CHAPTER 2. ROAD AND STREET SYSTEM

2.1 Introduction

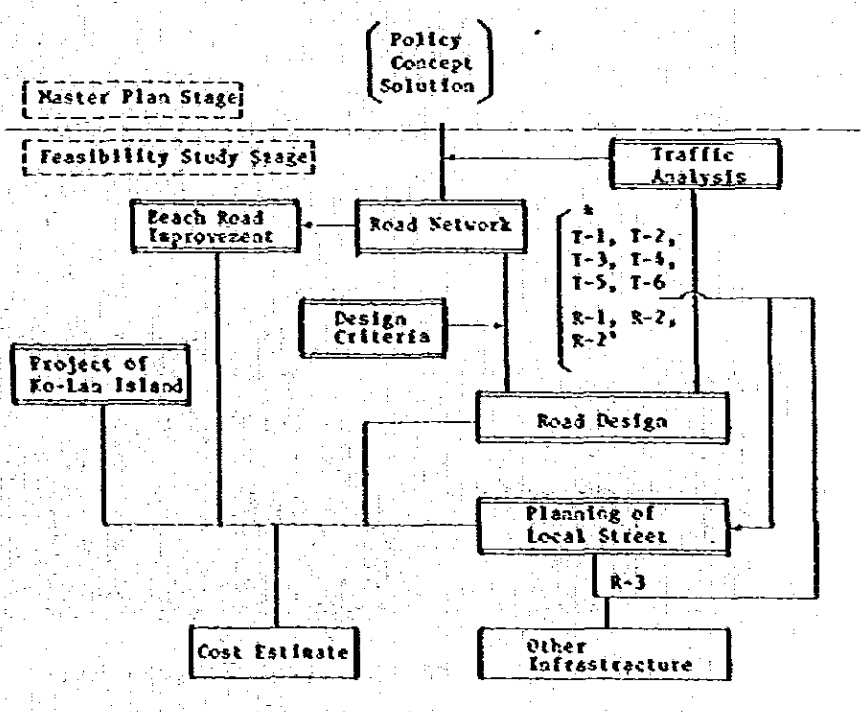
For the planning of the road and street system of the study area, consideration should be given to the landscape, landuse, proposed zoning, etc., as a tourist resort. Needless to say, the proposed widths of the roads must have sufficient capacity to meet the future traffic volume; however, the environmental effect of the roads on the surroundings should be substantially taken into consideration. Proper planning should be conducted so that, as it is an international tourist resort, the study area should be affected as little as possible by the noise, vibration, exhaust gas and other pollution coming from vehicles running on the roads and streets in the area.

As most of the roads in Thailand are planned according to the standards of the AASHO, these were adopted for the planning of the road and street network of Pattaya. If necessary, however, the standards of highway structures of the Japan Highway Association should be adopted as well.

The roads or highways of Thailand can be classified into two categories one of which is under the control of the Department of Highway, and the other, under the control of the provincial government.

The master plan on the road and street system has already been established and the feasibility study has been made to obtain greater accuracy following the concepts of the master plan. The basic concepts of the master plan have not been changed. The flow chart of the study items of the feasibility study is shown below.

Fig. 2.1.1 Work Flow Chart



* T-1 ∿ T-6 are shown as Tourism roads.
R-1, R-2, R-2' are shown as Residential roads.
R-3 is shown as local street.

The following are contained in this report.

- Existing Conditions
- Planning of the Road Network

Concepts of the master plan, traffic analysis, and evaluation and measures for dealing with the problem points.

- Road Design

Design criteria, technical examination of the intersections and other areas

- Planning of Local Streets

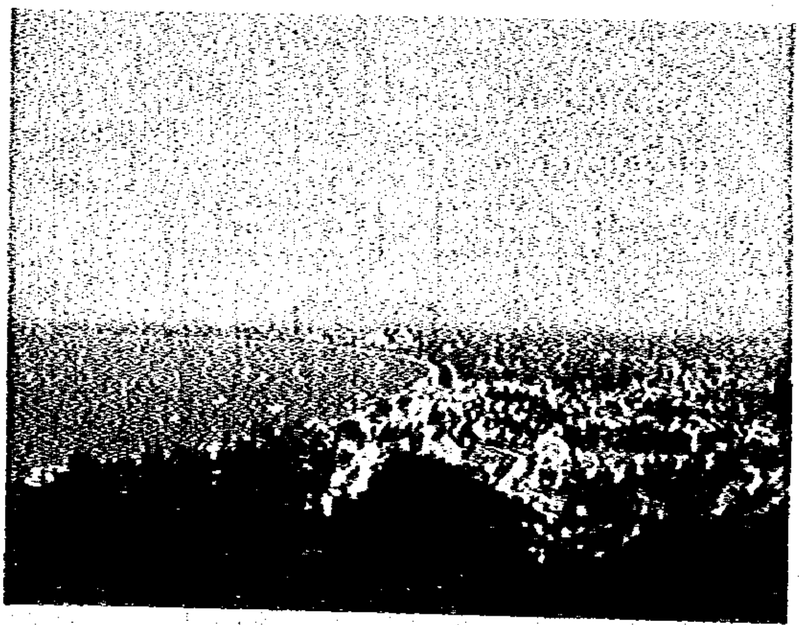
The landuse planning to establish the road and street network is described.

- Beach Road Improvement Planning

A comparison and examination of the circulation system is described from the viewpoint of tourism.

- Execution Program
- Costs of Construction, Maintenance and Operation

The local streets are not included in the calculation of the costs.



General View of Pattaya from Pattaya Hill

2.2 Existing Conditions

2.2.1 Outline

(a) Topography

1) The study area is generally characterized as flat land, and a gentle slope begins from the central part of the study area to the seashore line.

2) Pattaya hill rises 100m above sea level and is located in the central part of the study area; it has a potential to be the landmark for the Pattaya beach resort.

3) The area between Sukhumvit Highway and the provincial highway Route No. 3135 is a swampland where lotuses and other plants are growing.

4) The elevation at the Na Klua New Town B area is about 40m in height and from there, the gentle slope extends in northerly and southerly directions.

(b) Geology

The geology of the Pattaya area is composed of palaeo-rocks consisting of argillaceous quartzite which is brownish yellow to brownish gray interbedded with phyllite and microfolded chalk schists, and porphyritic hornblends, biotite and leucogranite; on these bed-rocks are found terrace deposits consisting of sand and gravel, and alluvial deposits consisting of clay, sandyclay, sand and gravel. In the neighborhood of the beach are found beach and esturine deposits mainly consisting of sand deposits. The schist at a point 20km to the north part is cut by a fault, and forms a peculiar topography. Granite is partly exposed in the southern part of Pattaya, but is widely distributed in the ridge portion of this area. Fig. 2.2.1 shows the geological distribution in this area.

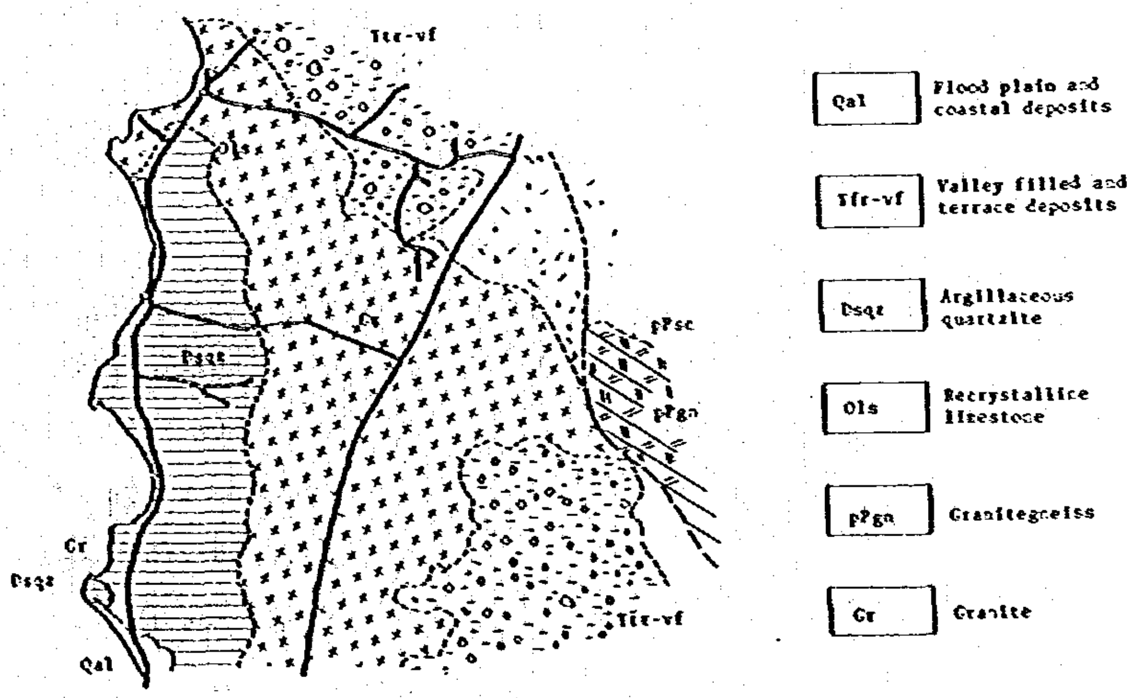
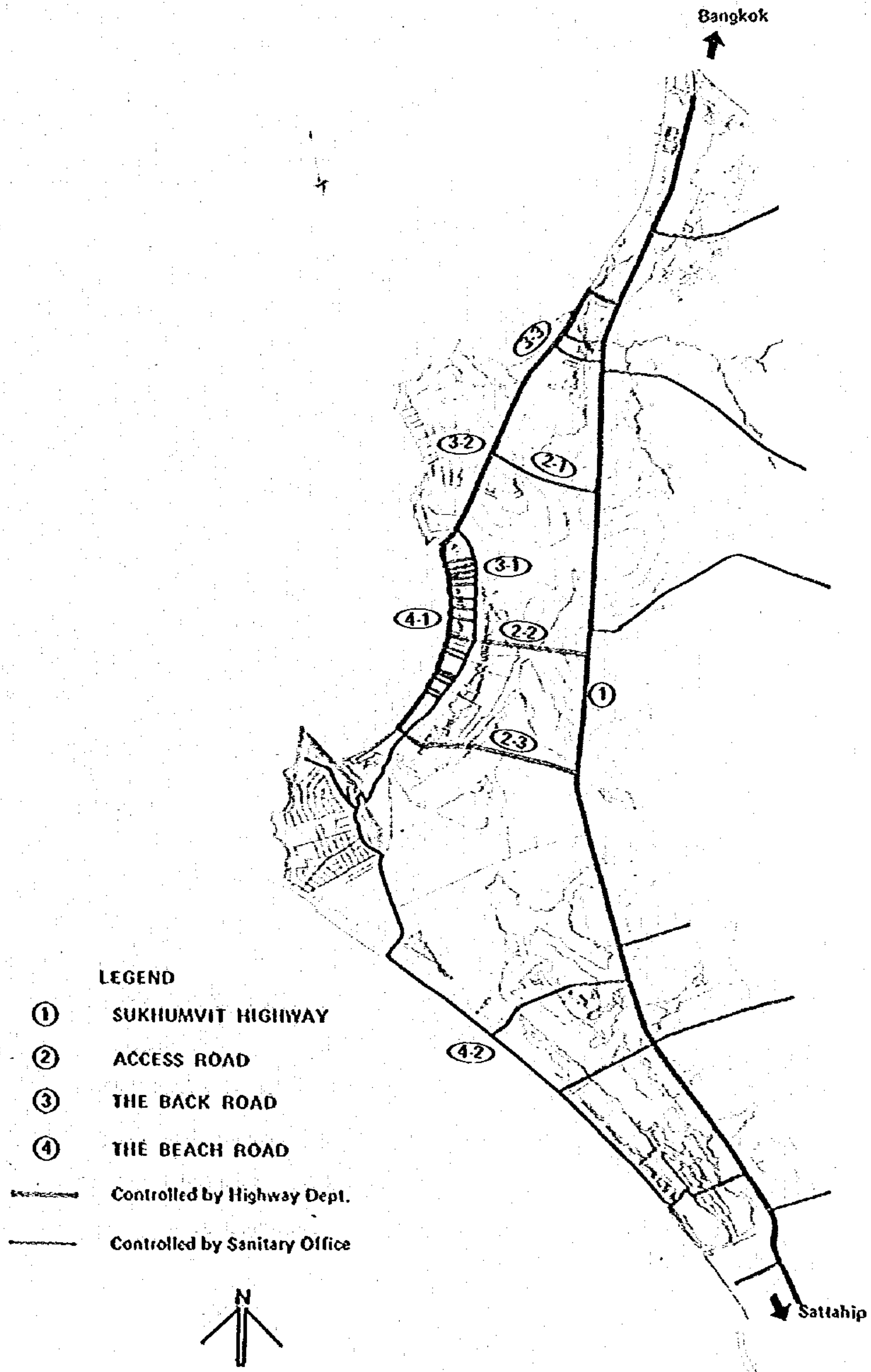


Fig. 2.2.1 Geological Outline

Fig. 2.2.2 EXISTING ROAD NETWORK



2.2.2 Existing Road Network

The road and street network of the study area is shown in Fig. 2.2.2. Its features are as follows:

- All the roads and streets are paved with asphalt, but there are many damaged portions requiring repair.
- Sukhumvit Highway is used as an access road from Bangkok to Pattaya, and the work to widen it to a four-lane divided highway will be soon completed.
- Three access roads from Sukhumvit Highway lead to Pattaya beach.
- The road network is controlled by the Highway Dept. and the provincial government as shown in Fig. 2.2.2.
- Most of the existing hotels, restaurants, stores, etc. are developed in the district lying between the two-lane beach road and the two-lane back road. These two parallel roads are connected by many connection roads (4m to 6m in width).
- At intersections on corners, the radius of the curves or the alignments are not satisfactory.
- Generally, sidewalks have not been constructed except on a part of the beach road.
- Most roads are not equipped with effective drainage ditches.
- Most of the existing roads are constructed on flat lands without large excavations and have low embankments, being paved with asphalt on sandy ground.

2.2.3 Width of the Existing Road

The location of the width measurements of the existing roads and the cross sections were shown in Fig. 2.2.3 and Fig. 2.2.4 respectively. The existing road widths in the study area are described below.

(a) <u>Na Klua Area</u>

1) The right of way of the access road from Sukhumvit Highway to the Na Klua market area is 13m to 16m while the paved roadway is 5m to 12m, and from this area to Pattaya beach it is 20m for the right of way and 7.5m for the paved roadway.

2) The width of the street linking the Na Klua market area to a new market-place is less than 3m at the corner of Na Klua market.

3) The width of the paved roadway of another access road linking the Na Klua market area to Pattaya beach is less than 5m.

(b) <u>Pattaya Area</u>

1) A typical cross section of the beach road was shown in Fig. 2.2.4-7. The pedestrian way is on the beach side to the northern part of the main beach and is shifted to the inland side to create parking space from the southern part of the beach to the downtown area.

2) The road in downtown Pattaya is so narrow that a one way system has been applied.

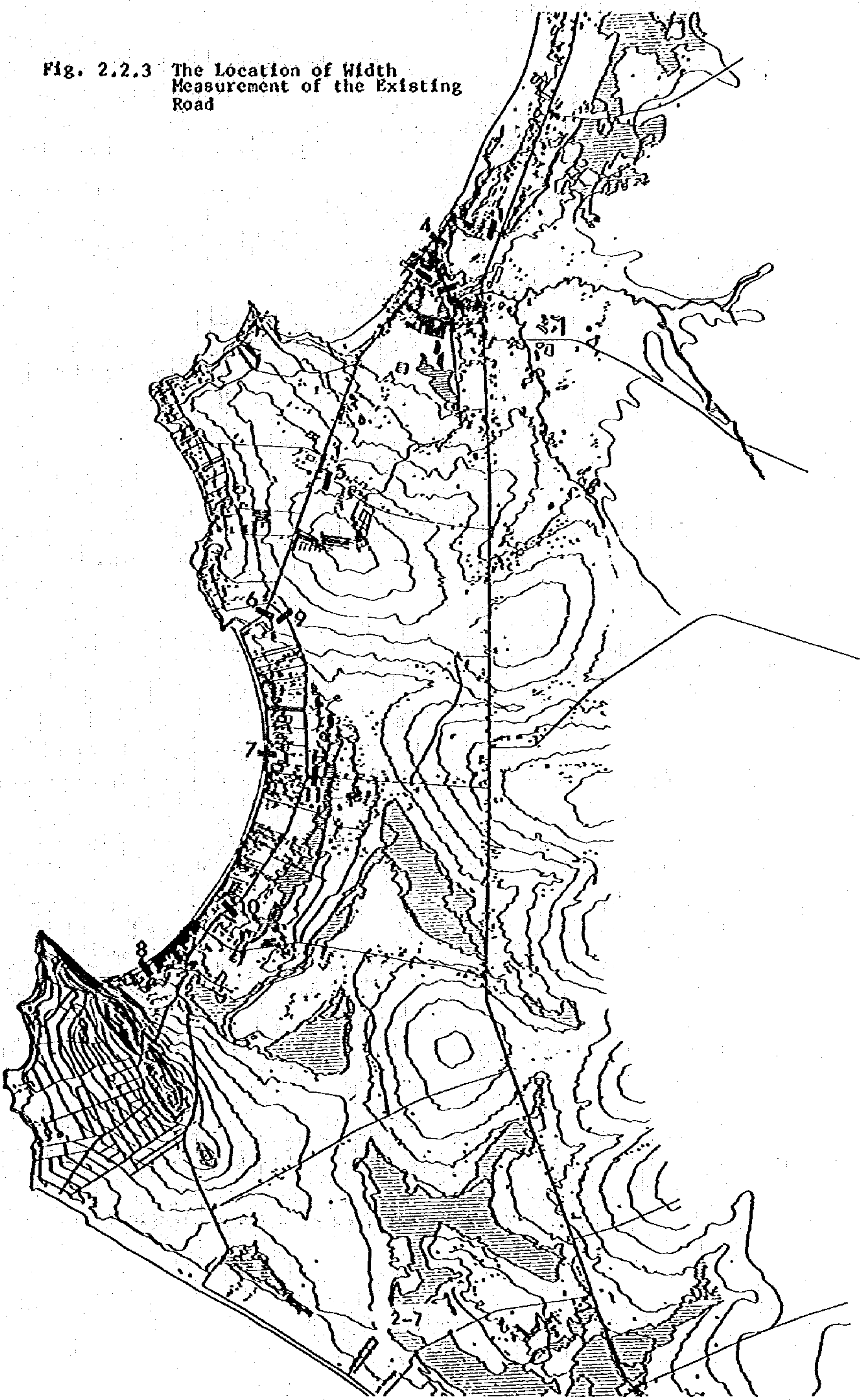
3) The width of the paved roadway of the back road from Orchid Lodge to the central intersection is 12m, while the southern part which has been widened up to 5m is still narrow.

4) The width of the central access as well as the southern access from Sukhumvit Highway are 6m in pavement and 20m in right of way.

Existing Road at Na Klua (near point 4 on Fig. 2.2.3)

Existing Road at Pattaya (near point 11 on Fig. 2.2.3)

Fig. 2.2.3 The Location of Width Measurement of the Existing Road



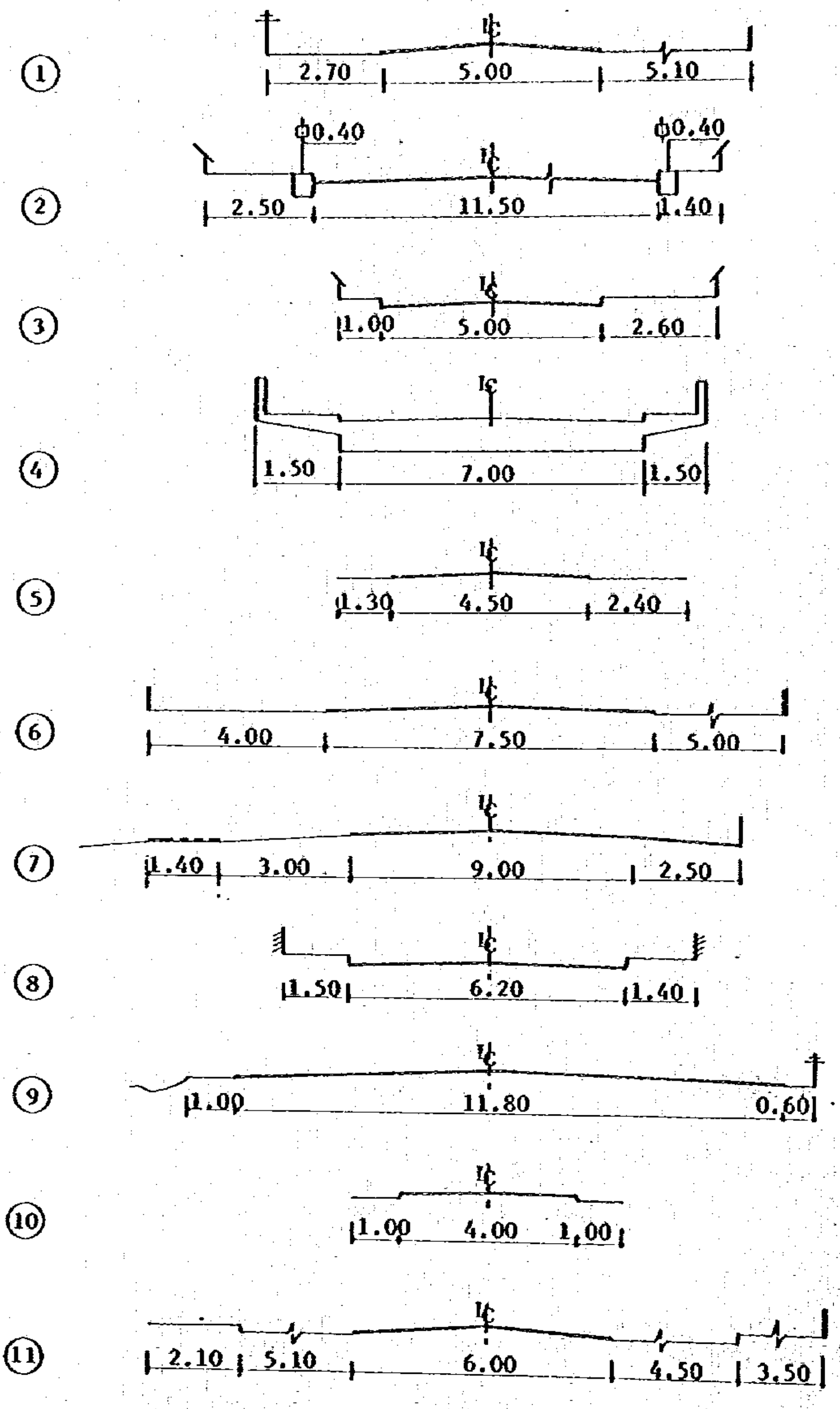


Fig. 2.2.4 Width of Existing Road (Cross Section)

2.2.4 Existing Traffic Volume

The study of the existing and future traffic volumes was carried out for the planning of the road and street system.

Date:	From January 13, 1978 (Friday) to January 17, 1978 (Tuesday) for 5 days
Duration of sampling:	08:00 AM to 08:00 PM ... 12 hours However, at sampling station No. 10, the sampling was carried out for 24 hours on January 14 (Saturday).
Sampling station:	The location is shown in Fig. 2.2.5.
Sampling method:	By vehicle and direction. The types of vehicles were classified into these five categories as follow: 1) Baht Buses (Taxis) 2) Private Cars 3) Large Trucks 4) Small Trucks 5) Scheduled Chartered Buses
Sampling results:	The total traffic volume by type of vehicle on the inflow traffic at intersections is shown in Fig. 2.2.6. The total traffic volume by type of vehicle by directions at intersections is shown in Fig. 2.2.7. The detailed sampling results by type of vehicles are given in Appendix "Survey on Traffic Volume".

Characteristics of the existing traffic pattern:

Judging from the sampling results, the characteristics of the existing traffic pattern are as follows:

1) The peak traffic volume was concentrated on Saturday and Sunday; this was caused by the concentration of tourists on weekends.

2) *Baht buses (taxis) are superior to other means of transportation. The baht bus is mainly used as a means of transportation for short range travelling in the area.

* The baht bus means a remodelled small truck with passenger seats.

3) There is a slight difference between the daytime and nighttime traffic volumes.

