b. Population increase will be maintained in the remaining residential areas inside the Circunvalar.

c. New residential areas to be formed outside the Circunvalar will have a gross population density of 150 persons/hectare and will be mixture of high- and middle-class detached houses and apartment houses.

(6) South Suburbs

A population of 200 persons/hectare will be accommodated, except in areas set aside for large-scale facilities such as the airport, Gran Central de Abastos and industrial zone. Housing will be a mixture of small- and medium-scale detached houses and apartment houses.

(7) Outer Area

The population estimated by EMPOTLAN will be used.

2) Distribution Results

Of the population increase of 843,000 persons expected between 1983 and 2000, it is established that 102,000 will live in the built-up area including the central district, 172,000 in the southwest suburbs, 257,000 in the northwest suburbs and 235,000 in the south suburbs. Population increase in the outer area will be 77,000 persons.

The new urban areas will initially expand in a southerly direction. After 1990, the expansion will be mainly in a northwesterly direction (Refer to Fig. 8-4-2).

8-4-3 Employment Distribution Plan

1) Distribution Policy

Factors for employment increase and policies for employment distribution for each sector in each zone are as follows:

a. Primary Industries

(1) Employment by the primary industries in the Barranquilla-Soledad district is expected to decrease as urbanization progresses.

(2) On the other hand, suburban-type agricultural industries such as poultry raising will most likely expand employment opportunities in the outer area, so that the number of workers in the primary industries will increase.

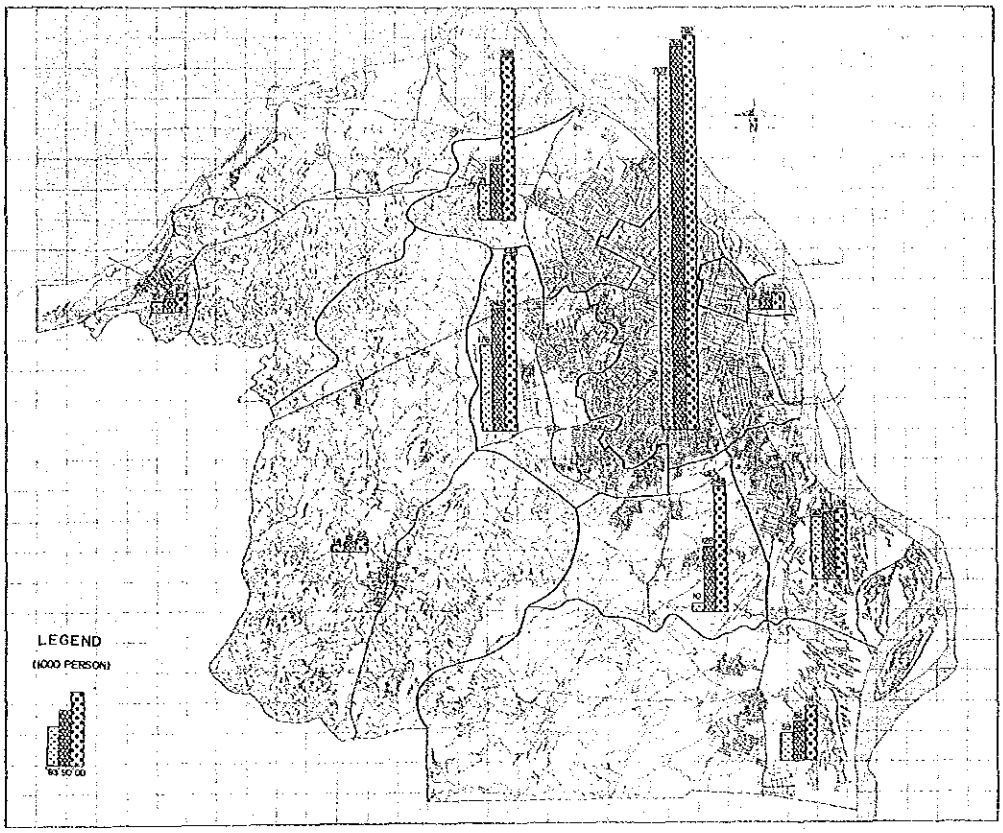

Fig. 8–4–2 Population Distribution Plan

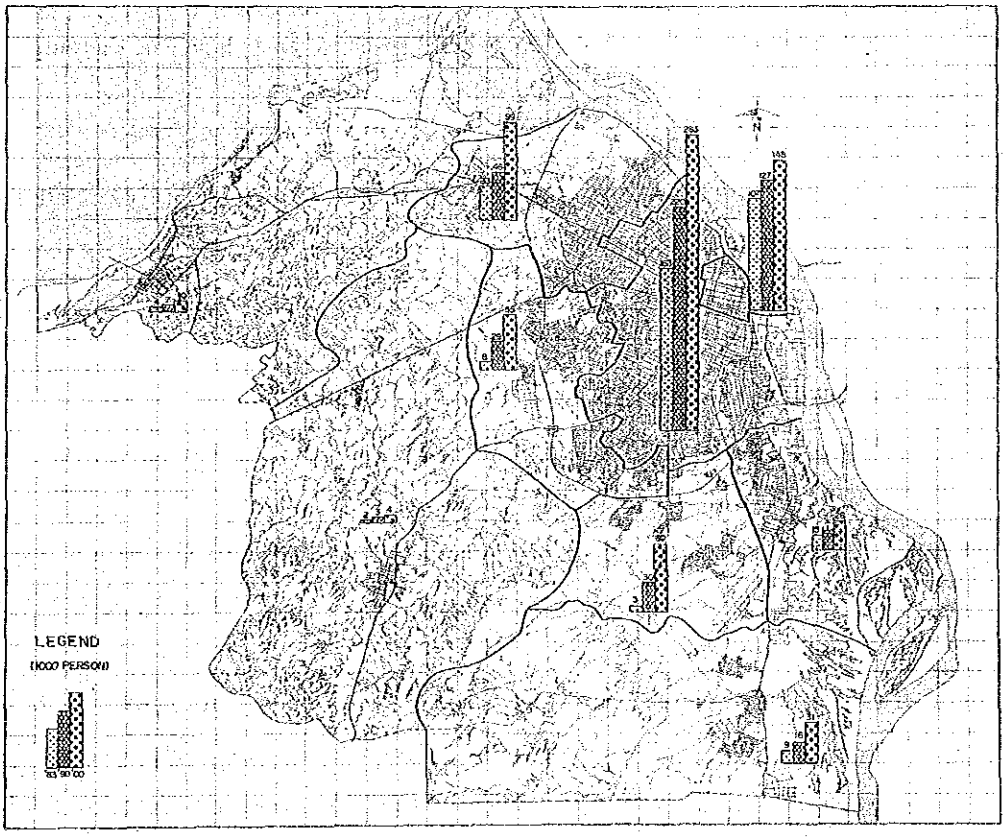

Fig. 8–4–3 Employment Distribution Plan

b. Secondary Industries

(1) The following three factors are considered to cause an increase inthe employment of the secondary industries:

- Population increase
- Growth of existing factories or businesses, or the appearance of related industries in nearby areas
- New projects such as industrial park construction

(2) The portion of employment increase that corresponds to population increase is distributed in proportion to the population increase in each zone during the periods 1983 to 1990 and 1990 to 2000.

(3) The portion of employment increase caused by the growth of existing businesses is distributed for 1990 in proportion to the number of those employed in the secondary industries in each zone in 1983, and for the year 2000 in proportion to the number of those employed in the secondary industries in each zone in 1990.

(4) The portion of employment increase that corresponds to new projects is distributed by taking into account the area of land set aside for industrial parks and the development schedule.

c. Tertiary Industries

(1) The following five factors are considered to cause an increase in the employment of the tertiary industries.

- Population increase
- The growth of exisitng stores or offices, or the emergence of related inductries in nearby areas
- New projects such as the Gran Central de Abastos construction and recreation center developments
- Policy that promotes the formation of sub-centers
- Transfer of some of the functions located in Centro, or restriction of further concentration in Centro

(2) The portion of employment increase that corresponds to population increase is distributed in proportion to the population increase in each zone during the periods 1983 to 1990 and 1990 to 2000.

(3) The portion of employment increase caused by the growth of existing businesses is distributed for 1990 in proportion to the number of those employed in the tertiary industries in each zone in 1983, and for the year 2000 in proportion to the number of

those employed in the tertiary industries in each zone in 1990.

(4) The portion of employment increase that corresponds to new projects is distributed by taking into account the area of land set aside for the planned Gran Central de Abastos, recreation centers, etc., and the development schedule.

(5) The portion of employment increase caused by the establishment of sub-centers is distributed in relation to the development scale of the districts where the municipal center, suburban district center and built-up area center are planned.

(6) The portion of employment increase caused by the renewal of the central district as redistribution of the employment increase forecasted to concentrate in the central district) is distributed in proportion to the accumulation of tertiary industries in each zone, excluding the central district.

2) Distribution Results

Of the employment increase of 381,000 persons between 1983 and 2000, 30% (120,000) will be created inside the Barranquilla built-up area. Employment in the Central District will increase by 1.4 times, but it will account for a smaller share of the total. In the suburbs, there will be an employment increase of 177,000 persons, largely due to population increase and sub-center formation (Refer to Fig. 8–4–3).

Chapter 9.

FORECAST OF FUTURE TRANSPORT DEMAND

Chapter 9 FORECAST OF FUTURE TRANSPORT DEMAND

9–1 Procedure and Model Building

9–1–1 Procedure

The general procedure for the forecast of future transport demand is illustrated in Fig. 9–1–1.

As elaborated before, the characteristics of the existing person trips are obtained from the person trip survey. The models for the transport demand forecast are established by analyzing the relationship between the trip characteristics and the present socio-economic conditions such as population, employment and land use pattern.

The forecasting procedure is composed of 4 steps: Trip generation/attraction, trip distribution, modal split and traffic assignment. Each step requires a corresponding forecasting model.

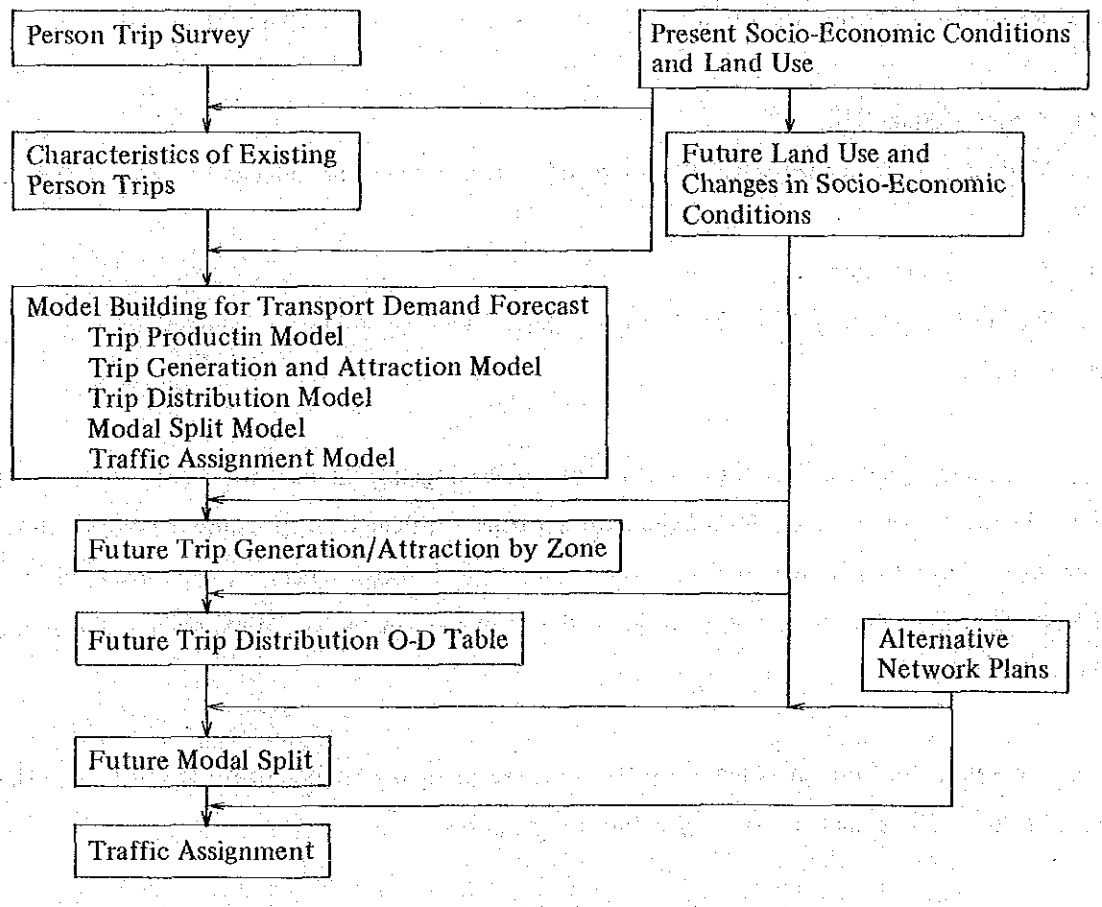

Fig. 9–1–1 Procedure for Future Transport Demand Forecast

1) Step 1: Trip Distribution

The total transport demand is generally forecasted at the first step and used as the control total for estimating the zonal transport demand. The zonal demand in the future in terms of trip generation and attraction is obtained by using a trip generation/attraction model, which is built based on the existing demand.

2) Step 2: Distribution

The trip distribution model makes up the trip distribution pattern in terms of the OD table based on the estimated trip generation/attraction by zone. This procedure is normally applied by considering the differences in trip distribution pattern by trip purpose. This procedure can be classified basically into the following two methods.

(1) Present pattern method

(2) Distribution model method

The present pattern method is employed assuming that the existing OD pattern would remain unchanged in the future, while, the distribution model method, takes into consideration the change in distance and other factors by zone pair as explanatory variables in the model.

3) Step 3: Modal Split

Modal split model forecasts the share of different transport means for each OD Pair.

4) Step 4: Assignment

Traffic assingment model simulates the traffic flow of vehicles/passengers on roads and other networks.

This 4-step procedure is applied only for forecasting the internal trips generated by the residents in the PT survey area. As for the external trips or through trips, a more simple method, ie. a growth rate method is applied. Since the external and through trips make up only 5% of the total person trips in the Metropolitan Region, the influence on the forecasting accuracy of the total is not significant.

Generally, the forecast is made by trip purpose in each step except for the last step. The forecast in this study is made by the following trip purposes.

(1) To work

(2) To school

(3) Business

(4) Shopping

(5) Private

(6) To home

9–1–2 Model Building

1) Trip Production Model

First of all, the total number of trips which are made by the residents in the study area is estimated. The trip production model is expressed by using the number of trips per person. This rate when multiplied by the numbers of persons over 5 years old gives the total number of trips in the future. This total number of trips in the study area is used as the control total for the trip generation/attraction by zone and also as the control total for the OD table.

In this study the production rate method is adopted for forecasting the future trip production. The production rate method assumes that the trip production rate by personal characteristics has the same value in the future.The trip production rate method should satisfy the following three conditions.

(1) The trip production rates by categories of personal characteristics should be stable for each zone.

(2) There is a clear difference in the population structure by categories between that at present and that in future.

(3) It is possible to forecast the population by categories.

Since trip production depends upon personal characteristics, such as age, occupation, industry, car-ownership and so on, the trip production rate can be defined as the number of trips per person as follows:

$$\alpha_i = G_i / P_i$$

where, α_i : Trip production rate by personal characteristics i

G_i: Trips which are produced by persons having characteristics i

P_i: Population having characteristics i

The population is obtainable from the person trip survey by each category of characteristics. Hence, the trip production rate as a whole is calculated as follows.

$$\alpha = \frac{\sum_{i} \alpha_i \cdot X_i}{\sum_{i=1} X_i}$$

wherein, α : Trip production rate

α_i : Trip production rate of category i in personal characteristics

X_i: Population of category i

2) Trip Generation and Attraction Model

For the estimation of trip generation and attraction, a linear regression model is employed. The general formula is as follows:

$$T = a + bX_1 + cX_2 + dX_3$$

where, T : Trip generation or attraction

X_1, X_2, X_3: Explanatory variables by zone such as population, employment

a, b, c, d : Constants

After examining various formulas by changing the combination of explanatory variables, the formula is calibrated by trip purpose and by generation and attraction. The results are shown in Table 9–1–1.

Table 9–1–1 Trip Generation and Attraction Model

	Trip Generation	Trip Attraction
Work	$T_i = 250.95 + 1.424\ X_{2-3}$ ($r = 0.981$) X_{2-3}: Working Population in Secondary and Tertiary Industries	$T_i = -601.55 + 1.30177\ W_{2+3}$ ($r = 0.976$) W_{2+3}: Number of Employees, in Secondary and Tertiary Industries
School	$T_i = 489.09 + 0.35176\ N_i$ ($r = 0.976$) N_i: Population in zone i	$T_i = 2,329.16 + 0.14740\ N_i + 1.23848\ W_3$ ($r = 0.751$) N_i: Population in zone i W_3: Number of employees in Tertiary Industries
Home	$T_i = \sum_{k=1}^{5} kA_i$ kA_i: Trip Attraction to zone i for trip purpose k excluding business trips.	$T_i = \sum_{k=1}^{4} kG_i$ kG_i: Trip Generation from zone i for trip purpose k excluding business trips.
Business	$T_i = 257.18 + 0.24497\ X_{2+3} + 0.6669\ W_i$ ($r = 0.836$) X_{2+3}: Working Population in Secondary and Tertiary Industries in zone i	$T_i = 54.76 + 0.28405\ W_i$ ($r = 0.920$) W_i: Total Number of Employees in zone i
Shopping	$T_i = 863.07 + 0.12363\ N_i$ ($r = 0.855$) N_i: Population in zone i	Refer to Table 9–1–2.
Private	$T_i = 309.86 + 0.19307\ N_i + 0.35662\ W_3$ ($r = 0.899$) N_i: Population in zone i W_3: Number of Employees in Tertiary Industry in zone i	$T_i = 984.00 + 0.1151\ N_i + 0.66449\ W_{2+3}$ ($r = 0.829$) N_i: Population in zone i W_{2+3}: Number of Employees in Secondary and Tertiary Industries in zone i

a. Work Trips

The selected explanatory variables are reasonable. The number of the trip generation to the work place is dependent upon the working population in Secondary and Tertiary industries residing in the corresponding zone. Also, in accordance with the number of employees in Secondary and Tertiary industries, the trip attraction for work purpose varies.

b. School Trips

Generally, the number of students and pupils or the number of schools are used as the explanatory variables for estimating the number of school trips. But the accurate information were not available in the study area.

In analyzing the location of higher level schools/universities in Barranquilla, most of them, especially the private ones are concentrated in the northern part of Barranquilla or near the central area, as shown in Fig. 9–1–2. It also shows that the distribution of these schools nearly coincides with the distribution of the employees in the tertiary industries. For this reason, the number of employees in tertiary industries was selected as an explanatory variable. Population was selected as one other variable, because the number of primary schools tend to increase in

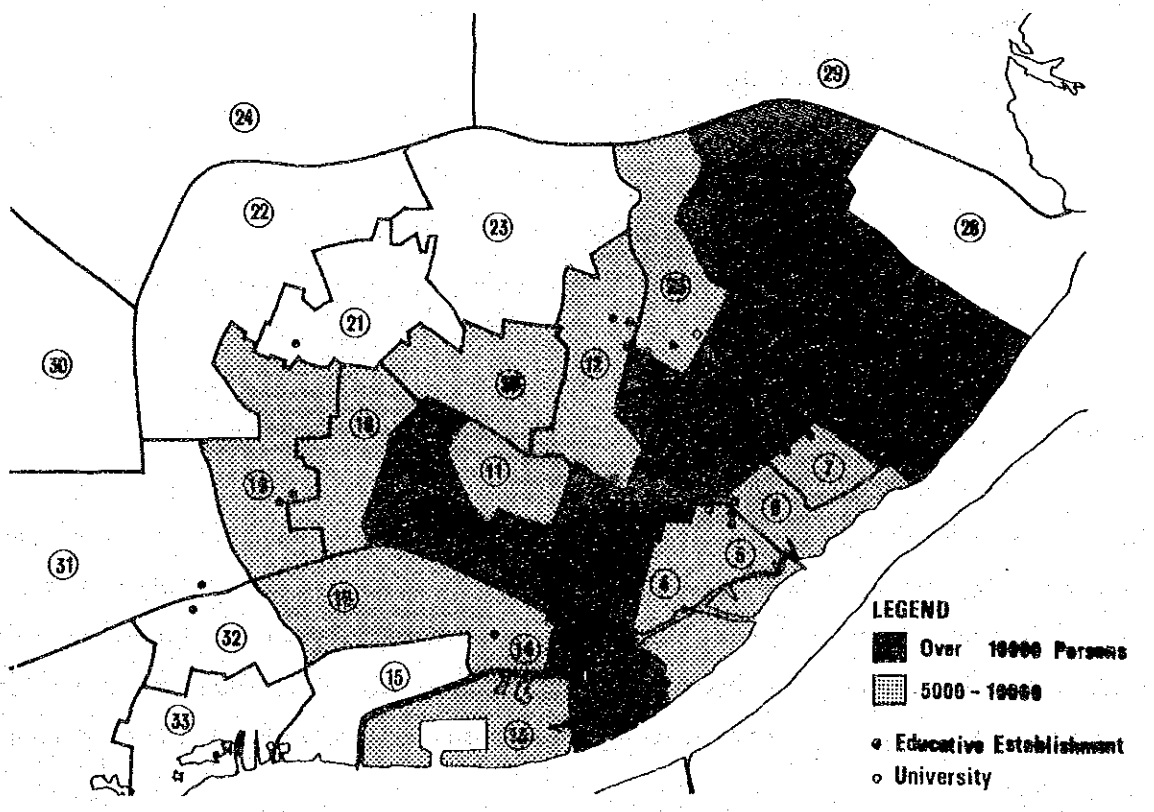

Fig. 9–1–2 Distribution of Employees in Tertiary Industry and Educational Establishment

proportion to the population growth in the corresponding zone.

c. Business Trips

Business trips are usually related to work activities. From this point of view, trip generation and attraction for business purpose can be explained in terms of the working population or the total number of employees.

d. Trip Generation for Shopping

Almost all shopping trips are made by housewives. Thus the shopping trip generation is explained by the population in the residential zone, which is considered to be proportional to the number of housewives.

e. Trip Attraction for Shopping

There exists a considerable difference in the trip attraction per number of employees in the tertiary sector among zones. The highest extreme is the trip concentration in the Central District, the lowest is found at the residential area with small-scale commercial shops. Therefore, in the case of the shopping attraction, the zones are classified in to the following clusters:

Cluster-1	Zone 1, 3, (8, 40, 42)
Cluster-2	Zone 8, 40, 42 (4, 27, 62)
Cluster-3	Zone 2, 4, 5, 9, 19, 20, 23, 24, 25, 27, 28, 30, 31, 32, 33, 41, 45, 48, 50, 54, 55, 57, 58, 62, 63, 67, 74, 75, 77
Cluster-4	Other zones (except the above mentioned zones)

Note: The zones in the parenthesis do not fit the corresponding line.

