X	A	Viaduct
PC Simple Inverted T-Beam	C	B	B	A	B	A	A	B	A	A	X	X	A	Small Bridge
PC Simple I-Beam	B	B	C	B	B	A	A	B	A	A	X	X	B	Bridge Over River
PC Simple Box Girder	B	B	A	B	B	C	C	C	C	A	X	X	B	
PC Continuous Box Girder	A	A	A	B	B	C	A/C	C	C	A	X	X	B	
Steel Simple Plate Girder	B	B	C	B	A	A	A	A	B	C	X	O	C	Speedy Erection
Steel Simple Box Girder	B	B	B	C	A	A	A	A	C	C	X	X	C	
Steel Continuous Box Girder	A	A	B	C	A	A	A	B	C	C	O	O	C	Curved Bridge with Long Span

FIG. 5.6.2: COMMON BRIDGE TYPE BY SPAN AND TYPICAL CHARACTERISTICS

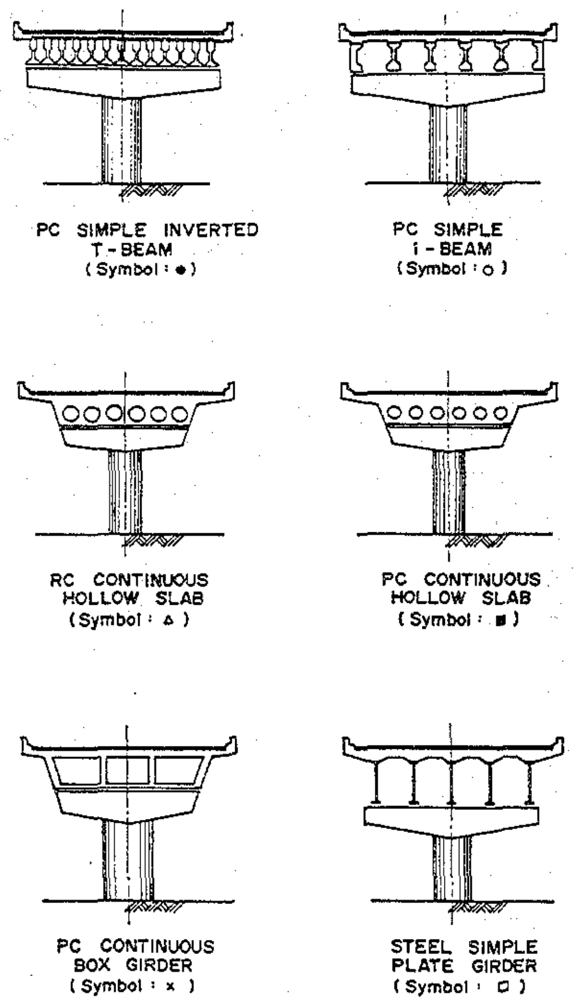
THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY

LEGEND :

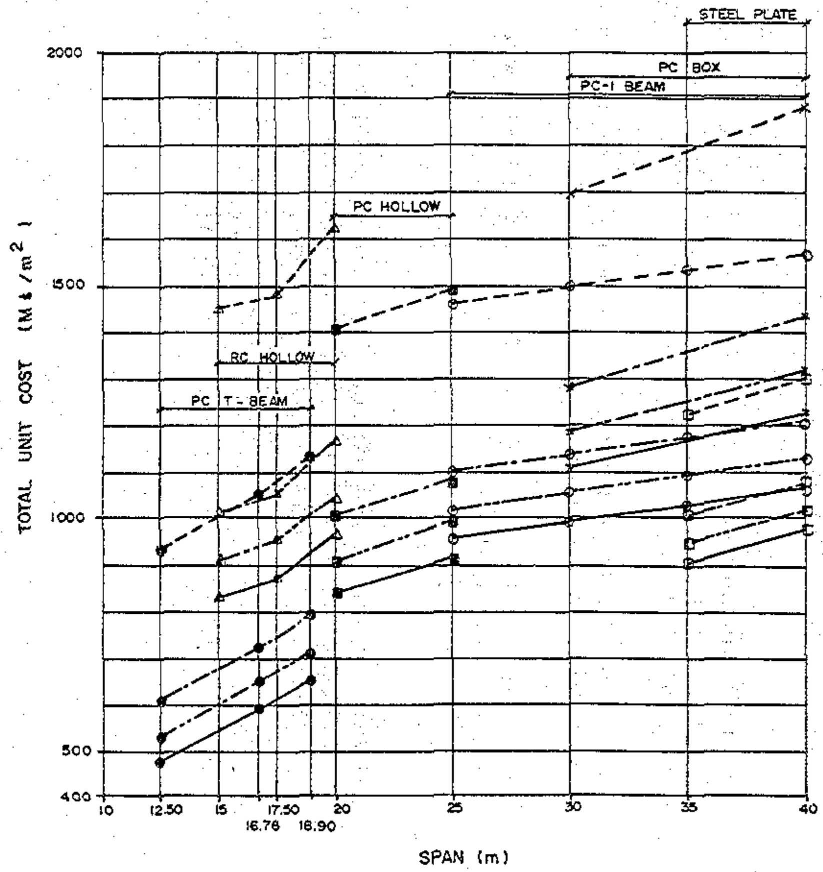
A : GOOD
B : FAIR
C : POOR

O : APPLICABLE
X : NOT APPLICABLE

SCALE :



TYPICAL CROSS-SECTIONS



TOTAL UNIT COST

Figure 5.6.3 : Bridge Total Unit Cost by Type and Span

LEGEND:

— — — —	STEEL PIPE PILE ø 610 x 40m FOUNDATION
—·—·—	PC PIPE PILE ø 450 x 20m FOUNDATION
—··—··—	RC SQUARE PILE ▫350 x 10m FOUNDATION
———	SPREAD FOOTING FOUNDATION

SCALE :

THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY

5.6.5 Bridge Substructures

(a) Abutments

Pile bent type abutment is adopted where land availability is good.

Inverted T-type abutment is adopted where land is limited.

(b) Piers

T-type with cylindrical column/columns is selected as standard type because of slender appearance and easy construction.

In Sungai Klang, wall type piers with pile bent foundation which is commonly practiced now is selected.

(c) Foundation

According to soil investigation, bearing stratum surface exists at a range of 5 to 40m in depth. Exposed bearing stratum surface is considered to be exceptional.

Considering soil survey results, geological maps and distribution of soft clay layer, pile foundation types and lengths are assumed as shown in Figure 5.6.4.

