5. Traffic Projection of Alternative Plans

TRAFFIC PROJECTION OF ALTERNATIVE PLANS

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5. TRAFFIC PROJECTION OF ALTERNATIVE PLANS

5.1 Procedure

After the future traffic demand is calculated, the alternative plans in the Study Area already selected in Chapter 4, are taken into consideration. According to these alternative plans, two (2) major estimations will be executed in this chapter.

1. To bring the modal split of the O-D table, already estimated in Chapter 3, in accordance with the intentions of the alternative plans and to complete the O-D table by alternative policies.

2. To apply the O-D table to the alternative road network and to estimate the traffic volume on each road.

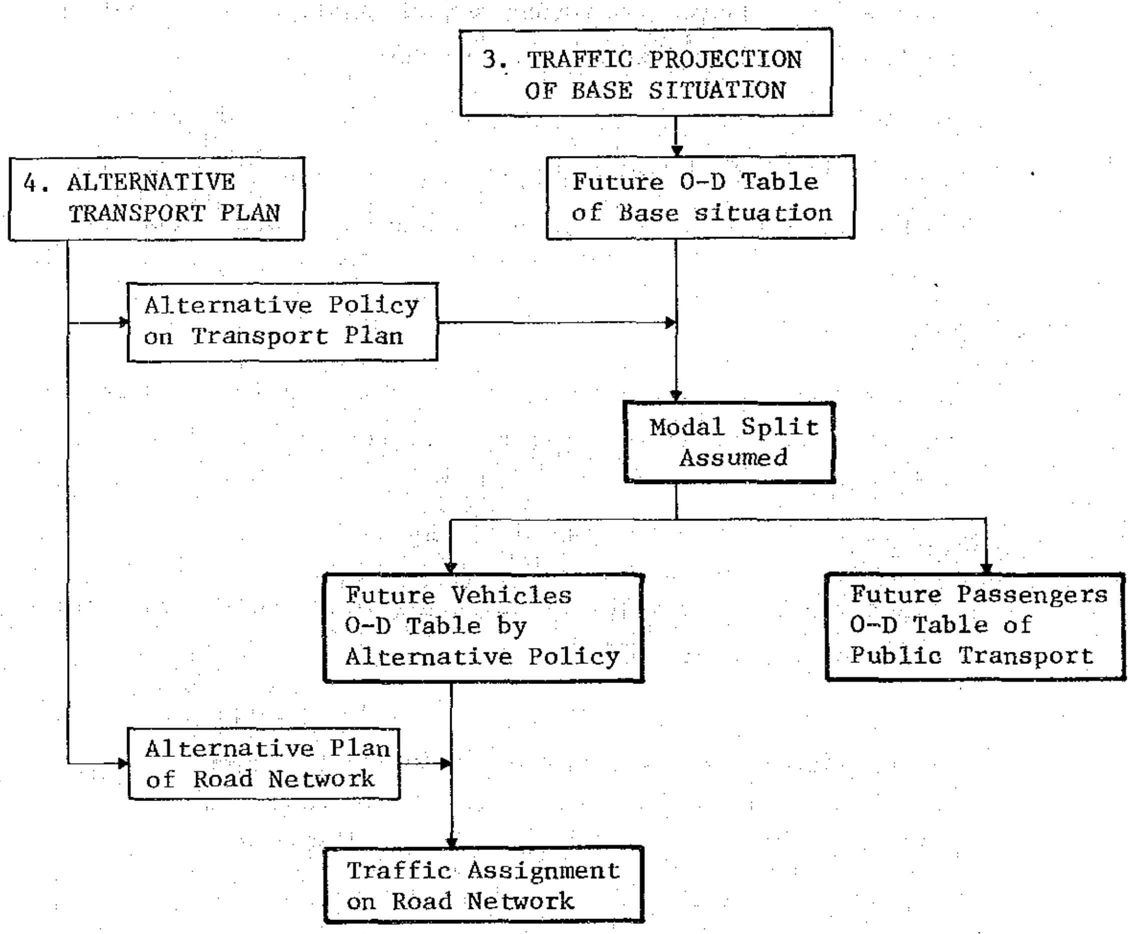


Fig. 5.1 PROCEDURE OF TRAFFIC PROJECTION

5.2 Estimation of Future Traffic Demand by Alternative Plans

The future O-D table described in Chapter 3 is estimated according to the demand of vehicles. However, this actual appearance of the traffic volume is affected by many restrictions and by any alternative transport, that is, if there are no parking areas, vehicle traffic will decrease and if there is some superior mode of transport faster than vehicles, some vehicle owners will divert to this new mode of transport.

In this chapter, the concept of modal split is introduced and future traffic demand is re-calculated by alternative plans.

The content of the alternative plans is already formed along the following four (4) alternatives:

1. Plan A

   There are no changes from the present situation. The estimation is already conducted in a previous chapter.

2. Plan B

   In this plan, the control of parking demand and the alternative transport, which is represented by exclusive bus lanes, are considered.

3. Plan C

   In this plan, a new transport system which is imagined as the Lightway Rail System is considered of Penang Island in addition to Plan B.

4. Plan D

   In this plan, the control of parking demand and the car pooling system are considered.

The estimations are executed as follows;

Year	Plan - B	Plan - C	Plan - D
1985	execute		
2000	execute	execute	execute

5.2.1 The Premises for Calculation

For the purpose of estimating the traffic demand by alternative plans, the following three (3) premises must be introduced first:

1. Control of Parking Demand
2. Diversion to Public Transport.
3. Car Pooling System.

1. Control of Parking Demand

The premises for calculation are as follows;

1) The object area of parking control is limited to C.B.D. in George Town (that is zone 111, 121, 131).

2) The differences in volume between the parking demand and the parking supply are to be controlled and diverted to the public transport.

3) These differences are subtracted from the traffic volume to C.B.D. whose purpose is 'going to work' by private car, and the equal amount is subtracted from the travel volume whose purpose is 'going home' by private car.

4) For the parking ratio and the average number of passengers the present figures which were obtained through the traffic survey are used.

5) There are no restrictions concerning motor-cycles.

6) The average number of passengers with the trip purpose "going to work' in each car, obtained from the present traffic surveys is 1.4.

The calculation will be executed according to the following flow cahrt.

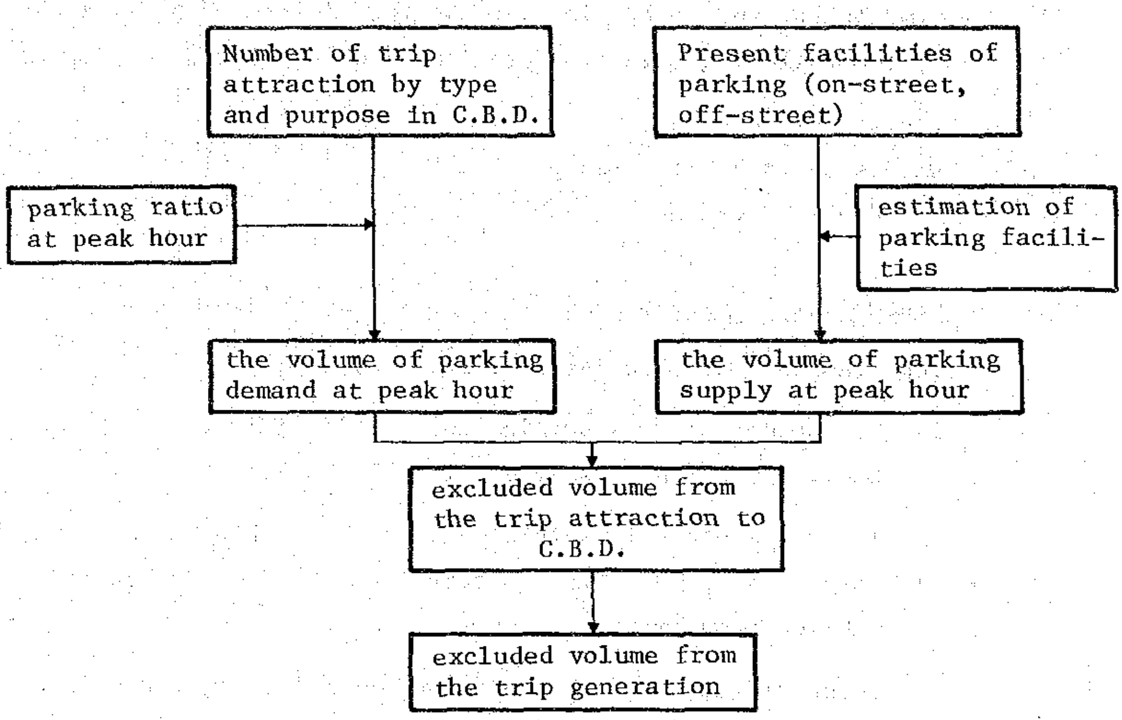


Fig. 5.2 THE FLOW CHART OF CONTROL OF PARKING DEMAND

According to this flow chart, the excluded volume due to control of parking demand is calculated as follows;

(a) Parking demand

The parking demand at peak hours is as follows:-

Table 5.1 PARKING DEMAND AT PEAK HOUR IN C.B.D.

(Unit : trip end)

	year	1979	1985	2000
Car	To Work	12440	15010	24410
	On Business	1880	2320	3930
	Private	1290	1690	3030
	Home	540	680	980
Lorry		1300	1600	3300
Total		17450 (100)	21300 (122)	35650 (204)

(b) Parking supply

The volume of parking supply is estimated by our parking survey as follows:-

Table 5.2 THE VOLUME OF PARKING SUPPLY

(Unit : vehicles)

year	1979	1985	2000
On-street	14133	11500	10000
Off-street	3491	6500	11000
Total	17624	18000	21000

From Table 5.1 and Table 5.2, the excluded volume due to the shortage of parking supply is calculated as follows;

Table 5.3 *THE EXCLUDED VOLUME BY CONTROL OF PARKING*

(Unit : 1000 trip end)

year	1979	1985	2000
demand volume	17.5	18.0	21.0
supply volume	17.6	21.3	35.7
difference	+0.1	-3.3	-14.7
excluded volume	-	-6.7	-29.3

2. Diversion to Public Transport

People who live in urban areas always choose a suitable mode of transport according to their own judgement. Various factors play a role in this choice, but generally these factors can be classified under the concept of distance from place of origin to destination.

The concept of distance means, of course, actual distance, time distance and economic distance which includes the travel fee.

In the "URBAN TRANSPORT POLICY AND PLANNING STUDY FOR METROPOLITAN KUALA LUMPUR", the diversion curve and the time differences between alternative periods of transport are chosen as the determining factors for the modal-choice model. As there is no other modal-choice data available for our study area, the above-mentioned data is used for the estimation of diversion from vehicle traffic volume to public transport.

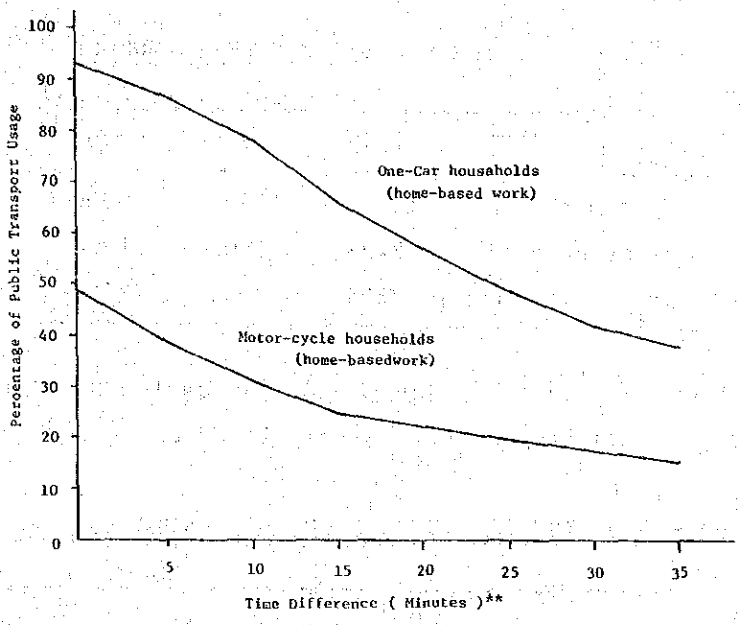


Fig. 5.3 MODAL CHOICE MODEL *

* SOURCE : URBAN TRANSPORT POLICY AND PLANNING STUDY FOR METROPOLITAN KUALA LUMPUR.

** (Public - Private transport)

The following premises have to be taken into consideration.

1) The object areas for diversion are limited to those areas which are directly related to the alternative public transport plans.

2) Since the calculation of diversion for "going to work" purpose by private car or motro-cycle, is the same as for the "going home" purpose by private car or motor-cycle, this calculation will suffice.

3) The ratio of diversion is calculated by means of the reduction time provided by means of the alternative public transport plan and the diversion curve of the above-mentioned study.

4) Travel time is calculated as follows:-

	BUS		N.T.S.
Schedule speed	25 Km/h	(Exclusive lane)	30 Km/h
	15 Km	(Urbanized area)	
	20 Km	(other area)	
Operation internal	5 min.	(Urbanized area)	10 min.
	10 min.	(other area)	
Approach distance to stops	250 m	(Urbanized area)	500 m
	500 m	(other area)	

5) Average passenger numbers of cars and motor-cycles with the trip purpose "going to work" are 1.4 and 1.2 respectively.

The volume of diversion from car and motor-cycles to public transport is shown in the following table.

Table 5.4 THE VOLUME OF DIVERSION BY TRANSPORT PLANS

(Unit : 1000 trips)

Year		In Penang Island		In Province Wellesley	
		Car	M/C	Car	M/C
1985 Caused by Bus exclusive Lane	internal trips	221.9	273.7	71.8	151.6
	volume of diversion	2.3	3.6	0.5	1.2
2000 Caused by Bus Exclusive Lane	internal trip	424.0	241.8	215.1	193.8
	volume of diversion	3.5	3.6	1.7	2.1
2000 N.T.S.	internal trip	424.0	241.8	-	-
	volume of diversion	12.9	9.1	-	-

3. Car Pooling System

The Car Pooling System is devised in order to prevent traffic congestion which is caused by private cars entering the C.B.D.

As a result of this system whereby cars are enforced to carry a minimum amount of passengers, the number of cars, hence the traffic volume will decrease.

The premises are as follows;

1) The enforcement area of the car pooling system is limited to the C.B.D. in George Town.

2) By imposing an additional charge on the cars which have few passengers, the average number of passengers will increase from 1.65 to an average of 3.0.

3) All cars entering or leaving the C.B.D. are subject to the Car Pooling System, irrespective of trip purpose ("going to work" or "private").

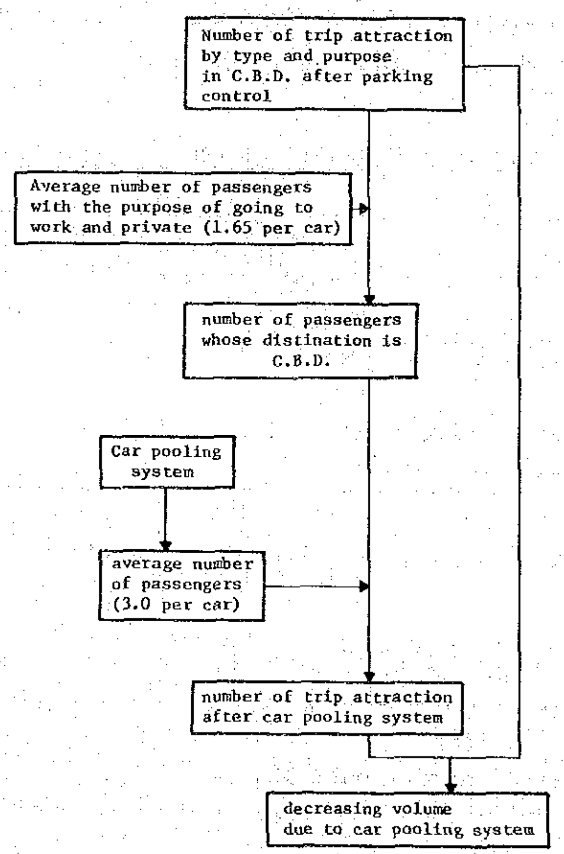


Fig. 5.4 FLOW CHART OF CALCULATION FOR THE YEAR 2000

The number of trip attraction in the C.B.D. after parking control is as follows;

Table 5.5 NUMBER OF TRIP ATTRACTION IN C.B.D.

(unit : 1000 trip ends)

		trip attraction
Car	To work	43.4
	On Business	28.0
	Private	43.3
	Home	24.4
Lorry		23.6
Taxi		7.5
Bus		5.9
Sub-total		176.1
Motor-cycles		95.5

From this table, the number of passengers whose trip purposes are "going to work" "private" total 143,100 persons (86,700 cars x 1.65 persons).

After the car pooling system is executed, there will be a decrease in the number of cars as follows.

Table 5.6 DECREASING VOLUME DUE TO CAR POOLING SYSTEM

(Unit : 1000 trip ends)

	number of trip attraction	number of passengers	average number of passengers
before car pooling system	86.7	143.1	1.65
after car pooling system	47.7	143.1	3.0
decreasing volume on one way direction	39.0		
decreasing volume on both way	78.0		

5.2.2 Estimation of Traffic by Alternative Plans

The total traffic volume related to the Study Area is estimated as follows:

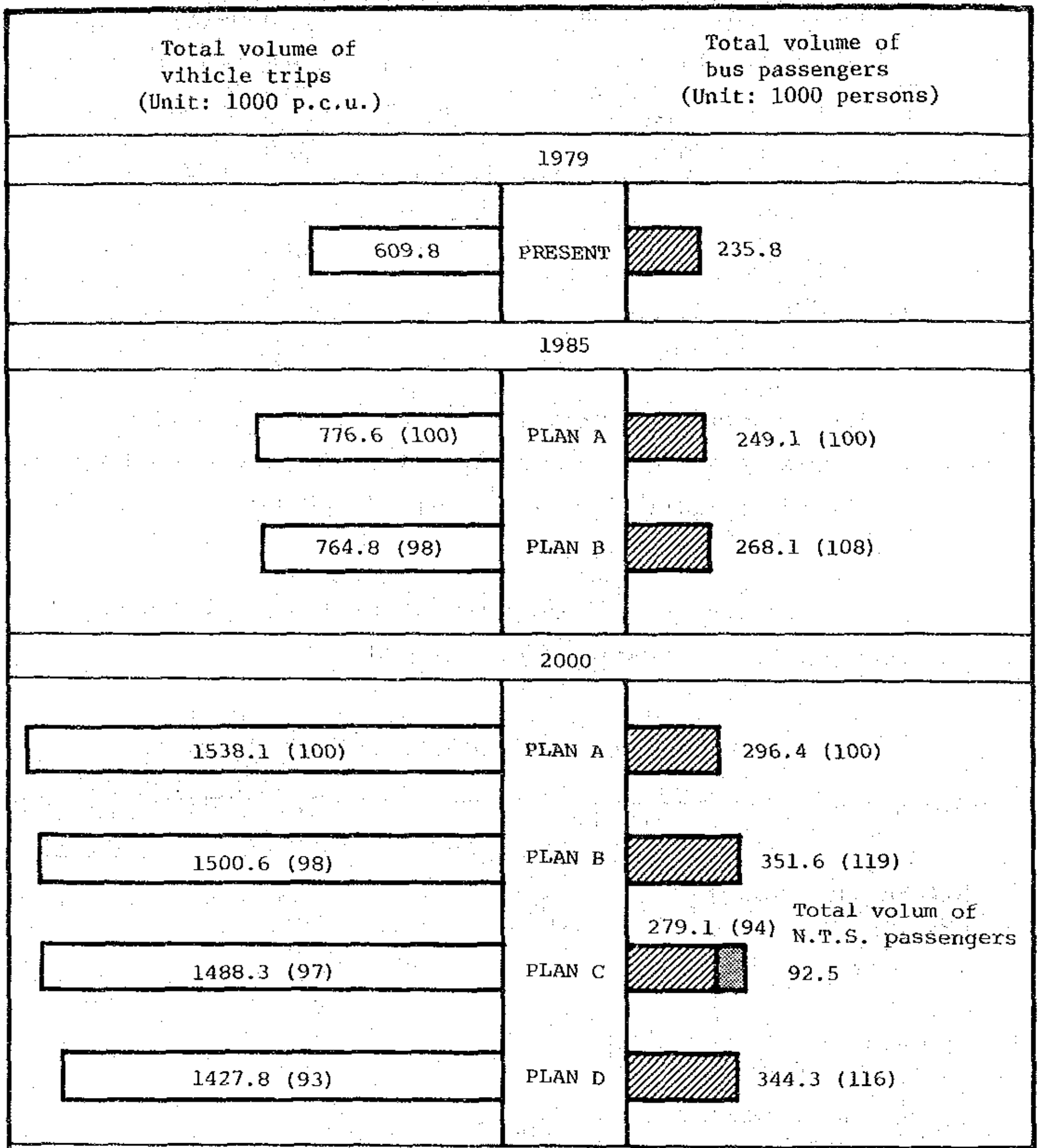


Fig.5.5 Total volum by Alternative Plan

Table 5.7 SUMMARY OF TOTAL VOLUME BY ALTERNATIVE PLANS

– 1985 – (Unit : 1000 trips, p.c.u., persons)

		Vehicle (trips)	Motor-cycle (trips)	C.P.U.	Bus passenger
	PLAN A	440.0	465.3	776.6	249.1
PLAN B	control parking demand	-6.7	-	-6.7	+9.4
	exclusive bus lane	-2.8	-4.7	-5.2	+9.6
	Total trips	430.5	460.5	764.8	268.1

– 2000 – (: 1000 trips, p.c.u., persons)

		Vehicle (trips)	Motor-cycle (trips)	C.P.U.	Bus passenger	N.T.S. passenger
	PLAN A	1044.9	477.9	1538.1	296.4	-
PLAN B	control of parking demand	-29.3	-	-29.3	+41.0	-
	exclusive bus lane	-5.2	-5.7	-8.0	+14.2	-
	Total trips	1010.4	472.2	1500.6	351.6	-
PLAN C	control of parking demand	-29.3	-	-29.3	+41.0	-
	N.T.S.	-12.9	-9.1	-17.5	-63.4	+29.1 +63.4
	exclusive bus lane	-1.8	-2.1	-2.8	+5.1	-
	Total trips	1000.9	466.6	1488.3	279.1	92.5
PLAN D	control of parking demand	-29.3	-	-29.3	+41.0	-
	car pooling system	-78.0	-	-78.0		-
	exclusive bus lane	-	-5.7	-2.9	+6.9	-
	Total trips	937.5	472.2	1427.8	344.3	-

