3.0 REQUIRED SPACE FOR CBD BUS TERMINAL

3.1 Forecasting Demand at the Terminal

The trend of bus passener volume can be expected to be greatly influenced by the progress of motorization and the improvement of bus service level or the implementation of a public transportation priority policy.

In this section, the daily passenger volume in the year 2000 is forecasted on the basis of the daily passenger volume carried by each route in the existing (1985) bus network and the population growth rate. Then the peak hour passenger volume is estimated from the daily passenger volume and hence the number of bus trips at peak hour can also be estimated using inputs of bus service level such as bus fleet size, bus capacity and headways. Using the capacity per berth as criterion, the number of berths required per hour is thus estimated. The value thus obtained is further checked by comparing with the capacity of existing facilities. If necessary the inputs of bus service level must be adjusted to satisfy the demand forecasted. When the demand forecasted can be satisfactorily met by the capacity of the terminal facilities planned, the number of berths required at the new bus terminal is determined. The procedure for forecasting demand at the terminal is illustrated as a flow-chart in Figure 3.1.1.

Table 3.1.1 shows the daily passenger volume, bus fleet size and the number of trips forecasted for the year 2000. In the estimation of bus trips it is assumed that the bus fleet size would be increased to enable the various bus companies to maintain their existing service level, especially the scheduled headway. Thus it is forecasted that in 2000, a total of 135,200 bus passengers would be transported by 178 buses running 2,840 trips daily.

Table 3.1.1 : Daily Bus Passenger Volume and Bus Service Level in 1985 and 2000

	Daily Passenger Volume		No. of Bus Fleet		No. of Trips	
	1985	2000	1985	2000	1985	2000
Urban Buses	36,600	48,100	50	55	1,376	1,370
Regional Buses	76,100	87,100	96	123	1,210	1,470
Total	112,700	135,200	146	178	2,586	2,840

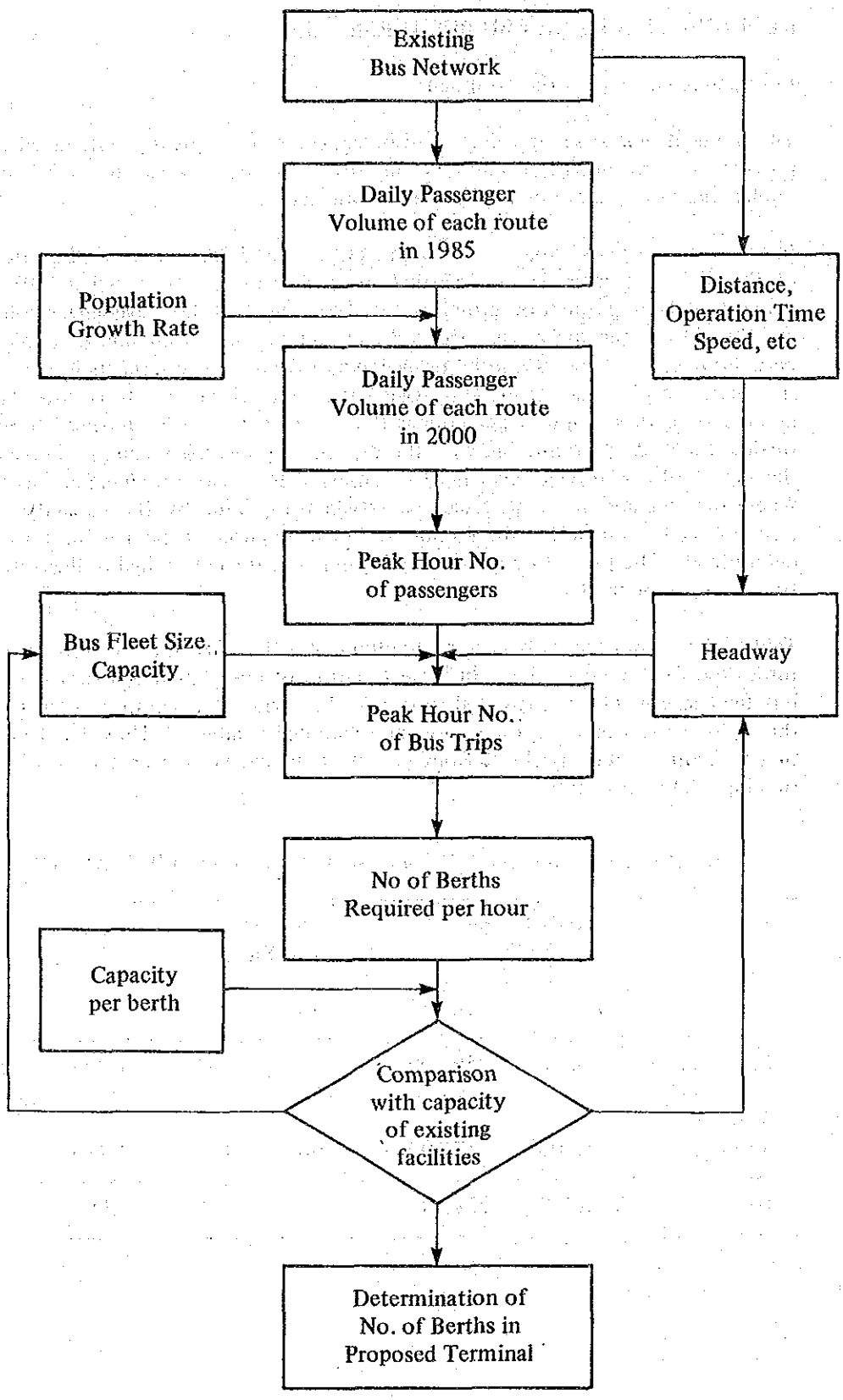


Figure 3.1.1 : Flow-chart for Forecasting Bus Terminal Demand

Next, in order to determine the berthing and parking requirement at the terminal, the number of trips running at peak hour in each direction must be known first. For this estimation the following asumptions were made:

(1) Peak rate is 10%

(2) Ratio of one direction to the other at peak hour is 0.8

(3) Berth capacity for urban bus is 10 trips/hour and for regional bus is 5 trips/hour
Capacity of berth for dropping off only is 30 trips/hour

(4) Ratio of buses parking at terminal is 0.5 and the average parking time is 15 minutes

(5) The forecasted peak hour demand for urban and regional buses is as below:

		North bound	West bound	South West bound	South bound	Total
Urban buses	Trip	8	28	10	18	64
	Berth	1	2	1	2	6
Regional Buses	Trip	27	27	0	25	79
	Berth	4	4	0	4	12

Thus, the Table 3.1.2 can be obtained based on the above assumptions and the forecasted daily passenger volume.