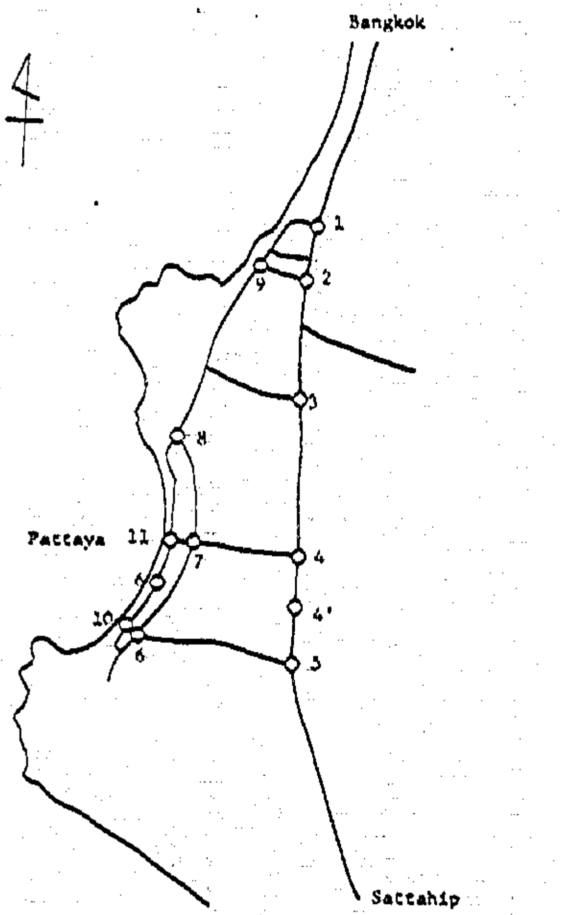
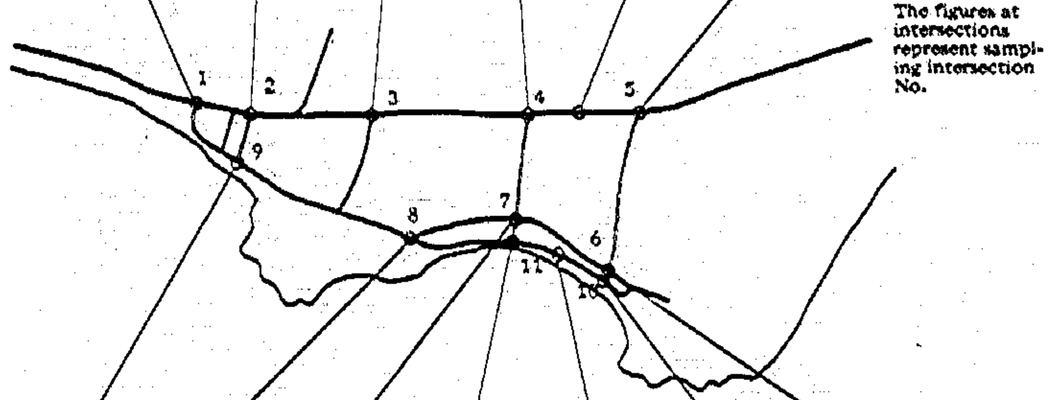


Fig. 2.2.5 The Locations of Traffic Survey

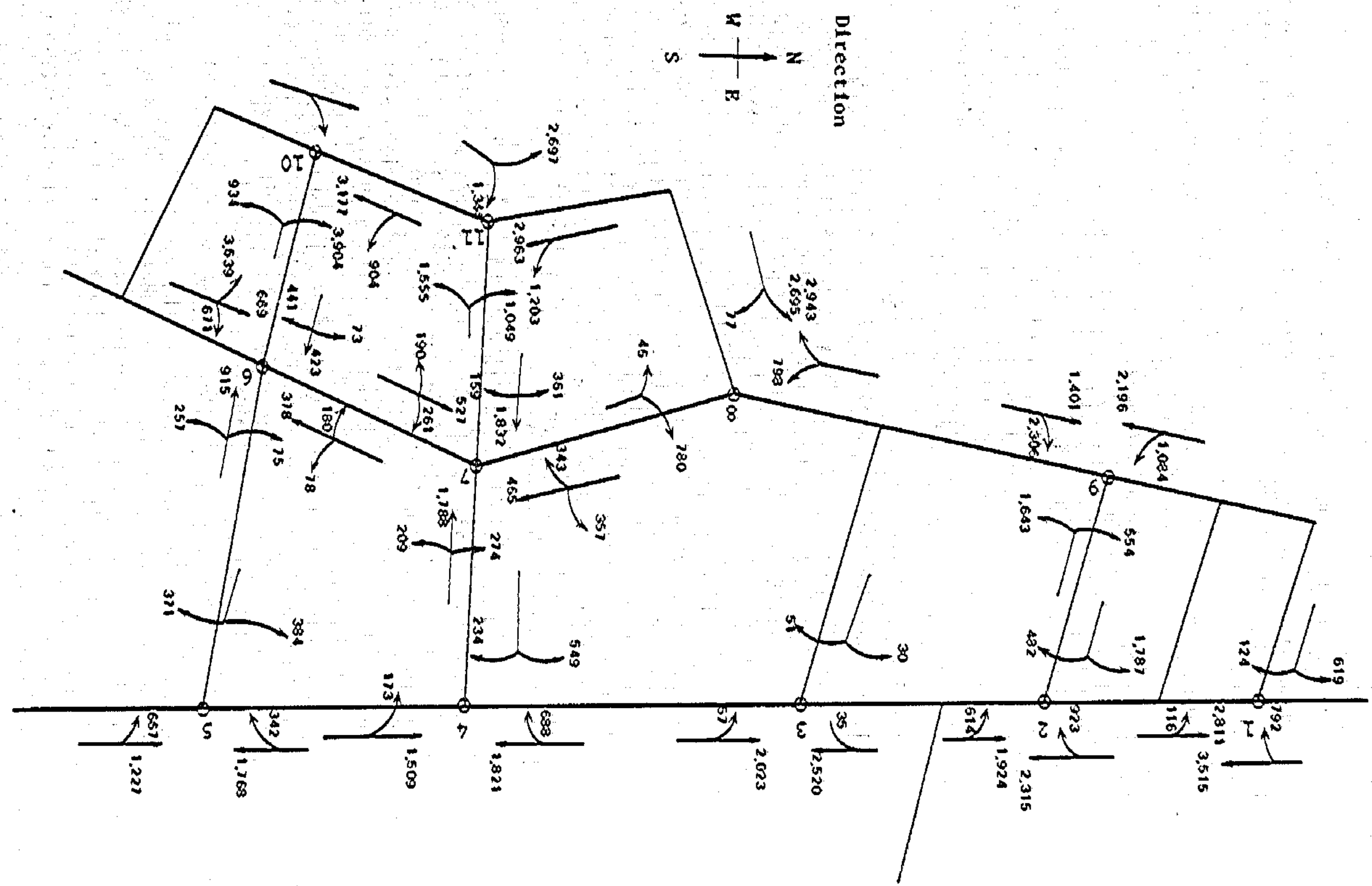
Date						
13(Fri)	6,982	7,581	4,271	4,562	3,619	4,125
14(Sat)	7,977	8,045	4,716	4,974	3,557	4,759
15(Sun)	8,030	8,220	4,886	5,060	3,623	4,695
16(Mon)	6,597	6,762	4,041	4,293	3,303	4,182
17(Tue)	6,217	6,419	3,811	4,135	3,245	3,926



Date							
13 (Fri)	8,316	6,260	6,636	8,466	7,277	7,805	6,739
14 (Sat)	9,184	7,339	6,766	10,811	7,761	8,919	7,699
15 (Sun)	9,920	8,111	6,854	10,991	8,118	8,468	7,277
16 (Mon)	8,513	6,584	5,703	9,079	6,602	7,199	6,151
17 (Tue)	8,248	6,129	5,687	8,940	5,885	6,898	5,900

Fig. 2.2.6 Inflow Traffic Volume of Intersection
(January 13 ~ 17th)

Fig. 2.2.7 Traffic Volume of Intersection by Directions (January 14th)



2.2.5 Survey of Existing Noise Conditions in Study Area

For designing the road and street system, it is necessary to study the effect of noise on the environment; so the noise survey was carried out as follows:

Date:	January 21, 1978 (Saturday) and January 22 (Sunday)
Duration of sampling:	24 hours
Sampling stations:	As shown in Fig. 2.2.8
Sampling method:	The measuring instruments were Bruel & Kjaer precision sound level meters (Type-2203), microphones for noise measuring, and recorders which meet the International Electrotechnical Commission's recommendation IEC-179.

Sampling results:

1) 24-hour sampling at Sampling Station 13 (downtown)

The sampling was carried out for 24 hours at the most congested place in downtown Pattaya. The sampling results were shown in Fig. 2.2.9, Fig. 2.2.10, and Table 2.2.1. The values of the basic noise levels of Swiss and English standards are given in Table 2.2.2 and Table 2.2.3. The results of the noise measurements made downtown (if regarded as a commercial district) exceed the values of the basic noise level of Swiss and English standards. The value of 89dB in the daytime from 11:00 to 16:00 in the downtown area (if regarded as a main road) is less than the basic noise level of Swiss and English standards. However, the noise level of 93dB at 20:00, 91dB at 22:00, and 90dB at 24:00 in the nighttime of the downtown station exceed the value of the basic noise level of the Swiss and English standards.

2) Noise measurements at Sampling Stations 1 to 14 (excluding 13)

The results of noise measurement at the Sampling Stations are given in Table 2.2.4. The value of L10 is 72dB at Station 12, and varies to 82dB at Stations 4 and 6. The value of L90 is between 46dB and 65dB. These values are satisfactory in comparison with the desired values in the daytime of Swiss and English (U.K.) standards. Generally, it can be said that there are not many noise problems in the Pattaya area (including the Na Klua area) excluding the downtown area and the beach road, as described later. However, as a peak noise of 99dB is quite undesirable, it is necessary to control horns and the speed of vehicles.

3) Measurement of noise at A-1 through A-5 (Beach Road)

The sectional measurements of A-1 through A-5 were carried out at three points set in the respective sectional directions. Table 2.2.5 shows the results of measurements at 15 points. In Fig. 2.2.11, noise levels are plotted along the sectional direction. Assuming that the beach is equivalent to a "Quiet Residential Zone" in the basic noise level of Swiss and U.K. standards (Table 2.2.2 and Table 2.2.3), the noise level at all points along the beach exceed 55dB, more than should be tolerated in the daytime.

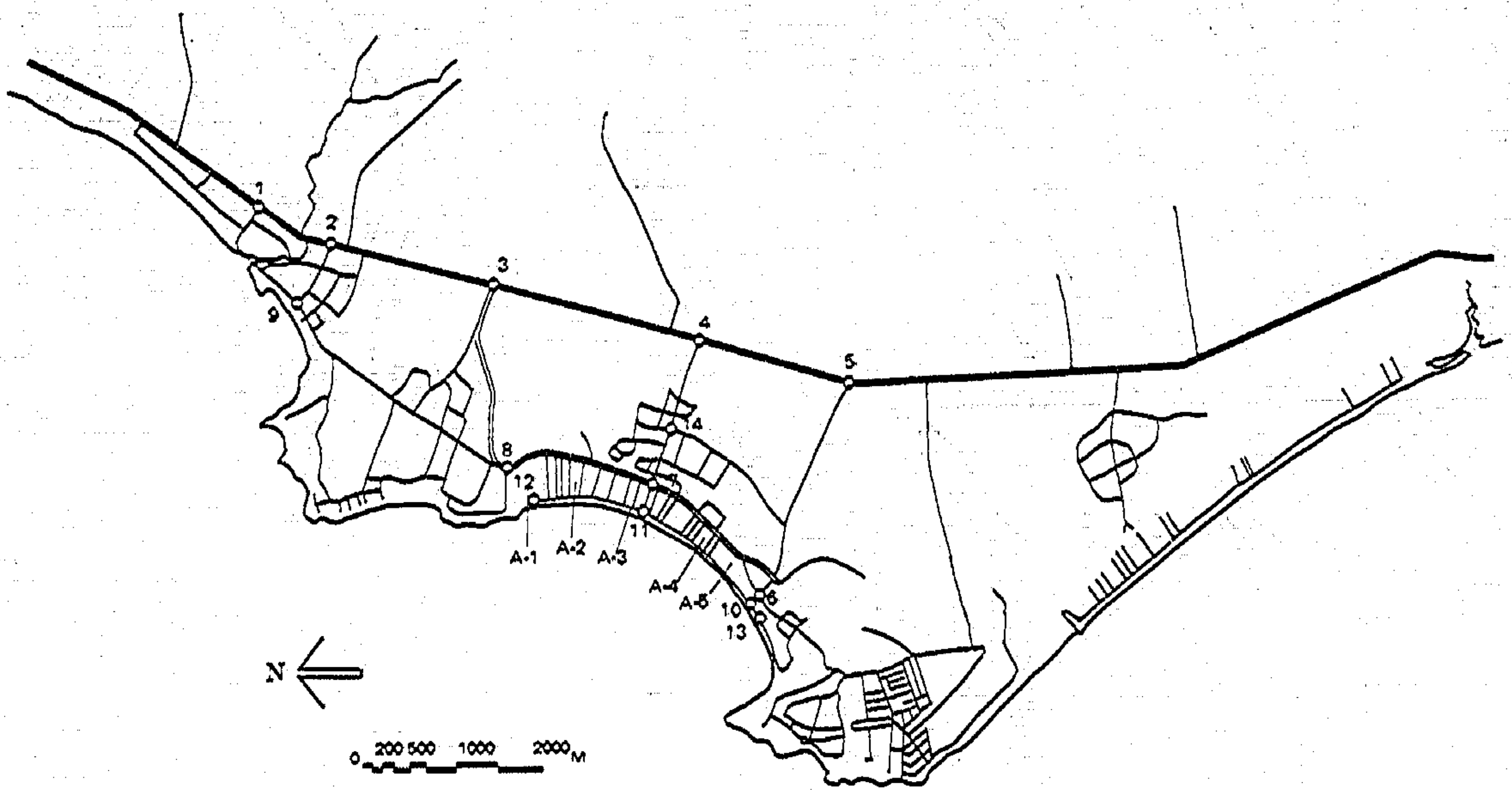


Fig. 2.2.8 Location of Sampling Stations

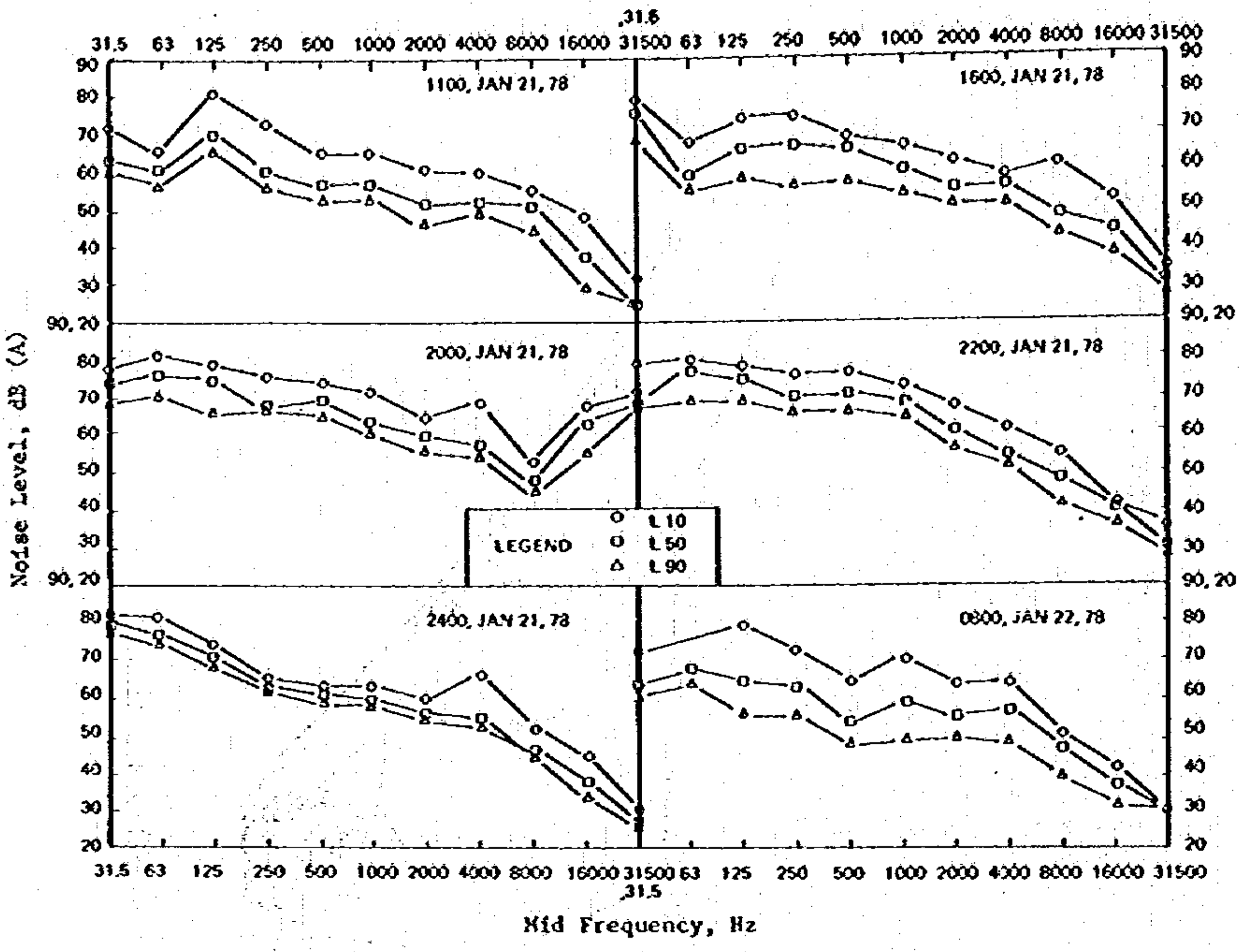


Fig. 2.2.9 Noise Level at Different Mid Frequency at Station 13

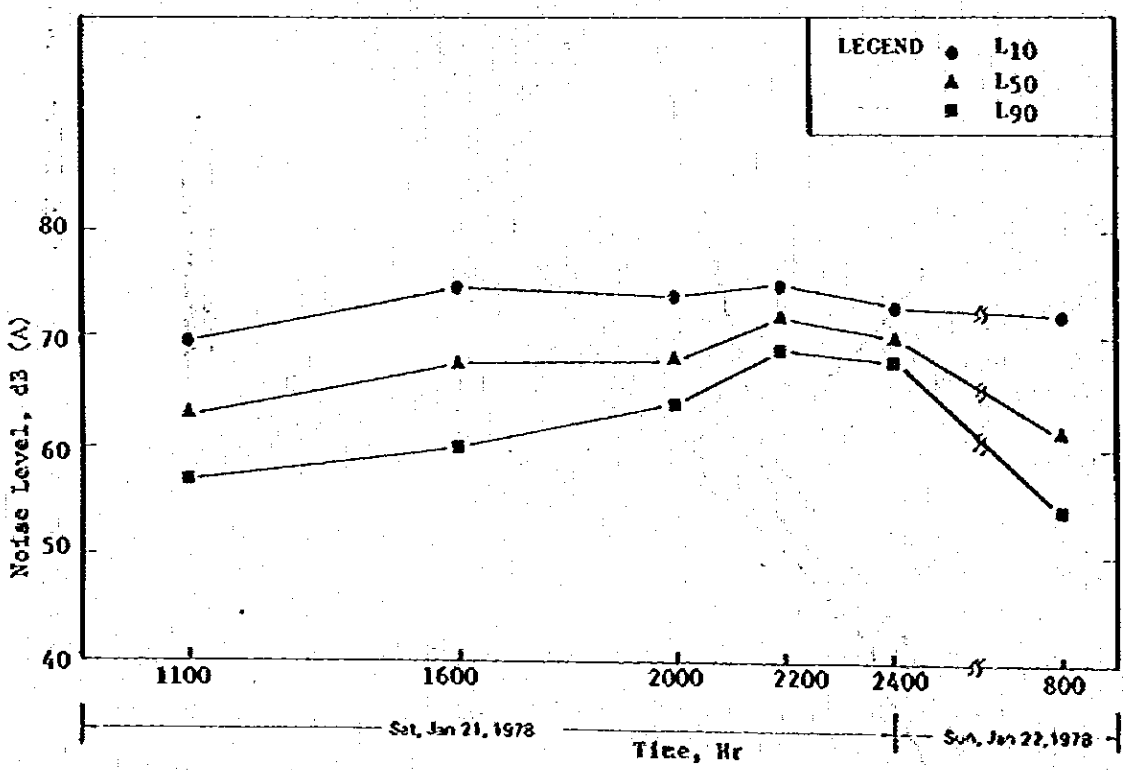


Fig. 2.2.10 Noise Level Variation at Different Time at Station 13

Table 2.2.1 Peak Noise Levels

Time	Peak Noise Level	
	dB	Frequency
11:00	89	125
16:00	89	31.5
20:00	93	31.5
22:00	91	63
24:00	90	63
08:00	85	63

Table 2.2.2 Tolerated Outdoor Noise Level in dB(A) for Switzerland

Zone	Basic Noise Level		Frequent Peaks		Infrequent Peaks	
	Day	Night	Day	Night	Day	Night
Hospital	45	35	50	45	55	55
Quiet Residential	55	45	65	55	70	65
Mixed	60	45	70	55	75	65
Commercial	60	50	70	60	75	65
Industrial	65	55	75	60	80	60
Main Road	70	65	80	70	90	80

Table 2.2.3 Tolerated Outdoor Noise Level in dB(A) for United Kingdom

Zone	Basic Noise Level		Frequent Peaks		Infrequent Peaks	
	Day	Night	Day	Night	Day	Night
Hospital	45	35	50	45	55	55
Quiet Residential	55	45	65	55	70	65
Mixed	60	45	70	55	75	65
Commercial	60	50	70	60	75	65
Industrial	65	55	75	60	80	70
Main Road	70	65	80	70	90	80

Table 2.2.4 Noise Level Measurements at Station 1 to 12 and 14
(Date: January 21, 1978)

Station	Time	Noise, Level, dB(A)					Station	Time	Noise, Level, dB(A)				
		L_{10}	L_{50}	L_{90}	Max	Min			L_{10}	L_{50}	L_{90}	Max	Min
1	13:50	79	72	63	92	56	9	13:33	73	68	64	81	58
2	13:42	78	69	63	86	58		16:35	78	71	65	87	62
3	14:28	74	64	56	80	52	10	11:40	73	69	65	92	63
4	14:06	82	69	58	89	53		15:45	77	73	65	85	62
5	14:33	76	67	62	89	59	11	10:54	81	72	64	89	59
6	11:30	82	72	62	99	53		15:20	73	68	64	88	61
	15:50	79	71	65	89	61	12	10:44	72	65	57	78	53
7	11:50	76	65	56	90	52		15:08	74	64	58	77	53
	15:28	76	68	60	83	57	14	11:55	76	64	55	88	44
8	10:34	70	65	57	79	51		15:35	74	61	46	85	42
	15:00	70	65	59	76	58							

Table 2.2.5 Noise Level Measurements at Stations A1-A5
(Date: January 22, 1978)

Station	Measuring Point	Time	Noise, Level, dB(A) L_{10}	L_{50}	L_{90}	Max	Min
A-1	A-1-1	10:33	77	68	57	82	53
	A-1-2	10:37	68	64	58	74	53
	A-1-3	10:41	72	68	63	76	59
	A-1-1	15:30	77	65	61	95	58
	A-1-2	15:33	70	67	65	79	62
	A-1-3	15:36	75	70	67	79	62
A-2	A-2-1	10:50	73	64	56	81	53
	A-2-2	10:54	62	67	56	76	53
	A-2-3	10:57	72	68	64	78	60
	A-2-1	15:02	76	69	61	84	58
	A-2-2	15:45	70	65	62	75	59
	A-2-3	15:48	78	74	69	83	67
A-3	A-3-1	11:05	74	65	64	92	59
	A-3-2	11:09	66	62	59	74	57
	A-3-3	11:12	73	69	68	75	63
	A-3-1	15:55	72	66	62	86	58
	A-3-2	15:58	70	68	63	79	61
	A-3-3	16:00	77	72	70	85	65
A-4	A-4-1	11:26	71	65	62	82	59
	A-4-2	11:29	72	68	65	80	61
	A-4-3	11:33	76	72	68	82	63
	A-4-1	16:15	78	70	64	89	62
	A-4-2	16:18	74	67	65	79	64
	A-4-3	16:22	75	73	69	87	66
A-5	A-5-1	11:43	74	69	64	79	61
	A-5-2	11:47	72	68	64	81	61
	A-5-3	11:50	74	71	66	82	62
	A-5-1	16:30	74	68	64	87	62
	A-5-2	16:34	74	71	68	76	66
	A-5-3	16:38	75	72	68	78	66

The values of L10, L50 and L90 are in the range from 62dB to 78dB, 62dB to 74dB, and 56dB to 69dB, respectively. The noise is reduced at the points located at a half of the distance between the pavement and the beach. The sounds of waves or the activities of the people on the beach are of less discomfort than those caused by trucks or other traffic.

The coconut tree barrier is effective in absorbing noises. The measurements at both sides of the coconut tree barrier are given in Table 2.2.6. According to this Table, the noise is roughly reduced by 11dB.

The results of the sectional measurements along the beach reveal that the noises are undesirable in view of the beach activity. Especially, the noise due to traffic, such as trucks, baht buses, etc., must be controlled.

Table 2.2.6 Noise Level Reduction by the Coconut Tree Barrier

Land Side	11:54	72	69	66	77	64
Sea Side	11:56	64	58	55	67	53
Reduction		8	11	11	10	10

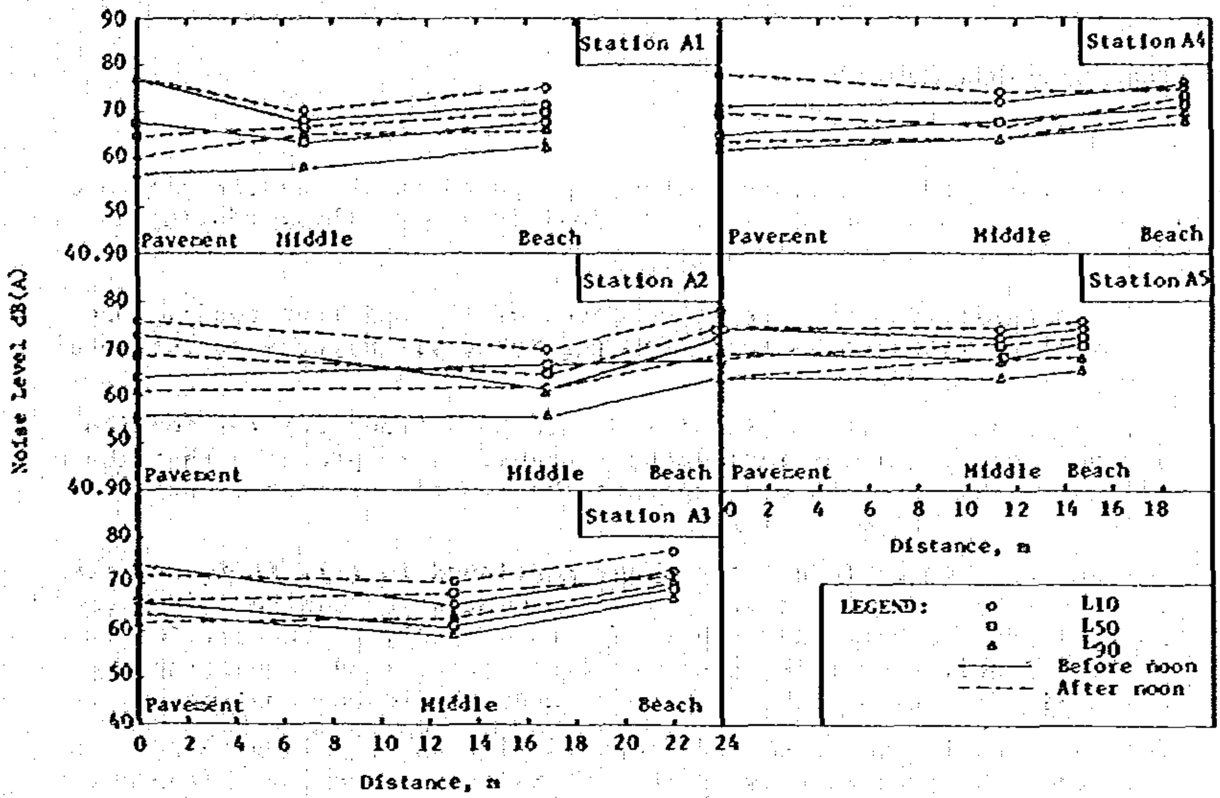


Fig. 2.2.11 Cross-Section of Noise Level at Stations A1 to A5

2.2.6 Traffic Control and Pedestrian Safety Facilities

The existing conditions of the facilities in the Pattaya and Na Klua areas are as follows:

- The illumination from street-lighting and its arrangement are not satisfactory.
- There are many roads and streets without lane markings.
- There are found to be not many effective signals in the roads and streets.