(1) Comparison of Alternative Plans

(a) Comparison by trip generation and attraction

Execution of the transport plans is particularly related to the C.B.D. area in George Town because these plans are devised to prevent traffic congestion around the C.B.D. area. Trip generation and atraction of the C.B.D. area (zone 111, 121, 131) by alternative plans are compared as follows:-

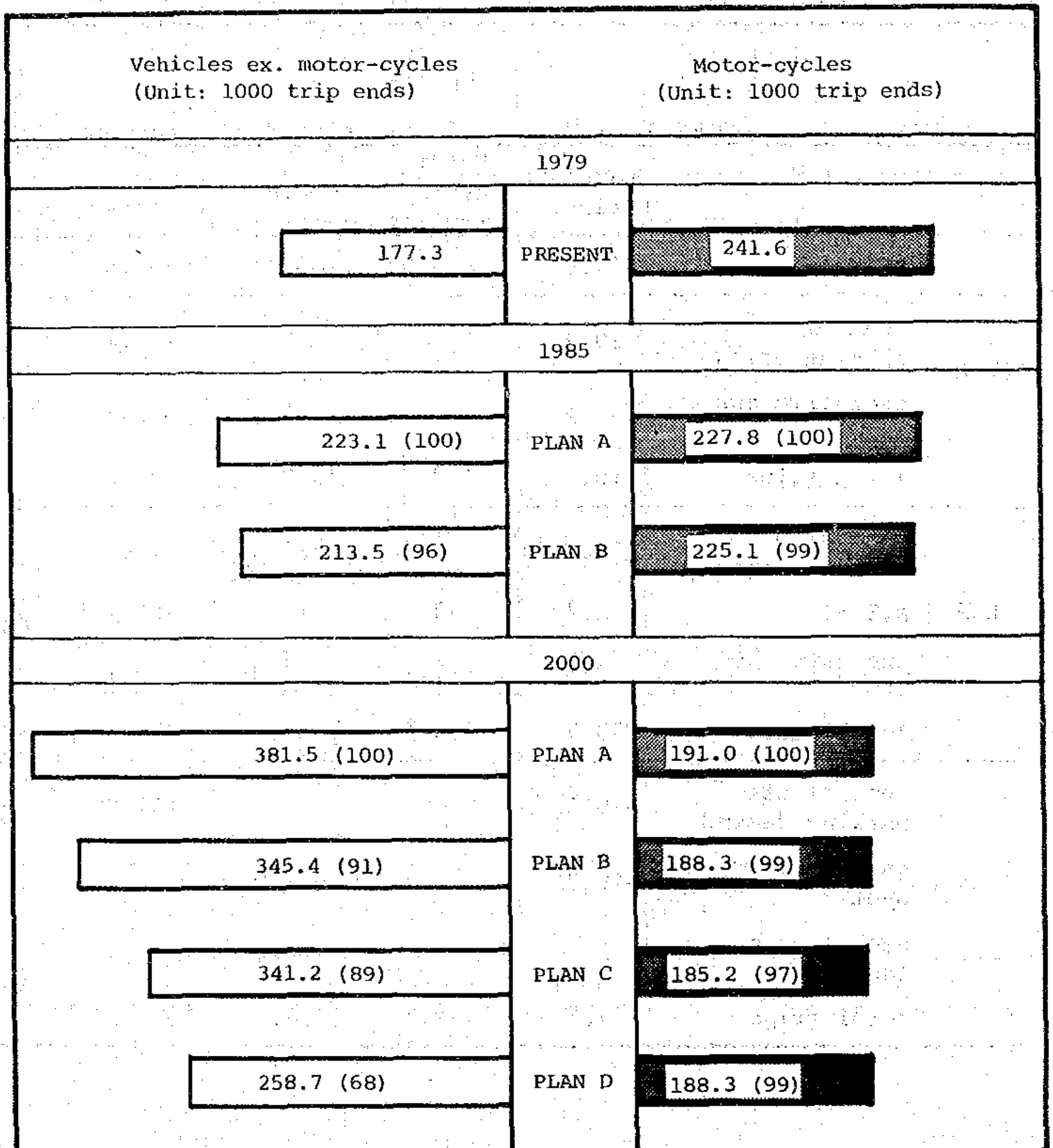


Fig.5.6 Comparison of Trip Generation and Attraction in C.B.D.

(b) Comparison by desired assignment

All transport plans, if executed, will increase the demand of vehicle trips. The effects are particularly notable on the cordon line of middle zone 11. The figures are shown as follows:-

Table 5.8 COMPARISON OF THE TRAFFIC DEMAND

(Unit : 1000 p.c.u.)

		Traffic demand on the cordon line of zone 111		Trassif demand on the line between George Town and Bayan Lepas	
1985	Plan A	127.7	-	105.7	-
	Plan B	165.6	-7.1	103.7	-2.0
2000	Plan A	293.9	-	239.1	-
	Plan B	272.1	-21.8	230.7	-
	Plan C	267.5	-26.4	255.5	-13.6
	Plan D	223.8	-70.1	212.0	-27.1
1979		147.9		62.9	

Note: The differences are subtracted from Plan A.

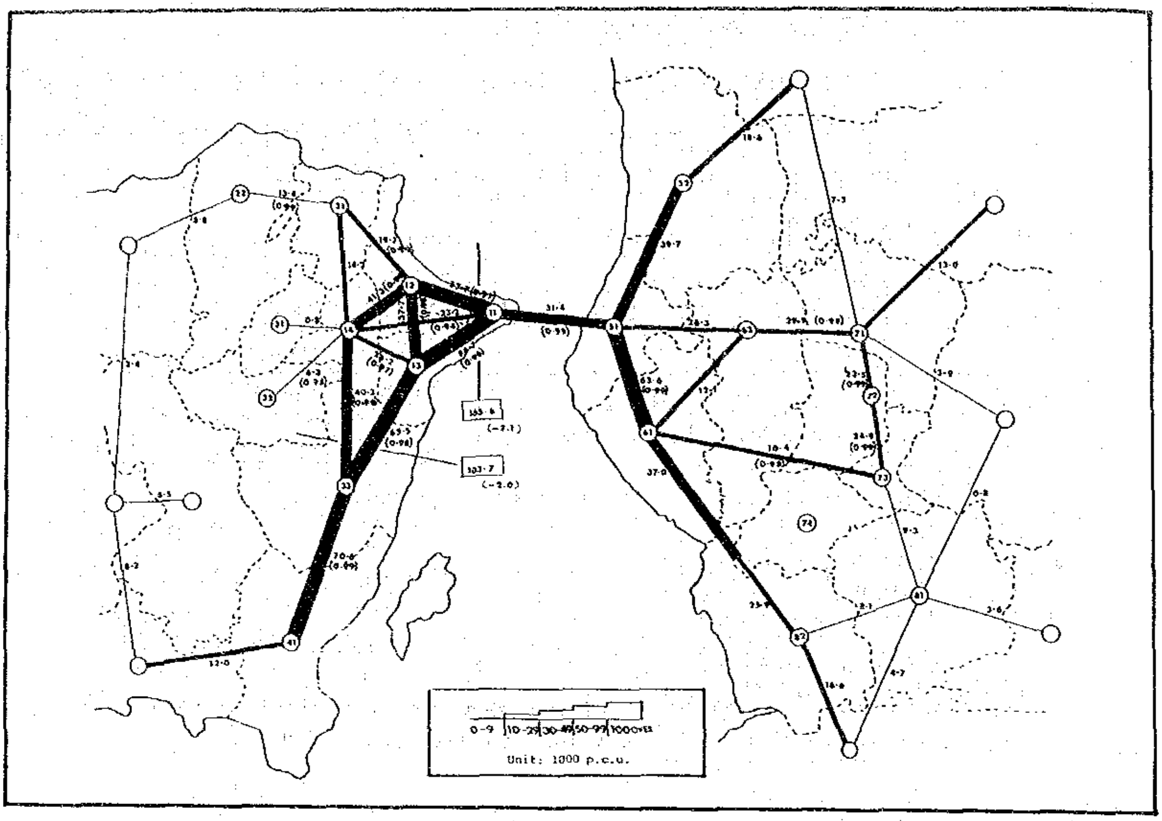


Fig. 5.7 Desired Assignment by Plan B (1985)

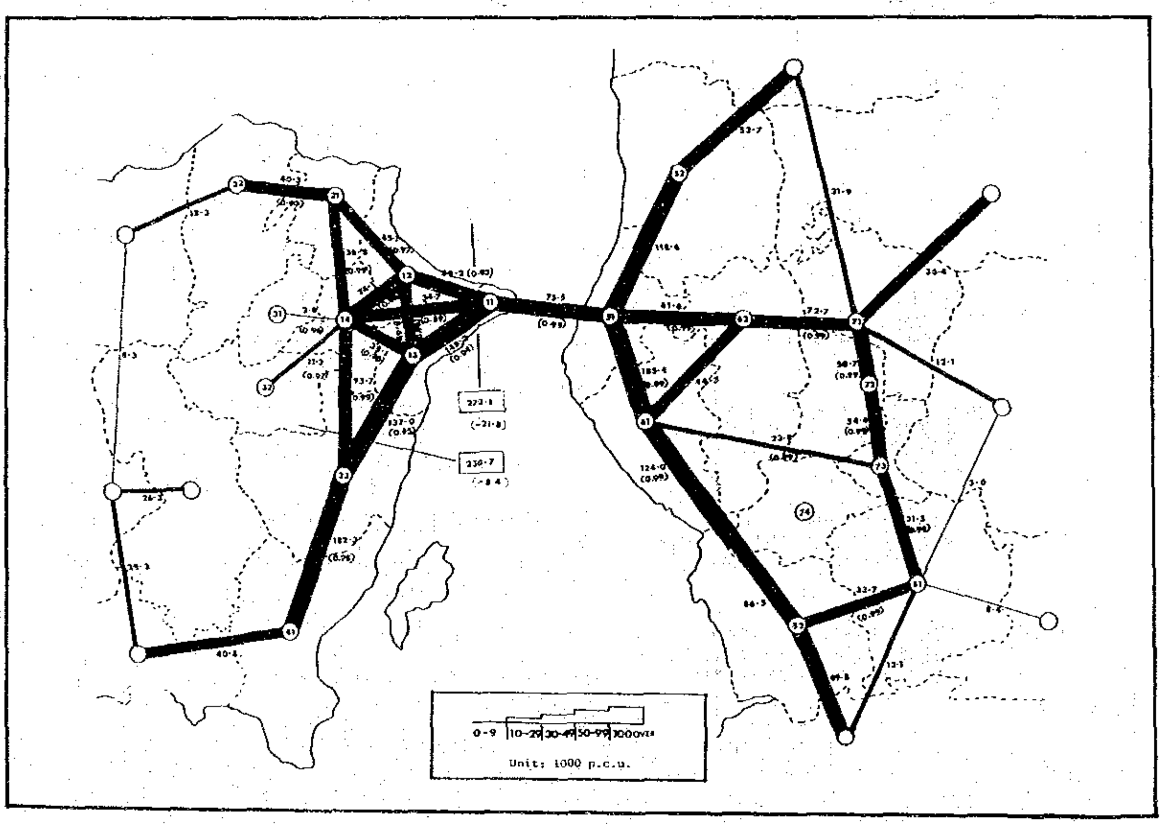


Fig. 5.8 Desired Assignment by Plan B (2000)

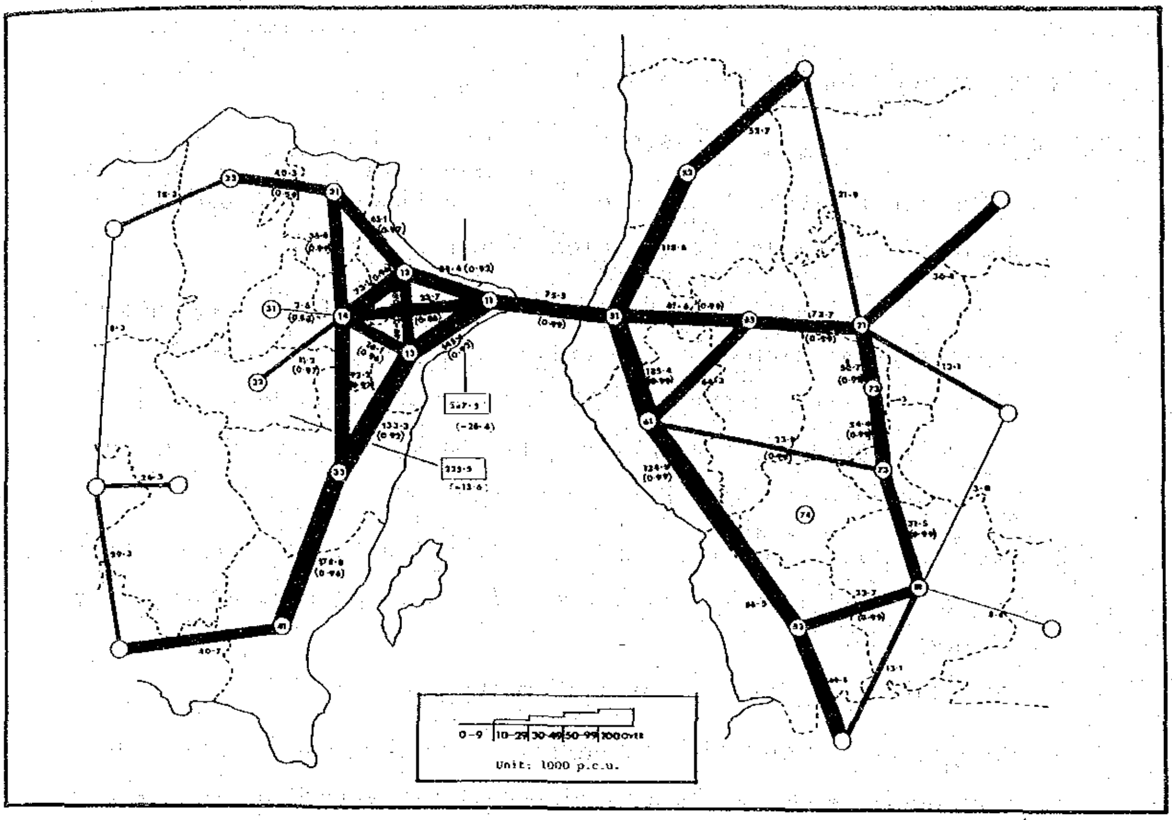


Fig. 5.9 Desired Assignment by Plan C (2000)

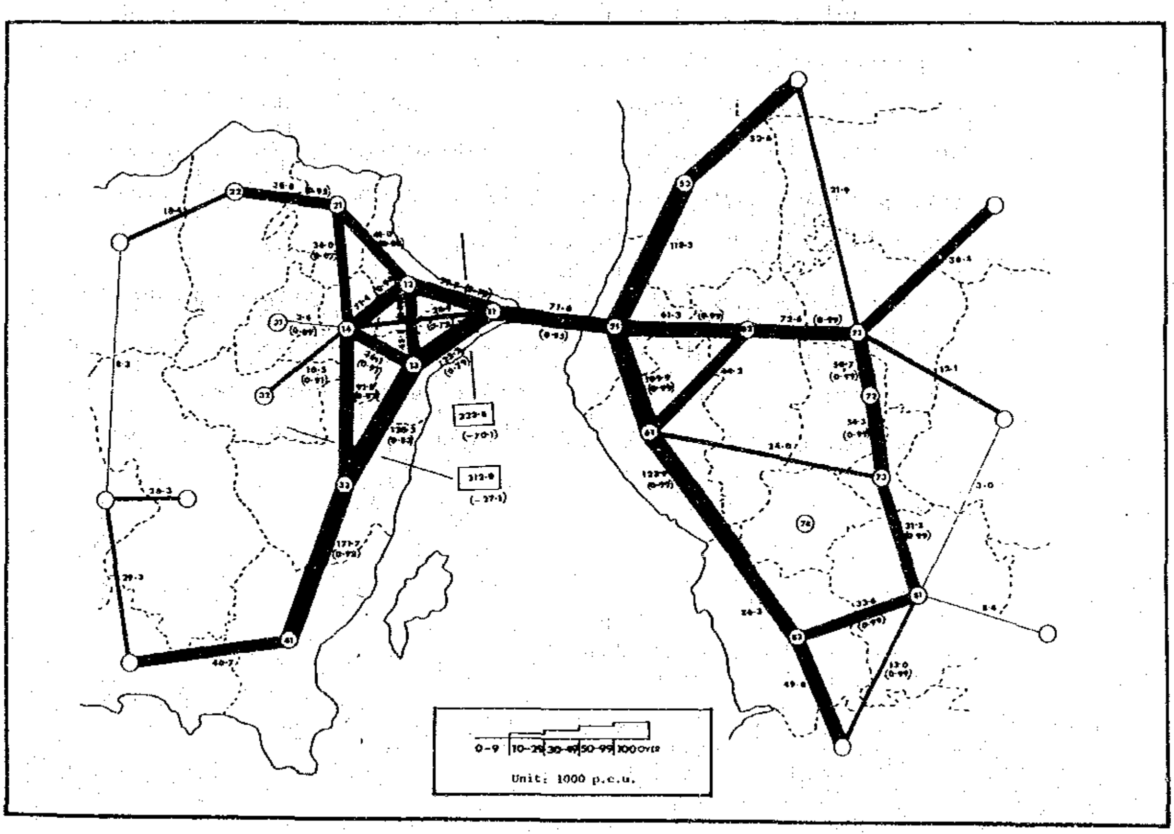


Fig. 5.10 Desired Assignment by Plan D (2000)

5.3 Estimation of Future Traffic Demand on Road Network

5.3.1 Procedure for Traffic Assignment

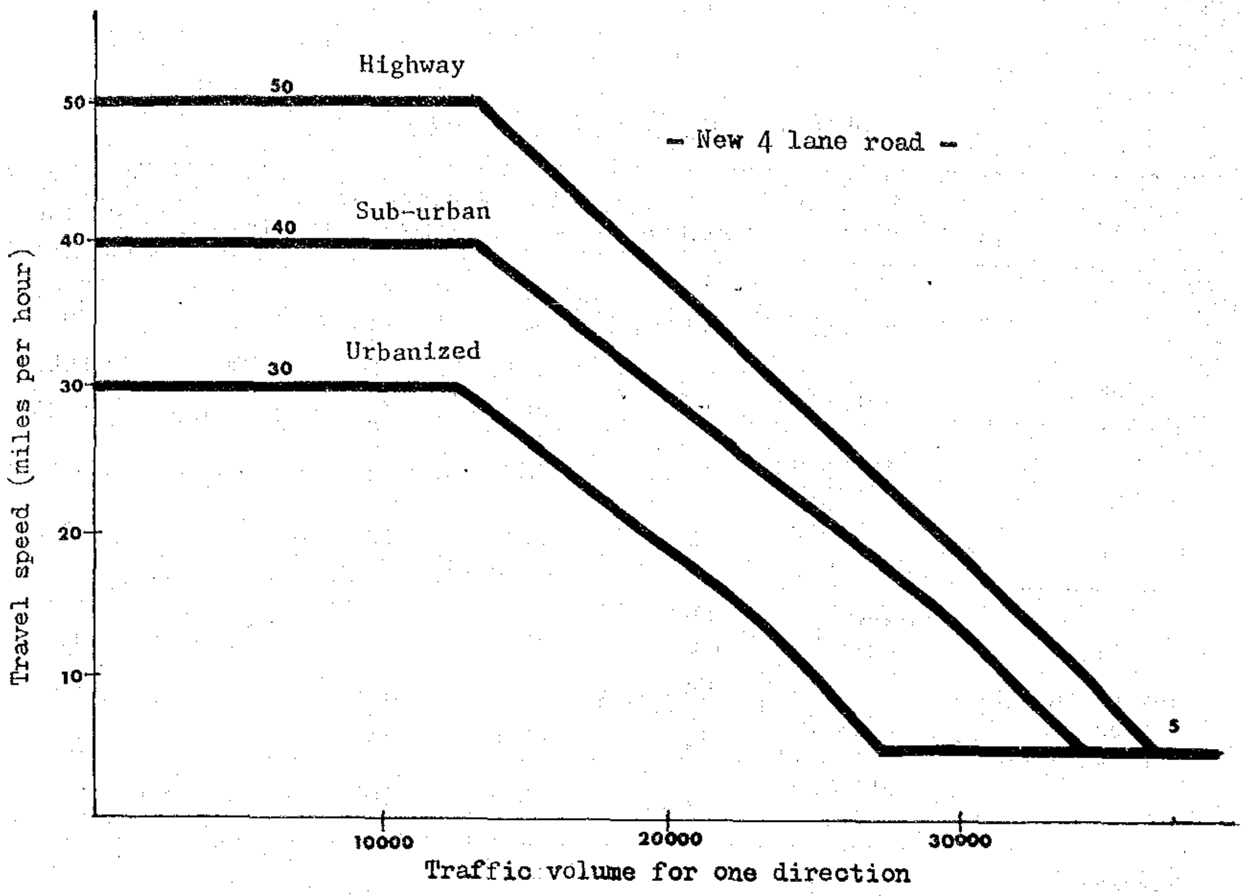
The traffic volume on each road is estimated through traffic assignment, the procedure of which is explained below.

1. Each link of the road network has its own relationship between the traffic volume and the travel time, i.e. the travel time increases with respect to the increase in the traffic volume already assigned. The travel time increases very rapidly as the traffic volume approaches the road capacity.

2. The traffic demand of each O-D pair is assigned to the shortest route in relation to the travel time decided upon by the above relationship.
   The so-called "all or nothing" method is used.

3. The traffic demand of O-D pairs is divided into several lots and the travel time is calculated repeatedly according to the traffic volume on a link at the assignment of each lot. The shortest route is obtained by the above calculations. The above procedure is repeated until all the lots of each O-D pair are assigned. Therefore, it rarely happens that the traffic demand of a particular O-D pair concentrates on a particular route.
   The relationship between the traffic volume and the travel time is calculated from the Q-V formula.