At the existing terminal many buses had been observed to remain parked at the berths for quite a while. Therefore, in the new terminal buses which have to park for sometime will be allocated parking lots. Furthermore, two (2) berths each will be allocated to inter-regional express buses and tour buses respectively.

Now, it must be noted that the demand at the new CBD Bus Terminal forecasted in this section is made for the purpose of determining the scale of the terminal to be built based on the assumptions made by the Study Team. For the purpose of a serious study on the reorganization of bus network or a reexamination of the bus scheduling in order to secure an efficient bus service level in the future, it would be necessary for the demand to be forecasted based on bus passengers OD data and other detail investigations and analyses.

Table 3.1.2 : Peak Hour Demand and Required Space

		Trips	Berths	Berths for Dropping off	Parking lots	Total Space for Terminal Level
Regional Buses	Peak Hour Demand (Nos.)	80	15	3	9	
	Required Space (sq.m)	Concourse 1600	Bus lane 2250	Platform 900	Parking 900	4050
Inter Regional Buses	Peak Hour Demand (Nos.)	10	2	0	1	
	Required Space (sq.m)	Concourse 200	Bus lane 300	Platform 120	Parking 100	520
Tour Buses	Peak Hour Demand (Nos.)	10	2	0	0	
	Required Space (sq.m)	Concourse 200	Bus lane 300	Platform 120		420
Urban Buses (Inter-change)	Peak hour Demand (Nos.)	40	4	0	0	
	Required Space (sq.m)		Bus lane 600	Platform 240		840
Car Parking	Supply (Nos.)				300	
	Required Space (sq.m)				7500	

Notes :

a) Peak rate is 10%

b) Ratio of one direction to the other at peak hour is 0.8

c) Berth capacity for urban bus is 10 trips/hour and for regional bus is 5 trips/hour
Capacity of berth for dropping off only is 30 trips/hour

d) Ratio of buses parking at terminal is 0.5 and the average parking time is 15 minutes

e) Required space per unit facility is as follows:

	Unit	Area
Bus Lane	Per Berth	150 sq. m
Platform	Per Berth	60 sq.m
Concourse Area	Per Trip	20 sq.m
Parking	Per Bus	100 sq.m

f) In addition, at the existing terminal many buses had been observed to remain parked at the berths for quite a while. Therefore, in the new terminal buses which have to park for sometime will be allocated parking lots.

3.2 Preliminary Design of CBD Bus Terminal

3.2.1 Main Facilities of Bus Terminal

A preliminary design of the CBD Bus Terminal is prepared on the assumption that the site on the land to be reclaimed near the entrance of Coastal Road is available. Like the Butterworth Bus Terminal, the main facilities in the terminal would consist of bus berth, car park, shop and other facilities which could help improve the financial viability of the project. Thus, the facilities to be provided in this terminal under two cases are shown in Table 3.2.1. Case 1 involves the construction of a terminal for regional/inter-regional buses whereas Case 2 is for urban and regional/ inter-regional buses.

The number of bus berth and parking space is as had been forecasted in the previous section. The number of ticket booths and bus control office is based on the existing number of bus operators. The scale of car park, shop, etc is assumed arbitrary. Besides these facilities, toilets, information centre, stalls, etc would also be necessary.

Table 3.2.1 : Main Facilities in the CBD Bus Terminal and their scale

Facility		Scale (Nos.)	
		Case 1	Case 2
Bus Berth	Urban bus	4	6
	Regional bus	12	12
	Inter-regional bus (express)	2	2
	Tour bus	2	2
	For dropping-off only	3	5
Bus parking lots		10	17
Ticket Booths		5	9
Bus Control Office		4	7
Car Park		300	450
Shops, stalls, etc.		40	50

Note : Case 1 regional/inter-regional buses only
Case 2 urban and regional/inter-regional buses

3.2.2 Calculation of Space Required, Cost and Revenue for Bus Terminal

The area to be occupied by the new bus terminal is calculated on the basis of the demand at the terminal estimated in the previous section. Generally, terminal facilities comprise four major elements, i.e. bus lane, platform, concourse area and parking space. The space requirement for each unit of these elements are set up as given in Table 3.2.2 and using these criteria, the area required for the terminal is calculated and shown in Table 3.2.3.

Table 3.2.2 : Space Requirement Criteria

	Unit	Area (sq. m.)
Bus Lane	Per Berth	150
Platform	Per Berth	60
Concourse Area	Per Trip	20
Parking	Per Bus	100

Table 3.2.3 : Terminal Space Requirement

Case 1

Purpose	Area (sq. m.)
Regional/Inter-regional Bus & Tour Bus	5,150
Interchange	850
Total Area	6,000

Case 2

Purpose	Area (sq. m.)
Urban Bus	4,000
Regional/Inter-regional Bus & Tour Bus	5,200
Total Area	9,200

Table 3.2.4 shows the project cost for CBD Bus Terminal under both cases. Project cost is M$7.35 million for the case where the terminal is used by regional/inter-regional buses and M$9.57 for urban and regional/inter-regional bus terminal. The implementation plan is given in Table 3.2.5.

The expected revenue per month is M$84,000 from the regional/interregional bus terminal and M$109,500 from the urban and regional/inter-regional bus terminal. Table 3.2.6 depicts the forecasted revenue of CBD Bus Terminal in 2000.

Table 3.2.4 : Project Cost for CBD Bus Terminal

Case 1

Item	Unit Cost	Quantity	Cost (M$ million)
Land Acquisition	M$300 per sq. m.	6,000	1.80
Building	M$500 per sq. m.	10,000	5.00
Terminal Level	M$ 80 per sq. m.	6,000	0.48
Pedestrian Bridge	M$100 per sq. m.	710	0.07
Total			7.35

Case 2

Item	Unit Cost	Quantity	Cost (M$ million)
Land Acquisition	M$300 per sq. m.	9,200	2.76
Building	M$500 per sq. m.	12,000	6.00
Terminal Level	M$ 80 per sq. m.	9,200	0.74
Pedestrian Bridge	M$100 per sq. m.	710	0.07
Total			9.57

Table 3.2.5 : Implementation Plan for CBD Bus Terminal

(Unit : M$ million)