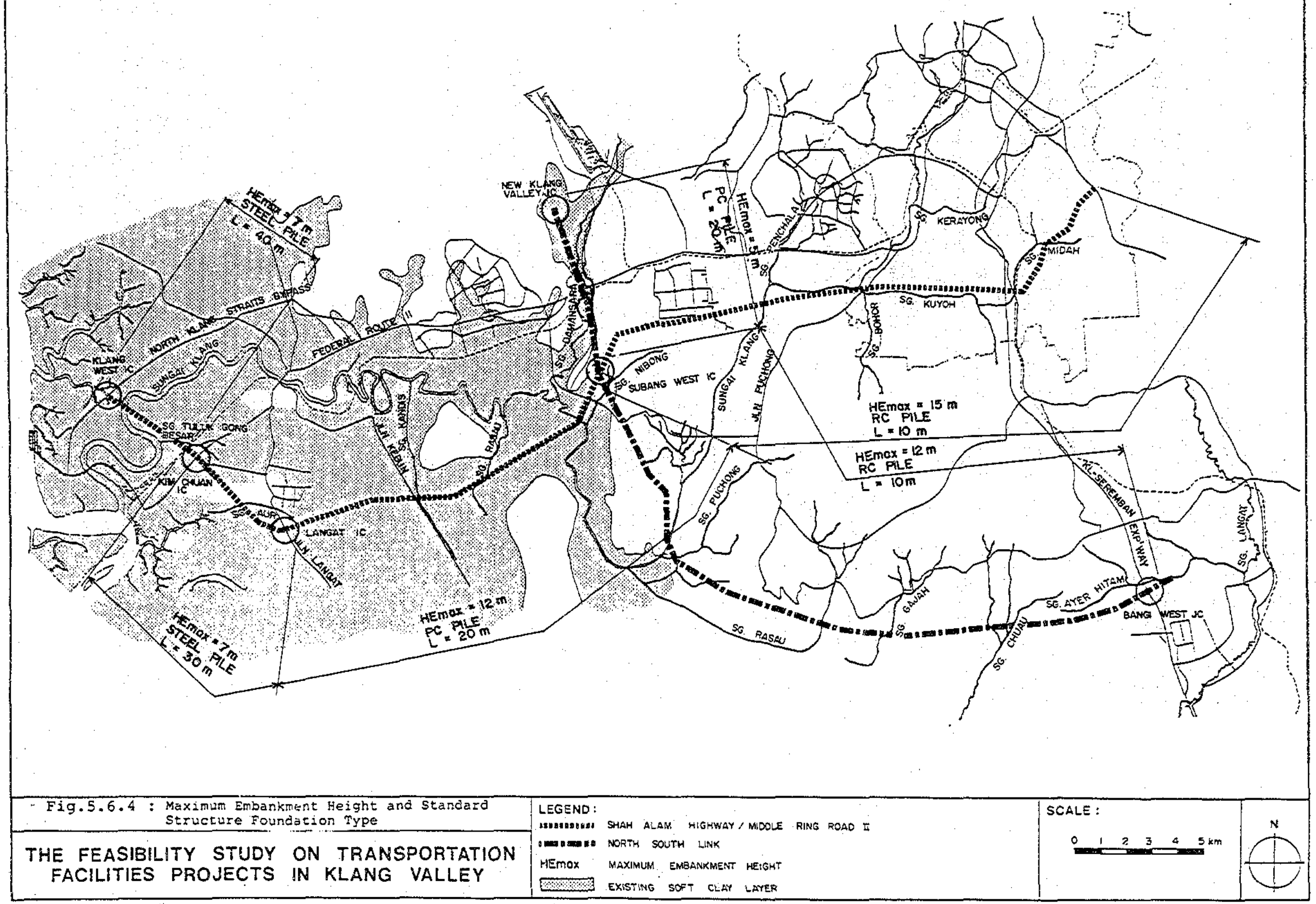


Fig.5.6.4 : Maximum Embankment Height and Standard Structure Foundation Type

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5.6.6 Study of High Embankment

The maximum embankment height is examined on the two aspects of slope stability and consolidation settlement.

A safety factor of slope stability exceeding 1.2 is adopted. In addition by adopting vertical sand drains as a practical soft soil treatment, remaining consolidation settlement is assumed to be less than 30cm before start of pavement work. Estimated quantities of vertical sand drains, 40cm diameter, 180cm spacing, are as follows:-

Location	Area (sq.m.)	Depth (m)
SHAH ALAM HIGHWAY		
Klang West IC-Langat IC	118,500	20
NORTH-SOUTH LINK		
New Klang Valley IC-Batu Tiga IC	293,400	5

The assumed embankment characteristics are as follows:-

Embankment Slope Gradient	...	1:2
Embankment Unit Weight	...	1.8 t/cu.m
Cohesion of soil	...	3.0 t/sq.m
Internal Friction Angle of Soil	...	10 degrees

The maximum embankment height applied to each road segment is also shown in Figure 5.6.4.

The detailed description for the study of high embankment is presented in Appendix 5.5.2.

5.6.7 Selected Bridge Type

Based on the abovementioned study on design of bridges, the location and bridge type selected for the study roads are listed in Tables 5.6.3 and 5.6.4.

There are a total of 43 bridges/viaducts on Shah Alam Highway/MRR-II and 47 bridges/viaducts on N-S Link, that is, a grand total of 90 bridges/viaduct structures on the study roads. The grand total bridge area is about 247,060sq.m.

TABLE 5.6.3: SHAH ALAM HIGHWAY/MRR-II BRIDGE LIST

NO.	NAME		CHAINAGE	LENGTH (m)	TYPE	WIDTH (m)
1	RAMP BR OVER RIVER	2 NOS.	0+000	70	PCH	6.75x2
2	RAMP BR OVER N. KLANG STRAITS BYP.		0+000	140	PCT	13.5
3	BR OVER SG. KLANG		0+660	760	PCI	17.5
4	BR OVER SG. TELUK GADONG BESAR		2+745	280	PCI	17.5
5	BR OVER RAILWAY		3+550	40	PCI	20.5
6	BR OVER PRN. RAJA MUDA MUSA		4+040	540	PCH	17.5
7	BR OVER JALAN KIM CHUAN		5+870	40	PCI	20.5
8	BR OVER JALAN LANGAT		9+265	48	PCT	20.5
9	BR OVER RAMP OF KLANG EAST IC		13+865	40	PCT	28
10	RAMP BR OVER SOUTH KLANG STRAITS BYP.		13+865	60	PCT	13.5
11	BR OVER JALAN KEBUN		14+875	140	PCT	25
12	FR BR OVER RIVER	2 NOS.	14+940	20	PCT	10x2
13	BR OVER PLANNED ROAD		17+045	48	PCT	28
14	FR BR OVER SG. RASAU		17+320	20	PCT	10
15	BR OVER SG. RASAU		17+790	20	PCT	28
16	FR BR OVER SG. RASAU		17+840	20	PCT	10
17	BR OVER SHAH ALAM CENTRAL ROUTE		18+660	60	PCT	28
18	FR BR OF SHAH ALAM SOUTH IC	2 NOS.	18+660	60	PCT	10x2
19	BR OVER PLANNED ROAD		19+750	48	PCT	28
20	BR OVER SG. KLANG		21+920	240	PCI	25
21	FR BR OVER SUNGAI KLANG		21+920	240	PCI	10
22	BR OVER JALAN HICOM-SHAH ALAM		22+850	160	PCT	25
23	BR OVER JALAN TUJUAN		27+470	40	PCT	28
24	BR OVER JALAN KEWAJIPAN		28+830	48	PCT	28
25	BR OVER RIVER		29+540	40	PCI	28
26	BR OVER JALAN PUCHONG-SG.BESI		31+180	48	PCT	28
27	BR OVER SG. KLANG		31+660	120	PCT/PCI	25
28	BR OVER PLANNED ROAD		32+570	20	PCT	28
29	FO BR OF KINRARA IC		34+520	60	PCT	20
30	BR OVER SG. KUYOH		35+520	80	PCI	28
31	BR OVER JALAN PUCHONG		35+770	48	PCT	28
32	BR OVER POND		36+005	100	PCT	25
33	FO BR OF AWAN BESAR IC		38+320	60	PCT	20
34	VD OF SRI PETALING WEST IC		39+320	240	PCT	25
35	VD OVER EXPWY JLN. SG.BESI RAILWAY		41+596	839	PCH/PCT	25
36	FR BR OVER KL-SEREMBAN HWY		41+590	64	PCT	10
37	A RAMP BR OF SRI PETALING EAST IC		41+590	820	PCH	6.75
38	B RAMP BR OF SRI PETALING EAST IC		41+590	736	PCH/PCT	6.75
39	C RAMP BR OF SRI PETALING EAST IC		41+590	284	PCH	6.75
40	VD NEAR LRT STATION		42+840	450	PCH	25
41	CENDEKIAWAN VD		44+535	1485	PCT/PCH	25
42	RAMP BR OF CENDEKIAWAN IC	2 NOS.	44+770	60	PCT	6.75x2
43	VD OVER JALAN CHERAS		47+065	990	PCT	25
44	RAMP BR OF CHERAS IC	2 NOS.	47+065	150	PCT	6.75x2
	TOTAL BRIDGE LENGTH		9876 m.			
	TOTAL BRIDGE AREA		190834 sq.m.			