4. The Q-V formula expresses the relationship between the traffic volume and the travel time. It is known that the more the traffic volume increases, the more the travel speed decreases. Therefore, the Q-V formula is determined by type of road as follows:-



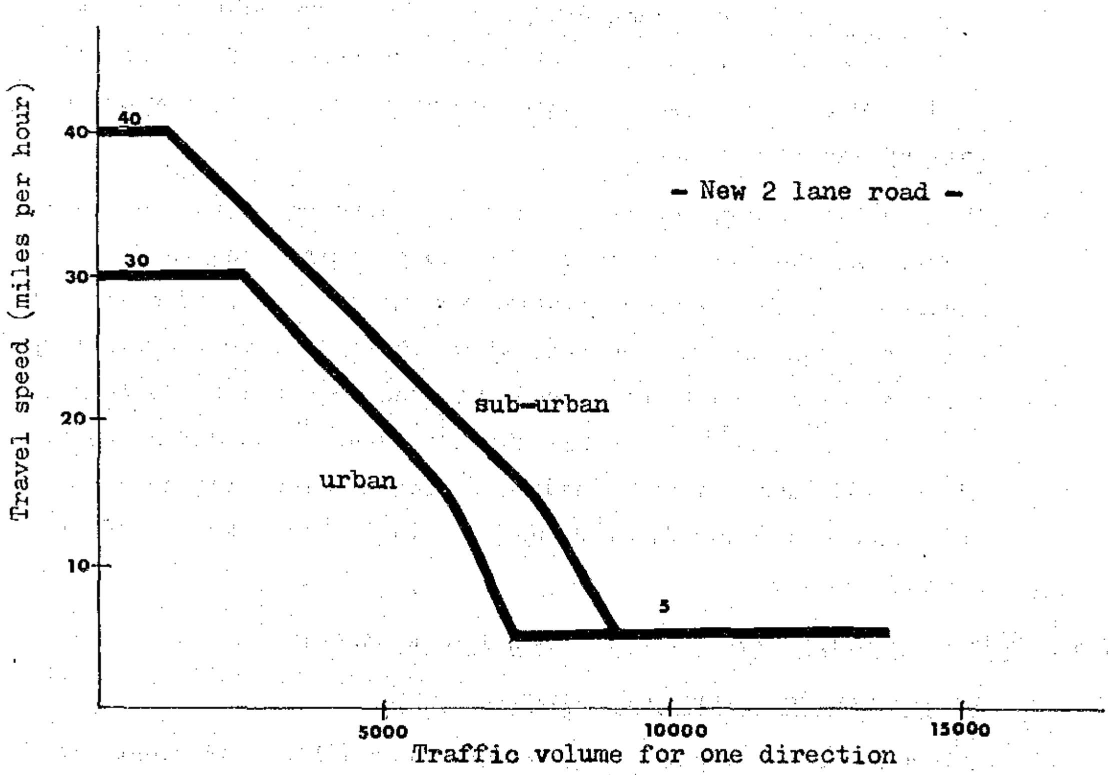


Fig.5.11 Example of Q-V Formula

Table 5.9 Q - V FORMULA FOR VEHICLE

Area	No. of land	Type of road	Speed (miles per hour) designed	limited	marginal	minimum	Capaticy for one direction
Urbanized Area	4	new	50	30	15	5	22500
		existing	40	30	15	5	18000
	2	new	40	30	15	5	6000
		existing (A)	40	30	15	5	4000
		existing (B)	35	30	15	5	3500
		existing (C)	30	30	10	5	3000
Sub-urban Area	4	new	60	40	15	5	29000
		existing	50	40	15	5	20500
	2	new	45	40	15	5	7500
		existing (A)	40	40	15	5	5000
		existing (B)	35	35	10	5	4000
Highway	4	new	80	50	15	5	32000

5. In the case of the Penang Bridge and the ferry collect tolls, the toll is added to the travel time which corresponds to the toll paid. To convert the toll paid to the travel time, divide the toll by the time value.

6. The traffic assignment is conducted through using the O-D table. Therefore, the size of the traffic zone limits the traffic assignment. The detailed traffic volume on each road cannot be obtained from this method and, also, there is more traffic than there actually should be around the zone node which represents a particular zone because all the trip generation and attraction of one zone are generated and attracted to/from this node. This should be kept in mind when looking at the results of trip assignment.

5.3.2 Estimation of Future Traffic Demand on Road Network

1. Estimation for Traffic Assignment

The alternative road network plans for traffic assignment are already selected as follows;

1979 Present

1985	Base Case
	Under Planning
	Proposed
	Under Planning & Proposed
2000	Under Planning & Proposed
	Ultimate

Estimations for traffic assignment are conducted according to Table 5.10.

Table 5.10 ESTIMATE FOR TRAFFIC ASSIGNMENT

	Year / O-D Type / Road Network	1979	1985		2000			
		Present	Plan A	Plan B	Plan A	Plan B	Plan C	Plan D
	Present	Present						
	Base Case		Base		Base			
1	Under Planning		1-A					
2	Proposed		2-A					
3	Under Planning & Proposed		3-A	3-B	3-A	3-B		
4	Ultimate				4-A	4-B	4-C	4-D

2. Comparison of Travel Speed by Each Case

One figure which is able to show the objective evaluation about the degree of road network improvement is the travel speed by road network plans.

In 1985, the average travel speed in all cases will exceed the present speed, even in the situation of "base case" due to the completion of the Penang Bridge and the dispersal roads.

In the year 2000, only the average travel speed of "ultimate" road network will be on par with the present level.

This shows that a large investment is required for the improvement of road networks in order to keep the traffic congestion at the present level.

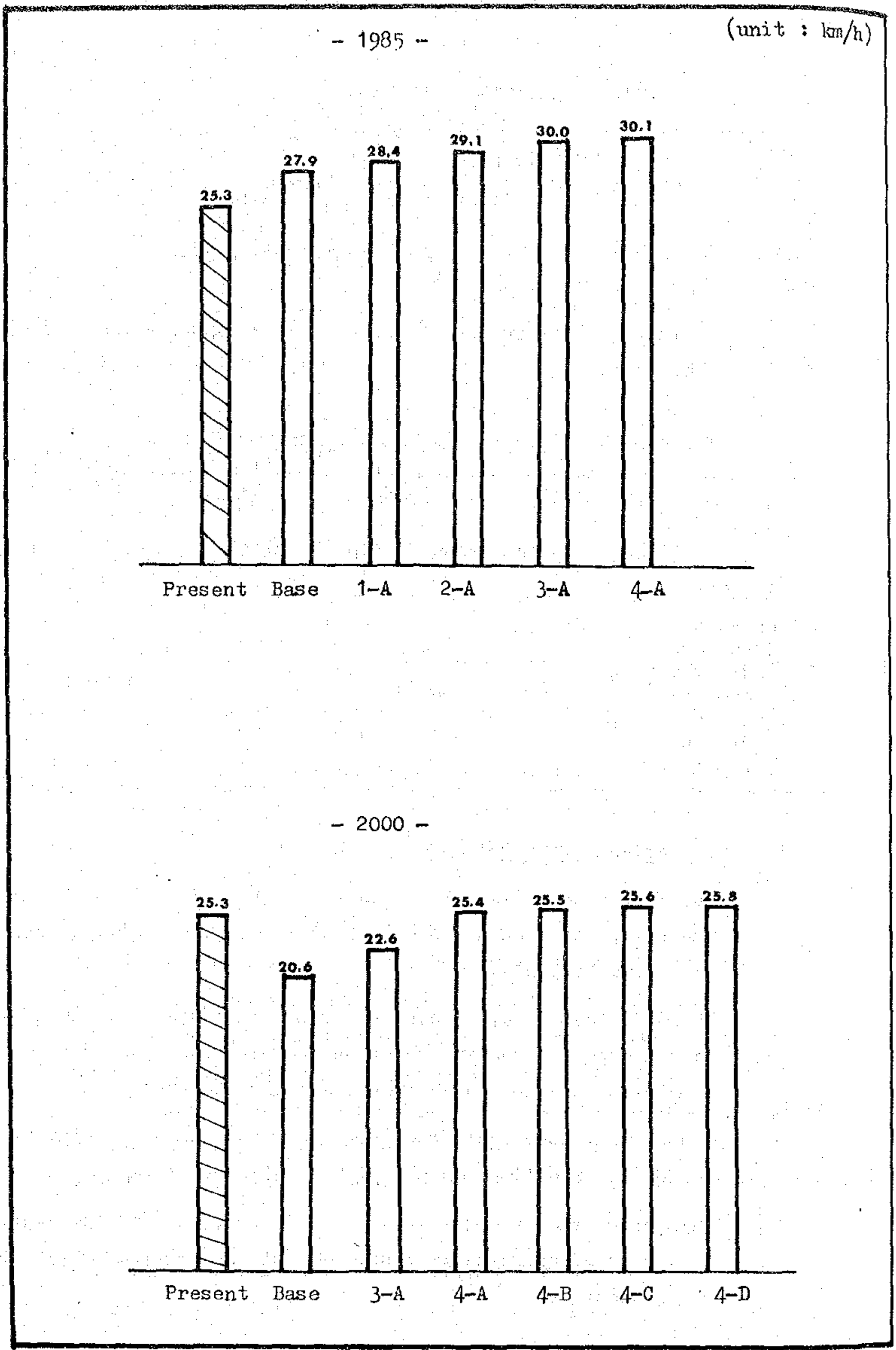


Fig. 5.12 The Comparison of Travel Speed

3. Comparison of the Degree of Congestion by Road Network Plans

Another way to compare the road network plans is to use the degree of congestion.

In this section, a comparison between those cases which can illustrate the apparent differences will be made. For a calculation of the degree of congestion the daily capacity is used as in Fig. 5.11 according to the type of road.

Table 5.11 THE DAILY CAPACITY

(Unit : 1000 p.c.u.)

	Urbanized Area		Sub-urban Area		Highway
	Existing	New	Existing	New	
2 lane	8000	12000	10000	15000	64000
4 lane	36000	45000	41000	58000	

(a) Comparison for the year 1985

For the year 1985, a comparison is made between road network "Under Planning" and "Under Planning & Proposed". Fig. 5.14 clearly shows the difference in the congestion degree. Therefore, it is advisable to complete the road network "Under Planning & Proposed" after opening of the Penang Bridge.

(b) Comparison for the year 2000

For the year 2000, a comparison is made between road network "Under Planning & Proposed" and "Ultimate". Due to the tremendous increase in traffic demand, there will be some congested links, even in the case of, "Ultimate". Therefore, this road network must be planned in time for the year 2000.

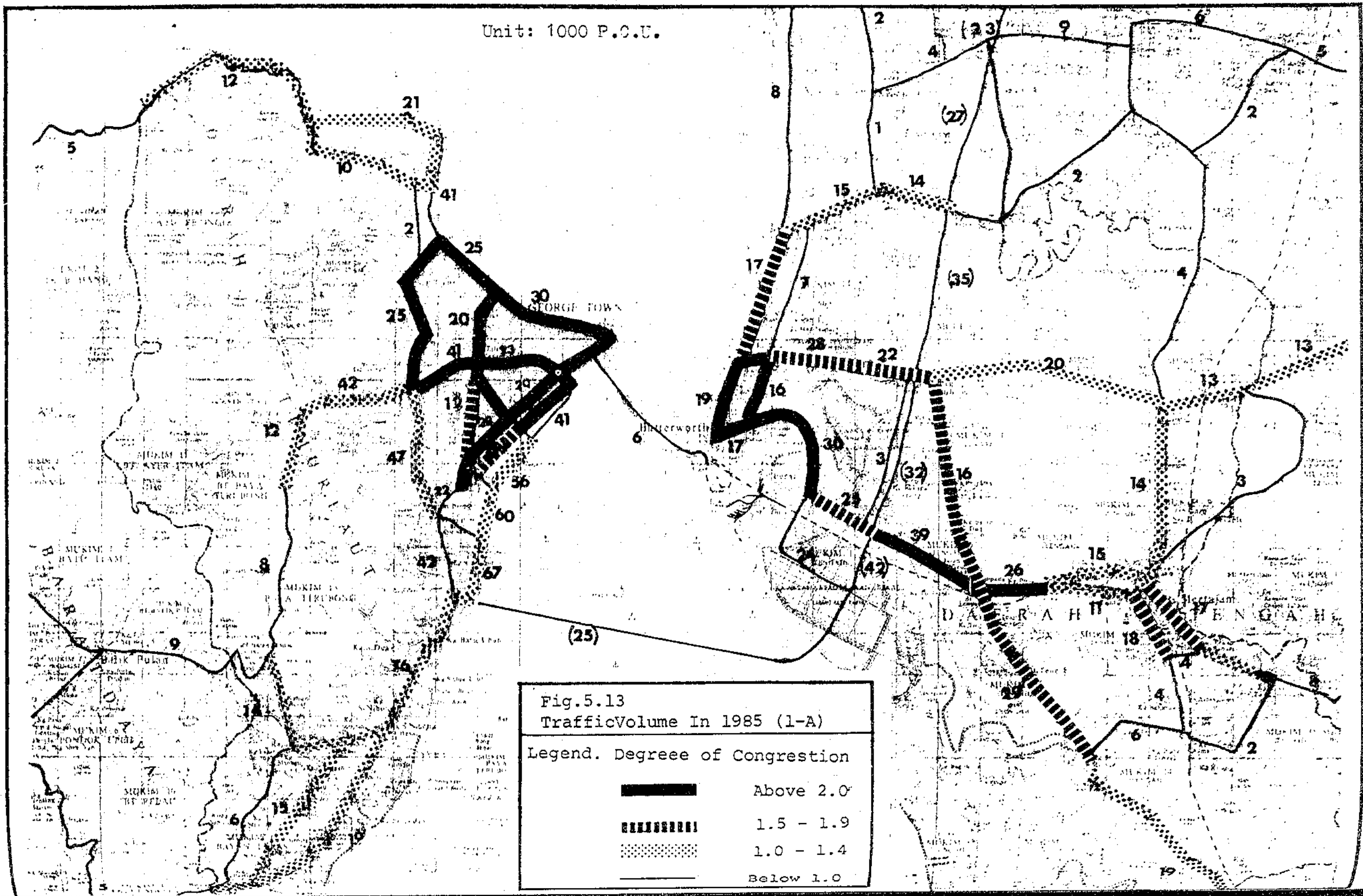


Fig.5.13
TrafficVolume In 1985 (1-A)

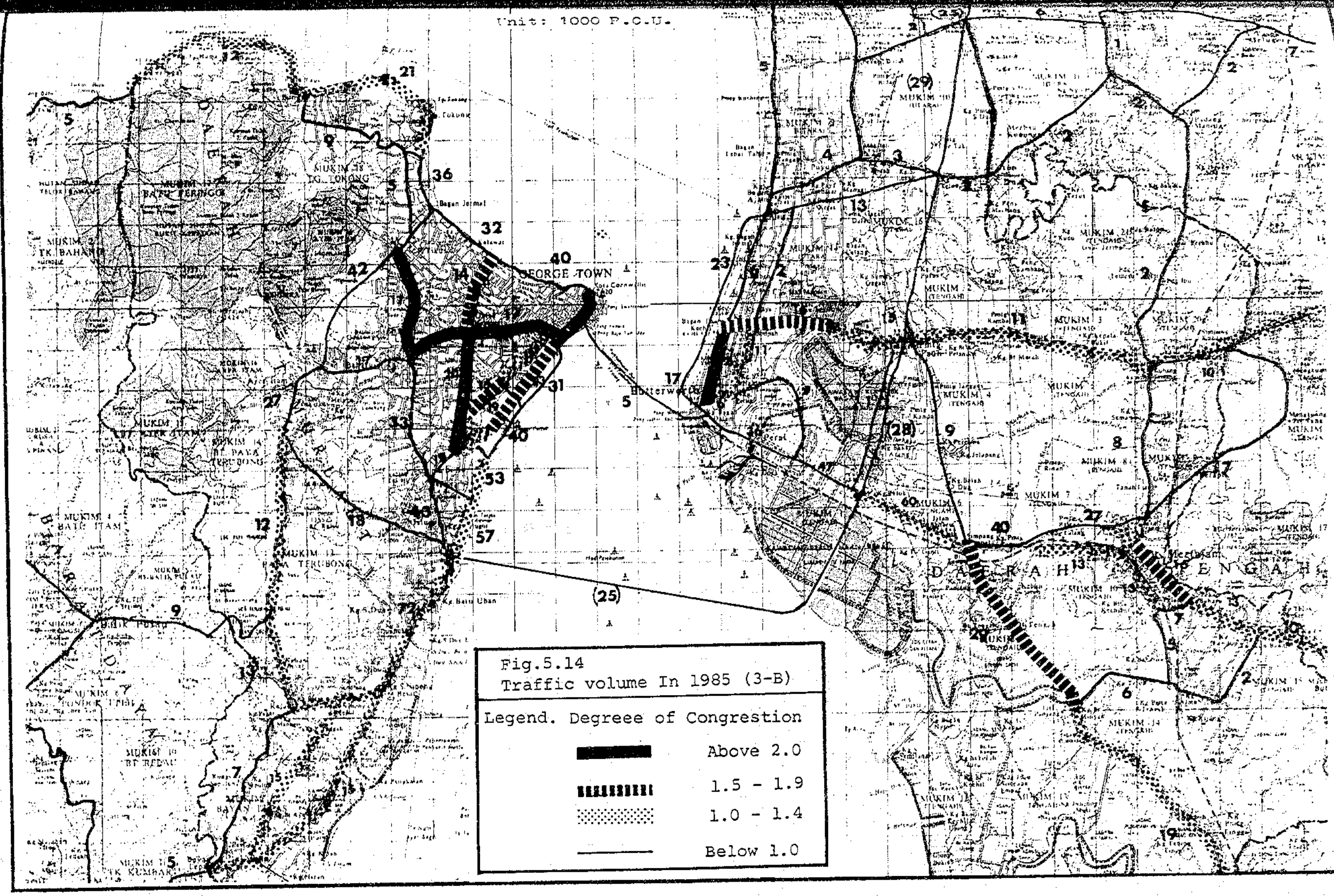


Fig.5.14
Traffic volume In 1985 (3-B)

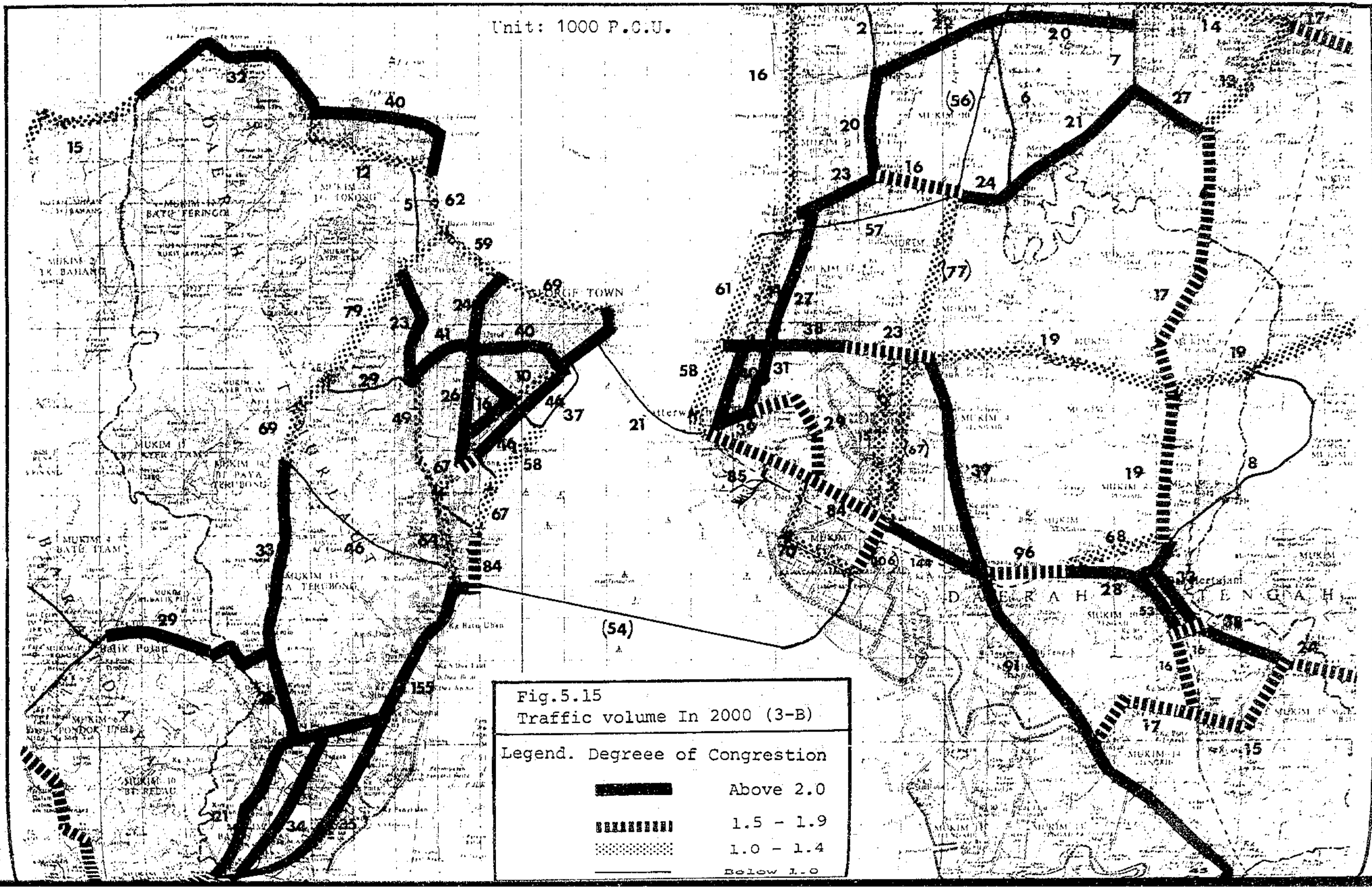


Fig.5.15
Traffic volume In 2000 (3-B)

Legend. Degreee of Congrestion

(thick solid line)	Above 2.0
(dashed thick line)	1.5 - 1.9
(dotted line)	1.0 - 1.4
(thin line)	Below 1.0

