4.5 KLORR and Kajang Traffic Dispersal Ring Road (KJRR)

Kajang Town is located in the south of Kuala Lumpur as one of the satellite towns. The two major roads (Federal Route No.1 and State Road B11) are criss-crossing in the town center running north-south and east-west directions as shown in Figure 4-5-3. Recent urbanization and motorization are inducing serious traffic congestion on the major road in he town. The Kajang Ring Road (KJRR) is proposed to ease the traffic congestion as a privatization project. In this section intends to examine the relationship between the KLORR and KJRR.

Functions :

KLORR	Provision of the bypass and alternative routes for the through traffic of the metropolitan region, as well as the traffic to and from the region.
KJRR	Revision of the bypass and alternative routes for external traffic (through and to/from) of the Kajang area.

Route :

The proposed alignment of the KJRR is shown in Figure 4-5-3. The eastern and southern route alignment will be planned in the same corridor as the KLORR.

Issues:

Several issues can be raised on the proposed KJRR. They are:

1. Urban road network system in the Kajang area encircled by the KJRR should be studied and the role and function of the KJRR will be identified.
2. The justification of the KJRR as a privatization project should be examined in line with other privatization project as Kajang Bypass, Jalan Cheras Widening and so on.
3. Whether a public consensus can be secured, as there are many toll gates in the town area.
4. Whether KLORR and KJRR can share a ROW or KLORR and KJRR should be separated in terms of their function and users convenience.

Result of the examinations:

The issue 1,2, and 3 are expected to study separately. Here will be discussed on the issue 4

First examination is what kind of traffic will use the KJRR.

There are three directional movements in the through traffic of Kajang Town. Those are Jln. Cheras to Jln. Semenyih, Jln Cheras to B11 (and KL-Seremban Expressway) and Jln. Semenyih to B11 as shown in Figure 4-5-2. Those through traffic of which trip length will be comparatively long, can be also utilized the KLORR.

Second examination is the distribution function of the KJRR.

The KJRR will provide alternative routes for the traffic to and from the Kajang Town so that the traffic can be distributed and prevents deterioration of the traffic

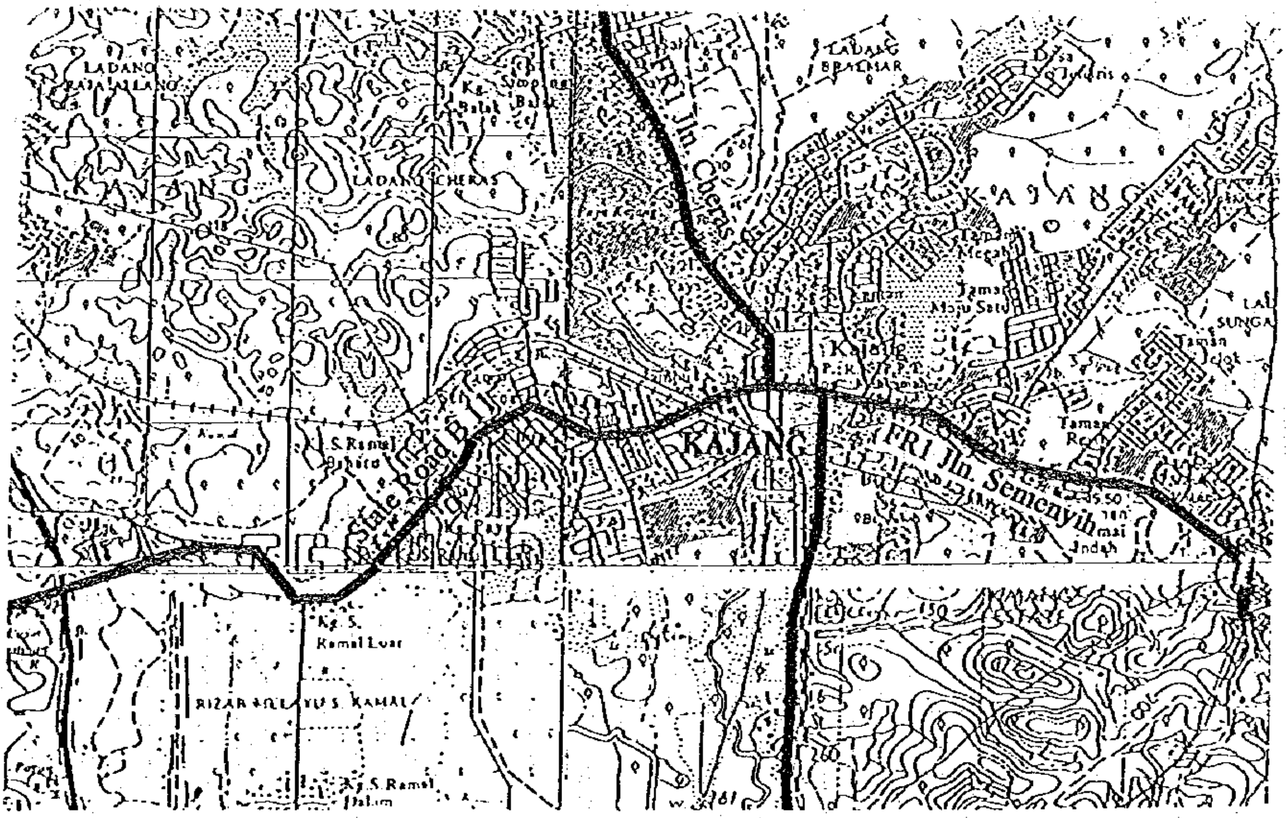


Figure 4-5-1 Existing Roads in Kajang Town

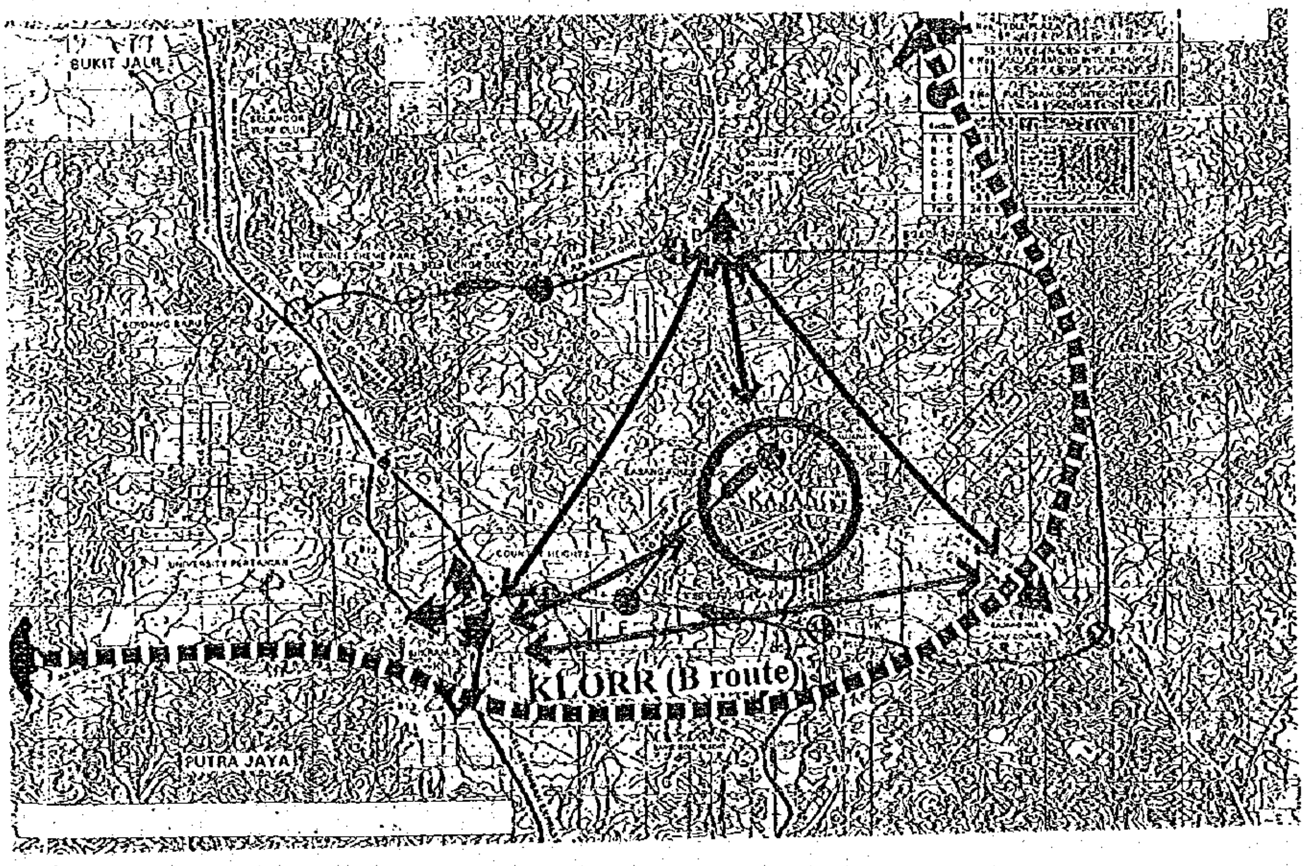


Figure 4-5-2 Location of Kajang Ring Road and KLORR

congestions. Three directional flows are observed on the external traffic flows, from Jln. Cheras, Jln. Semenyih and B11 (KL-Seremban Expressway). The traffic on the Jln. Cheras to Kajang Town will not take KJRR, because of the extremely long detour route and toll. The traffic north direction to the south of Kajang Town will use the KLORR from northern interchange and approach to the area from Semeniyh interchange or Kajang south interchange.

The traffic from east-south direction on the Jln. Semenyih will use the KJRR, as an alternative route in case of the toll free. However, the users will not pay the toll for that short distance. The traffic from east direction will be expected to use the KLORR, because of the well-managed network configuration.

Therefore, it is concluded that the KLORR will be able to share the function of the KJRR. In short, the KJRR will form a ring with the northern section of the proposed KJRR and KLORR, and appropriate number of interchange which will enable to distribute external traffic of Kajang Town should be Provided. The proposed interchanges and conceptual internal urban road network for the Kajang Town are shown in Figure 4.5.3.

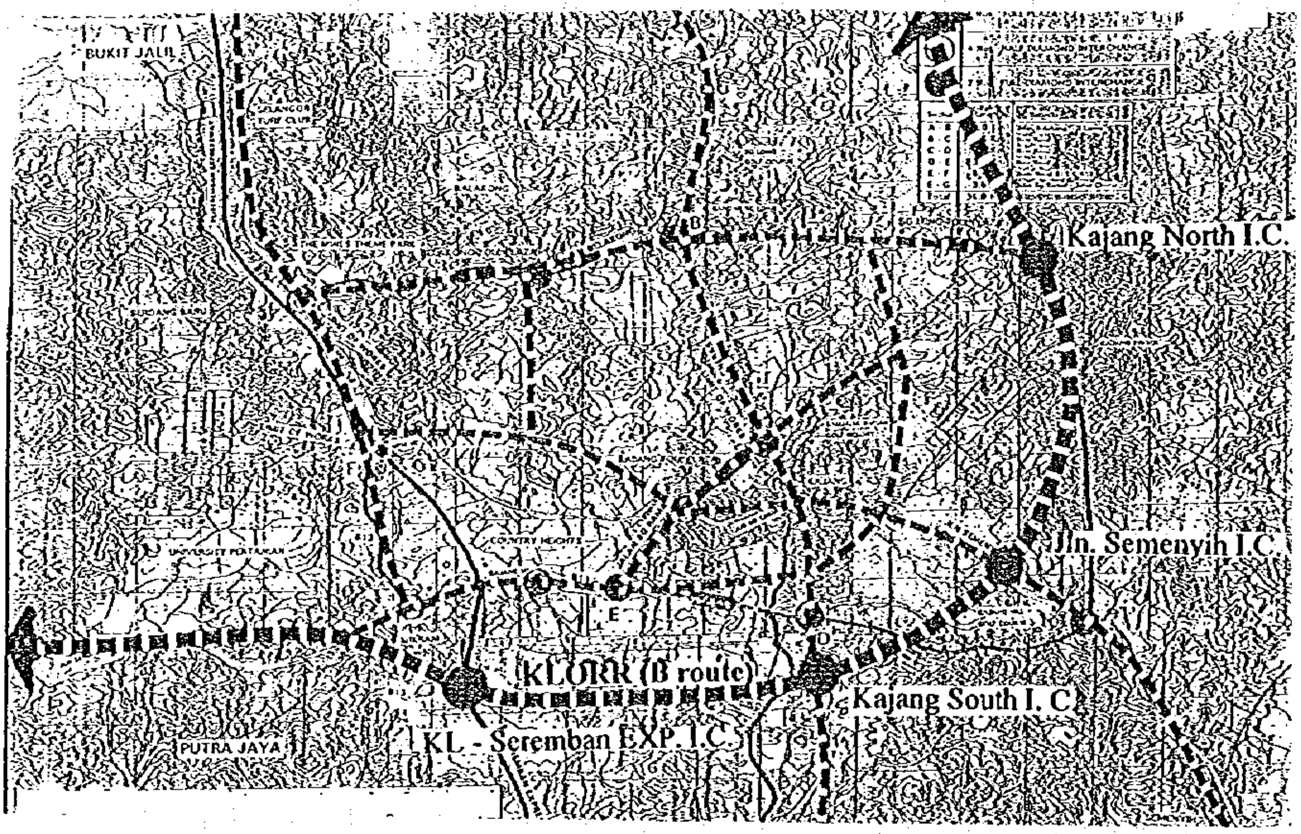


Figure 4-5-3 Conceptual Road Network Configuration of Kajang Town

4.6 FUTURE TRAFFIC DEMAND ASSIGNMENT

4.6.1 General

This section describes the analysis on the results of traffic demand forecasting based on traffic assignments of the origin-destination matrices described in Appendix C using the Traffic Network Models built for the alternative routes.

The 2020 base case Traffic Network Model comprises all the major road projects under-construction and already committed to implementation by the government via privatization or otherwise. The future road linkages, excluding the KLORR, in the Study Area include these projects:

- Shah Alam Expressway
- North South Central Link Expressway
- Middle Ring Road II
- 2nd carriageway for KL-Karak Highway
- Elevated Highway
- New Pantai Expressway
- KL North East Expressway
- Damansara-Putra Jaya Highway
- Dedicated Highway (KL-Putra Jaya-KLIA)
- West Coast Expressway

The Traffic Network Models for assignment scenarios with KLORR are built up by adding the alternative routes to the 2020 base case network.

4.6.2 Forecast Traffic Flows

For the purpose of route selection, the forecast traffic flows in the Traffic Network Models in the years 1995 and 2020 are calculated for the assignment scenarios without and with KLORR. The forecast traffic flows on the KLORR for the three alternatives in 1995 and 2020 are obtained from the traffic assignment results. The traffic flows for the intermediate years are then interpolated from those results.

The forecast traffic flows on the KLORR can be better described by dividing the road into three sections, namely Section 1 (from North-South Expressway to KL-Karak Highway). Section 2 (KL-Karak Highway to KL-Seremban Highway) and Section 3 (KL-Seremban Highway to NS Central Link Expressway).

<u>KLORR Alternative A</u>

Section 1 : Forecast traffic volume in 2000 is some 23,900 vehicles/day. This is expected to grow by 6.1%pa to reach an ADT of 78,700 vehicles/day by 2020.

Section 2 : Forecast traffic volume in 2000 is some 14,900 vehicles/day. This is expected to grow by 8.4%pa to reach an ADT of 75,300 vehicles/day by 2020.

Section 3 : Forecast traffic volume in 2000 is some 34,000 vehicles/day. This is expected to grow by 4.7%pa to reach an ADT of 84,900 vehicles/day by 2020.

KLORR Alternative B

Section 1 : Forecast traffic volume in 2000 is some 25,000 vehicles/day. This is expected to grow by 5.4%pa to reach an ADT of 72,000 vehicles/day by 2020.

Section 2 : Forecast traffic volume in 2000 is some 21,000 vehicles/day. This is expected to grow by 7.3%pa to reach an ADT of 86,400 vehicles/day by 2020.

Section 3 : Forecast traffic volume in 2000 is some 35,400 vehicles/day. This is expected to grow by 4.5%pa to reach an ADT of 84,700 vehicles/day by 2020.

KLORR Alternative C

Section 1 : Forecast traffic volume in 2000 is some 31,500 vehicles/day. This is expected to grow by 4.2%pa to reach an ADT of 71,800 vehicles/day by 2020.

Section 2 : Forecast traffic volume in 2000 is some 35,200 vehicles/day. This is expected to grow by 4.8%pa to reach an ADT of 89,500 vehicles/day by 2020.

Section 3 : Forecast traffic volume in 2000 is some 37,500 vehicles/day. This is expected to grow by 4.6%pa to reach an ADT of 92,200 vehicles/day by 2020.

Figures 4-6-1 - 4-6-4 shows the traffic assignment results for the four cases of without and with KLORR in year 2020.