NOTE:

BR - BRIDGE
VD - VIADUCT
PCH - PRESTRESSED CONCRETE HOLLOW SLAB TYPE
PCI - PRESTRESSED CONCRETE I-SHAPED BEAM TYPE
PCT - PRESTRESSED CONCRETE INVERTED T-SHAPED BEAM TYPE
FO - FLYOVER
FR - FRONTAGE ROAD

TABLE 5.6.4 : NORTH-SOUTH EXPRESSWAY LINK BRIDGE LIST

NO.	NAME	CHAINAGE	LENGTH (m)	TYPE	WIDTH (m)
1	A RAMP BR OF NEW K/VALLEY IC	0+000	130	PCH	6.75
2	B RAMP BR (1) OF NEW K/VALLEY IC	0+050	90	PCI	6.75
3	B RAMP BR (2) OF NEW K/VALLEY IC	0+100	360	PCH	6.75
4	B RAMP BR (3) OF NEW K/VALLEY IC	0+200	260	PCH	6.75
5	C RAMP BR (1) OF NEW K/VALLEY IC	0+300	600	PCH	6.75
6	C RAMP BR (2) OF NEW K/VALLEY IC	0+400	80	PCT	6.75
7	D RAMP BR OF NEW K/VALLEY IC	0+500	100	PCH	6.75
8	RAMP BR OVER SG. DAMANSARA	2+020	100	PCT/PCI	6.75
9	RAMP BR OVER SG. DAMANSARA	2+020	80	PCI	6.75
10	BR OVER FRII	2+100	65	PCT	29
11	FR BR OVER FRII 2 NOS.	2+100	65	PCT	10x2
12	BR OVER RAILWAY	2+260	40	PCT	29
13	FR BR OVER RAILWAY 2 NOS.	2+260	40	PCT	10x2
14	RAMP BR OVER RAIL (1), BATU TIGA IC	2+260	40	PCT	6.75
15	RAMP BR OVER RAIL (2), BATU TIGA IC	2+260	70	PCT/PCI	6.75
16	BR OVER SG. DAMANSARA	2+335	40	PCI	29
17	FR BR OVER SG. DAMANSARA 2 NOS.	2+335	40	PCI	14.5x2
18	BR OVER JALAN PUCHONG U-TURN	3+530	30	PCI	29
19	BR OVER JALAN PUCHONG	3+610	40	PCI	29
20	BR OVER RAMP OF SUBANG WEST I/C	4+490	48	PCT	21.5
21	RAMP BR OF SUBANG WEST IC	4+900	90	PCT/PCI	13.5
22	FO BR OF SHAH ALAM HWY	4+900	64	PCT	28
23	BR OVER RIVER	5+735	30	PCI	21.5
24	BR OVER JLN. PUCHONG BATU TIGA	7+640	48	PCT	21.5
25	BR OVER RAMP OF HICOM EAST IC	8+080	40	PCT	21.5
26	BR OVER SG. KLANG	13+380	240	PCI	18.5
27	BR OVER SG. PUCHONG	13+970	40	PCI	21.5
28	A RAMP BR OF SOUTH KLANG VALLEY IC	14+690	60	PCH	6.75
29	B RAMP BR OF SOUTH KLANG VALLEY IC	14+690	280	PCH	6.75
30	VD OVER POND	15+615	320	PCT	18.5
31	BR OVER RIVER	16+180	30	PCI	21.5
32	BR OVER RAMP OF PUCHONG SOUTH IC	17+265	40	PCT	21.5
33	BR OVER RIVER	17+350	30	PCI	21.5
34	RAMP BR OVER RIVER	17+350	30	PCI	6.75
35	BR OVER RIVER	18+250	30	PCI	21.5
36	FO BR TO KG. PULAU MURANTI DALAM	19+270	64	PCT	8
37	BR OVER SG. RASAU	18+820	40	PCI	21.5
38	BR OVER SG. GAJAH	22+920	40	PCT	21.5
39	BR OVER JLN. DENGKIL-KAJANG	25+180	20	PCT	21.5
40	BR OVER SG. CHUA	27+310	30	PCI	21.5
41	BR OVER SG. CHUA	28+570	30	PCI	21.5
42	BR OVER JALAN SG. MERAB	31+565	20	PCT	21.5
43	BR OVER EXISTING ROAD	31+850	20	PCT	21.5
44	BR OVER KL-SEREMBAN EXPRESSWAY	33+595	90	PCT	21.5
45	A RAMP BR (1) OF BANGI WEST IC	33+595	250	PCH	6.75
46	A RAMP BR (2) OF BANGI WEST IC	33+595	130	PCH	6.75
47	C RAMP BR (1) OF BANGI WEST IC	33+595	130	PCH	6.75
48	C RAMP BR (2) OF BANGI WEST IC	33+595	150	PCH	6.75
	TOTAL BRIDGE LENGTH	4704 m.			
	TOTAL BRIDGE AREA	56678 sq.m.			