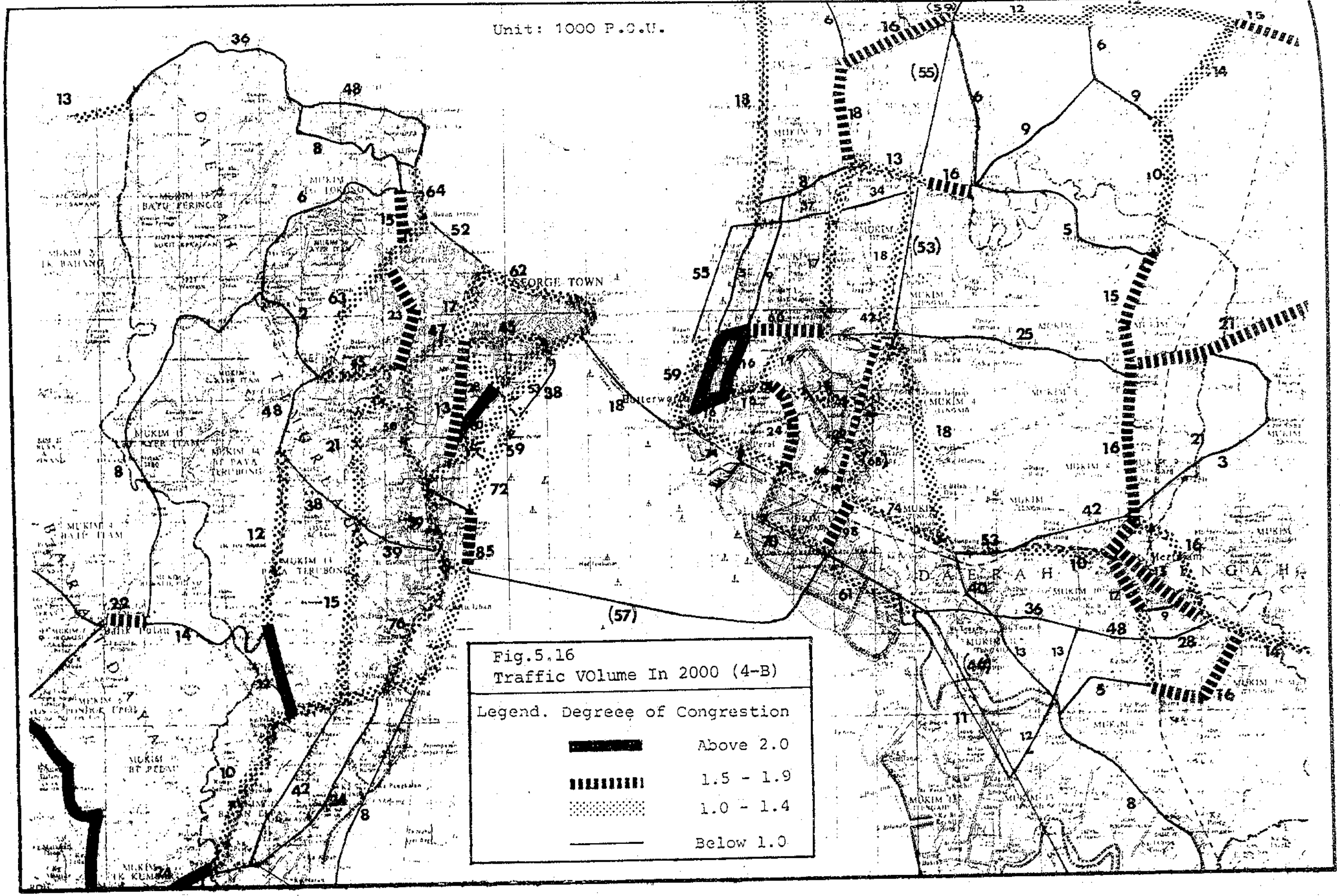


Fig.5.16
Traffic VOlume In 2000 (4-B)

5.3.3 Comparison of Traffic Demand Related to the C.B.D. by Alternative Plans

In order to compare the traffic demand by alternative transport policies, an inner and a center cordon line are planned (See Fig. 5.17). The results of the transport policies are particulary visible on these two (2) lines as the transport policies are devised to prevent traffic congestion around C.B.D.

1. Comparison for The year 1985

The decrease in traffic volume on these lines through execution of parking controls and introduction of exclusive bus lanes is shown in the following table:-

Table 5.12 DECREASE IN TRAFFIC VOLUME BY PLANS

(Unit : 1000 p.c.u.)

plan / line	Plan A	Plan B	difference (A - B)
inner cordon	183.7	178.2	5.5
center cordon	269.8	261.4	8.4

Note: Inner cordon : the line which surrounds the zone 111.
Center cordon : the line which surrounds the C.B.D. area (zone 111, 121, 131)

The reduction volume, which at first sight seems to be insignificant, corresponds to a capacity of a 2-lane road; therefore, it is advisable to introduce these policies by the year 1985.

(Unit: 1000 P.C.U.)
( ): The degree of congestion.

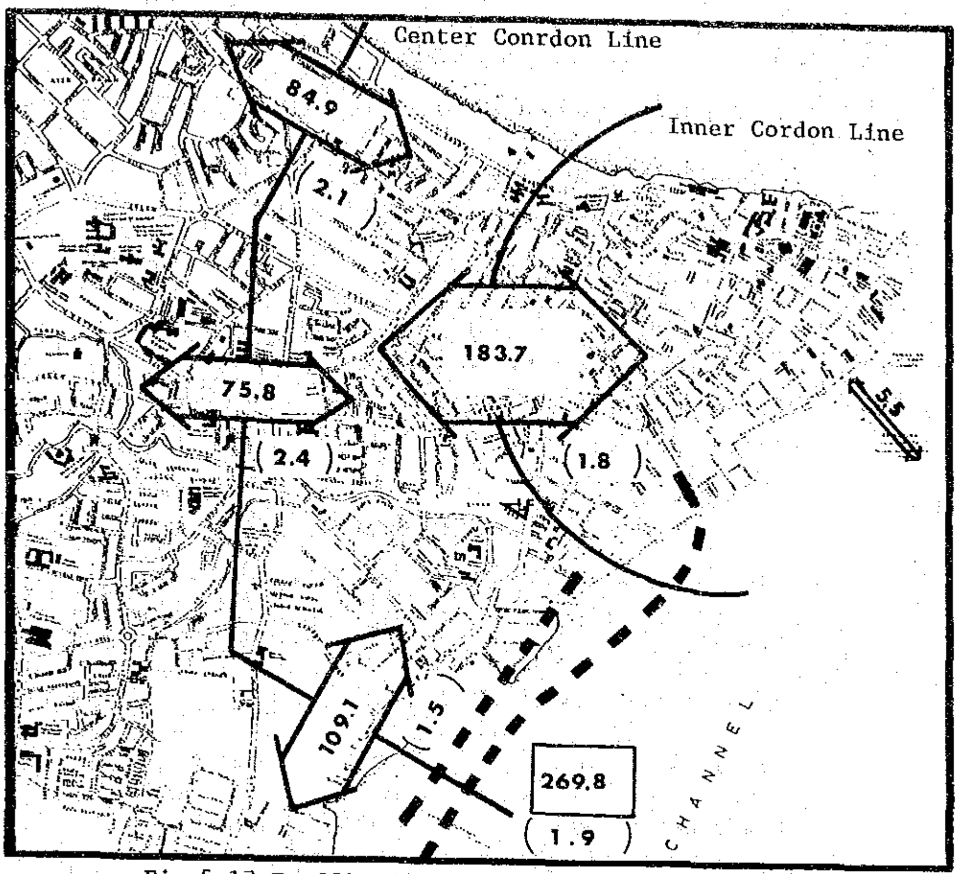


Fig.5.17 Traffic Volume by Plan 1-A in 1985

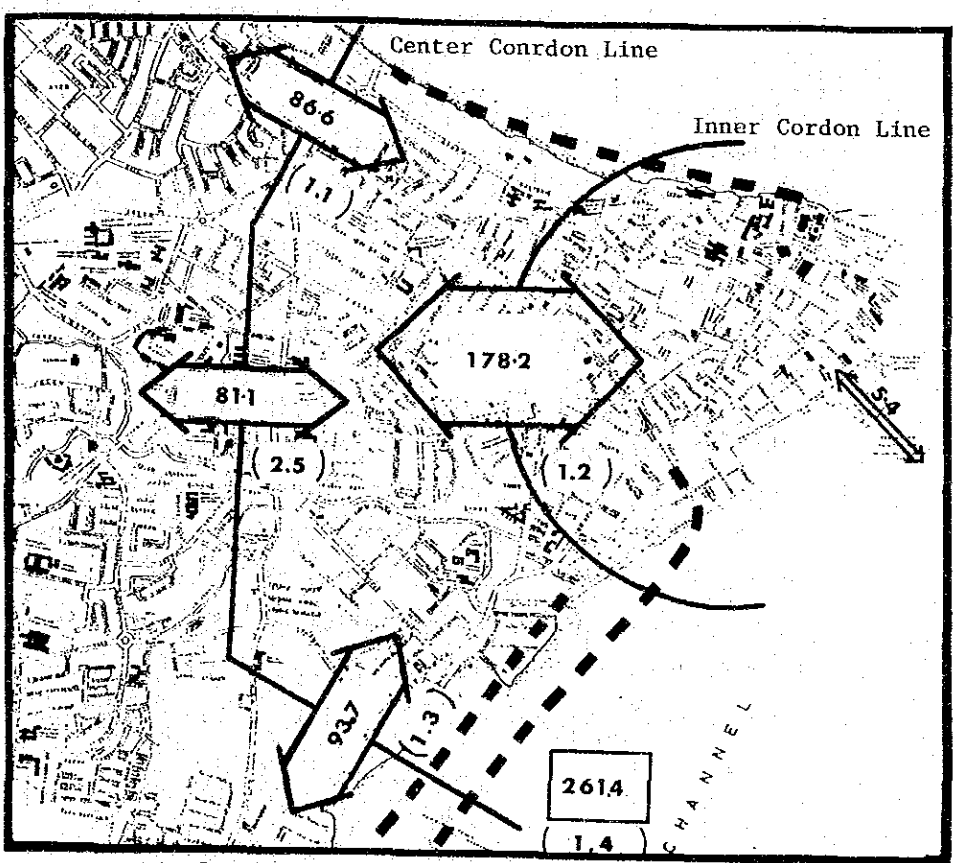


Fig.5.18 Traffic Volume by Plan 3-B in 1985

2 Comparison for the year 2000

For the year 2000, the following three (3) policies are examined:-

1) The control of parking demand and the introduction of exclusive bus lanes.

2) The introduction of N.T.S.

3) The execution of car pooling system.

The decrease in traffic volume through these policies is as follows:-

Table 5.13 DECREASE IN TRAFFIC VOLUME BY PLANS

(1000 : p.c.u.)

	Plan A	Plan B	Plan C	Plan D
Inner cordon	302.2	281.6	274.0	225.3
Difference from A	-	-20.6	-28.2	-76.3
Center cordon	428.5	400.0	393.8	337.2
Difference from A	-	-28.5	-34.7	-91.3

All policies produce, to a certain extent, the intended effect on present conbested traffic situations. However, the most effective policy is the car pooling system, whereby the traffic volume will be reduced by about 76,000 - 91,000 p.c.u. The difference between Plan B and Plan C is about 6,000 - 8,000 p.c.u., due to the introduction of N.T.S. This diversion volume from car to N.T.S. is not so large because the scheduled speed of N.T.S. and the travel speed of cars are not so different.

However, these figures will be re-examined in detail when the introduction of N.T.S. is close to actualization. Thus, in order to raise the function of the C.B.D. area, the level of traffic congestion should be kept, that is, the degree of congestion on the cordon line should not exceed 1.5. Fig. 5.24 shows that the above objective is effectuated only through introduction of Plan D. Therefore, it will be necessary to bring the car pooling system into effect by the year 2000.

(Unit:1000 P.C.U.)
( ):The degree of congestion.

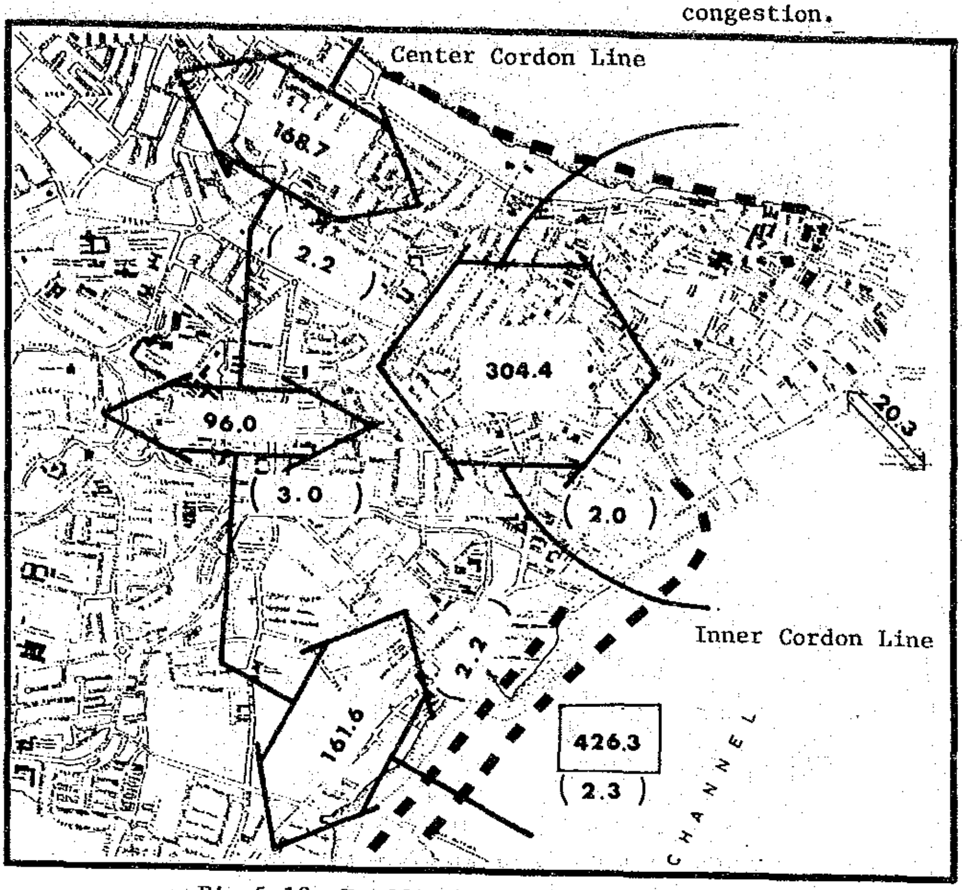


Fig.5.19 Traffic by Plan 3-A in 2000

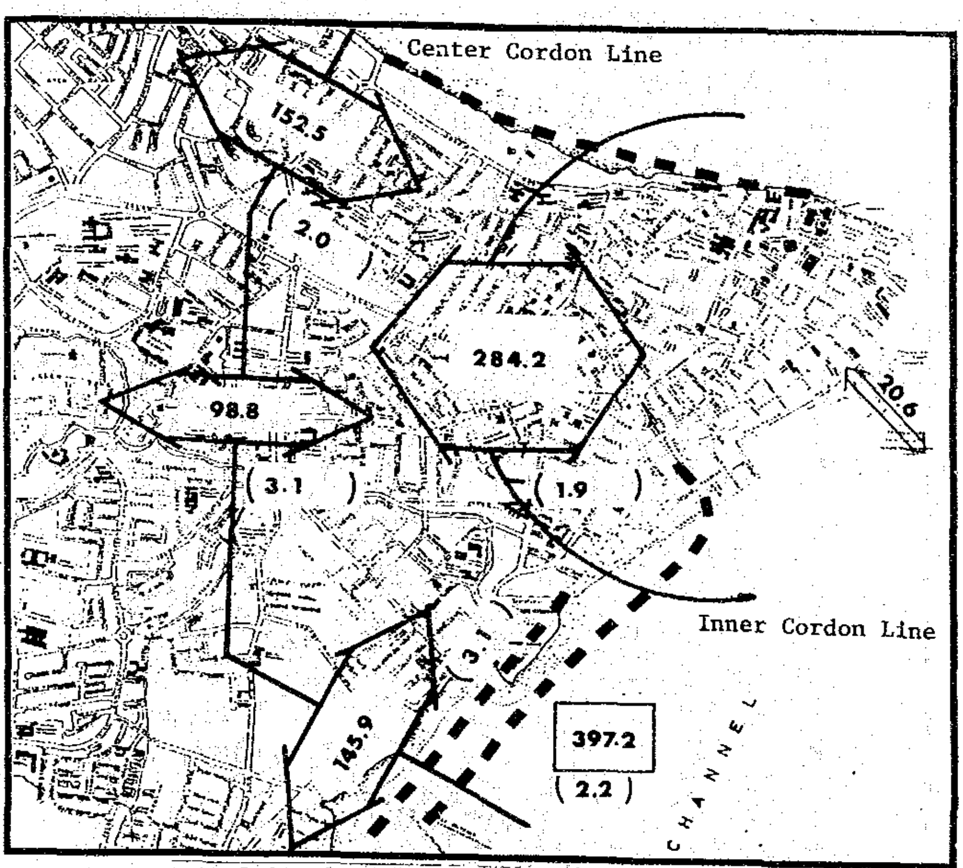


Fig.5.20 Traffic Volume by Plan 3-B in 2000

(Unit:1000 P.C.U.)
( ): The degree of congestion.

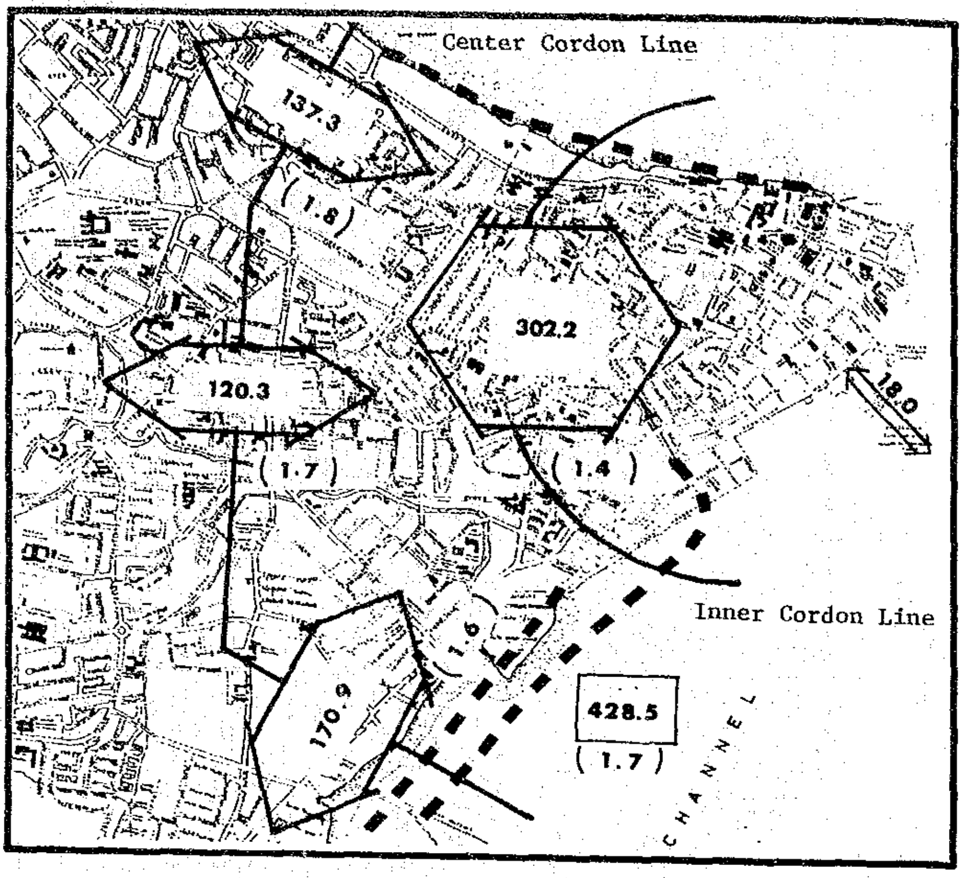


Fig.5.21 Traffic Volume by Plan 4-A in 2000

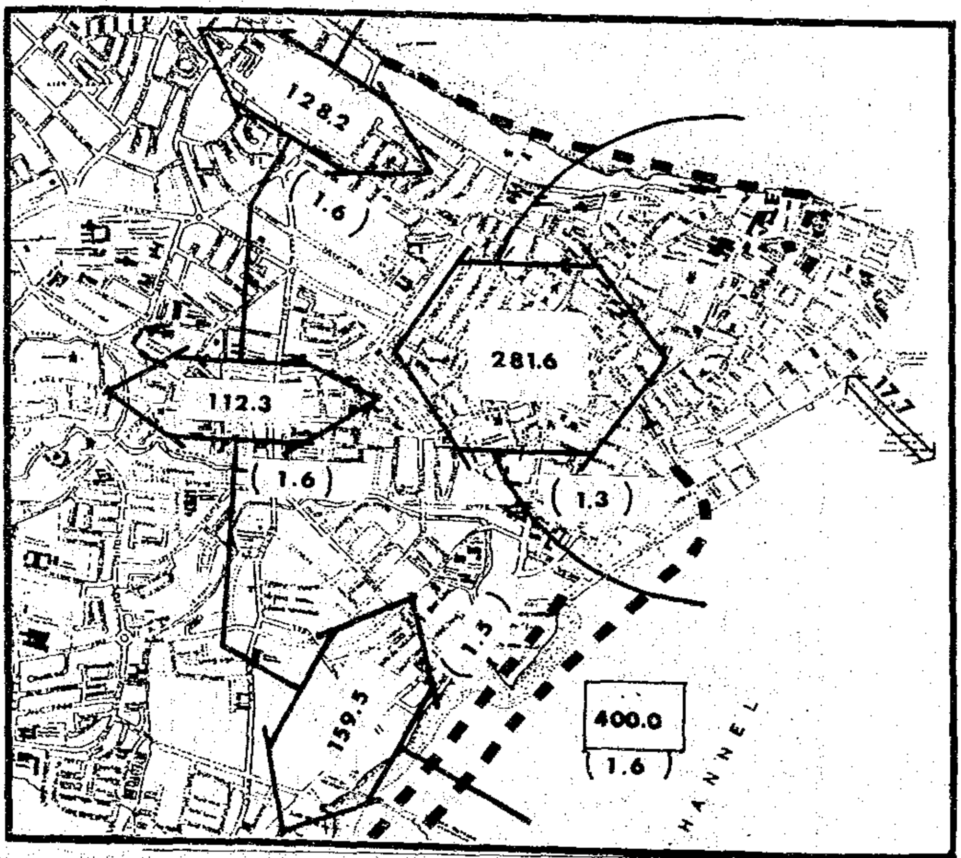


Fig.5.22 Traffic Volume by Plan 4-B in 2000

(Unit:1000 P.C.U)
( ):The degree of
congestion.