Item	1991	1992	1993	1994	1995. . .
Preparation					Opening of Coastal Road
Building (Concourse Level and Car Park)		1.8	2.5	2.5	
		(2.76)	(3.00)	(3.00)	
Terminal Level				0.48	
				(0.74)	
Pedestrian Bridge				0.07	
				(0.07)	
Total		1.8	2.5	3.05	
		(2.76)	(3.00)	(3.81)	
Operation & Maintenance	(Building Construction Cost x 3%)				0.16 → 0.16
					0.20 → (0.20)

Note : Numerals inside ( ) refer to Case 2

Table 3.2.6 : Forecasted Revenue of CBD Bus Terminal in 2000

Case 1 (at 1986 prices)

Item	Unit Revenue (per month)	Quantity	Revenue per Month (M$)
Bus Berth	M$500 per berth	33	16,500
Ticket Booth/Office/Shops	M$ 15 per sq. m.	500	7,500
Car Park	M$200 per bay	300	60,000
Total			84,000

Case 2 (at 1986 prices)

Item	Unit Revenue (per month)	Quantity	Revenue per Month (M$)
Bus Berth	M$500 per berth	44	22,000
Ticket Booth/Office/Shops	M$ 15 per sq. m.	500	7,500
Car Park	M$200 per bay	400	80,000
Total			109,500

3.3 Financial Evaluation of CBD Bus Terminal

In this section the financial viability of the proposed CBD Bus Terminal (i.e. Case 1) is evaluated using the criteria of financial rate of return and cash flow analysis.

In addition to the estimated project cost of M$7.35 million and forecasted revenue of about M$1.0 million per annum, the following assumptions are used in the financial evaluation.

(1) Project life is assumed as 25 years with construction of terminal building beginning in 1992 and project to be opened to the public in 1995.

(2) Interest on loan is assumed to be 6% per annum (long-term) for 50% of the loan and 12% per annum (short-term) for the rest.

(3) Operation and Maintenance Cost is assumed as 3% of building construction cost.

Thus, the financial rate of return (FIRR) is forecasted to be 10.4% indicating that the project is financially viable provided a low-interest loan is available. The cash flow of the project over a 25 year period is shown in Table 3.3.1. It can be observed that the annual profit/loss account shows a profit eight (8) years from the opening of the terminal building and to have a positive cumulative net balance twenty-three (23) years after opening.

Table 3.3.1 : Cash Flow Analysis for CBD Bus Terminal

START YEAR 1992
INTEREST RATE (LONG–TERM) AT 6% PER ANNUM FOR 50% OF LOAN
INTEREST RATE (SHORT–TERM) AT 12% PER ANNUM FOR 50% OF LOAN
INFLATION RATE AT 3% PER ANNUM

(in M$ million)

YEAR	REVENUE	OPERATION/ MAINTENANCE & DEPRECIATION	NET INCOME	INTEREST PAYMENT LONG	INTEREST PAYMENT SHORT	PROFIT/ LOSS	LOAN TAKEN LONG	LOAN TAKEN SHORT	TOTAL INFLOW	LOAN REPAYMENT LONG	LOAN REPAYMENT SHORT	TOTAL OUTFLOW	BALANCE AT YEAR	CUMULATIVE BALANCE	
1992				0.1	0.1	−0.2	1.1	1.1	2.0	0.0	0.0	2.2	−0.2	−0.2	
1993				0.2	0.3	−0.5	1.6	1.5	2.6	0.0	0.0	3.1	−0.5	−0.6	
1994				0.3	0.6	−0.9	1.9	2.0	3.0	0.0	0.0	3.9	−0.9	−1.6	
1995	1.0	0.6	0.4	0.3	0.6	−0.2			−0.5	0.0	0.5	0.5	−1.0	−2.8	
1996	1.1	0.6	0.5	0.3	0.5	0.0			−0.3	0.0	0.5	0.5	−0.8	−3.9	
1997	1.2	0.6	0.6	0.3	0.4	0.2			−0.1	0.0	0.5	0.5	−0.6	−4.9	
1998	1.3	0.6	0.7	0.3	0.4	0.3			0.0	0.0	0.5	0.5	−0.5	−6.0	
1999	1.4	0.6	0.8	0.3	0.3	0.6			0.2	0.1	0.5	0.6	−0.3	−7.0	
2000	1.5	0.6	0.9	0.3	0.3	0.7			0.3	0.2	0.5	0.7	−0.3	−8.2	
2001	1.7	0.6	1.1	0.3	0.2	1.0			0.6	0.3	0.5	0.8	−0.1	−9.3	
2002	1.8	0.7	1.2	0.2	0.1	1.2			0.9	0.3	0.5	0.8	0.1	−10.3	
2003	1.9	0.7	1.2	0.2	0.1	1.4			0.9	0.3	0.5	0.8	0.1	−11.4	
2004	2.1	0.7	1.4	0.2	0.0	1.7			1.2	0.3	0.1	0.4	0.8	−12.0	
2005	2.3	0.7	1.6	0.2	0.0	1.9			1.4	0.3	0.0	0.3	1.1	−12.2	
2006	2.4	0.7	1.7	0.2	0.0	2.0			1.5	0.3	0.0	0.3	1.3	−12.5	
2007	2.6	0.7	1.9	0.2	0.0	2.1			1.7	0.3	0.0	0.3	1.5	−12.5	
2008	2.9	0.7	2.2	0.2	0.0	2.2			2.0	0.3	0.0	0.3	1.8	−12.2	
2009	3.1	0.7	2.4	0.1	0.0	2.4			2.3	0.3	0.0	0.3	2.0	−11.7	
2010	3.3	0.7	2.6	0.1	0.0	2.5			2.5	0.3	0.0	0.3	2.2	−10.9	
2011	3.4	0.8	2.6	0.1	0.0	2.5			2.5	0.3	0.0	0.3	2.2	−9.9	
2012	3.5	0.8	2.7	0.1	0.0	2.6			2.6	0.3	0.0	0.3	2.4	−8.8	
2013	3.7	0.8	2.9	0.1	0.0	2.7			2.8	0.3	0.0	0.3	2.6	−7.3	
2014	3.8	0.8	3.0	0.1	0.0	2.8			2.9	0.3	0.0	0.3	2.7	−5.5	
2015	3.9	0.8	3.1	0.0	0.0	3.0			3.1	0.3	0.0	0.3	2.8	−3.4	
2016	4.0	0.8	3.2	0.0	0.0	3.1			3.2	0.3	0.0	0.3	2.9	−0.9	Loss
2017	4.1	0.9	3.3	0.0	0.0	3.2			3.3	0.2	0.0	0.2	3.1	2.1	Profit
2018	4.2	0.9	3.3	0.0	0.0	3.3			3.3	0.1	0.0	0.1	3.2	5.3	
2019	4.4	0.9	3.5	0.0	0.0	3.4			3.5	0.0	0.0	0.0	3.5	8.8	
TOTAL	66.6	18.0	48.8	4.5	3.9	45.2	4.6	4.6	49.6	4.6	4.6	18.4	31.2		

Note : Total does not add up due to rounding up of figures.