2.2.7 The Existing Conditions of Hotel, Restaurant and Downtown Areas.

The existing conditions surrounding the downtown area, including hotels, restaurants and the like, are given below.

- The noise caused by vehicles running on the beach road and their speed has on unpleasant effect on tourists. Especially, when a hotel guest walks across the road and relaxes at the beach, this effect is remarkable.
- Exhaust gas and vibration from the vehicles cause no troubles.
- In the rainy season, the southern and central access roads running from the Sukhumvit Highway to Pattaya beach are sometimes flooded.
- Many of the hotels having an entrance road from the back road desire the beach road to be improved, or the vehicle traffic on it to be regulated in the interest of the users of the beach.
- Every hotel has adequate parking space at the rate of one for three rooms on average.
- The roads and the beach are not satisfactorily cleaned.

2.3 Planning of Road Network

2.3.1 Outline

The road network and road cross sections proposed in the master plan are as shown in Fig. 2.3.1 and 2.3.2. The positioning of the roads in the road network is described below.

(1) The basic road network is composed of the existing roads. One arterial tourism access road from the Sukhumvit Highway to the hotel area has been added.

(2) The road network is classified into Road Group (T) for tourism and Road Group (R) for residents; thereby, it is proposed that there will be a system which can separate the traffic of Road Group (T) from that of Road Group (R).

(3) In order to achieve the purpose mentioned in (2), it is necessary to change the existing tourism and residential access road from the Na Kula area to Pattaya Beach into a road solely at the service of the residents. For this, a new tourism access road connecting the Sukhumvit Highway and the main hotel area should be constructed.

(4) The arterial tourism road proposed will be of a loop shape from the Sukhumvit Highway so that it is easy to approach from the Highway for the tourists and at the same time, should prevent tourism traffic from entering the residential access road.

(5) The beach road (T-3) which is a service road for tourism activity will be prevented from the inflow of automobile traffic with gradual steps, and will finally become an exclusive pedestrian promenade with bicycles and new slow moving conveyances.

(6) In the case of the service road for residents, the classification standard from R-1 to R-3 should be defined in order to prevent entrance of unnecessary through traffic into the residential area.

Existing Beach Road (T-3) and Main Residential Road to Sukhumvit Highway

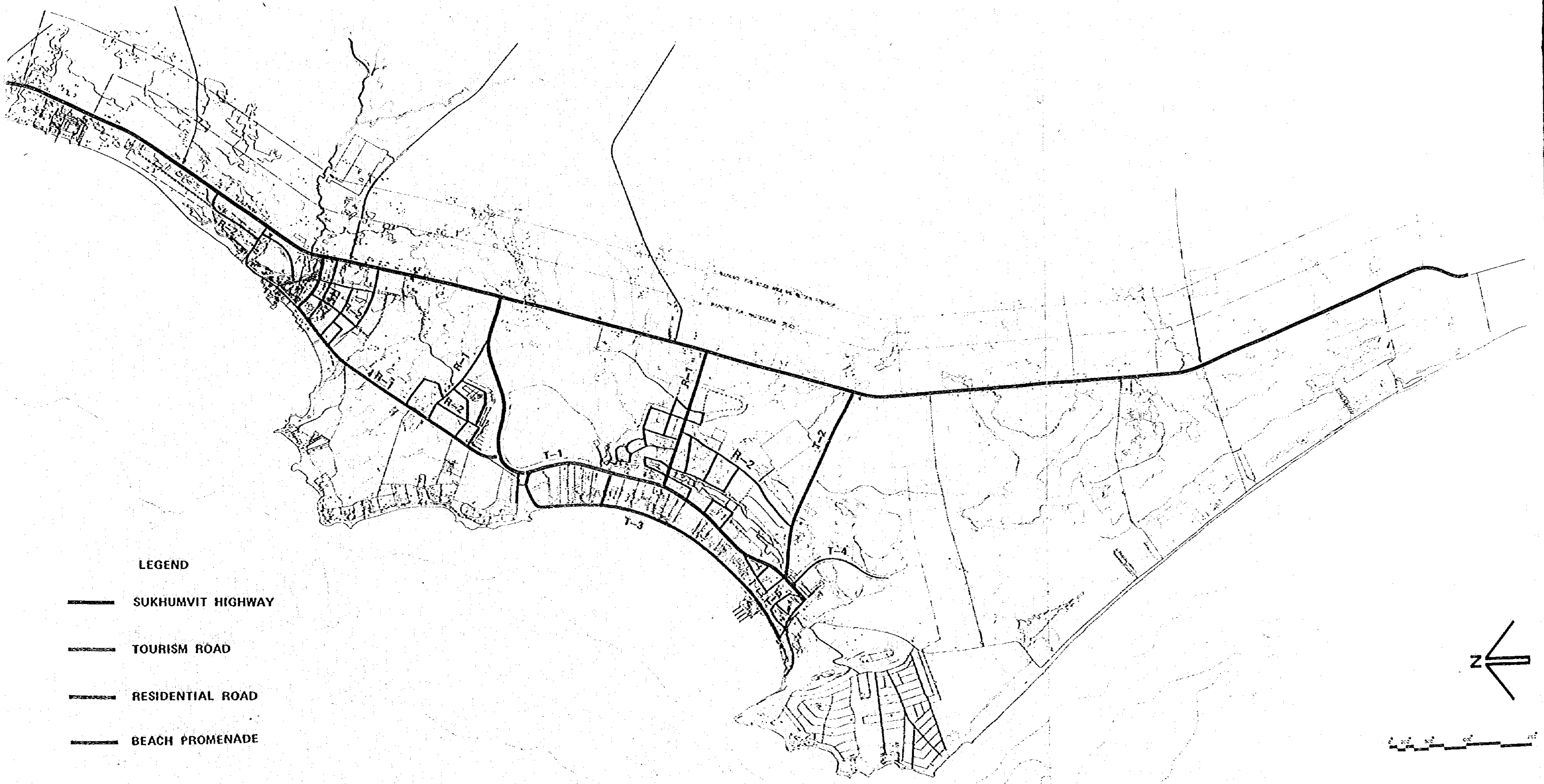
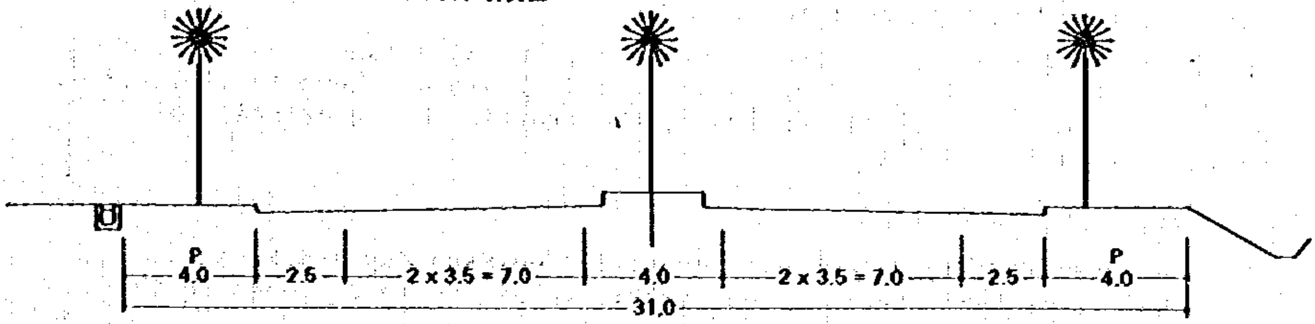


FIG 2.3.1 ROAD NETWORK

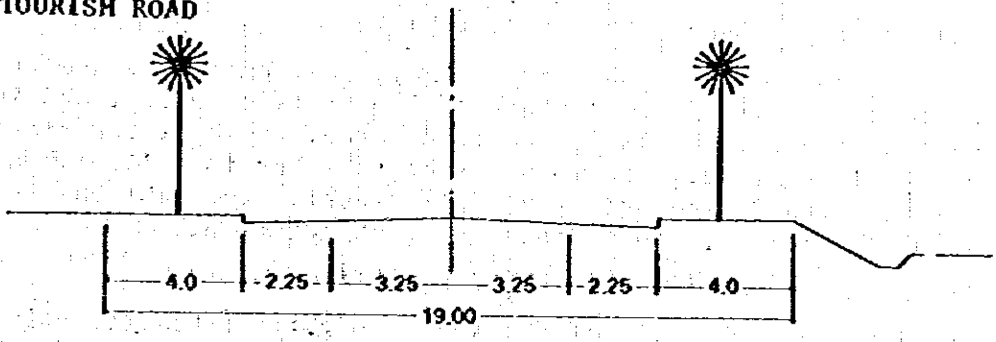
FIG 2.3.1 ROAD NETWORK

Fig. 2.3.2 Cross Section (Master Plan)

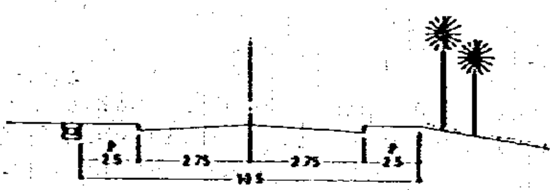
T-1 : ARTERIAL TOURISM ROAD



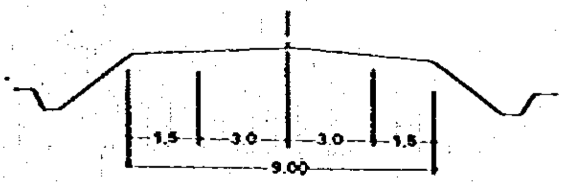
T-2 : TOURISM ROAD



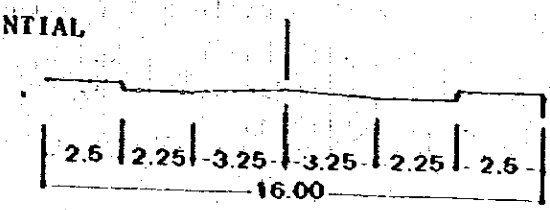
T-3 : BEACH PROMENADE



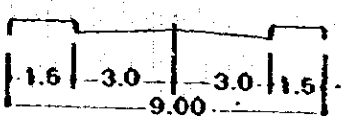
T-4 : PARK STREET



R-1 : MAIN RESIDENTIAL ROAD



R-2 : COLLECTOR STREET



2.3.2 Traffic Analysis

(a) <u>Existing Traffic Conditions</u>

The results of traffic sampling carried out at major junctions for 5 days from January 13, 1978 (Friday) to 17 (Tuesday) are as shown in Fig. 2.2.6. As a result of this traffic analysis, the traffic characteristics of Pattaya are itemized below.

(1) Weekly variation

The peak traffic volume was identified on Saturday and Sunday. This is probably because the traffic volume is in response to the tourism traffic pattern of Pattaya.

(2) Traffic volume by types of vehicles

In the case of the Sukhumvit Highway, passenger cars and trucks account for a large percentage of the traffic volume, and in the case of the main roads in the study area, the baht bus traffic is overwhelmingly large in volume (the baht bus is a local bus which has been remodelled out of a small truck). The baht bus is an important form of short distance transportation.

(3) Ratio of daytime to nighttime traffic volume

The differential ratio of daytime to nighttime traffic volume is as high as 1.62 on average; especially, the ratio for baht buses is high.

(b) <u>Forecasting Method of Traffic Volume</u>

The forecasting of future origins and destinations of the traffic in terms of volume and distribution of traffic volume is made on a flow chart in Fig. 2.3.3.

(c) <u>Estimation of the Origins and Destinations of the Traffic in Terms of Volume</u>

(1) Zoning

The study area is sub-divided into 21 zones, as shown in Fig. 2.3.4 taking into consideration the present landuse, road network and the master plan.

(2) Setting the factors of the origin and destination unit

The origin and destination unit can be found by dividing the existing origin and destination traffic volume by zones, by the existing value of the explanatory variable.

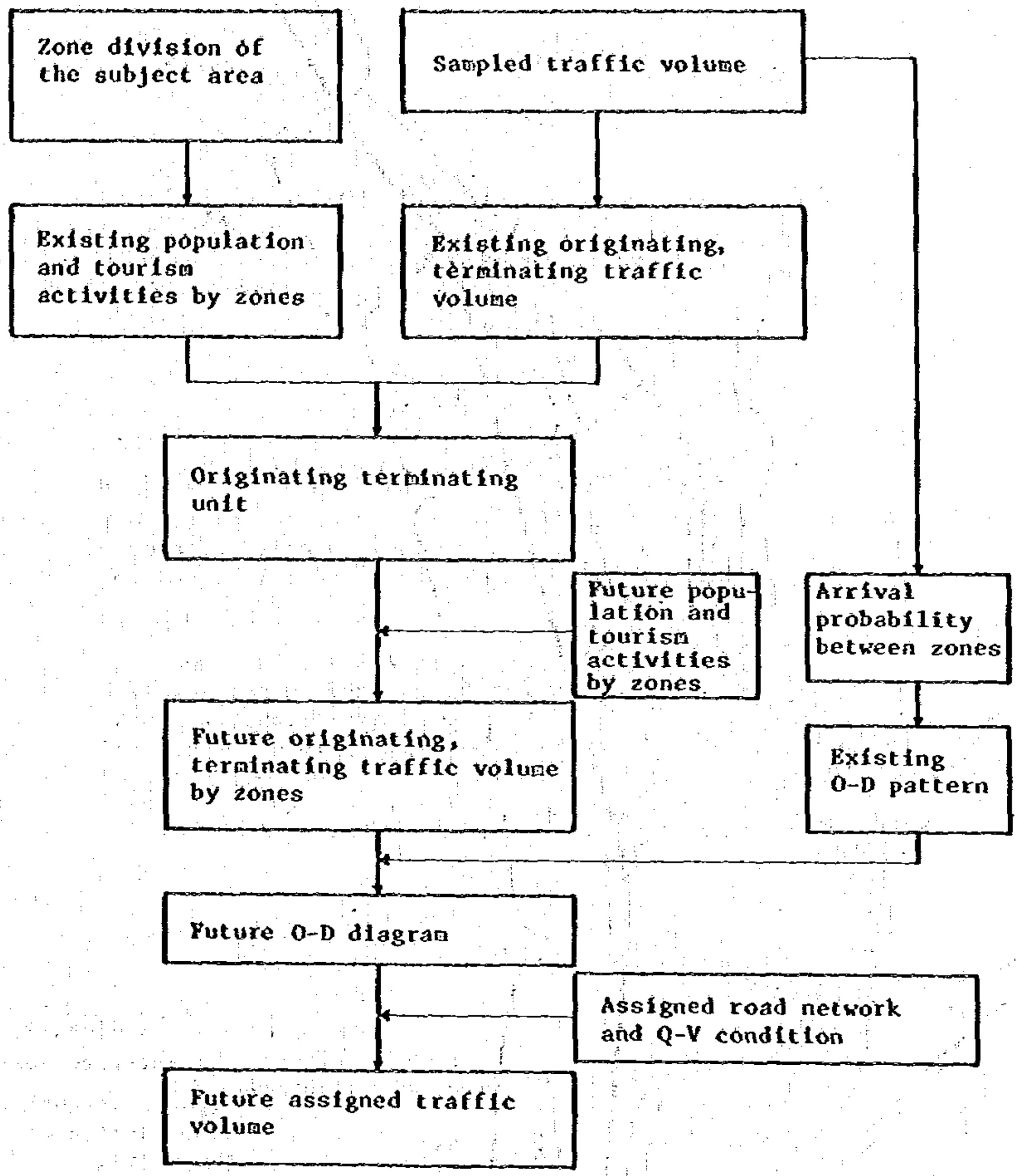
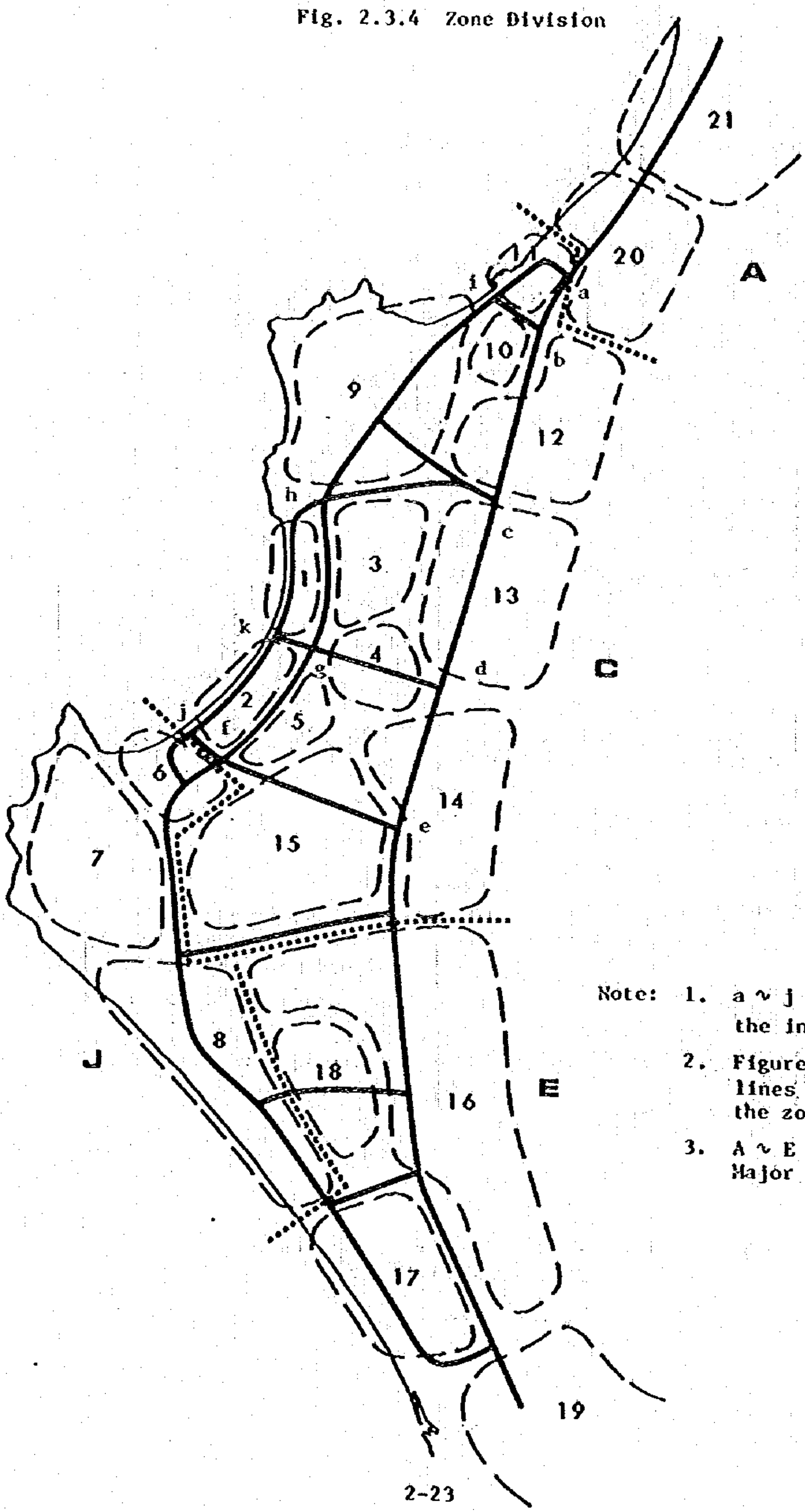


Fig. 2.3.3 Flow Chart for Estimation of Future Traffic Volume

Fig. 2.3.4 Zone Division



Note:
1. a ∿ j indicates the intersections.
2. Figures in dotted lines indicate the zones.
3. A ∿ E indicate Major Zones.

The explanatory variable used consists of the following combination of population, number of employees, and number of tourists by type of vehicle.

$$\text{Origin and destination unit} = \frac{\text{Existing Origin-destination traffic volume by zones}}{\text{Existing value of explanatory variable by zones}}$$

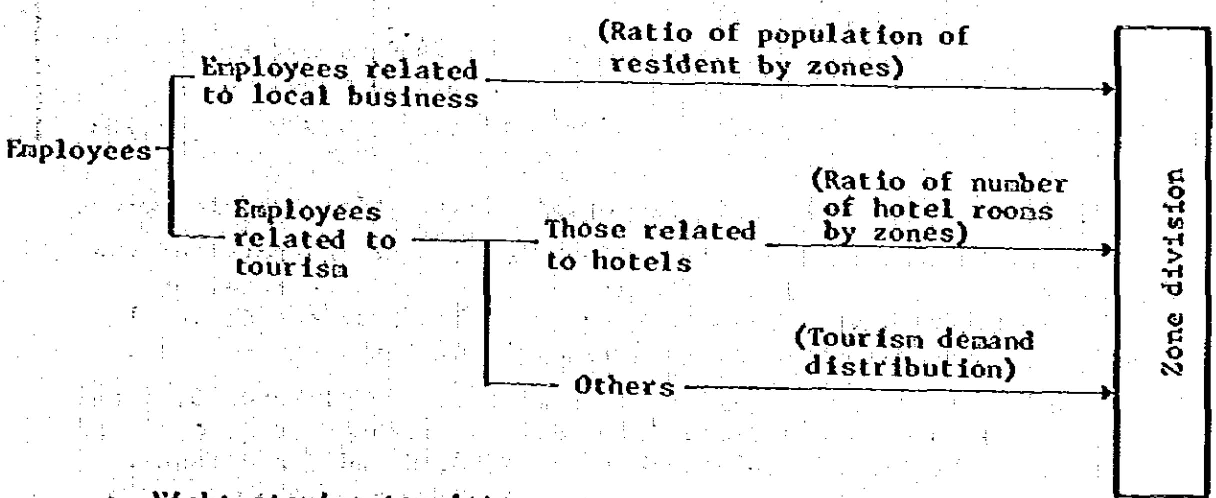
Type of vehicle	Explanatory variable
Baht-buses Passenger cars	Population of residents + number of workers + number of staying visitors + tourism demand
Trucks	Population of residents + number of workers

a. Resident-population by zone

The population in a zone was calculated by multiplying the total population with the proportion of the zoned area to the total area, forecasted in the master plan.

b. Number of workers by zones

The number of forecasted workers in the master plan was applied by dividing the workers in the proportions of the population in each zone. The workers related to tourism are divided into those related to hotels and others according to the master plan. The former are divided in proportion to the ratio of the number of hotel rooms by zones, and the latter are divided in proportion to the ratio of tourism demand distribution of (d. Tourism demand) by zones.



c. Night staying tourists

The number of night staying tourists by zones used in the number of visitors staying at hotels and bungalows is obtained by dividing in proportion to the ratio of the number of hotel rooms by zones.

d. Tourism demand

In the case of the future value of the tourism activities demand by zones, the number of tourists forecasted tourism facilities in the master plan is used, and the numbers are totalled by zones. The existing value is counted back by use of the future value and the estimated growth rate. All of the above explanatory variables are shown in Table 2.3.1.

Table 2.3.1 Explanatory Variables by Zones

unit: 100 persons

Zone No.	1976		1986		1996	
	Baht-bus Passen-ger cars	Truck	Baht-bus Passen-ger cars	Truck	Baht-bus Passen-ger cars	Truck
1	101	68	153	79	161	83
2	72	49	112	62	104	54
3	9	9	28	15	29	14
4	28	28	91	91	141	141
5	9	9	10	10	9	9
6	147	72	159	67	200	80
7	27	15	32	15	33	16
8	14	14	15	15	298	118
9	41	38	127	123	143	139
10	11	11	51	51	82	82
11	41	41	50	50	80	80
12	42	42	45	45	44	44
13	20	17	23	18	23	17
14	33	33	36	36	34	34
15	48	48	67	55	76	56
16	21	21	22	22	21	21
17	8	8	9	9	36	8
18	5	5	5	5	125	125
19	(Outside the area)					
20	67	67	74	74	72	72
21	(Outside the area)					
Total	743	595	1,109	842	1,719	1,203

(3) Estimation of the existing origin-destination traffic volume

The origin-destination unit is found by use of the total of the existing origin-destination traffic volume and the total of the explanatory variables of Zones 6, 7 and 8 of the above 21 zones. The unit thus obtained is applied to the other zones.

In order to obtain the existing traffic volume of Zones 6, 7 and 8, the 21 zones are divided into four major zones or A, C, E and J; then, the traffic volumes between A, C, E and J are found.

Major Zone	21 Zones
A	20 and 21
C	1 to 5, and 9 to 15
E	16 to 19
J	6, 7 and 8

The work process is explained in order as follows:

a. Of the traffic sampling results, the incoming and outgoing traffic volumes at the intersections by type of vehicle is converted into a 24-hour traffic volume using the ratio of daytime to nighttime.