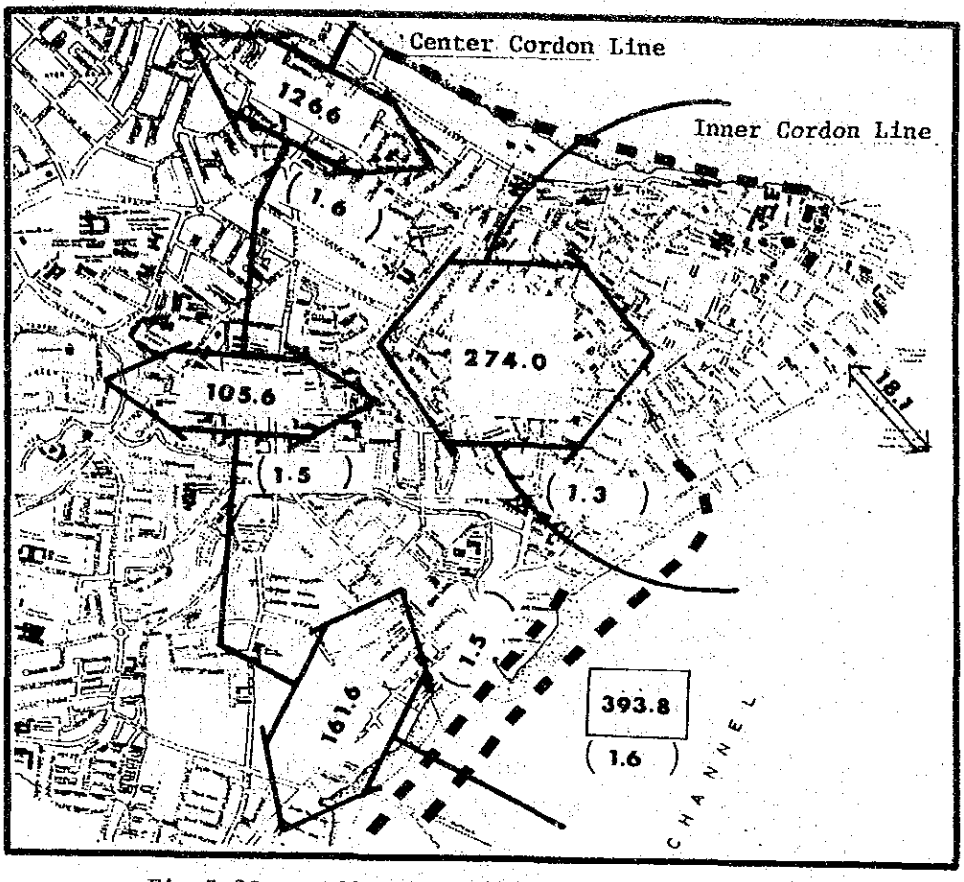


Fig.5.23 Traffic Volume by Plan 4-C in 2000

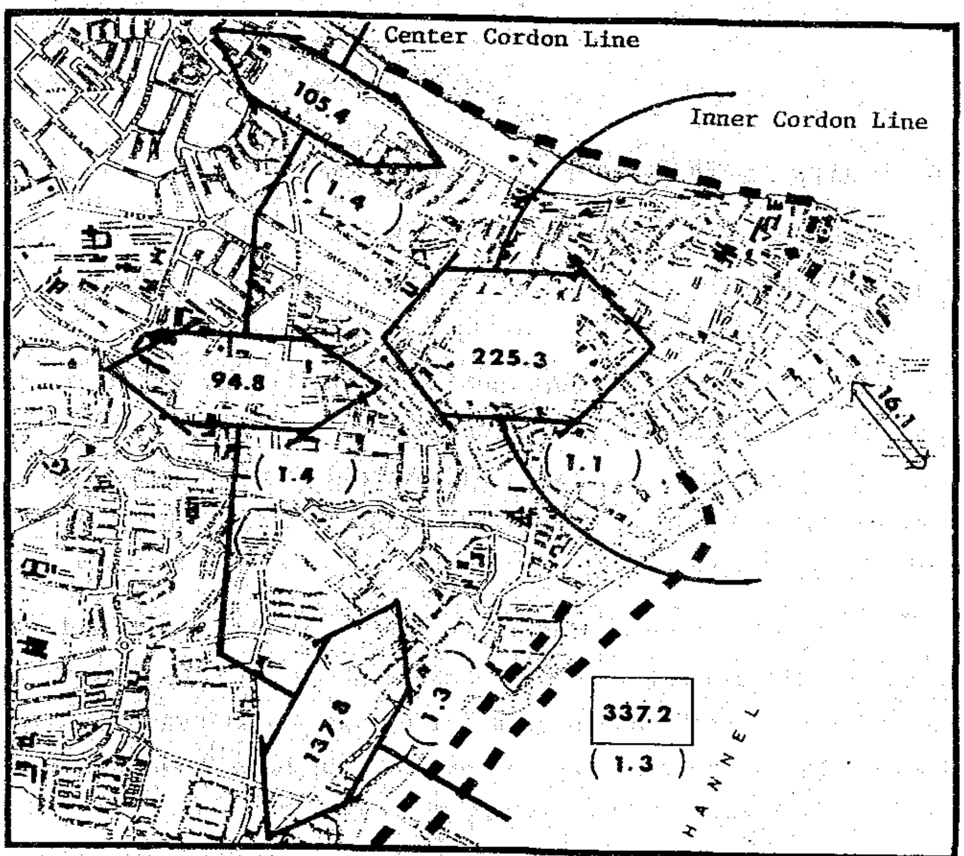


Fig.5.24 Traffic Volume by Plan 4-D in 2000

( ):The degree of congestion.

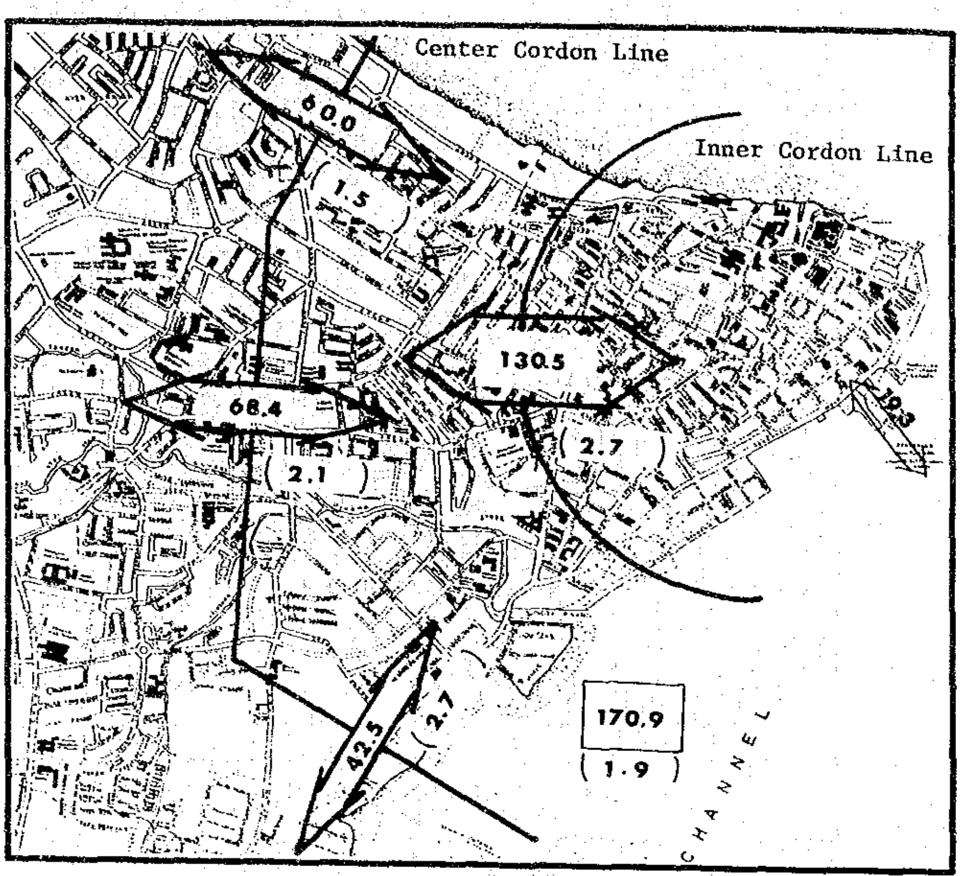


Fig.5.25 Present traffic Volume.

5.4 Estimation of the Future Traffic Demand on the Ferry

The ferry service plays a very important role at present due to it being the only means of public transport between George Town and Butterworth.

This situation will continue until the Penang Bridge is constructed. After the completion of the bridge, there will be two ways across the straits and so some changes in the overall traffic volume are expected when the services of both the ferry and the bridge are available without any protective strategies.

As the situation of the ferry service will be affected, our study should be divided into tow (2) phases; phase A being "before the completion of the bridge" and phase B being "after the completion of the bridge". Besides this, the progress from phase A to phase B should also be considered.

Although the ferry service in the future will surely experience a different situation, there are still some unknown factors such as the toll for the bridge, the actual terms of operation and so forth; thus, it can be said that the future role of the ferry is one of uncertainty. To ascertain this to a close extent, we will examine future demand in phase A and in phase B separately, after which the progress is considered.

5.4.1 Before Completion of the Bridge (Phase A)

The completion of the Penang Bridge is expected to be in late 1984. Prior to this, the ferry service is the only means to and fro across the straits. Thus, the role of the ferry will be the same as before.

1. Demand Forecast

The demand for the ferry service depends mainly upon the urban activity potential and partly upon the level of its service.

As the present service level seems almost adequate for satisfying the demand except during peak hours at Butterworth, it will be possible to forecast future demand by menas of tracing the present trend.

Some forecasts have already been done by a consultant in April 1978. Here, a summary of the projections is shown.

Table 5.14 FORECAST OF FERRY TRAFFIC GROWTH

(One Way Trips in Thousands)

		*Upper Bound		Growth rate (%)	*Lower Bound		Growth rate (%)
	1977 (actual)	1980	1985		1980	1985	
Trucks	486	640	1004	9.5	620	933	8.5
Motorcars	2900	4300	8570	14.0	3910	6450	10.5
Motor-cycles	3858	5870	11800	15.0	5210	8580	10.5
Bicycles	1084	990	850	-3.0	930	720	-5.0
Passengers	19644	23070	30147	5.5	21220	24120	2.6

*Note: "Upper Bound" as referred to in the data source is a "relatively straightforward extrapolation of the trend over the past 5-10 years. "Lower Bound" is based on macroeconomic indicators and follows the earlier projections made in connection with "The Penang Bridge Study".

Source: "Analysis of the capacity of the Penang Ferry Service", 1978. - E.G. Frankel Inc., U.S.A.

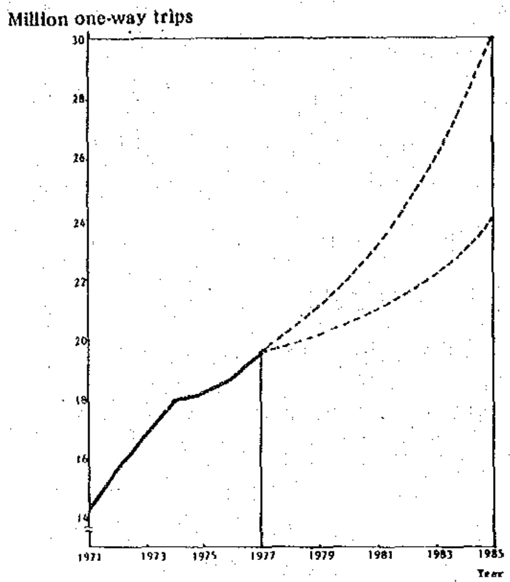


Fig. 5.26 Annual Passenger Traffic

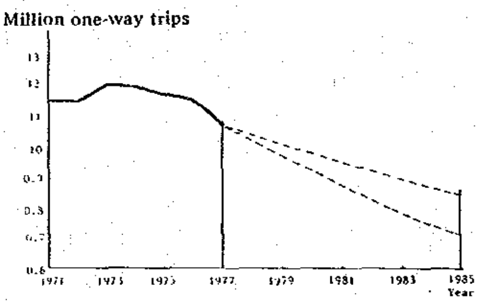


Fig. 5.27 Annual Bicycle Traffic

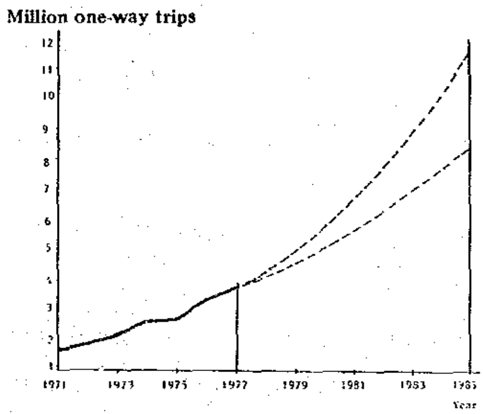


Fig. 5.28 Annual Motorcar Traffic

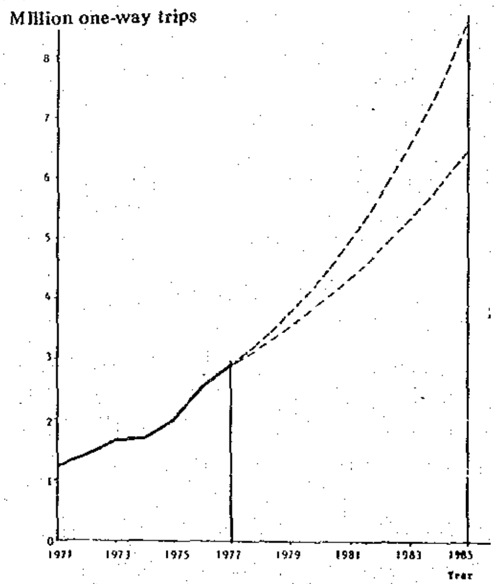


Fig. 5.29 Annual Motor-cycle Traffic

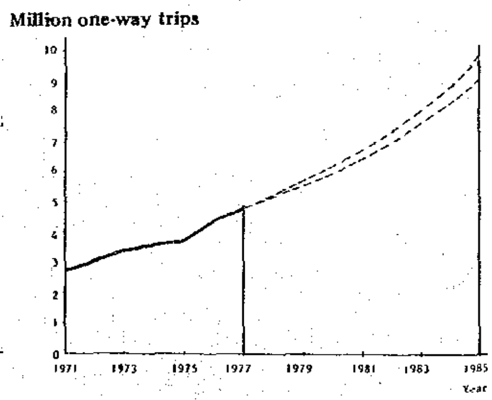


Fig. 5.30 Annual Lorry Traffic

According to these results, all traffic volume excluding bicycles are forecasted to increase by an annual growth rate of 5 percent to 15 percent in the upper bound and 3 percent to 11 percent in the lower bound.

When these estimates are examined against actual results in 1978, those of motor-cycles, trucks and passengers indicate a greater volume than that estimated in 1978; whereas the volume of cars and bicycles is within the range estimated. Therefore, it will be possible that in the future the demand will be beyond the upper bound estimated here above, even if some of the ferry capacity is strengthened according to the increase in demand.

In addition, the study team forecasted the traffic volume of motor-cycles, cars and trucks utilising the ferry in 1985 without the Penang Bridge.

The brief results are shown below.

Table 5.15 ESTIMATED FERRY TRAFFIC
(No. of vehicles/day)

	Motor-cycles	Vehicles	(Car ,	Trucks)
1979	13,000 (100)	10,800 (100)	(9,150 ,	1,650)
1985	14,400 (111)	14,600 (135)	(12,170 ,	2,430)

These estimates are obtained by the least square method (linear curve) from the results of in 1965 to 1979, and so these are less than those which are forecasted by applying quadric curve.

The traffic volume of the ferry will mainly depend on the ferry capacity provided, and the forecasted results range from 14,600 vehicles to 24,380 vehicles per day. Since the range of the forecasted results is very wide, it is difficult to reach a decision on the most correct forecasted volume. This can be done however by comparing the traffic volume before and after the Penang Bridge.

5.4.2 After Completion of the Bridge (Phase B)

1. Demand Forecast

The situation of the ferry service will completely change after the completion of the Penang Bridge. The projection of traffic volume until 1985, before the completion of the Penang Bridge, was made in the earlier section while in this section part of the results forecasted for 1985 and the year 2000 are shown.

In our traffic assignment, we obtained the traffic volume on the Penang Bridge and the ferry as well as on each road section by including these links in the whole network and by using the method in which the bridge toll and ferry fares are converted into the time resistance factor.

The folloiwng assumptions are made:

* The toll of the bridge is almost the same as that of the ferry.
* The time values are 3.7 M$/hour in 1979, 4.5 in 1985 and 7.3 in the year 2000 for passenger cars.
* Both fares are variable in accordance with the increase of time value.
* It takes over 5 minutes depending on the demand at the access of ferry terminal.

As a result the time resistance is calculated as 4.80 minutes/kilometer for the ferry and 1.40 minutes/kilometer for the bridge in case of passenger cars.

The results which are estimated based on these assumptions are shown as follows.

Table 5.16 TRAFFIC VOLUME ACROSS THE STRAITS

(per day)

Year	Type of Vehicel	Ferry	Bridge	Total
1979	Motor-cycle	13,000	-	13,000
	Car	9,150	-	9,150
	Truck	1,650	-	1,650
	(P.C.U.)	(19,300)	-	(19,300)
1985 Plan A	Motor-cycle	6,500	8,200	14,700
	Car	1,400	11,460	12,860
	Truck	280	6,060	6,340
	(P.C.U.)	(5,400) (17.1)	(26,200) (82.9)	(31,600) (100)
2000 Plan A	Motor-cycle	6,200	9,300	15,800
	Car	10,000	26,180	36,180
	Truck	1,840	14,880	16,720
	(P.C.U.)	(17,700) (23.4)	(58,000) (76.6)	(75,700) (100)

Regarding passengers, the share of fellow passengers in vehicles has increased as shown in section 2. If the ratio of fellow passengers by type of vehicle is constant and the diverted volume to the bridge is small, the following results are estimated.

Table 5.17 PASSENGER VOLUME ON FERRY

(Unit : person per day)

	Real passengers	Fellow passengers	Total
1979	39,800	16,300	56,100
1985	43,180*	3,240	46,420
2000	52,940**	17,840	70,780

* Estimated from the results in 5.4.1.

** Estimated by annual growth rate 1979 to 1985.

The volume of bicycles is also estimated from the trend.

Table 5.18 BICYCLE ON FERRY

	1979	1985	2000
No. of Bicycles	2,870	2,150	-

2. Effects of Bridge Tolls

When the traffic volume on the ferry and on the bridge are compared with each other, it is supposed that the time resistance factor influences the share of traffic demand to a large extent.

Four (4) cases of the bridge tolls are presented below in order to measure their effects in 1985.

The assumed factors are as follows.

Table 5.19 FARE & TOLL RESISTANCE EXPRESSED IN TERMS OF TIME (MIN/KM)

	Linkage (10.5 km)		Ferry (3.0 km)
Base Case	1.40	(1.00)	4.80
Case 1	0	(0.00)	4.80
Case 2	2.10	(1.50)	4.80
Case 3	2.80	(1.50)	4.80
Case 4	4.20	(3.00)	4.80

* Calculated by $\frac{\text{fare (cent/km)}}{\text{time value (cent/min.)}}$

The following results indicate only vehicle volume in P.C.U.

Table 5.20 COMPARISON OF EACH CASE

(unit : p.c.u.)

	Ferry	Linkage	Total
Base Case	2,170 (9.2) (100)	21,320 (90.8) (100)	23,490 (100)
Case 1	910 (3.9) (42)	22,580 (96.1) (106)	23,490 (100)
Case 2	2,570 (10.9) (1.18)	20,920 (89.1) (98)	23,490 (100)
Case 3	3,040 (12.9) (1.40)	20,450 (87.1) (96)	23,490 (100)
Case 4	4,530 (19.3) (209)	18,960 (80.7) (89)	23,490 (100)

Any change in the toll does not influence the traffic volume of the ferry greatly. The reasons seem to be as follows:

1. The total traffic volume across the straits is not so heavy compared with the capacity of access roads to the bridge in 1985.

2. In case of the ferry, the share of fare resistance to the total is smaller than that in case of the Penang Bridge.

5.5 Estimation of the Future Traffic Demand of Bus Passenger by Plan

The bus network for traffic assignment is provided based on the present one with the network in future not modified very much except for some new routes as the present network coverage is almost adequate in the Study Area.

The assumed running factors in consideration of the average speed of other vehicles and present conditions are as follows:-

Table 5.21 RUNNING SPEED

	in 1985	in 2000
Suburban Area	18km/hour	14km/hour
City Area	12	9

5.5.1 Effect of Introducing Exclusive Bus Lanes

In order to improve the service against the worsening road conditions, the study team proposed to introduce exclusive bus lanes in George Town and from Butterworth to Bukit Mertajam.

In forecasting the passenger volume, two (2) steps are taken into consideration; one is the diverted volume from vehicles by a control system of parking demand and the other is the diverted volume from vehicles and motor-cycles by exclusive bus lanes. The following shows only brief resutls.