NOTE:

BR - BRIDGE FO - FLYOVER

VD - VIADUCT FR - FRONTAGE ROAD

PCH - PRESTRESSED CONCRETE HOLLOW SLAB TYPE

PCI - PRESTRESSED CONCRETE I-SHAPED BEAM TYPE

PCT - PRESTRESSED CONCRETE INVERTED T-SHAPED BEAM TYPE

5.7 Design of Pavement

5.7.1 General

The design methods of pavement are based on the "AASHTO INTERIM GUIDE FOR DESIGN OF PAVEMENT STRUCTURE 1972 (Chapter III, Revised 1981), Second Edition" (hereinafter called the "AASHTO Interim Guide").

The pavement design was carried out on the design road segments based on the average daily traffic volume shown in Table 5.7.1.

Table 5.7.1 : Road Segment Categorised by Average Daily Traffic

Name of the Project Road	Road Segment	Design CBR	Number of Lanes	Average Daily Traffic (veh/day) Flexible Pavement (in 2000)	Average Daily Traffic (veh/day) Rigid Pavement (in 2005)	Percentage of Lorries* (%)	Percentage of selected Heavy Goods Veh.** (%)
Shah Alam Highway and Southern Part of Middle Ring Road II	North Klang Straits Bypass to South Klang Straits Bypass (L=12km)	5	4	34,500	44,000	15.2	8.7
	South Klang Straits Bypass to Jalan Cheras (L=35km)	5	6	87,500	94,000	15.2	8.7
North-South Link	New Klang Valley Expressway to Shah Alam Highway (L=5km)	5	6	61,500	78,000	15.2	8.7
	Shah Alam Highway to KL-Seremban Expressway (L=28km)	5	4	32,500	42,000	15.2	8.7

Note:
* Percentage of lorries is based on the traffic survey data (KVTS) on Federal Highway II
** Selected heavy goods vehicles refer to loaded lorries only

5.7.2 Design Standard for Flexible and Rigid Pavements

Considering climatic and environmental conditions, physical properties and condition of the roadbed soils and the heavy traffic use in Klang Valley the most reasonable design procedure was selected from procedures described in AASHTO Interim Guide.

(i) Flexible Pavement Structures

- Analysis period	..	10 years
- Terminal serviceability	..	Pt = 2.5
- Common denominator for the converted axle loads	..	18-kip (8.2 ton)
- Regional factor	..	R = 2.5
- Design CBR	..	5
- Soil Support Value	..	S = 4.0
- Layer Coefficients		
Asphaltic concrete surface course		0.44/inch
Asphalt treated base course	..	0.34/inch
Crushed stone base course	..	0.14/inch
Sand gravel subbase course	..	0.11/inch

(ii) Rigid Pavement Structures

- Analysis period	..	20 years
- Terminal serviceability	..	Pt = 2.5
- Common denominator for the converted axle loads	..	18-kip (8.2 ton)
- Modulus elasticity of concrete	..	Ec= 4.98 x 10^6 psi
- Modulus of rupture of concrete (Sc)	..	Sc= 570psi
- Modulus of subbase reaction	..	K = 480pci
- Working stress in concrete	..	Ft= 0.75xSc
- Subbase stiffness (Asphalt treated base)	..	E=1,000,000 psi (70,300 kg/sq.cm)

To keep the surface in smooth riding condition and to avoid frequent pavement maintenance on busy corridors after construction, the pavement should be adequately designed both structurally and functionally.

In any design procedure, the following minimum practical thickness are to be applied to each pavement course:-

Surface course, flexible pavement	..	5 cm
Surface course, rigid pavement	..	20 cm
Base course	..	10 cm
Subbase course	..	10 cm

For design purposes the surface course of flexible pavement includes wearing course and blinder course of similar stabilities.

The following features of each type of pavement are taken into consideration to select type of pavement by type of road.

(a) Ease at Construction and Maintenance
(b) Resistance to Rutting and Wearing
(c) Stage Construction
(d) Materials Used
(e) Skid Resistance
(f) Initial Investment
(g) Difficulty in Repair

The detailed description on these features is presented in Appendix 5.6.

5.7.3 Optimum Design of Flexible Pavement Structure

Flexible pavement is considered for throughway, ramps, frontage roads and bridges. The optimum design of flexible pavement structure for each road segment is shown in the following Figures 5.7.1 and 5.7.2.

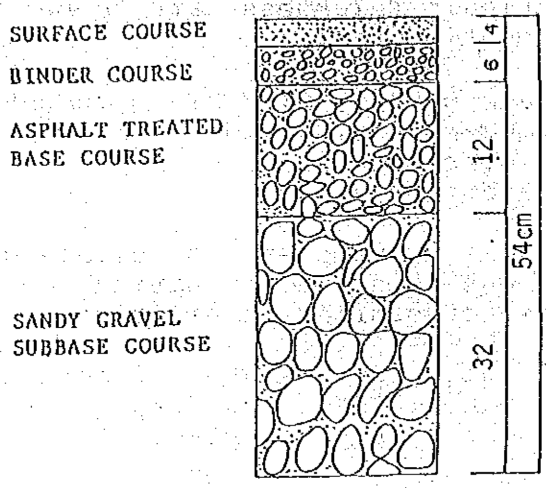


Figure 5.7.1 : Flexible Pavement Structure for Design Road Segment of North Klang Straits Bypass-South Klang Straits Bypass, New Klang Valley Expressway-Shah Alam Highway and Shah Alam Highway-Kuala Lumpur Seremban Expressway

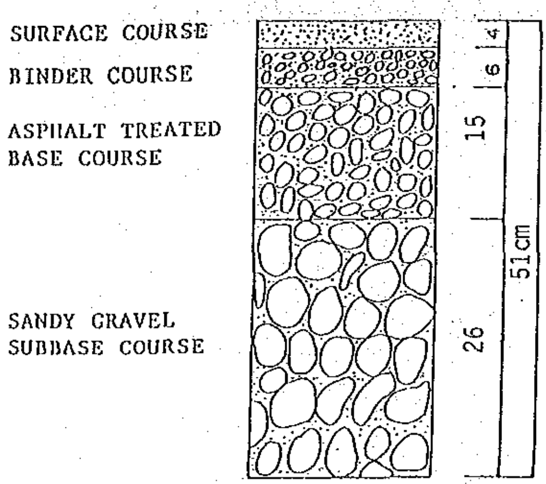


Figure 5.7.2 : Flexible Pavement Structure for Design Road Segment of South Klang Straits Bypass-Jalan Cheras

5.7.4 Optimum Design of Rigid Pavement Structure

Rigid pavement is recommended in toll plaza area. In the design of rigid pavement, slab thickness for all road segments is adopted as 30cm. The rigid pavement structure for project road is shown in Figure 5.7.3.

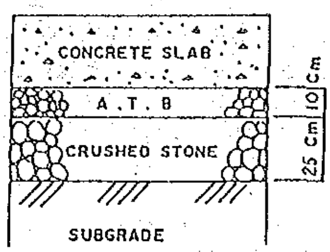


Figure 5.7.3 : Rigid Pavement Structure for Project Road

5.7.5 Pavement Structure of Hard Shoulder and Cycle Track

The following typical cross-sections as shown in Figures 5.7.4 and 5.7.5 are adopted for hard shoulder and cycle track in the project road.