The relationship between the number of trips and the number of employees in tertiary industries bv zone is shown in Fig 9–1–3.

Generally speaking, the zones in Cluster-1 are the highly developed areas such as Centro, Cluster-2 is an existing sub-center, Cluster-3 is the commercial area along the main street and Cluster-4 is the less developed area along the Circunvalar and those areas between the main streets. The zone grouping by above clusters is shown in Fig. 9–1–4. This map shows clearly the characteristics of each cluster. Considering the formation of new sub-centers in the future, the following zones should be changed in terms of the cluster for forecasting the future shopping attraction.

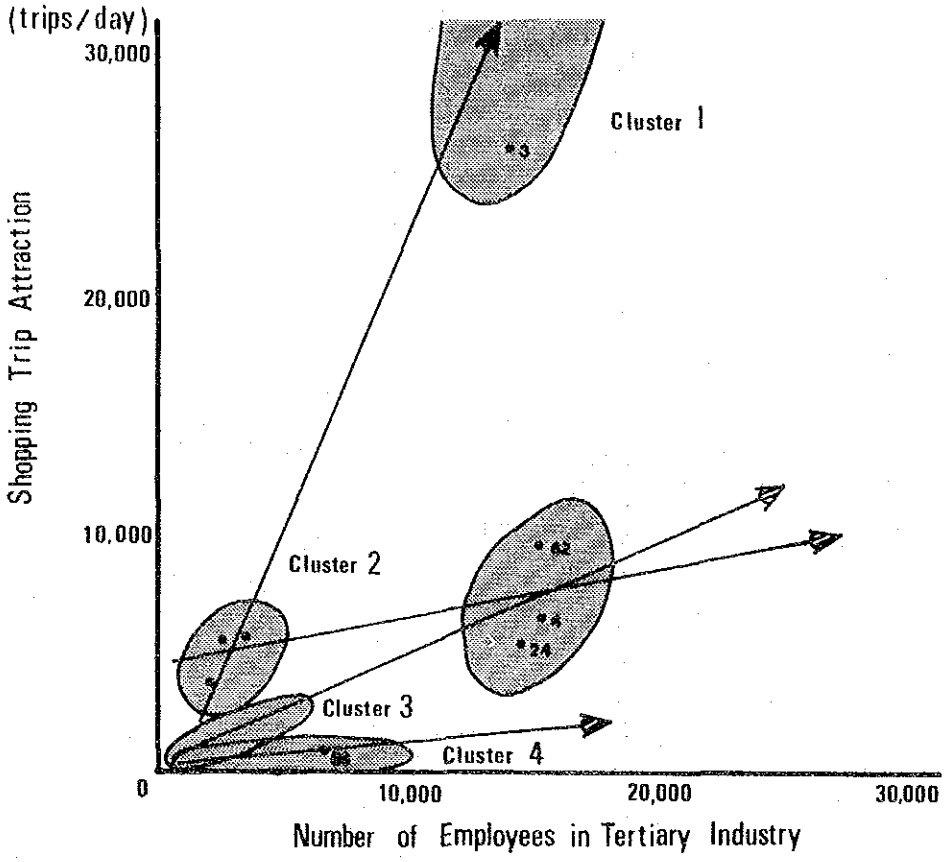

Fig. 9–1–3 Shopping Trip Attraction and Number of Employees in Tertiary Industry

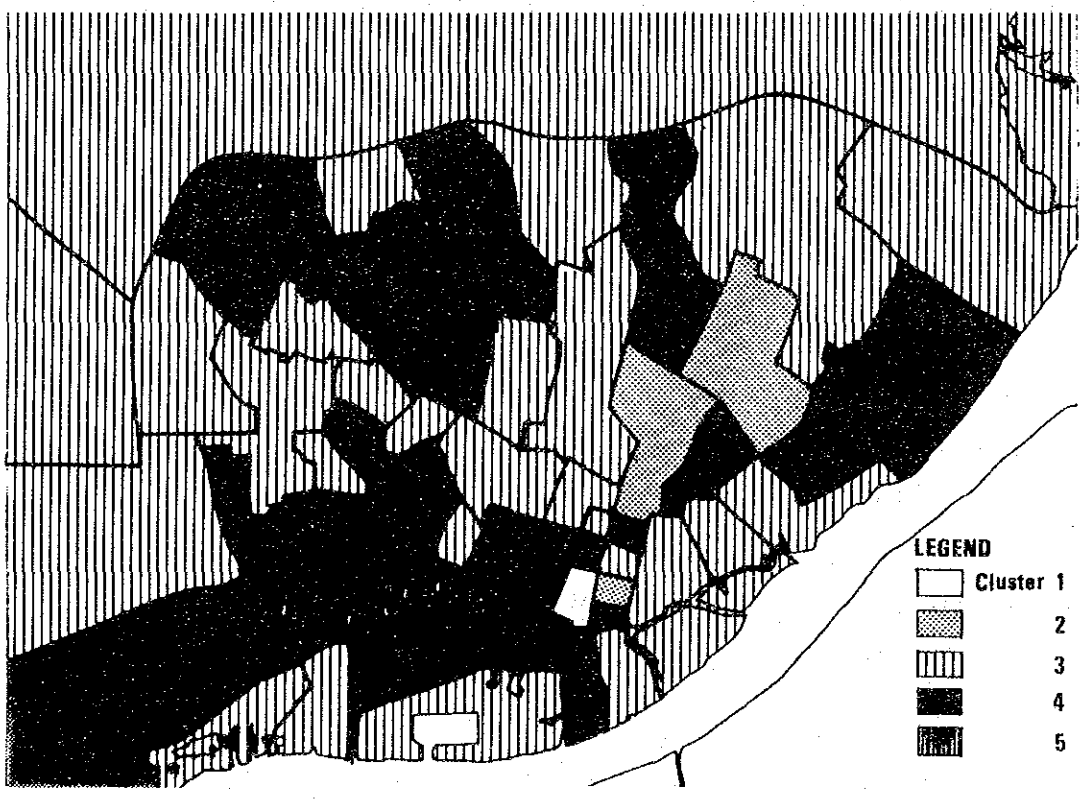

Fig. 9–1–4 Classification of the Cluster (Shopping Trip Attraction)

Zone	Change Cluster	
	From	To
51	4	3
65	4	3
69	4	2
73	4	2

The results of the correlation analysis are shown in Table 9–1–2.

Table 9–1–2 Trip Attraction Model for Shopping

Cluster	Equation		
1	T_i = 399.43 + 1.78835	W3	(r = 0.998)
2	T_i = 4,384.61 + 0.17823	W3	(r = 0.665)
3	T_i = 780.69 + 0.40667	W3	(r = 0.915)
4	T_i = 127.03 + 0.12207	W3	(r = 0.549)

Remark: T_i : No. of Trip Attraction in zone i
W3: Employee of Tertiary Industry in working zone
r : Correlation Coefficient

f. Private purpose trips

The trips defined as "private" include various purposes such as recreational, social, cultural, etc. Hence, the factors selected as the explanatory variables are commercial activities and population in each zone for both trip generation and attraction.

g. Home purposes

This trip purpose refers to returning to the residential zone. Returning from work, school, shopping and private are the main portion of trips for this purpose because these trips are almost all "home based trips". The "home" purpose trips can be easily obtained by reversing the direction of above-mentioned trips, i.e. changing the origin and destination, in as much as the number of the non-home based trips, for instance the trips from a working place to a shopping place, etc. are negligibly small when compared with the total number of "home" purpose trips. However, business trips are related to work which means that both trip ends are not usually connected with residential zone. Therefore, business purpose trips are excluded for obtaining "to home" trips.

3) Trip Distribution Model

The following three types are generally used as a trip distribution model.

(1) Present pattern method

(2) Gravity model method

(3) Opportunity model method

The present pattern method assumes that the existing OD pattern applies to the future OD pattern. This is mainly used for short range forecasting, since it is difficult to reflect a drastic change in city structure, a large scale development or improvement of transport facilities.

The Gravity Model method does not reflect the characteristics of city structures and are not taken into consideration in the explanatory variables. However, the gravity model does reflect the effect of transport facility improvement or large scale developments.

The opportunity model does not include the travel time which changes by traffic conditions. Therefore, compared with the Gravity Model the effect of traffic facility improvement is not easily reflected. However, the error in distance does not greatly influence on the estimation. On the other hand, there is a serious problem in setting the value of L, i.e., the probability of trip attraction by zone.

Accordingly all of the above models have advantages and disadvantages. In this study, a mixed method is employed: present pattern and gravity model. The trip generation and attraction in the future will generally increase in any zone.

The gravity model is applied only for estimating the trip distribution of incremental volume of trip generation/attraction.

The future O-D table, therefore, can be obtained by summing up the existing number of trips and the incremental number of trips estimated by the gravity model. The main reasons for employing the above method are as follows:

(1) The existing trip pattern will not drastically change in the case of trips within the built up area.

(2) However, in the case of sub-urban area, a new trip pattern will be created by various development projects such as housing, subcenters, industrial parks, etc. as identified by the future land use plan.

The gravity model employed in this study, which is the one developed by Bureau of

Public Roads in the U.S.A., is as follows:

$$T_{ij}^{k} = G_{i}^{k} \frac{A_{j}^{k} F^{k}(d_{ij})}{\sum_{j=1}^{n} [A_{j}^{k} F^{k}(d_{ij})]}$$

where, T_{ij}^{k} : Number of trips for purpose k from zone i to zone j

G_{i}^{k} : Trip generation for purpose k in zone i

A_{j}^{k} : Trip attraction for purpose k in zone j

$F^{k}(d_{ij})$: Travel time factor for purpose k.

The travel time factor $F^{k}(d_{ij})$ is determined by analyzing the existing trp length distribution by purpose.

In the case of the trips to school, another method is employed, namely the following type of gravity model is used.

$$T_{ij} = K \frac{G_{i}^{a} \cdot A^{b}}{D_{ij}^{c}}$$

where, T_{ij} : Number of trips for school from zone i to zone j

G_{i} : School trip generation in zone i

A_{j} : School trip attraction in zone j

D_{ij} : Distance between zones i and j

The constants are calibrated by using the existing O-D pattern as follows:

K : 0.2768

a : 0.5029

b : 0.4705

c : 0.3344

r : 0.90

The reasons for employing the above formula instead of the mixed type applied for other trip purposes are as follows:

(1) The trips by pupils to elementary schools mainly consists of short-distance trips, therefore, are mostly included in the intrazonal trips.

(2) On the other hand, the trips by students for higher level of schools of universities mainly appear as inter-zonal trips. The higher the school level is, the more specialized and the more distinctive features it has. This indicates that there are many students who would attend a school located in another area for its speciality even if there is a school of the same level near their residences.

(3) The composition ratio of trips by pupils to total school trips will decrease in future due to the declining tendency of birth rate and the increase of students in higher education.

(4) The above considerations suggest that the future trip pattern is likely to change in accordance with the future distribution of schools and the student's choice for more preferable education.

Hence the application of only the latter type of gravity model appears to be more appropriate for school trips.

With regard to "To Home" purpose, the O-D table can be obtained by reversing all the other purpose trips except for business, since most of the trips are home-based as mentioned before.

In addition to the interzonal trip distribution model, it is necessary to make and intra-zonal trip model. As the intra-zone model, the following two forms are examined:

Type 1 $T_{ii} = K \cdot G_i^a \cdot A_i^b$

Type 2 $T_{ii} = K \cdot Z_i \cdot [\text{Min. } G_i \text{ or } A_i]$

where, T_{ii} : Intra-zonal trip in zone i

G_i : Trip generation in zone i

A_i : Trip attraction in zone i

Z_i : Area of zone i

K, a, b : Constants

As a result, the first type is found to be more preferable than the second in terms of the correlation coefficient. This implicitly indicates that the size of intra-zonal trips in the study area is not largely affected by the area of zones. The results of the intra-zonal trip model by trip purpose are shown in Table 9–1–3.

Table 9–1–3 Intra-Zonal Trip Model

Model Type : $T_{ii} = K \cdot G_i^a \cdot A_i^b$

Trip Purpose	Constants			
	K	a	b	r
Work	0.425	0.6390	0.4522	0.83
School	0.4534	0.7716	0.1657	0.90
Bsuienss	0.1200	0.7449	0.2056	0.72
Shopping	0.0169	0.8924	0.4468	0.86
Private	0.0048	1.2181	0.0510	0.83

3) Modal Split Model

In order to find the modal choice in future, a modal split model is established by the following binary choice procedure, indicated in Fig. 9–1–5.

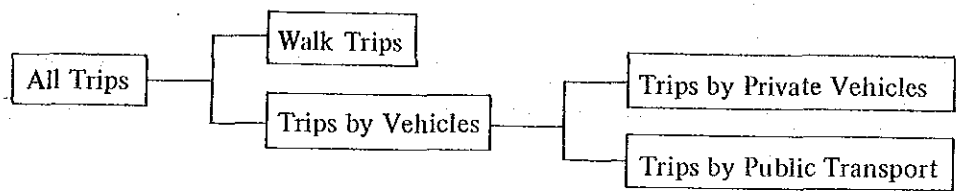

Fig. 9–1–5 Procedure of Binary Choices

Through the analysis of the existing modal choice, it is found that there exit a significant difference in the modal choices between a vehicle owner and a non-owner. Therefore, the modal split model is made by vehicle owners and non-owners. Initially all the trips are divided into two modes: walk trips and trips by vehicles. The trips by vehicles are further subdivided into two types: trips by private vehicles and trips by public transport. Taxi is in general classified as a public transport mode, but it is classified as a private mode in this study taking into account its characteristics of trip pattern and the capacity. Hence the private vehicles here include passenger cars, taxi and trucks.

The modal choice can be influenced by the transport policy to be taken in future, more particularly, road conditions, the service level of public transport etc. The modal split model, therefore, has to reflect the changes in transport conditions.

a. Walk Trips

The present modal share of trips by walk and motorcycles are shown in Fig. 9–1–6.

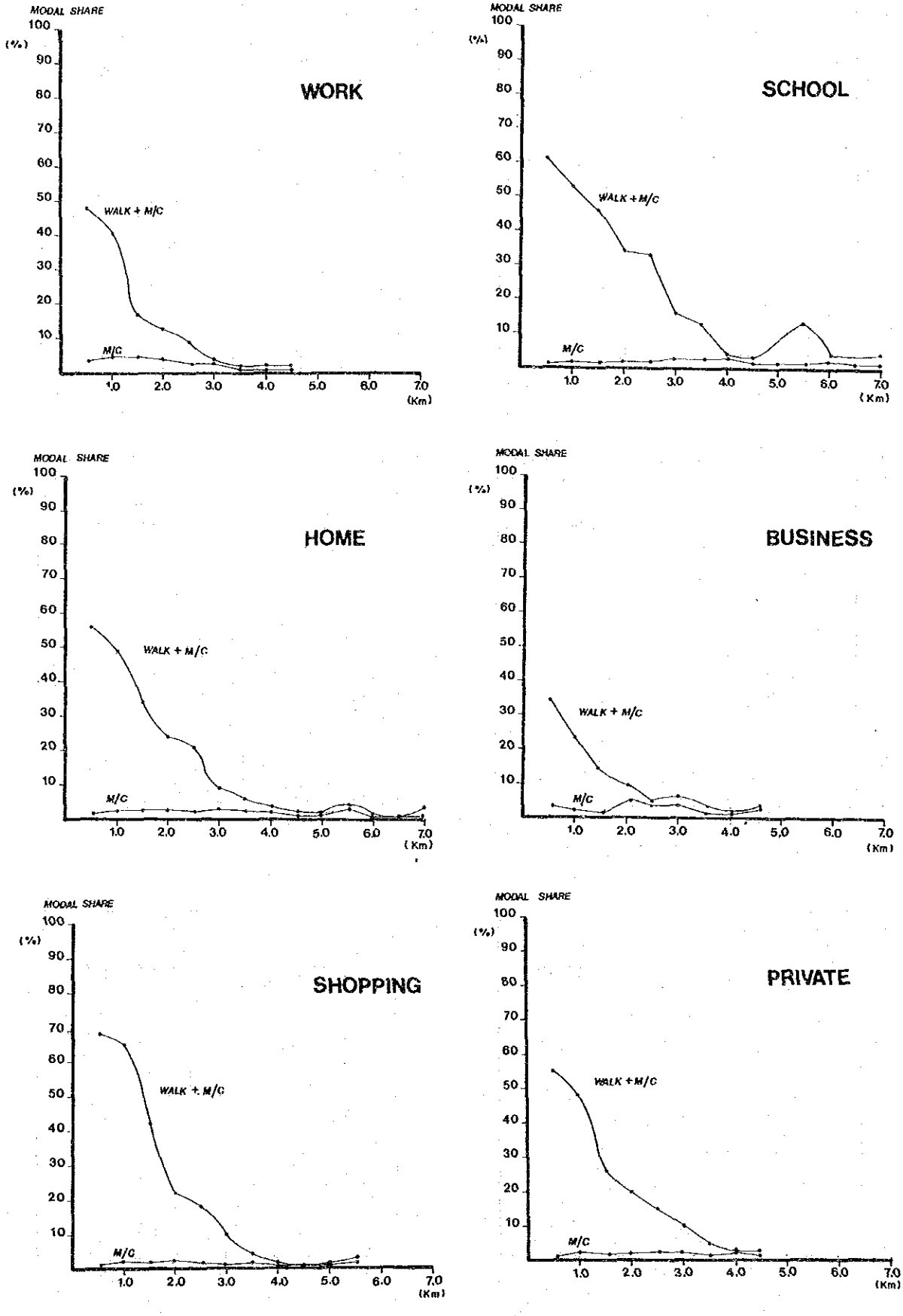

Fig. 9–1–6 Existing Walking Distance

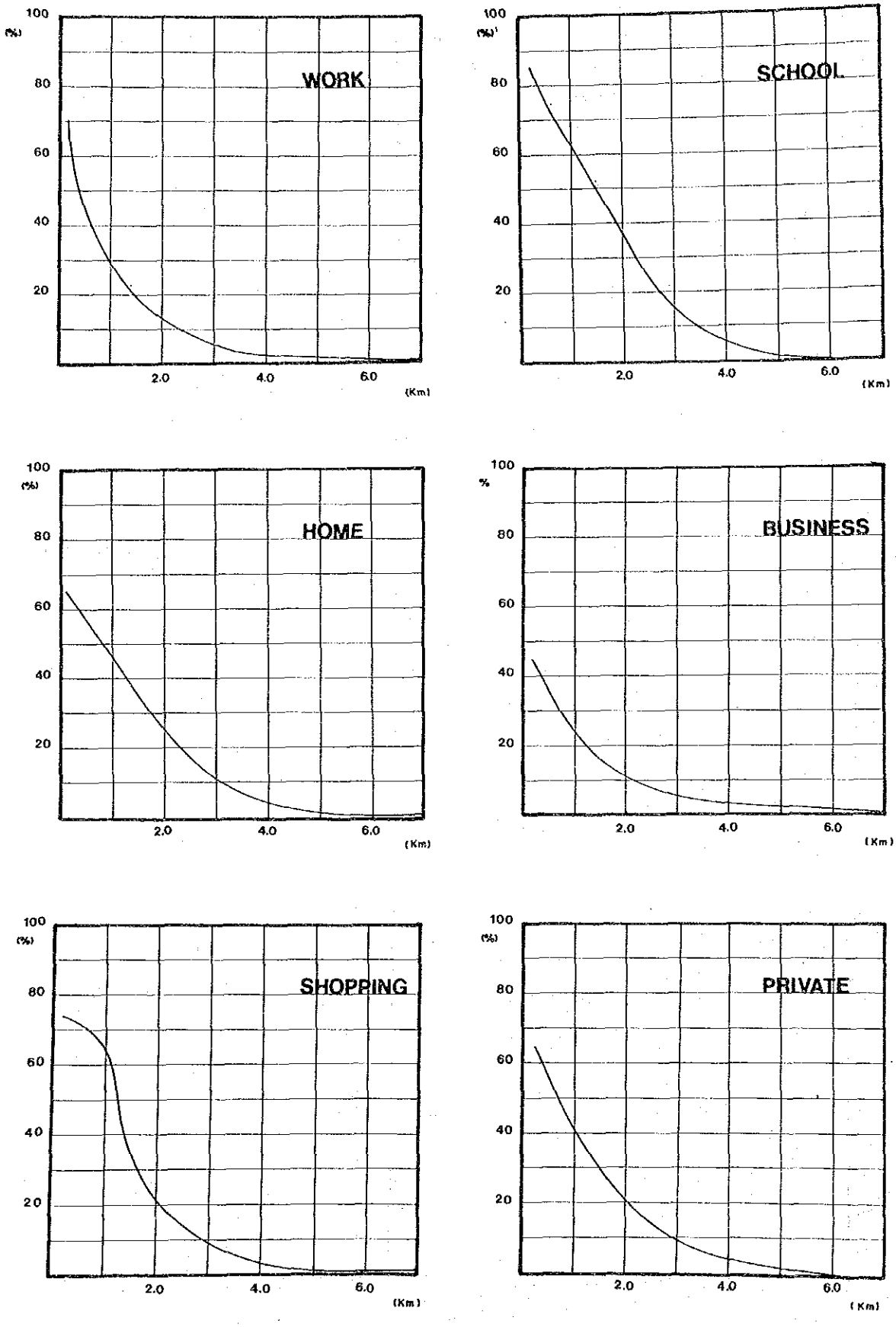

Fig. 9–1–7 Modal Split Curve (Walk and Motorcycle)

Since the share of motorcycles is extremely low, the trips by motorcycles are included in "walk trips" in the study.

In all cases of trip purposes, the modal share of walk trips sharply decreases in accordance with the increase in trip length, approaches almost zero % at the length of 5 or 6 km. By taking into account the characteristics by purpose, the modal split curves are depicted as given in Fig. 9–1–7.

b. Split model for private/public modes

The O-D volume excluding walk trips is subdivided into the trips by private vehicles and the trips by public transport.

In the similar way as the walk trips, the modal share of public transport is examined by trip length, however it is found that the modal share curves remain flat irrespective of the trip length. This indicates that the modal choice is little affected by trip length, therefore, it is difficult to establish an effective model by this method.