Table 5.22 BUS PASSENGERS BY PLAN B

(Unit : 1000 passengers)

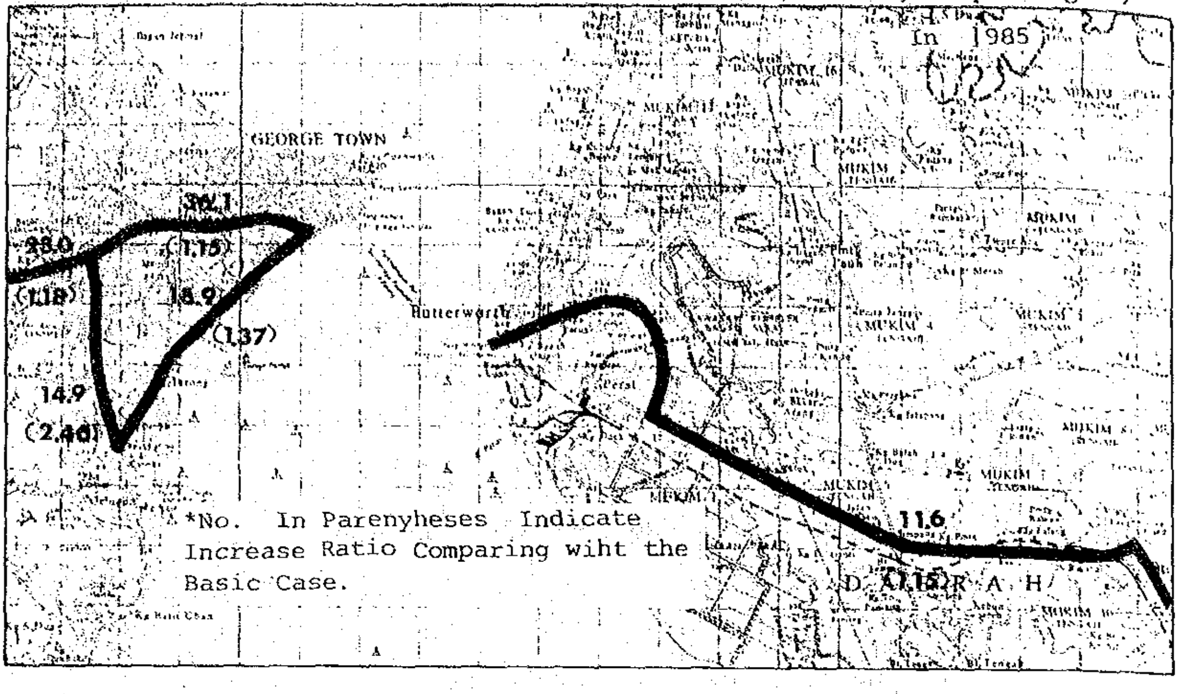
		in 1985	in 2000
Basic volume		249.1 (100)	296.4 (100)
Diverted volume by parking		9.5 (6.7)	41.1 (29.3)
Diverted volume by exclusive bus lane	Vehicle	3.9 (2.8)	7.3 (5.2)
	Motor-cycle	5.6 (4.7)	6.8 (5.7)
Total		268.1 (108)	351.6 (119)

Some bus priority measures are expected to increase the passenger demand to 8 percent in 1985 and 19 percent in the year 2000 respectively.

The assigned passenger volume along exclusive bus lanes is summarized as follows.

IN 1985

(unit: 1,000 passengers)



IN 2000

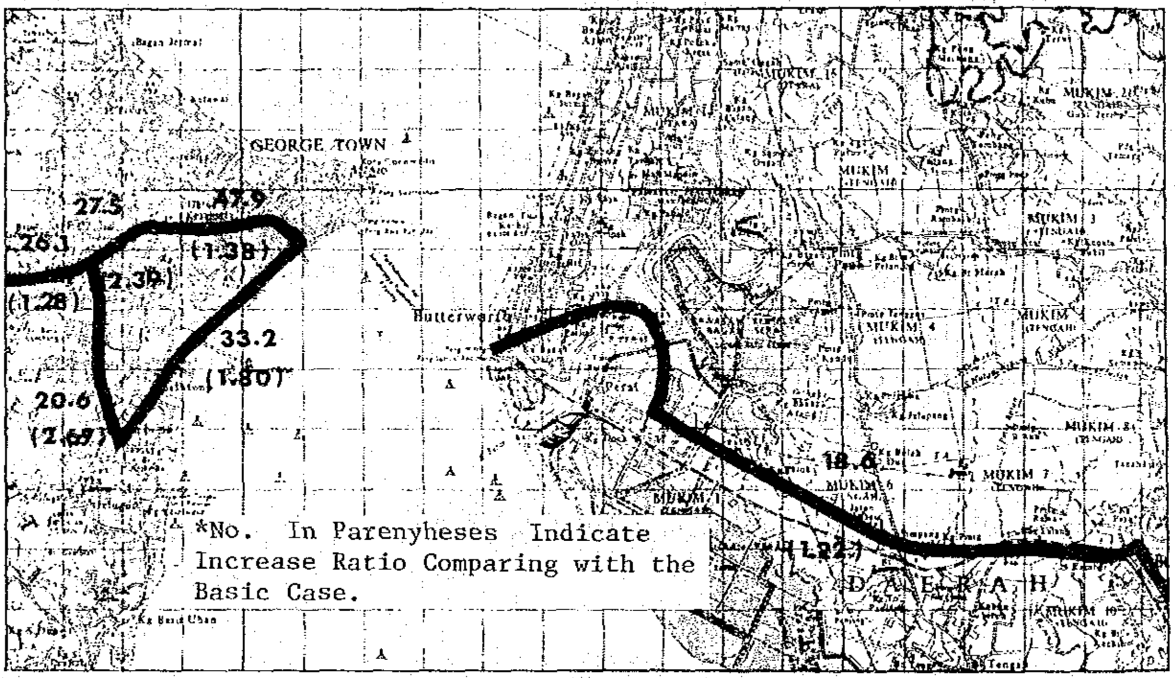


Fig. 5.31 BUS PASSENGERS ALONG EXCLUSIVE BUS LANES

As shown above, the effect of exclusive bus lanes is overwhelmingly great to attract passengers along these lanes.

5.6 Estimation of the Traffic Demand of New Transport System

According to the tremendous increase of motor vehicle traffic, the service of public transport on roads is deteriorating and various kinds of new transport systems are considered for the improvement of public transport service all over the world. The search for a new transport system is directed towards the invention of new modes of transportation which will satisfy the demand volume between that of bus transport and urban railway.

However, this is not the main subject in our study but nontheless, some comments on the new transport system will be made for the distant future, such as in the year 2000. This is because there seems to be certain possibilities on the introduction of a new transport system in such a city area as this which has a population of over 1 million.

Before an estimation of demand can be made, the following are assumed to be the basis of the New Transport System.

1. Route

   From the results of the bus passenger assignment, the most heavily demanded routes are chosen; that is from Air Itam to the center of the C.B.D. and from Bayan Lepas to the middle former section.

   The reason why these routes are chosen is either because it is possible to equip guideways and station facilities or because of sufficient road width.

2. Characteristics

System type	: Light guideqay system
Scheduled speed	: 25km/hour
Capacity	: 60 persons/car
Operation interval	: 5 minutes (for peak hour)

5.6.1 Demand Forecast

The demand forecast is done roughly according to the following procedure.

The diverted volume forecasted by the exclusive bus lane is added into the volume and the total volume of public transport passengers are estimated. This volume is 371,600 passengers.

Also, this volume is divided into N.T.S. passengers and bus passengers in consideration of both services.

The area measuring 500m along both sides of the route is supposed to be the service area and the traffic zones are classified into three (3) categories depending upon the share which the service area has in the zone.

The divertion ratio to N.T.S. by each zone pair are assumed according to the categories classified above, then the diverted volume is estimated.

The estimated result for N.T.S. is 92,500 and the O-D pattern is as follows:-

Table 5.23 N.T.S. PASSENGER O-D in 2000

Zone \ Zone	110	120	130	140	310	320	330	410	510	94	Total
110	-	78	100	116	-	6	58	69	-	2	429
120		-	78	50	1	4	17	20	-	1	249
130			16	68	1	11	52	48	-	2	392
140				-	-	1	20	22	2	1	280
310					-	-	0	0	-	0	2
320						-	20	16	-	0	58
330							8	17	-	1	201
410								16	-	-	224
									Total		92500

1. <u>Traffic Volume by Section</u>

The assignment of the demand is summarized as follows:-

(Unit : 1000 passengers per day)

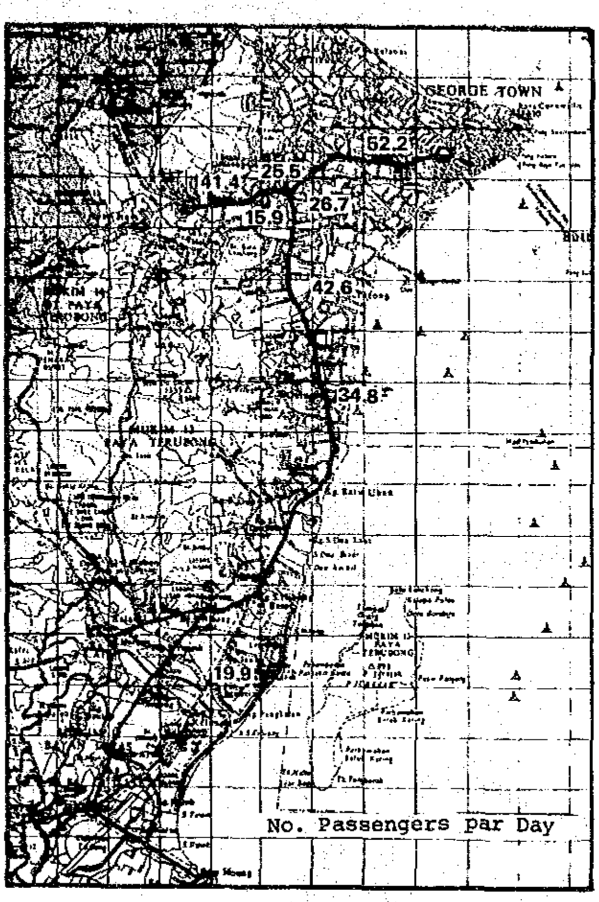


Fig. 5.32 N.T.S. PASSENGER ASSIGNMENT

2. <u>Summary</u>

The result of N.T.S. passengers demand are summarized as follows:

Length of the route	:	22km (Route 1 = 7km, Route 2 = 12km)
Total No. of passengers	:	92,500 pass/day
Passenger kilometers	:	742,100
Average kilometers	:	8.02 kilometer
Running hours	:	24,700
Average hours	:	16.05 minutes

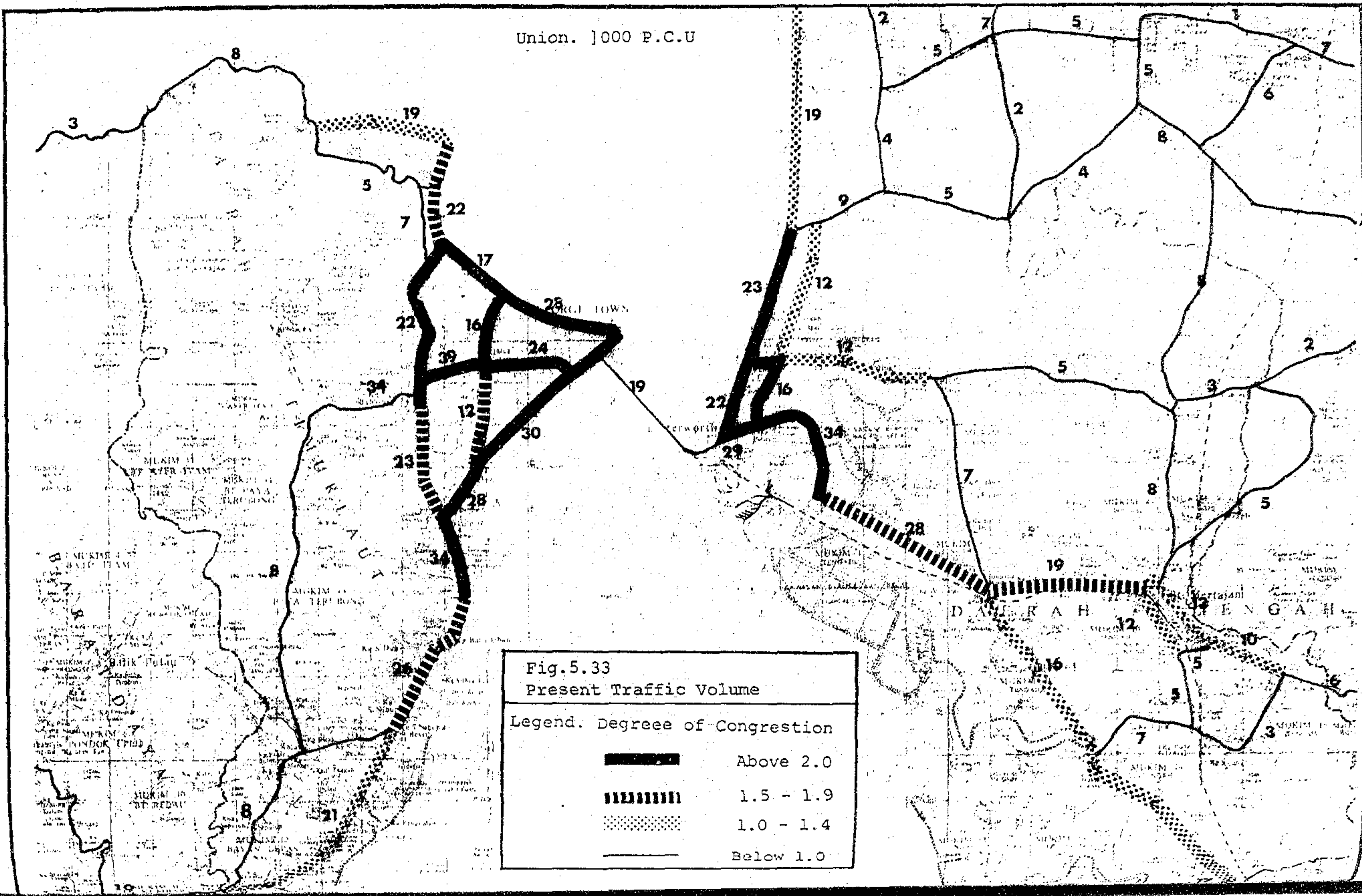


Fig.5.33
Present Traffic Volume

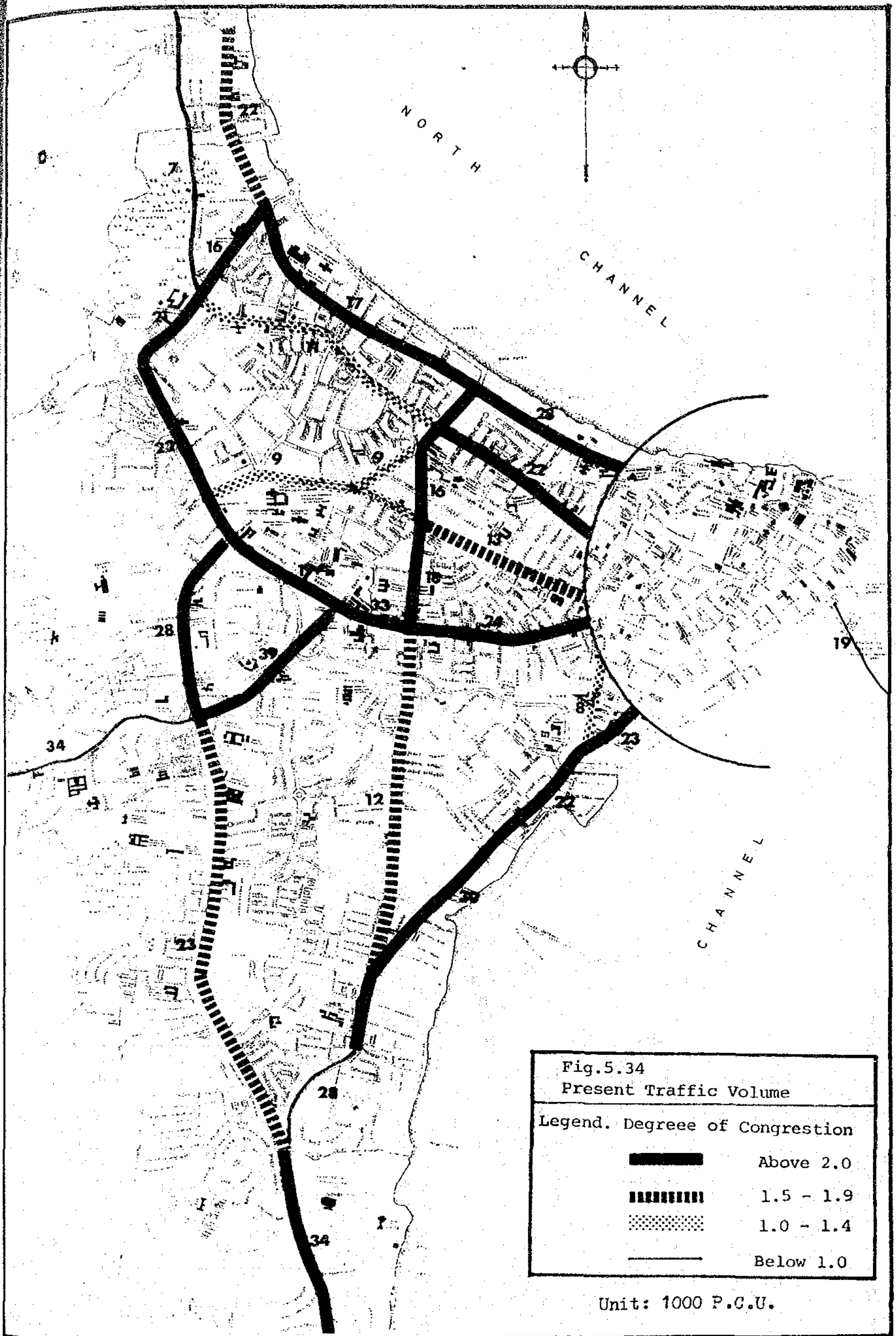


Fig.5.34
Present Traffic Volume

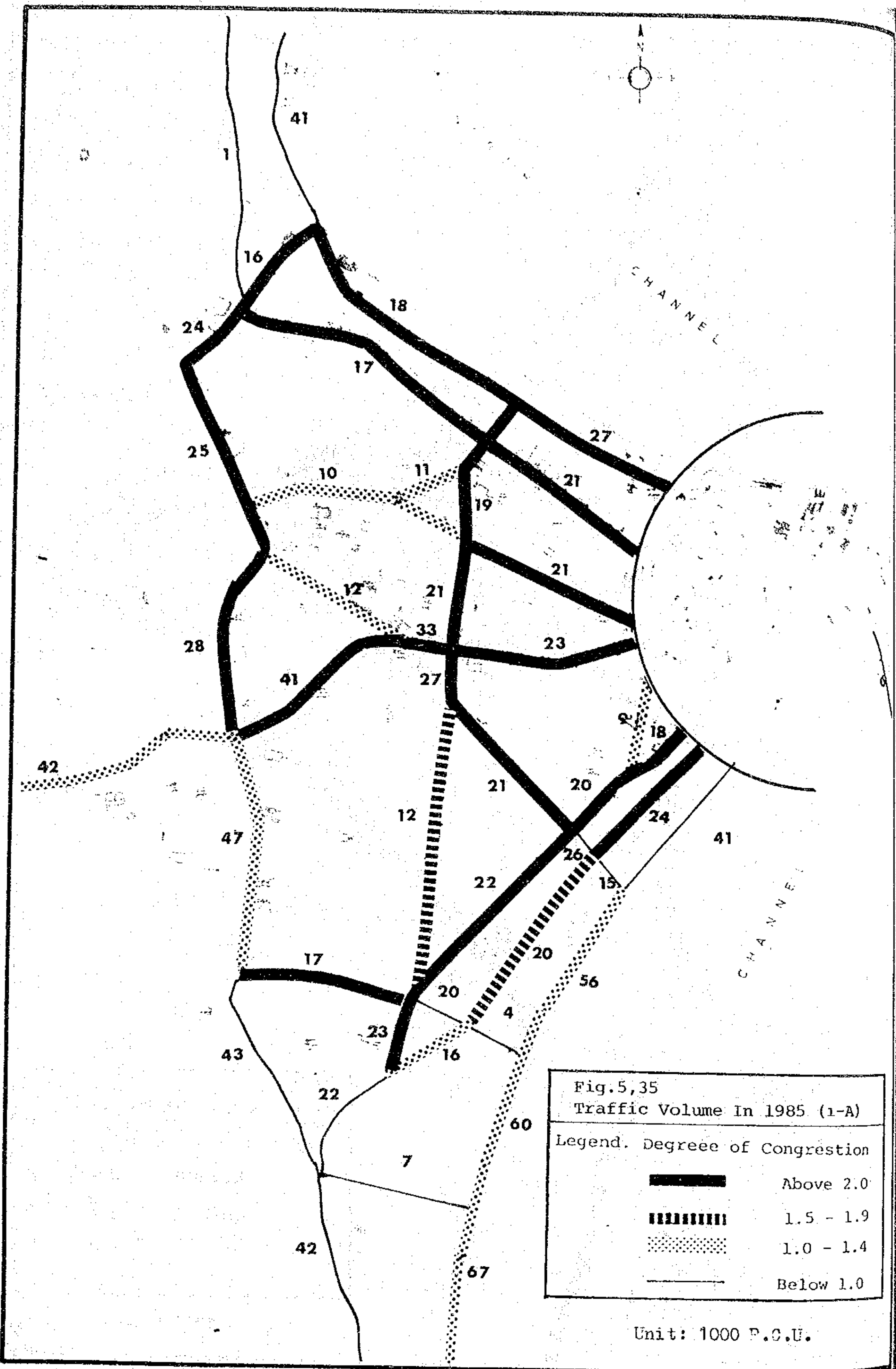


Fig.5,35
Traffic Volume In 1985 (1-A)