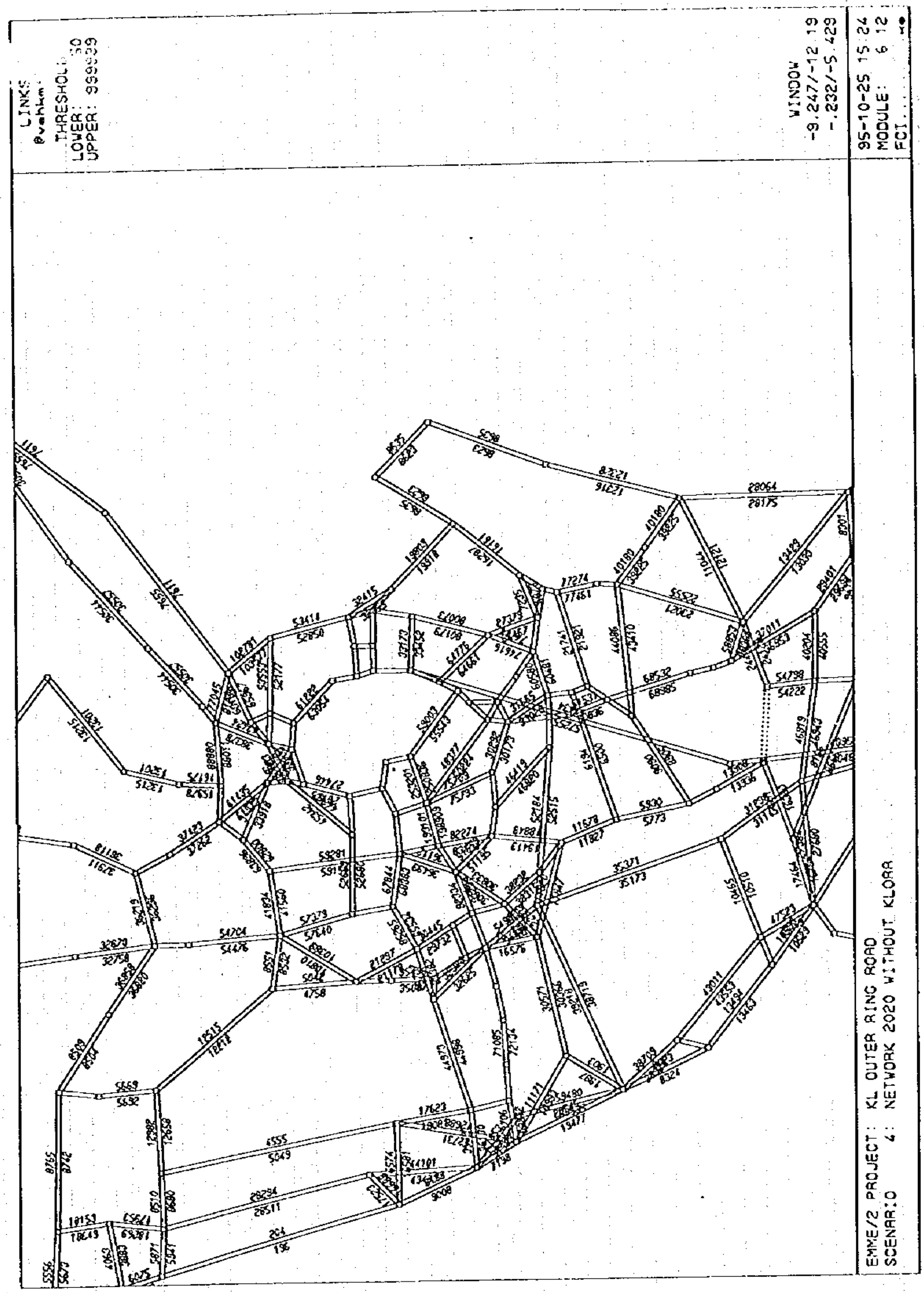


Figure 4-6-1 : Traffic Assignment Results Without KLORR in 2020

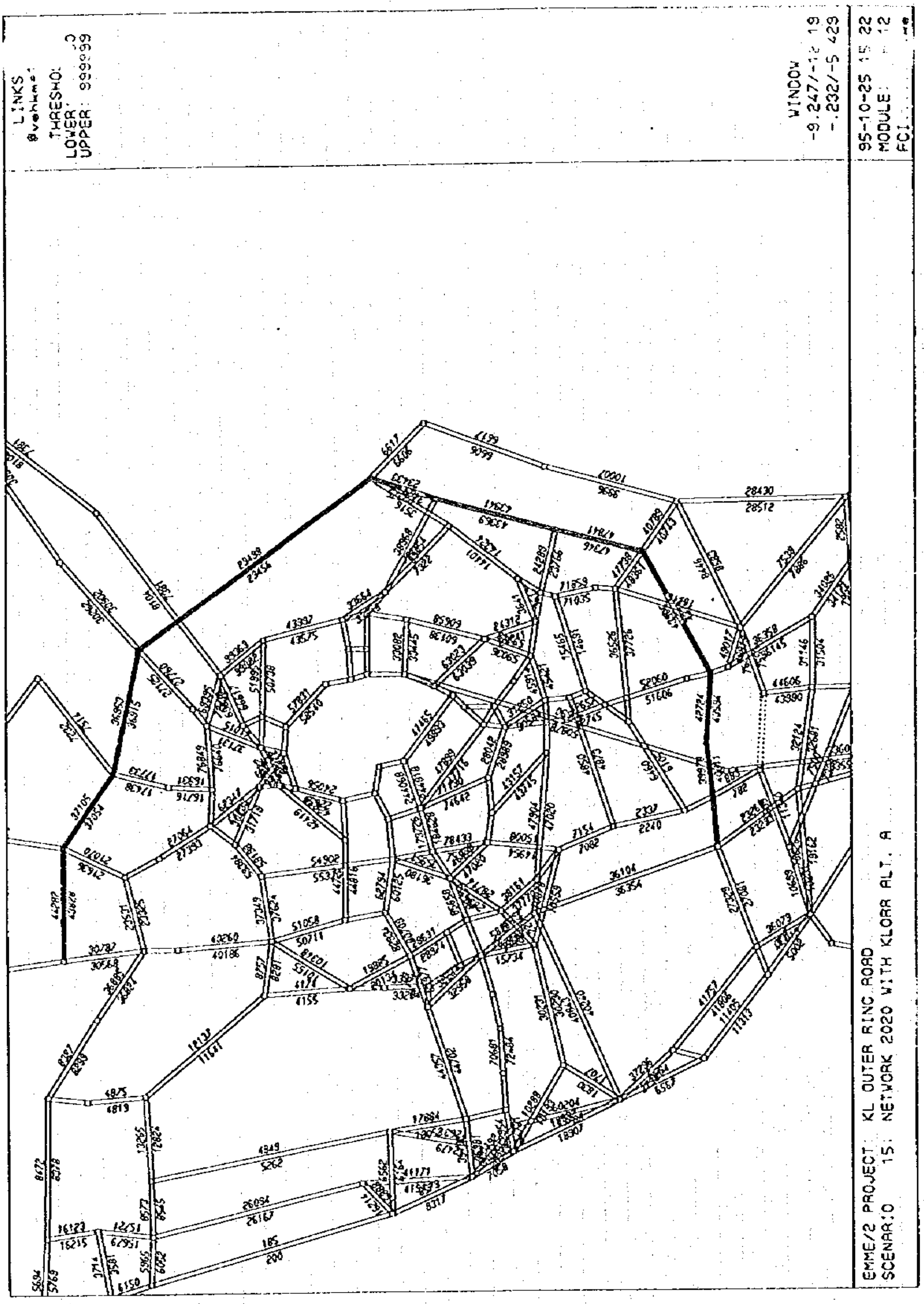


Figure 4-6-2 : Traffic Assignment Result With KLORR Alt. A in 2020

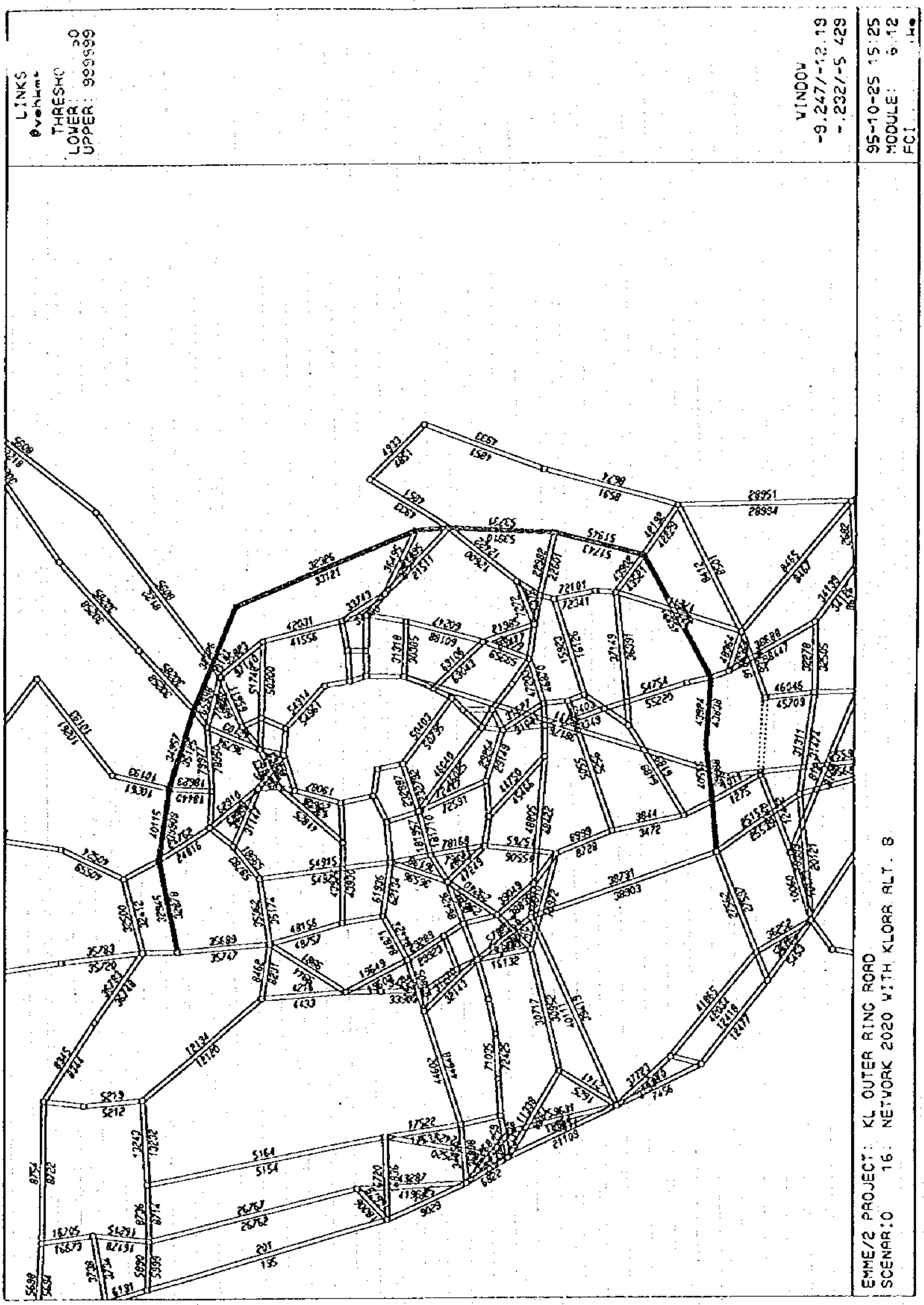


Figure 4-6-3 : Traffic Assignment Result With KLORR Alt. B in 2020

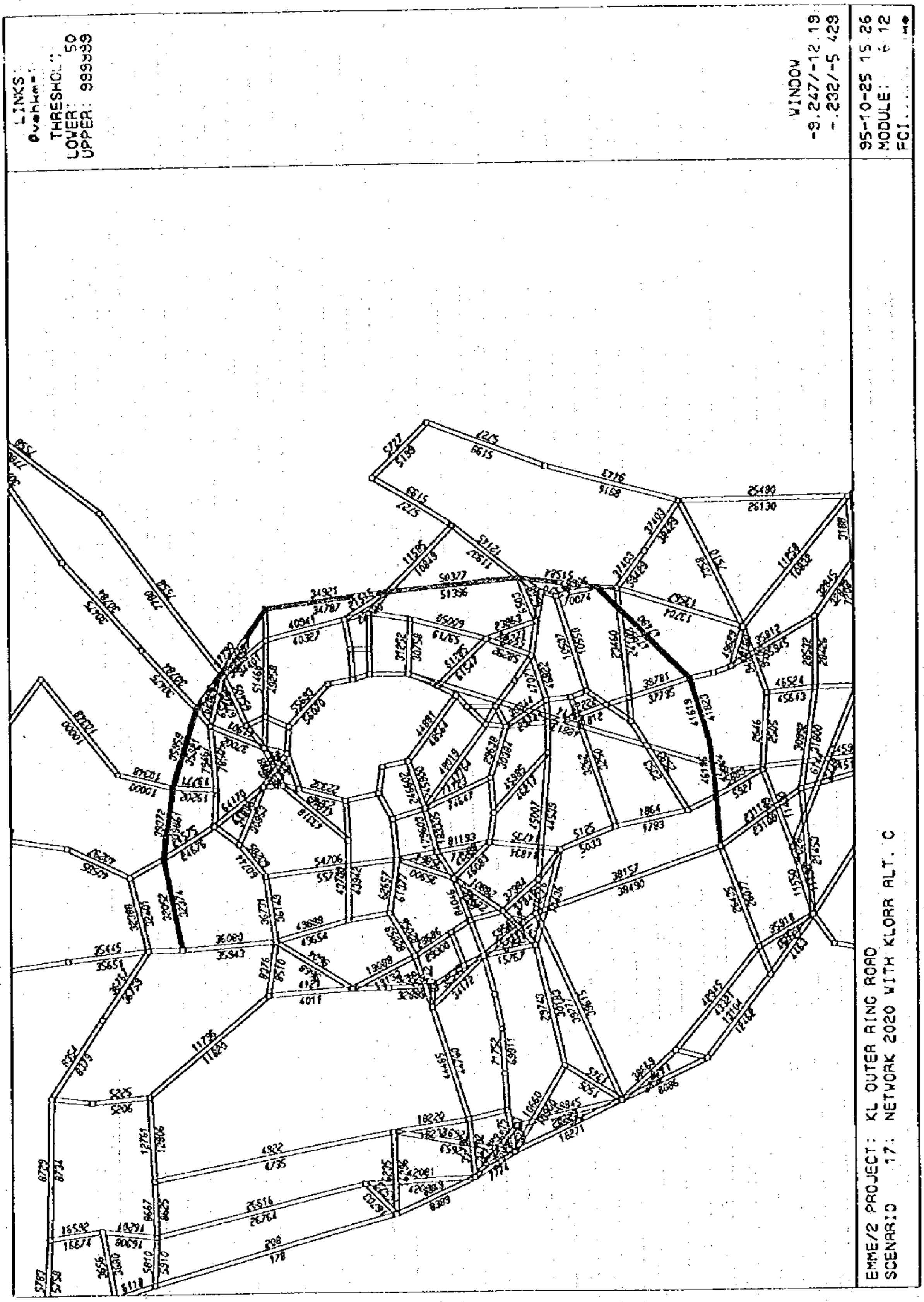


Figure 4-6-4 : Traffic Assignment Result With KLORR Alt. C in 2020

4.6.3 Comparison of Flows on Alternatives

Figures 4-6-5 - 4-6-7 shows the comparison of traffic flows in the network between a pair of alternatives. The positive values (in red colour) indicate the percentage of higher volume that one alternative has over one which is being compared. A larger extent of negative (green) values over the network would indicate that the alternative being compared has a greater effect to reduce traffic volume in the network.

Figure 4-6-5 compares Alternative A with Alternative B. Generally, the traffic flows in the northern and eastern sectors of Middle Ring Roads I and II show higher volume in Alternative A compared to Alternative B. This implies a better ability to reduce traffic flows inside Kuala Lumpur by Alternative B rather than Alternative A. Of the radial roads leading into Kuala Lumpur, the Federal Route 1 section between Serendah and Rawang has some 48% lower volume in Alternative A compared to Alternative B, while the Damansara-Puchong Highway (from Putra Jaya to Puchong) has some 20-39% lesser volume for Alternative A. But on the Dedicated Highway Alternative A has some 25% more volume than Alternative B.

Figure 4-6-6 compares Alternative A with Alternative C. Generally, the traffic flows in the northern and eastern sectors of Middle Ring Roads I and II show higher volume in Alternative A compared to Alternative C. This implies a better ability to reduce traffic flows inside Kuala Lumpur by Alternative C rather than Alternative A. Of the radial roads leading to Kuala Lumpur, the Federal Route 1 section between Serendah and Rawang has some 48% lower volume in Alternative A compared to Alternative C, while the Damansara-Puchong Highway (from Putra Jaya to Puchong) has some 20-52% higher volume for Alternative A. On the Dedicated Highway Alternative A has marginally 4% higher volume than Alternative C. The State Route B18 in Dengkil has some 64% higher volume for Alternative A compared to Alternative C.

Figure 4-6-7 compares Alternative B with Alternative C. Generally, the traffic flows inside the Middle Ring Road II show lower volume in Alternative B compared to Alternative C. This implies a better ability to reduce traffic flows inside Kuala Lumpur by Alternative B rather than Alternative C. Of the radial roads leading into Kuala Lumpur, the Damansara-Puchong Highway (from Putra Jaya to Puchong) has some 42-58% higher volume for Alternative B. On the Dedicated Highway Alternative B has some 22% lower volume than Alternative C. The State Route B18 in Dengkil has some 64% higher volume for Alternative B compared to Alternative C. However, Alternative C has the effect of carrying higher volume on the State Roads in Sepang area than either A or B.

4.6.4 Select Link Analysis

A select link analysis is done to analyze trip distribution pattern on selected links of each section of the KLORR. The trip distribution patterns for selected links in Section 1 and Section 2 for all alternatives show similar pattern of choice made by the longer distance north-south trips to use the KLORR. The trip distribution patterns for the select link analysis for Section 3 of the KLORR show much of the trips are shorter trips belonging to the Putra Jaya-Bangi Corridor.

The variations of trip distribution for the three alternatives are depicted in Figures 4-6-8 - 4-6-10 respectively. As seen in Figure 7.8, that the location of the northern terminus of KLORR at Serendah in Alternative A could divert more northern flows from the North South Expressway and Federal Route 1, with destinations at Putra Jaya and South, etc. to the KLORR. Figure 4-6-9 shows that the trip distribution of flows at the selected link in Alternative B is rather similar to that of Alternative A. On the other hand, the diversion of such trips in Alternative C is lesser than either A or B, as shown by Figure 4-6-10.

4.6.5 Vehicle-kilometer and Vehicle-hour

The performance indicators of vehicle-kilometer and vehicle-hour on the traffic assignment networks which are used in the economic analysis, are calculated for the cases of without and with the KLORR. These calculations are made on the major roads in the Study Area and excluding the vehicular movements inside the Middle Ring Road I, based on the road network comprising a total network length of some 3,544 km of single direction links in the case of without KLORR.

The vehicle-kilometer and vehicle-hour in year 2020 for the KLORR alternative alignments A, B and C are estimated as indicated in Table 4-6-5 which shows the summary of the traffic assignments in year 2020. The savings in vehicle-kilometer and vehicle-hour are calculated by comparing the respective alternatives with the case of without KLORR.

Figure 4-6-5 : Comparison of ALT. A and ALT. B
Relatives Difference ALT.A - ALT.B in %)

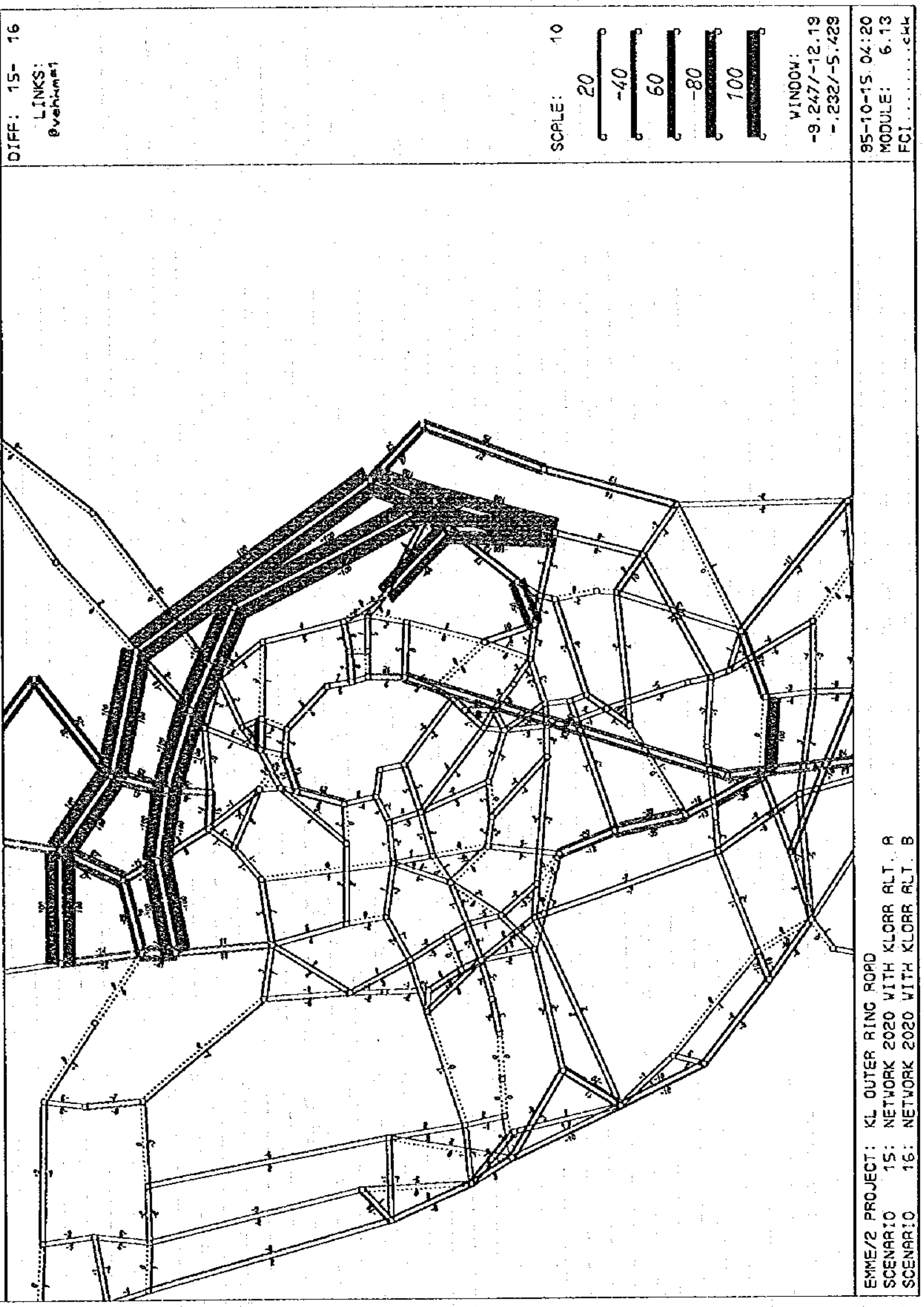


Figure 4-6-6 : Comparison of ALT. A and ALT. C
Relatives Difference ALT.A - ALT.C in %)