Part IV
Road and Intersection Improvement Plan

PART IV : ROAD AND INTERSECTION IMPROVEMENT PLAN

1.0 INTRODUCTION

This part describes the implementation plans for the improvement of Perak Road and Dato Keramat Road which are proposed to be carried out as soon as possible.

It also discusses the improvement plan for the intersection of Perak Road and Dato Keramat Road, in particular, the necessity of a flyover at this intersection.

2.0 ROAD IMPROVEMENT PLANS FOR PERAK ROAD AND DATO KERAMAT ROAD

The road improvement plans for Perak Road and Dato Keramat Road are designed using the following planning criteria.

The planning criteria are :

(1) both roads should be designated as primary roads,

(2) Dato Keramat Road and the section of Perak Road between Anson Road and Sungei Pinang Road should be a dual carriageway with uninterrupted two (2) lanes for each direction.

Based on the application of traffic survey data obtained by the Study Team and the abovementioned planning criteria to the intersection, geometric design criteria, road improvement designs for Perak Road and Data Keramat Road have been prepared. The layout plans of Perak Road with two and three lanes in each direction are shown in Figures 2.1 and 2.2 respectively whereas that of Dato Keramat Road is depicted in Figure 2.3.

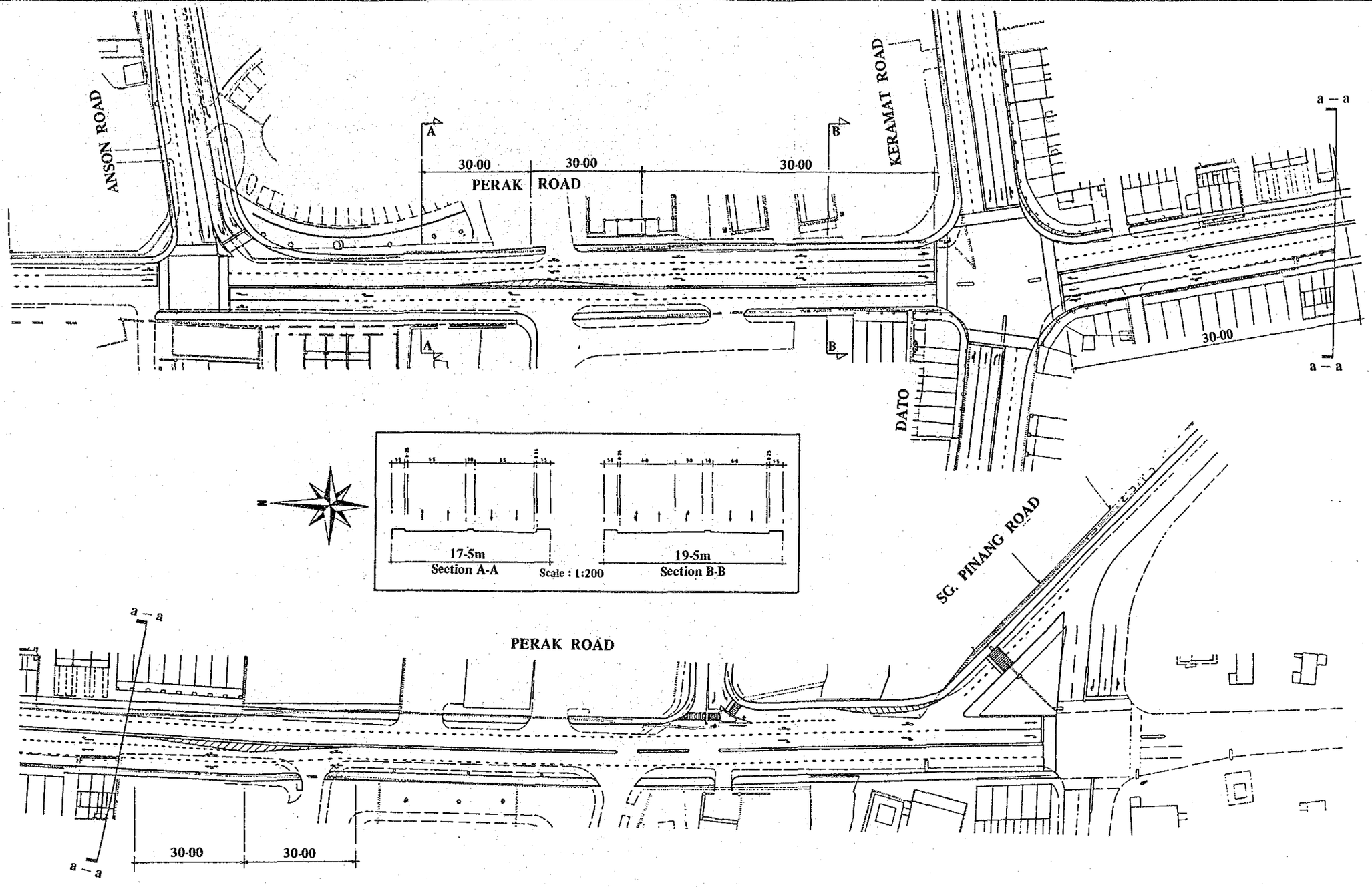
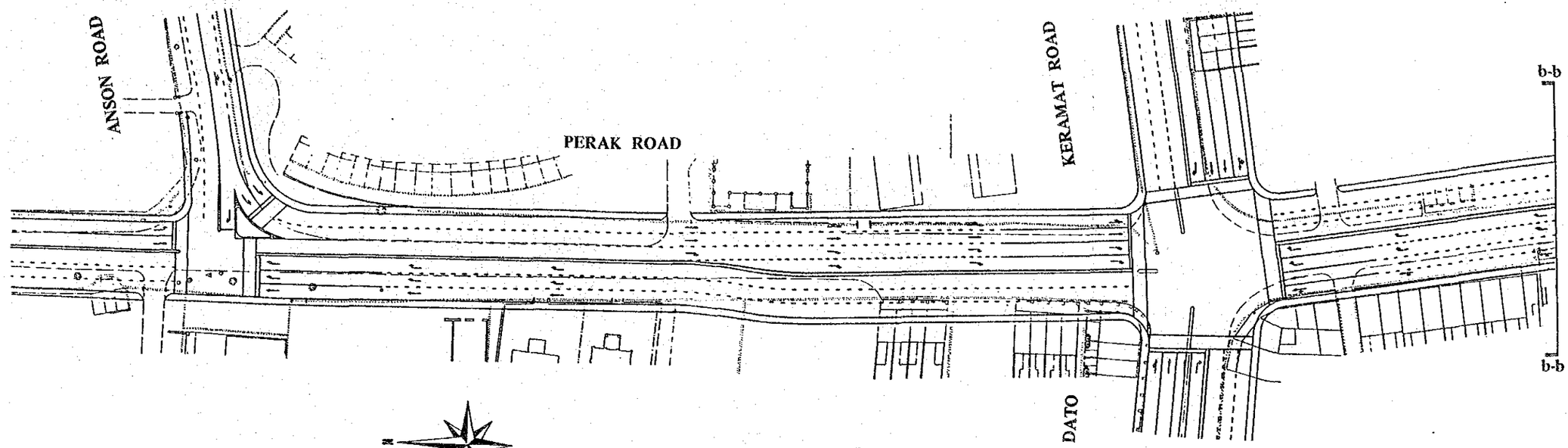
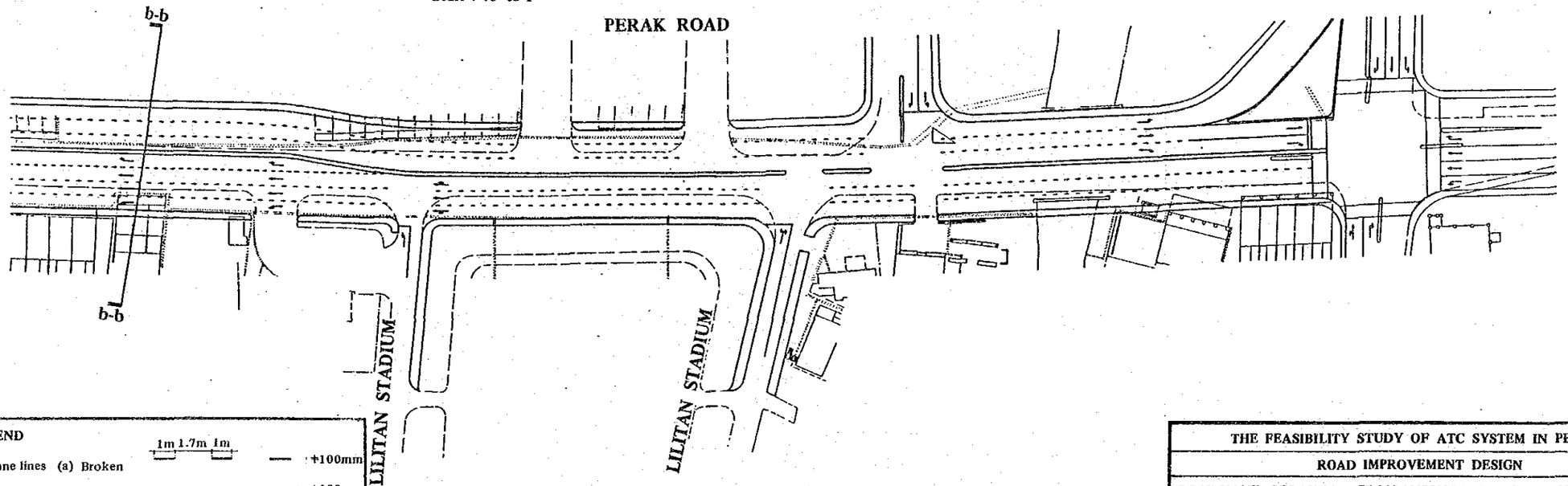