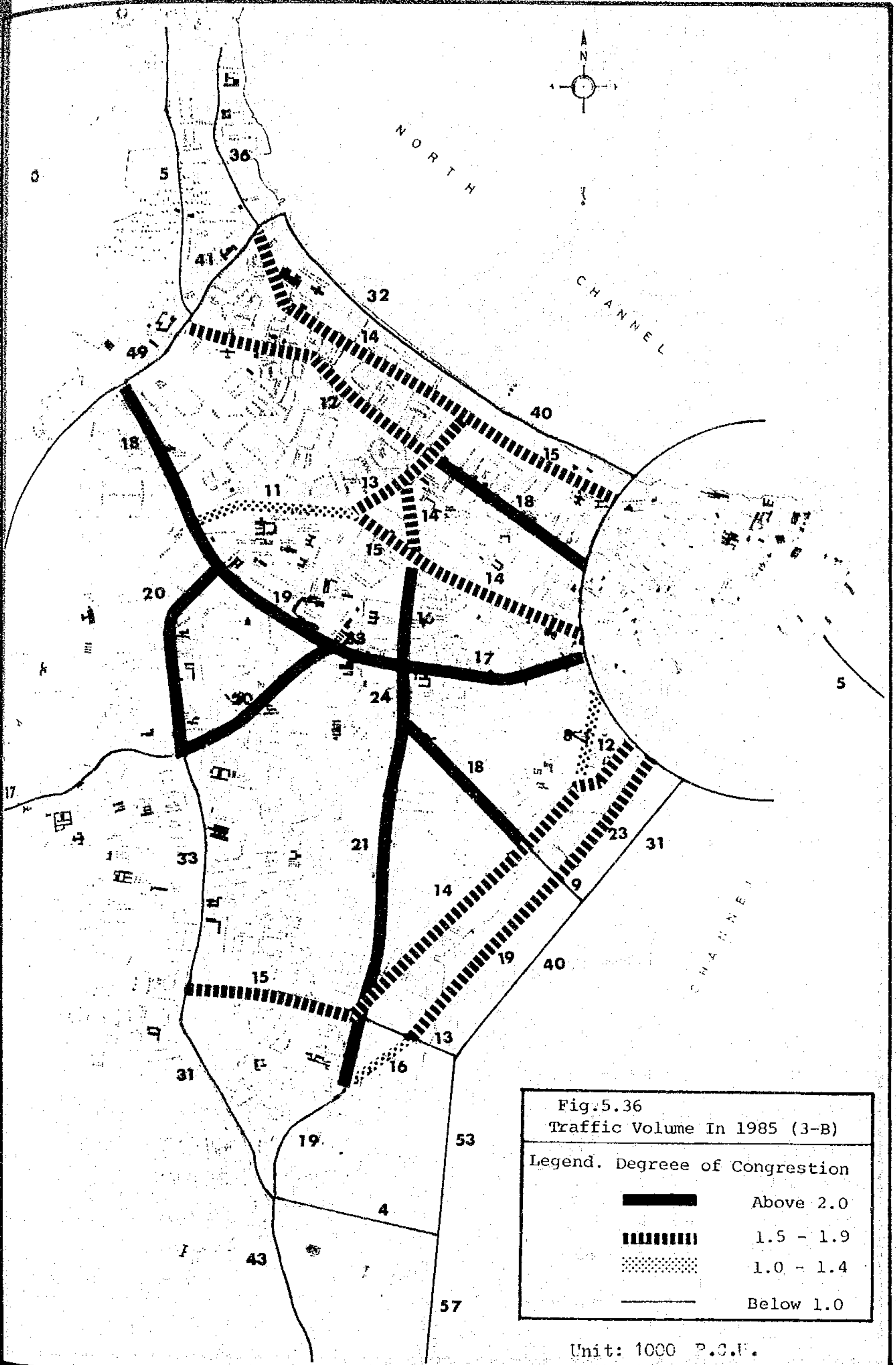
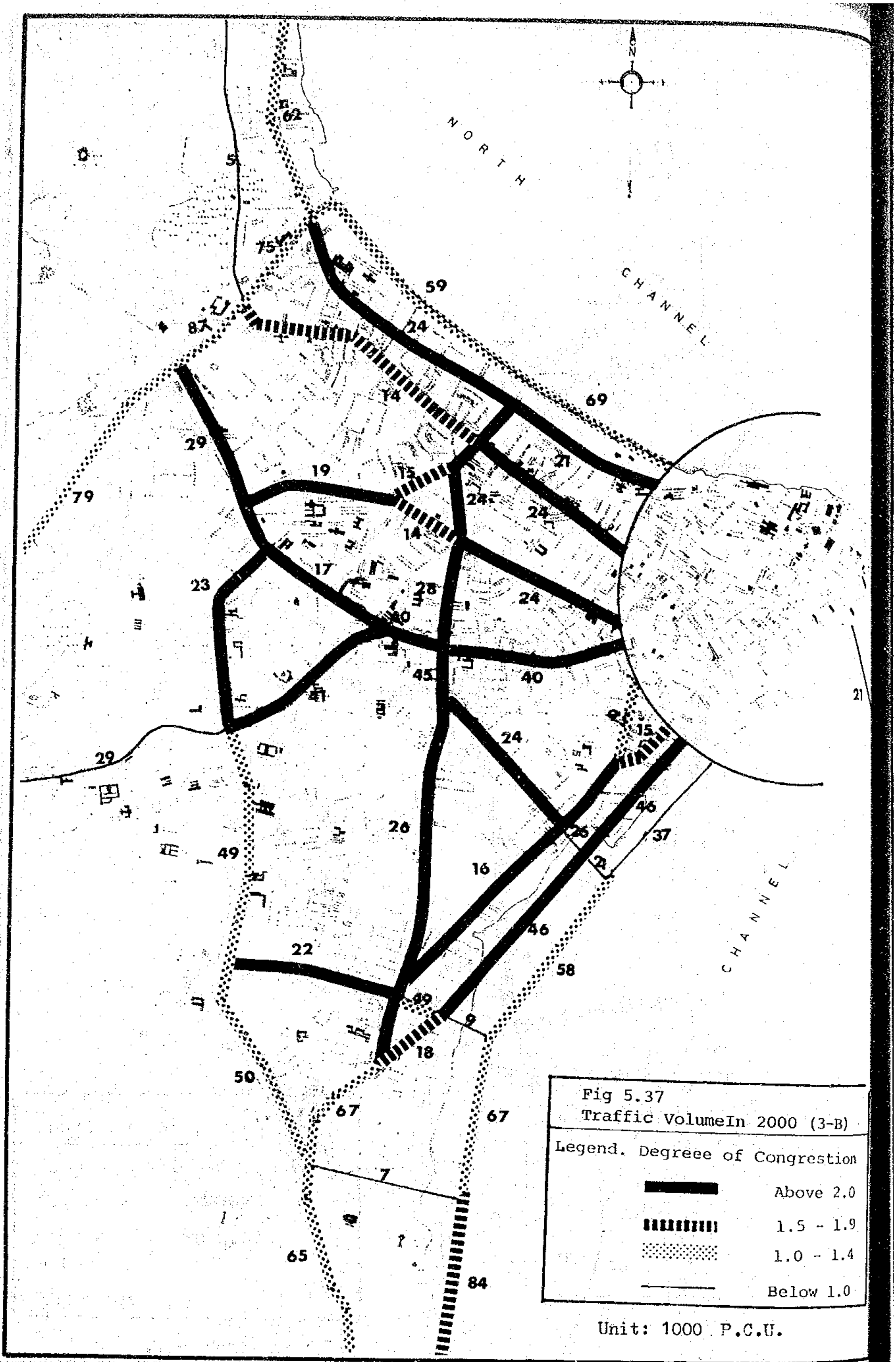


Fig.5.36
Traffic Volume In 1985 (3-B)

Legend. Degreee of Congrestion

(solid thick line)	Above 2.0
(hatched line)	1.5 - 1.9
(dotted line)	1.0 - 1.4
(thin line)	Below 1.0

Unit: 1000 P.C.U.



Unit: 1000 P.C.U.

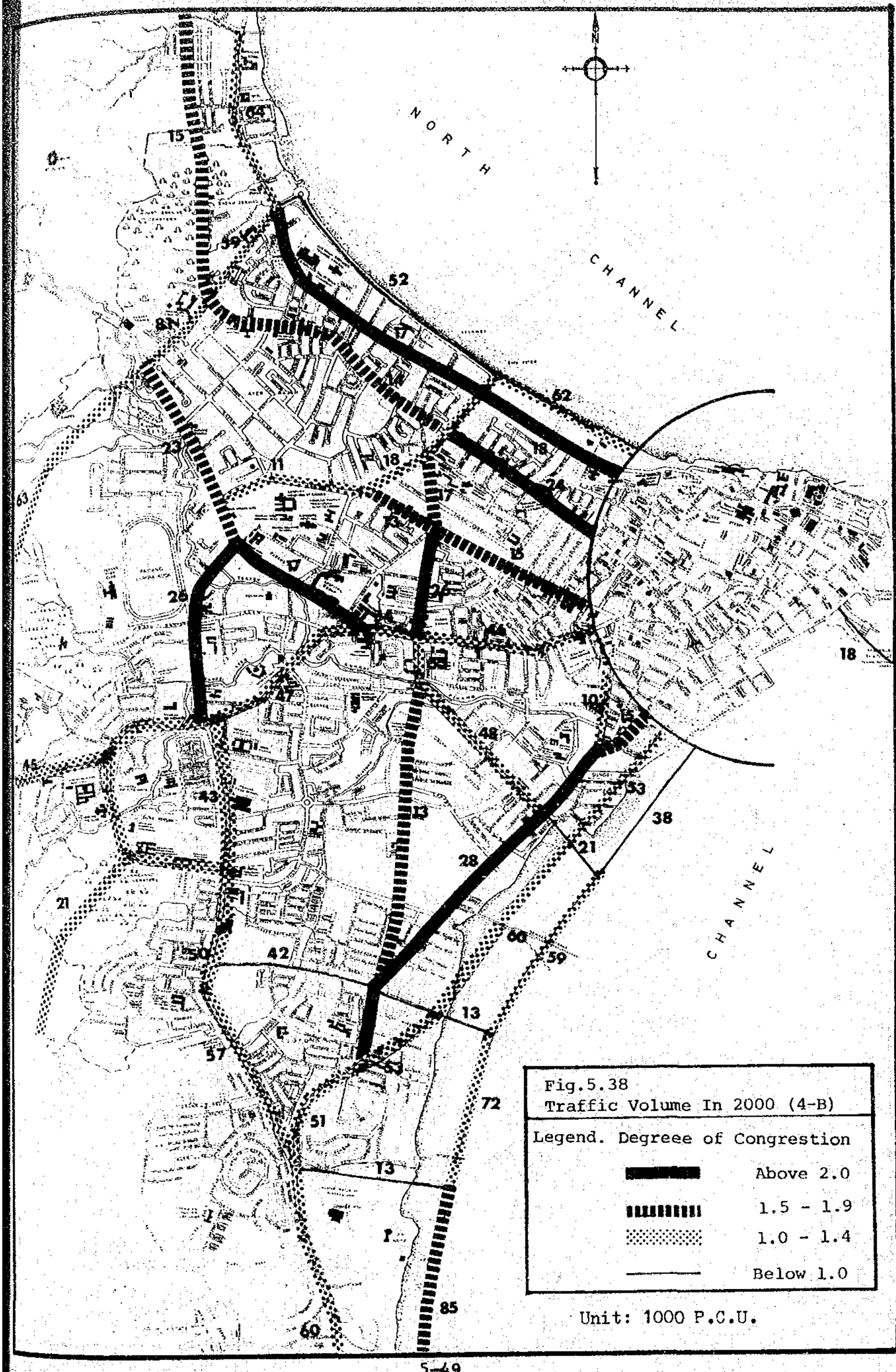


Fig.5.38
Traffic Volume In 2000 (4-B)

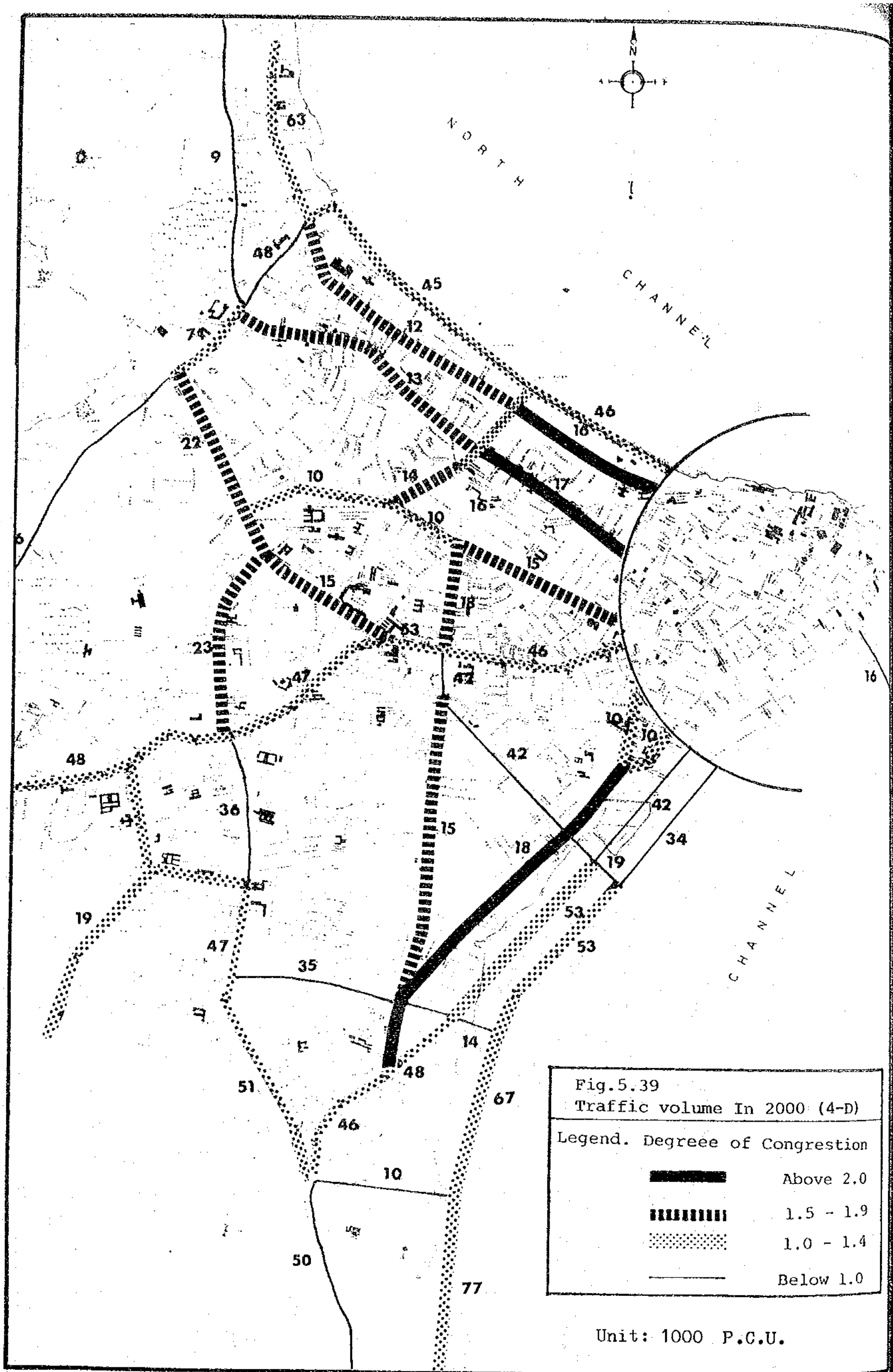


Fig.5.39
Traffic volume In 2000 (4-D)

6. Design and Cost of Alternative Plans

DESIGN AND COST OF ALTERNATIVE PLANS

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6. DESIGN AND COST OF ALTERNATIVE PLANS

6.1 Introduction

This study is aimed at designing and estimating the capital cost of short-term and long-term transport proposals. The transport proposals can be divided into the following:

1. Proposals concerning roads.
2. Public Transport.
   a. Bus transport
      Improvement of bus-stops
      Introduction of exclusive bus lanes
      Expansion of bus fleet
   b. New Transport System
3. Traffic Operations and Management
   Side-walks
   Traffic Signals
   Intersections
   Delineators
4. Parking.
5. Transport Terminal.
6. Transport Amusement Park.

6.2 The Highway

6.2.1 Highway Proposals

The transport network plan which will be reality in the year 2000, is shown in Fig. 6.3a. In this proposal, a long list of highway schemes were prepared on the basis of the pattern of future land use, traffic demands, the suitability of network configuration and other factors. Fig. 6.3b illustrates the road network by type of improvement. The study team proposed that roads be classified into four (4) categories in terms of their functions. They are:

(a) Primary distributors

These roads form the primary network for the town as a whole. All long-distance traffic movements to, from and within the town should be channelled to the primary distributors. The primary distributors may be divided into two (2) types; one type between urban areas (inter-urban) while the other in the urban areas (intra-urban).

(b) District distributors

These roads distribute traffic within the residential and industrial areas and principal business districts of the town and form a link between the primary network and the roads within the surrounding areas.

(c) Local distributors

These roads distribute traffic within the surrounding areas forming a link between district distributors and access roads.

(d) Access roads

These roads give direct access to buildings and land within the surrounding areas.

6.2.2 Design Criteria

The Malaysian design standard for roads is applicable only to the rural areas. This is the "Minimum Geometric Design Criteria for New Road." At present a Malaysian design standard for roads in the urban areas is non-existent although the various local authorities have their own criteria. The design criteria for roads proposed by the study team in terms of the functions of the roads as mentioned in section 2.1 are shown in Fig. 6.1 and Table 6.1.

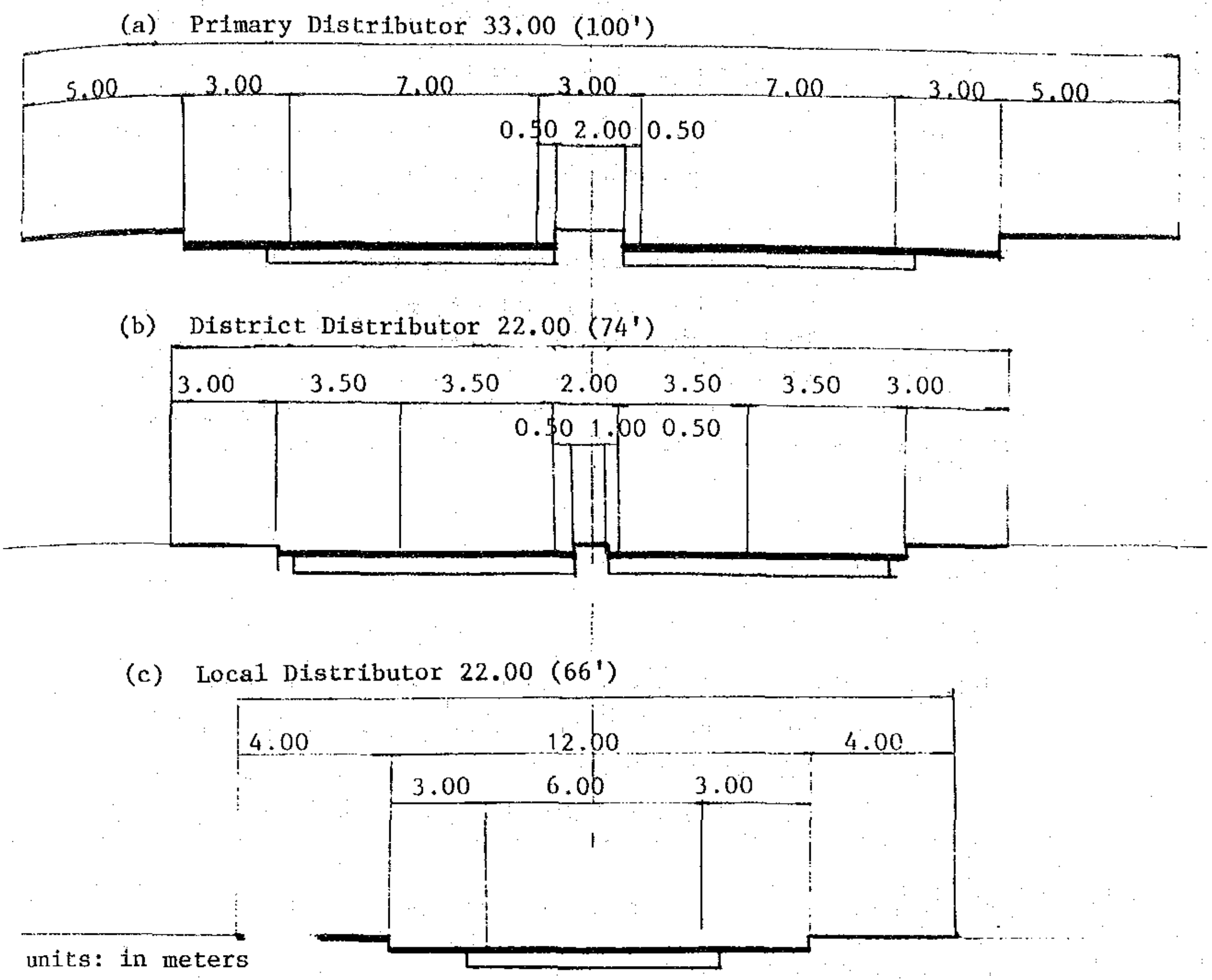


Fig. 6.1 DESIGN CRITERIA FOR ROAD SECTIONS BY FUNCTIONAL CATEGORIES
(Units: in meters.)

Table 6.1 ROAD CRITERIA

Classification of roads. \ Criteria		Number of lanes	Design speed (k/h)	Width of lanes (m)	Length of each (km)	Structure	Access Control	Parking	Intersection	Group of Standard
(a) Primary distributor	inter-urban	4–6	over 80 k/h	over 3.75	5.0–15.0	divided	full	No	Interchange	06
	intra-urban	4–6	60–80	over 3.5	1.4–5.0	divided	partial	No	grade separation	06
(b) District distributor road		2–4	40–60	over 3.0	0.5–1.0	divided	–	only in certain parts	at grade	05
(c) Local distributor road		2	30–50	over 3.0	0.2–0.5	–	–	OK	"	04 03

6.2.3 Types of Roads in Each Classification

Seven (7) types of cross-sections were prepared for the proposed road network based on the basic design criteria and local conditions.

Functional Classifications	Types of Roads
Primary Distributor	A. B. E. F. G
District Distributor	C
Local Distributor	D

The design criteria for every road proposed was also planned.

6.2.4 Cost Estimate

1. Unit Cost

The unit cost of road construction was arrived at from discussions with the J.K.R. of Penang, the City Council of George Town and from a study of the results of the various studies, eg., the Penang Dispersal Study, the New Federal Route 1 study and others.

The assumptions in the estimation are as follows.

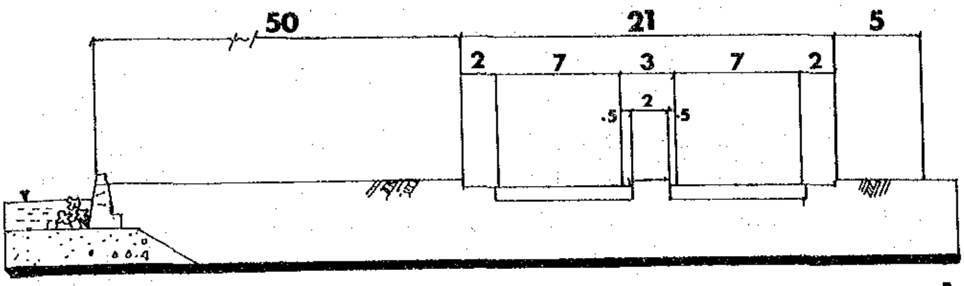
1) Site Clearance
In mountainous and rolling terrain, depth of site clearance is about thirty (30) centimetres.