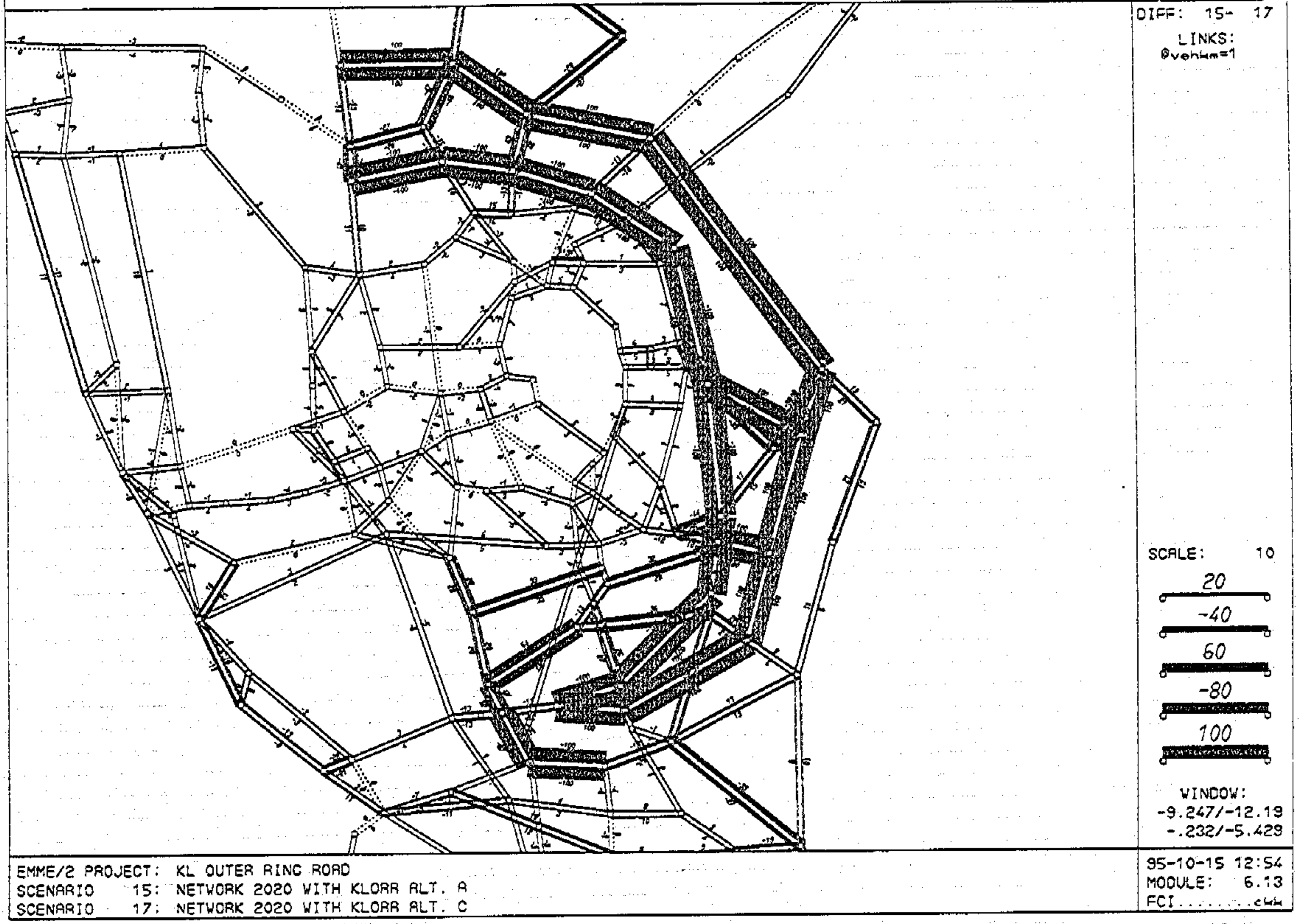
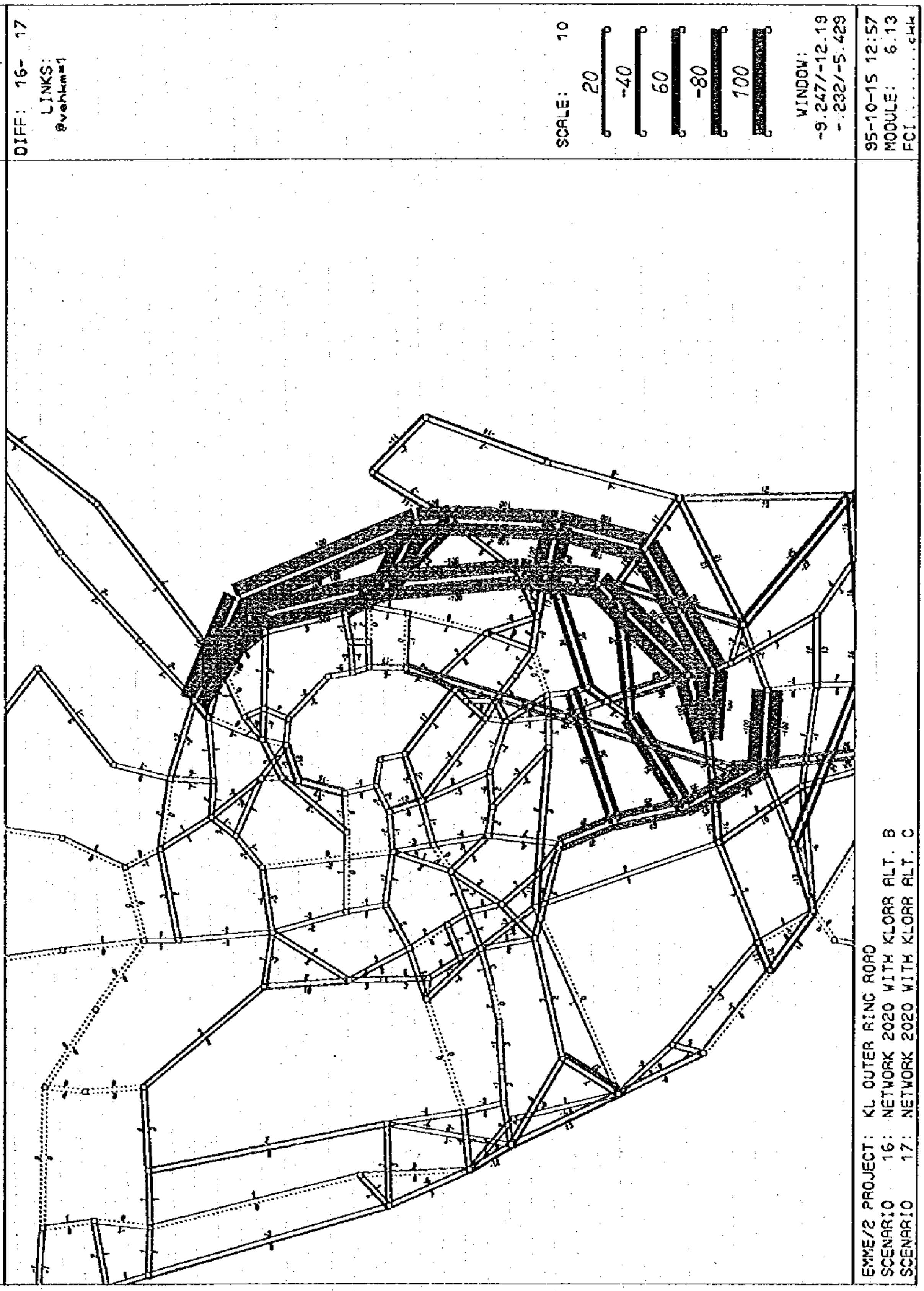


Figure 4-6-7 : Comparison of ALT. B and ALT. C
Relatives Difference ALT.B - ALT.C in %)



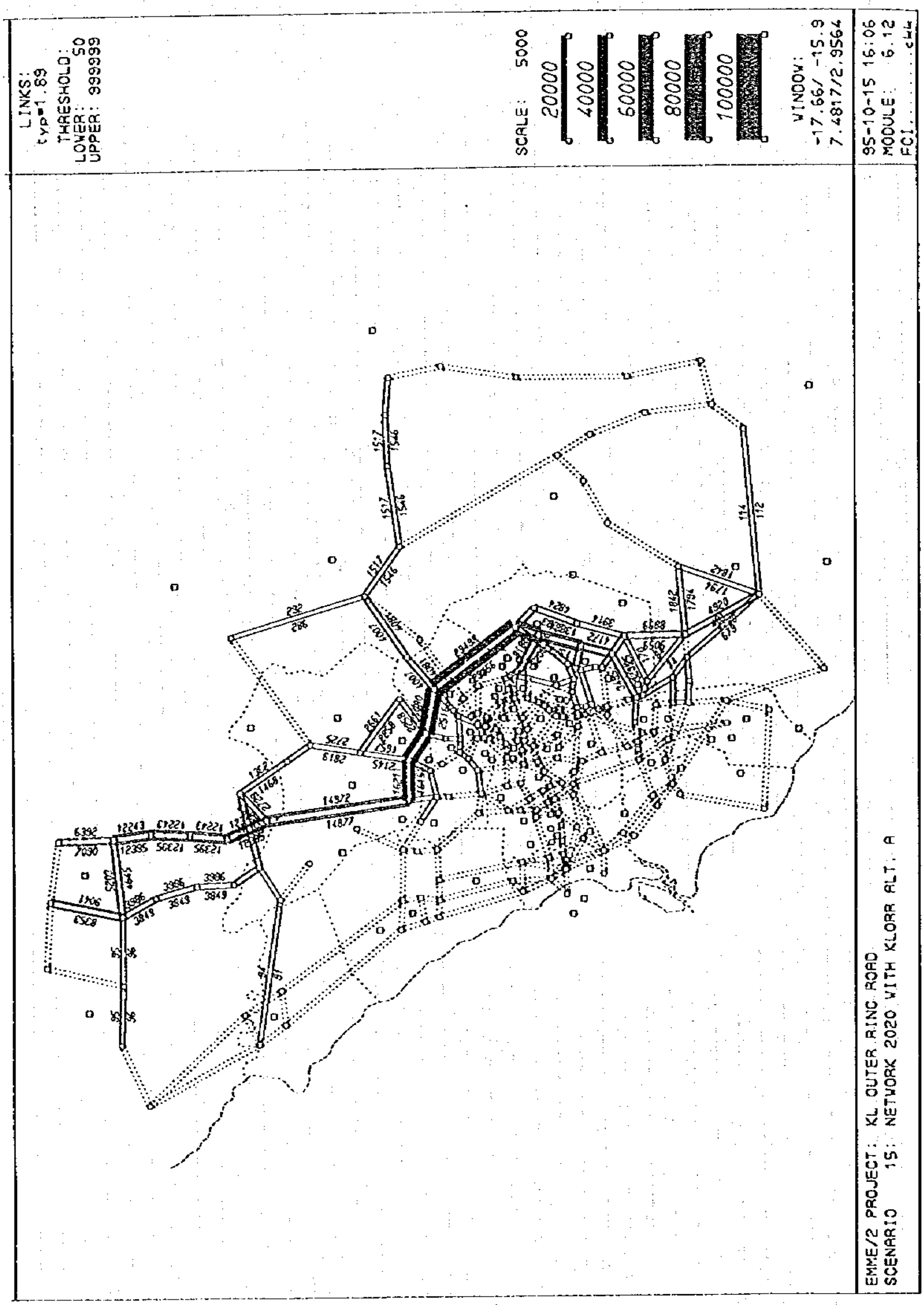


Figure 4-6-8 : Select Link on KLORR Alt. A, Section 2

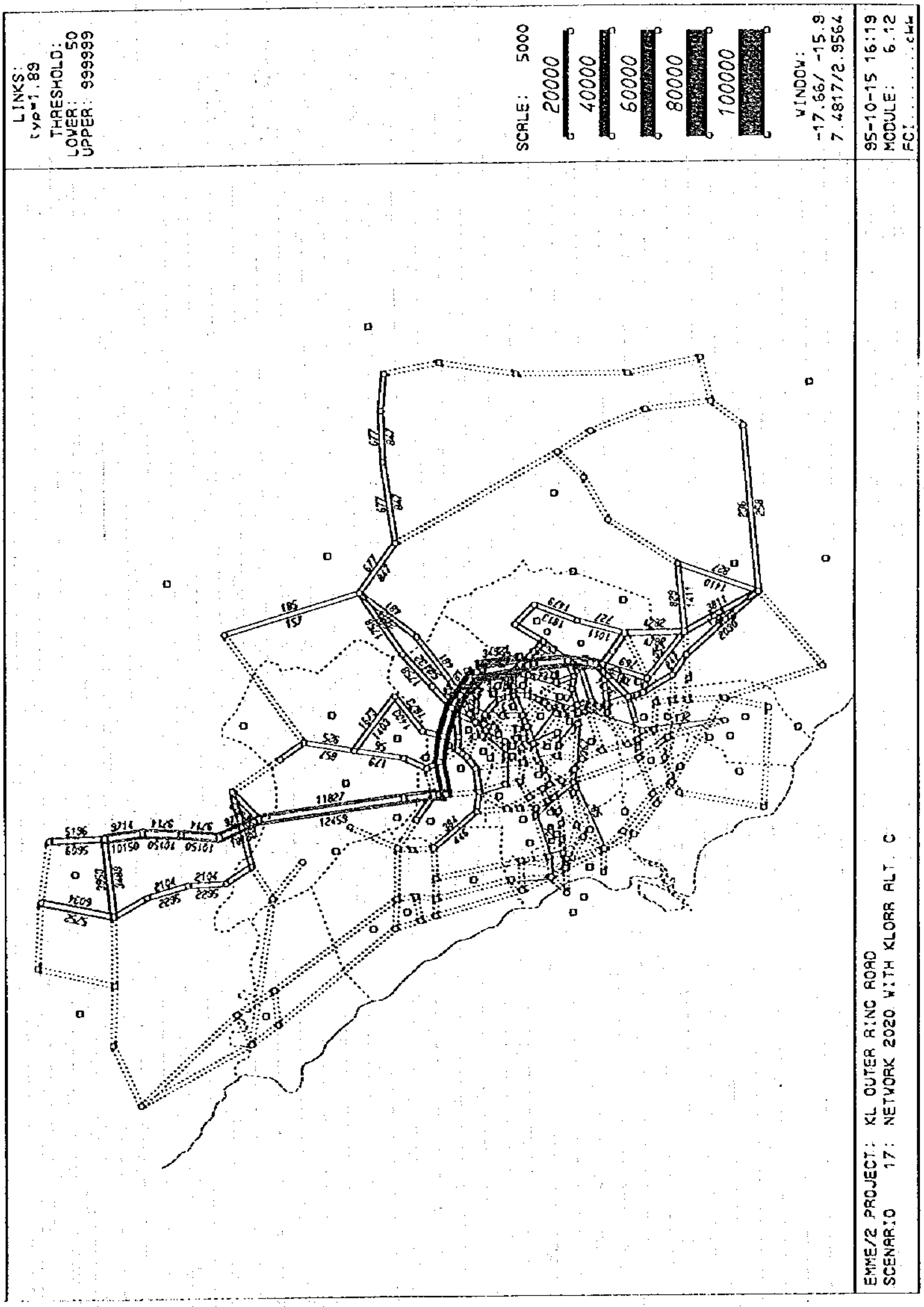


Figure 4-6-9 : Select Link on KLORR Alt. B. Section2

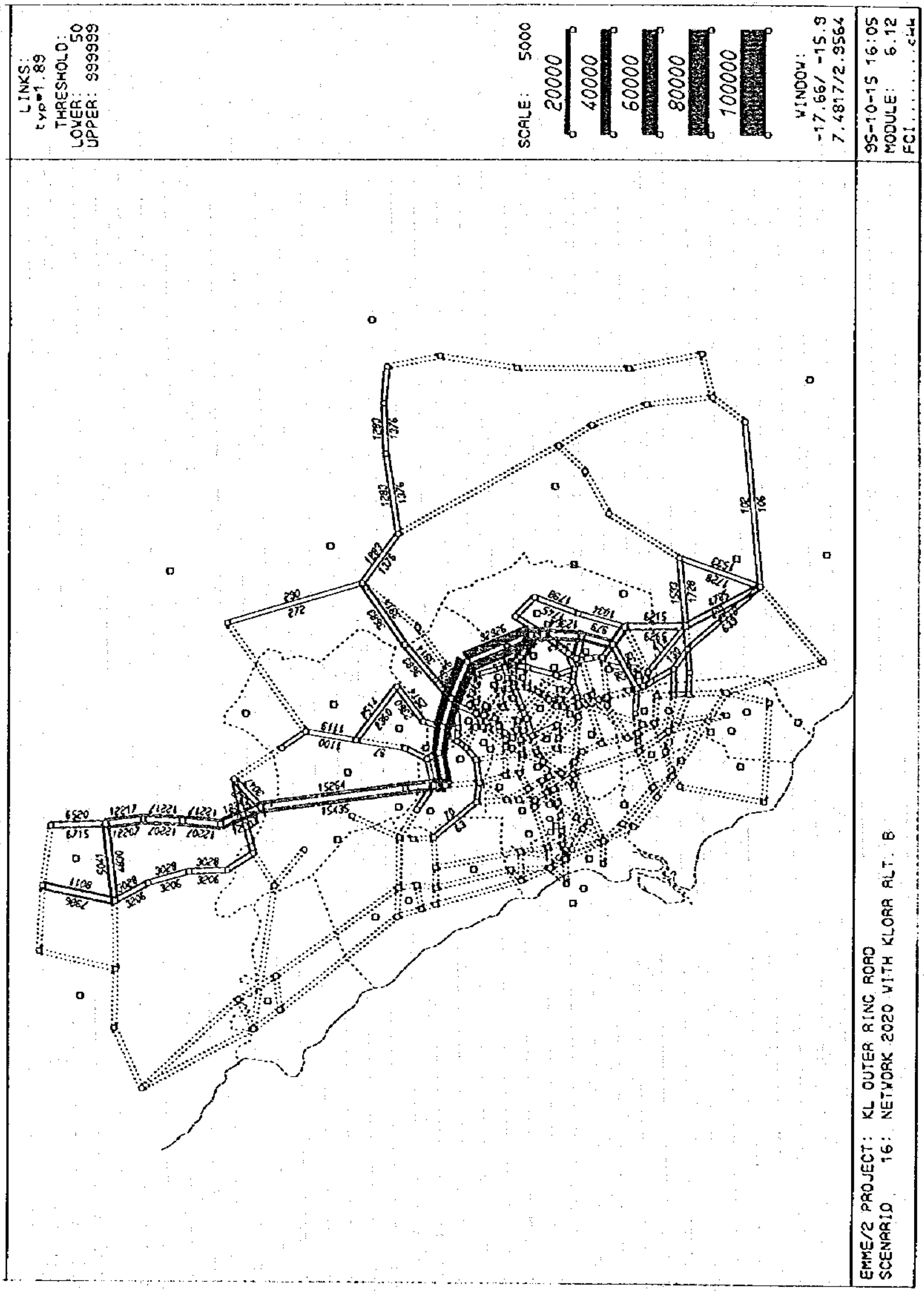


Figure 4-6-10 : Select Link on KLORR Alt. C Section 2

Table 4-6-1 : Summary of Traffic Assignment Result, 2020

Indicators	Without KLORR	With KLORR		
		ALT. A	ALT. B	ALT.C
Vehicle.km ('000s)	97951.9	97339.7	96875.5	95469.8
Vehicle.km savings ('000s)	-	612.2	1076.4	2482.1
Vehicle.hr ('000s)	5068.8	4373.2	4297.5	4292
Vehicle.hr savings ('000)	-	695.6	771.3	776.8
Average Speed (kph)	19.32	22.26	22.54	22.24
ADT on KLORR (veh/day)	-	79600	81000	84500
Total Network Length (km)	-3543.6	3747.8	3723.1	3698.2

4.7 COST BENEFIT ANALYSIS

The alternative routes are compared each other from the viewpoint of economic impacts to identify which is more advantageous. The comparison is made in terms of cost benefit analysis, using the benefit derived from the improved traffic service level and the cost accrued from the implementation of the alternatives.