The incoming and outgoing traffic volumes at the intersections (A, E, F and J) located at the respective contacts of Zone C and Zones A, E and J of the sampling intersections are a total of the origin-destination traffic volumes of the respective zones of A, E and J.

b. The ratio of traffic volume by directions at the respective intersections is calculated by the sampling results of traffic volume.

c. Set all the possible passing routes between Zones A, E and J by referring to the distances.

d. Calculate the ratio of arrival probabilties between zones for each route.

$$P\ell m = \sum_{k=1}^{\ell} [(P_{k1} \cdot P_{k2} \cdots\cdots P_{kn})$$

$P\ell m$: Arrival probability between zones $\ell \rightarrow m$ (%)

$P_{k\ell}$: Ratio of traffic volume by directions at the intersections included in k route between $\ell \rightarrow m$ zone (%)

ℓ = A or E or J $\quad$ m = A or E or J $\quad$ $\ell \neq m$

e. The traffic volumes between Zones A, C, E and J can be found by use of the incoming and outgoing traffic volumes at intersection A, E, F and J and the arrival probabilities there.

1. Between Zones A, E and J:

$$Q\ell m = q\ell m \frac{P\ell m}{100} + qm\ell \cdot \frac{Pm\ell}{100}$$

$Q\ell m$: Traffic volume between ℓ and m zones

$q\ell m$: The sum of the outgoing traffic volumes in the direction m at ℓ intersection (However, as for Zone J, assume that the sum of the traffic volumes at J and F intersections is that of ℓ intersection.)

ℓ = A or E or J $\quad$ m = A or E or J $\quad$ $\ell \neq m$

2. Between Zones A, E and J, and Zone C:

$Q\ell c = q\ell - \Sigma Q\ell m$

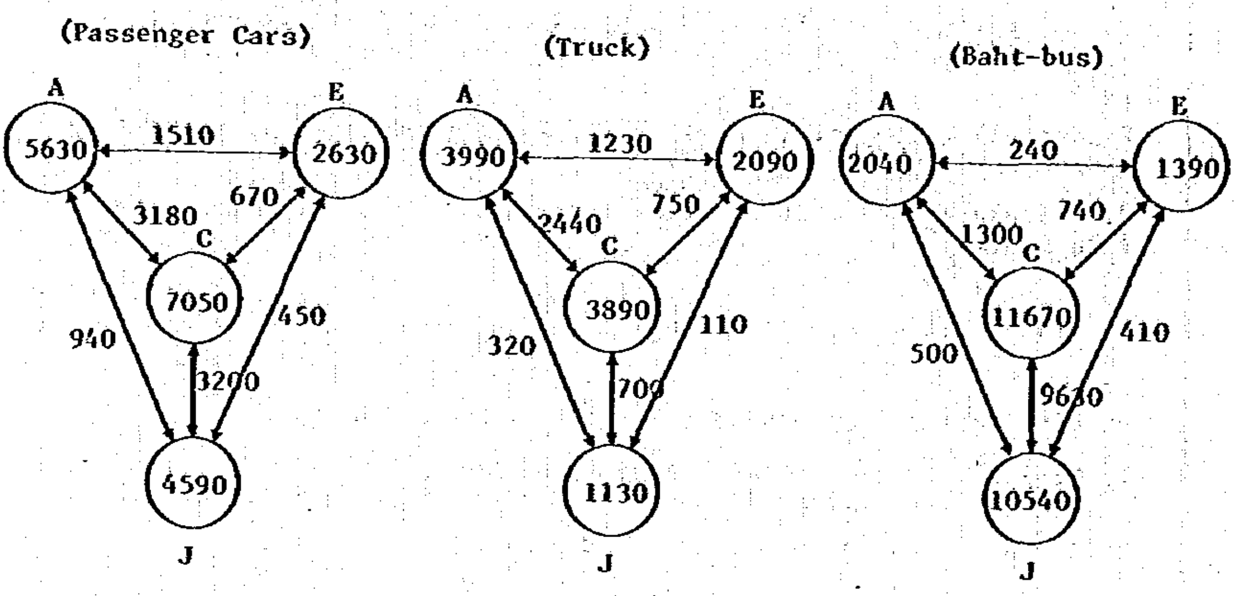
$Q\ell c$: Traffic volume between ℓ and C zones

$q\ell$: The sum of the incoming and outgoing traffic volumes at ℓ intersection. (However, as for Zone J, assume that the sum of the traffic volumes at J and F intersections is that of ℓ intersection.)

ℓ = A or E or J m = A or E or J $\ell \neq m$

The traffic volumes by types of vehicles between major zones obtained in the above process are shown below.

Fig. 2.3.5 Traffic Volumes by Types of Vehicles between Major Zones (Vehicle/day)



f. The traffic volumes obtained as above are those between major zones, excluding the intra-zone traffic in major zones. Hence, paying attention to Zone J, divide the traffic volume between J and C in proportion to the ratio of the explanatory variable of the origin-destination unit, and assume that the result thus obtained is the intra-zone traffic volume in Zone J. The volume obtained by adding this intra-zone traffic volume to J-Zone origin-destination traffic volume between major zones obtained according to (a) is a true J-Zone origin-destination unit.

(4) Origin-destination unit

Find the origin-destination unit by dividing the existing origin-destination traffic volume of J Zone (Zones 6, 7 and 8) obtained as above by the explanatory variable.

a. Passenger cars and buses

J-Zone origin-destination traffic volume (trip end)

$$4{,}590 + 2 \times 3{,}200 \times \frac{101}{393} \fallingdotseq 6{,}230 \text{ trips}$$

Origin-destination unit (trip end)

6,230 (trips)/188 (100 persons) = 33.14 (trips/100 persons)

b. Trucks

J-Zone origin-destination traffic volume (trip end)

$$1{,}130 + 2 \times 700 \times \frac{101}{393} \doteqdot 1{,}490 \text{ trips}$$

Origin-destination unit (trip end)

1,490/101 = 14.75 (trips/100 persons)

c. Baht buses (No intra-zone traffic is taken into consideration in view of the baht-bus running characteristics.)

J-Zone origin-destination traffic volume (trip end)

10,540 trips

Origin-destination unit (trip end)

10,540/188 = 56.06

(5) Origin-destination traffic volume

The traffic volume by zones is calculated by multiplying the origin-destination unit by the explanatory variable by zones; it is shown in Table 2.3.2. In the case of Zones 19 and 21 without the explanatory variable, the origin-destination traffic volume is calculated by deducting the known small-zone origin-destination traffic volume from the total origin-destination traffic volume of Zone E and Zone A. In the case of the buses and baht-buses, their running characteristics are taken into account so that in some zones, the origin-destination traffic volumes are a little corrected.

(d) Estimation of Distributed Volume

(1) Setting of OD pattern

The OD pattern is set by use of the incoming probability between zones as previously mentioned. The incoming probability between zones previously described is calculated between the major zones of A, E and J, but here the same calculation is made between minor zones; the results of which are made into the OD pattern as given in Table 2.3.3 (1) to Table 2.3.3 (3).

(2) Future distributed traffic volume

The future OD diagram was prepared by use of the OD pattern referred to in the preceding paragraph on the basis of the future origin-destination traffic volume and by making the convergence calculation according to the Fratar method. Table 2.3.4 (1) to Table 2.3.4 (9) show the present and the future OD diagrams by types of vehicles.

Table 2.3.2 Trip Generation Model (Trip = Ends by Zone)

Zone No.	1976 Passenger cars Bus	1976 Bath Bus	1976 Truck	1976 Total	1986 Passenger cars Bus	1986 Bath Bus	1986 Truck	1986 Total	1996 Passenger cars Bus	1996 Bath Bus	1996 Truck	1996 Total
1	3,350	5,660	300		5,070	8,570	350		5,340	9,020	370	
2	2,390	4,030	300		3,710	6,270	330		3,710	6,270	340	
3	300	500	130		930	1,560	220		950	1,610	210	
4	2,160	4,290	413		3,020	5,750	1,340		4,670	6,820	2,080	
5	300	500	130		330	560	190		330	560	150	
6	4,870	8,230	1,060		5,270	8,902	990		6,630	11,200	1,180	
7	890	1,510	220		1,060	1,790	220		1,090	1,850	240	
8	460	780	210		500	840	220		9,880	2,450	1,740	
9	930	650	560		4,210	1,980	1,810		4,740	2,230	2,050	
10	370	2,260	450		1,690	3,030	750		2,720	3,590	1,210	
11	1,920	3,950	1,420		2,420	4,800	1,540		3,870	7,690	1,950	
12	850	690	620		950	740	660		950	740	660	
13	660	300	250		760	870	270		760	870	250	
14	770	200	1,450		870	220	1,530		870	220	1,530	
15	1,420	1,170	250		2,050	1,630	300		2,400	1,850	310	
16	670	650	250		700	900	320		700	900	320	
17	260	330	110		290	370	130		1,190	1,490	130	
18	160	200	80		160	200	70		4,240	1,500	1,840	
19	1,600	0	1,650		2,590	0	2,650		4,260	0	4,370	
20	1,780	2,040	950		1,970	2,250	1,040		1,970	2,250	1,040	
21	3,850	0	3,050		9,100	0	4,930		10,250	0	8,120	
Total	29,580	34,500	13,903	77,983	47,640	51,232	19,860	118,732	71,420	63,110	30,120	164,650

Table 2.3.3 (1) OD Pattern (Passenger Car & Bus, 1976)

Table of Arrival Probability

1 + 2 / 2 + 1 Same in volume

	1	2	3	4	5	6	7	8	Total	9	10	11	12	13	14	15	16	17	18	19	Total	20	21
1		15.4	1.9	11.1	1.6	13.4	2.4	1.3	17.1	3.3	1.3	6.9	3.1	2.4	2.7	3.9	2.4	0.9	0.6	5.7		6.4	13.7
2	20.2		1.5	5.7	0.8	25.1	4.6	2.3	32.0	2.4	1.0	5.0	2.3	1.7	2.0	3.7	1.8	0.7	0.4	4.2		4.7	10.1
3	13.1	9.4		8.1	1.3	19.6	3.6	1.8	25.0	3.2	1.3	6.7	3.0	2.3	0.3	5.6	0.4	0.1	0.1	0.9	1.5	6.2	13.3
4	20.8	15.1	1.7		1.7	29.5	5.4	2.8	37.7	1.3	0.7	3.5	0.2	0.3	0.5	2.4	0.5	0.2	0.1	1.1	2.0	2.4	5.2
5	16.2	11.8	3.1	8.9		14.3	2.6	1.3	18.2	3.2	1.3	6.5	0.5	2.2	1.3	4.7	0.8	0.3	0.2	1.8	3.1	6.0	13.1
6	12.5	8.9	1.2	7.7	1.2		8.3	2.6		1.2	1.1	5.5	2.5	0.2	1.0	3.7	2.5	1.0	0.6	5.7	9.8	6.5	14.0
7	12.5	8.9	1.2	7.7	1.2	15.2		0.5		1.2	1.1	5.5	2.5	0.2	1.0	3.7	2.5	1.0	0.6	5.7		6.5	14.0
8	12.5	8.9	1.2	7.7	1.2	8.5	1.3			1.2	1.1	5.5	2.5	0.2	1.0	3.7	2.5	1.0	0.6	5.7		6.5	14.0
9	8.6	6.2	0.8	5.6	0.8	12.5	2.3	1.2	16.0		2.1	10.7	4.9	0.5	2.0	3.7	4.7	0.7	0.4	5.1		9.9	21.3
10	13.3	9.5	1.3	8.2	1.3	19.3	3.5	1.8	24.6	9.4		14.5	0.2	0.1	0.1	0.5	0.2	0.1	0	0.3	0.6	3.2	6.8
11	11.6	8.2	1.0	7.4	1.0	15.8	3.1	1.6		6.7	2.2		3.0	2.3	2.7	4.9	2.3	0.9	0.6	9.5		5.8	12.6
12	6.6	4.7	0.6	4.3	0.6	9.6	1.8	0.9		0.3	2.8	14.8		5.0	1.5	2.6	1.3	0.5	0.3	3.2		13.7	29.7
13	8.1	5.7	0.7	5.2	0.7	11.7	2.1	1.1		0.5	2.2	11.5	5.3		1.9	3.4	1.6	0.6	0.4	3.8		10.6	23.0
14	9.2	6.6	0.9	5.7	0.9	13.5	2.5	1.2	27.2	1.8	0.1	3.7	1.7	1.3		3.5	9.1	3.5	2.2	21.2	35.0	3.4	7.4
15	12.9	9.2	1.2	8.0	1.2	18.7	3.4	1.9	24.0	2.5	0.1	2.9	1.3	1.0	1.4		4.0	1.5	0.9	9.1	15.7	2.7	5.8
16	7.2	5.0	0.7	4.5	0.7	13.4	2.4	1.3	17.1	3.1	1.2	6.5	3.0	2.2	13.1	16.5		2.2	1.5	*		6.0	12.9
17	7.2	5.0	0.7	4.5	0.7	13.4	2.4	1.3		3.1	1.2	6.5	3.0	2.2	13.1	16.5	5.3		1.9	*		6.0	12.9
18	7.2	5.0	0.7	4.5	0.7	13.4	2.4	1.3		3.1	1.2	6.5	3.0	2.2	13.1	16.5	6.3	3.1		*		6.0	12.9
19	7.2	5.0	0.7	4.5	0.7	13.4	2.4	1.3		3.1	1.2	6.5	3.0	2.2	13.1	16.5	*	*	*			6.0	12.9
20	9.0	6.4	0.9	5.6	0.9	13.1	2.4	1.2	16.7	2.9	1.2	6.0	9.2	5.5	4.8	3.4	6.8	2.6	1.6	15.8	26.8		*
21	9.0	6.4	0.9	5.6	0.9	13.1	2.4	1.2	16.7	2.9	1.2	6.0	9.2	5.5	4.8	3.4	6.8	2.5	1.6	15.8		*	
									16.7												26.8	*	*

Table 2.3.3 (2) OD Pattern (Truck, 1976) — Table of Arrival Probability

1 + 2 / 2 + 1 Same in volume (16–19)

	1	2	3	4	5	6	7	8	Total	9	10	11	12	13	14	15	16	17	18	19	Total	20	21
1		13.9	0.6	2.0	0.6	13.0	2.7	2.6	18.3	2.9	2.3	7.3	3.0	1.2	7.1	4.8	2.1	0.8	0.6	11.9	15.4	4.8	15.7
2	7.5		1.1	3.6	1.1	12.8	2.7	2.5	18.0	2.4	1.9	6.1	5.4	2.2	12.7	2.1	2.5	1.0	0.7	14.4	18.6	4.0	13.1
3	3.8	3.8		1.5	1.4	13.6	2.8	2.7	19.1	3.2	2.5	8.2	2.3	0.9	5.4	3.8	3.1	0.4	0.3	6.1	7.9	5.4	17.6
4	6.7	6.7	2.7		2.7	23.3	4.9	4.7	32.8	8.7	1.6	5.1	2.2	0.2	0.4	6.7	1.6	0.6	0.4	8.9	11.5	3.4	10.9
5	3.8	3.8	1.5	1.5		13.6	2.8	2.7	19.1	3.2	2.5	8.2	2.3	0.9	5.4	3.8	1.6	0.6	0.4	8.9	11.5	3.4	10.9
6	4.4	4.4	1.9	6.0	1.9		5.2	5.2		8.2	6.5	20.8	0.1	0	3.6	4.2	1.3	0.5	0.4	7.5	9.7	6.7	21.6
7	4.4	4.4	1.9	6.0	1.9	12.3		1.0		8.2	6.5	20.8	0.1	0	3.6	4.2	1.3	0.5	0.4	7.5		6.7	21.6
8	4.4	4.4	1.9	6.0	1.9	12.5	1.1			8.2	6.5	20.8	0.1	0	3.6	4.2	1.3	0.5	0.4	7.5		6.7	21.6
Total													0.1	0	3.6	4.2							
9	0.5	0.5	0.2	0.7	0.2	1.8	0.4	0.3	2.5		6.8	21.8	1.1	0.4	2.6	0.4	0.1	0	0	0.8	0.9	4.5	46.9
10	3.9	3.9	1.6	5.1	1.6	13.7	2.9	2.7	19.3	16.1		24.2	0.8	0.3	2.0	3.9	0.1	0	0	0.6	0.7	3.9	12.7
11	1.7	1.7	0.7	2.2	0.7	6.0	1.2	1.2	8.4	8.0	7.9		4.2	1.9	0.6	1.7	2.5	1.0	0.7	14.1	18.3	9.0	33.0
12	0.5	0.5	0.2	0.6	0.2	1.6	0.6	0.3	2.3	0.3	5.9	19.2		1.9	0.5	0.5	1.9	0.7	0.5	10.5	13.6	2.7	41.2
13	0.2	0.2	0	0.2	0	0.5	0.1	0.1	0.7	7.5	5.9	19.0	8.3		0.2	0.2	0.6	0.2	0.2	3.3	6.3	2.6	69.8
14	1.5	1.5	0.6	1.9	0.6	5.1	1.1	1.0	7.1	0.4	0.3	0.9	0.4	0		1.5	11.1	4.2	3.1	62.4	80.7	0.6	2.0
15	2.9	2.9	1.3	3.8	1.9	10.2	2.1	2.1	14.4	5.1	1.7	5.5	2.4	0.3	16.3		3.6	1.4	1.0	20.3	26.3	3.6	11.5
16	1.5	1.5	0.6	2.0	0.6	5.3	1.1	1.0	7.4	2.4	3.2	10.4	4.6	0.5	34.4	1.5		3.1	2.1	*		6.9	22.4
17	1.5	1.5	0.6	2.0	0.6	5.3	1.1	1.0	7.4		3.2	10.4	4.6	0.5	34.4	1.5	8.1		4.5	*		6.9	22.4
18	1.5	1.5	0.6	2.0	0.6	5.3	1.1	1.0	7.4	2.4	3.2	10.4	4.6	0.5	34.4	1.5	7.5	6.3		*		6.9	22.4
19	1.5	1.5	0.6	2.0	0.6	5.3	1.1	1.0	7.4	2.4	3.2	10.4	4.6	0.5	34.4	1.5	*	*	*			6.9	22.4
Total	1.5	1.5	0.6	2.0	0.6				7.4	2.4	3.2	10.4	4.6	0.5	34.4	1.5						6.9	22.4
20	1.6	1.6	0.7	2.1	0.7	5.7	1.2	1.1	8.0	11.3	8.8	28.5	2.5	1.2	0.4	1.6	4.2	1.6	1.2	23.8	30.8		*
21	1.6	1.6	0.7	2.1	0.7	5.7	1.2	1.1	8.0	11.3	8.8	28.5	2.5	1.2	0.4	1.6	4.2	1.6	1.2	23.8	30.8	*	
Total	1.6	1.6	0.7	2.1	0.7				8.0	11.3	8.8	28.5	2.5	1.2	0.4	1.6						*	*

Table 2.3.3 (3) OD Pattern (Baht-bus, 1976) — Table of Arrival Probability

1 + 2 / 2 + 1 Same in volume (16–19)

	1	2	3	4	5	6	7	8	Total	9	10	11	12	13	14	15	16	17	18	19	Total	20	21
1		9.9	0.9	19.1	0.7	26.3	4.8	2.5	33.6	1.5	9.7	12.0	0.8	0.5	0.5	1.6	1.2	0.5	0.3	-	1.9	7.3	*
2	20.2		1.3	15.5	2.5	29.9	5.5	2.8	38.2	0.8	5.3	8.0	0.7	0.9	0.3	3.9	1.7	0.6	0.4	-	2.7	5.4	*
3	8.8	5.4		24.4	9.8	28.7	5.3	2.7	36.7	0.7	4.9	6.1	0.6	0.5	0.4	1.7	3.2	1.2	0.7	-	5.1	2.9	*
4	25.0	17.9	2.1		1.8	36.3	6.7	3.4	46.4	1.1	0.8	1.9	0.2	0.4	0.1	0.6	0.7	0.3	0.2	-	1.2	1.5	
5	13.2	9.4	9.3	29.3		19.4	3.5	1.8	24.5	0.5	3.6	5.3	0.4	0.4	0.1	4.5	3.3	1.3	0.8	-	5.3	3.2	*
6	28.7	17.7	0.7	14.1	1.6		0	0	1.0	1.1	7.6	10.9	0.8	0.9	0.2	6.1	1.7	0.7	0.4	-	2.8	6.8	-
7	28.7	17.7	0.7	14.1	1.6	0		0		1.1	7.6	10.9	0.8	0.9	0.2	6.1	1.7	0.7	0.4	-	2.8	6.8	-
8	28.7	17.7	0.7	14.1	1.6	0	0			1.1	7.6	10.9	0.8	0.9	0.2	6.1	1.7	0.7	0.4	-	2.8	6.8	-
Total	28.7	17.7	0.7	14.1	1.6					1.1	7.6	10.9	0.8	0.9	0.2	6.1					2.8		
9	12.8	9.1	0.3	0.9	0.3	19.0	3.5	1.8	24.3		17.4	21.6	2.5	1.0	0	0.1	0.1	0.1	0	-	0.2	10.5	-
10	17.4	12.3	0.4	1.2	0.4	25.8	4.8	2.4	33.0	2.0		21.5	3.4	1.4	0.2	0.1	0.2	0.1	0	-	0.3	6.5	-
11	18.4	13.0	0.4	1.3	0.4	27.3	5.0	2.6	34.5	3.0	14.7		3.6	1.4	0.3	0.1	0.2	0.1	0	-	0.3	8.3	-
12	12.4	8.9	0.2	0.5	0.5	18.1	3.3	1.7	23.1	0.2	1.0	28.2		0.6	0.3	1.5	2.1	0.8	0.5	-	3.4	10.8	-
13	15.6	11.2	0.9	1.0	0.5	22.7	4.2	2.1	29.0	1.0	0	9.4	1.9		2.7	2.2	5.9	2.3	1.4	-	9.5	13.6	-
14	18.8	13.2	1.0	2.4	1.3	27.1	5.0	2.6	34.7	0.7	5.0	7.5	0.7	0.9		2.6	3.7	1.4	0.9	-	6.0	5.2	-
15	21.5	15.4	0.4	0.9	0.8	31.4	5.8	3.0	40.1	0.4	3.0	5.4	0.5	1.0	0.5		3.7	1.4	0.8	-	5.9	4.2	-
16	18.5	13.2	0.2	0.2	0.6	26.9	5.0	2.5	34.4	0.5	0	13.3	1.4	5.8	2.8	4.7		0	0	-		4.4	-
17	18.5	13.2	0.2	0.2	0.6	26.9	5.0	2.5	34.4	0.5	0	13.3	1.4	5.8	2.8	4.7	0		0	-		4.4	-
18	18.5	13.2	0.2	0.2	0.6	26.9	5.0	2.5	34.4	0.5	0	13.3	1.4	5.8	2.8	4.7	0	0		-		4.4	-
19	18.5	13.2	0.2	0.2	0.6	26.9	5.0	2.5	34.4	0.5	0	13.3	1.4	5.8	2.8	4.7	-	-	-			4.4	-
Total	18.5	13.2	0.2	0.2	0.6	26.9	5.0		34.4	0.5	0	13.3	1.4	5.8	2.8	4.7							
20	16.5	11.8	0.3	0.3	0.4	20.2	3.7	1.9	25.8	3.3	0.2	16.6	13.0	1.4	1.3	0.2	4.8	1.8	1.2	-	7.8		*
21	16.5	11.8	0.3	0.3	0.4	20.2	3.7	1.9	25.8	3.3	0.2	16.6	13.0	1.4	1.3	0.2	4.8	1.8	1.2	-	7.8	*	
Total	16.5	11.8	0.3	0.3	0.4				25.8	3.3	0.2	16.6	13.0	1.4	1.3	0.2					7.8	*	*

Table 2.3.4 (1) O-D Diagram (Passenger car & bus, 1976)

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	T.E.
01	-	478	44	420	44	606	86	50	102	44	224	64	64	72	166	50	18	12	124	214	462	3,344
02		-	28	232	24	584	80	46	60	28	134	38	36	44	114	16	6	4	38	128	274	2,392
03			-	28	6	60	8	4	8	4	18	6	4	4	16	2	0	0	6	18	38	302
04				-	30	610	82	43	44	24	112	20	20	30	94	20	8	4	48	92	198	2,164
05					-	54	8	4	8	4	18	2	6	4	16	2	2	0	6	18	40	296
06						-	256	90	106	70	344	96	48	88	278	100	38	24	240	372	806	4,870
07							-	4	14	10	48	14	6	12	38	14	6	4	32	54	116	892
08								-	8	6	28	8	4	6	22	8	4	2	20	30	66	458
09									-	30	124	18	4	16	49	18	6	4	44	88	190	932
10										-	48	12	8	0	10	4	2	0	10	18	40	372
11											-	82	58	36	70	38	14	8	116	126	274	1,920
12												-	32	10	18	10	4	2	28	132	286	882
13													-	10	18	10	4	2	26	94	204	658
14														-	24	60	22	14	146	54	118	770
15															-	76	28	18	186	60	128	1,420
16																-	10	6	0	70	152	666
17																	-	4	0	26	58	260
18																		-	0	16	34	158
19																			-	168	364	1,692
20																				-	0	1,778
21																					-	3,848

Table 2.3.4 (2) O-D Diagram (Truck, 1976)

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	T.E.
01	-	26	4	16	4	38	8	6	2	10	16	8	4	38	10	2	0	0	14	22	76	300
02		-	4	18	4	36	6	6	2	8	14	14	6	52	6	2	0	0	14	20	62	300
03			-	6	2	18	4	4	2	4	8	4	2	14	4	0	0	0	4	12	36	132
04				-	6	84	16	14	10	14	20	10	2	28	18	4	2	0	20	30	56	414
05					-	20	4	4	2	4	8	4	2	16	4	2	0	0	6	10	32	134
06						-	34	34	24	50	92	6	0	106	32	8	2	2	46	102	328	1,062
07							-	2	4	8	18	2	0	20	6	2	0	0	8	20	62	224
08								-	4	8	10	0	0	18	6	2	0	0	8	18	58	208
09									-	26	48	4	6	14	4	2	0	0	6	94	306	560
10										-	54	10	4	12	10	2	0	0	8	48	156	436
11											-	72	32	14	14	12	4	4	63	212	636	1,422
12												-	24	12	6	10	4	2	54	90	288	624
13													-	0	0	2	0	0	6	38	124	252
14														-	64	130	48	34	744	20	64	1,448
15															-	4	2	0	20	20	62	292
16																-	2	2	0	26	82	236
17																	-	2	0	10	30	106
18																		-	0	6	22	74
19																			-	144	368	1,638
20																				-	0	962
21																					-	3,044