Figure 2.1 : Layout Plan Of Perak Road With Two Lanes In Each Direction



Scale : 40' to 1"



LEGEND

i) Lane lines (a) Broken — 1m 1.7m 1m — ±100mm

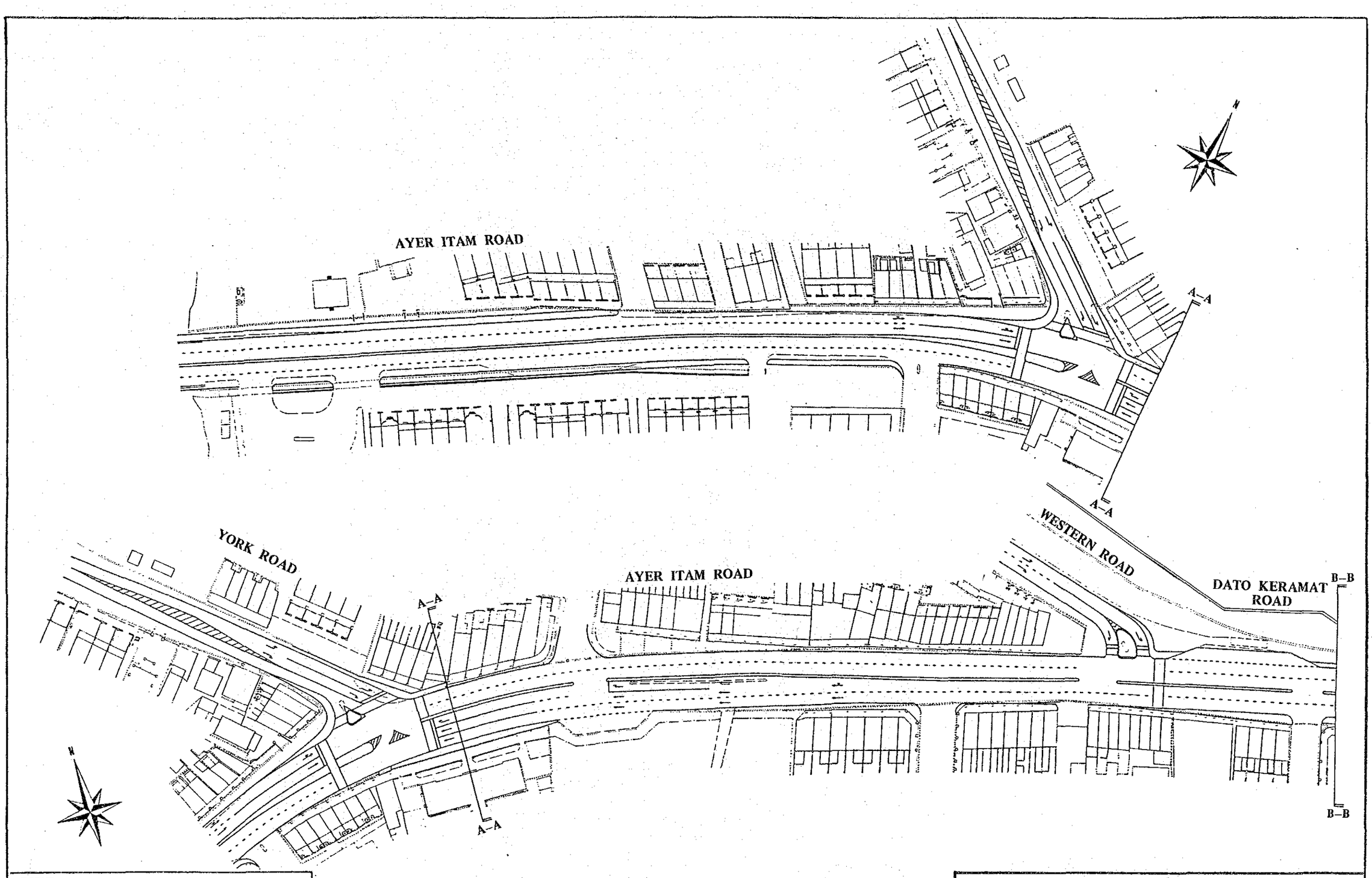
(b) Unbroken — ±100mm

ii) Edge lines — ±150mm

iii) Continuity lines — 1m 1m 1m — ±200mm

THE FEASIBILITY STUDY OF ATC SYSTEM IN PENANG
ROAD IMPROVEMENT DESIGN
ROAD NAME: PERAK RD. (FROM ANSON RD. TO SG. PINANG RD.) (6 lanes) SCALE : 1/400
DATE: Sept., 1987 SHEET NO __ OF __ PLAN NO 4004
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

Figure 2.2. : Layout Plan Of Perak Road With Three Lanes In Each Direction



LEGEND

i) Lane lines (a) Broken — 1m 1.7m 1m — ±100mm

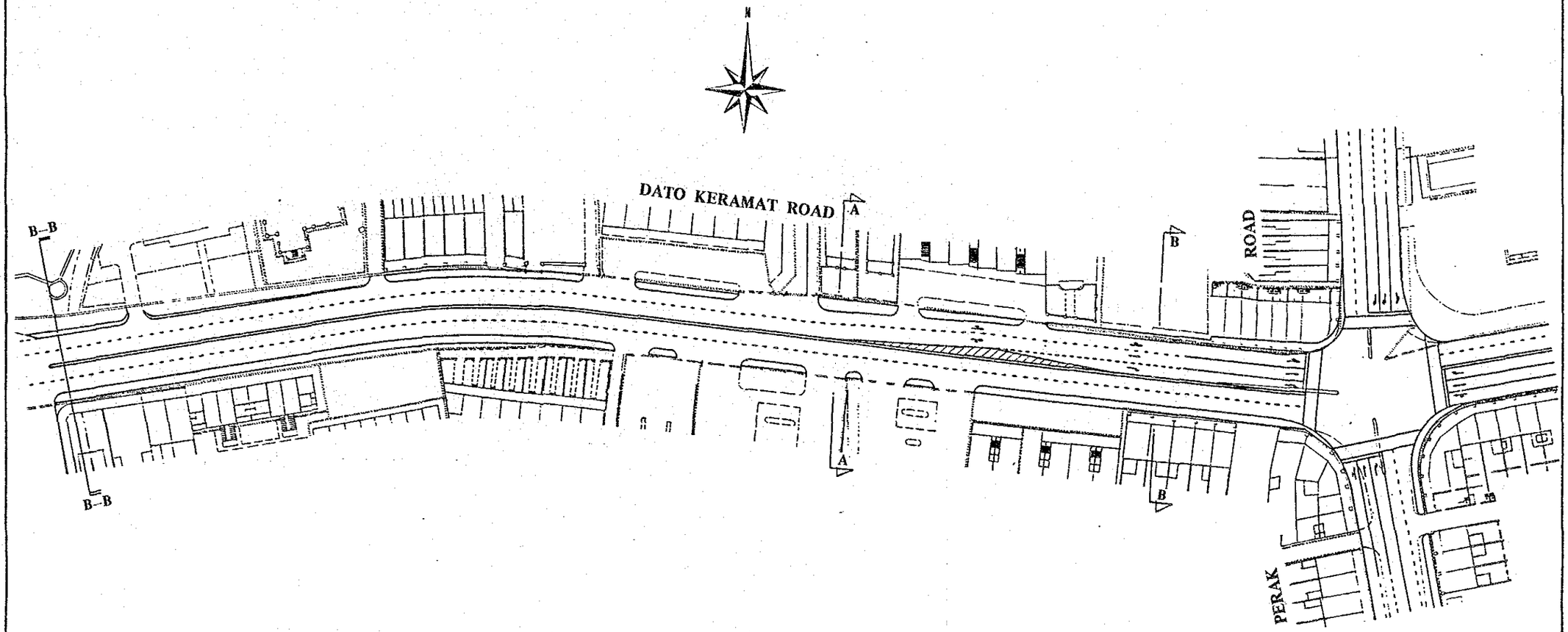
(b) Unbroken — ±100mm

ii) Edge lines — ±150mm

iii) Continuity lines — 1m 1m 1m — ±200mm

THE FEASIBILITY STUDY OF ATC SYSTEM IN PENANG
ROAD IMPROVEMENT DESIGN
ROAD NAME: DATO KERAMAT ROAD (FROM YORK RD. TO PERAK RD.) (1)
SCALE : 1/400
DATE: Sept., 1987 SHEET NO ___ OF ___ PLAN NO 4001
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

Figure 2.3 (1) : Layout Plan of Dato Keramat Road



LEGEND

i) Lane lines (a) Broken — 1m 1.7m 1m — +100mm

(b) Unbroken — +100mm

ii) Edge lines — +150mm

iii) Continuity lines — 1m 1m 1m — +200mm

THE FEASIBILITY STUDY OF ATC SYSTEM IN PENANG
ROAD IMPROVEMENT DESIGN
ROAD NAME: DATO KERAMAT ROAD (FROM YORK RD. TO PERAK RD.) (2) SCALE : 1/400
DATE: Sept., 1987 SHEET NO.__ OF__ PLAN NO 4002
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

Figure 2.3(2) : Layout Plan of Dato Keramat Road

3.0 IMPROVEMENT PLAN FOR THE INTERSECTION OF PERAK ROAD AND DATO KERAMAT ROAD

The intersection of Perak Road and Dato Keramat Road is one of the heavily congested intersections, even though the ATC System – Stage I has successfully reduced its congestion to a lower degree. However, this intersection will become a serious traffic bottleneck in future if nothing is being done.