For estimating the benefits and costs, the traffic conditions should be compared between the "Alternative Route" case and "Base Case". The base case is defined as the existing network including the committed projects, such as Middle Ring Road II, Ampang Bypass, the extension of New Klang Valley Expressway etc.

The Outer Ring Road is assumed as a toll road whereas the Middle Ring Road II is free except for the privatized section. The toll rate is assumed to be same as the current rate for North - South Expressway.

1) Cost

The implementation schedule of the ORR as well as other committed projects has not fixed yet, then tentatively assumed as follows.

(1) The construction of the ORR will be started in the year 2000 and completed by the end of the year 2004, hence it is assumed to be open to traffic in the year 2005.

(2) The other committed projects are also assumed to be completed by the year 2005.

The project costs for the alternative routes are summarized in Table 4-7-1.

Table 4-7-1 : Project Costs by Alternative Routes

(RM million)

	Route A	Route B	Route C
Construction Cost	4580	3850	3924
Land Acquisition Cost	298	335	398
Total	4878	4185	4322

The land acquisition cost is assumed to be disbursed in the year 2000 and the construction cost be disbursed for the period from the year 2001 to 2004.

The operation and maintenance costs are also roughly estimated on the basis of the annual costs for the North - South Expressway as well as the Kuala Lumpur - Karak Highway.

2) Benefit

Among the various benefits derived from the construction of the ORR, the following factors are counted as a benefits.

(1) Saving in vehicle operating cost

(2) Saving in passenger time cost

The saving in vehicle operating cost is estimated by using the total saving in vehicle-km and total saving in the veh.hr multiplied by unit vehicle running cost and unit time related cost respectively.

The saving in passenger time cost is estimated by using the total saving in vehicle.hr multiplied by passenger time value.

As shown in Table 4-7-2 the savings in veh.km and veh.hr are obtained from the results of the traffic assignment.

Table 4-7-2 : Total Saving in Veh.km and Veh.hr

Alternatives	Veh.km Saving ('000)		Veh.hr Saving ('000)	
	2005	2020	2005	2020
Route A	300.4	612.2	147.6	695.6
Route B	464.9	1,076.4	181.1	771.3
Route C	797.1	2,482.1	189.3	776.8

The Table 4-7-3 shows the estimated benefits in the year 2005 and 2020. The project life is assumed as 30 years. The benefits are interpolated by assuming a constant annual growth rate for the intermediate years from 2005 to 2020 and assumed to remain at the same level as that in 2020 for the years after 2020.

Table 4-7-3 : Estimated Benefit

(Unit : RM million)

Alternatives	2005	2020
Route A	444.7	2341.5
Route B	556.1	2636.7
Route C	613.2	2801.4

In addition to above benefits, other benefits from the Project are summarized below :

(1) Reduce traffic congestion in the Kuala Lumpur City Centre by providing an alternative conduit for north-south traffic,

(2) Enable economic / business activities and the consequent job opportunities to be increased substantially,

(3) Accessibility to the outskirts of Klang Valley,

(4) Upgraded infrastructure and amenities for the people, and,

(5) Increase revenue to the authority.

3) Evaluation Indicators

The total cost and benefit streams are compared by alternative route, assuming the discount rate of 12% per annum. The evaluation indicators are shown in Table 4-7-4 in terms of the internal rate of return (IRR), benefit-cost ratio (B/C) as well as the net present value (NPV). The route C shows the highest indicators. However, the difference with Route B is not significantly large; the IRR for Route B is 17.9 % while 18.2 % for Route C.

Table 4-7-4:Result of Cost Benefit Analysis

	Route A	Route B	Route C
IRR (%)	14.8	17.9	18.2
B/C Ratio	1.39	1.90	1.97
NPV (RM million)	898.0	1765.5	1984.3

As a consequence, the cost benefit analysis suggests that the Route C or Route B should be selected.

Technical Volume

Chapter **5**

PRELIMINARY ENGINEERING STUDY

CHAPTER 5 PRELIMINARY ENGINEERING STUDY

5.1 GEOTECHNICAL CONSIDERATION

5.1.1 General Geological Condition in the Study Area

The geological map of the Study Area is shown in Figure 5-1-1. The general geology of the Study Area comprises various lithology of igneous, sedimentary and metamorphic rocks. The main mountain range consists of extensive masses of granite where original sedimentary cover has been removed by weathering and erosion. The low-lying areas mark the margin between granite and stratified rocks.

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

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

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

1) Hilly Areas

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

The surface of these rocks is overlaid with thick residual soil layers due to heavy weathering under the tropical circumstances. The geological condition in the hilly areas is shown in Figure 5-1-2.

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

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

2) Alluvial Area

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

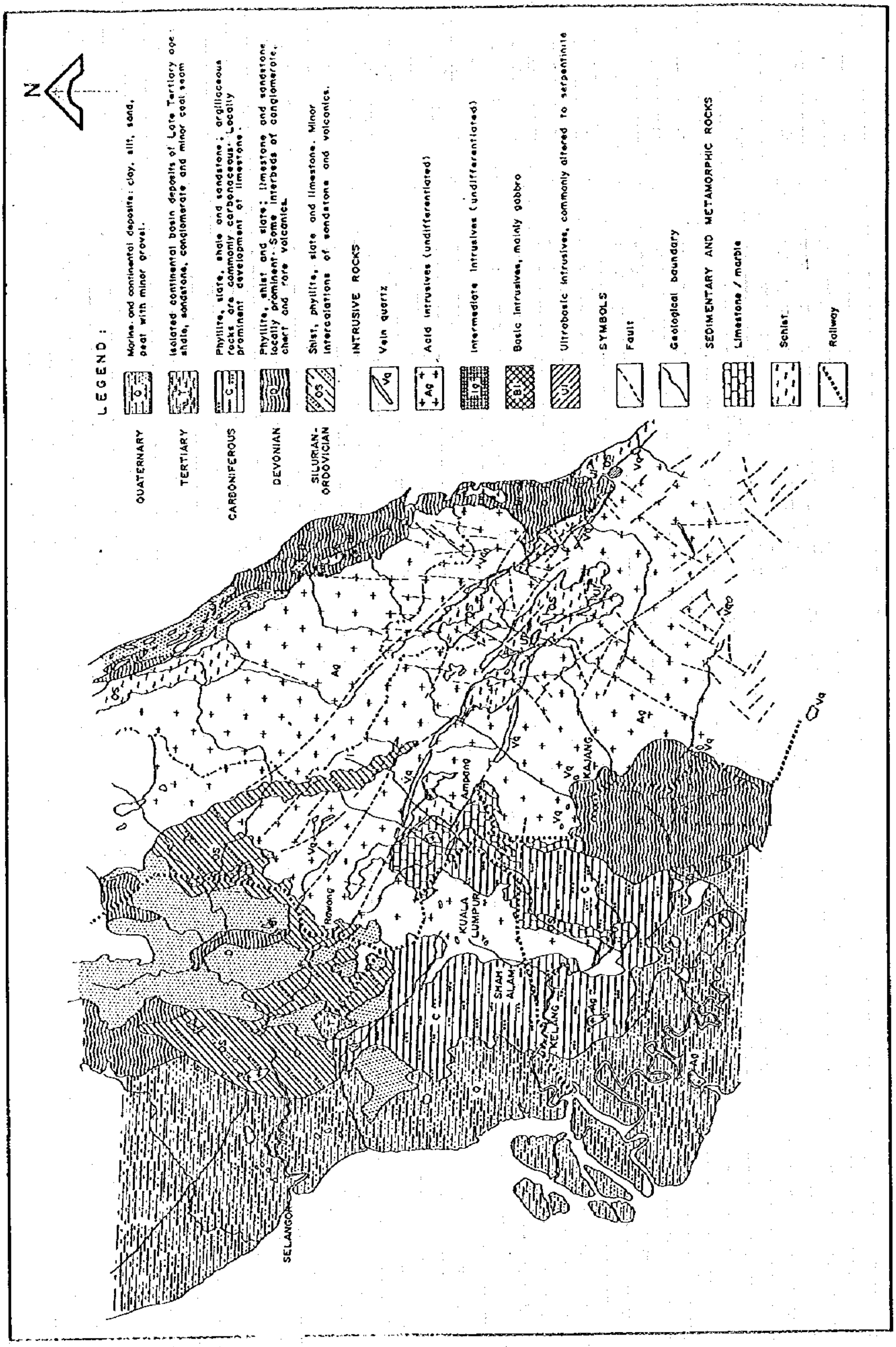


Figure 5-1-1 : Geological Map Around Site Area

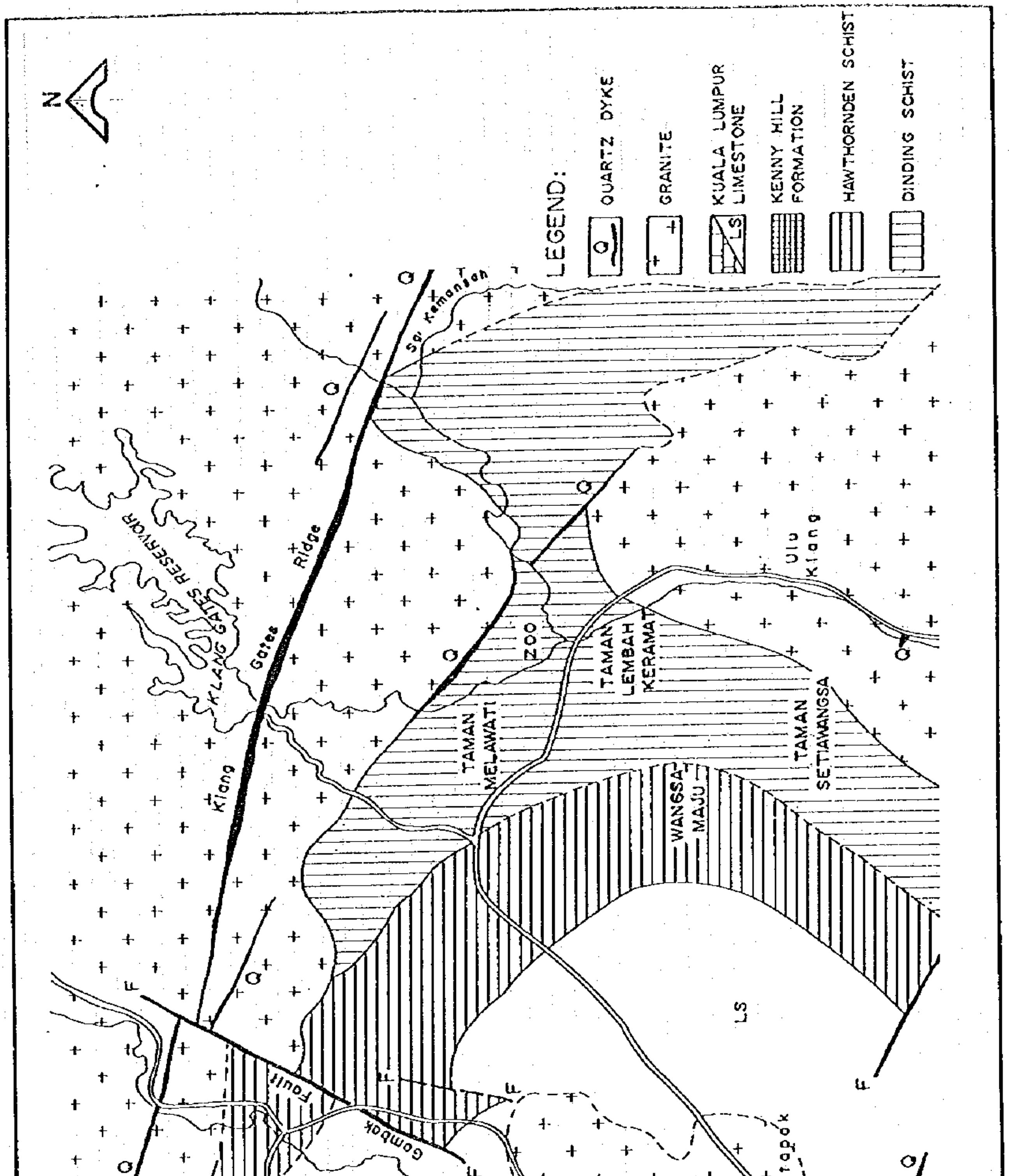


Figure 5-1-2 : Geology of Hulu Kelang Area

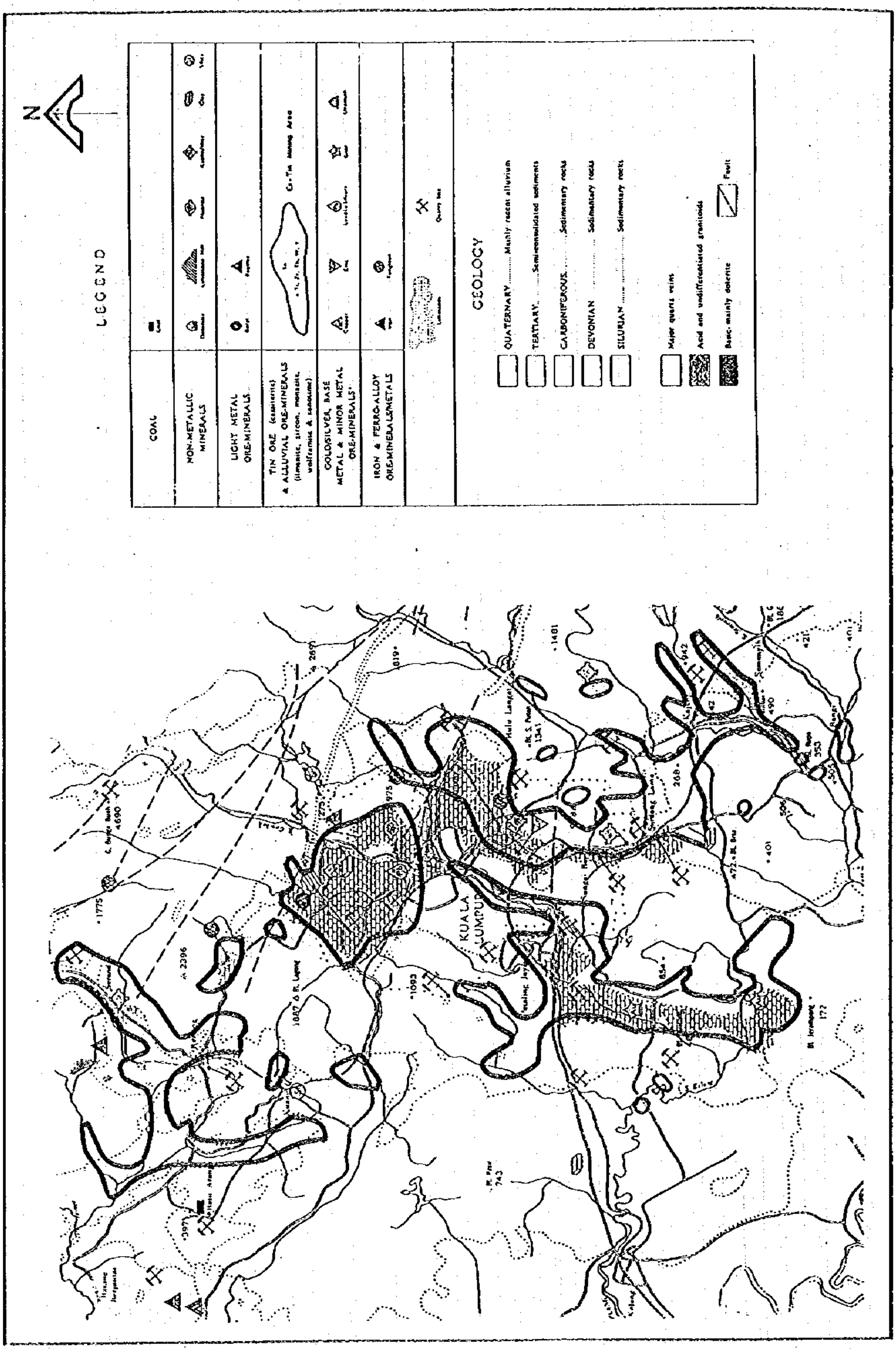


Figure 5-1-3 : Ex-Tin Mining Areas and Mineral Resources Map Around Selangor

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

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

3) Mining Pond Area

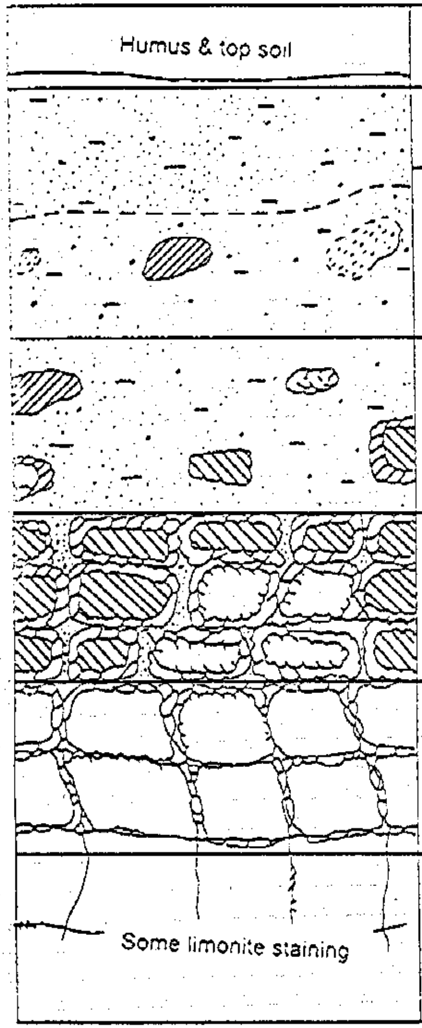
Numerous mining ponds were excavated and so left mine tailing deposits in the alluvial plains around Kuala Lumpur as shown in Figure 5-1-3. Many parts of these mining ponds have already been refilled by various kinds of materials, such as domestic wastes and spoiled soils.

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

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

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

Each consideration for the anticipated problems from the results of site survey are summarized hereinafter. Rock weathering and engineering judgements for construction methods are shown in Table 5-1-1 - Table 5-1-2.



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

Table 5-1-1 : Rock Weathering Grade of Granite

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

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

Table 5-1-2 : Provisional Classification of Altered Granitic and Metasedimentary Rocks

5.1.2 Geotechnical Consideration at Each Site

For the road construction the following items should be considered carefully.