Table 2.3.4 (3) O-D Diagram (Baht-bus, 1976)

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	T.E.
01	-	494	46	1048	42	1712	312	262	80	396	628	54	28	30	144	112	44	26	0	300	0	5,658
02		-	43	572	64	1216	224	114	42	206	372	38	26	18	154	96	34	22	0	186	0	4,032
03			-	130	50	106	20	30	4	16	24	2	2	2	8	12	4	2	0	10	0	502
04				-	98	1628	390	154	32	34	78	6	8	6	22	24	10	6	0	34	0	4,290
05					-	120	22	12	2	12	22	2	2	2	16	14	6	4	0	10	0	550
06						-	0	0	124	634		192	66	40	494	242	94	56	0	484	0	8,228
07							-	0	22	118	204	18	12	8	99	44	18	10	0	88	0	1,510
								-	12	69	106	10	6	4	48	22	8	6	0	46	0	780
09									-	82	149	8	4	0	4	4	2	0	0	70	0	650
10										-	548	42	12	8	18	4	2	0	0	68	0	2,260
11											-	174	36	16	36	68	26	14	0	330	0	3,940
12												-	4	2	8	16	6	4	0	192	0	658
13													-	6	8	32	12	8	0	28	0	300
14														-	6	20	8	4	0	20	0	200
15															-	56	22	12	0	24	0	1,170
16																-	0	0	0	92	0	858
17																	-	0	0	34	0	330
18																		-	0	22	0	196
19																			-	0		0
20																				-	0	2,038
21																					-	0

Table 2.3.4 (4) O-D Diagram (Passenger car & bus, 1986)

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	T.E.
01	-	711	127	579	44	570	100	51	414	182	240	56	62	77	233	47	19	11	178	245	1125	5,071
02		-	65	344	27	592	59	50	262	123	154	36	33	52	173	16	7	3	59	157	722	3,711
03			-	79	31	119	20	10	71	32	39	9	10	18	46	5	2	1	17	43	197	931
04				-	30	572	94	45	176	94	120	17	20	32	133	19	8	4	69	103	479	3,020
05					-	37	6	3	25	12	14	2	4	4	16	2	1	0	7	15	71	331
06						-	200	62	289	197	249	57	32	64	266	64	27	14	236	289	1335	5,271
07							-	4	45	33	43	10	5	10	43	11	5	2	49	51	236	1.060
08								-	25	17	22	5	3	5	23	6	2	1	21	26	118	502
09									-	343	384	45	12	50	165	48	20	11	181	291	1346	4,211
10										-	149	29	20	2	40	12	5	2	43	63	269	1,692
11											-	55	44	29	75	27	11	6	130	112	518	2,421
12												-	20	7	17	7	3	1	25	95	445	942
13													-	8	18	7	3	2	27	76	350	762
14														-	25	43	18	10	161	47	220	872
15															-	73	29	16	222	69	317	2,049
16																-	7	4	0	54	250	702
17																	-	2	0	22	101	292
18																		-	0	12	56	158
19																			-	200	925	2,591
20																				-	0	1,971
21																						9,100

Table 2.3.4 (5) O-D Diagram (Truck, 1986)

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	T.E.
01	-	25	5	50	4	29	6	6	8	14	14	8	3	29	9	3	1	1	25	19	92	351
02		-	5	51	4	25	5	5	7	12	12	12	5	37	5	3	1	1	24	16	75	330
03			-	30	3	20	4	4	6	9	10	4	2	17	5	1	1	0	12	14	67	219
04				-	21	188	39	39	92	64	58	27	3	65	50	12	5	2	103	77	364	1,340
05					-	15	3	3	5	7	7	3	1	12	4	1	0	0	10	8	39	150
06						-	21	22	49	51	61	3	0	58	21	7	3	1	57	63	296	930
07							-	1	11	10	13	3	0	12	4	1	1	0	12	13	63	220
08								-	10	10	13	3	0	12	5	1	1	0	11	13	62	219
09									-	102	123	11	14	30	10	4	1	1	33	226	1069	1,812
10										-	69	13	6	12	12	2	1	0	21	58	275	748
11											-	58	27	9	11	12	5	3	103	161	773	1,542
12												-	20	8	5	10	4	2	82	68	321	661
13													-	0	3	1	0	0	10	31	145	270
14														-	42	112	44	24	336	12	59	1,530
15															-	3	1	1	29	14	69	301
16																-	3	2	0	24	116	318
17																	-	1	0	10	45	129
18																		-	0	5	25	69
19																			-	206	976	2,650
20																				-	0	1,038
21																					-	4,933

Table 2.3.4 (6) O-D Diagram (Taxi, 1986)

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	T.E.
01	-	991	184	1684	52	2654	412	195	314	642	918	75	103	42	268	142	69	32	0	401	0	8,571
02		-	215	1095	80	1459	293	139	167	341	552	53	99	24	287	122	47	27	0	251	0	6,268
03			-	423	124	258	52	24	24	52	73	6	20	7	27	29	13	6	0	26	0	1,561
04				-	98	1528	320	149	105	45	92	7	26	6	32	25	11	7	0	36	0	5,749
05					-	89	18	8	6	13	19	2	3	1	19	11	5	3	0	9	0	560
06						-	0	0	293	625	955	87	151	33	557	186	78	41	0	392	0	8,903
07							-	0	60	126	198	17	30	7	112	38	16	8	0	79	0	1,791
08								-	28	59	93	8	14	3	53	17	7	4	0	37	0	838
09									-	267	435	25	32	2	32	8	4	2	0	190	0	1,980
10										-	659	48	37	8	28	4	2	0	0	75	0	3,031
11											-	161	101	15	49	64	27	13	0	325	0	4,739
12												-	11	2	11	15	6	3	0	182	0	739
13													-	14	28	78	32	17	0	72	0	870
14														-	8	12	7	4	0	19	0	220
15															-	67	27	14	0	30	0	1,629
16																-	0	0	0	78	0	902
17																	-	0	0	31	0	371
18																		-	0	18	0	199
19																			-	0	0	0
20																				-	0	2,251
21																					-	0

Table 2.3.4 (7) O.D Diagram (Passenger car & bus, 1996)

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	T.E.
01	-	506	97	620	33	503	82	856	356	214	278	47	54	47	163	35	58	236	252	146	757	5,340
02		-	61	365	19	490	76	779	211	135	168	28	31	29	116	11	19	68	78	88	455	3,711
03			-	86	8	106	17	170	61	38	45	8	9	5	33	3	5	22	24	26	134	959
04				-	32	713	109	1140	213	157	197	20	25	27	131	19	32	123	137	87	455	4,668
05					-	32	5	53	21	33	16	1	3	2	11	1	2	10	10	9	47	328
06						-	192	1203	290	269	337	57	32	45	216	55	93	363	388	201	1043	6,628
07							-	69	45	42	54	9	4	7	33	9	15	57	61	33	373	1,092
08								-	452	435	557	94	48	66	362	92	156	602	642	337	1751	9,850
09									-	465	507	44	31	34	131	40	68	263	291	197	1025	4,741
10										-	268	38	27	2	43	14	23	83	95	58	301	2,720
11											-	71	59	27	80	31	51	208	282	102	532	3,871
12												-	19	4	13	5	9	35	39	64	333	938
13													-	5	15	6	10	49	43	51	268	769
14														-	14	25	42	168	182	22	117	870
15															-	50	82	320	355	38	397	2,401
16																-	19	87	0	32	164	698
17																	-	183	0	52	271	1,190
18																		-	0	205	1067	4,149
19																			-	223	1159	4,261
20																				-	0	1,971
21																					-	10,249

Table 2.3.4 (8) O.D Diagram (Truck, 1996)

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	T.E.
01	-	19	3	52	2	23	5	38	7	17	13	5	2	13	6	2	3	16	39	12	95	369
02		-	3	53	3	20	4	32	6	15	31	8	4	16	4	2	1	15	38	10	77	341
03			-	28	2	15	3	23	5	10	8	3	1	6	3	1	0	7	17	8	63	209
04				-	21	213	44	333	108	103	73	26	3	49	51	14	5	88	227	68	526	2,031
05					-	11	2	17	4	7	6	2	1	5	2	1	0	6	15	5	37	149
06						-	18	143	44	66	60	3	0	27	17	6	2	40	98	43	331	1,160
07							-	8	10	14	13	1	0	6	4	1	0	8	20	9	70	240
08								-	71	102	96	4	0	43	27	9	3	60	145	67	521	1,739
09									-	137	126	9	11	14	8	4	1	21	58	160	1245	2,059
10										-	100	15	6	9	14	3	1	20	53	58	455	1,210
11											-	49	24	5	10	12	4	80	198	123	971	1,981
12												-	13	3	4	7	3	45	119	39	303	663
13													-	0	1	1	0	6	15	18	143	249
14														-	18	54	18	349	868	4	35	1,531
15															-	3	1	18	44	9	69	313
16																-	3	46	0	17	132	318
17																	-	35	0	6	45	129
18																		-	0	111	864	1,838
19																			-	274	2135	4,366
20																				-	0	1,041
21																					-	8,120

Table 2.3.4 (9) O.D Diagram (Taxi, 1996)

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	T.E.
01	-	762	152	1711	42	2152	354	473	278	599	1254	58	72	30	231	123	298	212	0	307	0	9,018
02		-	171	1068	63	1489	245	325	142	305	724	39	65	17	238	102	159	171	0	184	0	6,270
03			-	444	104	279	46	61	22	50	103	5	14	5	24	26	41	41	0	20	0	1,608
04				-	102	2114	350	461	118	54	160	7	22	6	35	28	49	56	0	35	0	6,820
05					-	95	16	21	5	12	27	2	2	1	17	10	16	17	0	7	0	559
06						-	0	0	346	765	1763	87	135	31	627	212	355	355	0	393	0	11,198
07							-	0	57	127	290	14	22	5	104	35	59	59	0	65	0	1,849
08								-	76	166	383	19	29	7	138	46	77	77	0	86	0	2,450
09									-	275	656	21	24	2	11	8	16	11	0	160	0	2,228
10										-	1051	43	29	7	28	4	8	0	0	67	0	3,590
11											-	235	118	19	72	95	161	145	0	425	0	7,689
12												-	8	1	9	13	20	21	0	134	0	739
13													-	9	21	58	95	97	0	48	0	868
14														-	6	14	23	24	0	13	0	220
15															-	63	100	100	0	25	0	1,849
16																-	0	0	0	65	0	992
17																	-	0	0	102	0	1,459
18																		-	0	114	0	1,500
19																			-	0	0	0
20																				-	0	2,250
21																					-	0

(e) Traffic Assignment

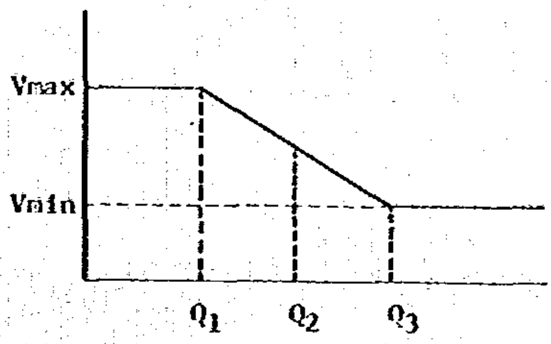
(1) Assigned network

The design road network and the number of lanes to which the traffic volume is assigned are shown in Fig. 2.3.6, and the intersection design and the conditions of linking, given in Table 2.3.5.

(2) Conditions of assignment

The traffic assignment is a 5-time assignment by dividing the OD diagram into 5 equal parts. In the assignment, the shortest time course is selected by use of the following Q-V formula.

Q-V Formula



$Q_1 = 0.6Q_0$

$Q_2 = 1.5Q_0$

$V_{min} = \frac{1}{3}V_{max}.$

Q: Traffic volume

Q_0: Designed traffic capacity

V: Design speed

Q-V Conditions

Name of road	Q_0	$V_{max.}$	$V_{min.}$
Sukhumvit H.W.	38,000 vehicle/day	50 km/hr	17 km/hr
T-1	38,000	50	17
T-2 R-1	9,600	50	17
R-2	8,000	50	17

(3) Results of assignment

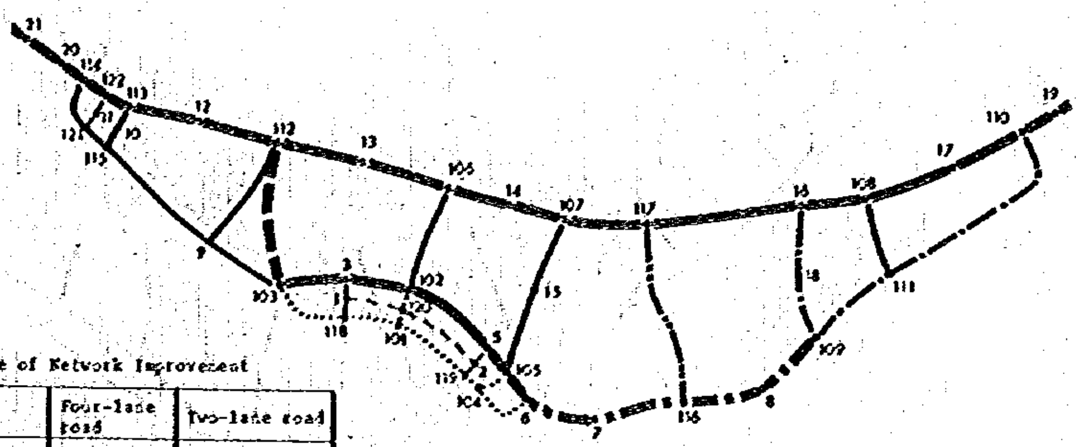
The results of the assignment of the future traffic volume are shown in Fig. 2.3.7 (1), Fig. 2.3.7 (2). For reference, the results of the assignment of the future traffic volume to the existing road network are shown in Fig. 2.3.8 (1), Fig. 2.3.8 (2). In these figures, the degree of congestion obtained from the following formula is shown in the parenthesis.

$$\text{Degree of congestion} = \frac{\text{Traffic volume}}{\text{Designed traffic capacity}}$$

By the above calculation, in 1986, the degree of congestion on the road connecting Pattaya to Na Klua will exceed 1 (over-congestion) and one route of the road between Sukhumvit Highway and the back road, in 1996. In the case of the assignment to the present road network, many roads such as Sukhumvit Highway, the beach road, etc. in addition to the above roads are over-capacity.

Existing Connecting Road, Pattaya to Na Klua

Fig. 2.3.6 Assigned Road Network



Outline of Network Improvement

		Four-lane road	Two-lane road
86	Improvement		
	New Construction		
96	Improvement		
	New Construction		
Controlled section			
Dummy			

The improvement means improvement of the existing roads.

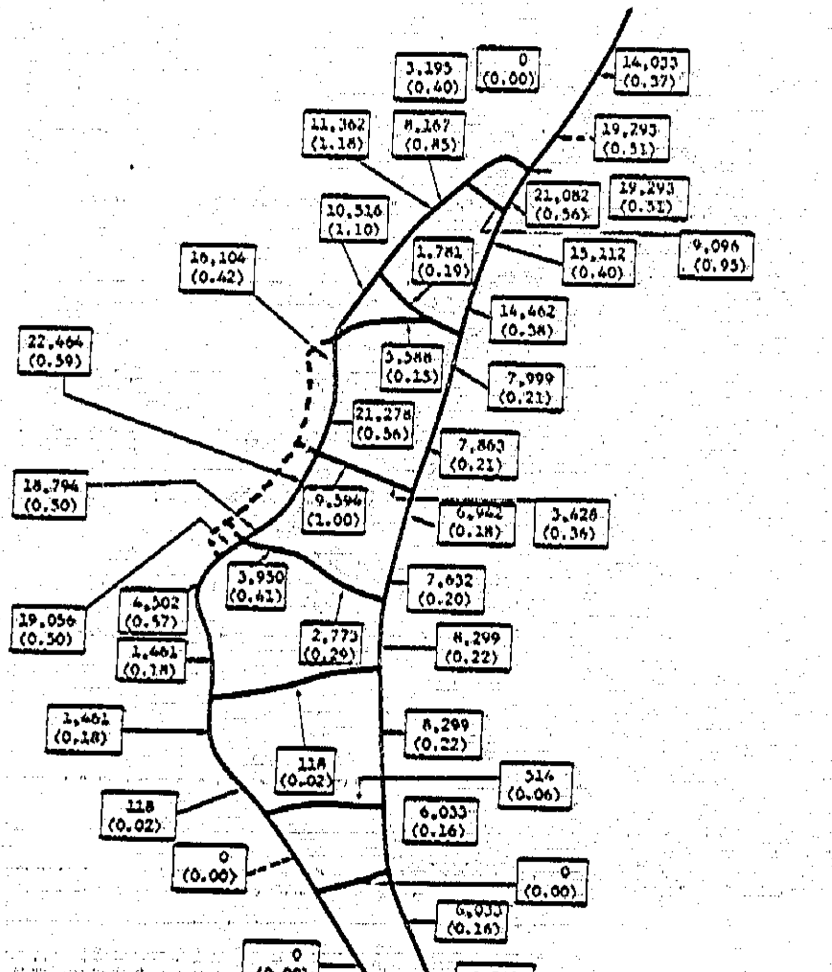
The present roads are assumed as 2 lane roads.

Table 2.3.5 Q-V Code

LINK	Node from	Node to	Distance (km)	QV Code Case 1 '76	QV Code Case '86	QV Code Case '95	(Note)
1	1	3	10.0	1	—		Dummy L.C
2	1	118	10.0	1	—		〃 〃
3	1	120	10.0	1	—		〃 〃
4	2	5	10.0	1	—		〃 〃
5	2	119	10.0	1	—		〃 〃
6	2	120	10.0	1	—		〃 〃
7	3	102	0.7	4	2	-	
8	3	103	1.0	4	2	-	
9	4	102	0.8	3	—		
10	4	106	0.8	3	—		
11	5	102	0.7	4	2	-	
12	5	105	0.8	4	2	-	
13	6	7	1.1	4	-	2	
14	6	104	0.6	3	—		One-way traffic 104- 6 L.C
15	6	105	0.3	4	2	-	
16	7	116	1.0	4	-	2	
17	8	109	0.8	4		2	
18	8	116	2.1	4	-	2	
19	9	103	1.1	3	—		
20	9	112	1.6	3	—		
21	9	115	2.0	3	—		
22	10	113	0.3	3	—		
23	10	115	0.3	3	—		
24	11	121	10.0	1	—		Dummy
25	11	122	10.0	1	—		〃
26	12	112	0.6	3	1	-	
27	12	113	1.4	3	1	-	
28	13	106	1.2	3	1	-	
29	13	112	1.2	3	1	-	
30	14	106	0.8	3	1	-	

LINK	Node from	Node to	Distance (km)	QV Code Case 1 '76	QV Code Case '86	QV Code Case '96	(Note)
31	14	107	0.9	3	1		
32	15	105	1.3	3	—	-	
33	15	107	1.4	3	—		
34	16	18	1.0	4		3	
35	16	108	0.8	3	1	-	
36	16	117	2.3	3	1	-	
37	17	108	1.0	3	1	-	
38	17	110	1.0	3	1	-	
39	18	109	1.1	4	-	3	
40	19	110	10.0	1	—		Dummy
41	20	21	10.0	1	—		〃
42	20	114	1.0	3	1	-	
43	101	118	0.7	3	—		L.C
44	101	119	0.7	3	—		〃
45	101	120	0.1	3	—		〃
46	102	120	0.2	3	—		〃
47	103	112	2.0	x	2	-	(L.C)
48	103	118	1.1	3	—		L.C
49	104	105	0.2	3	—		〃
50	104	119	0.7	3	—		〃
51	107	117	0.8	3	1	-	
52	108	111	1.4	x	x	4	(L.C)
53	109	111	1.3	4	-	3	
54	110	111	3.4	4	-	3	
55	113	122	0.3	3	1	-	
56	114	121	0.9	4	—		
57	114	121	0.9	3	1	-	
58	114	122	0.4	4	—		
59	116	117	3.1	x	x	3	(L.C)

Fig. 2.3.7 (1) Assigned Traffic Volume (Proposed Network - 1986)



Degree of Congestion

$\frac{Q_F}{Q_0}$ = Forecast of Traffic Volume / Capacity of Traffic Volume

These degree are shown in ( ).

Traffic Volume in vehicles a day.

Fig. 2.3.7 (2) Assigned Traffic Volume (Proposed Network - 1996)

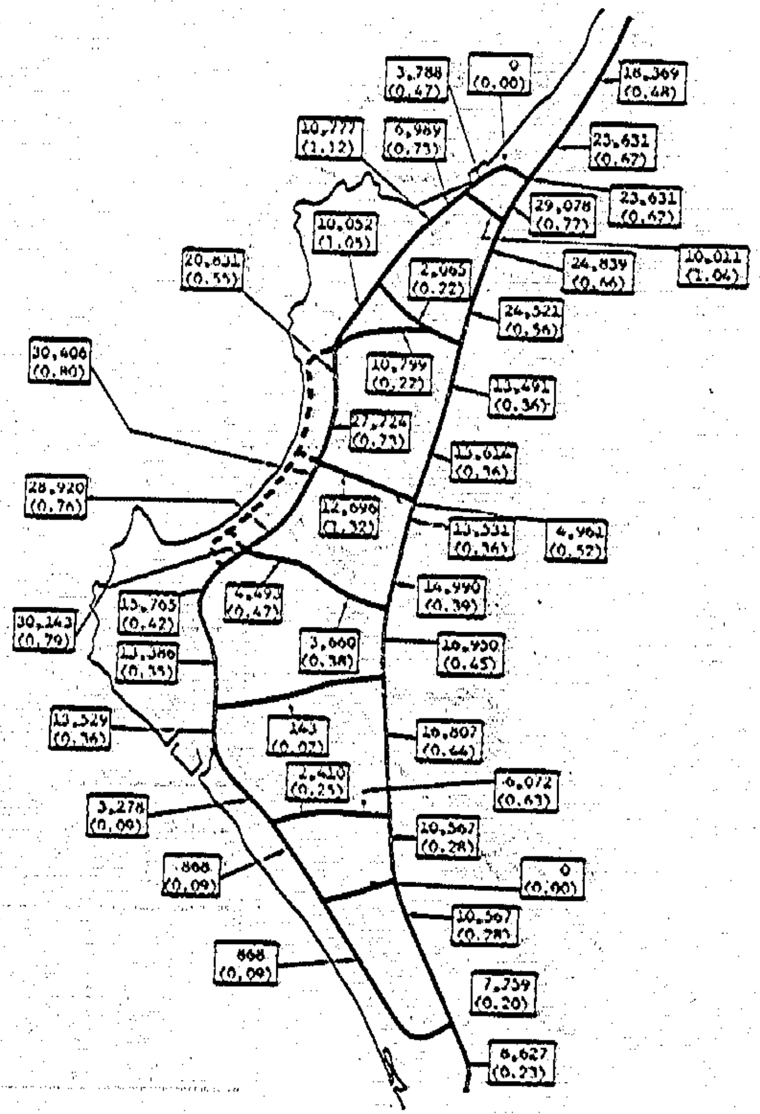


Fig. 2.3.8 (1) Assigned Traffic Volume (Present Network - 1986)