After examining the fitness of various models, a modal share model, which is explained by the ratio of travel time between bus and private vehicles is established. As the regression curve, a logistic type curve is employed as shown below:

$$Y = \frac{K}{1 + \alpha e^{\beta \chi}}$$

where, Y : Trip share of public transport mode

χ : The ratio of travel time between bus and private vehicles

e : Exponential

α, β, K : Constant Parameters

The parameters are shown in Table 9–1–4 (Refer to Fig. 9–1–8)

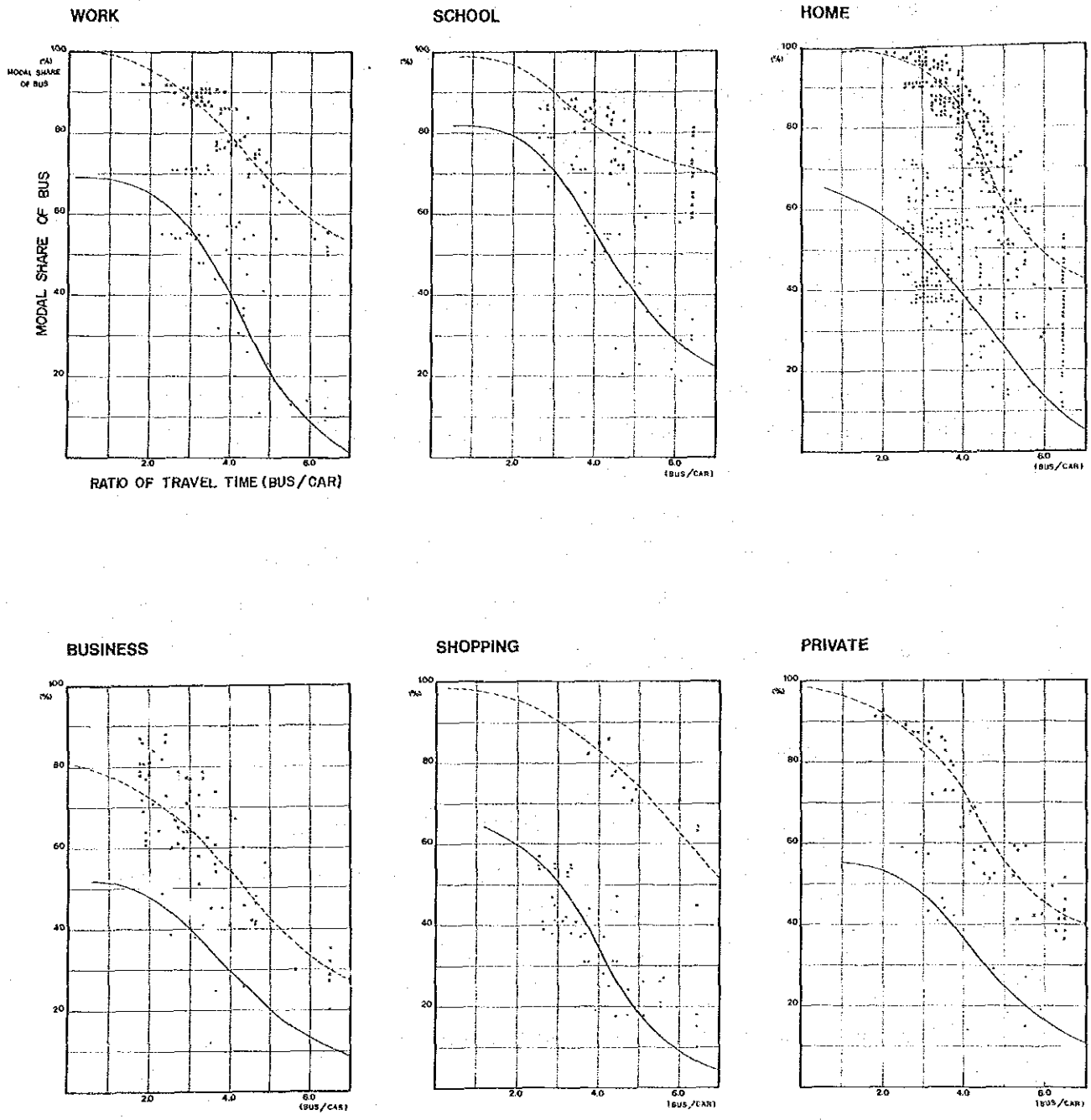

Fig. 9–1–8 Modal Split Curve (Public Transport)

Table 9–1–4 Parameters of Split Model for Private/Public Modes

	Car Owner			Non Car Owner		
	α	β	r	α	β	r
Work	0.0872	0.895	0.945	0.0006	1.168	0.941
Shool	0.1042	0.507	0.967	0.0038	0.758	0.969
Home	0.2086	0.565	0.945	0.0038	0.936	0.970
Business	0.4000	0.488	0.953	0.1083	0.429	0.948
Shopping	0.1729	0.667	0.951	0.0012	1.062	0.955
Private	0.4144	0.398	0.948	0.0027	1.056	0.947

4) Traffic Assignment Model

The person trips in terms of O-D volume obtained by the trip distribution model above are converted into vehicle trips by using average vehicle occupancy rates. In order to find the traffic conditions of roads and public transport in future, transport demands for both private and public are assigned to the road network and the public transport network respectively. Since the bus network is a part of the road network, the result of bus traffic assigned on bus network should reflect the total traffic capacity of roads.

The traffic capacity of roads is calculated by section based on the Highway Capacity Manual. The level of services is assumed as shown in Table 9–1–5.

Table 9–1–5 Level of Services

Area	Level of Services	Vehicle/capacity ratio
Rural	C	0.7
Urban Road	C	0.8
CBD Road	C	0.8
Urban Expressway	D	0.9

The average daily road capacity is calculated by the following formula:

Multi-lane roads : $C = 100/K \times 50/D \times C_H$

2-Direction 2-lane roads : $C = 100/K \times C_H$

where, C : Average daily road capacity

K : Ratio of the 30th highest hourly traffic volume to annual average daily traffic volume

D : Directional distribution rate

C_H : Hourly road capacity

The reduction factor of urban road capacity due to signalized intersections etc. is assumed as follows:

Urban road	0.57
CBD road	0.46

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 every assignment of each lot. The minimum time path is searched in this way.

This procedure is repeated until all the lots of traffic demand are exhaustively assigned to the road network. The travel time is calculated from the Q-V formula, which expresses the relationship between traffic volume and running speed on the road as follows (Refer to Fig. 9–1–9).

The Q-V formula is determinated by taking into account the characteristics of each road such as the land use condition along the road, number of lanes, design speed and number of signaled intersections, etc. As a result, 60 Q-V formulas were established and applied to each road by classifying the actual conditions in Barranquilla.

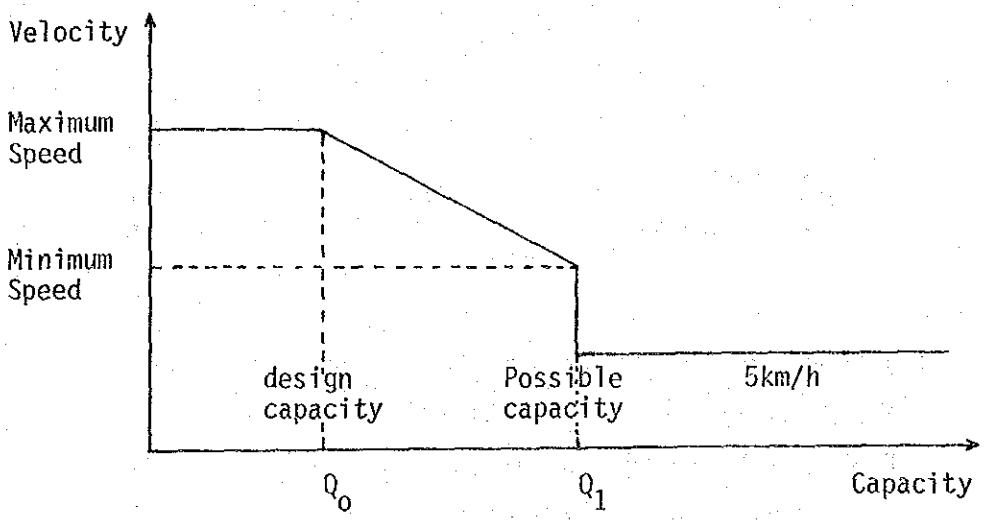

Fig. 9–1–9 Q-V Formula

9–2 Results of Demand Forecast

9–2–1 Trip Production

Total population for the year 2000 is estimated in Chapter 8. See also Table 9–2–1 below.

Table 9–2–1 Total Population – 2000–

	1983	2000	Growth
B/Q Population	1,106,600	1,873,000	1.693
5 years and older	960,900	1,711,700	1.781

The population by industry in the year 2000 is estimated also in Chapter 8. See also Table 9–2–2.

Table 9–2–2 Composition of Population by Industry

	Composition 1983 (%)	Trip/Person 1983 (Trip)	Composition 2000 (%)
Primary	0.5	3.75	0.2
Secondary	7.9	3.16	8.1
Tertiary	24.6	3.35	30.4
Non-workers	67.0	2.38	61.3
Total	100.0	2.69	100.0

Note: Population over 5 years old

The composition of vehicle ownership for the year 2000 estimated in Chapter 8 is as shown in Table 9–2–3.

Table 9–2–3 Vehicle Ownership

	Composition 1983 (%)	Trip/Person 1983 (trip/person/day)	Composition 2000 (%)
Owner	14.8	3.12	24.3
Non-worker	85.2	2.61	75.7
Total	100.0	2.69	100.0

Note: Study team estimated

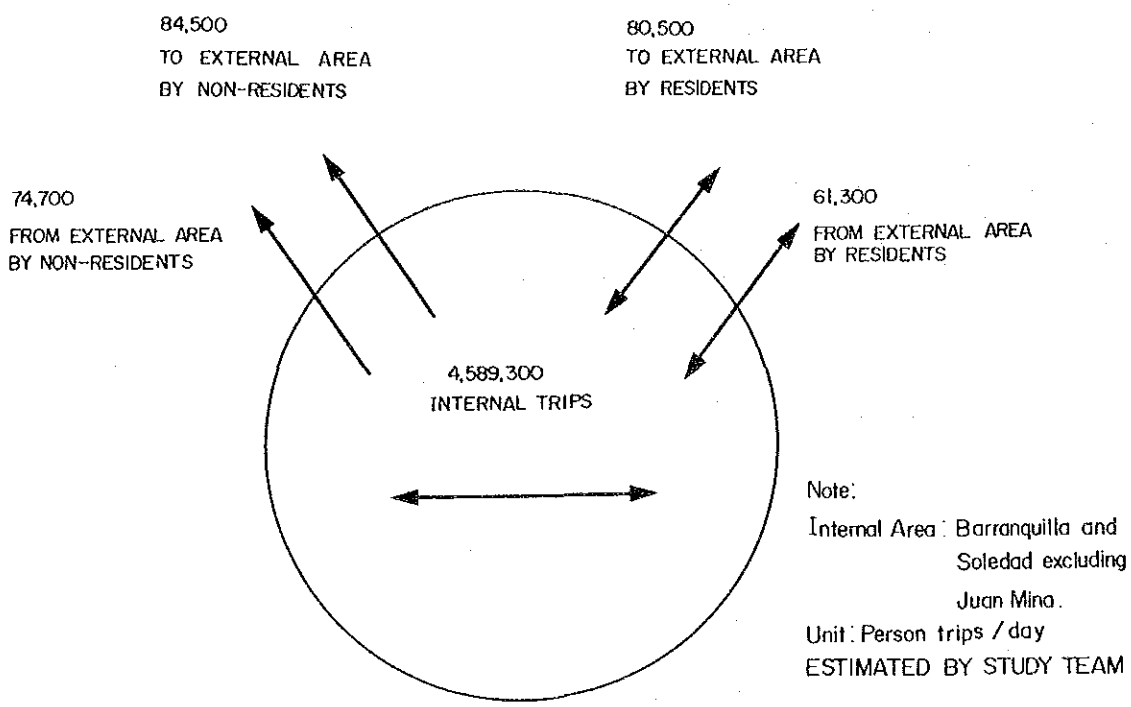

Fig. 9–2–1 Trip Production in 2000

The changes in the industrial structure and the vehicle ownership have a marked influence upon the trip production rate. Therefore, these changes in personal characteristics should be taken into consideration when the trip production rate is estimated.

As a result, the trip production rate is estimated to grow from 2.69 in 1983 to 2.74 in the year 2000 with the growth ratio of 1.02. Accordingly the total trip production grows from 2,581,000 in 1983 to 4,690,000 in the year 2000 with the growth rate of 1.81.

9–2–2 Trip Generation and Attraction

Using the trip generation/attraction model mentioned in 9–1–2, the future zonal trip generation and attraction is estimated by applying the future trip production as the total control. The increase in trip generation is shown in Fig. 9–2–2. The growth rate of trip generation outside the Circunvalar is extremely high, for example, in the newly developed area of Soledad (zone 30, 31), the trip generation grows from 22,000 trips in 1983 to 415,000 trips in 2000.

Table 9–2–4 Number of Trip Production by Purpose in 2000

	Trip Production Rate 1983	2000	No. of Trip Production 1983	2000	Growth Factor
	(trips/person/day)		(trips/day)		
Work	0.39	0.42	375,473	718,900	1.915
School	0.44	0.43	424,498	736,000	1.734
Home	1.28	1.29	1,225,523	2,208,100	1.802
Business	0.10	0.12	96,978	205,400	2.118
Shopping	0.20	0.20	191,859	842,300	1.784
Private	0.28	0.28	266,715	479,300	1.797
Total	2.69	2.74	2,581,046	4,690,000	1.817

Note: Excluding the trips by the non-residents of the PT survey area.

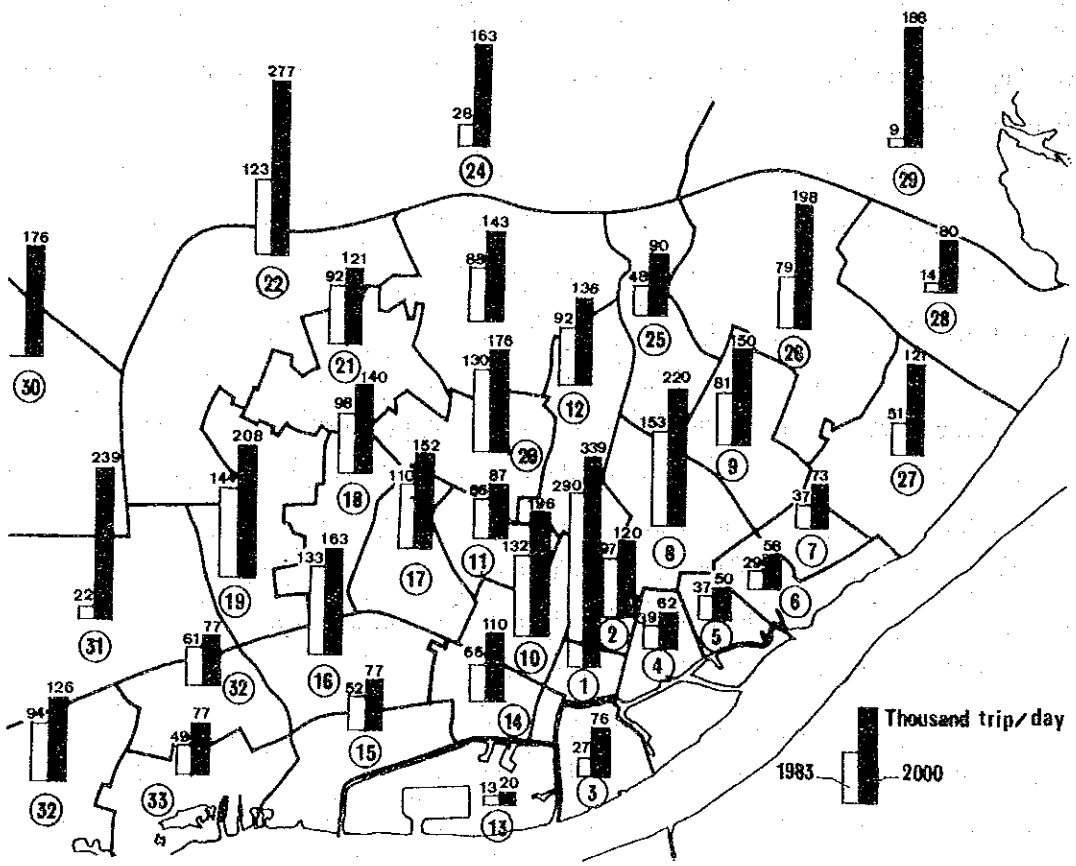

Fig. 9–2–2 Trip Generation in 1983 and 2000

On the other hand, the growth rate of the built up area inside of the Circunvalar is relatively low; the total trip generation in 2000 is about 1.6 times that in 1983. Particularly the Central District has a low growth rate, only about 1.3 times.

9–2–3 Trip Distribution

1) Total Trip Distribution

Table 9–2–5 tabulates the O-D values for 1983 and Table 9–2–6 shows the values for the year 2000. The total number of person trips related to the Barranquilla Metropolitan Region will increase from 2.7 million in 2983 to 4.9 million in 2000.

The growth rate of person trips between the inside area of Circunvalar and the outside area is comparatively high, about 3.2 times the existing level, while the movement inside of Circunvalar is only about 1.5 times the trips in 1983, reflecting the high population growth expected in the suburban area.

The trips originated or destinated from/to the Central District will increase by only 30% above the present level, however, the incremental number of trips, about 250,000 trips/day which are additionally expected will contribute to the serious traffic congestion in the Central District in the future.

The transport demand between Barranquilla and new urbanized area of Soledad will increase from 2500 person trips in 1983 to about 600,000 person trips in 2000, owing to the large number of housing developments in Soledad.

The transport demand between the existing built up area and the north-west new urbanized area of Barranquilla is also forecasted to grow substantially from 18,000 person trips in 1983 to 250,000 person trips in 2000.

2) Characteristics of Trip Distribution by Purpose

Fig. 9–2–3 shows the future distribution patterns of trip. In general, the concentration rate of trips into the Central District will relatively decrease in the future, because of the formation of sub-centers. There are, however, some noteworthy observations by trip purpose. Following are the outlines of these observations.

(1) In the case of work trips, the existing commuting pattern remains in the year 2000, however, a remarkable change in the trip pattern can be also found. The residents in the newly urbanized area mainly outside of the Circunvalar tend to work in the areas adjacent of their residences, owing to the new job opportunities mainly created by the sub-centers.

Table 9–2–5 OD Table in 1983

(Person trip/day)

		1	2	3	4	5	6	7	8	9	10	11	Total
1.	Certain District	42,823	351,236	242	6,926	2,725	26,847	124	1,214	1,874	5,399	12,610	452,020
2.	Inside Area of Circunvalar	346,927	1,392,419	8,875	9,313	10,306	50,581	182	4,637	4,907	12,657	24,322	1,865,126
3.	N.W. Area of B/Q	273	8,693	168	0	0	81	0	58	34	32	39	9,378
4.	West Area of B/Q	6,846	9,448	0	11,331	110	262	0	3	73	57	149	28,279
5.	Newly Developed Soledad	2,348	10,617	18	88	3,458	4,701	0	4	47	546	403	22,230
6.	Present Urbanized Soledad	25,586	50,682	81	263	4,649	114,417	1	99	480	2,944	3,150	203,352
7.	Puerto Colombia	171	344	0	3	1	10	72	3	12	22	59	697
8.	Juan Mina	1,437	4,225	82	35	7	172	5	142	41	47	64	6,261
9.	Galana	1,645	3,128	0	47	1	426	0	3	0	31	35	5,316
10.	Malambo	5,971	13,079	3	99	337	2,081	0	103	25	42	72	21,812
11.	Outside Area	11,751	27,365	103	171	586	3,078	18	50	204	342	3,608	47,270
	Total	446,770	1,871,140	9,572	28,276	22,180	242,656	400	6,316	7,697	2,219	44,811	2,661,747

Table 9–2–6 OD Table in 2000

(Person trip/day)

		1	2	3	4	5	6	7	8	9	10	11	Total
1.	Certain District	69,017	426,129	11,474	16,684	19,040	28,675	310	2,575	2,738	10,458	17,356	654,454
2.	Inside Area of Circunvalar	447,270	2,113,773	118,842	90,252	115,995	63,488	307	6,789	8,801	21,686	41,585	3,028,788
3.	N.W. Area of B/Q	11,381	114,903	66,238	12,009	383	141	12	8,731	142	29	165	124,134
4.	West Area of B/Q	17,255	93,422	13,356	42,895	4,386	585	73	129	3,996	116	481	176,681
5.	Newly Developed Soledad	19,525	117,204	422	4,244	240,937	42,057	0	4	243	25,281	1,224	451,141
6.	Present Urbanized Soledad	30,284	65,301	150	581	43,461	127,245	5	193	607	7,262	3,737	288,824
7.	Puerto Colombia	325	374	50	76	1	10	10	0	1	1	3	820
8.	Juan Mina	2,416	5,514	7,503	89	7	201	0	370	0	0	0	
9.	Galana	2,756	6,468	144	3,217	174	415	0	0	260	0	0	13,464
10.	Malambo	10,064	18,966	6	95	20,197	5,417	0	0	0	842	338	53,825
11.	Outside Area	16,004	332,034	150	445	1,030	1,786	0	0	0	4	7,456	58,909
	Total	626,297	2,994,088	218,335	170,587	445,641	270,050	717	18,789	16,785	65,678	72,345	4,895,815

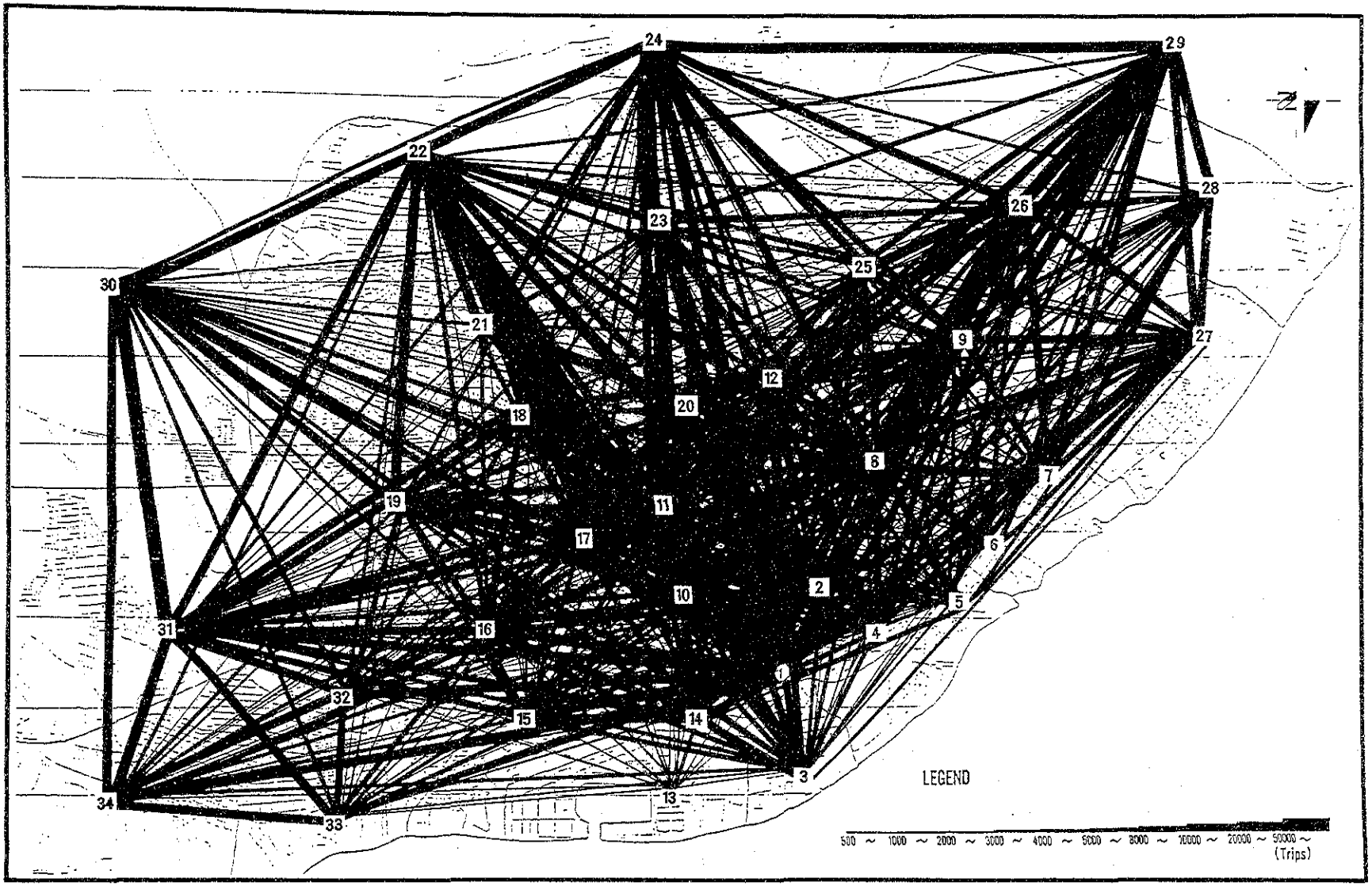

Fig. 9–2–3 OD Pattern in 2000 (All Purpose)

(2) A considerable portion of school trips continues to be attracted to the areas where education facilities concentrate at present, such as the area adjacent to the Central District of the northern built-up area, due to the continuation of the existing pattern and the exansion of the existing facilities. However, a concentration to newly urbanized areas is also found, since some new schools would be established in these area in correspondance with the population growth.