- Embankment .... Settlement, Bank Failure
- Bridge .... Type of Foundation
- Cut Slope .... Stability Analyst is for Landslide & Rockfall
- Tunnel .... Selection of Construction Method

These preliminary considerations are summarized in Table 5-1-3 to 5-1-4 for each the site locality listed below:-

1) Rawang Areas
2) Templer park Area
3) Batu Dam Area
4) Gombak Area
5) Hulu Kelang Area
6) Hulu Langat Area
7) S. Langat Area
8) S. Long Area
9) Asa Jaya Area
10) S. Langat/Bangi Area
11) Expressway/Bangi Area
12) Ayer Hitam Area
13) Power Station Area
14) Ex-Mining Pond & Swamp Area

Some general similarities in the engineering properties between many of the sites occur. For example, those sites in granite areas have more or less the same characteristics with regards to the soil stratification, soil type, depth to bedrock as well as the index properties, CBR & compaction properties. The same applies to the various sedimentary/ setasedimentary rock formations, though greater variation is expected within each of these formation because of the stratified nature of the rock. Alluvial deposits on the other hand have somewhat different properties.
Therefore, for general discussions, the geotechnical consideration are based basically on the rock formations, and such as bridges, embankments which include cut slopes and fills as well as tunnels, if applicable, are briefly discussed. Where certain anticipated problems are highlighted, references are then made to the relevant site localities concerned.

Site	Site No.	Rock Formation	Depth To hard layer	Depth to bedrock	Bridges	Embankments		Tunnels
						Cut Slopes	Fills	
Rawang Area	1,2 & Extra S - 2	Kenny Hill Formation	5 - 9m	Not confirmed	Deep foundation, either driven or bored piles	Avoid unfavourable dip-slope structure. Shale & phyllite weather & deteriorate to very weak slope material. Require gentler slope.	Generally fine grain silty soil. May be suitable as fill material if not too clayey.	Not applicable
Templer Park Area	3	Granite	0.5 - 10m	0.5m to HW - CW granite	Fault zone cuts across alignment near bridge. Not picked up by drilling. Shallow foundation (setting into granite) where bedrock near surface. Deep foundation (bored pile) for thicker soil cover. Driven pile not recommended because of granite boulders in soil.	Unfavourable orientation of prominent joint sets (usually 3 sets) to slope are prone to failures. Rock anchoring or shotcrete to reinforce weak structures.	Granular & loose sandy soil with some amount of clay & silt. Generally suitable fill material.	Avoid weathered & fault zone. Fresh granite generally very string. Highly jointed nature is advantageous to blasting & tunneling work. Avoid weaker Hawthornden schist and limestone (potential activities) nearby proposed tunnels
Batu Dam Area	4	Hawthorn-dem Schist	5 - 7m	Not confirmed	Deep foundation e.g. bore piles. Driven piles not recommended because of granite boulders in soil.	Unfavourable dip-slope structure especially in graphitic schist highly prone to frequent and major slides, therefore either slope reinforcement measures or gentler cut slope.	Mixture of mostly clay and silt and little send. Being generally fine grain and cohesive, may have limitations for use as fill material.	Two entrances of tunnels at or near granite / schist contact. Weathered graphitic schist especially problematic material. Requires special reinforcements. Granite area generally O.K. if rock is fresh.
Gombak Area	5	Granite	7 - 16m	18.5m to FR Granite	Gombak Fault zone cuts across alignment. Drilling did not detect deep weathering profile. Deep foundation e.g. bored pile but mot driven pile (bouldery soil, granite area).	Look out for unfavourable joint orientation. Loose sandy soil causes severe gully erosion; either remove completely or special slope protection e.g. effective drainage system. Rock anchoring & or shotcrete may be necessary.	Typical granite soil. General sandy with varying amount of silt and clay. Generally suitable as fill material.	Fresh granite generally very strong.
Hulu Kelang Area	6 & 7	Granite	9 - 14m	In some specific areas, 2.5 - 6m to FR Granite	Shallow foundation where bedrock near surface e.g. setting into rock. Deep foundation in thick soil e.g. bored pile. Since in granite area, driven pile not recommended.	Deep cuts lead to pressure / stress-release jointing or sheet joints. Depending on orientation to cut slope, usually causes rock falls or toppling. Rock anchoring may be required. Gabion or netting fence as safety measures for passing vehicles against potential rock fall.	As above	Tunneling through granite and quartz dyke no anticipated problem
Hulu Langat Area	8	Granite	3m	3 - 7.5m to MW - FR Granite	Shallow to deep foundation. Shallow bedrock requires setting in granite & thicker soil cover need bored piles. Driven piles not recommended.	As above	As above	Not applicable

Table 5-1-3 : Geotechnical Consideration of Each Site

Site	Site No.	Rock Formation	Depth To hard layer	Depth to bedrock	Bridges	Embankments		Tunnels
						Cut Slopes	Fills	
Sungai Langat Area	9	Granite	5m	6 - 10m to HW - MW Granite	Deep foundation. Bored piles. Driven pile not recommended.	Unfavourable joints orientation may lead to rock fall, thus required reinforcement like rock anchoring or nailing.	Sandy granite soil generally suitable fill material.	Not applicable
Sungai Langat Area	R - 1	Alluvium over Granite	4m	5.5 - 6.5m to FR Granite	Deep foundation. Bored piles or driven piles.	Not applicable	Not applicable	Not applicable
Sungai Long Area	10	Granite	6 - 8m	Not confirmed	Deep foundation. Bored piles recommended. Driven piles not applicable.	Unfavourable joints orientation may lead to rock fall, thus required reinforcement like rock anchoring or nailing.	Sandy granite soil generally suitable fill material.	Not applicable
Asa Jaya Area	11	Granite	8.5 - 9.5m	Not confirmed	As above	As above	As above	Not applicable
Sungai Langat / Bangi Area	12	Kajang Formation	7 - 14.5m	Not confirmed	Deep foundation. Bored piles or driven piles.	Unfavorable dip-slope structures prone to slides or failures. Weathered phyllite generally weak slope material. Gentler cut and more berms required.	Silty - sandy soil. Probably suitable as fill material.	Not applicable
	R-2	River Alluvium over Kajang Formation	4 - 12.5m	Not confirmed	Deep foundation. Bored piles or driven piles.	Not applicable	Not applicable	Not applicable
Express-way / Bangi Area	13	Kajang	4 - 12.5m	Not confirmed	Deep foundation. Either driven piles or bored piles.	Unfavaourable dip-slope structures prone to slides or failures. Weathered phyllite generally weak slope material. Gentler cut and more berms required.	Mixed of clay, sand & silt. May be suitable as fill material.	Not applicable
Ayer Hitam Area	14	Kenny Hill Formation	4 - 7m	5m to weak highly fractured sandstone	Deep foundation. Bored piles where weathered bedrock close to surface, or driven piles in thick soil.	Dip-slope structures are prone to slides or failures. Weathered shale and phyllite become very weak slope material. Increased numbers of berms & decreased slope angle maybe necessary for long term measure of slope protection.	Silty - clayey soil with sand. Probably can be used as fill material.0	Not applicable

Table 5-1-3 : Geotechnical Consideration of Each Site (continued)

Table 5-1-3 : Geotechnical Consideration of Each Site (continued)

Site	Site No.	Rock Formation	Depth To hard layer	Depth to bedrock	Bridges	Embankments		Tunnels
						Cut Slopes	Fills	
Power Station Area	R - 3	River Alluvium over Kenny Hill Formation	4 - 6.5m	Not confirmed	Deep foundation. Bored piles or driven piles.	Not applicable	Not applicable	Not applicable
Ex-mining Pond & Swamps Area	15	Alluvium	>13 - 15.5m	Not confirmed	As above	Not applicable	Alluvial sand need to be washed to remove wood or plant materials before use. Generally abundant ex-mining sand (tailing) sand for fill material.	Not applicable
	16	Alluvium over Kenny Hill Formation	10.5m	8m into HW - CW Shale	As above	Not applicable	As above	Not applicable

Note :

HW - Highly Weathered
CW - Completely Weathered
FR - Fresh
MW - Moderately

5.1.3 Granite

General

The residual soil cover in granite area vary widely. The soil is generally 0.5 - 18.5m thick. Commonly, not all the 3 soil layers based on SPT criteria are encountered, especially when bedrock is near the surface. The residual soil in granite area usually contain weathered granite boulders. The bottom or hard layer, where encountered, is usually very thin. Depth to the hard layer where present is 4 to 16m and depth to bedrock varies from 0.5 to 18.5m.

Bridges

In areas where granite bedrock is close to the surface, eg. Site 3 BH1, Site 7 BH1, shallow foundation i.e. setting of foundation in granite is necessary. Where the soil cover is generally thicker, deep foundation is required, eg. using bored piles. Because of the occurrences of granite boulders in the soil, driven pile is not recommended.

Site 3 and site 5 are located near fault zones. Though these fault zones are not picked up in the drilling, precaution against possibly deeply weathered zones are necessary.

Embankments

Cut Slopes

Granite is usually jointed with 3 prominent joint sets. Deep cuts in granite may lead to pressure-release or stress release joints or sheet joints. Depending on orientation of these joint intersections to the cut slopes, rock falls or toppling may occur.

Rock nailing or anchoring may be required. Shotcrete may also be necessary for the weaker or fractured parts and netting fence may serve as a hindrance to prevent falling rock into the road endangering passing vehicles and passengers.

Loose sandy soil typical of granite slopes tend to slide down or cause severe gully erosion. These should either be completely removed or require special slope protection measures, eg. gentler cut slope with berms or an effective drainage system including both horizontal and vertical drains.

Fills

Typical residual soil of granite area is generally granular and loose because it contains mainly sand with varying amount of clay, silt and gravels. Usually the upper layers are finer grained with more clay and silt. The bottom layers have more coarse sand and gravels.

Residual soil of granite has been commonly used as fill material in road construction in Malaysia. Because of its sandy nature, it can be reasonably well compacted for use as fills in road construction.

Tunnels

Tunneling is only applicable in site 3, 5, 6 & 7. Fresh granite and quartz dyke (between Site 5 & 6) are generally very hard and strong. Because of the joint systems, this is advantageous to blasting and tunneling work.

However, deeply weathered granite zone and fault zone must be avoided particularly between Site 2 and 3 (south of Kanching Forest Reserve) where the fault cuts across the route near a proposed tunnel.

Near Site 3, where granite is bordering on Hawthornden Schist and limestone further to the northwest, special attention is needed, if possible, to avoid these weaker or problematic materials.

5.1.4 Kenny Hill Formation

General

The thickness of residual soil of Kenny Hill Formation to SPT termination criteria is generally 10.14 to 14.39m, except in Site 14 BH1 which is 5.1m into sandstone bedrock.

All the three layers are always encountered. Depth to the bottom hard layer ranges from 4 to 9m. Residual soil of the Kenny Hill Formation contains generally more silt and clay in the upper part and more sandy in the lower part.

Bridges

Bridges probably need to be constructed at Sites 1 and 2 only. At these sites, deep foundation either using driven piles or bored piles may be applied.

Embankments

Cut Slopes

Being a stratified rock formation, the engineering properties of the Kenny Hill Formation is much more variable depending on the rock type and degree of weathering compared to granite which is more uniform in mechanical properties. Dip-slope structures (refer Figure 4.1(a), (b) and (c) are especially unfavorable and need more slope protection measures such as rock anchoring or nailing.

Shale and phyllite tend to weather rapidly and deteriorate to very weak slope material. Where such material are present in abundance, more gentle slope angle with more berms may be a long term solution against slope failures.

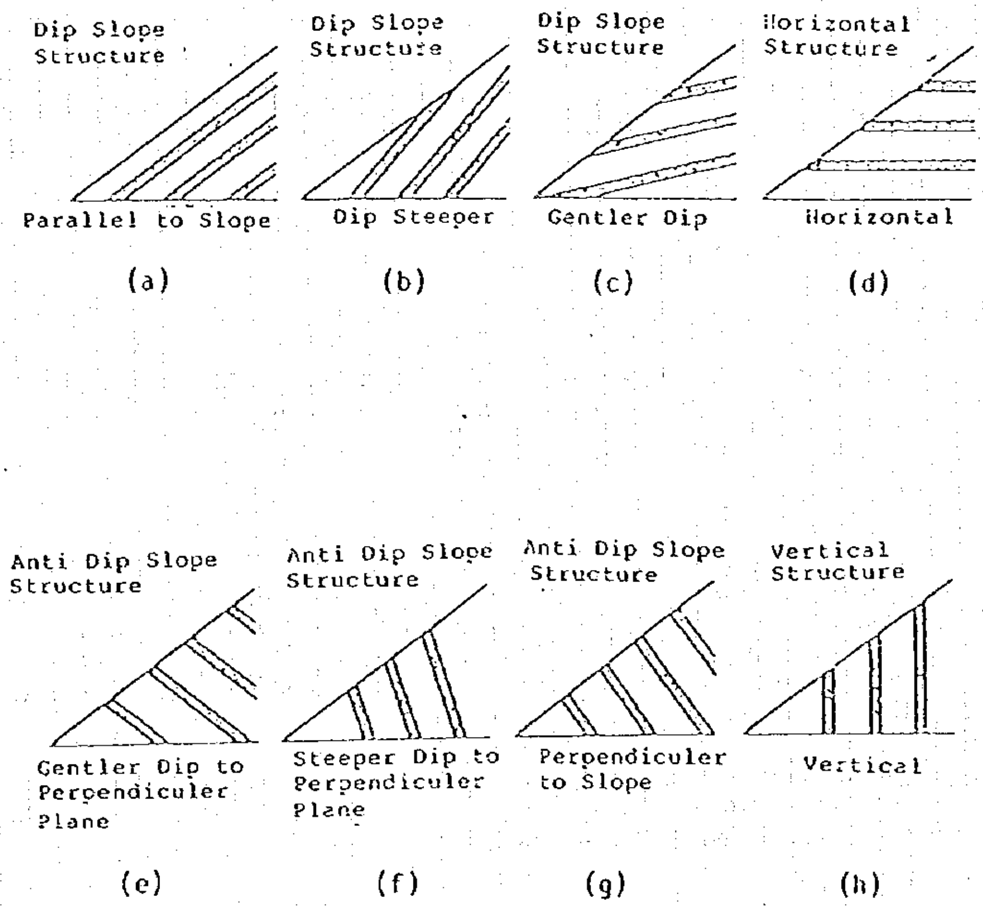


Figure 5-1-4 : Relationship between Slope Angle and Dip of Strata

Fills

Residual soil of Kenny Hill Formation is generally fine grained and silty material. These are generally cohesive compared to the granular and loose granite soil. Because these are derived from stratified rock formation, the soil are more variable in the proportion of fine and coarse size particles, both laterally and vertically which is in contrast to the generally more uniform and homogenous granite soil.

Nonetheless, if sufficient sand is present, residual soil of Kenny Hill Formation may probably be suitable as fill material. Residual soil from dominantly shale or phyllite area may have high clay content hence may not be suitable.

No tunnel is to be constructed in Kenny Hill Formation area.

5.1.5 Hawthornden Schist

General

The thickness of residual soil cover of Hawthornden Schist at Site 4 is 11.29 - 12.29m to SPT termination criteria. All the three soil layers are encountered. The top layer is generally thin and middle layer commonly contain granite boulders, Site 4 being close to granite area. Penetration of the hard layer is 5 to 7m. The soil type range from silty clay to clayey silt to sand.

Bridges

Because depth to SPT termination criteria is generally more than 10m, deep foundation is required. Bored pile is applicable because of occurrences of granite boulders in the soil, and driven pile is therefore not practical.

Embankments

Cut Slopes

Cut slopes in Hawthornden Schist especially through graphitic schist should avoid unfavorable dip-slope structures. Previous studies on Kuala Lumpur - Seremban Expressway have shown that weathering of graphitic schist over time is prone to frequent slides some of which are fairly major ones. Therefore more gentle cut slope angle may be required as a long term slope stabilization measure.

Fills

Hawthornden Schist consists predominantly graphic schist which generally weather to fine grain silty - clayey soil with minor amount of sand and quartz gravels. These fine grained soil are generally cohesive material which may pose some problems and limitations for use as fill material because of possible or foreseeable difficulties in compaction.

Tunnels

As mentioned earlier at Site 3, two entrances of tunnels beside Site 4 may be founded on Hawthornden Schist bordering on granite. If this being the case, special reinforcement measure may be needed because weathered rocks of Hawthornden Schist, especially graphitic schist are generally weak and problematic material.

5.1.6 Kajang Formation

General

The residual soil of the Kajang Formation is generally the thickest to SPT termination criteria. It ranges from 9.3 - 19.33m averaging 15.5m. All the 3 soil layers are encountered and depth to the hard layer is 4.3 to 13.5m. The soil type is generally silty clay to silty sand.

Bridges

Deep foundations are required. Either bored piles or driven piles may be used.

Embankments

Cut Slopes

Unfavorable dip-slope structures which are prone to slides or slope failures should be avoided. Weathered phyllite are generally weak slope material. In both cases, more gentle cut slope with more berms are required for long term measure on slope stability.

Fills

Residual soil of Kajang Formation contain mainly silty to sandy soil with some amount of clay and gravels which is expected to vary both laterally and vertically. In general, it may probably be suitable as fill material. However the more clayey and cohesive layers, if occur in substantial thickness, may be found to be unsuitable fill material.

5.1.7 Riverine Alluvium

General

Riverine alluvium are underlain by granite at Site R-1, residual soil of Kenny Formation at R-2 and residual soil of Kajang Formation at R-3. Two soil layers of river alluvium occur.

At R-1 depth to granite bedrock is 5.5 - 6.3m ; at R-2 & R-3, depths to hard layers range from 4 to 14.5m. The soil consists of silty clay to sand and gravely layers, often with decomposed wood or plant materials.

Bridges

At all the 3 Sites i.e. R-1, R-2 and R-3, deep foundation either by driven piles or bored piles may be used.

No embankment nor tunneling work is applicable at these sites.

5.1.8 Quaternary Deposit

General

The Quaternary deposit have been mined for tin and thus turned into ex-mining land. These consist of alluvial silty clay, sand and gravels with decayed wood and plant detritus. At Site 15, the boreholes bottomed at alluvial hard layer whereas at Site 16, residual soil of Kenny Hill Formation underlie the alluvium. Depth to hard layer at alluvium is 8 - 10m whereas depth to hard layer at residual soil of Kenny Hill Formation is 21m.

Bridges

Because of thick soil cover, deep foundation using either driven piles or bored piles is necessary.

Embankments

No cut slope is needed because of low lying and swampy area.

Fills

Generally abundant tailing sand is available as fill material. However, the sand need to be prewashed to get rid of decayed wood and other plant materials before use to avoid subsidence problems at a stage because of deleterious decaying wood.

5.1.9 Slope Failures

The outcrops of granitic rocks are widely well exposed along Kuala Lumpur - Karak Highway. Sedimentary formation including crystallize schist of Mesozoic - Paleozoic age are observed along Kuala Lumpur - Seremban Highway. All the rocks are weathered and covered with lateric soil, showing various characteristics of physical properties. (see Table 5-1-1 & 5-1-2).

Since their completion, many slope failures have occurred along the highway. Some cut slopes also suffered severe gully erosion. A lot of remedial work such as clearing of the failure and recutting were needed.

Moreover, under severe tropical weathering conditions, various types of collapses still persist to occur every now and then on the existing slopes. (see Figure 5-1-2)

In general, one of the most important factors causing slope failure is the discordance between slope height and its appropriate gradient as determined by the soil and rock properties as well as the effects of long term weathering.

The recommended gradient of cut slopes based on a factor of safety 1.5 by PLUS is summarized as follows :-

Rock Weathering Grade	Slope Geometry	Angle of Slope
VI & V	IV : 1.5H with berm every 4.5m	33 - 34°
IV	IV : 1H with berm between IV & V	45°

As regards to gully erosion, a close relationship is believed to exists between the slope configuration and rain water seepages.

Even small ditches can prevent the gully erosion to widely develop. Therefore drain facilities are considered indispensable to be constructed at the top of slopes and on berms.

Nevertheless, some drains or ditches do not work well because these are inadequately constructed or are already blocked or buried by eroded gully soils.