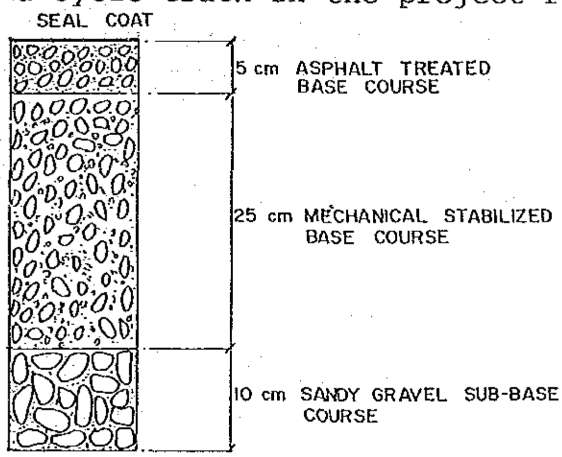


Figure 5.7.4 : Typical Cross-section of Hard Shoulder

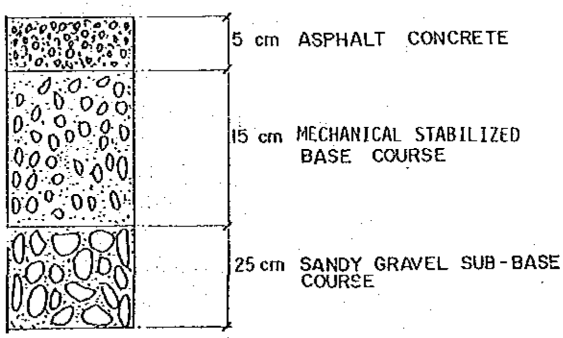


Figure 5.7.5 : Typical Cross-section of Cycle Track

5.8 Hydrological and Road Drainage Study

5.8.1 Hydrology

The Study Area is located in the Klang River Basin with a catchment area of 1,288 sq.km.

The study roads cross Sungai Klang at four points and several of its tributaries as shown in Figure 5.8.1. Necessary data for the design of bridges, finished grade of the planned road in flood prone areas and dimension of drainage structures were obtained by referring to the following two studies:-

(i) Kuala Lumpur Flood Mitigation Project Drainage Improvements, Master Drainage Plan, 1978; and

(ii) Study on the Flood Mitigation of the Klang River Basin, 1988.

Site survey and data collection were also carried out to supplement data and to prepare a proper basis for the preliminary design.

The detailed description about the hydrology considered in the Study is presented in Appendix 5.7.1.

5.8.2 Run-Off

(1) General

The provision of adequate drainage is extremely important for the maintenance of the roads and for traffic safety. Attention was paid to the following items:-

* Surface water drainage: rainwater on the pavement surface, embankment slope and other surface within the limits of the right-of-way;

* Roadside drainage: rainwater on the roadside and adjacent inhabited areas, outside the limits of the right-of-way which will affect the roads: and

* Opening for waterways which the road will cross.

(2) Frequencies of Excessive Rainfall

The frequency of excessive rainfall for design of the drainage system have been proposed as shown below.

Drainage System	Frequency of Excessive Rainfall
Surface Water Drainage	5 years
Rivers or main drainage channels	50 years

The reasons for selecting the above periods are as follows:-

(a) Surface Water Drainage

It is assumed that water ponding for a very short time over limited areas will occur once in five years and that this is tolerable to achieve a less costly drainage system.

(b) Rivers of Main Drainage Channels

Selection of a frequency of a long period results in the road construction cost becoming excessive. It is considered that a frequency of 50 years will not cause serious damage or loss during its design life and that this is reasonable.

The adopted method for estimating run-off is given in Appendix 5.7.2.

5.8.3 Study Result of Hydraulic Calculations

The design discharge and shape of channel required to deal with the rivers and drains were calculated incorporating the available study data. Manning's formula and various flow equations were used to calculate the mean velocity and discharge capacities of each waterflow. Tables 5.8.1 shows the result of these calculations.

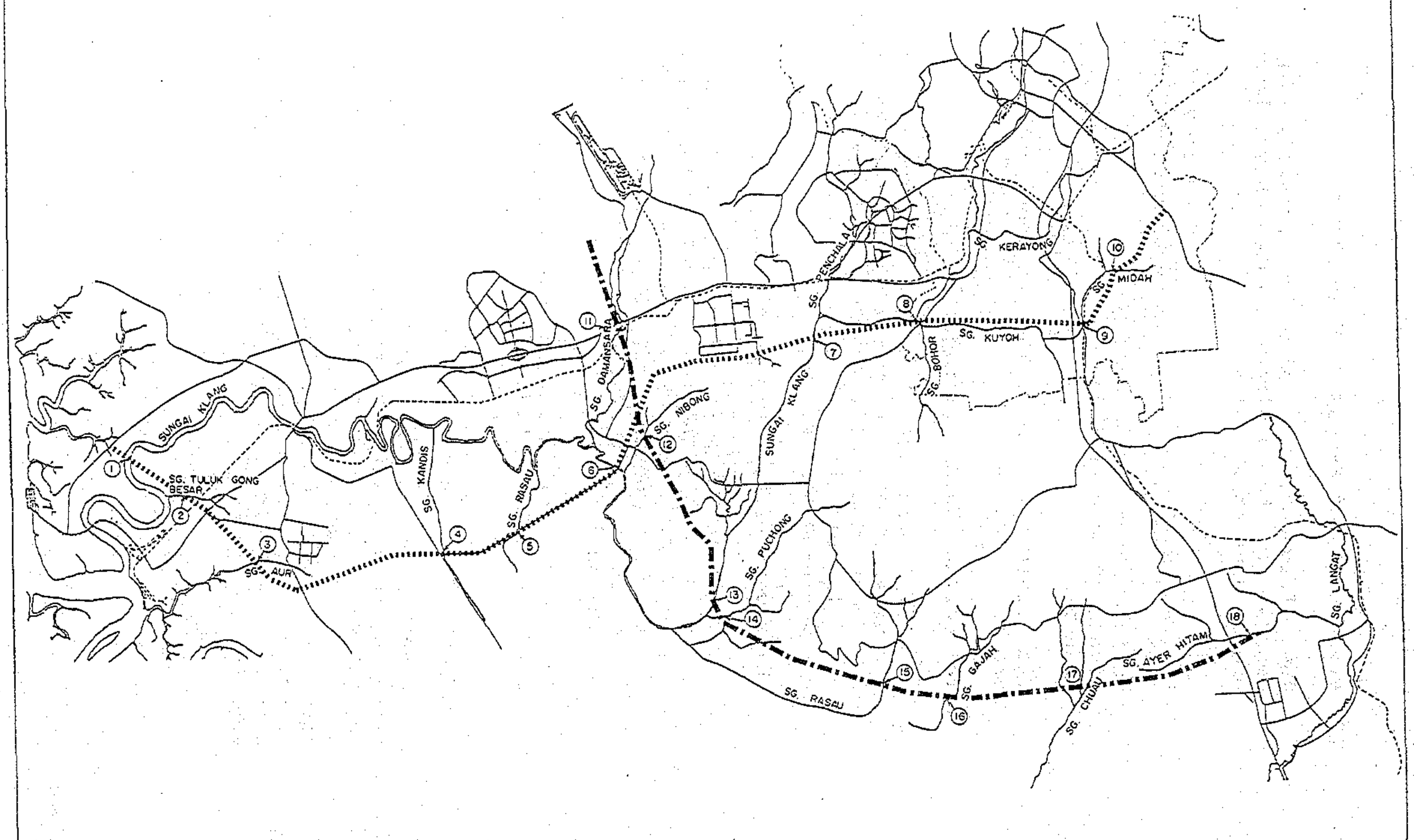


Fig.5.8.1 : Rivers Related to the Project

THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY

LEGEND:

- SHAH ALAM HIGHWAY / MIDDLE RING ROAD II
- NORTH - SOUTH LINK

Table 5.8.1 : Result of Hydraulic Calculations for Rivers and Canals (1)

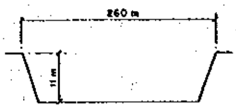
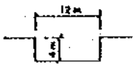
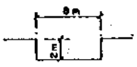
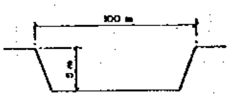
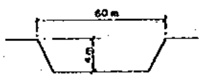
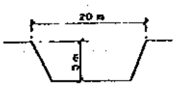
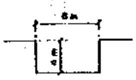
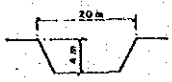
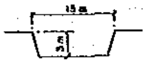
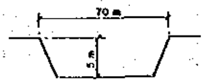
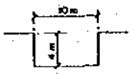
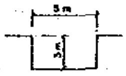
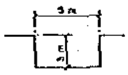
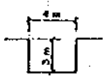
NO.	RIVER/CHANNEL	EXISTING CROSS SECTION	ADJACENT CROSSING STRUCTURE	CATCHMENT AREA (km²)	DISCHARGE (m³/sec)	FREEBOARD (m)	PROPOSED CROSSING STRUCTURE
1	SUNGAI KLANG		- 400m long bridge is under construction in 6km downstream - No inundation	1288	1770	1.0	- 400m long bridge covering river reserve
2	SUNGAI TELUK GONG BESAR		- 10m span bridge is located at the crossing point of Persiaran Raja Muda Musa	10	49	0.5	- 20m span bridge
3	SUNGAI AUR		- 10m span bridge is located on Jalan Langat	7	34	0.5	- 15m span bridge
4	SUNGAI KANDIS		- 10m span bridge is located on Jalan Bukit Kemuning in the vicinity of Jalan Kebun Intersection	3.5	14	0.5	- 10m span bridge
5	SUNGAI RASAU		- 16m span bridge is located on Jalan Bukit Kemuning	11	44	0.5	- 20m span bridge
6	SUNGAI KLANG		- 230m long bridge is located on Jalan Bukit Kemuning in the vicinity of HICOM - Flood level 4.2m	845	1350	1.0	230m long bridge covering river reserve
7	SUNGAI KLANG		- 80m long water supply pipe crosses the river - Flood level 10.6m	695	1110	1.0	150m long bridge covering river reserve
8	SUNGAI KUYOH		- 40m span bridge is located on Jalan Puchong - Flood level 22.5m	82	100	1.0	40m span bridge
9	SUNGAI MIDAH		- 10m span bridge is located on Jalan Sungei Besi	5	46	0.5	10m span bridge
10	SUNGAI MIDAH		- Two 1.2m diameter pipe culverts cross a local road	3.5	43	0.5	10m span bridge

Table 5.8.1 : Result of Hydraulic Calculations for Rivers and Canals (2)

NO.	RIVER/CHANNEL	EXISTING CROSS SECTION	ADJACENT CROSSING STRUCTURE	CATCHMENT AREA(km^2)	DISCHARGE (m^3/sec)	FREEBOARD (m)	PROPOSED CROSSING STRUCTURE
11	SUNGAI DAMANSARA		- 20m span bridge is located on Federal Route II	148	266	1.0	40m span bridge
12	SUNGAI NIBONG		- Five-cell box culvert crosses HICOM-Shah Alam road	8	60	1.0	15m span bridge
13	SUNGAI KLANG		- 230m long bridge is located on Jalan Bukit Kemuning - Flood level 10.6m	720	1150	1.0	230m long bridge covering river reserve
14	SUNGAI PUCHONG		- Box culvert crosses Puchong-Kajang road - Flood level 10.6m	24	61	0.5	25m span bridge
15	SUNGAI RASAU		- 12m span bridge is located on Puchong-Kajang road	110	132	1.0	40m span bridge
16	SUNGAI GAJAH		- Pipe culvert crosses a local road	9.5	45	0.5	15m span bridge
17	SUNGAI CHUAU		- 6m span bridge is located on Puchong-Kajang road	9	41	0.5	15m span bridge
18	SUNGAI AYER HITAM		- 10m span bridge is located on a local road	125	53	0.5	15m span bridge

5.8.4 Preliminary Design of 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 5.8.2. The combined drainage facility will be maintained by the relevant authorities after maintenance limits have been decided.

Outlets of the road drainage system will be constructed at the following points:-

(i) The sag point on the road profile
(ii) The crossing point of existing drainage structures
(iii) Points accessible to existing waterways

The proposed typical road surface drainage systems are shown in Figure 5.8.2 and are described as follows:-

* Outer shoulder which has 4% crossfall and 3.0m width will be utilised for the location of road gulleys;

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

* Concrete pipes not less than 40cm 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 strip and connected to the existing main drain, canal or river.