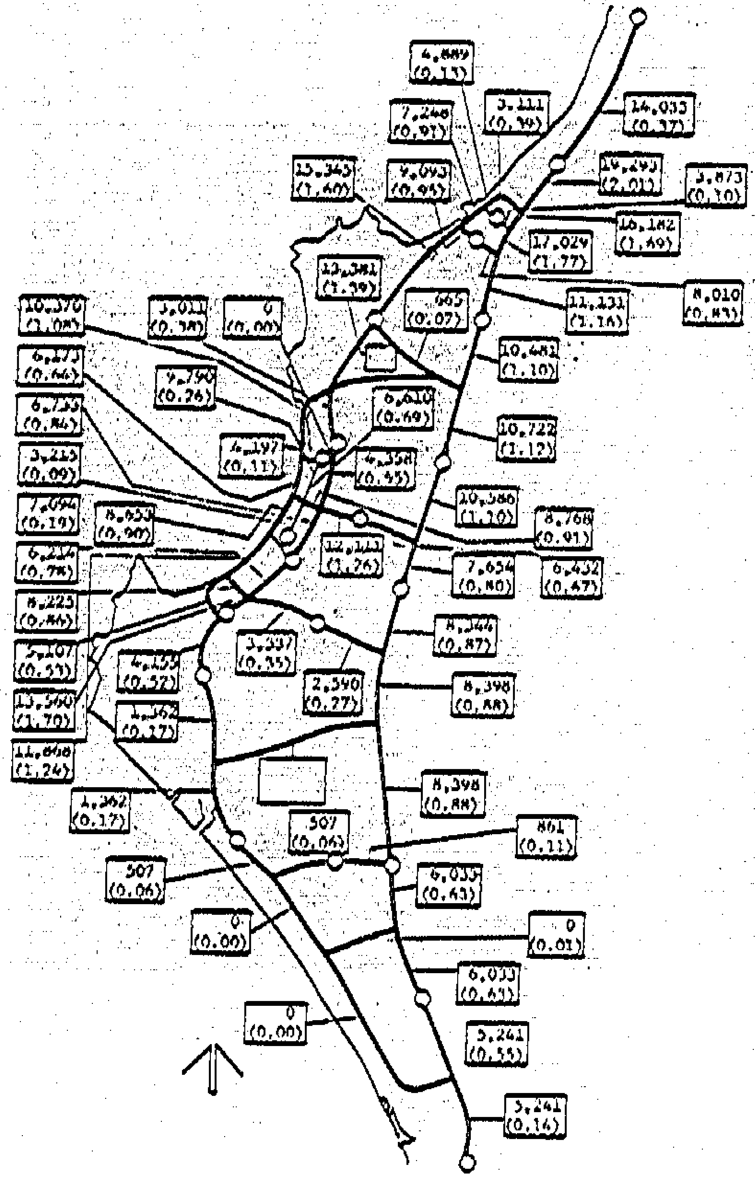
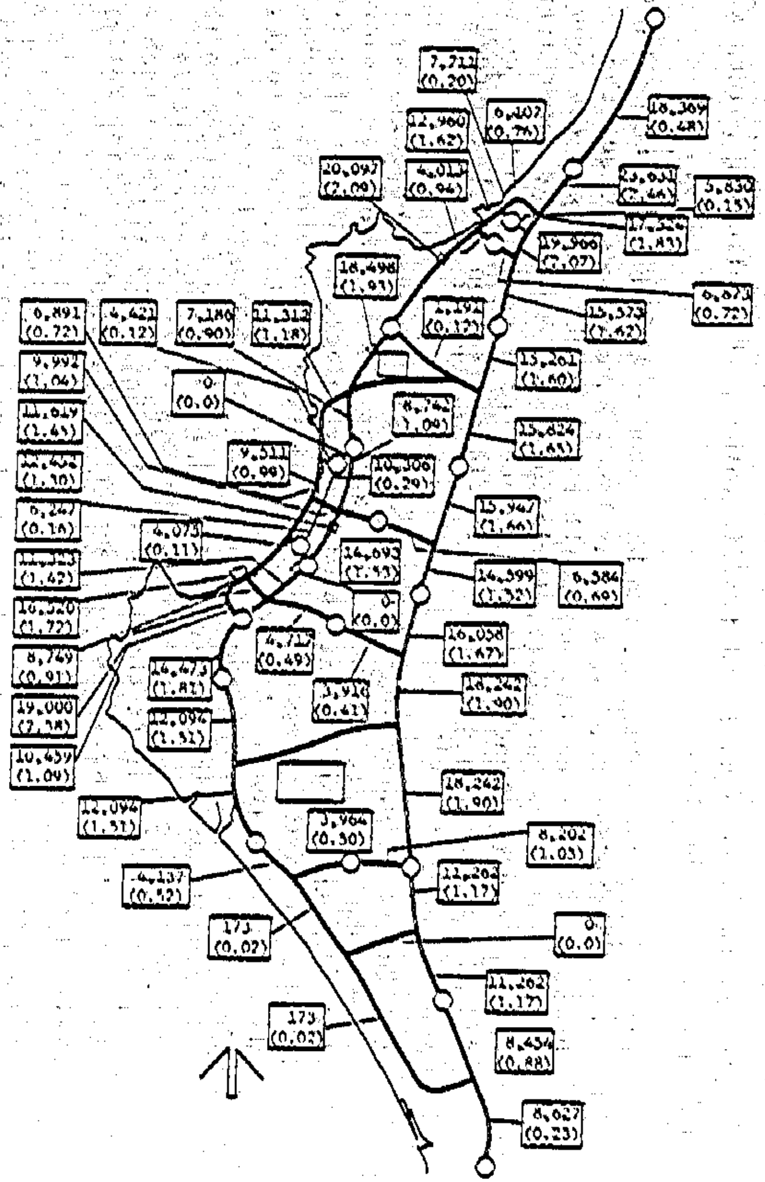


Fig. 2.3.8 (2) Assigned Traffic Volume (Present Network - 1996)



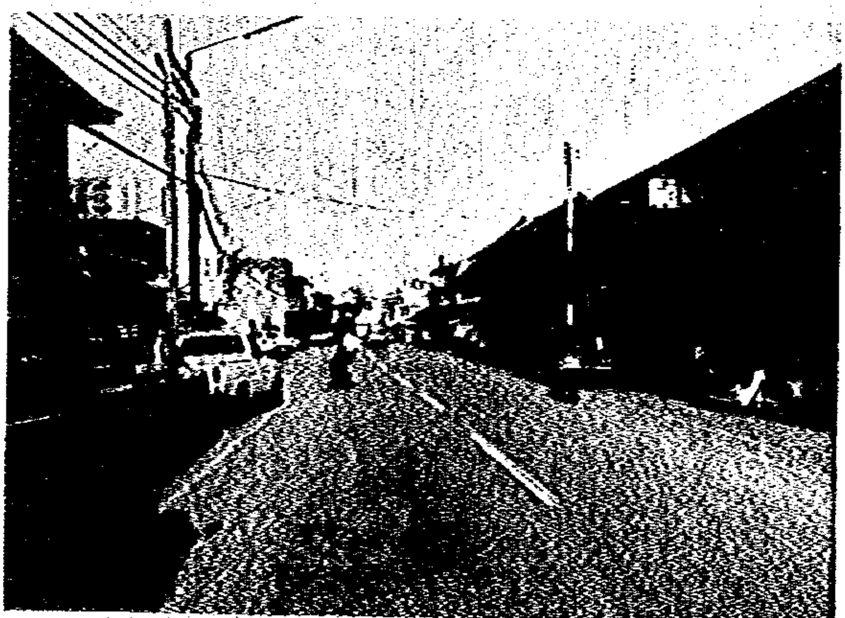
2.3.3 Examination of and Measures against Difficult Problems

In view of the future assigned traffic volume, the following points are taken into consideration.

(1) The traffic volume of the back road will exceed 20,000 vehicles a day in the future, but as four lanes have been secured, the present capacity of the road will fully be able to meet the above traffic volume. Therefore, it is possible to transfer the traffic volume from the beach road to the back road, and there will be no difficult problems concerning traffic control on the beach road as regards traffic volume.

(2) The road connecting Pattaya to Na Klua is over capacity as a result of using it as one of the access roads to Pattaya. In order to solve this problem, it is necessary to conduct the traffic from this road to the proposed main access road which directly connects with the back road. A concrete measure for this would be to remove the guide sign to Pattaya installed on the Sukhumivit Highway at present, and instead to install a guide sign to Pattaya in the neighborhood of the entrance of the new road. Further, it is advisable to prohibit the running of large-sized vehicles such as large trucks, buses, etc. on the road directly connecting Pattaya with Na Klua.

(3) As it can be seen from the comparison between Fig. 2.3.7 and Fig. 2.3.8, the traffic volume of the proposed main access road to the back road is expected to be reduced by 4,000 cars/day in 1986 to 8,000 to 9,000 cars/day, so that the over-capacity of the road connecting Pattaya to Na Klua will be reduced. Accordingly, in order to maintain the residential environment of the Na Klua area, it is recommended that this new road be constructed as soon as possible.



Existing Road at Na Klua

2.4 Road Design

2.4.1 Outline

This section describes the technical explanation of the road network plan proposed in Section 2.3 for each road referring to 1/2000 topographic maps, and a summary of the road design on the basis of cost estimation with economic and financial considerations.

The roads herein referred mean the arterial tourism road as shown in Fig. 2.4.1, and include Tourism roads (T-1 and T-2) mainly for tourism access from the Sukhumvit Highway, the park street (T-4 the pedestrian and bicycle road) therefore, the tourism access road (T-5) having the function of a tourism road, but low in road standards, and the main residential road (R-1) and the Collector street (R-2) are mainly provided for linking the various sections of the residential area.

The road network in Pattaya is arranged by effectively utilizing the existing roads so as to economize on construction costs. In the proposed design outline, such utilization is fully taken into consideration, on the basis of which an examination of the geometric design and road structure has been performed so that many troubles occurring on the existing roads can be eliminated and safe and smooth driving conditions will be provided as well as meeting traffic demand.

2.4.2 Design Criteria

The geometric design of this plan is based on AASHO standards, and made also with reference to the "The Standards of Highway Structure of The Japan Highway Association" as the occasion demands.

(a) <u>Design Speed</u>

As stated previously, the designed road network of the study area is composed of one for tourism (T-1, T-2 and T-5) another one for service to the residents (R-1, R-2 and R-2').

Table 2.4.1 <u>Design Speed</u>

Area	Road division		Design Speed
Tourism	Arterial Tourism Road	T-1	80 km/h
	Tourism Road	T-2	80
	Tourism Access Street	T-5	40
Residential	Main Residential Road	R-1	60 km/h
	Collector Street	R-2	40
	Collector Street	R-2'	40

As given in the above Table 2.4.1, the design speed of the respective roads is set taking into account their characteristics and functions.

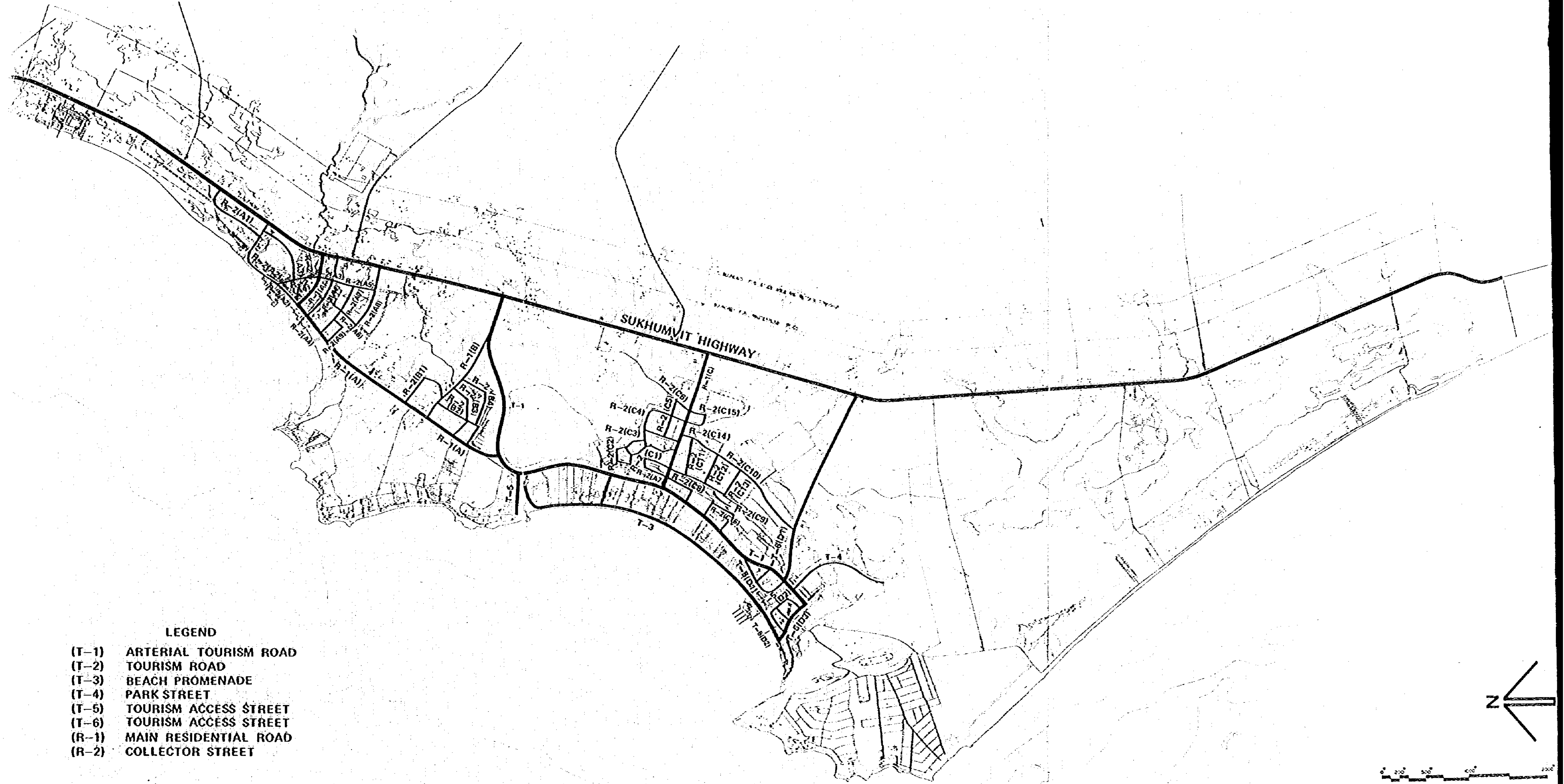


FIG 2.4.1 PROPOSED ROAD CLASSIFICATION

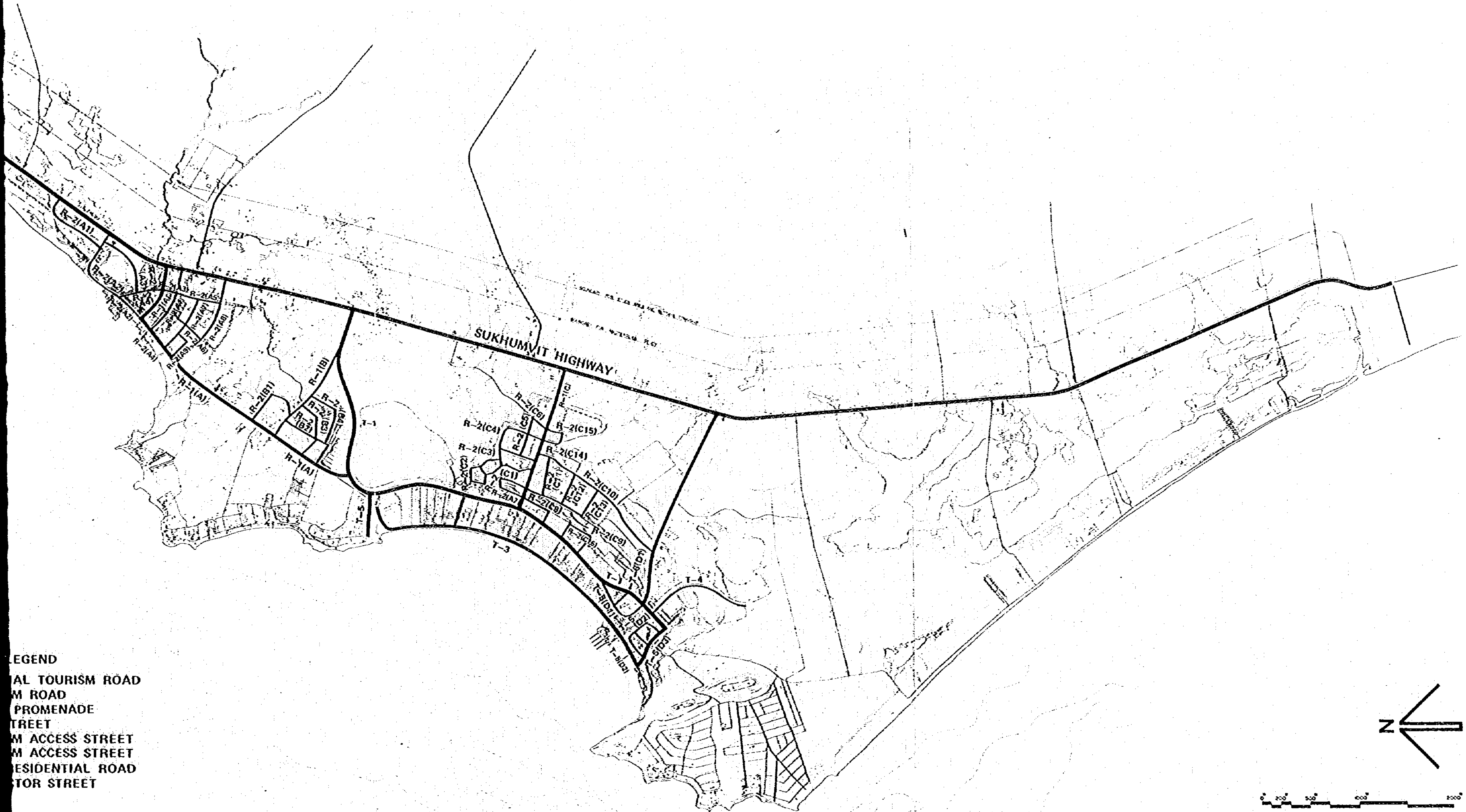


FIG 2.4.1 PROPOSED ROAD CLASSIFICATION

(b) Component of Cross Section in Width and Cross Slope

1) Cross section in width: (See Fig. 2.4.2)

The components of the cross sections in the widths of each of the roads are set as given in Table 2.4.2 for the following reasons.

- Since the inflow of large-sized vehicles to the respective roads is considered to be not great in view of their character, the width of road is determined as 3.50 m maximum (T-1), and 3.25 m or 3.00 m corresponding to the type of the road.
- For the purpose of excluding through-traffic on R-2, the width of the road is 3.00 m without a shoulder; this component of the cross sectional width is lower than the standard.
- R-2' is the same in terms of road character as R-2, but R-2' being located in a commercial area, a lower traffic capacity (congestion) due to on-street parking, etc. should be taken into consideration; therefore, the construction of a shoulder is included in the planning of the cross sectional width as the same as R-1.

Table 2.4.2 Component of Cross Section in Width

Road division		No. of lane	Width of lane	Width of shoulder
T	T-1	4 (separated)	3.50	2.50
	T-2	2	3.25	2.50
	T-5	2	3.25	2.25
R	R-1	2	3.25	2.25
	R-2	2	3.00	0
	R-2'	2	3.25	2.25

2) Cross slope

ASSHO specifies that the cross slope of a street or road shall be 1.5 to 3.0%. (Surface Type ∿ Intermediate)
Since the study area is a located in a heavy rain forest zone, the cross slope of the street or road is determined as 2.5% taking into account surface drainage. With regard to the cross slope of the shoulder, it is considered that there are not many cases of on-shoulder parking on the arterial tourism road (T-1) and the tourism road (T-2) in view of their road characteristics, and there are many cases of on-shoulder parking on the main residential road and the main collector streets. Therefore, the cross slopes of the respective roads are determined as follows:

T-1 and T-2 : 5.0%

R-1, R-2, R-2', etc.: 2.5%

TYPICAL CROSS SECTION

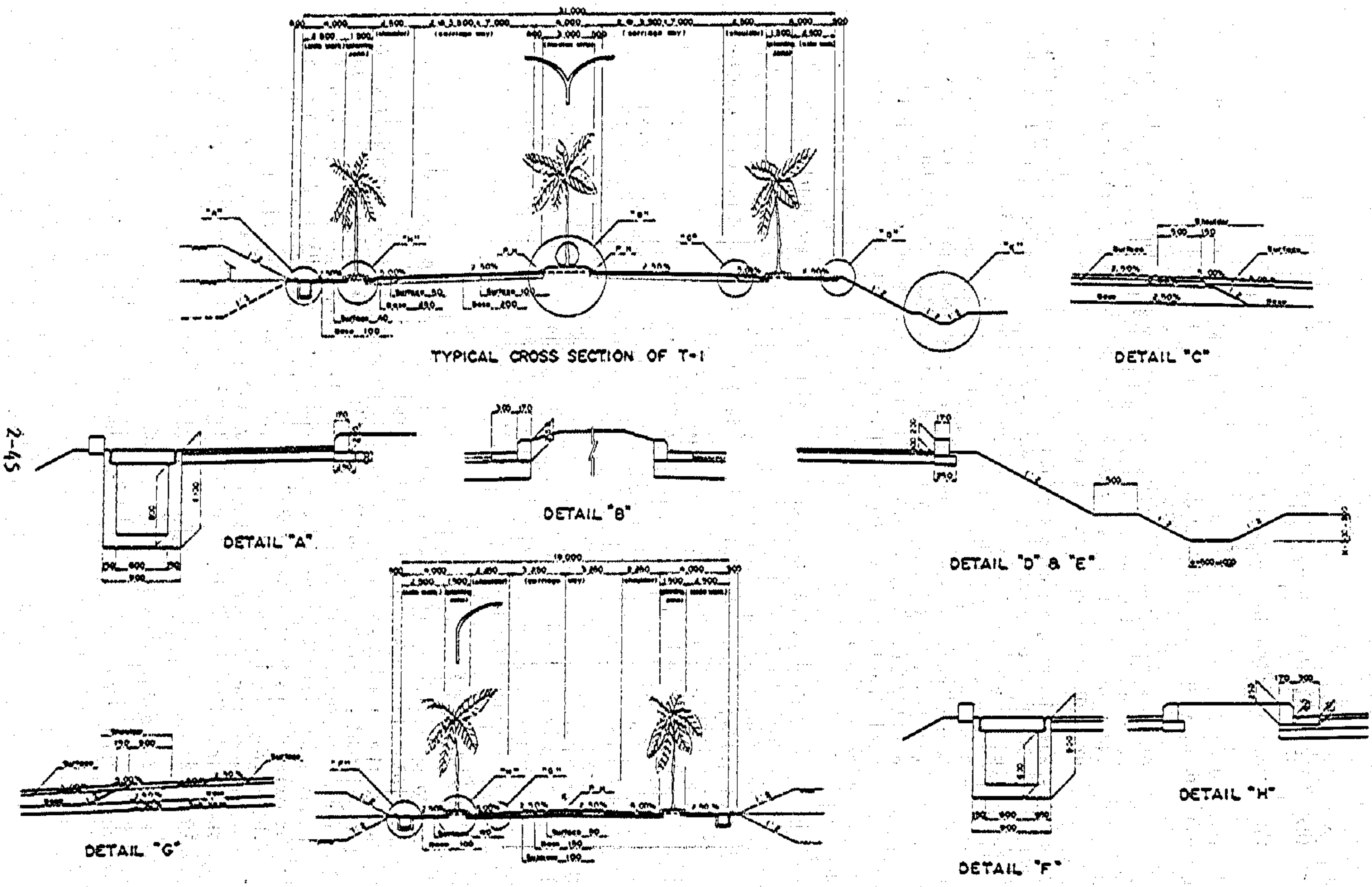


Fig. 2.4.2(1) Typical Cross Section

TYPICAL CROSS SECTION

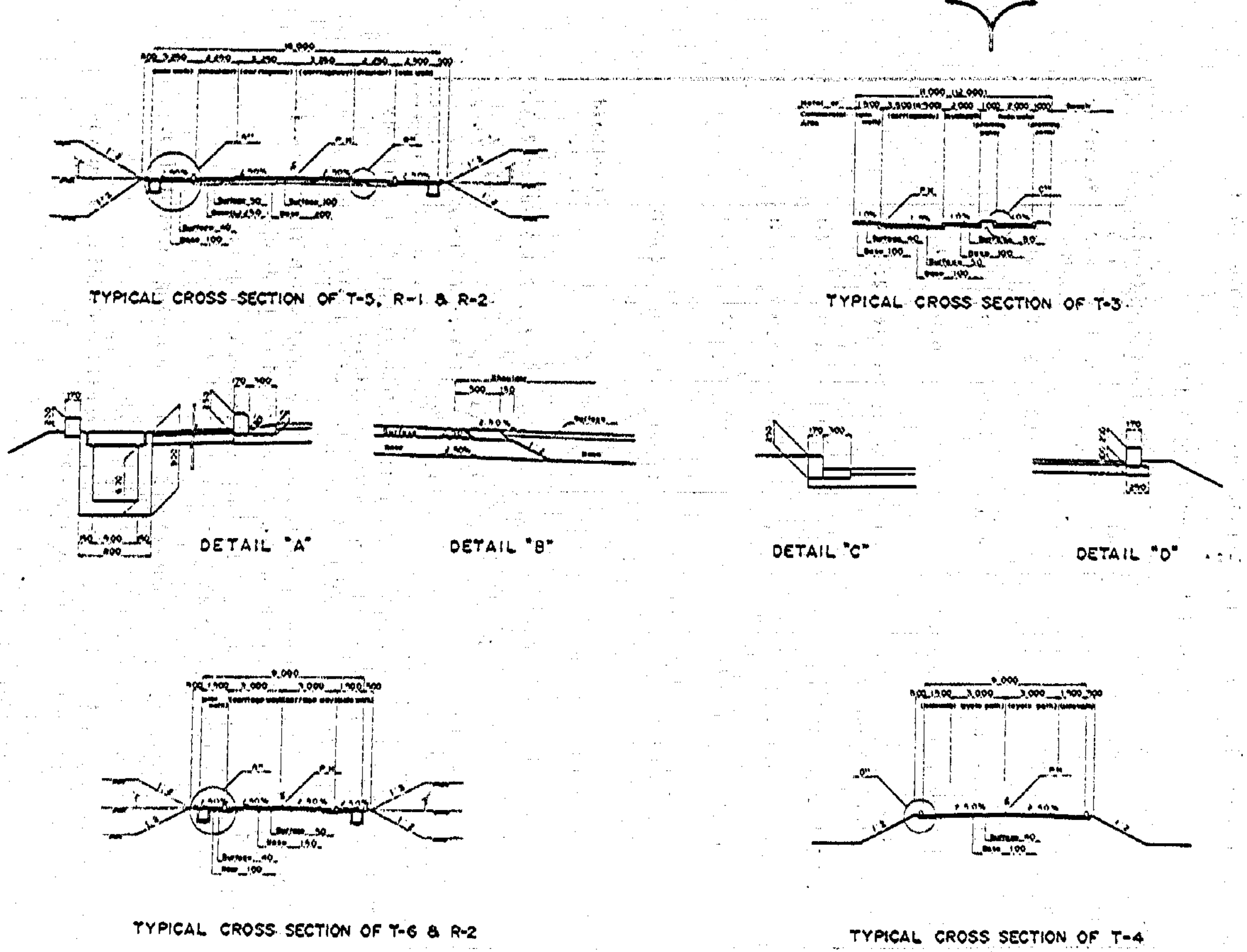


Fig. 2.4.2(2) Typical Cross Section

(c) Criteria of Alignment

The criteria of alignment in this study are given in Table 2.4.3.