Therefore suitable maintenance work should be applied to these slopes. Vegetation cover was seen as the most common slope protection system. However, vegetation usually grow poorly on most slopes of either granite or schist. This is because cut slopes originally consist of barren soil of weathered rock which are rather acidic from laterization. Moreover the gradients are too steep for vegetation. The seeds sowed on steep slopes by hydroseeding methods are easily washed-away by heavy rain or cannot grow well because of dry ground due to severe dry weather. Shortcrete, gabion, anchoring and horizontal drain at the toe of slope are the most common preventive measures taken against slope failures along the existing highways near the proposed routes.

Schist cut slopes are common along Kuala Lumpur - Seremban Highway which runs through on gently rolling hilly terrain. Although their height of slopes are in general relatively low, dip slope structure which is one of the main contributing factors in slope failure should be taken into serious consideration in the designing of slopes. Such a dip slopes structure is believed to have been one of the major causes of the recent landslide at the Genting slip road that killed 20 peoples and injured another 23 peoples.

Some study reports on cut slope stability along certain highway routes in and around Selangor are available. Based on these, a compilation of the weathering profiles and engineering characteristics of the rock formations around Kuala Lumpur area have been made and are as shown in Table 5-1-4 ~ Table 5-1-8.

In granite areas which form mountainous topography, such as the section of the route from Rawang - Gombak - Hulu Kelang - Hulu Langat areas, huge cut slopes are to be designed along the proposed highway. This is the stretch where the occurrence of faults and release of in-situ stress may significantly affect the stability of cut slopes.

It is therefore important that failure risk study of cut slopes be carefully prepared in order to decide on the cut slope designs of the newly proposed highways. With regards to the slope protection method presently being used in Malaysia, the following protection systems are the most commonly applied :

- Shortcrete
- Gabion
- Anchoring
- Horizontal drains at toe of slope and berms
- Vegetation cover

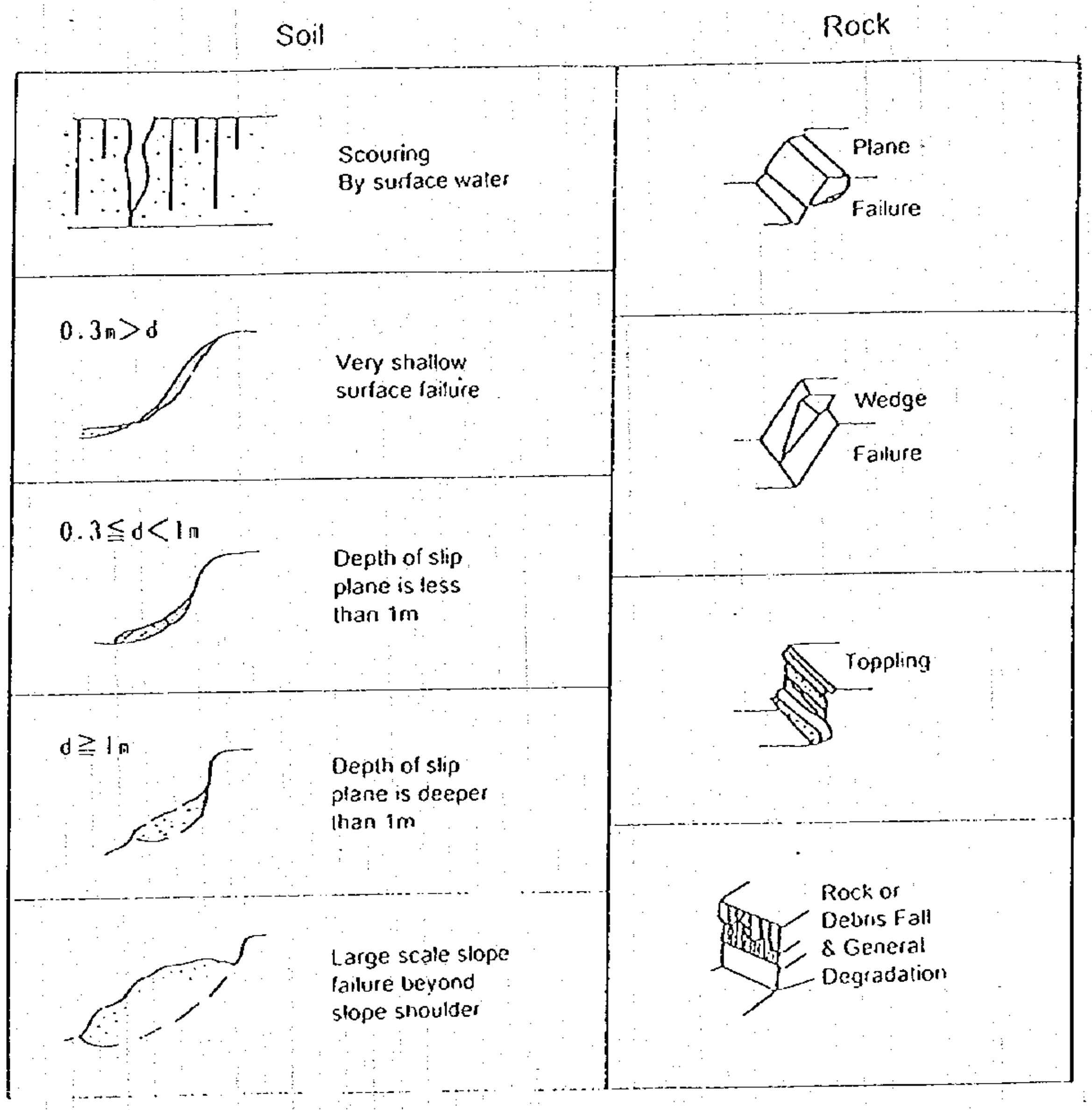


Figure 5-1-5 : Type Of Failure

Table 5-1-4 : Weathering Profile and Engineering Characteristics of Rock Formation (KL Area)

Formation	Rock Types	Residual Soil Thickness	Weathered Rock Zone	Strength of Rock (Mpa)	Geological Structures, Plane of Discontinuities	Possible Slopes
Granite	Granite	1 - 50m, mostly <20m (3-6m)	(26 - 50m)	100 - 200	- Joint prominent - 3 main sets (smooth - rough & undulating)	soil ≥ 45° rock ≥ 80°
Kenny Hill Formation	Meta - arenite meta - argillite (quartzite & phyllite)	5 - 15m	thick up to 30m	25 - 100	- Interbeds of strong & weak beds - Shale - flaking - Softening upon weathering	quartz - phyllite (30 - 51°)*
Kajang Formation	Schist ± limestone, phyllite	<10m	thin	25 - 150	- Schist - schistosity - Phyllite - cleavages, exfoliate upon desiccation	quartz mica schists (33 - 46°)
Hawthornden Schist	Quartz - mica schists, graphitic schist, phyllite ± limestone	5 - 10m	thin	50 - 200	- Graphitic schist - most prone to failures	graphitic schist (30 - 37°)*
Kuala Lumpur Limestone	Limestone (Marble)	very thin	thin	40 - 100	- bedding plane & joints weaken upon weathering - hard blocky rock masses - formation of cavities, sink holes	≥ 70°
Quartz Ridge	Vein Quartz	thin	thin	> 200	- prominent joint sets	≥ 70°

( )* : Actual case studies - Seremban - Ayer Keroh. Expressway. (Ting.WH et.al1990)

NB:
1) granite - in case of hydrothermal alteration or in fault zone, residual soil thickness >40m.
2) for sedimentary/metasedimentary rocks - relation between slope of cutting & dip of strata very important in slope stability.
3) rate of weathering of meta - arenite, meta - argillite > schist.
4) schist - normally plastic (deform rather than fracture), therefore depth at change from soil to rock difficult to ascertain.

Table 5-1-5 : Factors Relating to Slope Stability - Granite

Rock Type	Terrain	Soil Nature & Weathering Profile	Causes of Failure	Possible Slope of Cuts
Granite	rugged - steep terrain, require huge cut slopes	- c.g. - f.g. (coarse grained-fine grained) sandy soil, > silt/clay closer to ground surface - VI (3 - 6m) weathered granite becoming soil - V (6-14m) f.g. weathered granite - IV (10-18m) c.g. weathered granite - III (10-18m)' transitional zone from weathered granite to rock - Depth to bedrock of ridge top 29-56m, average 42m - Quartz weather & become friable; grain size composition changed by compaction if used as fill material - Alteration of physical properties of soil due to weathering result in slope failures	- Joints prominent (in various directions) stacked block structures - Joints of dip slope associated with vertical joints - wedge failure - Dip slope structure at boundary between VI & V/IV - failure along boundary - Fault Zone (crushed ground): deep weathering (>60m) - Soil & rock falls	- c.g. loose soil, 40-60° stable, but intense gully erosion - Ipoh - Changkat Jering* 30-80° (mostly 40-50°) - KL-Karak* A:35-80° (40-50°) B:40-70° (45-60°) A: failure most likely to occur B: failure may occur C: safe slope (presently) Type / No / % A / 8 / 14 B / 25 / 45 C / 23 / 41

* : actual case studies by K-J 1989

Table 5-1-6 : Factors Relating to Slope Stability - Sedimentary/Metasedimentary Rock

Rock Type	Terrain	Soil Nature & Weathering Profile	Causes of Failure	Possible Slope of Cuts
Hawthornden Schist, Kajang Fm - quartz-mica schist (QMS) - graphic schist (GS) - quartz-phyllite (Q-P)	gentle rolling hills, require generally low cut slopes	heavily weathered to clayey soil but with relict schistosity	- Schistosity or bedding often result in dip slope structures - Mineral alignments result in weak planes eg. sericite (mica) graphite carbonaceous materials - troubles if high cut slopes - Swelling or expansive clays eg. Montmoronlinite	- KL - Melaka*1 25-55° (mostly 35-50°) Type No. % A 10 32 B 17 55 C 4 13 - Seremban-Ayer Keroh*2 QMS 33-46° 6-15m GS 30-37° 5.8-22m Q-P 30-51° 7.8-11.6m NB: Most no. of failure & also mostly major failures occur in graphitic schist 1

* 1 : K-J case study 1989
* 2 : Plus (Ting W.H. et.al 1990)

Table 5-1-7 : Type of Failure and Methods of Slope Stabilization for Granite Rock

Type of Failure	Changing Geometry			Full Control				Slope Surface Protection Cover				Reinforching Slope	External Retaining System						Drainage System			
	Flattern Slope	Bench	Butress	Rock-trap-ditch	Rock-trap Fence/Wall	Rock Net	Scaling of Loose Blocks	Gunite Facing	Mansony Facing	Slope Grids	Gravel Mat	Rock Bolt	RC Retaining Wall	Mansony Retaining Wall	Crib Wall	Anchored Wall	Anchor	Pile	Drainage Ditch	Short Horizontal Drainage	Long Horizontal Drainage	Vertical Draining Well
Fall	○			○	○	○	○	○				○	△	△	△	○	○		○	△	△	
Topple	○	○		○	○	○	○	○				○	△	△	△	○	○		○	△	△	
Transitional Slide	○	○	○					○	○	○	△	○	△	△	○	○	○	△	○	○	○	○

Table 5-1-8 : Type of Failure and Methods of Slope Stabilization for Sedimentary and Metasedimentary Rocks

Type of Failure		Changing Geometry			Full Control				Slope Surface Protection Cover				Reinforching Slope	External Retaining System						Drainage System			
		Flattern Slope	Bench	Butress	Rock-trap-ditch	Rock-trap Fence/Wall	Rock Net	Scaling of Loose Blocks	Gunite Facing	Mansony Facing	Slope Grids	Gravel Mat	Rock Bolt	RC Retaining Wall	Mansony Retaining Wall	Crib Wall	Anchored Wall	Anchor	Pile	Drainage Ditch	Short Horizontal Drainage	Long Horizontal Drainage	Vertical Draining Well
Fall		○			○	○	○	○	○				○	△	△	△	○	○		○	△	△	
Topple		○	○		○	○	○	○	○				○	△	△	△	○	○		○	△	△	
Slide	Circular	○	○	○					○	○	○	○	○	△	△	○	○	○	△	○	○	○	○
	Transitional and Wedge	○	○	○					○	○	○	○	○	△	△	○	○	○	△	○	○	○	○

○ Commonly Used

△ Used in Special Circumstances

5.1.10 Erosion and Floods

In developed and built up areas, flash floods are not a natural hazard but can be traced to the negative impacts of improperly planned catchment developments, and in particular, urbanization.

The frequency and severity of flooding have escalated over the years as the result of land use changes, such as conversion of forest into agriculture and agriculture into urban uses.

As the land is stripped of vegetation and turned into concrete surfaces, it results in higher surface run-off flowing down in a shorter time, as there is no soil or vegetation to absorb the excess water and drain it slowly.

With regards to the siltation of river beds downstream this is mainly the results of severe soil erosion in upland areas due to rapid development and the absence of mitigative measures during land clearing like storm water retention ponds, silt traps, slope stabilization and vegetation cover.

According to Drainage & Irrigation Department report, upstream development of Kelang river has led to soil losses of 2.32 million tones per annum and more than half of the amount goes into rivers, exceeding their carrying capacity.

Rate of soil loss for the Bangsar / Damansara and Hill View areas are summarized as follows:-

- High	50 ~ 80	ton/ha/year	(source DOE)
- Severe	80 ~ 150	ton/ha/year	(source DOE)
- Very Severe	> 150	ton/ha/year	(source DOE)

This explains why rivers overflow, resulting in flash floods and houses being inundated. Until and unless upstream development is controlled, there will be no end to the problem of flash floods. Future development should be focussed away from highly erosive lands while dam catchments, state forests and curing ponds should be protected.

5.1.11 Construction Materials

Rock and sand are required mainly for the construction of roads. Details for such materials are briefly discussed below :

5.1.11.1 Crushed Rock

Crushed rock in this report refers to quarried rock materials which are sold in various sizes, up to 10 inches (25cm) across. These products are mainly used as road metal and constructional aggregate. However, limestone in powder or chip forms is also used in the making of terrazzo, cement and in the chemical and fertilizer industries.

Resourcewise, rocks suitable for coarse aggregate are more than adequate but the cost of supply depends very much on the distance from the market. With the continued emphasis on environmental safety and protection, shortages in some urban and industrialized areas are expected to continue as the location of crushed rock quarries become more and more limited to the more remote areas.

Many quarries are operating in and around Selangor due to the disposal of the spoiled rock mass from blasting and excavation work at new development areas. Some of them are large scale operations whereas others are on a rather minor scale. From the results of route survey, transportation distance from the quarries to the road construction sites are estimated to be within 5 km.

The number of quarries in Peninsular Malaysia according to rock type can be obtained from the Geological Survey Department's, 1992, Report on Commodity Production Statistics of Crushed Rock Aggregate in Peninsular Malaysia, 1993.

5.1.11.2 Sand and Gravel

Sand and gravel are basic materials used in the construction of buildings and roads. In Selangor these commodities are obtained mainly from mine tailing dumps and river bed, with a small amount from offshore areas.

Reserves of sand and gravel in the form of mine tailings are fast depleting with the scaling down of tin mining activities. Moreover, mine tailing sand is also being extracted and used as raw materials in the production of silica sand. This situation is further aggravated by the fact that in many areas, reserves are being sterilized by development.

Nevertheless enough volume of sand are available around the ex-mining areas scattered along the road from Puchong to Dengkil. These sand mines have washing equipment for the tailing sands that is extracted from the ex-mining land. It is therefore anticipated that the quality of washed sand is fairly good.

5.1.12 Conclusions

i) The proposed route alignment passes through areas with various landform such as low lying alluvial plains and swamps, low rolling hilly country and rugged and steep mountainous terrain.

ii) The route alignment traverses through lands of various vegetation cover and landuses like forest reserves and water catchment areas, oil palm and rubber plantations, ex-mining land as well as built up areas such as residential areas and factory sites.

iii) The natural ground conditions are considered to be generally stable except for some small scale landslips and rock falls that may occur along certain less stable cut slopes

iv) Alluvial plains are not widely developed. These are scattered along the main rivers and swampy area south of Puchong.

v) The geology of the proposed main tunnel areas consist of granitic rock. The average depth of weathering is to be around 10m except the sheared zone areas which may exceed 60m.

vi) The Quartz Ridge consisting of vein quartz near Kelang Gates Dam is considered not to be of severe tunneling problem like slow progress in the blasting work. This is because the rock is widely jointed and many of the joints have open cracks which have resulted in heavy weathering.

vii) The geological condition along the proposed route is anticipated to be rather complex due to the intrusion of granitic rocks and its related tectonic activities.

viii) A large scale of faulting which is in turn further chopped up into smaller fault blocks occur along the proposed route from Hulu Langat to Hulu Gombak areas.

ix) Some large scale slides are commonly observed around the site areas, especially at slopes with no vegetation cover.

x) The proposed route passes through the Kajang formation and Kenny Hill Formation from Bangi area to Ayer Hitam area and the Hawthornden Schist and Dinding Schist at Gombak to Hulu Kelang. These consist of weathered sedimentary rocks which may be weak materials, especially the graphitic schist, which warrant more detailed studies on the stability problems in slope cuttings.

xi) Strict control is indispensable in order to prevent excessive erosions from the weathered rocks during the terms of road construction.

xii) It is anticipated that the materials for embankment are sufficiently available from decomposed granitic rocks judging from the experiences gathered from the newly constructed Karak Highway and the other expressways.

xiii) Rock and sand materials are also believed to be sufficiently available from the several new quarries scattered along the proposed route.

5.2 Geometric Design Standard

JKR and MHA have prepared the following geometric design guide and standards, namely:

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

The recommended geometric design standards for the KLORR are mainly derived from these guides and standards, supplementing some necessary items.

Main design elements for the KLORR, comparing the guide and standards are shown in Table 5-2-1.

5.2.1 Design Controls

1) Road Classification

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

2) Design Vehicles

For designing the project road, truck combination WB-50 is used as specified in the Guide.

3) Design Speed

The design speed of the KLORR is decided at100 km/h. A design speed higher than this will not be necessary, considering the function of the KLORR. Long and high speed trips will not be predominant, as with the intercity expressway. But, a design speed of 80 km/h might be necessary for the ORR passage through mountainous and hilly areas.

5.2.2 Design Element

1) Sight Distances

Stopping sight distance is the sum of two distances;

- The distance traveled by the vehicle from the instant that the driver sight an object on the surface necessitating stop to the instant that the brakes are effective (brake reaction time), and
- The distance required for the vehicle to stop from the instant that brake applications begins (braking time).

2.5 seconds is used for the former and the later is depend on the initial speed and

Table 5-2-1: Geometric Design Standard for the Outer Ring Road

Road Categories : Expressway

				JICA (KL Outer Ring Road Project)	
Design Control & Criteria	1	Design Standard	-		
	2	Access Control	-	FULL	
	3	Area Type	-	F	R.M.
	4	Design Speed	km/hr	100	80
Cross Section Elements	5	Lane Width	m	3.65	
	6	Shoulder Width	m	3.00	
	7	*1 (Structure >100m)	m	1.00	
	8	Median Width (Minimum)	m	4.00	
	9	Median Width (Desirable)	m	-	
	10	Marginal Strip Width	m	0.50	
	11	Minimum Reserve Width	m	60	
Elements of Design	12	Stopping Sight Distance	m	225	150
	13	Passing Sight Distance	m	Not Applicable	
	14	Minimum Radius	m	375	230
	15	Minimum Length of Spiral	m	See Table	
	16	Maximum Superelavation	Ratio	0.10	
	17	Maximum Grade (Desirable)	%	3	4
	18	Maximum Grade	%	5	6
	19	Crest Vertical Curve (K)	-	(R) 12,000	6,000
	20	Sug Vertical Curve (K)	-	(R) 5,000	3,000
Overhead Clearance			m	5.40 (5.20 + 0.20)	

the coefficient of friction between tire and pavement. The following equation is used for the calculation of stopping sight distance.