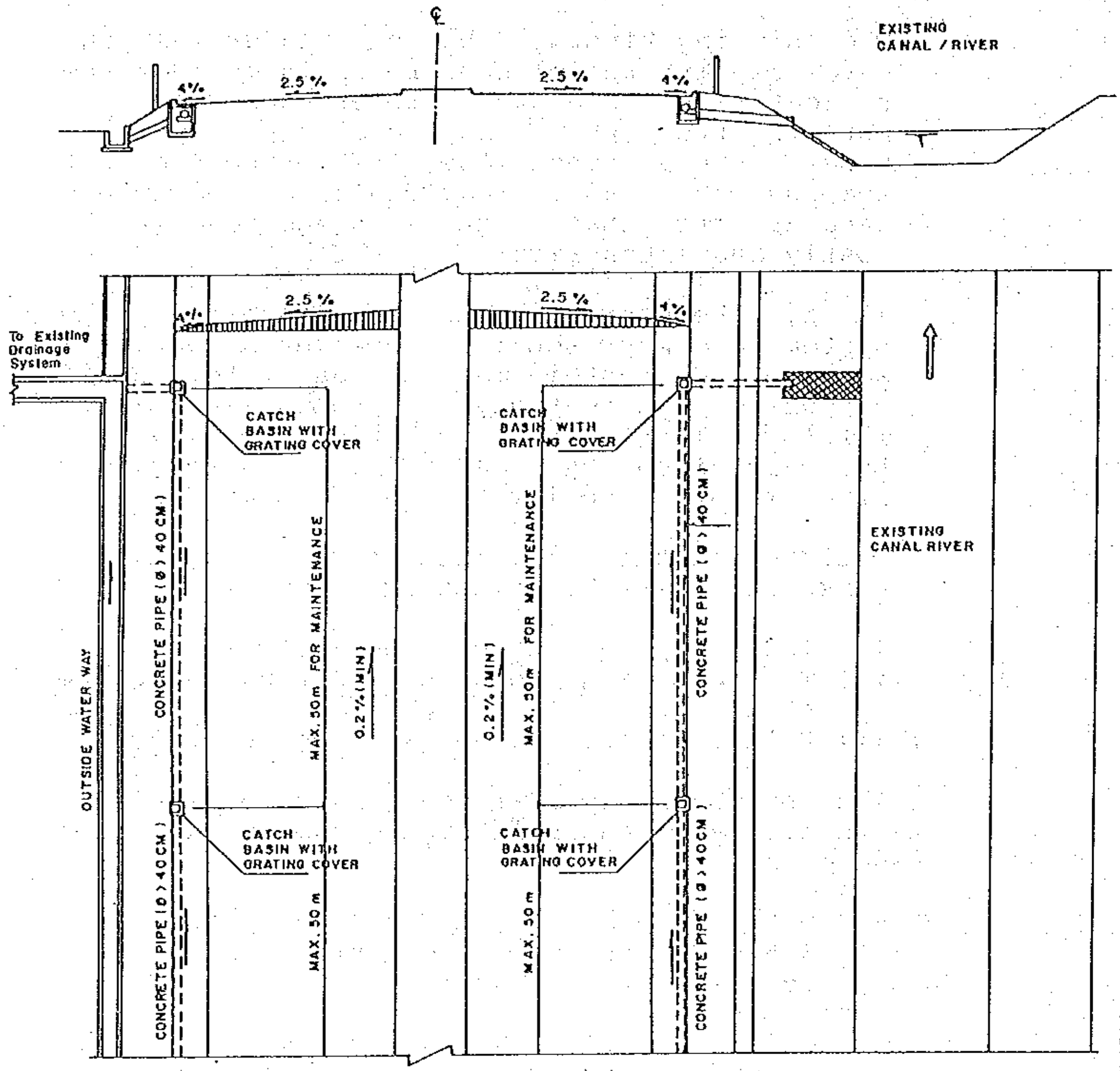
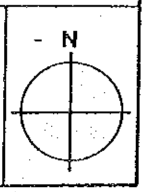


FIG. 5.8.2 : TYPICAL DRAINAGE SYSTEM

LEGEND :

THE FEASIBILITY STUDY ON TRANSPORTATION FACILITIES PROJECTS IN KLANG VALLEY

SCALE :



5.9 Design of Road Supporting Facilities

The objective of the road supporting facility is to maintain smooth and safe traffic flow and to ensure the benefit of the user.

The following facilities are considered:-

* Traffic Signs
* Traffic Markings
* Road Lighting
* Landscaping and Safety Facilities
* Cycle Tracks
* Traffic Barriers
* Toll Gate
* Bus Stop
* Emergency Opening
* Pedestrian Crossing Facilities
* Emergency Telephone
* Traffic Signals
* Traffic Surveillance and Control

5.9.1 Traffic Signs

Traffic signs are one of the traffic control devices which are used to regulate, warn or guide road users. To be effective, traffic signs like other traffic control devices should meet the following four elementary requirements:-

(1) They should fulfill an important need
(2) They should command attention
(3) They should convey a clear, simple meaning
(4) They should give adequate time for proper response

Three kinds of signs namely regulatory signs, warning signs and guard signs are designed according to JKR standards as shown and specified in Manual on Traffic Control Devices. Standard Traffic Signs (Arahan Teknik (Jalan) 2A/85) and in Manual on Traffic Control Devices, Traffic Sign Applications (Arahan Teknik (Jalan) 2B/85).

The details of traffic signs are given in Appendix 5.8.1.

5.9.2 Traffic Markings

Traffic markings include all traffic lines (both longitudinal and transverse), symbols, words, object markers, delineators, cones or other devices, except signs that are applied or attached to the pavement or mounted at the side of the roadway to guide traffic or warn of an obstruction.

Road markings are particularly important to help in regulating traffic, warning or guiding road users. All road markings, like other traffic control devices should be uniform in design, position and application so that they may be recognized and understood immediately by all road users. Furthermore, all markings on highways shall be reflectorized.

Road markings shall be drawn as specified in JKR Manual on Traffic Control Devices, Road Marking and Delineation (Arahan Teknik (Jalan) 2D/85).

The details of traffic markings are given in Appendix 5.8.2.

5.9.3 Road Lighting

Lighting may improve safety of a highway or street and the ease and comfort of operation thereon. Statistics indicate that night time accident rate is higher than that during day time hours, which, to a large degree, may be attributed to impaired visibility. There is evidence that in urban area and suburban area, where there are concentration of pedestrians, fixed source lighting tends to reduce accidents.

The recommended standard for road lighting and its application are presented in Appendix 5.8.3.

5.9.4 Landscaping and Safety

The appearance of the highway and its impact on the environment has been constantly in focus throughout the design process.

The grassed areas along the study roads, because they are relatively small in size and are an important part of the landscape effect, will require considerable effort in the construction of curbs and drainage structures to make them attractive. While grass is widely used for preventing erosion the utilization of trees and shrubs are also considered.

Coordination of slope grading, drainage and planting (i.e. planting of trees, shrubs, vines, ground cover, or other vegetation) were considered in the design of all roadways and structures, not only to enhance the appearance of the area and safety, but also to keep construction and maintenance costs to a minimum.

The detailed description is given in Appendix 5.8.4.

5.9.5 Cycle Tracks

The exclusive cycle track is provided in the stretch where a high standard road is estimated to have a considerable volume of motorcycles, as the exclusive cycle track may contribute to increase safety, comfort and mobility of a highway largely. However, it is also inevitable that an exclusive or restricted cycle track makes interchanges and viaducts complicated and expensive.

Therefore, the exclusive cycle track is recommended to be provided to Shah Alam Highway and the western section of MRR-II as a high rate and volume of motorcycles heading towards Kuala Lumpur is forecasted. Since N-S Link is designated as a part of a bypass to connect Kuala Lumpur-Seremban Expressway with Kuala Lumpur-Tanjung Malim Expressway, the number of motorcycles will be negligible so that provision of cycle track may not be warranted.

In the eastern section of MRR-II (Jalan Cheras to Kuala Lumpur-Seremban Expressways), viaducts and interchanges will be required due to the restricted land conditions, railway overpassing and connection with major roads. Motorcyclists will be restricted on this stretch and be forced to use a frontage road from the economic viewpoint.