Table 2.4.3 Design Criteria

Item	Unit	Design Criteria			
		T-1 T-2	R-1	T-5 R-2 R-2'	Remarks
Terrain	-	FLAT	FLAT	FLAT	
Design speed	km/h	80	60	40	
Maximum superelevation	%	6.0	6.0	6.0	
Value of superelevation	%	Refer to Fig. 2.4.3			
Minimum Radius	m	260	140	60	
Maximum gradient	%	4.0	5.0	7.0	
Stopping sight distance	m	110	90	70	
Minimum radius for curve not requiring transition curve	m	(2,000)	(1,000)	(500)	
Transition curve	m	$\frac{R}{3} \leq A \leq R$			Clothoid curve
Minimum vertical curve length	m	Refer to Fig. 2.4.5 Table 2.4.5			
Superelevation run-off rate	-	1/150(i) or 1/200(ii)	1/175	(1/100)	(i) 4 Lanes (ii) 2 Lanes

Note: Inside ( ) are the figures followed the standards of Highway Structure of the Japan Highway Association.

1) Maximum superelevation and minimum radius of curvature

In this study, a maximum superlevation of 6% is used which is the maximum value of superelevation in urban areas according to AASHO.

This value is determined due to the chracteristics of the roads in urban areas, and taking into account the following.

- The problems on many intersections and stopping of vehicles.
- The problem of the use of roadsides, etc.

When the maximum superelevation is given, the minimum radius of curvature will be found using the following formula.

$$R \geq \frac{V^2}{127\ (f + e)}$$

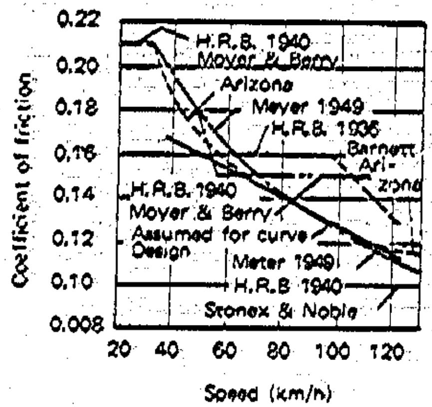


Fig. 2.4.4 Coefficient of Friction

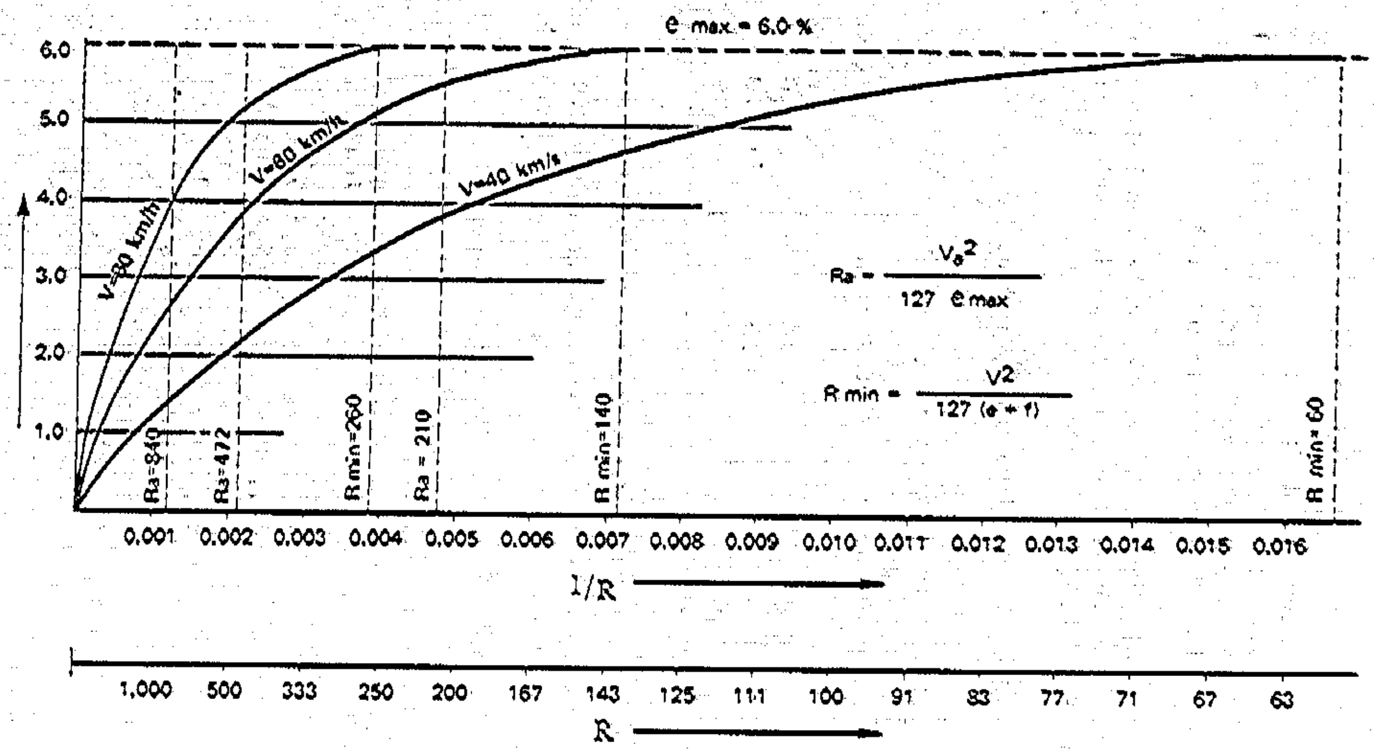


Fig. 2.4.3 Radius of Curvature and Superelevation

Where V: Design speed (km/h)
f: Coefficient of friction (See Fig. 2.4.4)
e: Max. superelevation (%)
R: Min. radius of curvature (m)

The minimum radius of curvature and the relation between the radius of curvature and the superelevation are shown in each design speed in Table 2.4.4 and Fig. 2.4.3.

Table 2.4.4 Minimum Radius of Curvature

Design speed V(km/h)	Max. superelevation e	Coefficient of friction f	$R = \frac{V^2}{127(f+e)}$	R min
80	0.06	0.14	252.0	260
60	0.06	0.15	135.0	140
40	0.06	0.165	56.0	60

2) Vertical curve

The vertical curve is determined referring to Table 2.4.5 and Fig. 2.4.5.

Table 2.4.5 Vertical Curve

Design speed	Radius		Absolute mix. value
	Crest vertical curve	Sag vertical curve	
80 mph (129 km/h)	40,000 ft (12,200 m)	18,500 ft (5,600 m)	240 ft (73 m)
75 (121)	32,500 (9,900)	16,000 (4,900)	225 (69)
70 (113)	25,500 (7,800)	14,500 (4,400)	210 (64)
65 (105)	21,500 (6,600)	13,000 (4,000)	195 (59)
60 (97)	16,000 (4,900)	10,500 (3,200)	180 (55)
50 (80)	8,500 (2,600)	7,500 (2,300)	150 (46)
40 (64)	5,500 (1,700)	5,500 (1,700)	120 (37)
30 (49)	2,800 (900)	3,500 (1,100)	90 (27)

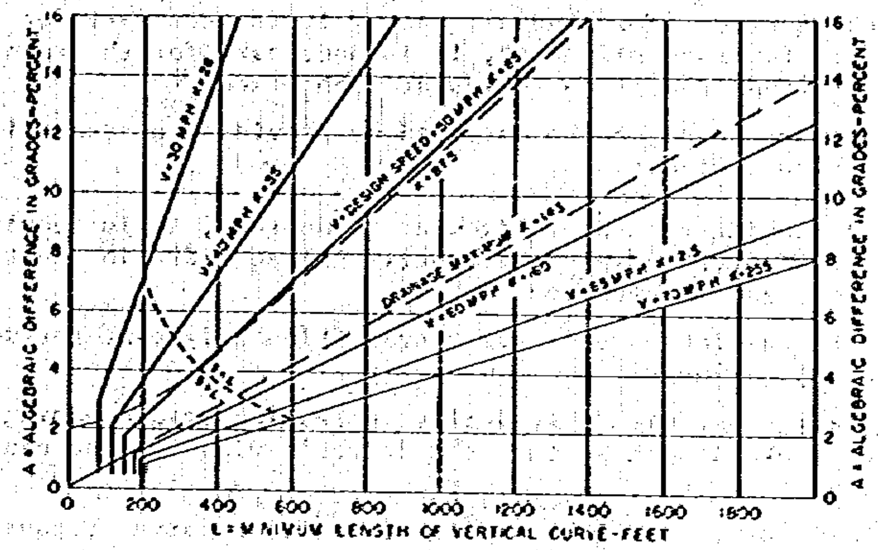
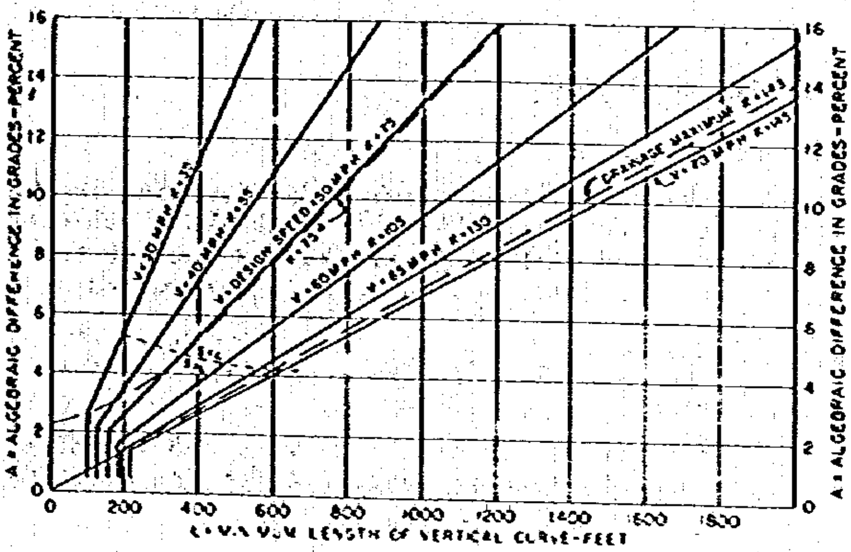


Fig. 2.4.5(1) Design Controls for Crest Vertical Curves



Based on Desirable Stopping Sight Distance

Fig. 2.4.5(2) Design Controls for Sag Vertical Curves

3) Transition curve

In order to be able to drive smoothly on the transition part from the straight line section and the circular curve section, or from circular curve sections to different curvatures, gradually changing curvatures have to be considered. For road alignment, it is necessary for consideration. For road alignment, it is necessary for the running of vehicles to provide transition curves at such places.

The following advantages can be obtained by providing a transition curve to the transition sections.

- When running from one alignment to another, it is required for the curve to make the centrifugal acceleration continuously increase or decrease.
- The transition curve makes a transition alignment for superelevation run-off.
- The alignment with a gradually increasing or decreasing curvature looks smooth so that the driver's visual sense can be eased.

Clothoid curves shall be used as transition curves because a Clothoid curve is a curve of locus when a vehicle is running at a constant angle of acceleration.

(d) Planning of Pavement

The planning of the pavement is made for each road division according to "Thickness Design" by the Asphalt Institute Manual Series No. 1 (MS-1), 1970.

1) Setting of design conditions

(1) Design load

The thickness of the pavement is determined according to the traffic volume of large-sized vehicles, but the large-sezed vehicles in the study area are concerned with large trucks and tourist buses, so that the upper limit of their design load is determined as follows:

- Single axle load limit: 10 ton
- Average gross weight : 20 ton

For reference, the limit values of the large-sized vehicles in foreign countries are as given in Table 2.4.6. (As of 1970)

Table 2.4.6 Limit Values of Large-Sized Vehicles in Foreign Countries (As of 1970)

Limit value / Countries	Length (m)				Width	Height	Axle weight (t)		Vehicle gross weight (t)				Remarks
	Single car		Trailer						Single car		Trailer		
	2-axle car	3-axle car	Semi-trailer	Full-trailer	(m)	(m)	Single axle	Tandem	2-axle car	3-axle car	Semi-trailer	Full-trailer	
International Road Traffic Treaty	10	11	14	18	2.5	3.8	8	14.5	22.5	22.5	32	36	Joined in 1964.
E.E.C (Australia) (1965.4)	12	12	15	18	2.5	4.0	10 13	16 19	16 19	22 26	38	38	Draft A, Draft B (Output is more than 5PS/t or more.)
West Germany	12	12	15	18	2.5	4.0	10 13	16 21	16 19	22 26	36~38	38	Only Saar district
France	11 12	11 12	15	18	2.5	–	13	21	19	26	35	35	Exception
U. K.	11	11	15	18	2.5	4.6	9~11	16~18	14~16	20~28	20~32	32	
Italy	10	11	14	18	2.5	4.0	10	14.5	14	18	28~32	–	
U. S. A.	12.2	12.2	16.8	19.8	2.59	4.12	9.08	14.5	12.7	18.2	21.8 ~32.7	39.3	Output is 5.5PS/t or more (AASHO)
Japan	12	12	25	25	2.5	3.5	10	20	20	20	–	–	The control on the length of coupled cars is according to Low of Road Traffic

(2) Design traffic volume

Designing of pavement is made based on the results of traffic analysis for 1986 which is described in section 2.3.
The forecasts of traffic volume and the inflow rate of large-sized truck are estimated in section 2.3.

(3) Bearing ratio of subgrade soil

The bearing capacity of subgrade soil is judged by the value of CBR, and estimated according to the "Subsoil Investigation for Pattaya Tourism Development Project, No. 77", which was made in 1976 by the survey team.

(4) Pavement disregarding large-sized vehicles

In case of the collector street (R-2) or the pedestrian and bicycle road, low cost pavement is used.

2) Planning of pavements

(1) The tourism road (T-1. and T-2) and the main residential road (R-1)

The coefficients of relative strength (TA) calculated for each road division are given in Table 2.4.7.

Table 2.4.7 Calculated TA

Road division	ADT cars/day	A (%)	B (%)	NHT cars/day	DTN cars/day	CBR (%)	TA (cm)
T-1	22,500	3	45	310	520	10	20
T-2	4,000	4	50	80	130	15	16
R-1	11,500	5	50	290	480	10	20

Where ADT: Average daily traffic volume in the year designed (cars/day)

A: Average inflow rate of large-sized vehicles (%)

B: Inflow rate of large-sized vehicles for the designed lane (%)

NHT: Number of large-sized vehicles for the year designed

$$(NHT = ADT \times \frac{A}{100} \times \frac{B}{100})$$

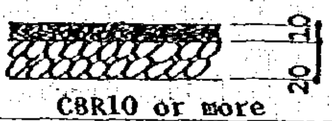
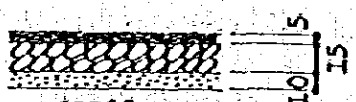
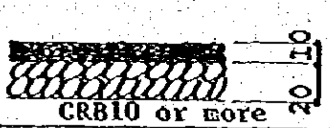
DTN: The design traffic number (cars/day)

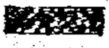
TA: Coefficient of relative strength

(This indicates the required thickness when all the pavements are made with hot-laid asphalt mixture for the surface.)

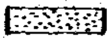
The structure of pavement determined for each road division from the calculated required TA is as shown in Table 2.4.8.

Table 2.4.8 Typical Pavement Section

Road Division	Typical Pavement Section	Check of TA
T-1	 CBR10 or more	TA = 20 ≤ $10 + \frac{20}{2.0} = 20$ cm
T-2	 CBR15 or more	TA = 16 ≤ $5 + \frac{15}{2.0} + \frac{10}{2.7} = 16.2$ cm
R-1	 CRB10 or more	TA = 20 ≤ $10 + \frac{20}{2.0} = 20$ cm

 Surface

 Base Course (High Quality)

 Subbase Course (Low Quality)

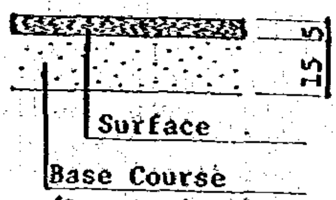
However, the untreated granular bases used in Table 2.4.8 must meet the following requirements.

Test	Test Requirements	
	Low-Quality TA=1/2.0	High-Quality TA=1/2.7
CBR, minimum or	20	100
R-value, minimum	55	80
Liquid limit, maximum	25	25
Plasticity index, maximum	6	NP
Sand equivalent, minimum	25	50
Passing No. 200 sieve, maximum	12	7

(2) Collector street (R-2) and the pedestrain and bicycle road

Collector street (R-2) are in a residential area, and as a matter of course, the through-traffic of large vehicles, should be excluded; in order to ensure safety, the DTN given in Fig. 2.4.6 is to be light traffic of less than 10 and the section of pavement is as shown below.

Collector street



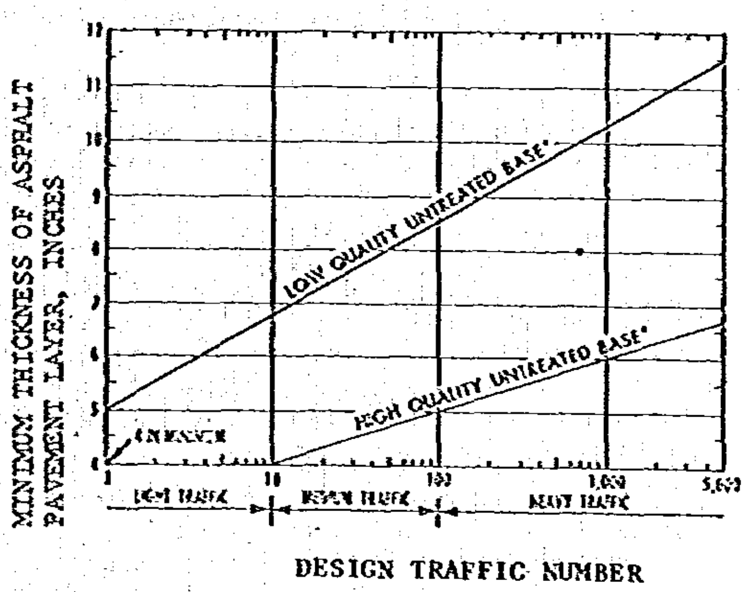
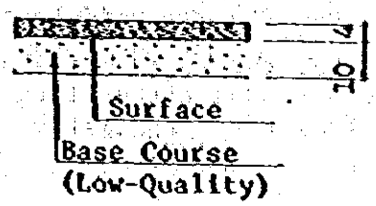


Fig. 2.4.6 ______ thickness of asphalt pavement layers over untreated granular bases

The pedestrian and bicycle road is to be determined with a maximum thickness of surface and base course, and the section of pavement is as shown below.

Pedestrian and bicycle road



2.4.3 Plan and Profile

Plan and profile designs are to be made for each road division with the arrangement of the road network set in section 2.3.

Moreover, the road drainage design to keep the road in a good condition will be also examined in 2.4.3 (b).

(a) Design of Alignment

As the alignment of a road is foundamental to its design and the execution of work, it is necessary to carefully take into account and design the various aspects of road design and work execution. Concurrently, the safety, comfort and efficiency of driving greatly depends on the alignment of the road itself, so that examining of the alignment of the road itself, so that examining of the alignment of the road is very important. The fundamental items in road alignment design are listed as follows.

- Safety and comfort of driving in view of kinematical dynamics or mechanics.
- Being satisfactory in view of the sense of sight or perception.
- Keeping harmony with the environment and scenery.
- Economically being reasonable in view of the topographical considerations.

The investigation of the designed road division is as given in Tables 2.4.9. Regarding the road network, refer to the figures as well. The outline of the road divisions is described below.

(1) Arterial tourism road (T-1)

Arterial tourism road (T-1) is a major road connecting the Sukhumvit Highway to the Pattaya beach area.

It is divided into the new access part between the Sukhumvit Highway and the back road (STA0 to STA21), and the back road (STA21 to STA49) in the hotel area. For the planning control, attention was paid to the following points.

a. Primary concern with visual conditions by providing the area as a whole with sufficient alignment in order to make T-1 into an arterial road for tourism.

b. Consideration of environmental harmony in the access road area by separating it by 100m from the Na Klua Residential Area B to the arterial tourism road.

c. Preparation of a plan which would allow the existing roads to be utilized as much as possible and ensure that the proposed expansion of the back road takes place on the inland side instead ot on the existing hotel side to keep adverse effects to the minimum.

For vertical control, attention was paid to the following points.

a. It is desirable that for the residential area of Na Klua Town B adjacent to the access road a cut section of road may be used in view of environmental aspects especially noise control.

Table 2.4.9 (1) Total Length in Each Area

Area	Total Road Length	Road Nos.
Tourism	12,492 m	10
Na Klua	14,541	19
New Town	10,604	17
Total	37,637	46

Table 2.4.9 (2) Total Length in Road Divisions

	Length
T-1	5,959m
T-2	2,325
T-4	1,200
T-5	1,895
T-6	1,113
R-1	6,376
R-2	17,431
R-2'	1,348
Total	37,637

Table 2.4.9 (3) Total Length of Proposed Road

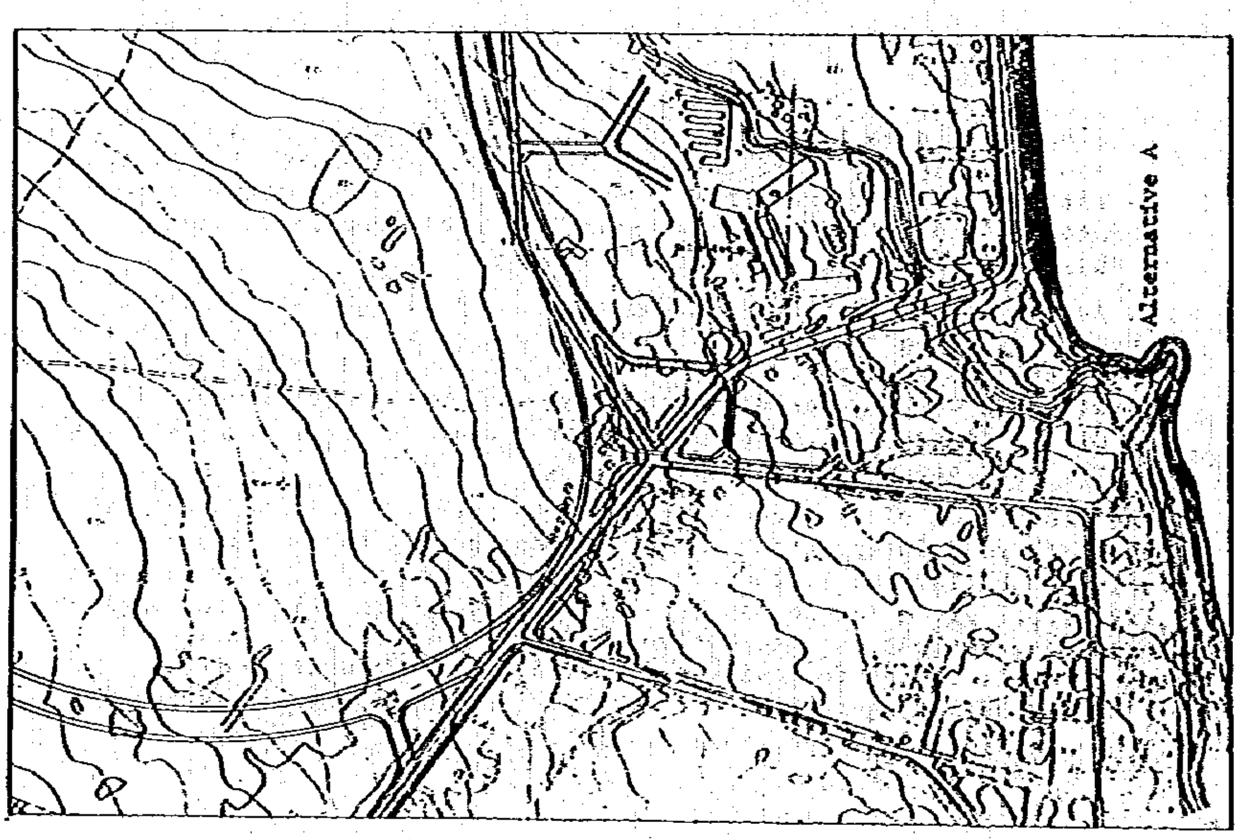
Tourism Area		Na Klua A & B		Northern New Town	
Road Name	Length	Road Name	Length	Road Name	Length
T-1	5,959 m	R-1(A)	3,520 m	R-1(C)	1,626 m
T-2	2,325	R-1(B)	1,230	R-2(C_1)	854
T-4	1,200	R-2(A_1)	813	(C_2)	495
T-5	470	(A_2)	956	(C_3)	170
T-5(D_1)	485	(A_3)	693	(C_4)	1,063
(D_2)	405	(A_4)	469	(C_5)	430
(D_3)	535	(A_5)	463	(C_6)	183
T-6(D_1)	220	(A_6)	470	(C_7)	687
(D_2)	700	(A_7)	660	(C_8)	460
(D_3)	193	(A_8)	704	(C_9)	670
		(A_9)	351	(C_{10})	1,700
		R-2(B_1)	690	(C_{11})	428
		(B_2)	815	(C_{12})	363
		(B_3)	679	(C_{13})	323
		(B_4)	680	(C_{14})	295
		R-2'(A_1)	749	(C_{15})	166
		(A_2)	314	(C_{16})	691
		(A_3)	144		
		(A_5)	141		

Since that area is located on a hill with a height of about 40 m above sea level, where tourists can see an extensive view of the Pattaya area for the first time, the aspects of scenery and road economy should be given high priority. Therefore, the plan was based on the topography there.

b. As the back road (Arterial Tourism Road T-1) intersects with the many existing roads, the planning was done in accordance with the existing topography. Also the road was designed in coordination with the storm water drainage so as not to flood the road. The discharge terminal of the storm water drainage will be linked with the main storm water drainage system.