This section examines the necessity of a flyover (or overbridge for vehicle) at the intersection from the traffic engineering view point.

A. Future Traffic Demand

The future traffic demands in 2000 are estimated* based on the data obtained by traffic count survey and traffic assignment simulation.

The observed peak hour volume in 1987 was 5,550 PCU per hour. The estimated peak hour in 2000 is 8,420 PCU per hour, which is about 1.5 times of the existing volumes.

The peak hour volume of each traffic movement at the intersection of Perak Road and Dato Keramat Road in 2000 is shown in Figure 3.1.

Footnote:

* The traffic volumes are estimated using PCU value of 0.5 for motorcycle. However, at intersection, it is advisable to use PCU value of 0.33 for motorcycle. Thus, the estimated volumes are higher by about 11% than the actual volume at the intersection.

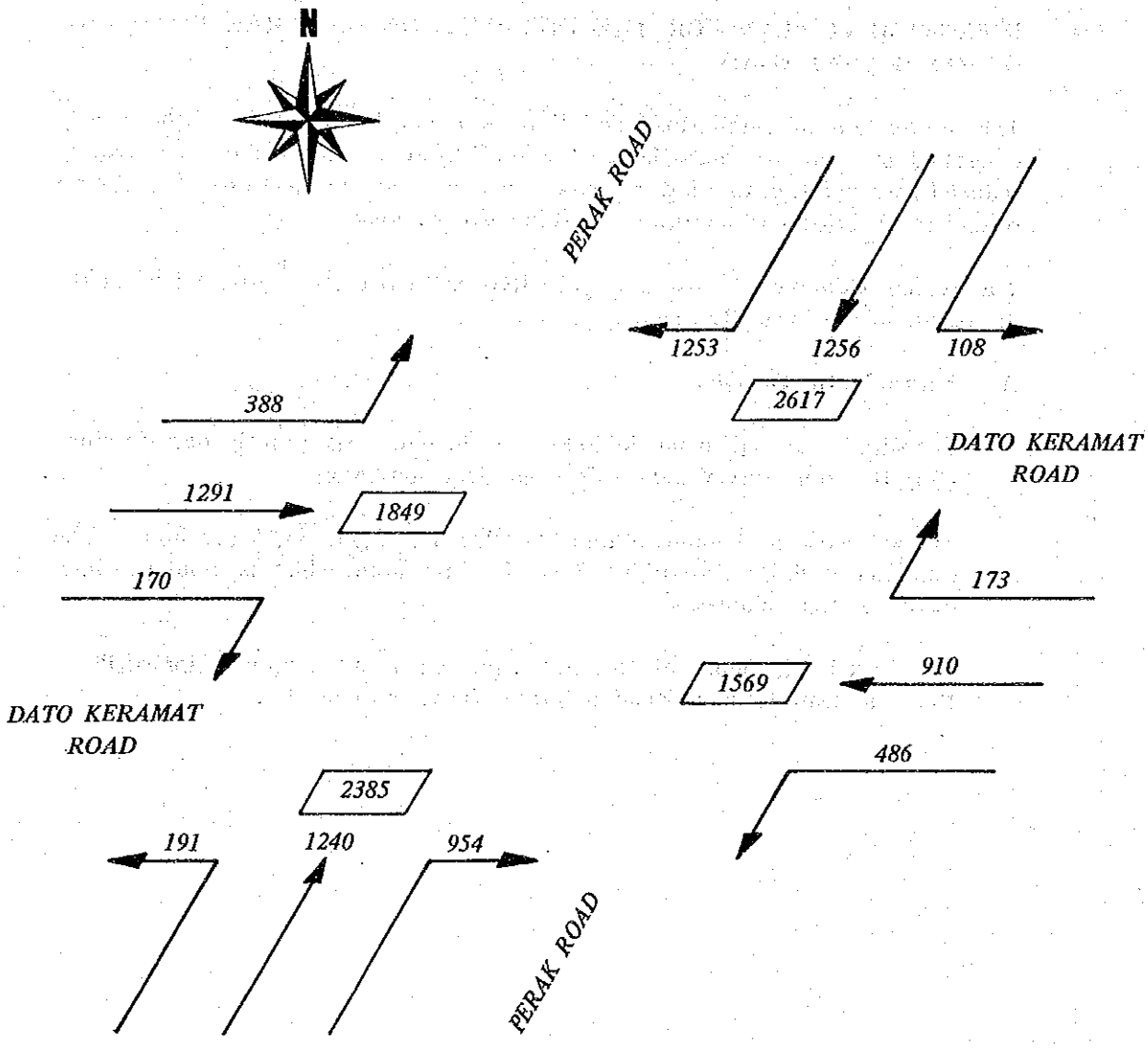


Figure 3.1 : Estimated Peak Hour Volume at Perak Road and Dato Keramat Road Intersection in 2000

B. Alternatives For Improvement

This analysis involves the consideration of four alternatives.

1. Alternative 1

The present intersection geometrics is not changed at all. There are three lanes on all the approaches : two lanes for through-traffic and one lane for right-turn traffic.

2. Alternative 2

All the approaches are widened to four lane operation with provision of left-turning lane.

On the approaches of Dato Keramat Road, three lanes for through-traffic movement and one lane for right-turn movement are considered.

On the approaches of Perak Road, two lanes for through-traffic and right-turn movements each are considered.

3. Alternative 3

This alternative provides a flyover with dual carriageway on Perak Road and two lane side road. The operation of approaches on Dato Keramat Road is the same as that of Alternative 2.

4. Alternative 4

This alternative provides a flyover on Dato Keramat Road and two lane side road. The operation of Perak Road approaches is the same as that of Alternative 2.

C. **Examination of Each Alternatives**

Figure 3.2 shows the traffic congestion degree under each alternative plan based on the relationship between traffic demand and intersection capacity.

It is found from the analysis that :

(1) If the present geometrics is not improved, the intersection will have serious problems before 2000.

(2) Alternative 2 can be adopted until 2000.

(3) It is necessary to provide a flyover at the intersection after 2000 and Alternative 3 (the provision of a flyover on Perak Road) is preferable.