(3) As for shopping, a high concentration to centro remains in the future, however, some trip attraction to new commercial area including sub-centers can be observed.

(4) Regarding business trips, although a concentration to Centro and the area around Calle 72 or to new sub-centers can be recongnized, the concentration rate is fairly low compared with other purposes.

(5) Private purpose trip pattern shows a strong linkage between the residential area and business/commercial areas such as Centro and the sub-centers.

3) Average Trip Length

Generally the average trip length increases in accordance with the expansion of the urbanized area.

As shown in Table 9–2–7, the average trip length for any purpose except "work" is forecasted to increase. With regard to "work" trips, its trip length will decrease, reflecting the formation of sub-centers which are planned with the intention of reducing the commuting distance by creating job opportunities sufficiently close to new residential areas.

The trip length for "school" purpose will increase. The reason is considered as follows. Although new schools may be established in new urbanized area, higher level schools may have specialities, therefore, the students select them according to their preference irrespective of the distance from their home to the school. On the other hand, the trips at the elementary level are considered to be of short distance, and mainly absorbed in the same zone or a zone adjacent to the residential zone. However, the relative percentage share of elementary school age population is likely to decline due to the decrease in the birth rate and the increasing tendency for higher education. The relocation of high school and universities to sub-urban areas and the expansion of existing private schools mainly located at the northern part of Barranquilla built-up area will be additional factors contributing to the increase in the trip length.

As for business and private trips, the trip length will increase in accordance with the progress of mobility of the residents due to the growth in income of car ownership and development of transport facilities.

Table 9–2–7 Average Trip Length

(km)

Trip Purpose	1983	2000
Work	5.35	5.20
School	3.76	4.62
Home	4.60	4.91
Business	5.07	5.19
Shopping	4.37	4.80
Private	4.48	4.87
Total	4.60	4.92

9–2–4 Modal Share

By using the modal split model, the future modal share is estimated as follows. Refer to Table 9–2–8.

Table 9–2–8 Modal Share of Person Trips

	1983		2000		Growth Rate
	Number of Trips (thousand trip)	Composition (%)	Number of Trips (thousand trip)	Composition (%)	'83-2000
Walk	697	26.1	903	18.4	1.3
Private Cars	531	19.9	1,277	26.1	2.4
Public Transport	1,446	54.0	2.720	55.5	1.9
Total	2,674	100.0	4,899	100.0	1.8

The number of person trips by vehicles is estimated to increase to twice as much as the current level. The trips by private vehicles will grow 2.4 times, while the average growth of total modes is 1.8 times the existing level. Accordingly the percentage share of private vehicle use expands from 19.9% to 26.1% of the total person trips. Although the share of public mode does not grow as much as private vehicles, it is noted that more than half of the total trips will be made by public transport even in the year 2000. The person trips can be converted into vehicle trips by using the average occupancy rate. Refer to Table 9–2–9.

Table 9–2–9 Modal Share of Vehicle Trips

	1983		2000		Growth Rate
	Number of Trips (thousand trip)	Composition (%)	Number of Trips (thousand trip)	Composition (%)	'83-2000
Private Vehicle	336	78.9	735	81.3	2.2
Public Transport	90	21.1	169	18.7	1.9
Total	426	100.0	904	100.0	2.1

Note: Vehicle trips are expressed in terms of passenger car units (pcu).

The total traffic volume in terms of vehicle trips will increase by about 2.1 times. The growth of private vehicle traffic during the period 1983–2000 is about 2.2, with an increase of the modal share from 79% to 81%.

9–2–5 Traffic Assignment of Traffic Demand

In order to identify the bottlenecks associated with the existing network in the year 2000, the traffic demands in 1983 and 2000 are assigned on the actual network. The traffic assignment is based on the asumption that the traffic interruption problem by Arroyo system is completely solved by the countermeasure proposed in Chapter 11 by the year 2000.

The results of traffic assignment for 1983 and 2000 are shown in Fig. 9–2–4 and Fig. 9–2–5 respectively. As a whole, the pattern of traffic flow does not drastically change from 1983 to 2000, however, it is noted that the road links with a large traffic volume will extend toward the peripheral area of the existing built-up area and the volume on the arterial roads will increase 2 to 3 times the present level. The growth of traffic between the Central District and Soledad including the new sub-center area in the south, and between the Central District and the new sub-center area at the north-west, will be extremely high as expected. These growths of traffic demand reflect the changes in the land use pattern and the population distribution.

The comparison of future traffic demand and existing road capacity, i.e. the degree of the traffic congestion, is shown in Fig. 9–2–6. As seen in this figure, there are many road sections where the traffic demand exceeds the capacity, and in several sections the congestion degree is more than 1.5. The results of traffic assignment and congestion degree implicitly indicate the following:

(1) In the new urbanized area of Soledad, there does not exist a main road at present, however, an adequate road network should be prepared in configuration with the new devel-

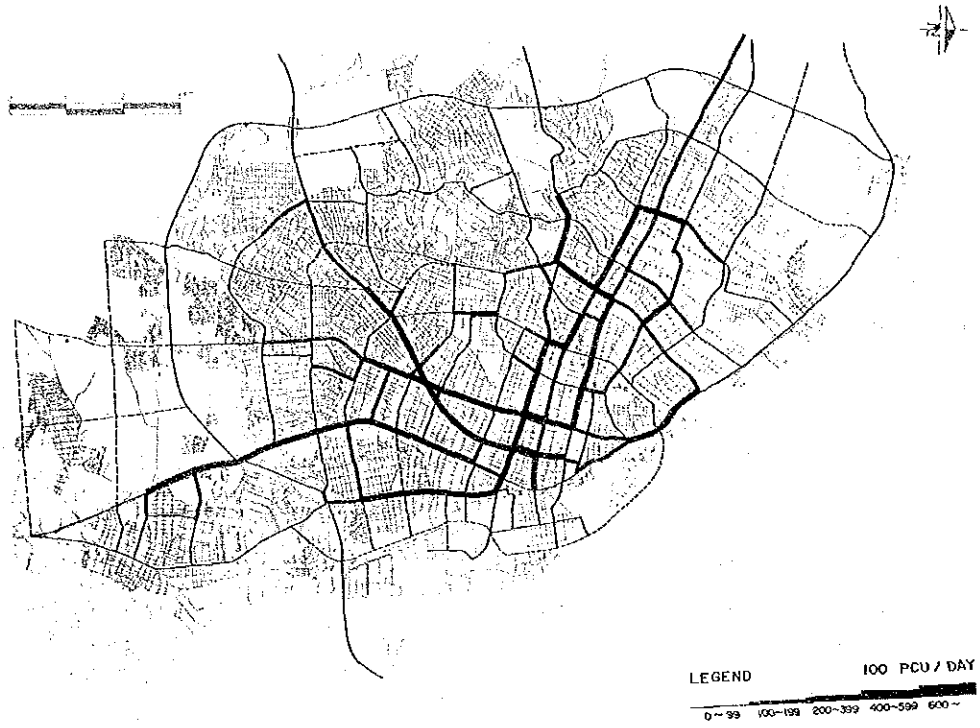

Fig. 9–2–4 (1) Traffic Demand in 1983 (Existing Network)

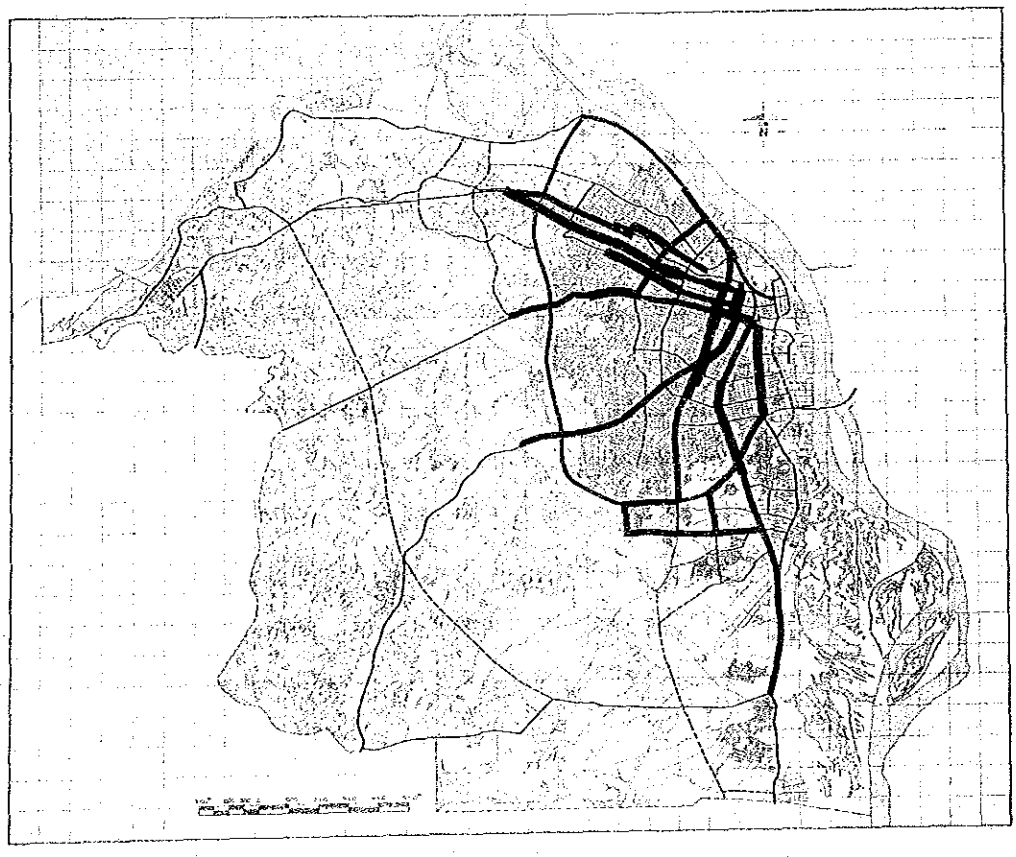

Fig. 9–2–4 (2) Traffic Demand in 1983 (Existing Network)

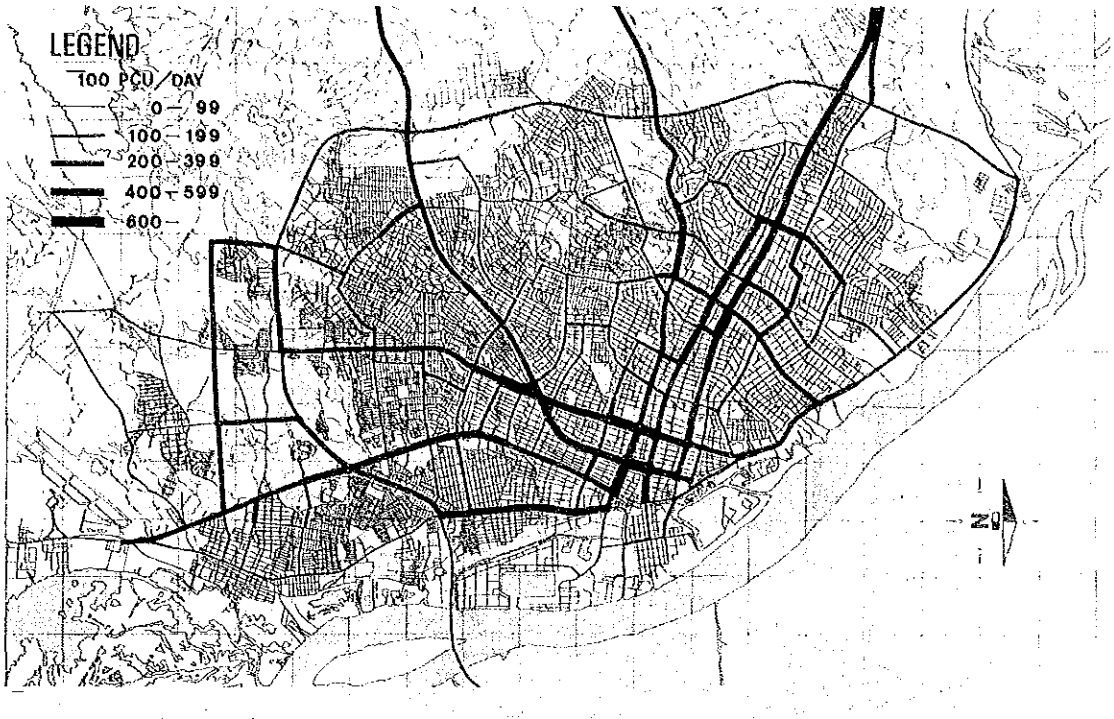

Fig. 9–2–5 (1) Traffic Demand in 2000 (Existing Network)

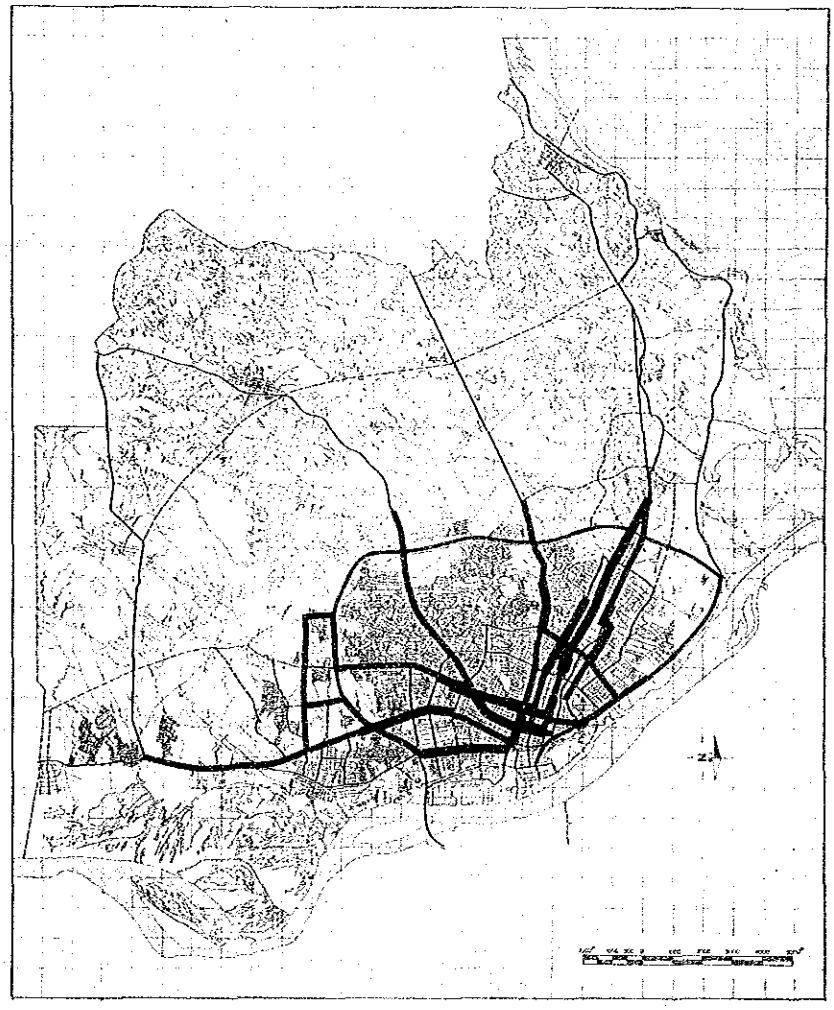

Fig. 9–2–5 (2) Traffic Demand in 2000 (Existing Network)

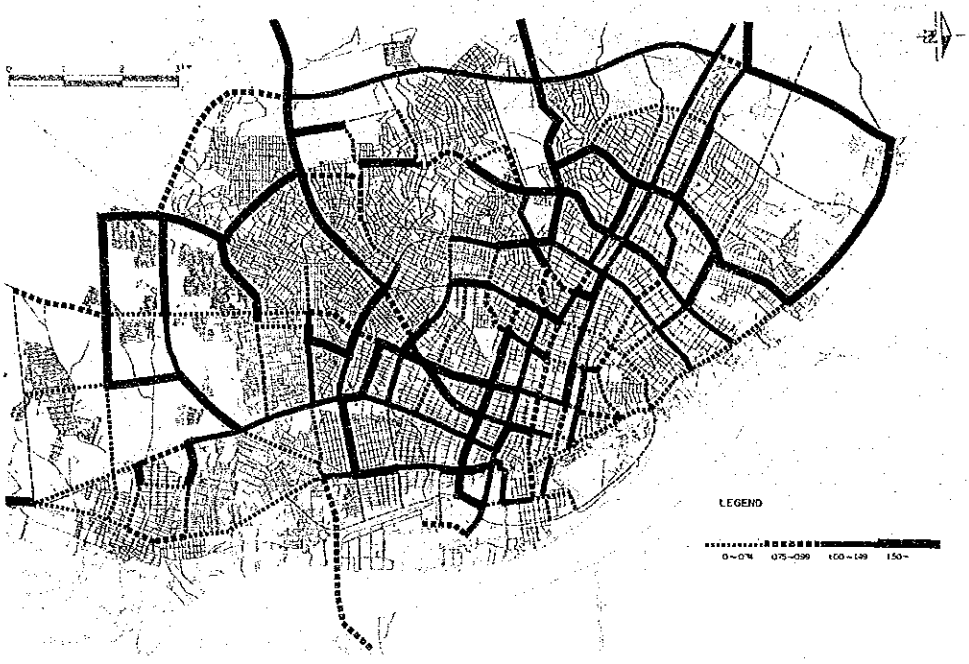

Fig. 9–2–6 Traffic Congestion Degree in 2000 (Existing Network)

opments in housing, sub-center, industries and other important projects including Gran Abastos.

(2) In the axis connecting the south area including the new urbanized area with the Central District, the existing roads such as Calle 45, Calle 30 and Calle 17 fall short in their capacity. Therefore, some cuntermeasures to expand the capacity will be required.

(3) Also in the axis connecting the northwest area with the Central District, th .as like Cra. 46, Cra. 51B will have an excess load if the capacity is not expanded.

(4) The radial roads to the west such as Calle 47, Cra. 38 have only 2 lanes at present, the future demand will exceed the capacity of these roads.

(5) At present, there does not exist a circumferencial road inside of Circunvalar, however, a necessity seems to exist. The congestion in Calle 84 and in the roads connecting Vía 40, Cra. 46, Calle 47 and Calle 45 show the need for this type of circumferential road, the congestions in Calle 51 or Cra. 38 also show that much traffic exists which is detouring the Central District.

(6) If a circumferential road is built, the congestion in the Central District will be eased particularly on the arterial roads such as Calle 45, Cra. 38, etc.

(7) Also on the Circunvalar, there exist many sections where the demand exceeds the capacity of the existing 2 lanes.

9–3 Major Issues for Transport Planning

From the results of the transport demand forecast, the future transport problems are summarized as follows:

(1) Due to the growth in the vehicle ownership rate and the changes in the industrial structure, the mobility of people in Barranquilla will grow in the future. Hence the person trip production rate will increase.

(2) The increases in population and employment in the future will result in an increase in person trips. Particularly in the present suburban area, mainly outside of Circunvalar, high growths in population and employment will result in a large increase in trips. However, the majority of the future trips pattern will be related to the present built-up area as it is at present.

(3) In accordance with the expansion of urbanized area, the average trip length will increase in the future. The increase in trip length results in a growth of traffic load and a substantial growth of traffic demand.

(4) The future growth of road traffic demand, which results directly from the growth of vehicle ownership, will require a large amount of investment for road improvement and development.

(5) With regard to the traffic demand pattern, the traffic flow from the new urbanized area in Soledad to the Central District will be the largest, followed by the traffic flow from the new urbanized area in the northwest to the Central District.

Accordingly transport facilities should be adequately developed to meet these traffic demand patterns and at the same time the countermeasures to cope with the increasing traffic congestion in the Central District should be applied.

Based on the above perspectives, the major issues for urban transport planning are identified as follows:

(1) Development of Transport Network

As the main traffic flows will be those from/to new urbanized areas in the south and northwest to/from the Central District, the development of transport facilities to meet these flow is of immense importance for the future network.

It is also important to urgently establish a transport network plan for the newly urbanized area in Soledad or in the northwest, since it would be more costly to build up the network after the area is fully built up.

(2) Development of Public Transport

In order to cope with the traffic demand increase, there are various strategies to restrict the private vehicle use, for example, an imposition of more taxes on private vehicles or fuel. However, this policy may induce a stagnation of economic activities, since the alternative transport mode has not been well developed in the Study Area. In addition, vehicle ownership is still at a low level, and more private vehicle use will be inevitable in order to promote the higher economic growth in the study area.

In the case of Barranquilla Metropolitan Region, it is more important to develop the public transport system, since its modal share is predominant at present as well as in the future. The public transport system is not only to be improved in its service level for passengers but also to be expanded in its transport capacity for future demand.

(3) Improvement of Traffic Management System

The traffic congestion in the Central District is almost chronic at present and will be more serious in the future. Since it is difficult to build a new road or to widen an existing road in the Central District without a drastic renewal, the existing roads should be effectively utilized. For this purpose, it is important to improve the traffic management system particularly for the Central District. The traffic management system to be implemented has many features such as how to deal with bus traffic, parking problems, how to create smoother traffic flows, etc.

Chapter 10.

ALTERNATIVE TRANSPORT NETWORK PLANS IN THE LONG TERM

Chapter 10 ALTERNATIVE TRANSPORT NETWORK PLANS FOR THE LONG TERM

10–1 Basic Planning Policy

By the year 2000, the population of the Metropolitan Area will increase from 1.2 million to 2.0 million and about 4,000 hectares of land will be developed for urban activities in the Study Area. The economic development will result in a large increase in transport demand, approximately twice the present vehicular travel demand. This will make the transport conditions in the Central District more accute and require new facilities in the newly urbanized area.

Thus, the development of the transport network is urgently required to meet future demand and to promote further economic development.