D = 0.694xV + 0.00394xV2/f
where
D: Stopping sight distance (m)
V: Initial Speed (km/h)
f: Coefficient of friction between tires and pavement

Stopping sight distance by each design speeds on the wet condition are shown in Table 5-2-2.

Table 5-2-2 : Stopping Sight Distance

Design speed km/h	Initial speed km/h	Friction Coe	Stopping Sight Distance(m)	
			Calculated	Adopted
120	120	0.28	285.9	285
100	100	0.29	205.3	205
80	80	0.30	139.6	140
60	60	0.33	84.6	85
50	50	0.35	62.8	65
40	40	0.38	44.3	45

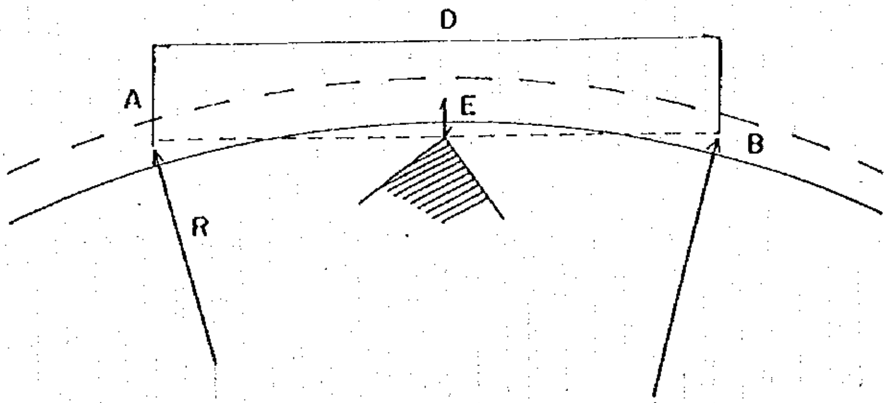
Sight Distance is defined as the distance along a roadway that an object of specified height (h=0.15 m) is continuously visible to the driver with eye-height of 1.07 m above the road surface. Figure 5-2-2 shows relationship of sight distance and side clearance for some radius. The side clearance from carriageway edge to road side structure should be considered at curved section to keep sight distance.

(2) Maximum Superelevation and Minimum Radius

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

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

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



A : driver's eye
B : object
D : sight distance
E : side clearance
R : radius

Figure 5-2-1 Sight Distance and Side Clearance

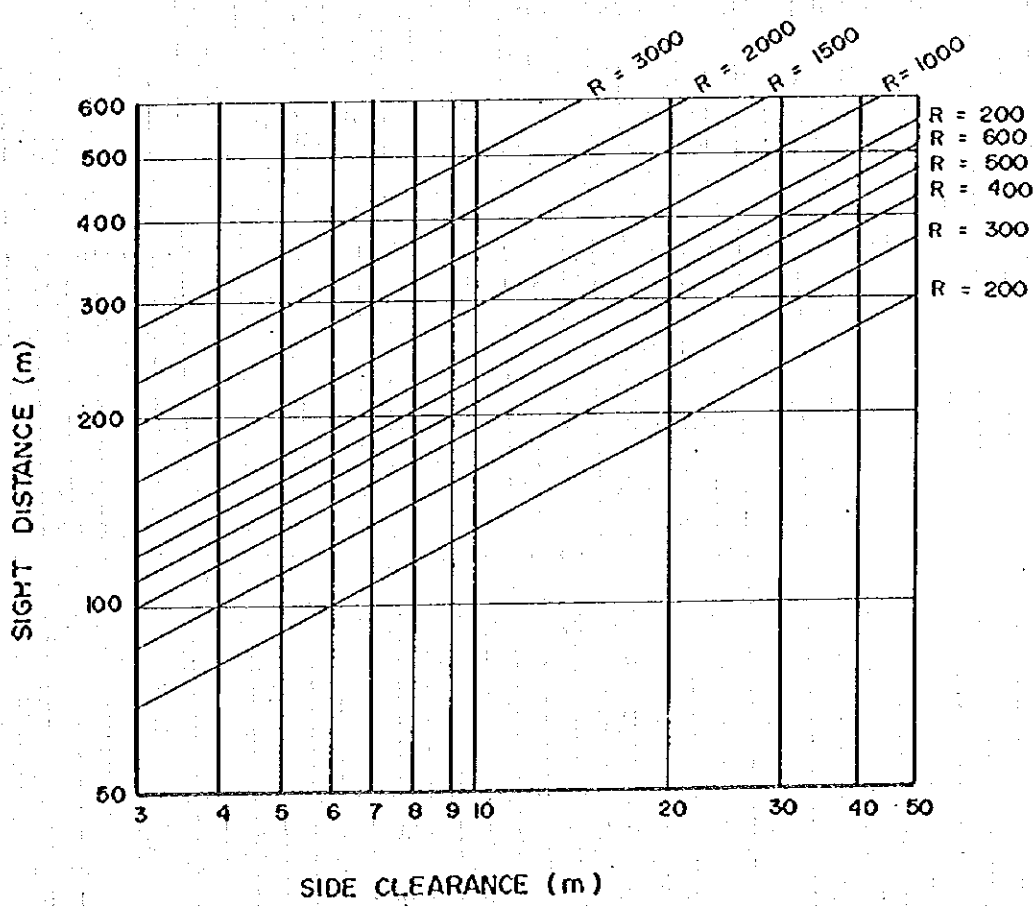


Figure 5-2-2 Relationship of Sight Distance, Radius and Side Clearance

Maximum allowable lateral friction coefficient, maximum superelevation and minimum radius are shown in Table 5-2-2.

Table 5-2-3 : Maximum Superelevation and Minimum Radius

Type of Road	Throughway			Ramp		
Design Speed (km/h)	120	100	80	60	50	40
Maximum Lateral Friction Coefficient : f	0.10	0.11	0.12	0.2	0.2	0.2
Maximum Superelevation : I (%)	10	10	10	10	10	10
Minimum Radius (m)	650	375	230	125	85	50

Superelevation and lateral friction should de distributed orderly for corresponding radius, generally the share of lateral friction increase promotionally as radius decrease.

Some Comment on Superelevation of Urban Road and Expressway

1) Urban Road

It is reasonable to use maximum 6% for urban road because of consideration of access from abating property. But, if the road is access controlled expressway the condition should changed.

The lateral friction is felt by drivers as centrifugal force. The maximum centrifugal force occurs at the smallest curve with 10 % superelevation in rural area but it occurs smallest curve with 6% superelevation in urban area. This might induce the driver unstable driving condition in urban area.

It is recommended that:

I) for the access controlled road in urban area the maximum suoerelevation should be 10 % same as in rural area and necessary superelevation for each radius of curve should follow that of rural road.

ii) for the street of design speed 60 km/h for example, maximum superelevation can be 6 % but, radius should be 320 m but, not 150 m.

2) Expressway

According to the design stnadard of "Interurban Toll Expressway System in Malysia" the maximum superelevation is 7%. This fact itself is not problem. But, wahat might be problem is that the maximum lateral friction occurs at this percent of superelevation. The drivers on the expressway sometimes feel lack of superelevation and strong centrifugal force at sharp curve section. As mentioned in urban road, curveed section should be so esigned that the maximum lateral friction should occur at the section of the maximum superelevation in the coutry, ie. 10 %.

If, the maximum superelevation should be lilited at 7 % for expressway, the minimum radius should be 700 m following superelevation for rural road (Table 4-4A: pp.41 "A Guide on Geometric Design of Road") for design speed of 100 km/h, but not 450 m as prescribed in the expressway standard.

(3) Minimum Transition Curve Length

Transition curves are necessary on high grade road to be insurted between circular curves of substantially different radii and between tangents and circural curves.

The length necessary for controlling the steering on a curve is calculateda from the following equation provided required length for a natural and easy-follow path for drives.

$L = vxt = V/3.6xt$

where

- L : minimum transition curve length (m)
- v: design speed (m/sec)
- V: design speed (km/h)
- t: running time through the transiton curve (sec)

Desirable running tome through the curve to allow control of the steering is reported to be 3 to 5 seconds.

To make the change of centrifugal acceleration be tolerable for drivers, the rate of increase of centrifugal acceleration (Pm/cu.sec) is obtained by Short's equation:

$P=(V/3.6)^3/LxR$

where

- P: rate of increase of centrifugal acceleration (m/cu.sec)
- V: design speed (km/h)
- L: minimum transition curve length (m)
- R: mininium curve radius (m)

P max = 0.5 m/cu. Sec for expressway /highway and P max = 0.75 m/cu.sec for other road are adopted. Table 5-2-4 shows the minimum transition curve length and its rate of acceleration.

Table 5-2-4 Minimum Transient Curve

Typpe of Road	Throughway			Rampwa		
Design Speed (km/h)	120	100	80	60	50	40
Running time (sec)	5	5	3	5	5	5
Minimum Curve Radius (m)	650	375	230	125	85	50
Minimum Transition Curve Length (m)	165	130	70	50	40	35
Rate of Increase of Centripetal Acceleration P (m/cu.sec)	0.35	0.43	0.65	0.44	0.45	0.50

This length of transition curve is longer than that needed for supelevation unoff. The longer transition curve is recommended to be used more frequently.

4) Minimum Horizontal Curve Length

Minimum horizontal curve length is designnated to cover all the horizontal curve lenght, including transition curvesm if any, and to be of sufficient length for drivers to comfortably adjust their steering.

Rider comfort (tolerable limit)

$L = 0.278x\ Vd \times t$

Where

L	:	minimum horizontal curve length (m)
Vd	:	design speed
T	:	minimum required steering time on curve (sec)
t	:	6 seconds

Table 5-2-5 Minimum Horizontal Curve Length

Design Speed (km/h)	120	100	80	60	50	40
Minimum length caluculated (m)	200	200	133	100	83	67
Adopted (m)	200	200	140	100	85	70

In the case where the intersecting angle is small, 7 degree or less for example, it si desirable to use horizontal curve length longer than the minimum required value of 7 degree should be used.

(5) Maximum and Minimum Grade

Maximum gradient are normally determined based on the condition that fully loaded trucks can climb slope maintaining speed of at least half the design speed. The gradient of 3%, 4%, 5%, 6%, 7% for design speed of 100 km/h, 80km/h, 60km/h, 50km/h, 40km/h are adopted respectively as a desirable maximum grade.

At slope where steeper grade than desirable grade are needed, critical length of grade should be considered. Table 5-2-6 shows allowable steeper grade with its critical length by design speed.

For longitudinal drain of preciptation on the carriageway it is required to prescribe minimum grade. A desirable minimum grade for the usual case is 0.5%, but a grade of 0.35% may be used where there is a high-type pavement accurately crowned and supported on firm subgrage.

Table 5-2-6 : Critical Length of Grade by Design Speed

Design Speed (km/h)	Grade (%)	Critical Length of Grade (m)
120	3 4 5	500 400 300
100	4 5 6	500 400 300
80	5 6 7	500 400 300
60	6 7 8	300 250 200
50	7 8 9	250 200 170
40	8 9 10	200 170 150

(6) Vertical Curve

Vertical curves have effect in smoothing vertical alignment between tangent grades in crest or sag. They should be designed that the sag and crest will be safe, comfortable in operation, pleasing in appearance and adequate for drainage. The minimum vertical curve length is shown in Table 5-2-7.

Table 5-2-7 : Minimum Vertical Curve Length

Design Speed (km/h)	Sight Distance (m)	Crest Curve		Sag Curve	
		Vertical Curve Length (m)	Radius of Vertical Curve (m)	Vertical Curve Length (m)	Radius of Vertical Curve (m)
120	285	120 x i	12,000	60 x i	6,000
100	205	60 x i	6,000	40 x i	4,000
80	140	30 x i	3,000	28 x i	2,800
60	85	15 x i	1,500	17 x i	1,700
50	65	10 x i	1,000	12 x i	1,200
40	45	10 x i	1,000	7 x i	700

5.2.3 Cross Section Elements

Figure 5-2-3 shows a standard cross section of KLORR.

1) Crossfall of Carriageways and Shoulders

It is advantageous for pavements to drain rapidly during rainstorms, thus a crossfall of 2.5% is adopted as a standard on expressways / highways and other roads.

2) Lane Width and Marginal Strips

Careful consideration of lane width is important to road planning. It reflects the speed and nature of traffic, which the road should serve. For the KLORR, a lane width of 3.65m is adopted.

The KLORR will not be inter-urban expressways, which have a lane width of 3.75m serving high speed, long inter-city trips. But, to serve development projects in the suburbs, a lane width of 3.50m will not be enough.

A marginal strip of 0.50m is adopted following the existing standards.

3) Shoulders

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

4) Medians

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

5.2.4 Interchanges

1) Design elements of through highway

Table 5-2-8 : Design Elements of Through Highway in Interchange Area

Highway Design Speed (km/h)	Minimum Radius (m)	Maximum Gradient (%)	Minimum Vertical Curve Length in K value	
			Crest	Sag
120	2,000	2	450	160
100	1,500	2	250	120
80	1,000	3	120	80
60	500	4.5	60	40
50	300	5	40	30

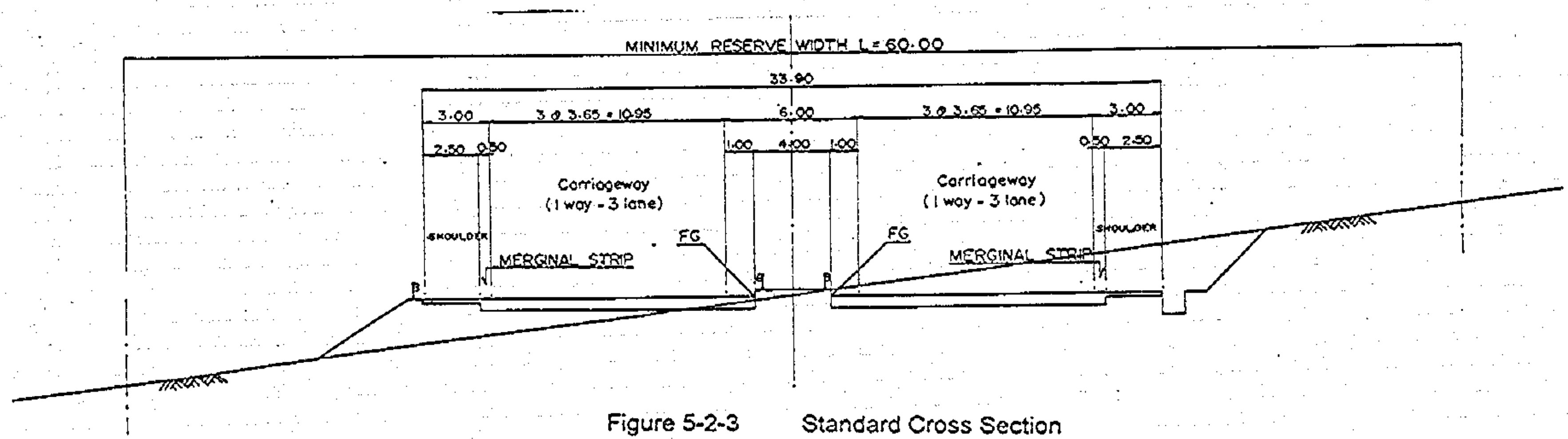


Figure 5-2-3 Standard Cross Section

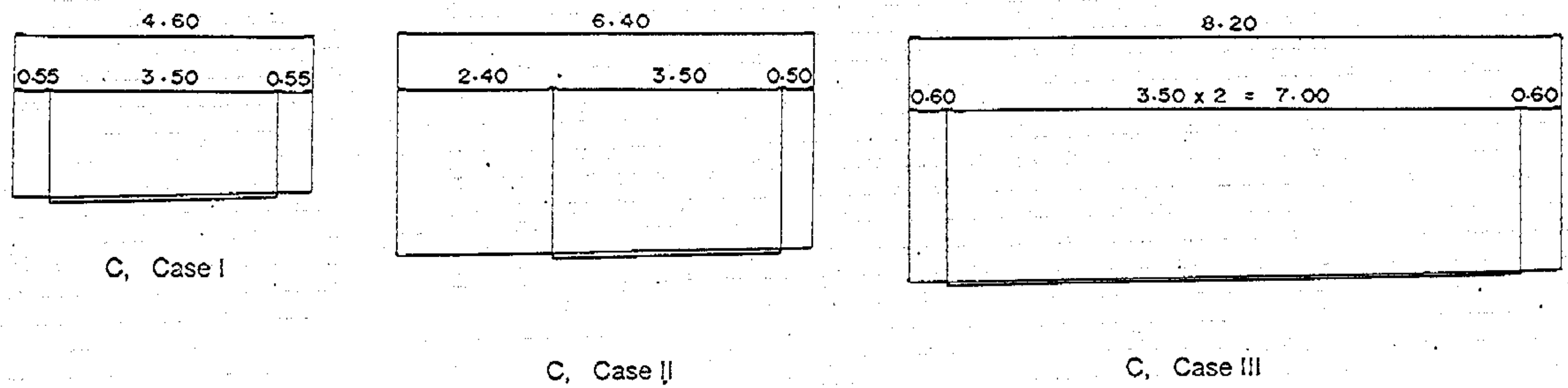


Figure 5-2-4 Cross Section of Ramp

The geometric design standard of through highway at an interchange area should be higher than that of a normal section highway to facilitate diverging, merging and weaving, and to provide longer sight distance. That standard is shown in Table 5-2-3.

As for sight distance 25% longer than normal highway sections is recommended for sight distance.

2) Design speed interchange ramp

"A Guide to the Design of Interchanges" recommends table for the ramps design speed as in Table 5-2-9.

Table 5-2-9 : Ramp Design Speed

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

( ) is applicable only for loops

3) Design Elements

Design elements of the ramp are almost the same as for the through lane.

4) Cross Sections

The ramp is classified according to the usage of design vehicle:

A = predominantly P vehicles, but some consideration for SU trucks.

B = sufficient SU vehicles to govern design, but some consideration for semi-trailer vehicles WB-50

C = sufficient buses and combination type vehicles WB-50 to govern design.

For the KLORR Interchange, category C is selecte d.It is also classified by service level:

Case I = one lane one-way operation - no provision for passing a stalled vehicle.

Case II = one lane one-way operation with provision for passing a stalled vehicle

Case III = two lane operation, either one-way or two-way.

Cross sections of these classifications are shown in Figure 5-2-4.

5) Design of Ramp Terminal

Ramp terminal consists of acceleration (deceleration) lane and taper. And for fomer is further divided parallel type and taper type. Generally, for entrance ramp (mersing) parallel type is preferred, as itisieasier for drivers to find sufficient gap on main flow to merge. And for exit ramp (diversing) tapered type is preferred as it eadier for drivers to flow the align ment to diverge.

Necessary length for acceleration and deceleration is shown in Table 2-17, and Table 2018 respectively. Table 2-19 showns necessary taper length of parallel type acceleraion lane.

Table 5-2-10 : Minimum Acceleration Lane Length

Hiway design speed	Acceleration Length (m) For Entrance Ramp Design Speed								
	stop	25	30	40	50	60	7	80	90
50	60								
60	115	100	75	65	40				
80	235	215	190	180	150	115	50		
100	360	325	330	300	275	245	180	120	50
120	485	470	460	430	405	375	310	250	180

Table 5-2-11 : Minimum Deceleration Lane Length

Hiway design speed (km/h)	Deceleration Length (m) For Entrance Ramp Design Speed								
	stop	25	30	40	50	60	7	80	90
50	70	55	50	45					
60	95	90	80	70	60	50			
80	130	125	120	110	95	85	70	55	
100	160	155	150	140	130	125	105	90	75
120	190	180	175	170	155	150	130	120	105

Table 5-2-12 : Minimum Taper Length

Highwa Design Speed (Km/h)	Taper Length (m)
50	50
60	60
80	70
100	80
120	90

Toll booth is essential prt of highwy when it is operated toll highway. There are two types of toll booth. One is installed at main through lanes suitable for open toll system, it is sometimes called toll barrier. The other I installed at interchang ramp, suitable for close toll system, it is sometimes called toll plaza.