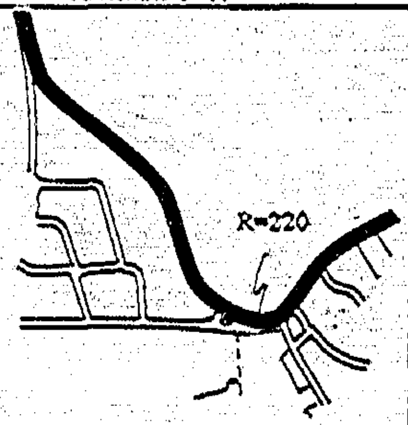
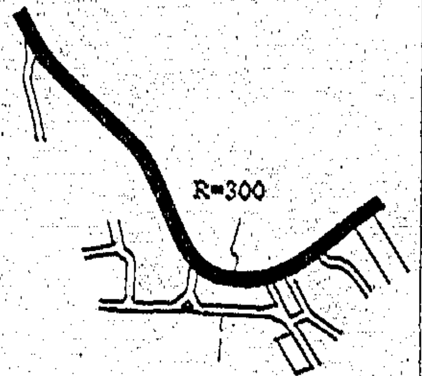
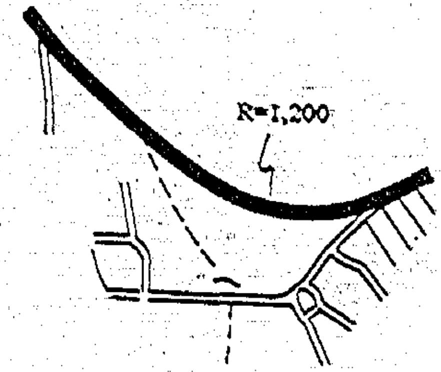
The connection of the access area of the arterial tourism area with the back road intersects with R-1 (A) connecting the Na Klua area with the Pattaya area; the traffic there is heavy. If alternative A Fig. 2.4.7 given in the master plan is used, there will occur various problems, so that an alternative study has been carried out.
As a result of the following evaluation, it is determined that planning according to alternative B is more appropriate. (which is shown in Fig. 2.4.7 and Table 2.4.10).

Alternative B



Alternative A

Table 2.4.10 Alternative Plan

Item	Alternative A	Alternative B	Alternative C
Sketches			
Features	This is recommended in the master plan.	This is an alternative in which the horizontal alignment is improved to simplify the intersections.	This is an alternative in which the horizontal alignment is determined approximately at R = 1,200m so that the whole of T-1 is well balanced and also the length of the road can be shortened.
Alignment	This is not so much recommended due to the need to secure the horizontal alignment corresponding to a design speed of 80 km/h. However, in a special case, the neighborhood of intersection, R = 220m can also be applied as an alternate radius.	Compared with alternative A, this is excellent in respect of the geometric design.	This alternative is most superior to the other alternatives.
Intersection and service ability	The intersection with R-1 (A) is near that of T-5, and also there is an existing road near the intersection, so that the intersections will become complicated and the traffic capacity on T-1 will be reduced.	R-1 (A) is a main residential road connecting Na Klua and Pattaya carrying heavy traffic. The complicated intersections around T-5 are simplified by separation of those intersections and the reduced traffic capacity will considerably be improved.	In the case of T-1, a smooth and direct access service to the hotel area is obtained, but T-1 cannot be used for access to the amenity area.
Safety	Due to the lack of proper horizontal alignment on the T-1 curving portion and having a complicated intersection, traffic safety will be lowered.	This alternative is superior to alternative A because of improvement of the alignment and simplification of the intersection.	Same as alternative B.
Landuse	This alternative is the most suitable in respect of the existing landuse.	By shifting the radius curvature away from R-1, extraland will be created where the landmark identification will be situated for the northern core.	A considerably large parcel of land will be produced, but the land will be considered unnecessary and, furthermore, the valuable conserved high land will be divided.

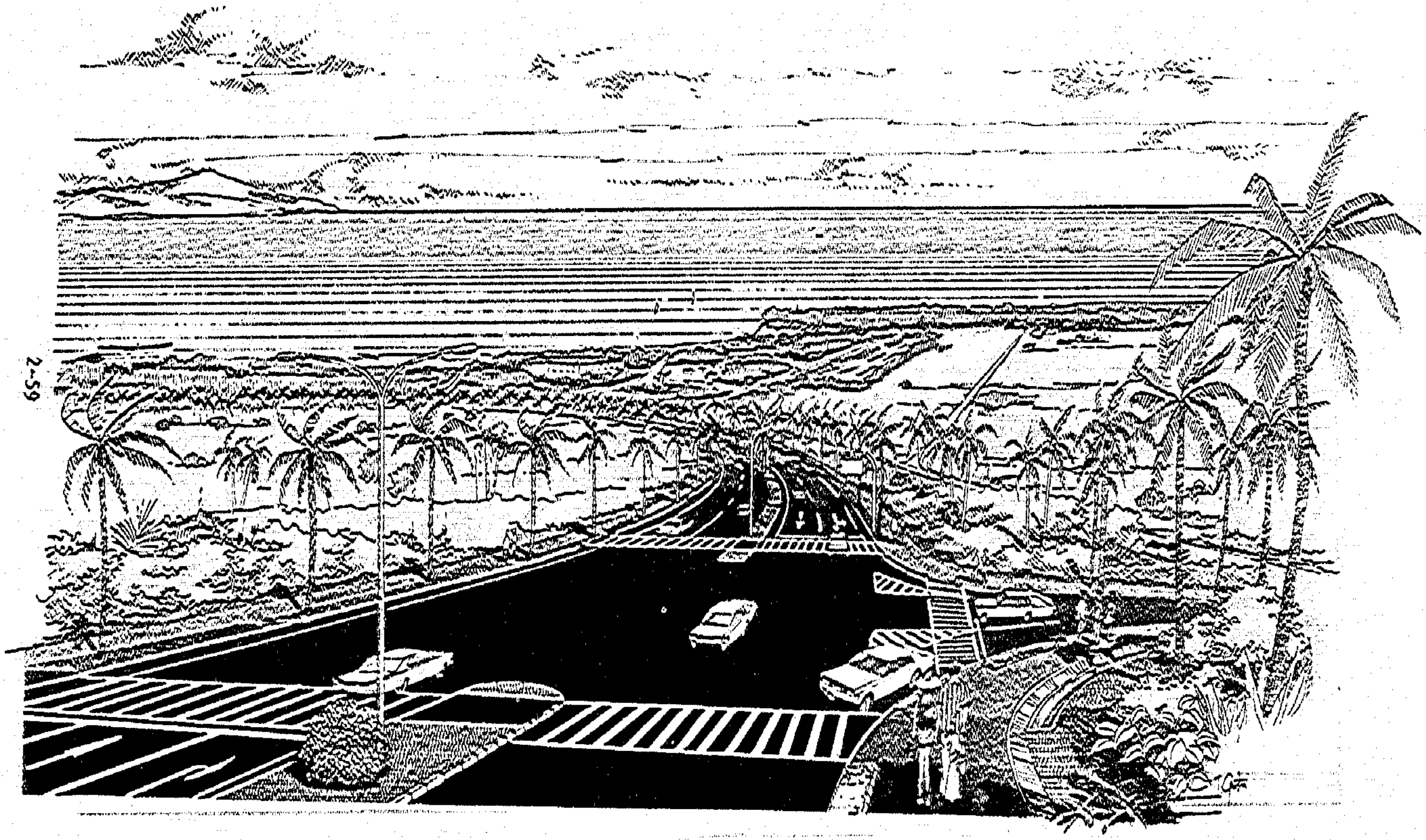


Fig. 2.4.8 Arterial Tourism Road

(2) Tourism road (T-2)

The tourism road (T-2) is one of the arterial tourism roads, which links to T-1 from the Sukhumvit Highway and forms a loop system. It utilizes the present route because the vertical and horizontal alignments are considered proper with slight modifications provided. The vertical alignment has been designed considering the storm water drainage canal near STA.2 and STA.5+40m as the control points.

(3) Main residential road (R-1)

The main residential road (R-1) is a residential road which controls regional traffic. Since the R-1 road planned in Pattaya will be of an arrangement utilizing effectively the existing roads, the road network basically is determined accordingly and the implementation will be carried out by slight modification of the roads. Particularly since there are many houses along the roadside of R-1, adverse effects on the residents in the case of implementation should be maintained at a minimum.

(4) Collector street (R-2)

Collector street (R-2) is a collector road in the residential area mainly linked with the main residential road (R-1). Since R-2 consists of continuous narrow street entrances and exits and the distance between interesections is short, it is not necessary to provide very smooth driving conditions with efficient alignment to provide uninterrupted flow. The same thing can be said from the sense of excluding through traffic. Therefore, alignment of R-2 has been designed based on economic considerations being the main aim. The vertical alignment has been particularly designed so as to promptly take care of the drainage of storm water in the residential area.

(5) Tourism access street (T-5)

Although the road characteristics differ from R-2, the functions are the same as R-2 and it has been planned in accordance with R-2.

(b) Drainage Plan

Generally, road damage is often caused directly and indirectly by rainwater. Drainage of roads is an important factor for maintaining roads in good condition.

(1) Design conditions

a. The rainfall intensity is shown in Fig. 2.4.9.

b. Maximum rainfall for design (Return period in years)

- Surface drainage once for 2 years
- Adjacent area drainage once for 5 years

c. Duration of rainfall

- Surface drainage 10 minutes
- Area adjacent to roads In accordance with "Kerby's formula."

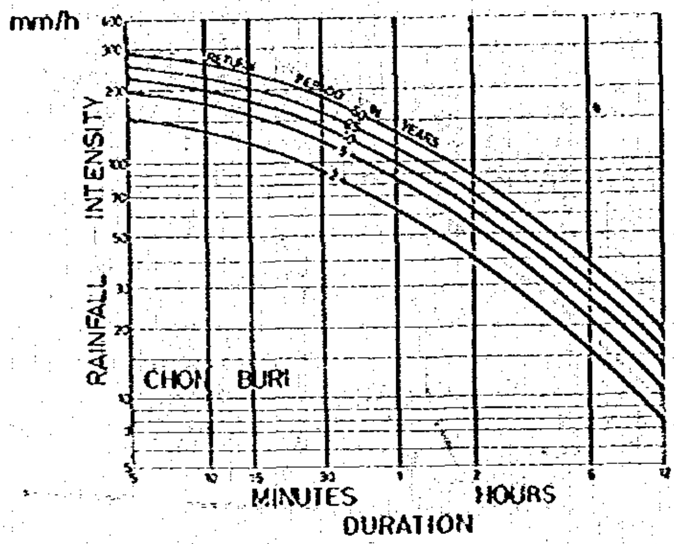


Fig. 2.4.9 Rainfall Intensity in Chonburi

d. Run-off is calculated by the "Rational Formula."

$$Q = \frac{1}{3.6} C. I. A.$$

Road Surface: C = 0.9
developed Area C = 0.5
undeveloped Area C = 0.2

whereas, Q : Run-off (m^3/sec)
C : Run-off coefficient
I : Rainfall intensity within duration period (mm/hr)
A : Catchment area (Km^2)

e. The flow velocity is calculated by "Manning's formula".

$$V = \frac{1}{n} R^{2/3} i^{1/2}$$

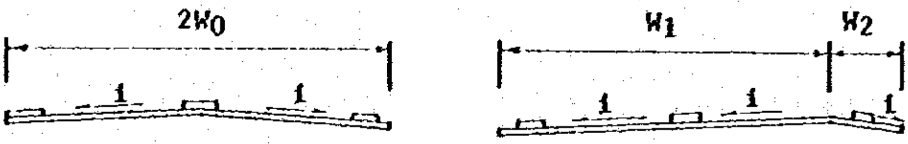
whereas, V : Flow velocity (m/sec)
n : Manning's coefficient of roughness
R : Wetted perimeter (m)
i : Gradient

f. The maximum allowable discharge volume shall be 80% of the discharge capacity.

(2) Types of drainage of road surface and adjacent area to road

a. For surface drainage, utilize the L-type side elevated section of the shoulder and median, secure openings on the median and L-type side elevated sections at points where the capacity exceeds the discharge and perform drainage by guiding the water to the gutter which has been designed at the sidewalk end.
The catchment area of the road is classified as below according to the general section (up grades from both portal sections) and superelevation section.

Cross Slope and Catchment Area of Road



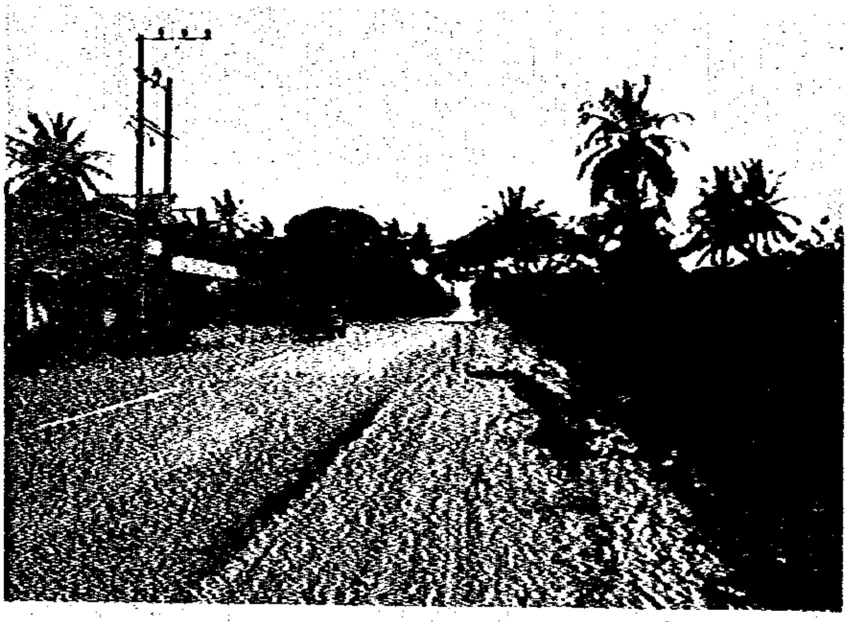
Cross Slope and Width of Road

Road Type	W0	W1	W2
T-1	15.50 M	25.00 M	6.00 M
T-2	9.50	13.25	5.75
R-1, R-2', T-5	8.00	11.75	4.25
R-2, T-4, T-6	4.50	7.50	1.50

b. Drainage of rainwater from adjacent areas shall not be planned to flow into gutters but shall flow into open channels.

c. A pipe of ϕ1,000 mm shall be used when crossing the road.

The Drainage system of this area which takes into consideration the above-mentioned aspects is shown in Fig. 2.4.10. Furthermore, the drainage capacity of the shoulder section, gutter, open channel and crossing pipe are shown in Fig. 2.4.11.



Typical Road Shoulder of Existing Road

FIG 2.4.10 DRAINAGE SYSTEM ALONG ROAD AND STRE

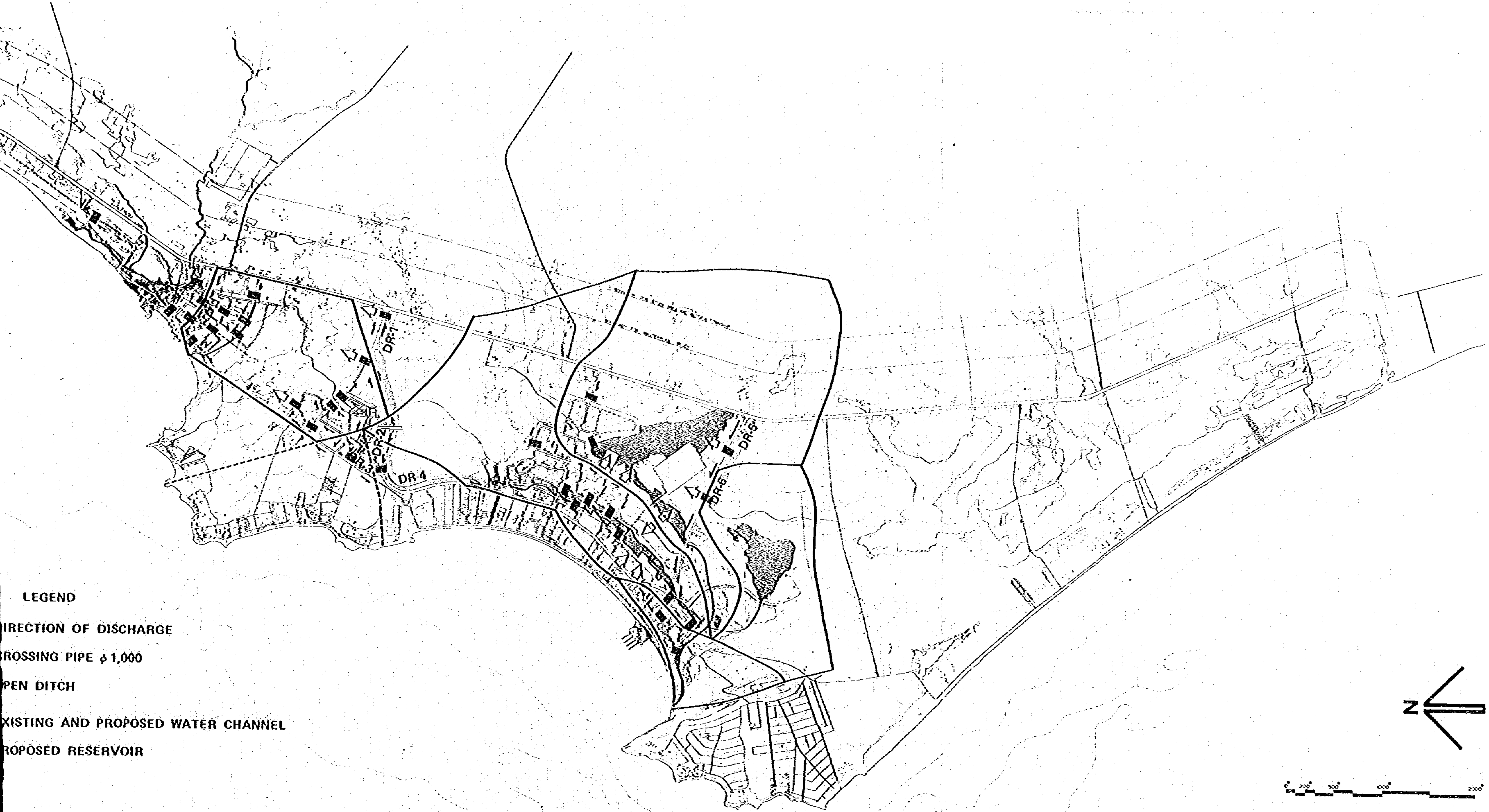
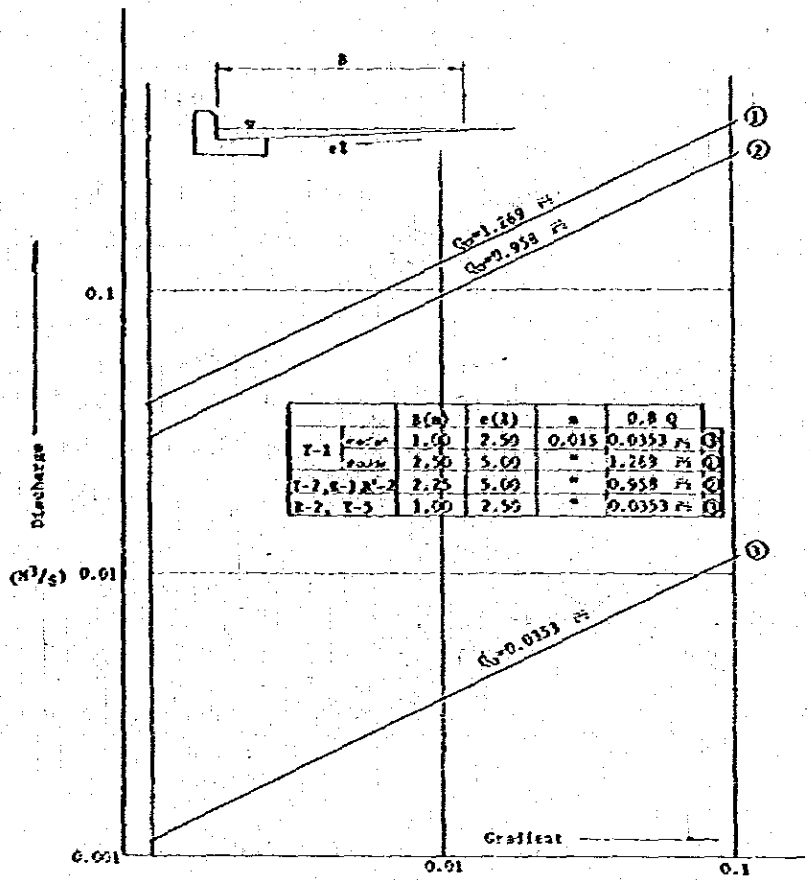
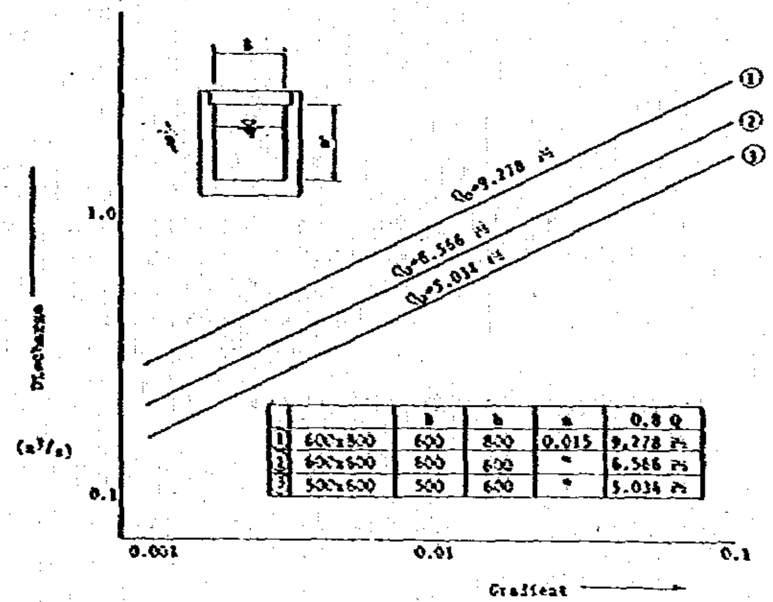


FIG 2.4.10 DRAINAGE SYSTEM ALONG ROAD AND STREET



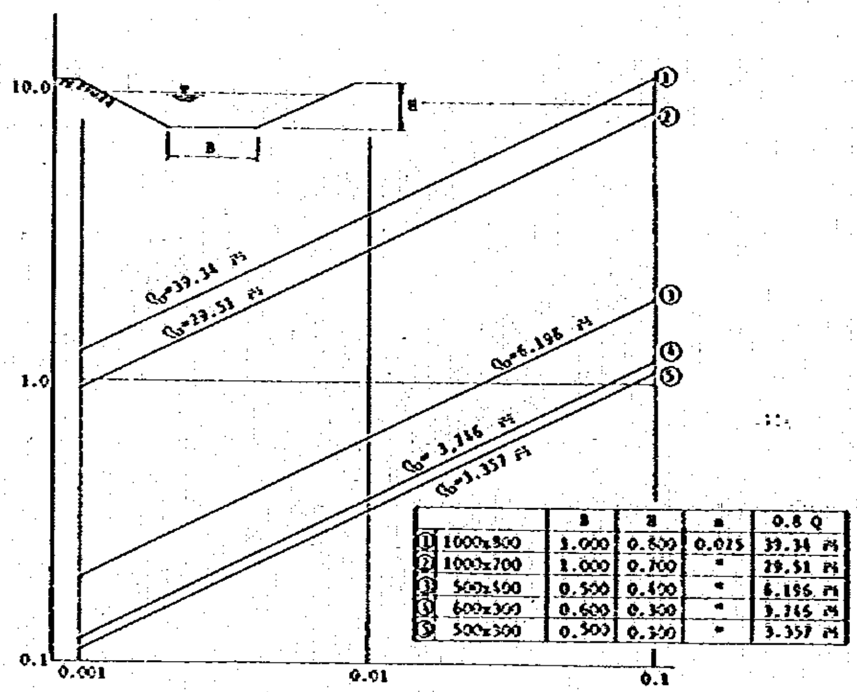
		B(m)	e(%)	n	0.8 Q	
Y-1		1.00	2.50	0.015	0.0353	③
		2.50	5.00	"	1.269	①
Y-2, K-1 K'-2		2.25	5.00	"	0.958	②
K-2, Y-5		1.00	2.50	"	0.0353	③

Fig. 2.4.11(1) Surface Discharge



		B	h	n	0.8 Q
1	600x800	600	800	0.015	9.278
2	600x600	600	600	"	6.566
3	500x600	500	600	"	5.034

Fig. 2.4.11(2) Discharge Capacity of Concrete Channel



	B	H	n	0.8 Q
① 1000x800	1.000	0.800	0.025	39.34 m³/s
② 1000x700	1.000	0.700	"	29.51 m³/s
③ 500x400	0.500	0.400	"	6.196 m³/s
④ 600x300	0.600	0.300	"	3.765 m³/s
⑤ 500x300	0.500	0.300	"	3.357 m³/s

Fig. 2.4.11(3) Discharge Capacity of Open Ditch

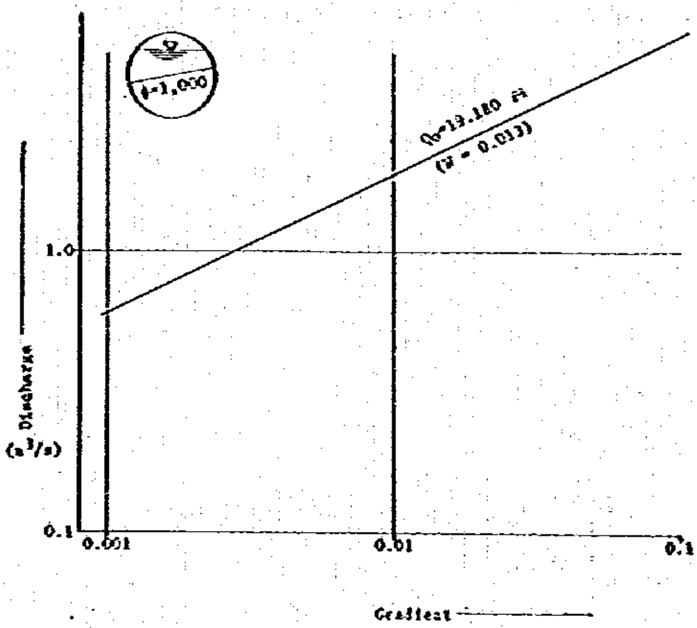


Fig. 2.4.11(4) Discharge Capacity of Pipe (φ1,000)