2) Excavation
Including transport cost.

3) Embankment
Common soil is used for embankment with the compacting cost included.

Fig. 6.2 Cross-Section of Road

Units in Meters



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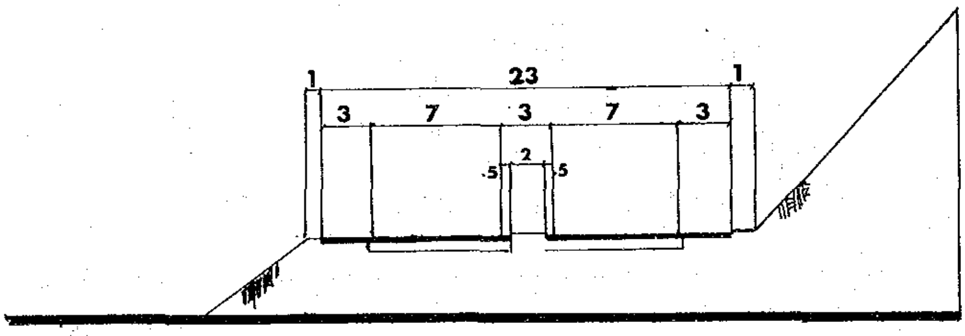

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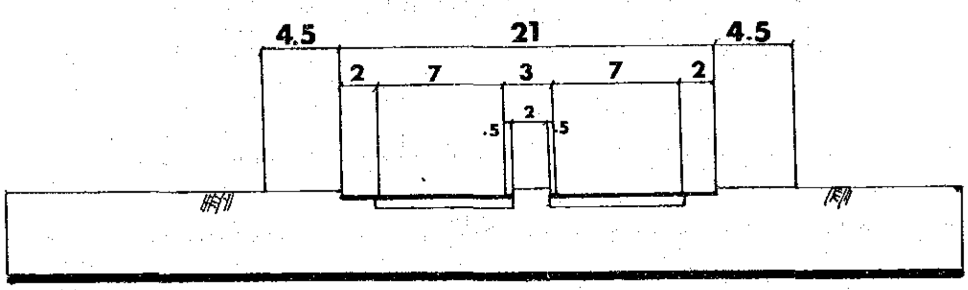

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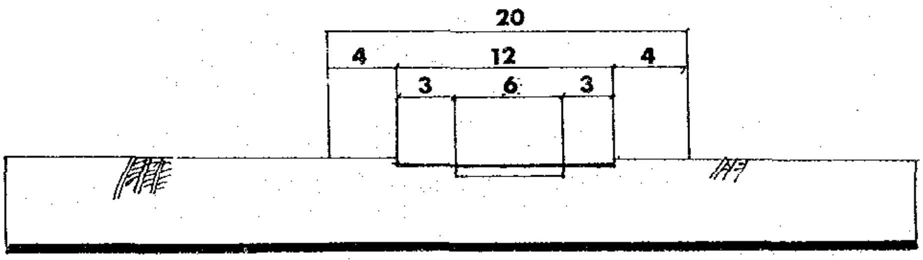

type D

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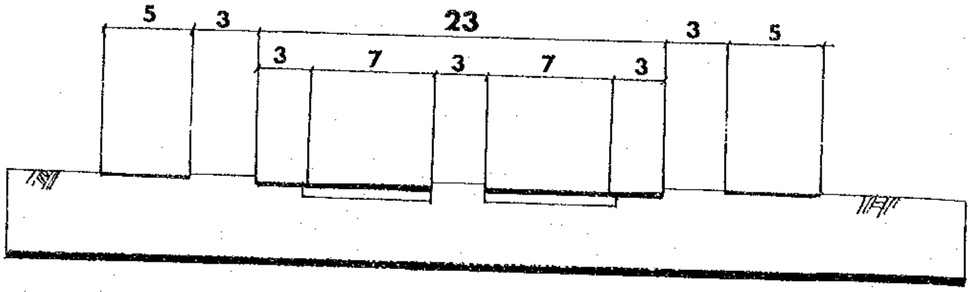

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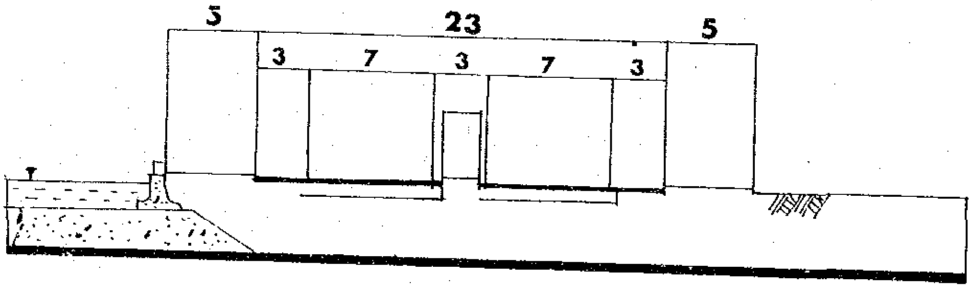

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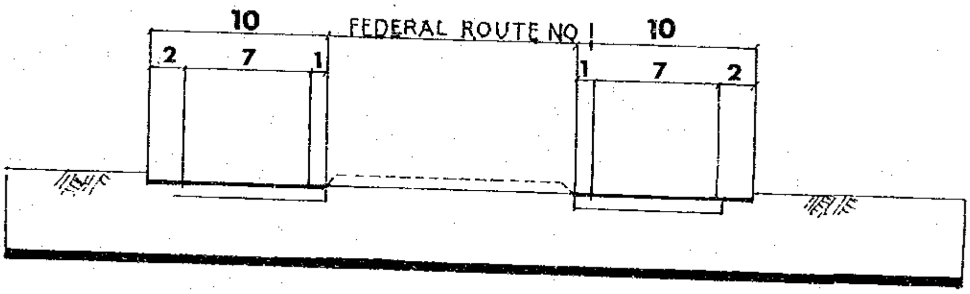

type G

Table 6.2 LIST OF UNIT COST

Specification	Description	Unit	Unit Cost (M$)	Remarks
1. Site Clearing		Km^2	200,000	
2. Excavation	common	m^3	5	
	rock	"	10	
	marine clay	"	8	
3. Embankment	common	"	5	
4. Turfing	close	m^3	3	
	tree	"	5	
5. Pavement	carriage-way	"	25	
	pedestrian	"	15	
	shoulder	"	15	
6. Drain	V-shaped	m	20	
	U-shaped	"	20	
7. Culvert pipe	Rc ϕ 600	m	150	
	Rc ϕ 900	"	250	
	Rc ϕ1,000	"	380	
	Rc ϕ1,500	"	540	
	Rc ϕ1,800	"	710	
8. Culvert Box	1.0 x 1.0	"	210	
	1.5 x 1.5	"	490	
	2.0 x 2.0	"	610	
	2.5 x 2.5	"	1,470	
	3.0 x 3.0	"	1,790	
9. Reinforced concrete	$\bar{\sigma}_{28}=280kg/cm^2$	m^2	260	Bridge
	$\bar{\sigma}_{28}=240kg/cm^2$	"	200	Wall
	$\bar{\sigma}_{28}=180kg/cm^2$	"	150	Foundation
10. Form	wood	m^2	26	
11. Reinforcement	SD 30	Ton	1,200	
12. Sand		m^2	21	Transport 5km
13. Gravel	$\frac{3}{4}$"	"	25	
14. Crushed stone	2"	"	20	
15. Guard-rail		m	50	
16. Block	concrete	m^2	29	
17. Median	3.00 a.m.	m	20	

2. Cost Estimate

Construction cost was estimated from the following procedures.

1) Classify the cross-section of the proposed road network.

2) Estimate the cost per unit length of each type of road.

Table 6.3 ROAD PLAN & COST IN PENANG ISLAND
(In Thousand Dollars at 1979 Prices) Province Wellesley

	Typical Cross-Section	Total Length (Kms)			Detailed Engineering and Construction Supervision	Construction Cost			Total Project Costs
		Improvement Section	New Construction Section	Total		R-O-W Acquisition Cost	Construction Cost	Total	
1. Gurney Drive Extension	A	1.5	3.1	4.6	3,377	–	42,211	42,211	45,588
2. Outer Ring Road from Bagan Jermal to Ayer Itam	B	1.5	4.0	5.5	2,241	23,750	28,016	51,760	54,007
3. Outer Ring Road from Ayer Itam to Green Lane	B	0	9.5	9.5	1,900	28,325	23,750	52,075	53,975
4. Green Lane from Ayer Itam Road to Roundabout	C	5.0	0	5.0	295	–	3,685	3,685	3,980
5. Scotland Road from Ayer Itam Road to Western Road	C	1.4	0	1.4	83	1,680	1,032	2,712	2,795
6. Western Road from Scotland Road to Gottlieb	C	1.5	0	1.5	88	1,800	1,106	2,906	2,994
7. Middle Ring Road (Perak Road, Pangkor Road)		2.4	0	2.4	141		1,769	1,769	1,910
8. Weld Quay Extension	C	0	4.0	4.0	406	–	5,080	5,080	5,486
9. Pair Route from Ayer Itam to Outer Ring Road	D	0	5.3	5.3	444	5,300	5,545	10,845	11,289
10. Pair Route from Outer Ring Road to Dispersal Road	D	0	3.5	3.5	283	3,500	3,535	7,035	7,318
11. Bayan Lepas Road	B	0	3.6	3.6	366	4,320	4,572	8,892	9,258
12. East Coastal Road	C	0	5.8	5.8	469	–	5,858	5,858	6,327
13. North Coast Road from Tanjong Bungah to Batu Feringgi	D	5.4	6.1	11.5	1,116	14,790	13,944	28,734	29,850
14. Penang Island Road from Airport to Telok Kumbar	D	4.6	0	4.6	320	3,220	4,000	7,220	7,540
15. Penang Hill Road Section 1	D	0	5.0	5.0	404	5,000	5,050	10,050	10,454
16. Penang Hill Road Section 2	D	0	13.0	13.0	1,050	13,000	13,130	26,130	27,180
17. Penang Hill Road Section 3	D	0	2.0	2.0	162	2,000	2,020	4,020	4,182
18. Jelutong Road	I	0.3	0	0.3	25	3,600	314	3,914	3,939
19. Leboh Mc. Nair	H	0.2	0	0.2	12	2,400	147	2,547	2,559
20. Maxwell Road	H	0.9	0	0.9	187	4,792	2,343	7,135	7,322
21. Dato Keramat-Ayer Itam Road to Ayer Itam Intersection	F	2.2	0	2.2	2,112	1,621	26,400	28,021	30,133
22. Ayer Itam Road from Ayer Itam	F	4.0	0	4.0	3,832	2,948	48,000	50,948	54,780
23. Penang View Road	J	0	6.5	6.5	1,099	6,500	13,741	20,241	21,340
Total		30.9	71.4	102.3	20,412	128,546	255,248	383,794	404,206

Table 6.4 ROAD PLAN & COST IN PROVINCE WELLESLEY
(In Thousand Dollars at 1979 Prices) Province Wellesley

Name of Roads	Typical Cross-Section	Total Length (Kms)		Total	Detailed Engineering and Construction Supervision	Construction Cost			Total Project Costs
		Improvement Section	New Construction Section			R-O-W Acquisition Cost	Construction Cost	Total	
1. S. Dua Road from Kg. Bagan Ajam to S. Dua	E	4.5	0	4.5	265	6,498	3,317	9,815	10,080
2. West Coastal Road from Kg. Bagan Ajam to New Port	F	0	5.5	5.5	2,712		33,897	33,897	36,609
3. West Coastal Road from New Port to intersection at Alor Star - Changkat Jering Highway	E	2.0	3.0	5.0	1,620	10,800	10,255	31,055	32,675
4. Federal Route 1 of Intersection at Alor Star - Changkat Jering Highway and Jalan Methopalaniapa	E	7.5	0	7.5	442	10,830	5,528	16,358	16,800
5. Ring Road in B. Mertajam from Kg. Uma to P. Jatoh	E	0	2.5	2.5	400	5,000	3,175	8,175	8,575
6. Ring Road in B. Mertajam from P. Jatoh to Alor Star - Changkat Jering Highway	E	0	5.5	5.5	559	11,000	6,985	17,985	18,544
7. Permatang Pauh Road from Kg. Sama Gagah to S. Ampat	C	6.5	0	6.5	383	9,386	4,791	14,177	14,560
8. B. Tengah Road from S. Ampat to Kg. Bukit Minyak	C	5.0	0	5.0	297	7,187	3,718	10,905	11,202
9. Bukit Minyak Road to Alor Star - Changkat Jering Highway	C	0	3.9	3.9	624	7,800	4,953	12,753	13,377
10. Jalan Mohamed Saad - Jalan Bagan Lalang	D	0	4.0	4.0	210	880	2,628	3,508	3,718
11. Road from S. Puyu to Mak Mandin	D	0	3.7	3.7	168	814	2,098	2,912	3,080
12. Road from Mak Mandin to Chain Ferry Road	D	0	1.8	1.8	82	396	1,021	1,417	1,499
13. Heng Choon Thiam Extension	D	0	3.8	3.8	172	836	2,155	2,991	3,163
14. Prai Road	E	2.6	0	2.6	264	5,200	3,302	8,502	8,766
15. Permatang Pauh Road	E	5.0	0	5.0	508	7,220	6,350	13,570	14,078
16. Frontage Road from Kg. Tok Hamid to Kg. Bagan Serai	G	0	4.0	4.0	217	1,600	2,716	4,316	4,533
17. Frontage Road from Kg. Bagan Serai to Kg. Telok	G	3.9	0	3.9	212	1,560	2,648	4,208	4,420
18. Frontage Road from Prai Industrial Estate to Kg. Tok Kangar	G	0	5.8	5.8	315	2,320	3,938	6,258	6,573
19. Jalan Raja Uda - Jalan Siram - Jalan S. Nyior	D	0	2.5	2.5	270	5,000	3,375	8,375	8,645
20. Sg. Nyior, Siram, Raja Uda Roads	F	2.8	0	2.8	165	1,960	2,063	4,023	4,188
Total		39.8	46.0	85.8	9,885	96,287	118,913	215,200	225,085

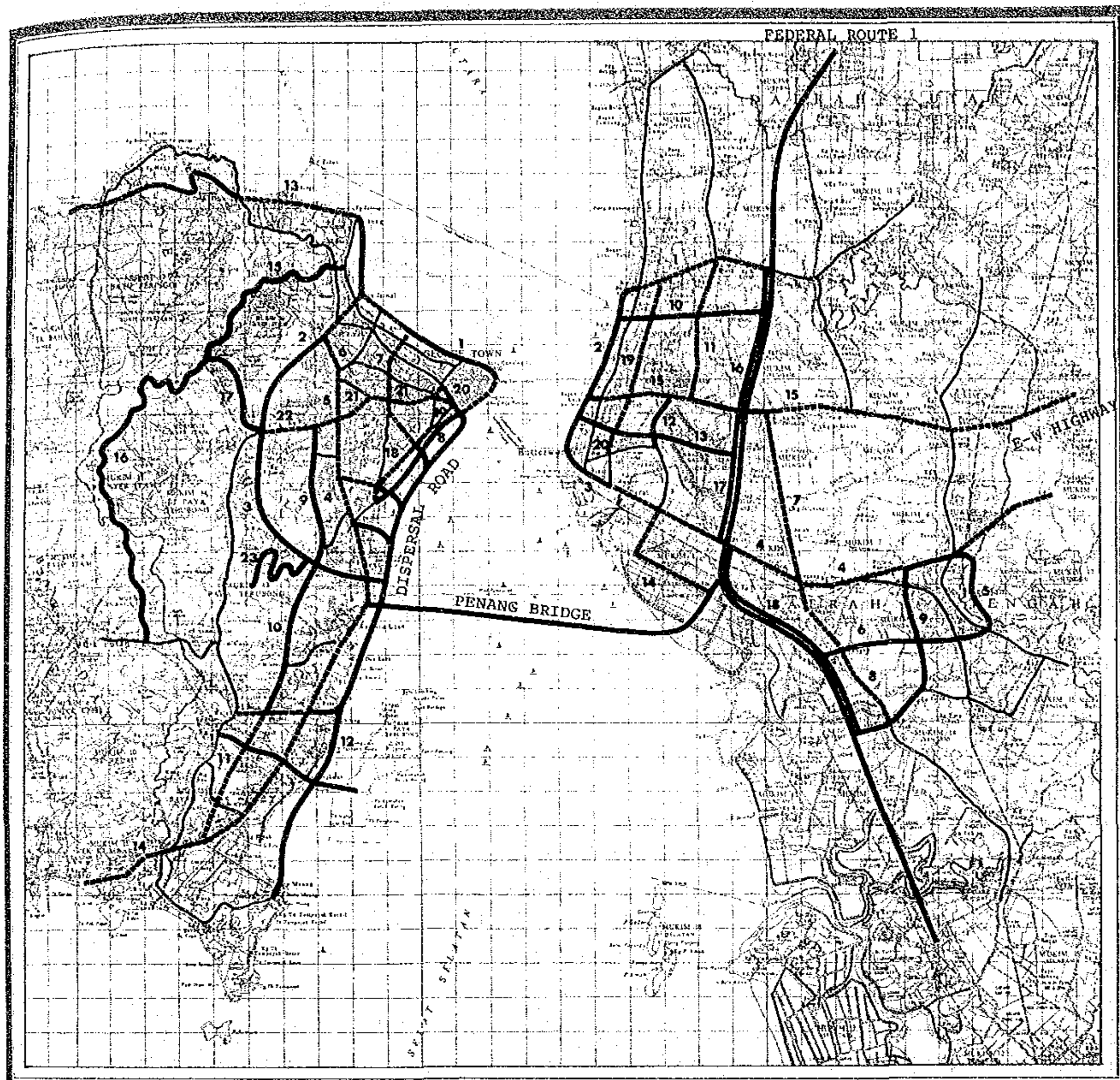

Fig. 6.3(a) Proposed Road Network and Road Number

NORTH

Construction

Improvement

Existing Roads

Note: Numbers correspond to tables 5.1 and 5.2 respectively

PENANG URBAN TRANSPORT STUDY

URBAN TRANSPORT STUDY IN GREATER METROPOLITAN AREAS OF GEORGETOWN, BUTTERWORTH AND BUKIT MERTAJAM

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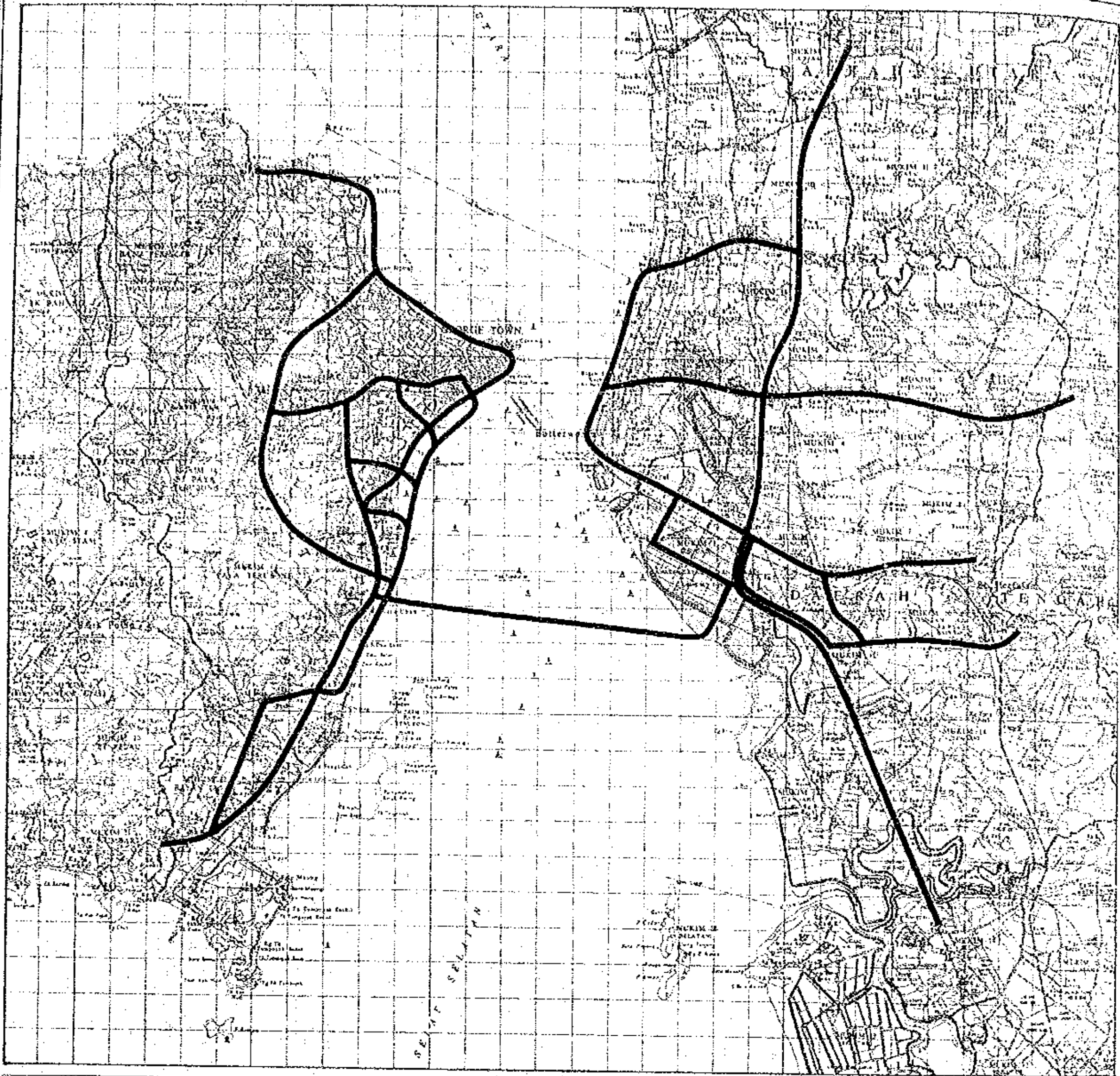

Fig.6.3b Roads with 4 lanes

NORTH

Road with 4 lanes

PENANG URBAN TRANSPORT STUDY

URBAN TRANSPORT STUDY IN GREATER METROPOLITAN AREAS OF GEORGETOWN, BUTTERWORTH AND BUKIT MERTAJAM

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