In the creation of a better urban transport system, the following objectives can be identified:

(1) To support and promote the socio-economic development of Barranquilla Metropolitan Region.
(2) To pursue a social equity for transportation of the urban poor.
(3) To create and maintain a high quality of urban environment.

These objectives are translated into the following targets:

(1) Satisfaction of future transport needs.
(2) Effective use of existing facilities.
(3) Assuring the mobility for the residents with equal access to transport services.
(4) Compatibility with the future urban structure and the land use plan.
(5) Improvement of traffic safety.
(6) Minimization of adverse effects on the environment.
(7) Creation of higher quality of urban environment and beatification of urban landscape.
(8) Minimization of resource consumption.

10–2 Preparation of Alternative Network Plans

10–2–1 Requirements

With the planning targets above-mentioned in mind, the future transport plans are formulated to cope with the existing and foreseeable problems.

The future transport network should be established taking into consideration future land use pattern, the future transport demand and the effective use of the existing network.

1) Compatibility with the Future Land Use Pattern

a. The future urban structure of Barranquilla Metropolitan Region has the following elements to be contended with:

- Although a part of urban functions such as commercial and cultural activities will be dispersed to the peripheral area of Barranquilla, the Central District will function as the center of the Metropolitan Region in the future as well.
- The expansion of the Central Business District to the west and the development of the commercial area along Calle 72 will form a continuous commercial and business area from Centro to Calle 72.
- Two new sub-centers will be established at the northwest and south of Barranquilla outside of the Circunvalar.
- Industrial area will form a belt by the expansion of existing industries and development of industrial parks along the Rio Magdalena.

b. Accordingly the transport network has to meet the following requirements.

- The main transport axes are shaped by the letter L which is composed of the axis to the south from the Central District and the axis to the northwest.
- The axis to the northwest is centering around Cra. 46. High class residential area is expected to expand in this direction, therefore the dependency on the private vehicles will be continuously high in terms of modal choice. However there is a plan to relocate the Universidad del Atlántico at the adjacent area of the proposed sub-center. The demand for public transport is also predicted to rise.
- In the case of axis to the south, there exist two major roads, i.e. Autopista to the Airport (Calle 30) and Murillo Avenue (Calle 45).

  The extension of Murillo from Circunvalar to Malambo is now under construction.

  In order to enforce this axis, it is one of the planning issues to examine the possibility or necessity of widening these existing roads and of the construction of new parallel roads.

- The transport demand generated from the sub-center in the south and its surrounding residential area may increase not only to the Central District but also to the commercial area along Calle 72. If a new road is constructed between the south sub-center and the area along Calle 72, it is expected to contribute to the formation of district commercial cores in the built up area.
- Circunvalar will have the function to serve for the transport demand between the two new sub-centers at the northwest and south, and/or among the districts to be newly developed along the Circunvalar. Hence its major role will change from serving intercity traffic to serving urban traffic.

2) Requirements from Future Transport Demand

From the results of traffic assignment of the demand in 2000 on the existing network, it is found that the traffic demand exceeds the existing capacity on many road sections.

In order to quantify the shortage of capacity by sections in each direction, the comparison of total demand and capacity is made as shown in Fig. 10–2–1 and Table 10–2–1.

(1) As for the axis to the northwest, the transport demand in 2000 is predicted to be about 2.5 times the present level in terms of vehicle trips, hence the total demand will slightly exceed the existing capacity at all of sections A_1-A_1, A_2-A_2 and A_3-A_3. Therefore, it is required to examine the possibility of widening existing roads such as Cra. 46 etc., and the possibility of development of a new road connecting the Central District with the sub-center at the northwest.

(2) In the corridors to the west i.e. for Juan Mina (Section B-B) or for Galapa Section C-C), the ratio of traffic demand and capacity becomes extremely high, but this is because there is only one 2-lane road in both sections. The shortage in capacity is only about 20,000 pcu for both sections. Accordingly the widening of the existing roads will be examined.

(3) On the axis to the south, the growth of transport demand is extremely large owing to the formation of a new sub-center and the development of new residential area etc.

Hence in this direction, the shortage of road capacity is seriously large at all of sections D_1-D_1, D_2-D_2 and D_3-D_3; the shortage is about 60,000 pcu/day at sections D_2-D_2, D_3-D_3. Therefore, the possibility of widening the existing roads and construction of new road will be considered.

The dependency on the public transport is very high at present and is anticipated to continue to be high in future as well. It is, therefore, important to increase the transport capacity of bus services and to examine the introduction of a mass transit system.

(4) In the corridor to the east i.e. for Santa Marta, the traffic growth is relatively low, the present road has sufficient capacity for the future demand (Refer to section E-E)

(5) The transport demand either originated or destinated in the Central District in 2000 is forecasted to grow only about 1.4 times the existing demand, however, the incremental number of trips is extremely large; about 250 thousand person trips are additionally expected. Therefore, a combination of various countermeasures should be examined to mitigate the anticipated traffic congestion. One such countermeasure is to by expand the traffic capacity of arterial roads by widening them, and the other is to fully employ traffic management techniques, together with the development of public transport facilities.

(6) The future trip pattern shows that there exist a significant number of transport demand for circumferential direction within the built-up area (Refer to the section X_2-X_2, Fig. 10–2–1). In order ot serve these trips and eliminate the through traffic from the commercial and business districts, including the Central District and to facilitate the dispersal of the traffic originated or destinated in this commercial and business district, the construction of circumferential type road should be examined.

(7) The demand growth for circumferential direction can be seen also at the Circunvalar. Due to the new urbanization along Circunvalar and the formation of sub-centers, the capacity of Circunvalar will be short in 2000 (See section X_1-X_1, Fig. 10–2–1). The widening of Circunvalar should be examined.

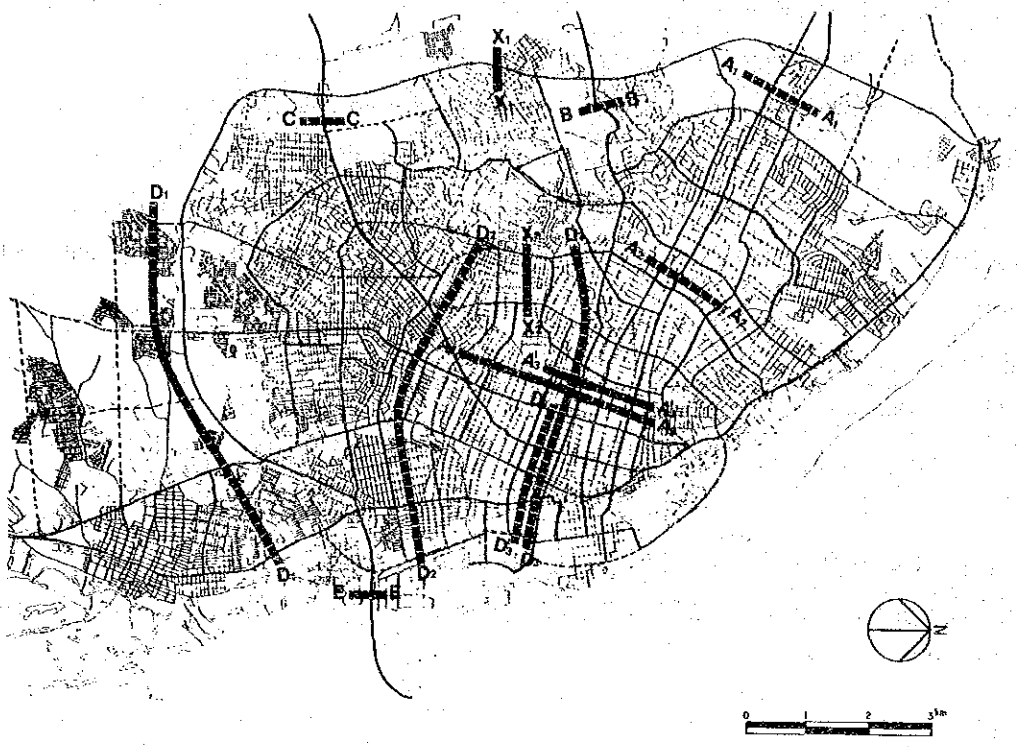

Fig. 10–2–1 Sections by Directions

Table 10–2–1 Comparison of Traffic Demand and Capacity

Section	Traffic Demand in 2000 (pcu/day)	Existing Capacity (pcu/day)	Traffic Volume Capacity Ratio
A_1-A_1	60,900	54,000	1.3
A_2-A_2	127,700	112,000	1.1
A_3-A_3	153,100	132,000	1.2
A_3'-A_3'	139,300	116,000	1.2
B - B	34,600	10,000	3.5
C - C	28,800	10,000	2.9
D_1-D_1	113,700	91,000	1.3
D_2-D_2	199,600	142,000	1.4
D_3-D_3	210,500	132,000	1.0
D_3'-D_3'	170,900	108,000	1.6
E - E	7,200	12,000	0.7
X_1-X_1	15,700	12,000	1.3
X_2-X_2	28,200	16,000	1.8
Total	1,210,000	947,000	1.3

10–2–2 Alternative Network Plans

In preparing alternative network plans, the main axes to be considered are the linkages shaped by letter L which connect the Central District with two new sub-centers as mentioned above. The alternatives are prepared for these axes from the aspect of how effectively the plan can provide a higher level of transport services with less investment. The future land use pattern has already been prepared in Chapter 8, therefore the alternative network plans are guided by how to meet the future transport demand. In this study the following two factors are considered for setting alternatives.

(1) Physical pattern of the main axes

(2) Public transport service method

The first factor, (namely, the Physical pattern of the main axes) is concerned with how to collect and disperse the traffic in each direction. The following 3 alternative patterns can be considered (Refer to Fig. 10–2–2).

(1) Intensive Pattern

This network pattern serves the traffic intensively by establishing bold axes with high capacity. The traffic is collected and dispersed through the semi-arterial or collector roads and flows mainly on the major axes.

(2) Dispersal Pattern

This pattern serves the demand in a dispersed way by establishing several axes which run in parallel. In this case, therefore, each axis does not have as much capacity as Intensive Pattern.

(3) Mixed Pattern

This pattern is a mixed type of above two patterns.

The second factor is concerned with how to provide public transport services to meet the transport needs for the majority of residents, and whether or not public transport system is innovated by introducing a new transport mode such as a rail transit system. Accordingly the following 2 alternative systems can be considered.

(1) Without introducing any new mode, only the transport capacity of bus services will be expanded.

(2) Public transport system is creatively developed by introducing a rail transit system.

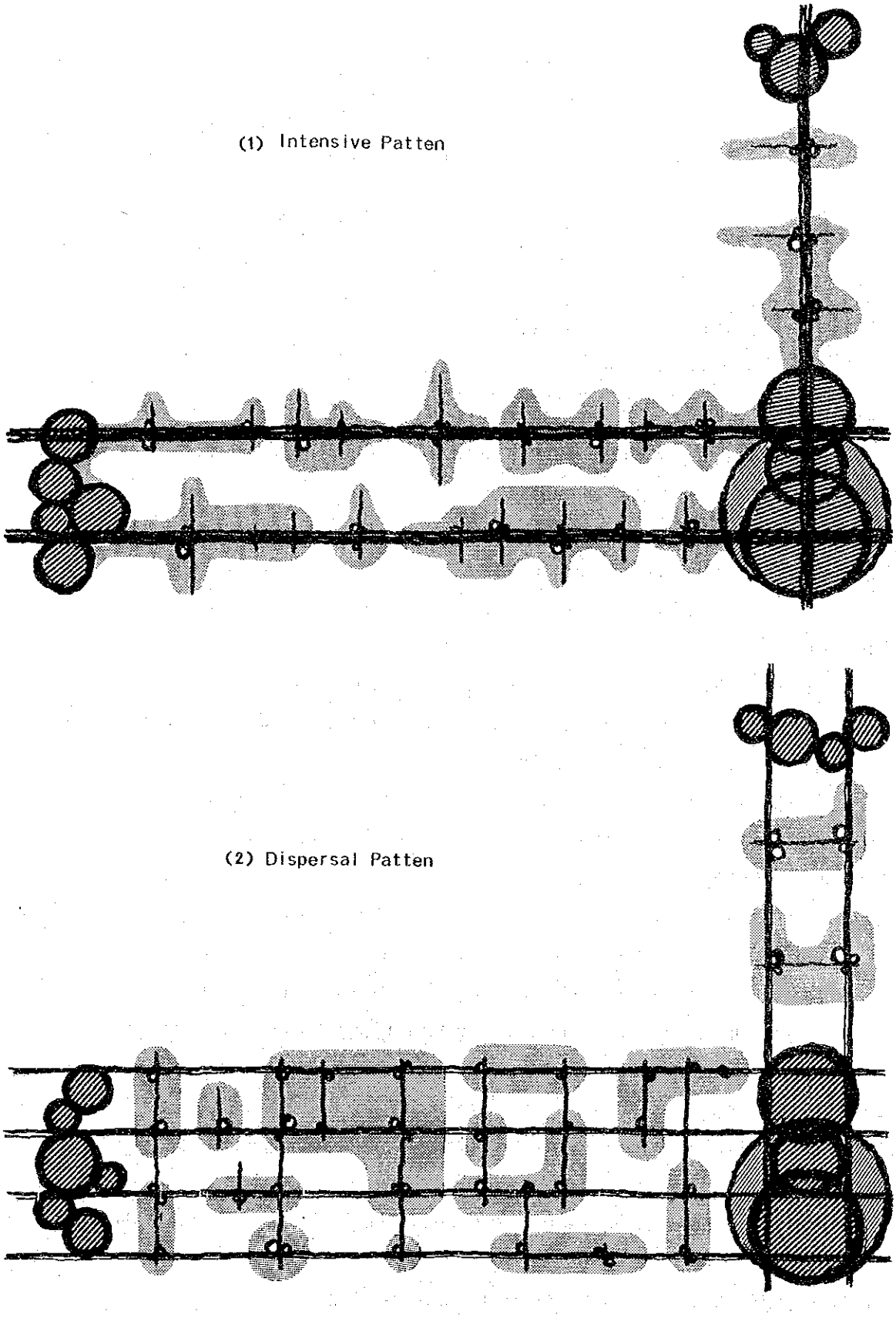

Fig. 10–2–2 Physical Pattern of Main Axes

By combining above factors, the alternative network plans are conceptually represented as follows (Refer to Table 10–2–2).

Table 10–2–2 Alternative Network Concepts

Physical Pattern of Network	Public Transport System	
	(1) Without Innovative System (Bus service only)	(2) With Innovative System (Rail Transit System)
(1) Intensive Pattern	Alternative 1	Alternative 4
(2) Dispersal Pattern	Alternative 2	–
(3) Mixed Pattern	Alternative 3	Alternative 5

Alternative Network 1

In order to strengthen the skeleton of the letter L, the existing trunk roads are widened and expanded as to their capacity.

Alternative Network 2

By constructing new roads in the main axes, the total transport capacity will be increased without improving the existing roads drastically.

Alternative Network 3

In the corridor to the south, which will particularly have a shortage of capacity in the future, one of the existing trunk roads is widened to be as a bold axis and new roads are additionally constructed in parallel to meet the future demand.

Compared with Alternative Network 2, less investment for new road is required, while additional investment for widening of existing road is necessary.

Alternative Network 4

A rail transit system is introduced in the main axes; one is to connect the Central District with the new sub-center in the south and the other is to connect the Central District and the commercial area around Calle 72 with the new sub-center at the northwest.

In this alternative, the required investment for road development is less than for Alternative 1.

Alternative Network 5

Like as the Alternative Network 4, a rail transit system is introduced in the main axes.

The alternative network plans are presented in Fig. 10–2–3, 10–2–5, 10–2–7, 10–2–9 and 10–2–11.

10–2–3 Traffic Assignment on the Alternative Network Plans

In order to find the effects of the alternative network plans identified in the previous sec-

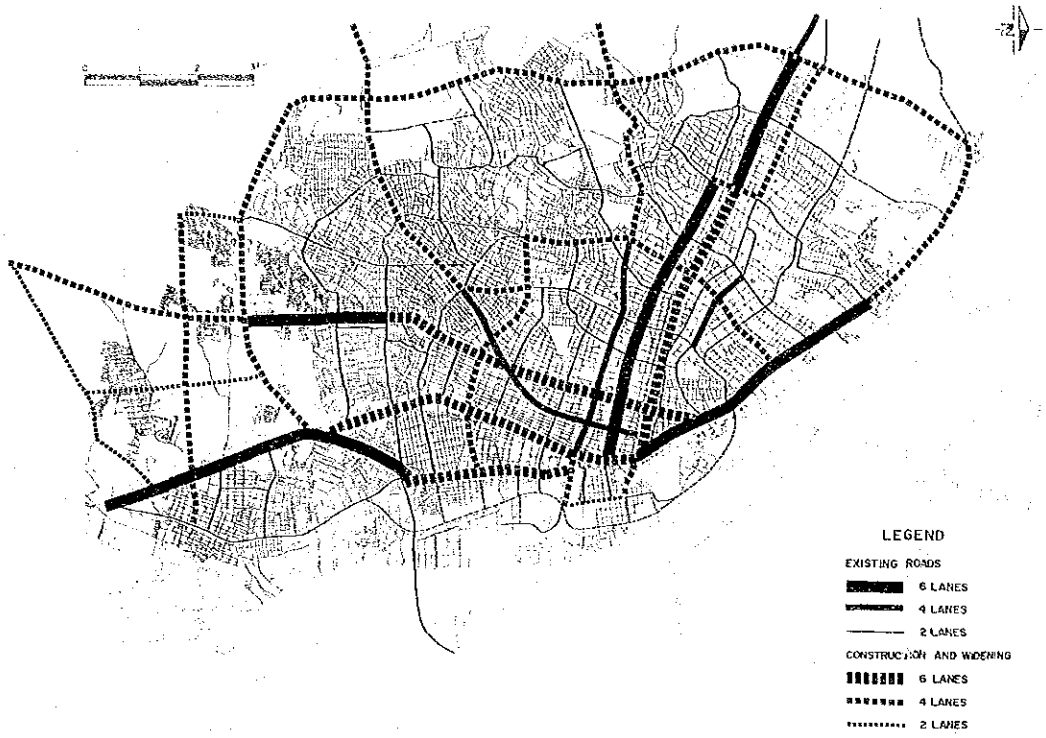

Fig. 10–2–3 Alternative Network 1

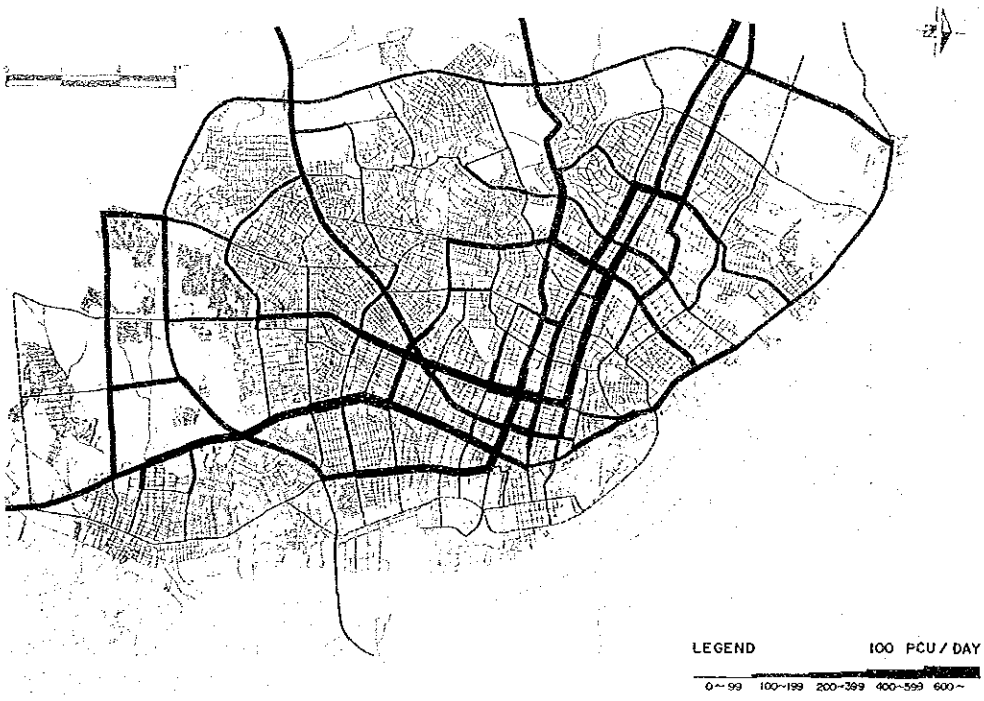

Fig. 10–2–4 Traffic Assignment on Alternative 1 (2000)

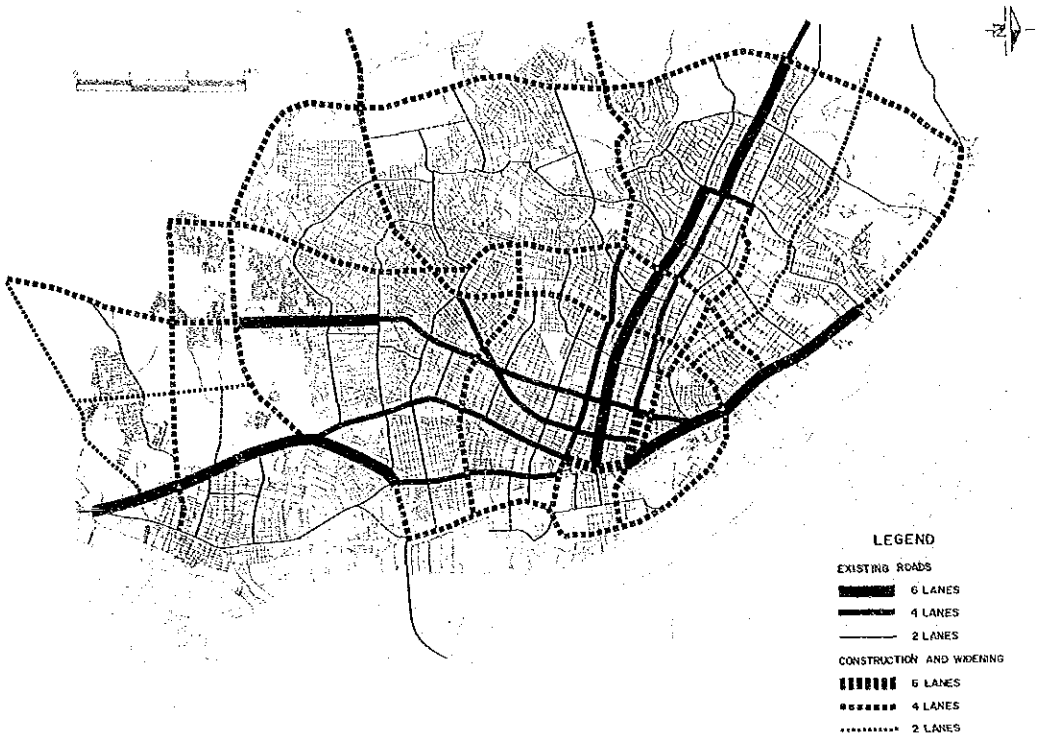

Fig. 10–2–5 Alternative Network 2

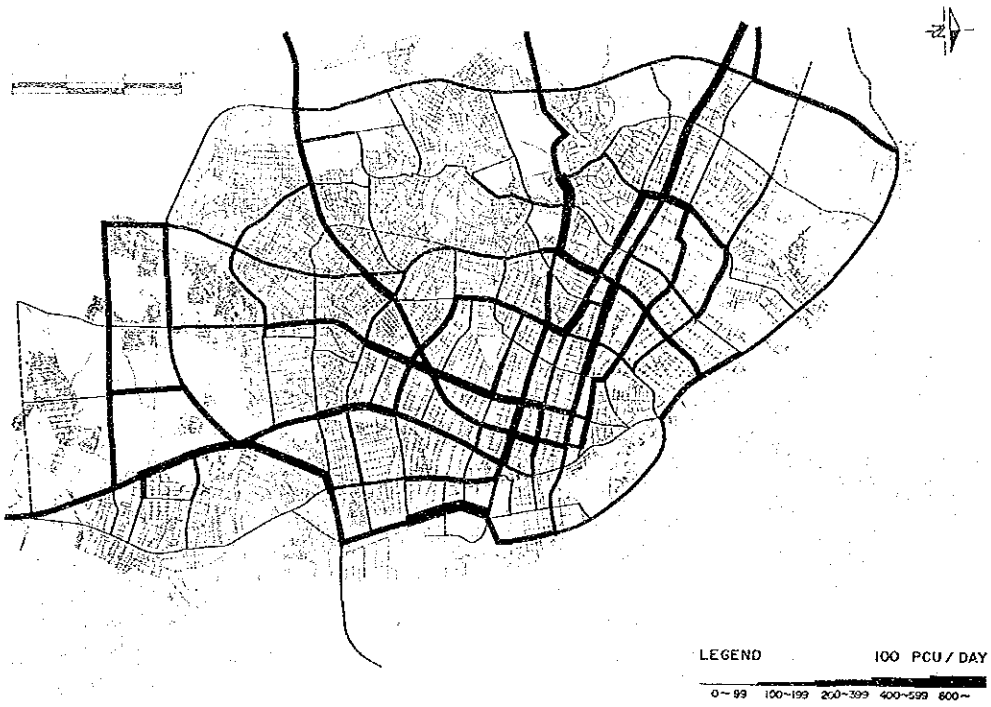

Fig. 10–2–6 Traffic Assignment on Alternative 2 (2000)