A typical toll booth design is shown in Figure 5-2-15. It sonsists of lane and island where booth is installed. Figure 5-2-6 shows design of toll plaza which consists of toll booth nd starage lane and taper.

5.2.5 Capacity

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

1) Service Levels

Service levels for expressway is defined as level C . Volume capacity ratio is 0.70 to 0.80, according to the Guide. 0.75 is selected for the KLORR.

2) Lane Width and Lateral Clearance

Lane width and lateral clearance are good enough, their coefficient them is 1.00.

3) Ratio of Heavy Vehicles

For the purpose of capacity analysis, the following vehicle composition ratio is used:

Pm:	ratio of medium lorries	0.12
Ph:	ratio of heavy lorries	0.08
Pb:	ratio of busse	0.05

Table 5-2-13 : Capacity Analysis

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

4) Passenger Car Equivalent

A passenger car equivalent for each type of vehicle, is shown in Table 5-2-8:

Table 5-2-14 : Passenger Car Equivalent

Type of Vehicle	Passenger Car Equivalent
Passenger Car	1.0
Medium Lorry	2.5
Heavy Lorry	3.0
Bus	3.0

Composite passenger car equivalents (=E) is calculated using ratio of each vehicle type and its equivalent:

$$
\begin{aligned}
E &= 1 \times (1 - Pm - Ph - Pb) + 2.5 \times Pm + 3.0 \times Ph + 3.0 \times Pb \\
&= 1 + (2.5 - 1) \times Pm + (3.0 - 1) \times Ph + (3.0 - 1) \times Pb \\
&= 1 + 0.44 \\
&= 1.44
\end{aligned}
$$

Composite passenger car equivalencies for interchange ramps are assumed to be 3.8 for semi-direction and 4.3 for loops and diagonals, respectively, due to the steeper grade.

5) Peak Hour Factor and Directional Distribution Ratio

Peak Hour factor (PHF) varies at the range of 7.2% and 9.7%, while the directional distribution ratio (DDR) at peak hour varies from 51% to 69%. PHF of 8% and DDR of 60% are used for the KLORR.

5.3 TOLL COLLECTION SYSTEM

5.3.1 Introduction

Toll system will be an important part of operation of KLORR if it will be constructed by privatized scheme. To ensure smooth traffic flow and fair toll system, it is proposed that toll system of KLORR should be close system and the toll system should be common among the toll expressway and highway in Malaysia. As there is an increasing tendency the number of concession companies to construct expressway, it is necessary to establish the method to manage toll system.

It is proposed considering to render good service of expressway to user and to reduce emission of pollutant with stop and go operation at toll booth. If the toll booth be installed at the entrance of every different managing body of expressway the convenience of driver will increase. KLORR will connect existing toll expressway, at the connecting interchanges such a problem will occur. Also if KLORR be constructed by plural concession companies, the problem would happen in the KLORR itself.

5.3.2 Examination of Toll System

There are many toll expressway and highways already open to traffic in Malaysia. Two toll systems, i.e. close toll system and open toll system are commonly in use. Open toll system is suitable system for the road of considerably short section, sometimes bridge and tunnel section are operated by this system. Driver stop and pay toll fee at toll barriers installed in the main through lane, whereas, close system is suitable for long stretch of road, drivers pay toll fee proportionally to their travel length on the road at the exit toll booth. Possible toll systems are discussed thereafter.

1) Open Toll System

Toll barriers on main lane are needed to be installed dividing KLORR several sections. Figure 5-6 shows possible toll barrier installation. In Section 1, one toll barrier between Templer Park and Batu Dam is planned. In Section 2, two toll barriers are planned, one between KL-Karak Highway and Ulu Langat and the other is between Ulu Langat and FR No. 1. In Section 3, one toll barrier is planned between interchange with Putra Jaya urban motorway and Damansara - Puchong Road.

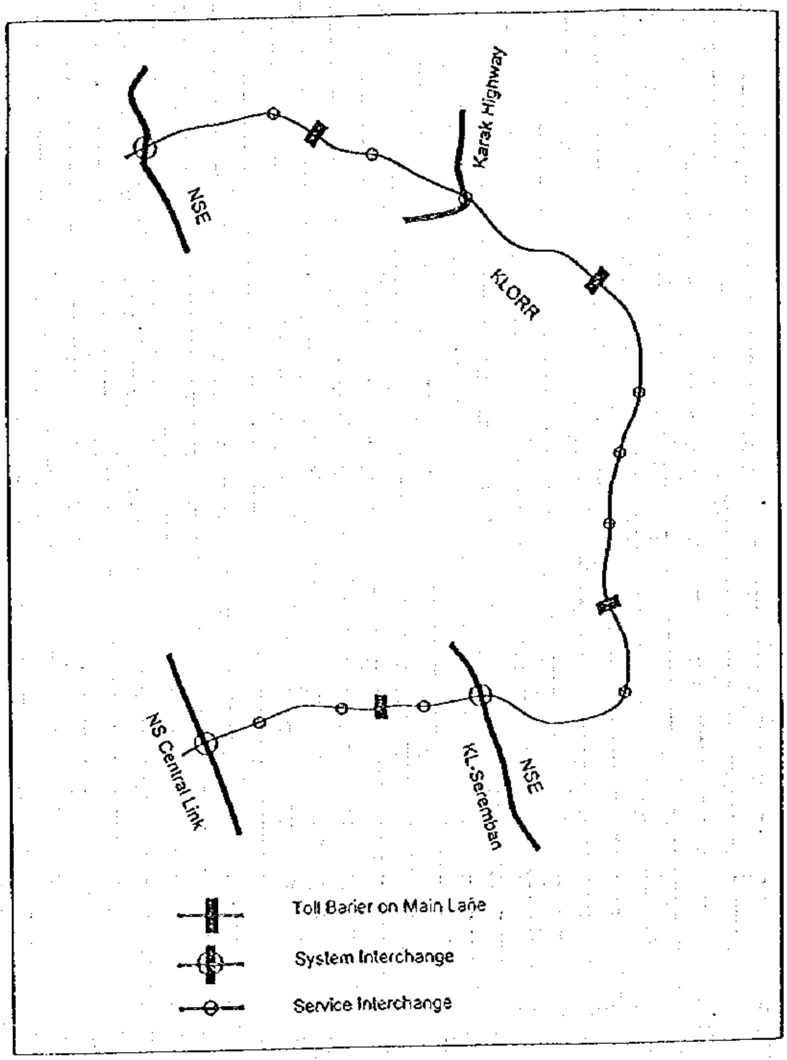
In this system there are some trips which are not covered by this toll barrier installation. It means there are some trips which will use KLORR without paying toll. But, to catch them some more toll barrier are needed to be installed.

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

2) Closed Toll System

Instead of installing toll barriers toll plaza are installed at entrance and exit of service interchanges and system interchange class B. Users will pay toll fee proportionally to travel distance on the expressway at exit ramp toll booth. As KLORR will cover 89 km long section, toll rate should be fair for every users. And to increase service level by

Figure 5-3-1 : Open Toll System



offering smooth traffic flow without stopping on the main through lane, this system has advantage.

It is also proposed to integrate KLORR to the existing expressway toll system and to form common toll system all over the country so to improve service level at interchanges. In this system interchange with the existing toll expressway will be constructed without installing toll plazas.

Comparing these two system it is concluded that close toll system with common toll will be better for KLORR considering to offer the drivers good service and to reduce pollutant emission, and foreseeable high technology which will be tool to attain the system performance.

5.3.3 Basic Consideration for Network Type

There will be different network types in process of the road development. They are "tree" and "mesh - close circuit" types. In tree type there is a single travel route on expressway between any interchange pair, while in mesh type there are plural route for a certain pair of interchange.

1) Tree Type of Toll Road Network

a) To Charge Toll

In the case of a close toll system, toll booths are installed on ramp ways on interchanges and not on main road. A ticket is issued to driver at entrance ramp way and toll fee is collected at exit ramp way.

The amount of fee can be calculated by a data processor (CPU) based on the data stored in the ticket such as type of vehicle and name of interchange where the ticket is issued. It means that the trip length is a distance from the interchange where the ticket is issued, to the interchange where the ticket is submitted and the amount of toll fee can be calculated by multiplying the trip length-by unit rate of each vehicle type.

Even if the trip is made over the section managed by a body, the basic consideration will be the same.

b) To Distribute Revenue

The collected toll revenue should be fairly distributed among the bodies managing the toll roads, on the basis of the trip length of individual travel (Traffic volume-Km) on the respective toll roads.

It is possible to measure the trip length of individual travel on a section managed by each body by the O-D data between origin interchange and destination interchange. Therefore, the due amount of revenue to be distributed to each managing body can be calculated.

2) Basic Consideration in Closed Circuit (Mesh) Type of Toll Road Network

In closed circuit type of toll road network, there are alternative routes which facilitate the users to choose the best route for their convenience in contrary to no choice of route for drivers in tree type of network.

In this type of network, two methods for collection of toll can be used which are explained as follows:

(1) Collection of Toll Fee on the Trip Length Basis

a) Necessary data to get information on driver's route

The information on driver's route can be obtained by:

- The data of O-D interchanges can be obtained by the on and off ramp activities as mentioned in the tree type network.

- The information of the route which is used by driver is necessary.

b) How to get the necessary data

- A ticket is issued at an entrance at a location of main road or ramp ways and the fact that the vehicle passed through the check point is recorded on the ticket. The checking point is on either side or both sides of the road depending upon the accuracy required.

- Driver's additional action is required to insert the ticket into the slot of automatic checking machine which can record the data of passing the point on the ticket.

- At the exit ramp of interchange, the toll fee is calculated including the fee for driving on the mentioned route.

c) Merit

- Exact toll fee is collected from users on trip length basis.

- The bodies managing the toll roads can fairly share toll fee in proposition to the usage even if the fee amounts are different on every alternative route.

d) Demerit

- Inconveniences to drivers such as many stops, speed down, inserting ticket, time delay, congestion etc. at the checking points.

- High possibility of occurrences of accidents.

- Provision with toll booths, checking machine, expanding of road width for all toll booths, etc.

- Necessity of operation, maintenance and repair of these facilities and machines.

- Vigilance needed for trouble against users, machines etc.

(2) Collection of the Cheapest Fee among Alternatives

This method will be adopted by the negotiation and mutual agreement on the same prices for the alternative routes among the managing bodies.

a) Necessary Data

- The O-D data at interchanges can be calculated from the records of the tickets at the entry and exit at ramp ways.

- The through traffic volume on both routes or either one.

b) How to get Necessary Data

The first method is:

- To install vehicle detectors to detect vehicle type including function in order to measure total traffic volume on main roads.

- To calculate the number of through traffic by subtracting the number of trips which are made to/from an interchange located in a route from the total volume. The trips to/from the given route can be obtained from the O-D data between interchanges.

To obtain an accurate data of traffic volume, it is necessary to:

I) Install detectors on both routes,
ii) Increase number of counting points,
iii) Install CCTV cameras for checking detector's accuracy,
iv) Conduct traffic surveys.

The second method is:

- Through traffics are counted by periodical surveys held manually such as O-D surveys and traffic count surveys.

However, the method is not preferred because of no response to road, traffic and incident conditions as well as demand changes. Also, extra expenditure for survey is needed.

c) Distribution of Toll Revenue to Managing Bodies

The total toll fee collected can be distributed depending upon the through traffic and type of vehicles under the condition of the same price or negotiated price.

5.3.4 Connection with The Existing Toll Expressways/Highways

1) Connection with Those Operated under Close Toll System

There are various types of toll operation methods suitable to different types of highway network and two practical methods out of such methods are introduced here for the closed circuit type of network. The proposed method is to be combined with these methods depending on situation such as no agreement on prices between managing bodies, big difference in the distance of alternative routes, etc.

The KLORR will connect with three system interchanges of North-South Expressway which is operated under close toll system and also with Karak Highway operated under open toll system.

a) Connection with North-South Expressway

(i) Basic Method

It is recommended to introduce the same price operation for through traffic on North-South Expressway and KLORR and also the trip length based operation system for traffic which has a terminal of trip in the KLORR. If no agreement on the same prices between the bodies which manage the KLORR and North South Expressway is made, it is required to introduce trip length based operation for all the users on either road which will be managed by bodies in no agreement.

(ii) Adoption of Practical Method

Two types of practical methods are as follows:

- Case of agreement between bodies

  Traffic count detectors are installed at strategic locations on main road as shown in Figure 8-1.

- Case of no agreement between bodies

  Toll booths equipped with checking machine are installed at a strategic location on main roads or ramp ways connecting between the KLORR and North-South Expressway.

2) Connection with Toll Roads Operated Under Open Toll System

The basic consideration in this system is the same as close toll system. It can be assumed that the function at the point connected with two toll roads is the same as that of on and off ramps of a toll road, that is, to issue a ticket for entering drivers in to the close toll system highway and to collect toll fee at exit. However, there might be many problems while operating the toll system in reality.

The typical example of this toll system is in the case of the KLORR linking to Karak Highway.

(1) Practical Method for the KLORR

The KLORR will connect with three system interchanges of North-South

Expressway which is operated under close toll system and also with Karak Highway operated under open toll system.

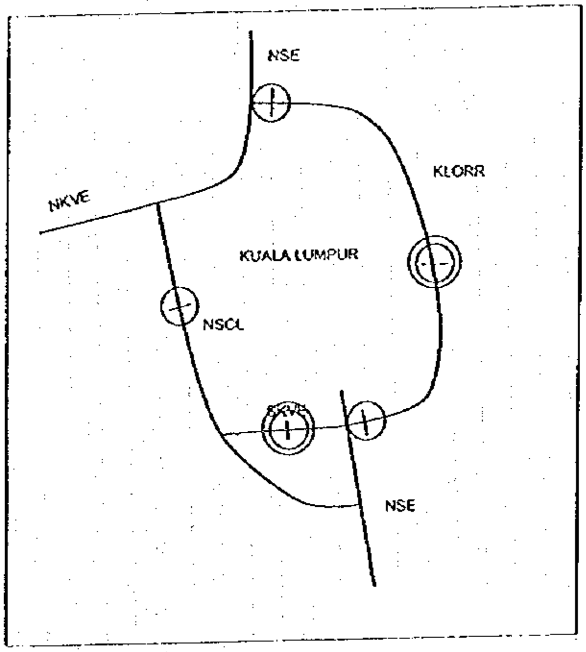


Figure 5-3-2 : The Locations on Main Road where Necessary Devices are to be installed

Note :

- The locations where devices are required to be installed.
- The locations where devices to check data are to be installed.

(2) Connection with Karak Highway

(i) Characteristics and Problems

- Generally, close toll system road has only one or a few toll barriers. Some drivers already pay toll fee after the barrier whereas others do not pay toll fee before the barrier.

- Under open toll system, fixed fee is charged to drivers because a trip length is almost the same as the distance of the road in operation.

- If another highway is connected to the middle of the road section, the trip length will be changed. In such case, the unfair toll would be charged to users if same toll system is operated.

(ii) Adoption of Practical Method

The following two methods are considered as practical methods:

- To move the existing toll barrier to the east side of the interchange of the KLORR and Karak Highway; and to install two toll gates on the ramp ways - one at entrance gate (B) to the KLORR and the other at exit gate (A) from the KLORR.

- To install four toll gates separately for every directional traffic at the rampways in order to issue a ticket and to collect toll fee as shown in Figure 5-3-3.

At Gate A:	To collect toll fee for both the KLORR and Karak Highway.
At Gate B:	To collect toll fee for the KLORR.
At Gate C:	To collect the toll fee for Karak Highway and to issue a ticket for the KLORR.
At Gate D:	To issue a ticket with a mark of payment for Karak Highway and to collect the KLORR fee deducing the prepaid amount.

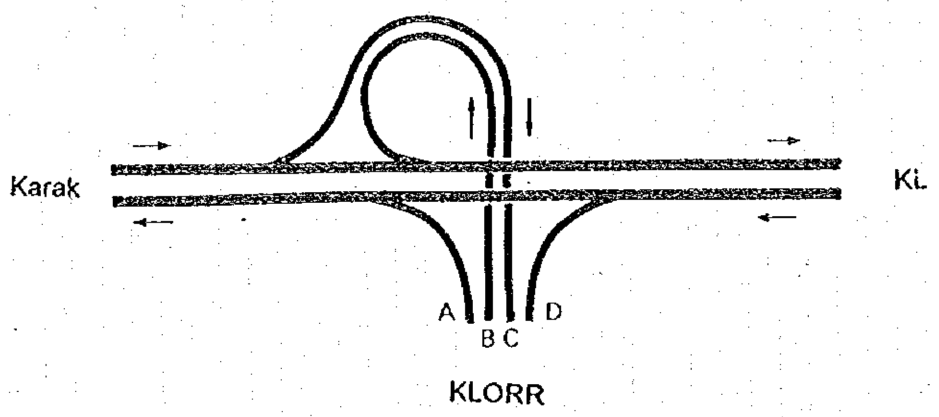


Figure 5-3-3 : Location of Toll Gates

5.3.5 An Advanced Toll Collection System

1) TELEPASS in Italy

An advances toll collection system, so called "non stop toll collection" system was experimentally implemented in Italy and is studied in other European countries and in Japan. The purposes of introduction of this system are to be increase service expressway by eliminating queuing at toll booth, to mitigate environment pollution by reducing stop and start operation and to decrease operational cost of toll booth by no man operation. Here is brief introduction of the system.

The system installed in Autostrada in Italy was called "TELEPASS". Vehicles equipped on-board unit with a card can pass entrance toll booth without stopping, and at exit toll booth the toll fee is automatically calculated and is displayed on the unit then the amount is deducted from the card.

There are two ways to pay amount. One is to use pre-paid card and the other is to transact from the authorized bank account. Autostrada rents the on-board unit by free charge, the unit start functioning after the card is inserted.

Ground base system consists of gantry antenna to identify the vehicle by radio wave, and the data is transmitted to control center. If unauthorized vehicle happened to center, CCTV camera will identify the license number and the data is transmitted to the center, and necessary measures will be taken.

Among 300 toll plazas which are managed by Autostrada this non stop lanes have been installed at 130 booth plazas.

2) Tendency in Europe

In line with unifying EU and increasing tendency of international trip, toll system on expressway became to debate. There are some countries which utilize toll expressway system and also some do not utilize. France is one of the former country and Germany is one of the latter country.

The debate is : when french vehicles travel in Germany, German people think about unfairness that french drivers can travel on expressway without paying any construction cost. When German vehicles travel in France, on the contrary German driver think unfairness that the construction cost is charged for non French people.

In the future expressway in all E.U countries will be toll operation. Non stop operation to collect toll fee is studied using system like TELEPASS. Managing body of expressway of any country will be able to obtain due toll revenue based on the trip length on the expressway in the country.

3) Japan

Japan is famous for toll operation of expressway. High construction cost is being refunded by high toll fee. There are four authorized public corporations to construct and maintain expressway with toll operation. Japan Highway Public Corporation is managing intercity expressway and two corporation are managing Tokyo area and Osaka area, and the last one is managing Honshu-Shikoku Bridge.

Toll system of inter city expressway is close system, but in Tokyo, Osaka, Honshu-Shikoku Bridge open system was introduced. Toll plazas are constructed at the connecting points of the different system. Toll fee is collected at the toll plaza of each expressway independently.

A study of non stop toll collection system was started in 1995 by Ministry of Construction and four expressway authorities. It will be installed experimentally at some of toll booth in 1996.

Non stop operation will be introduce to the expressway not only of close toll system but also to that of open toll system. Distribution method of toll fee among different managing authorities is one of the study theme.