5.9.6 Traffic Barriers

Traffic barrier installation on shoulders prevent vehicles running off steep embankments or into fixed objects whereas median barriers are used between the roadways of divided highways to prevent "across the median" collisions with opposing traffic.

Traffic barriers should be considered under the following conditions:-

(a) Roadways on high embankment and embankment with steep side slopes
(b) On highways with roadside obstacles and hazards such as structures and appurtenances
(c) Divided highways with narrow medians, carrying large volume of traffic
(d) Other conditions such as horizontal curves, pedestrian protection and severe accident experience.

The details of traffic barriers are given in Appendix 5.8.5.

5.9.7 Toll Gate

In the planning and design of the toll gate, considerations have to be made regarding the road, topographical and other conditions as well a as the system for the control and operation of the road. That is, in determining the type of interchange for a toll road, the system of toll collection has to be studied at the same time. The following items are studied based on the "Design Manual, Volume 4 of Japan Expressway Public Corporation" and "LLM (Malaysia Highway Authority) Standard".

(1) Toll System
(2) Number of Traffic Lanes to a Toll Gate
(3) Geometric Structure Standard at Toll Plaza

The detailed description is presented in Appendix 5.8.6. The proposed number of lanes to a goll gate is tabulated in Table 5.9.1.

Table 5.9.1: Number of Booths at a Toll Gate

Road	Location	Type of Toll Gate	Number of Booths		
			On-Ramp	Off-Ramp	Total
Shah Alam Highway/ MRR-II	CH.12+750	Barrier	-	-	10*
	CH. 25+700	Barrier	-	-	12*
	CH. 37+100	Barrier	-	-	13*
N-S Link	Batu Tiga IC (No.18)				
	CH. 1+550	On/Off	3	5	8
	CH. 2+650	On/Off	2	2	4
	Subang West IC (No. 9)	Barrier	4	9	13
	HICOM East IC (No.19)	Barrier	2	2	4
	Puchong South IC (No.21)	Barrier	2	3	5
	Bangi West IC (No.22)	Barrier	3	6	9

Note: * includes three reversible lanes in centre

5.9.8 *Bus Stop*

Most of the areas within subcorridor of Shah Alam Highway and MRR-II will be developed into residential, commercial and recreation areas, so that there will be many bus routes on the subcorridor of these project roads in future. In order not to disturb the traffic flow, the provision of exclusive space for buses to stop is very necessary.

A stopping space 15.0m long of 3m width is sufficient for one large bus to stop and 24m length of taper provides minimum disturbance to other vehicles in the through lanes.

A shelter with lighting is provided at each bus stop of type similar to the existing ones used in the Federal Route 2.

Final locations of bus stops are determined in accordance with the following criteria:

(i) Places close to pedestrian crossing facilities and bridges planned in the study, while respecting the existing locations of bus stops as much as possible because bus users usually return to the same place, but on the opposite side of the subcorridor.

(ii) Places where with the provision of a bus-bay there remain, enough side strip space within the given ROW, and

(iii) To avoid as much as possible places where the stopping and starting movement of buses is likely to be interfered with by vehicles from minor accesses.

5.9.9 Emergency Opening of Median

Opening of median is provided to accommodate the emergency use of the study roads. The design should allow fire engines and other emergency vehicles can enter and leave the Study road more quickly.

Also, these openings could be utilized as the emergency entrance and exit of extra large vehicles which cannot pass through normal size toll gates.

The length of the opening is 20 meters. Every emergency opening in the median and in the two outer separations is provided with a movable fence which is opened as necessary for emergency vehicles and closed during normal operation of the study road.

5.9.10 Pedestrian Crossing Facilities

At-grade pedestrian crossings are not possible in case of the Highway or Expressway. At locations where the Highway or Expressway are elevated by flyovers, pedestrians will be able to cross the road at ground level.

There are two types of facility planned. These are, at-grade crossings painted on the pavement surface under flyovers, and elevated pedestrian bridges. No underpass by box culvert is planned because of security and flooding problems.

As a general policy it is proposed that pedestrian crossing facilities will be located approximately every 500 meters where high pedestrian demand is forecasted. Where land adjacent to the study road is still substantially undeveloped pedestrian facilities are provided in the midway. Additional crossings are to be provided later when the area is developed.

Pedestrian bridges are to be provided in accordance with the following criteria in order to supplement the at-grade crossings under flyovers:-

(i) Effective deck width is 2.0 meters;
(ii) Access stairways are to be provided in one direction only at each end of a bridge;
(iii) Piers shall be located in median and border, not in the outer separation;
(iv) Heavy duty type steel guardrails shall be installed for pier protection; and
(v) All beams shall be precast concrete type (i.e. post-tensioned P.C. T-girder for overcrossing spans and precast R.C. beams for the stairways).

The criteria for selection of the location of pedestrian overbridges are as follows:

(i) Existing demand arising from the social facilities such as schools, markets, official buildings, hospitals and existing at-grade crossings marked by paint, etc.

(ii) Interval of the facilities along the subcorridor

(iii) Width of the side strip to allow the setting of columns, and

(iv) Locations away from minor accesses which would prevent the provision of staircases.

5.9.11 Emergency Telephone

The proposed communications system must be suitable for transmitting information between pre-established point located at regular intervals along the expressway and the operations centre, employing a two-way communications system. It is necessary that the emergency assistance personnel be able to communicate with the user so as to be able to take necessary steps immediately.

The use of the equipment and its maintenance must be simple, and it should be easily understandable to the user.

The detailed description is presented in Appendix 5.8.7.

5.9.12 Traffic Signals

Traffic signals provide for the orderly movement of traffic at intersections thus reducing the likelihood of collisions.

In installation of traffic signal, in order for the driver to respond effectively, these basic requirements has to be considered:-

(i) The amount of light reaching the driver's eye.

(ii) The position of the signal in the driver's field of view.

(iii) The ratio of the signal-to-background contrast.

(iv) The amount of competing information sources (visual clutter or "noise").

(v) The degree to which the appearance of the signal is expected.

(vi) The degree to which the precise location of the signal is known.

(vii) The degree to which the message conform to the driver's knowledge and expectations.

5.9.13 Traffic Surveillance and Control

The Traffic Surveillance and Control System aims at making traffic flow safer and smoother by collecting and analyzing factual data on the highway network; conveying such information as advisory and mandatory information to the driver; controlling the traffic control devices and compiling the statistics reports.

In the control centre, almost all information are transmitted directly from:-

(i) vehicle detector which are installed above or under the roads to detect the presence or absence of vehicles on the sites;

(ii) CCTV cameras which are installed at strategic location on highways;

(iii) observations by a patrol car which will report the traffic situations such as congestion, incident or other problems using a two-way radio system; and

(iv) road users who are involved in or have observed a traffic accident or other incidents on the highway.

These information are processed into more refined and integrated information, some of which are displayed on wall map in the control centre, some are transmitted to related agencies and some are conveyed to road users by broadcasting through radio, by the using of changeable message sign which are installed at strategic points on the road network, and by communicating with road users through telephone.