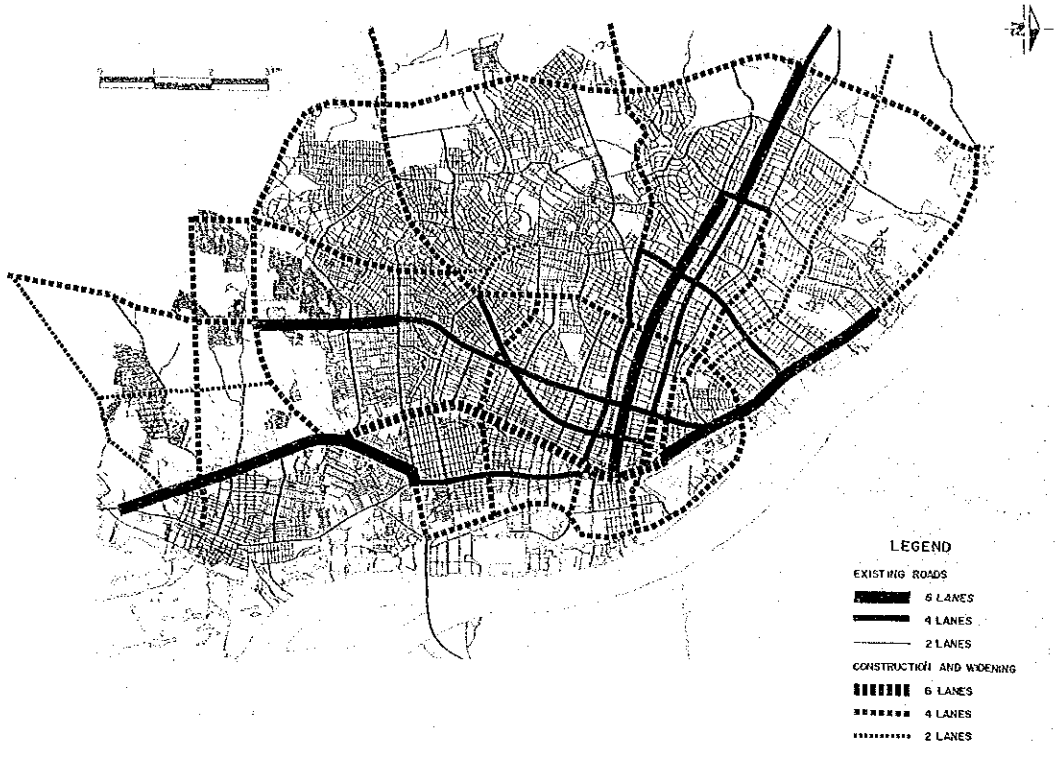

Fig. 10–2–7 Alternative Network 3

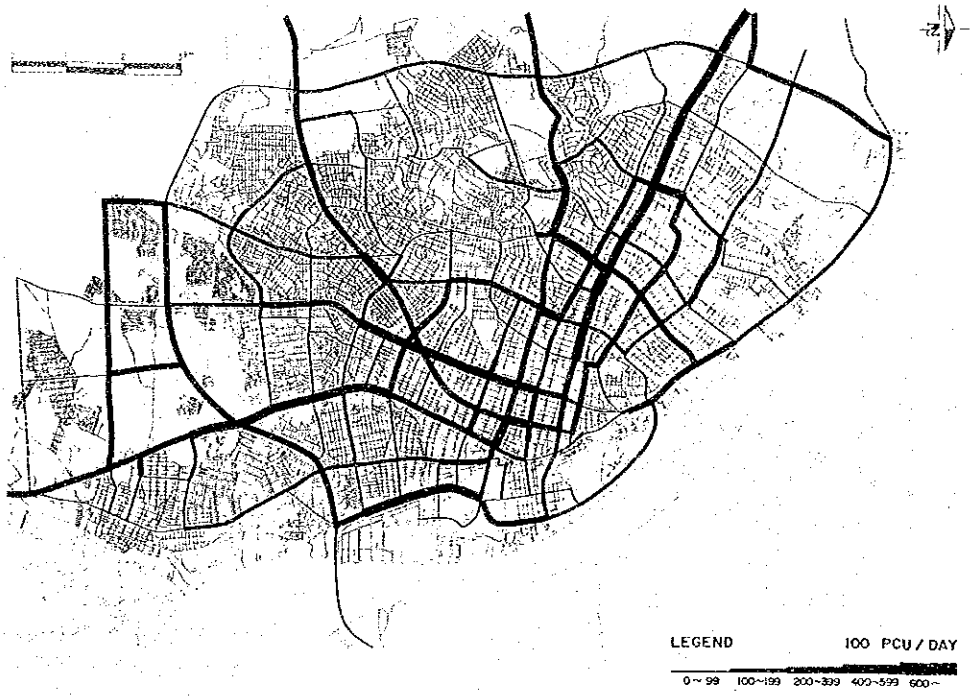

Fig. 10–2–8 Traffic Assignment on Alternative 3 (2000)

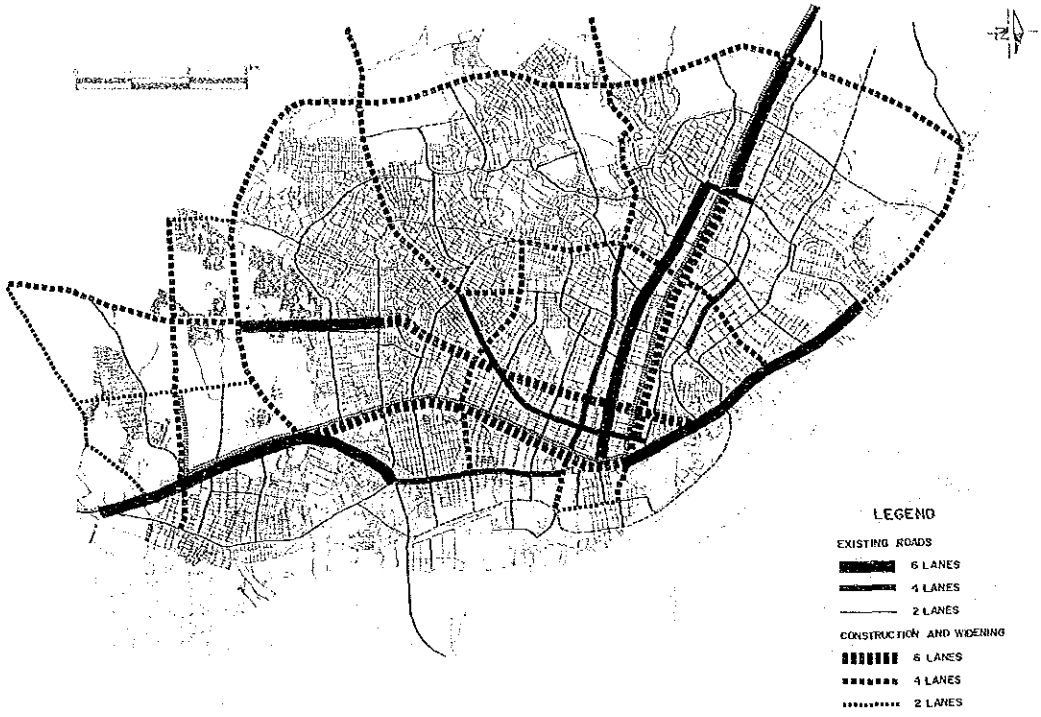

Fig. 10–2–9 Alternative Network 4

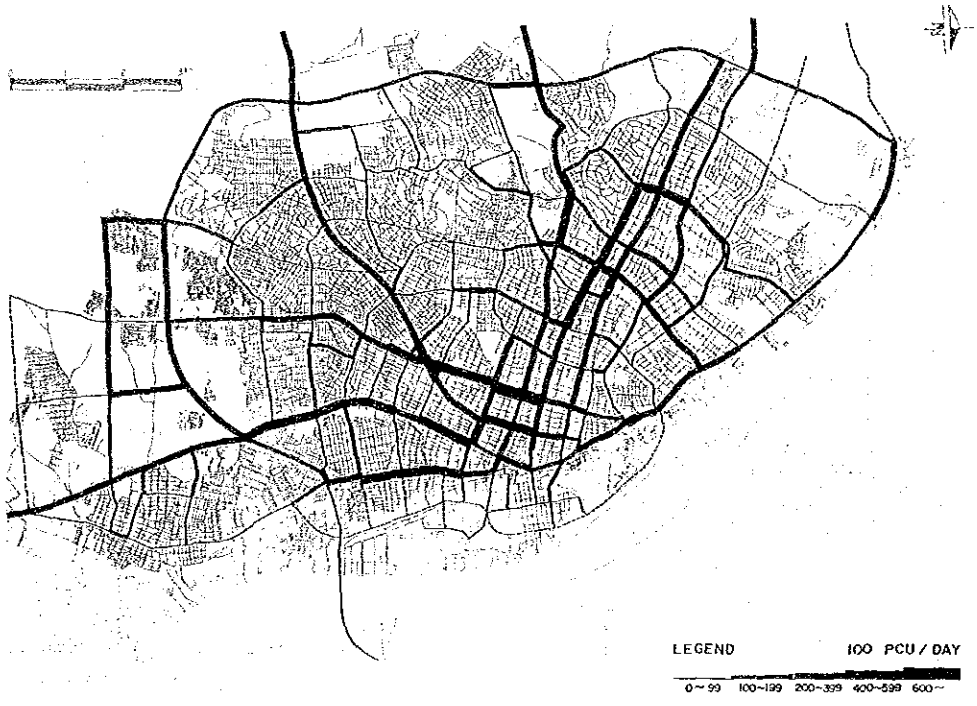

Fig. 10–2–10 Traffic Assignment on Alternative 4 (2000)

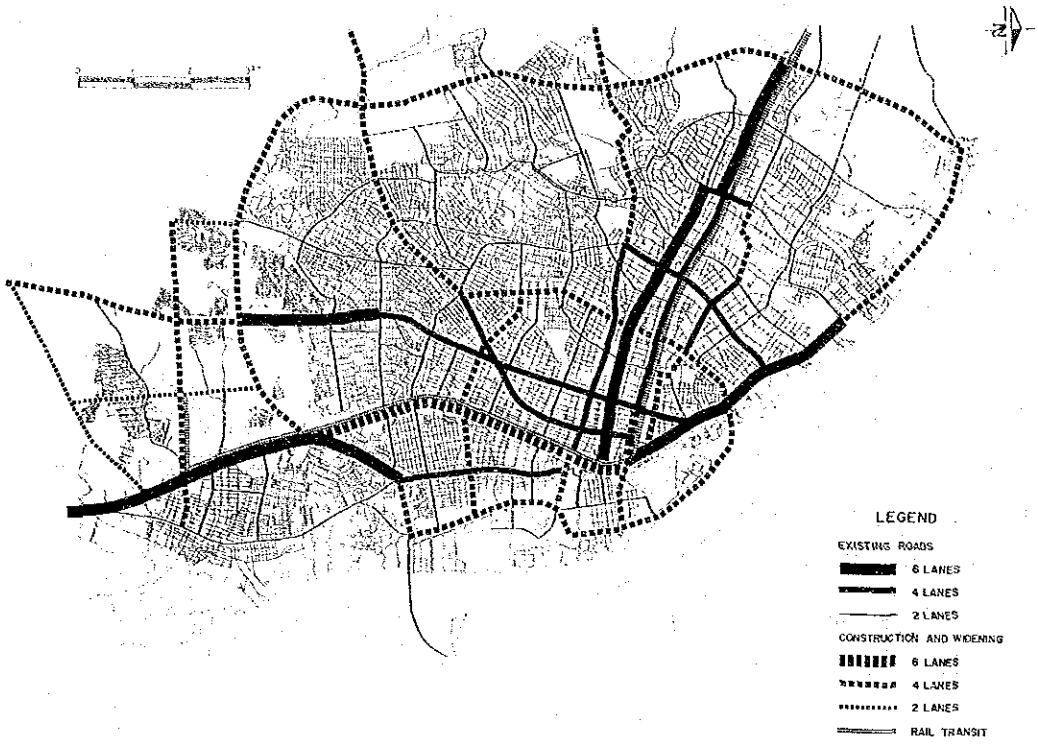

Fig. 10–2–11 Alternative Network 5

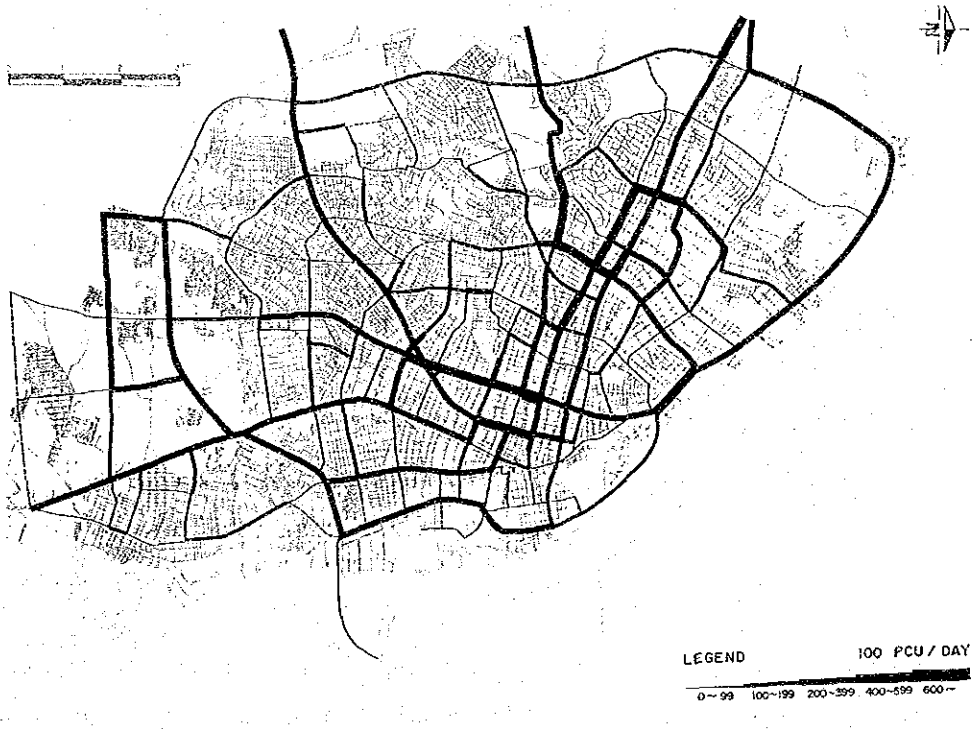

Fig. 10–2–12 Traffic Assignment on Alternative 5 (2000)

tion, the future traffic demand is assigned on the alternatives.

At first, the modal split is calculated by alternative public transport system. The trips by private vehicles and by public transport are assigned on the road network and public transport network respectively. The public transport network is represented by bus network as a base and a new transit system is added in the corresponding cases.

The alternative network plans are prepared so that each will have a similar level of services in terms of degree of congestion (about 0.5–0.6 for the Metropolitan Area and 0.8–0.9 for the Central District). The result of traffic assignment are shown in Fig. 10–2–4, 10–2–6, 10–2–8, 10–2–10 and 10–2–12.

In order to grasp the differences in traffic flows as a whole among the alternative network plans, several indicators such as vehicle-kilometers, vehicle-hours, etc. are calculated as shown in Table 10–2–3.

Table 10–2–3 Summary of Traffic Assignment on Alternative Network Plans

	Present Situation	Do-nothing Case	Alternative Network Plans				
			1	2	3	4	5
Total Length of Network (km)	287.1	287.1	337.3	354.9	354.9	359.1	376.7
Total Vehicle Km. (1000 veh.km)	1,834.5	4,643.3	4,339.5	4,466.5	4,211.7	4,211.7	4,255.4
Total Vehicle Time (1000 veh·hr)	83.2	325.4	218.1	207.6	119.2	183.4	174.7
Average Congestion Rate (Study Area)	0.5	1.4	0.9	0.9	0.9	0.8	0.8
Average Congestion Rate Central District	0.9	1.4	0.9	0.9	0.9	0.8	0.8
Average Travel Speed (km/hr)	32.8	21.0	30.0	30.7	30.0	33.2	33.5

Compared with the Do-nothing case, the indicators of all the alternative network plans show a considerable improvement of traffic conditions. With regard to the total vehicle-km, the reduction rate is not so high in the case of the alternatives 1, 2 or 3; more or less 5 or 6% only.

This may be caused by the fact that the length of the road which has a reduction effect in vehicle-km is relatively short when compared with the total road length. However, the alternatives 1 and 3 have a slightly higher effect than the alternative 2. In the case with a rail transit system, the total vehicle-im is reduced as much as 8 or 9% of that in Do-nothing case, due to the diversion from buses and private vehicles to the rail transit system.

In term of the total vehicle-time, all the alternative plans have savings from 30% to 50% compared with the Do-nothing case. Among the alternative plans, alternatives 3 and 5 have the highest effect in the reduction of the total vehicle-hours for the cases without and with a rail transit respectively. As for the average congestion rate and the average travel speed, there do not exist much differences among the alternative plans, nevertheless, alternatives 3 and 5 show slightly better traffic conditions than the other cases in the respective categories regarding a rail transit system.

As a consequence, alternative 3 among the cases without a rail transit system, and alternative 5 in the case with a rail transit system are considered to be more preferable in terms of the improvement in the traffic conditions.

As mentioned in the previous section, the introduction of a rail transit system affects the modal choice of a person trips.

The results of the modal split by alternative plan are given in Table 10–2–4.

Table 10–2–4 Modal Share of Person Trips by Alternative Plan
(thousand person trips/day)

	Alternative Network Plans			
	Without Rail Transit (Alternative 1 – 3)		With Rail Transit (Alternative 4, 5)	
Walk	902	(18.4%)	902	(18.4%)
Private Vehicles	1,276.6	(26.1%)	1,264.8	(25.8%)
Bus	2,720.0	(55.5%)	2,439.4	(49.8%)
Rail Transit System	–	–	292.4	(6.0%)
Total	4,899.0	(100.0%)	4,899.3	(100.0%)

In the case "with rail transit system", about 290,000 person trips are diverted from buses and private vehicles to a rail transit system. Consequently, the modal shares of bus and private vehicles slightly decrease from 55.5% to 49.8% for bus, and from 26.1% to 2.58% for private vehicles.

10–3 Preliminary Evaluation of Alternative Network Plans

In order to assess the effectiveness of the alternative network plans from the national economic viewpoint, a benefit-cost analysis is roughly made in this section. Since the investment program for each plan is not defined yet, this evaluation is still at the preliminary stage, and should be utilized to find the relative superiority among the alternative plans. Therefore, the economic evaluation as a masterplan in a more strict sense will be made in Chapter 16.

10–3–1 Premise for the Preliminary Evaluation

(1) The project cost by alternative plan is the total cost including construction and improvement cost, land acquisition and compensation costs, and operation and maintenance costs for the network. The economic cost is obtained by subtracting all the taxes from the financial cost.

(2) All the projects involved in each alternative are completed by the end of the year 2000. The annual investment is assumed to increase in proportion to the annual growth rate of GRDP during the period from 1986 to 2000, and is computed as follows:

$$I_t = \frac{r(1+r)^{t-1}}{(1+r)^{15}-1} \cdot C$$

where, I_t : Annual Investment in Year t (t = 1 in 1986)

r : Annual Growth Rate of GRDP

C : Total Cost

(3) In calculating the benefits acrued from the project, the following are considered:

a. Savings in vehicle operating costs

b. Savings in travel time

These benefits are obtained by calculating the differences in vehicle operating costs and in travel time between the Do-nothing Case and each of the alternative cases. The unit vehicle operating cost and the unit time cost are shown in Chapter 16.

(4) Since the investment program is unknown at present, it is difficult to accurately calculate the annual benefit for the years between 1985 and 2000. As the year 1986 is the first year of the investment, the benefit in 1986 is assumed to be zero. Only the benefit in the year 2000 can be obtained by the above method. Therefore, the annual benefit is assum-

ed to grow as a linear line till the year 2000 by setting the benefits in 1986 and 2000 as mentioned above.

(5) As for the investment schedule of rail transit, it is assumed as follows:

1988 – 1991 Land acquisition and engineering cost

1991 – 1995 Construction and rolling stocks cost

Accordingly, the rail transit system is assumed to open to public in 1996. The operating cost is estimated to be 865.6 million pesos/year for the year 1996 and grow at 2% annually till the year 2000.

(6) The project life is assumed to be 25 years for the roads and 30 years for the rail transit system. The annual benefit is calculated till the year 2000 and the residual value is taken into account for the years after 2000.

(7) The discount rate is assumed to be 12% which is normally used for the economic evaluation in Colombia.

10–3–2 Project Cost by Alternative Network Plans

The project cost is obtained by summing up the construction and improvement costs, and land acquisition and compensation costs required for all the facilities of the network (Refer to cost estimation in Chapter 11). The total project costs are calculated on the basis of the economic cost of the alternative plans as shown in Table 10–3–1.