However, the analysis on the flyover design shows that Alternative 3 is not desirable. It is because the flyover on Perak Road blocks the intersection of Perak Road and Anson Road and also the end of the flyover is too near the intersection of Perak Road and Sungei Pinang Road.

D. **Proposed Improvement Plan**

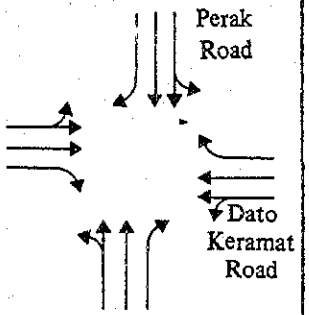
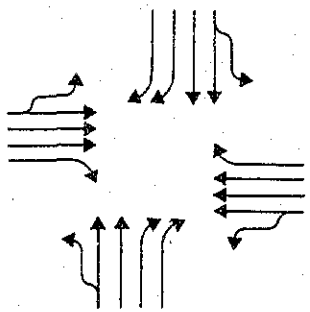
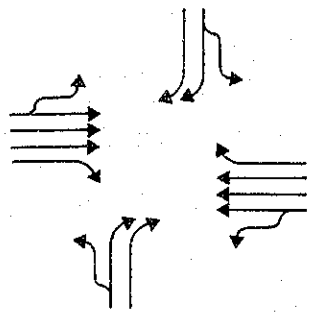
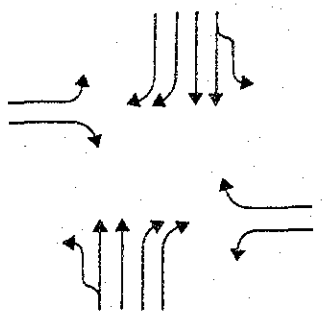
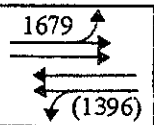
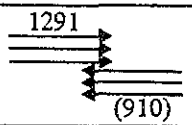
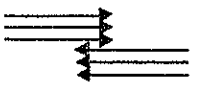
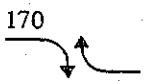
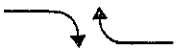
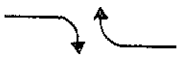
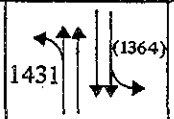
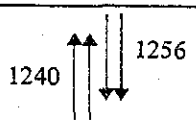
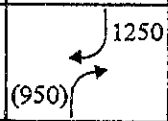
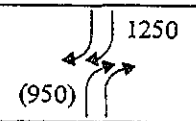
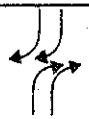
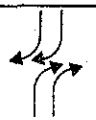
Based on the analysis and the road condition in the periphery of the intersection, the followings are proposed:

(1) widening of all the approaches of the intersection depending on traffic demand, in particular, the widening of Perak Road is more important than that of Dato Keramat Road

(2) provision of a flyover on Dato Keramat Road after 2000

However, before the decision on the implementation is made, it is important to consider traffic conditions at the up-stream and down-stream intersections.

Figure 3.3. shows the proposed flyover design on Dato Keramat Road.

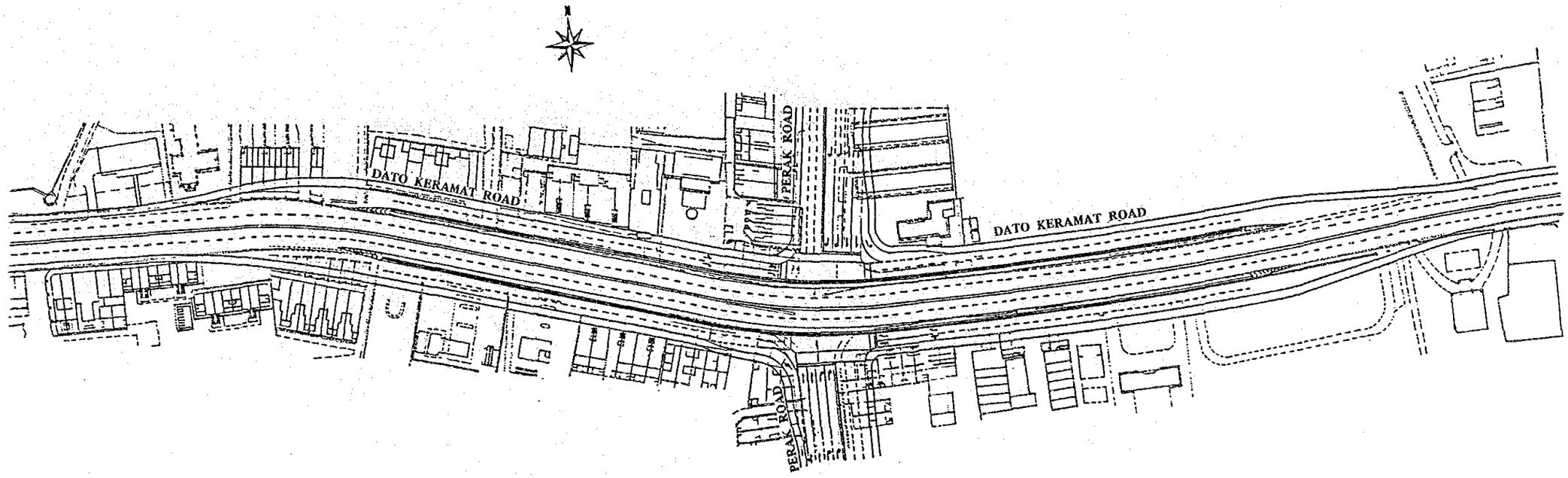
Phasing	Alternative 1 No Changing of Geometrics		Alternative 2 Widening on Perak Road and Dato Keramat Road		Alternative 3 Flyover on Perak Road		Alternative 4 Flyover on Dato Keramat Road	
								
1		0.47		0.24		0.24		0.00
2		0.09		0.09		0.09		0.09
3		0.40		0.35		0.00		0.35
4		0.69		0.35		0.35		0.35
		1.65		1.03		0.68		0.79

Notes : Lane Capacity is 1800 PCU

: The Values show the congestion degree for the critical movement

: Each estimated value should be lessened by 11% due to lower PCU for motorcycle

Figure 3.2 : Traffic Congestion Degree of each Alternatives in 2000



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FLYOVER ON DATO KERAMAT ROAD
DATE: Sept., 1987 SHEET NO __ OF __ PLAN NO 4005
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

Figure 3.3 : Proposed Flyover Design On Dato Keramat Road