Table 10–3–1 Total Economic Project Cost by Alternative Network Plans

(million pesos)

	Alternative Transport Network Plans				
	1	2	3	4	5
Road Construction Cost	17,654.9	19,618.4	19,645.6	16,791.1	18,182.9
Land Acquisition Cost	1,713.6	1,584.6	1,546.5	1,676.1	1,502.0
Compensation Cost	5,896.3	4,369.0	4,073.7	4,837.6	3,336.8
Rail Transit System	–	–	–	33,587.1	33,587.1
Total Cost	25,265.4	25,572.0	25,205.4	56,891.9	56,608.8

Note: 1984 prices.

10–3–3 Estimation of Benefits by Alternative

The total benefit derived through the adoption of each alternative plan is calculated by adding the estimate savings from vehicle operating costs and travel time costs, and is expressed by the following formula.

$$B = (VOC^{WO} + TC^{WO}) - (VOC^{W} + TC^{W})$$

where, B : Benefits by each alternative plan

VOC^{WO} : Vehicle Operating Cost in Do-Nothing Case

TC^{WO} : Travel Time Cost in Do-Nothing Case

VO^{W} : Vehicle Operating Cost in each alternative case

TC^{W} : Travel Time Cost in each alternative case

VOC and TC are expressed by the following equations.

$$VOC = \sum_{k} RC_k \cdot VL_k + \sum_{k} FC_k \cdot VT_k$$

where, RC_k : Unit running cost of mode k.

Note : Since the operating cost of the rail transit is counted in the cost stream, it is not included here.

VL_k : Vehicle Km per year of mode k.

FC_k : Unit fixed cost of mode k.

VT_k : Vehicle time per year of mode k.

$$TC = \sum_{k} V \cdot T_k$$

where, V : Unit time value of passengers.

T_k : Total passenger time of mode k.

Note (1) In the case with a rail transit, the passengers of the rail are taken account.

(2) Only the trips for work and business are considered.

The results of the computations indicate the total benefits in 2000 by each case as shown in Table 10–3–2.

Table 10–3–2 Vehicle Cost and Time Cost in 2000

(million pesos)

Case	Vehicle Operating Cost		Travel Time Cost		Total Cost	Benefit
	Running Cost	Fixed Cost	Vehicles	Rail Transit		
Do Nothing	15,321	18,042	11,287	–	44,650	–
Alternative 1	14,485	15,564	4,133	–	34,181	10,469
Alternative 2	14,583	14,756	4,006	–	33,345	11,305
Alternative 3	14,782	14,194	3,770	–	32,746	11,904
Alterantive 4	13,374	13,113	2,905	382	29,774	14,876
Alternative 5	13,546	12,441	2,763	378	29,146	15,504

10–3–4 Preliminary Evaluation

The benefit/cost ratio, the net present value and the internal rate of return (IRR) for each alternative network plan are estimated as follows: (Refer to Table 10–3–3)

Table 10–3–3 Results of Preliminary Evaluation

Alternative	Total Cost (million $)	B/C Ratio	Net Present Value (million pesos)	IRR (%)
1	25,265.4	1.98	6,847.3	24.2
2	25,572.0	2.24	8,527.0	26.9
3	25,205.4	2.53	10,370.4	30.4
4	56,891.9	1.16	2,436.3	14.6
5	56,608.8	1.32	4,980.9	17.7

Note: The base year is assumed to be 1984.
The annual discount rate is 12%.

The above table indicates that the benefit exceeds the cost by a substantial margin in all cases, and that all the alternative plans are economically justified.

It is found that the alternative 3 has the highest indicators, therefore, this is the most preferable alternative from the economic viewpoint. The alternatives with a rail transit system, ie., alternatives 4 and 5, show relatively lower indicators than the others. This is because the rail transit system requires a vast amount of cost. It is also noted that alternative 5 is economically more preferable than alternative 4. This fact is consistent with the evaluation result that the mixed pattern in the road network physical pattern (alternative 3) is superior than the intensive pattern (alternative 1).

As a consequence, the transport network masterplan will be drawn up based on the alternative 3. However, a special consideration will be given to the introduction of a rail transit

system, since it is anticipated that the public transport system by bus and taxi services only, will not be able to meet the transport demand someday in the near future.

The introduction of a rail transit system requires not only a large amount of investment but also a lot of lead time for its preparation and construction, therefore, it is necessary to take appropriate actions for its preparation beforehand. These preparations can include a more detailed study on the demand, the alignment and the location of stations, the establishment of a co-ordinated plan in a more detailed sense, along with the urban renewal of the central district.

Chapter 11.

TRANSPORT NETWORK MASTERRLAN MASTERPLAN

Chapter 11 TRANSPORT NETWORK MASTERPLAN

11-1 Basic Policy

11-1-1 Network Formulation

As elaborated in the previous chapter, the alternative transport network plans, were made compatible with the future land use pattern and the future transport demand.

Accordingly, the transport network masterplan for the year 2000 is formulated on the basis of the Alternative 3, taking into account the other requirements such as social, regional development and environmental aspects.

(1) Necessity of functional classification

At present, the classification of the roads in Barranquilla is not obvious, therefore, the road network is not effectively utilized. This is mainly because the trunk road network is not established and most of roads have not been built to proper design standards. For example, a street which functions as arterial road sometimes has lower design standards than other local street.

Each road forming part of the road network should have appropriate standards as to alignments, cross section, etc. to fulfill the functional classification it is supposed to provide, including starting and ending points, traffic volume, surrounding land use conditions, etc. All the roads are classified and planned on the basis of the road classification shown in the succeeding section.

(2) Urban development

As explained in Chapter 8, the Barranquilla Metropolitan Area is expected to be developed by upgrading the economic activities in the central district and establishing two new sub-centers in the north and south. In order to promote and support these urban developments, the road network should be well conceived not only inside these centers but also in between them.

In the central district, the widening of Calle 30, Cra. 45, and Cra. 50, and the construction of Riverside Bypass will highly contribute to the renewal of centro and the development of Barranquillita. In addition, for improving the accessibility from Barranquillita to the surrounding area Cra. 46 and Calle 17 are proposed to be extended.

For the development of the south sub-center, Via Caracolf and the Transversal road will

be constructed as a 4-lane road. Moreover, Via Soledad 2000 will be improved to promote the housing projects around the sub-center.

(3) Public transport development

In accordance with the increase in the transport demand, the bus transport capacity should be expanded by reorganizing the bus route pattern, increasing the service frequency, and replacing buses to a higher capacity types. The reorganization of bus route network will be made by the introduction of a bus circular system in the central district and enhancing several trunk bus routes including a circumferencial route as elaborated in Chapter 12. The bus transport, however, has a limit as to its transport capacity as well as the road capacity around the bus terminal facilities in the central district, since it is difficult to drastically expand the road spaces inside of the built-up area.

A rail transit system, therefore, is considered to be necessary sooner or later in the future. Hence, the preparation of a rail transit system should be considered in this masterplan for the future development of the public transport system.

For providing a better service to bus passenger, an exclusive bus lane or several bus bays will be installed on the trunk bus routes. When a rail transit system is introduced, these spaces can be converted to the spaces for the right of way, stations, etc. of the rail transit system.

(4) Urban environment

In realizing the transport network masterplan, special consideration should be given to the preservation and creation of a better urban environment. Particularly the important in Barranquilla is the Arroyo problem. When it rains heavily in Barranquilla, the road traffic is significantly affected by rain water flowing down to the Rio Magdalena along the roads. To cope with this problem, several countermeasures are proposed in this study. In order to create a better landscape, and since greenery is insufficient in Barranquilla, roadside trees should be provided along major streets. As for the area crowded with pedestrians, like the central district, pedestrian facilities such as pedestrian mall, wide sidewalks, and pedestrian crossings, should be developed. In addition, traffic regulations for heavy vehicles related to the industrial area might be necessary to protect the CBD area from becoming a public nuisance.

11-1-2 Road and Street Classifications and Geometric Elements

The road and street classifications used for the Road and Street Plan in the present survey are described in detail in Chapter 4. The following points, however, should be noted at the time of road and street planning associated with the new improvements.

1) Arterial Roads and Streets

These are roads and streets connecting Barranquilla with other major traffic generating points. In order to meet the future traffic demand, the high capacity of these roads and streets for traffic should be maintained as much as possible. The physical locations and accessability of these roads and streets should be taken into consideration in order to integrate them with the activities of the city.

2) Semi-Arterial Roads and Streets

Along with arterial streets, these roads and streets will connect the major traffic generating points in the city, such as the Centro District, residential areas and industrial areas, etc. In particular, a semi-arterial street will be needed to supplement the traffic capacity between the Centro District and the sub-centers planned in the south and the north-west of the city. Semi-arterial streets should also be located around the business area which is centered in the Centro District so that a concentration of traffic can be mitigated.

3) Collector Streets

Collector streets should be distributed in such a way that the traffic between local streets and arterial streets can be smoothly conducted with efficient gathering and dispersing. This distribution should be carried out in line with the Bus Route Plan.

4) Local Streets

The main purpose of local streets is to provide a service for local traffic along these streets and also to secure the necessary space for daily activities. In addition, local streets will mark the outer limits of local areas and will also determine the sizes and shapes of these areas. Connections to local streets will be made using collector streets in such a way as to eliminate through traffic as much as possible and to keep the driving speed low.

5) Geometric Elements and Cross-Sections of Roads and Streets

The geometric elements and the cross-sections of roads and streets in the present plan are

shown in Table 11–1–1 MOPT Standard, based on AASHTO Standards, will be adopted as the standards for geometric elements.

AASHTO Standards and the Japanese Standards should be referred to when detailed street descriptions are not clearly given in the MOPT Standards. While the functional classification of roads and streets is pursuant to road standards, the cross-section elements and the number of traffic lanes in particular will be decided based on the future traffic demand.

Table 11–1–1 Geometric Elements of the Street

		Arterial	Semi-Arterial	Collector	Local	Remark
ADT	per/day	more than 12000	more than 10000	2000		
DS	km/h	60	60–40	40–30	30	
TTL	lanes	4–8	4	2	2	
Laine Width	meters	3.25	3.25	3.25–3.00	3.00	
Median	meters	3.00–1.00	3.00–1.00	1.00	–	
Shoulder	meters	2.50～ 0.75	150～0.50	1.50～ 0.50	0.50	
Sidewalk	meters	more than 3m	more than 3m	Δ	Δ	
FR		Δ	–	–	–	
HC	meters	more than 200	more than 200	100	65	
GV	%	5	6	7	9	
CVC	meters (approx)	1300	1300	700	400	
SVC	meters (approx)	1300	1300	700	400	
Superelevation	%	2 (1.5)	2 (1.5)	2 (1.5)	2	( ): Concrete pavement
Intersection		* Over pass or at-grade	* Overpass or at-grade	Signalized and/or channelized at-grade	Δ	
Pedestrian Bridge		○	Δ	Δ	–	
Road Estructure		Semi access control or at-grade	at-grade	at-grade	at-grade	

ADT: Average daily traffic
DS : Design speed
TTL : Through traffic lanes
FR : Frontage road
HC : Horizontal curvature
GV : Vertical grade
CVC: Vertical curve crest
SVC : Sag vertical curves
○: Necessary
Δ: If possible
* : The result of traffic demand

11–2 Transport Network Masterplan

11–2–1 Transport Network

The transport network masterplan for the year 2000 is shown in Fig. 11–2–1 and Fig. 11–2–2. The network plan for the Metropolitan Region shows that in the direction to the south, the Soledad, Malambo areas including the new sub-center and the airport are connected with the central district of Barranquilla by the Autopista al Aeropuerto as the main axis. The extension of

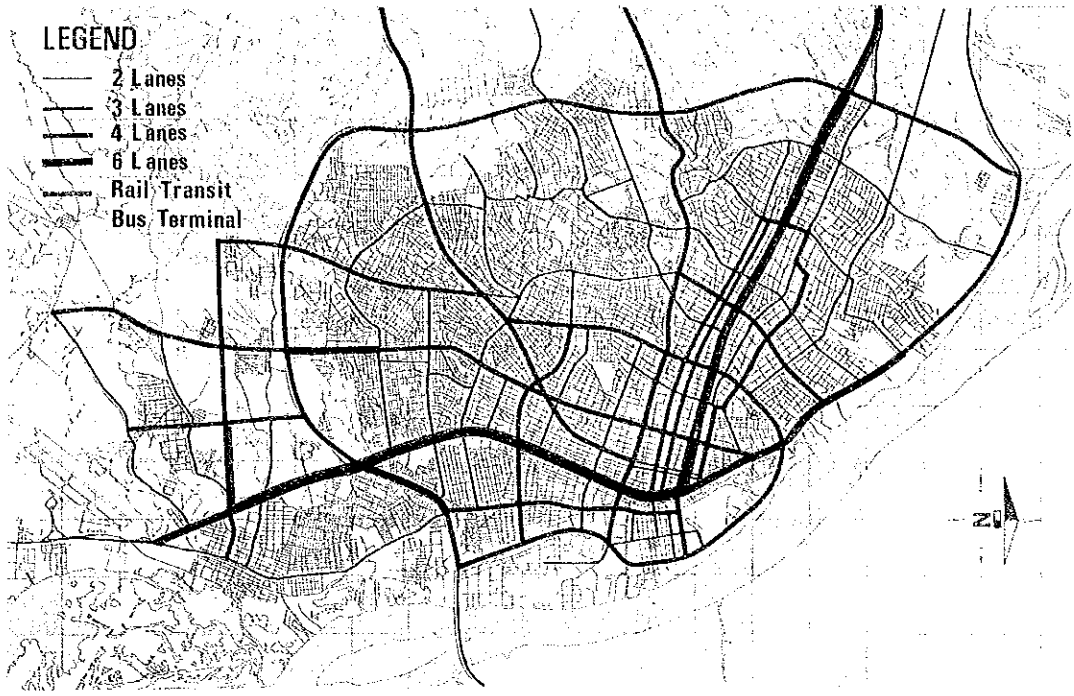

Fig. 11–2–1 Transport Network Master Plan for 2000 Barranquilla

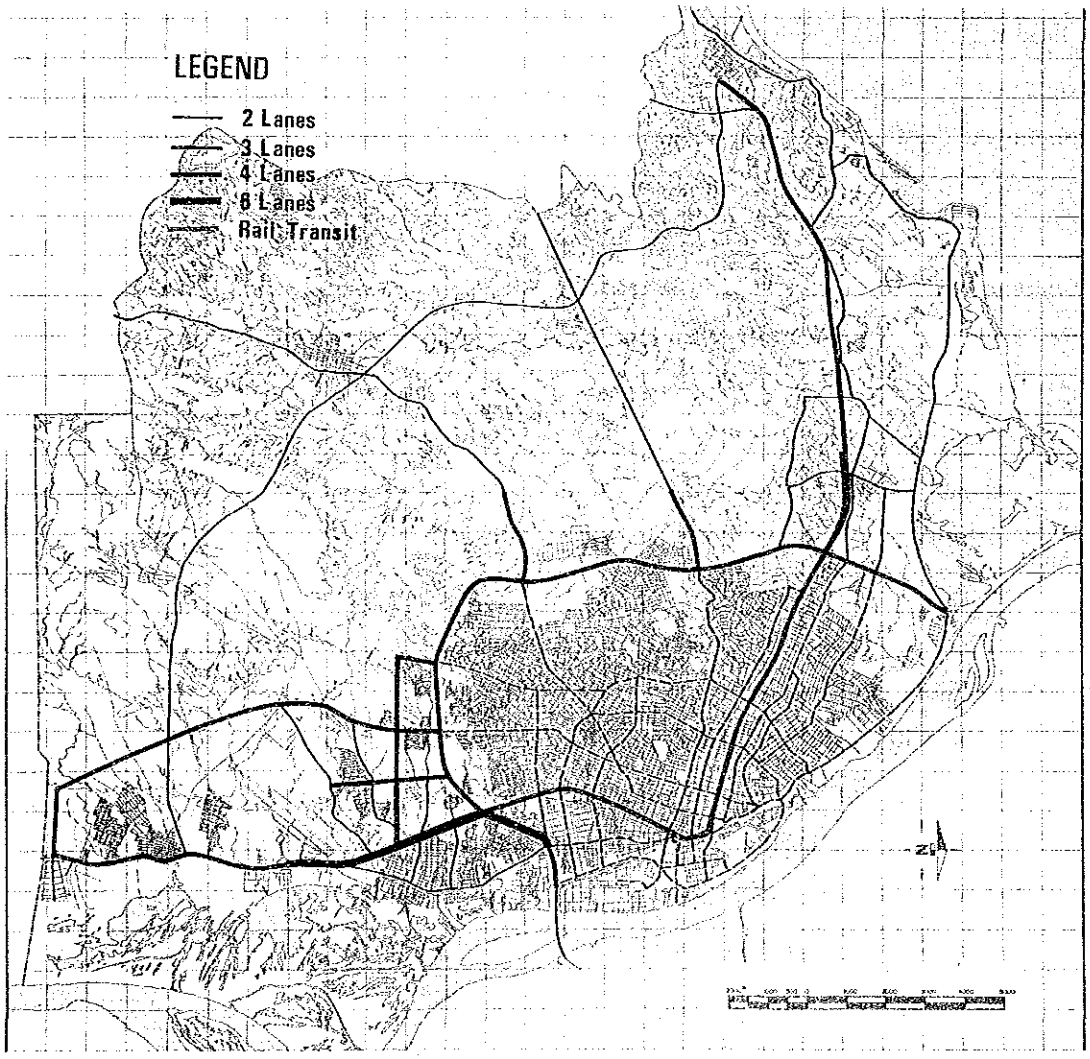

Fig. 11–2–2 Transport Network Master Plan for 2000 Metropolitan Region

Calle 45, which runs from Circunvalar toward Malambo, parallel with the Autopista al Aeropuerto, will function as an arterial road to develop the new sub-center and support various ongoing projects such as the Central de Gran Abastos, Airport Industrial Park, a number of housing projects, etc.

Regarding the north-west direction, the Autopista to Puerto Colombia will be the main axis connecting the new sub-center in the north with the central district.

As a linkage among the satellite cities of Barranquilla, the Carretera Metropolitana is proposed to be constructed. It forms an outer Circunvalar and is expected to contribute to the development of those cities as well as the rural area. The Circunvalar will be widened to a 4-lane road in line with the urbanization outside of the Circunvalar.

With regard to the network plan in Barranquilla, Calle 30 and Cra. 46 will form the main axes to the south and north-west from the Centro. The construction of the Riverside Bypass is expected to contribute not only to the service for the traffic related to the port or industrial area along Via 40, but also to the development of Barranquillita and expediting the construction of the intermunicipal bus terminal.

Another prominent road is the Inner Circunvalar Road, which is established mainly by widening the existing roads such as Cra. 22, Calle 53, etc. to 4 lanes. This road is considered to be very helpful to relieve the traffic congestion in Centro with a bypass effect.

The proposed transport network masterplan is basically almost the same as the Alternative network plan 3. The differences are as follows:

(1) Calle 17 is extended to Barranquillita with 4 lanes to develop the Barranquillita area.

(2) Transversal road in the south sub-center is constructed as a 4-lane road.

(3) A connection road between Circunvalar and the Inner Circunvalar is improved for the enhancement of the sub-center, by upgrading Cra. 26 and Calle 76D to upgrade the mobility of the existing built-up area along the road.

As for the rail transit, the alighment is planned to be along the trunk roads, Calle 30 and Cra. 46 as elaborated hereinafter.

As the other major road developments, the following can be enumerated:

(1) Construction of Via Caracoli with 4 lanes as a main street of the south sub-center.

(2) Widening with a partial construction of Calle 45D from 2 lanes to 4 lanes as a connection between the west part of Soledad, the southwest densely populated area of Barranquilla and the Inner Circunvalar Road.

(3) Widening of Cra. 47 for Galapa from 2 lanes to 4 lanes. This is an on-going project by the Municipality.

(4) Widening of Cra. 38 for Juan Mina from 2 lanes to 4 lanes.

(5) Extension of Cra. 46 to Barranquillita is planned as a 4-lane road at the same time with the redevelopment of Caño Ahuyama. This road will effectively function to create a better access to Barranquillita from Centro together with the improvement of the short stretch of Cra. 38 between Calle 30 and the Riverside Bypass.

(6) Improvement of Cra. 50 and Cra. 54 will be carried out for the purpose of alleviation of the excessive load on Cra. 46. These are to be widened to 4 lanes in the section from Via 40 to Calle 54 and the section from Calle 54 to Calle 84 respectively.

11-2-2 Planning Conditions

1) Topography and Geology of Barranquilla

The city of Barranquilla is located around the rivermouth of Rio Magdalena. Its urban area has developed alongside the river and it now completely includes the hill lying to the west. Although the hill was formed by the upheaval of the seabed, it mainly consists of sand and volcanic ash. This sandy soil was transported from the volcanic area upstream of Rio Magdalena, deposited on the river and seabeds and compacted. These beds later surfaced due to subsequent upheavals and contributed to the formation of the hill. The hill shows a comparatively gentle development along the north-south axis, its eastern slope is gentle with the foot reaching the bank of Rio Magdalena, however, the western slope at the back of the city is so steep that parts of it are prone to landslides. As a result, the western slope now forms a boundary for the city and presents a critical problem for the planning of the street network.

Barranquillita is the result of the development of the river island which was originally formed at the rivermouth of Rio Magdalena. Although the surface is compacted for the upper 2.0 to 3.0 m, a 13.0 to 15.0 m thickness of solft ground exists. Accordingly, pile foundations will be required if major structures are constructed.

2) Points of Consideration for the Road and Street Plan

The following elements should be taken into consideration when roads and/or streets are planned.

a. Control Points

The planned routes should avoid special topographic features, places prone to landslides, major structures, areas where it would be very difficult to dedicate for road usage due to their

particular land use plan, etc.

b. Intersection Improvement

Channelization and/or left-turn lanes will be introduced at intersections of arterial and/or semi-arterial streets depending on the traffic demand for individual directions.

c. Interchanges

Overpasses will be constructed for the main traffic flow at intersections where the future traffic volumes are expected to exceed the planned intersection capacities. Clover leaf type interchanges will be constructed for arterial streets crossing Circunvalar, and where arterial streets will be overpassed.

d. Bridge Planning

Except for pedestrian overpasses, pre-stressed concrete beam bridges will be used. Foundation piles will be driven in conjunction with the newly built streets along Rio Magdalena. Spread footings will be used for bridge foundations in Barranquilla. All pedestrian overpasses will be 3.0 m wide and will be of metallic material.

e. Street Drainage System

Rainfall on and around roads and streets involved in the development plan will be guided to the gutters which will be installed alongside these roads and streets. Catch basins will then drain the water into box culverts installed under the sidewalks. Catch basins will be located at points where the flow capacities of the gutters have reached their full capacity.

f. Arroyo Countermeasures Plan

Countermeasures will be provided for those Arroyo which pass or cross the arterial and semi-arterial streets under the plan. Flow of Arroyo in the Centro District will be prevented. In order to achieve these objectives, a highly practical plan should be prepared in which the present Arroyo are integrated and/or rerouted and box culverts, reservoirs, etc. are introduced.

3) Road and Street Maintenance System

The proposals to improve the Road and Street Maintenance System are given below based on the results of the Road Inventory Survey.

a. Establishment of Road and Street Maintenance System

It will be necessary to establish a division in charge of roads and streets as part of the city administration. Although this division should keep in close communication with E.P.M., the administrative responsibility of the division should be clearly defined. Streets in the city are currently heavily damaged, showing the lack of a proper street maintenance system. It is not simply a question of the lack of an adequate budget for street reapris. Many of the present prob-

lems will be solved if a technically, as well as administratively, organized system is established.

b. Improvement of Administrative System

(1) A comprehensive road and street policy covering the entire area of the city will be necessary with regard to planning, design, construction and maintenance, etc.

(2) The responsibility of the administrative division related to roads and streets should be clearly defined so that the necessary paper work involving higher administrative organizations, the securing and execution of the budget and the communication and consultation with other related organizations, etc. be carried out and the permission and/or the authorization of street use by citizens be given.

(3) The technical department should be responsible for all technical aspects of surveys, planning, design and management during construction and maintenance work and its responsibility should be clearly defined.

(4) Contractors are normally relied upon by the city administration design and construction as well as surveys. As a result of this, interim inspections, in particular the quality inspection, appear to be neglected. Neither City Government officials who place the original orders, nor representatives of the contractors are seen on the construction sites, Consequently, the extent of the actual work is left to the workers with the result that the finish is inferior due to the lack of on-site management and quality control.

(5) On-site management by engineers and the introduction of a mechanised construction method should be considered in order to improve the work efficiency of the construction effort.

(6) on-site management costs and quality control work undertaken by the contractors should be provided for in the overall construction budget.

(7) It will be necessary to completely separate the design offices and contractors offices so that their respective scopes of responsibility can be clearly defined.

(8) It will be necessary to carry out thorough discussions with MOPT in order that the design standards and work specifications, etc. for Barranquilla can be established.

c. Street Surface Management

(1) It is very important that construction related damage to road surfaces be kept to a minimum. Any damage caused to sidewalks by water related work should be immediately repaired after the work has been completed. Permission should be received in advance from the office in charge of road management before any water related work is carried out.

(2) The materials used for road signs should be changed from those poor quality ones being used currently to better and more durable one which can be clearly seen by motorists at night. In addition, maintenance work should be continuously carried out.

(3) The maintenance of a sidewalks should be carried out by those in charge of street management and the planting of trees and the management of the surfaces should be continuously conducted. The private use of sidewalks should be completely prohibited.

(4) A Street Register should be prepared as soon as possible. In addition, the construction limits for buildings along roads and streets inside the city should be quickly established and strictly enforced.

(5) The city's street management office should introduce a permanent street monitoring system in order that the current conditions of the roads and streets are always known.

(6) The street management office should communicate with the public using the information media, so that the public will recognise the roads and streets as public properties.

(7) The practice by many citizens of throwing rubbish into Arroyo which flows down the streets during periods of rain, should be stopped by direct appeals to the citizens as well as education.

(8) Countermeasures to prevent the inflow of sand into the Arroyo should be considered.

11–3 Road and Street Plan

On the basis of the transport network masterplan, the development plans for each road and street are described in more detail below, taking into consideration the existing site conditions and the planning conditions stated in the previous section. Each road component of the network is shown in Fig. 11–3–1. The cross section plans are illustrated in Fig. 11–3–2.

11–3–1 New Road and Street Construction Plan

1) Riverside Bypass

This road will extend from the Acceso Puente Pumarejo to Via 40, for a distance of 7.5 km.

(1) Existing road conditions and improvements

This road is to be newly constructed as it can only follow the alignment of Calle 3 of Barranquillita for a very short length. Since the portion of Calle 3 included in this road will be raised as part of the construction plan for Barranquillita, the work would be the same as new road construction. The new road will run along the west bank of Caño

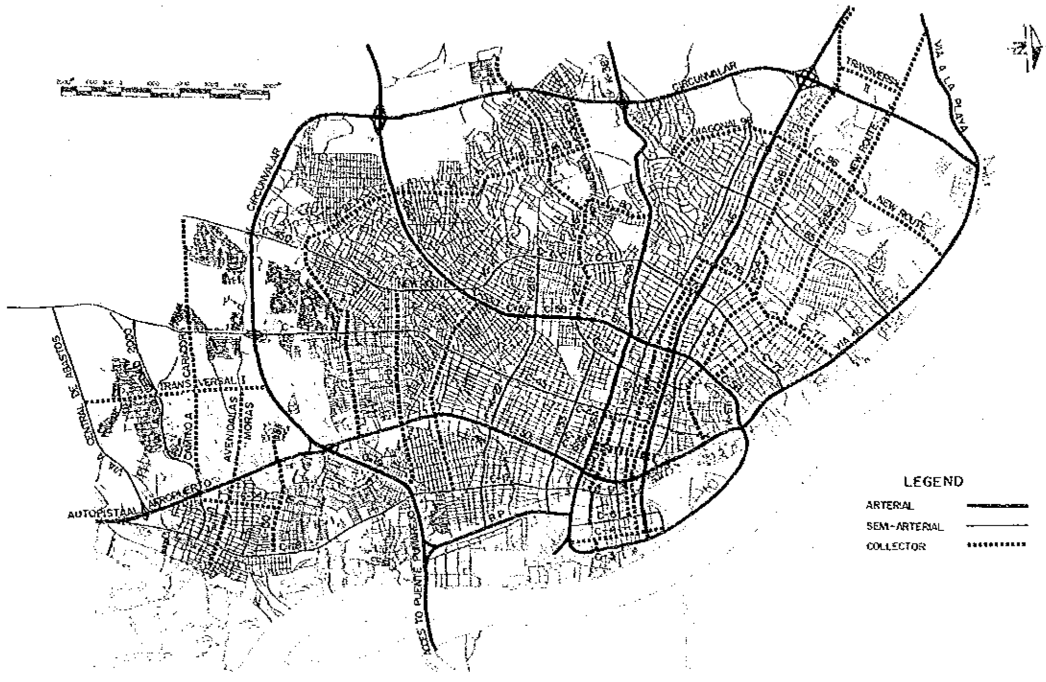

Fig. 11–3–1 (1) The Future Road Network Plan

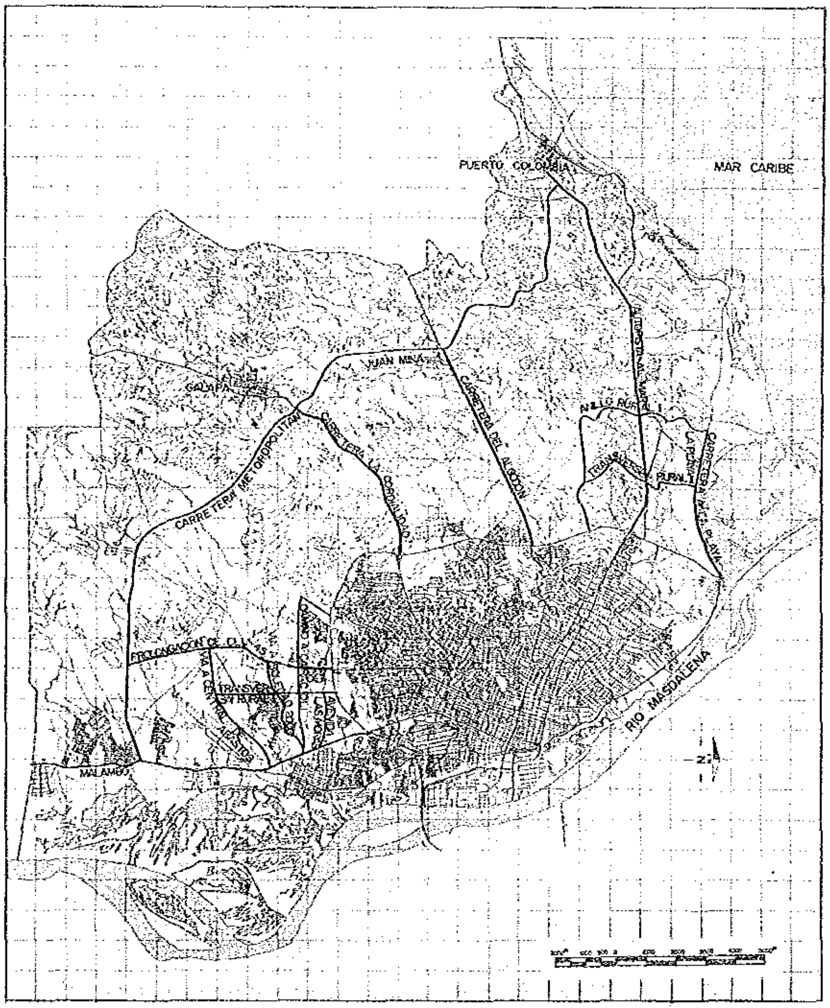

Fig. 11–3–1 (2) The Future Road Network Plan

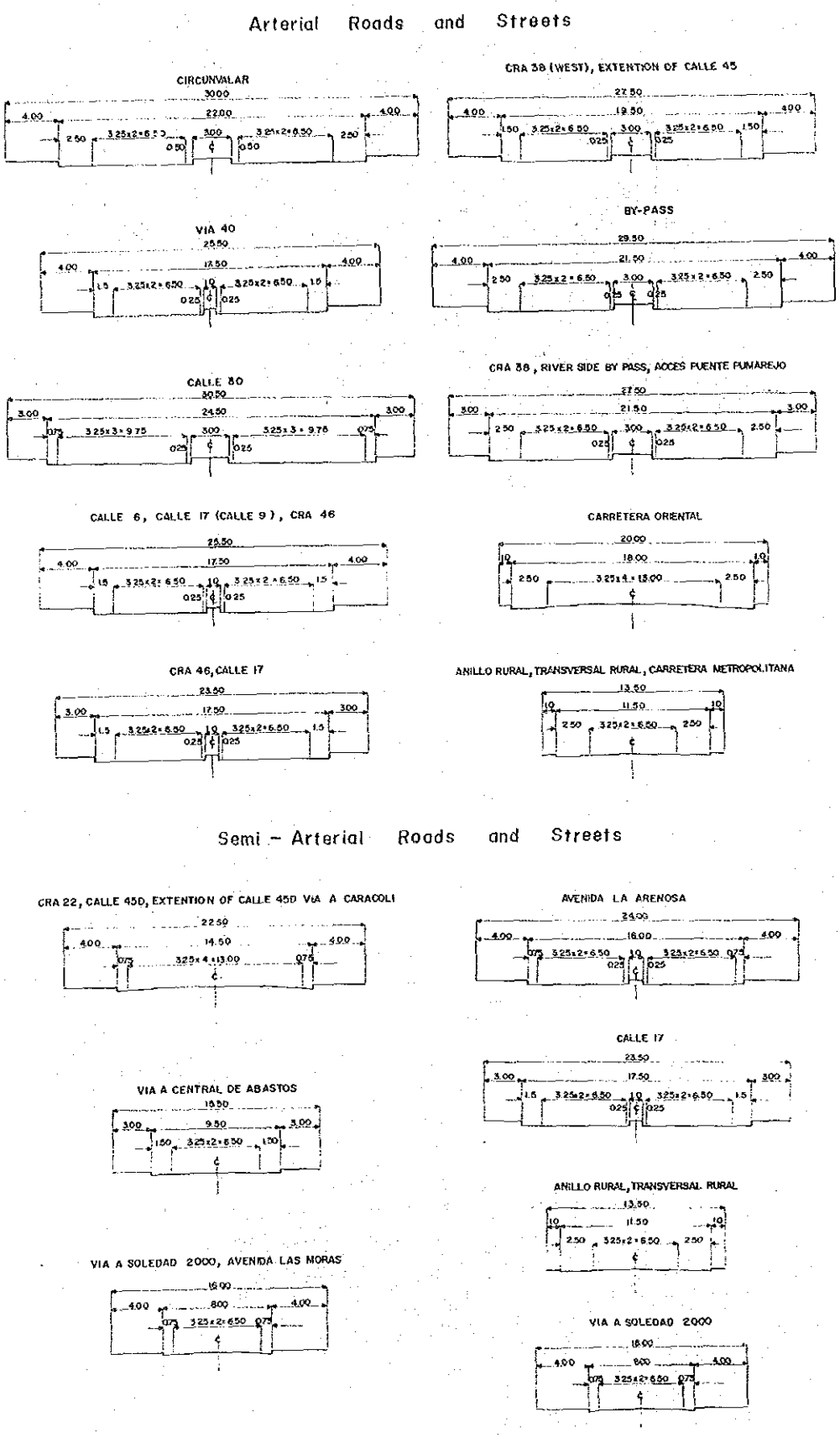

Fig. 11–3–2 (1) Cross Section for the Streets Plan in Barranquilla

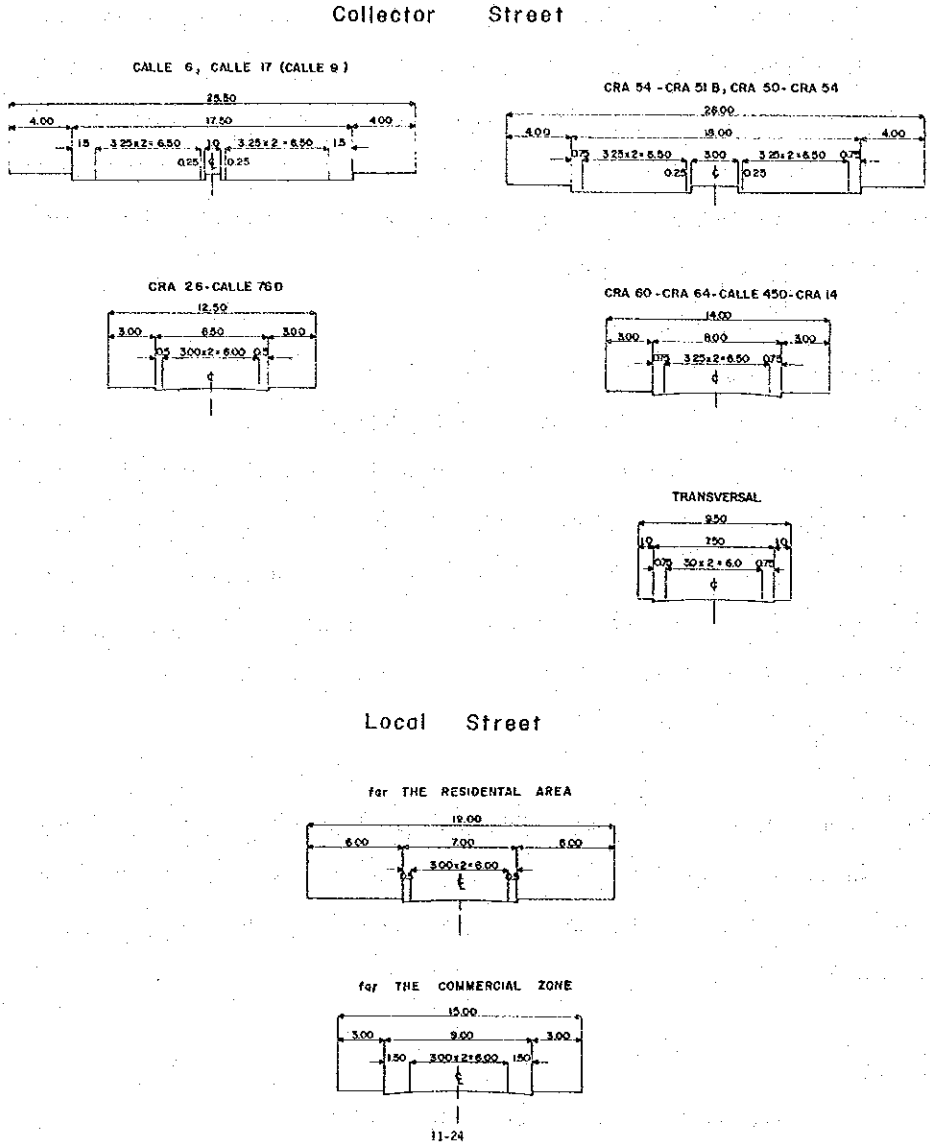

Fig. 11–3–2 (2) Cross Section for the Streets Plan in Barranquilla

Ahuyama, located along Zona Franca between Acceso Puente Pumarejo and Cra. 38. Since the area between the canal and Calle 17 is occupied by an industrial complex, the route will be set-up using the vacant space near the canal. In the Barranquillita and Loma sections, the road will run through the area will mostly empty spaces on both sides. A total of five (5) bridges will be constructed over such canals as La Ahuyama, Arriba, Los Tramposos and Las Compañias, etc.

(2) Topography and geology

The road will run through the area where the sandbank of Rio Magdalena has developed. Soft soils 13.0–15.0 m thick with weak bearing power are encountered below the 1.0–2.0 m thick firm top layer. The use of foundation piles, etc. should be considered for the construction of major structures such as bridges. Improvement of the soft soils will be required when the exceeds 3 m. The high water elevation of the river is 0.58 m and the difference between this water level and the present ground level at Barranquillita and Loma is, on the average, as little as 1 m. The topography of the area is almost flat and the soils are mostly sandy silt.

(3) Road plan

The design speed will be 60 kph. The cross-section of the road includes 4 through traffic lanes (hereinafter referred to as "lane(s)") with a 3 m wide median. On both sides of the road, 2.5 m wide shoulders and 3 m wide sidewalks will be provided. The width of each lane will be 3.25 m.

2) Cra. 46

This road will extend between the Riverside Bypass and Calle 30 for a distance of 1 km.

(1) Existing street conditions and planned route

Cra. 46 is currently an arterial street connecting Circunvalar and Calle 30. It will be extended from Calle 30 to the Riverside Bypass in accordance with the land preparation work and renewal plan for Barranquillita. This section will run through the warehouse and factory zone, and will pass through the partially filled section of Caño los Tramposos due to the land preparation work for Barranquillita. Chapter 13–4 describes this land preparation work in detail.

(2) Street plan

The design speed will be 40 kph and the cross-section will be four-3.25 m lanes with a 1.0 m wide median. 1.5 m shoulders and 3.0 sidewalks will be provided on each side of the road.

3) Calle 17

This road will extend between Cra. 36 and Cra. 46 for a distance of 1.3 km.

(1) Existing street conditions and planned route

This street currently runs from Acceso Puente Pumarejo to Cra. 38. In the present study, Calle 17 will be extended to Cra. 46 in Barranquillita in accordance with the former's land preparation work and the renewal plan for the Centro District. The extension route will branch out from Calle 17 at the intersection with Cra. 36, run through Barranquillita and reach Cra. 46 via Calle 9 in Barranquuillita. The section between Cra. 36 and Cra. 38 is a low-income residential area. A brewery and old warehouses are located between Cra. 38 and Calle 9. A series of markets and warehouses are located alongside of Calle 9.

(2) Street plan

The design speed will be 40 kph and the cross-section will be four-3.25 m lanes with a 1.0 m wide median. 1.5 m shoulders and 3.0 m sidewalks will be provided on each side of the street.

4) Calle 45D Extension Street

This section will extend between Circunvalar and Via Caracoli for a distance of 1.3 km.

(1) Existing street conditions and planned route

This street will improve the existing collector street, Calle 45D, and will extend to the outside of the Circunvalar. There is no existing street for this extended section and an overpass will be constructed at its intersection with the Circunvalar. While this street will mostly pass through uncultivated fields, a new residential area is being developed on its eastern side.

(2) Street plan

The design speed will be 40 kph and the cross-section will be four-3.25 m lanes without a median. 0.75 m shoulders and 4.0 m sidewalks will be provided on each side of the street.

5) Calle 45 Extension Street

This section will extend between Central de Abastos and Malambo for a distance of 6.0 km.

(1) Existing street conditions and planned route

This street will be an extension of the existing semi-arterial street Calle 45. A section of Calle 45 from the city central to the Circunvalar is currently used as one of Barranquilla's major streets. The section outside the Circunvalar is currently under construction. In the

present study, this route will be further extended to Malambo, with most of the proposed route running through uncultivated fields. Since the soils in the area which the road traverses are mostly sandy, no special problems for construction are anticipated.

(2) Street plan

The design speed will be 60 kph and the cross-section will be four-3.25 m wide lanes with a 3.0 m wide median. 1.4 m shoulders and 4.0 m sidewalks will be provided on each side of the road.

6) Camino A Caracoli I

This road section extends between Autopista Al Aeropuerto and Calle 45D for a distance of 5.05 km.

(1) Existing road conditions and planned route

This road will involve complete new construction between Calle 45D and Autopista Al Aeropuerto within a total distance of 5.4 km from the extension road of Calle 45D to Calle 18 in Soledad. Except for the newly developed residential complex along Calle 45, most of the area consists of uncultivated fields. As there are a few middle or small-size natural water channels, including Arroyo Soledad which run through the fields, the construction of bridges, box culverts, etc. will be necessary for this road. Although the fields' sandy soil is a suitable material for the construction of embankments, it will be necessary to pay particular attention to the protection of slopes. Structures such as bridges will not require any special foundations provided they are adequately protected against scouring by Arroyo.

(2) Road plan

The design speed will be 40 kph and the cross-section will be four-3.25 m wide lanes without a median. 0.75 m shoulders and 4.0 m sidewalks will be provided on each side of the road.

7) Via Central de Abastos

This section extends between Central de Abastos and Autopista Al Aeropuerto for a distance of 4.7 km.

(1) Existing road conditions and planned route

This road will start from the extension road of Calle 45, pass the area between the residential complex of Soledad 2000 and Barranquilla Airport and end at its connection with Autopista Al Aeropuerto. No passable street for vehicles currently exists for this rute.

The point of connection will be 500 m north of the Calle 18 interchange. Most of the area along the proposed route consists of uncultivated fields.

(2) Road plan

The design speed will be 40 kph and the cross-section will be two-lanes with a total width of 6.5 m. 1.5 m shoulders and 3.0 m sidewalks will be provided on each side of the road.

8) Transversal I, II

This section extends between Via Central de Abastos and Circunvalar for a distance of 3.4 km.

(1) Existing road conditions and planned route

This road will connect the newly planned route Via Central de Abastos and the Circunvalar in the north-south axis and will pass through the core of the sub-center envisaged in the Land Use Plan. It will also pass through the center of the new residential complex of Soledad 2000. Half of the northern side of this route is currently uncultivated fields.

(2) Road plan

The design speed will be 40 kph and the cross-section will be two lanes with a total width of 6.0 m at the initial stage, to be ultimately widened to 4-lanes. 0.75 m shoulders and 3.0 m sidewalks will be provided on each side of the road. The actual construction plan for this road will be divided into 2 sections, i.e. (I) from Central de Abastos to Soledad 2000 and (II) from Soledad 2000 to the Circunvalar.

9) Avenida Las Moras

This section extends between Autopista al Aeropuerto and Transversal for a distance of 1.5 km.

(1) Existing road conditions and planned route

This road will run almost parallel to Camino A Caracoli on its northern side. A narrow, unpayed road currently exists, which will be incerperated with the necessary land space for the new road construction. Much of the area alongside the proposed route is uncultivated fields.

(2) Road plan

The design speed will be 40 kph and the cross-section will be two lanes with a total width of 6.5 m. 0.75 m shoulders and sidewalks will be provided on each side of the road.