KINGDOM OF THAILAND

FEASIBILITY REPORT

ON

BANGKOK-THONBURI BRIDGE NO. 1 PROJECT

(APPENDIX)

TRAFFIC FORECAST BETWEEN BANGKOK AND THONBURI

IN 1975 AND 1990

OCT. 1968

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

CONTENTS

CHAPTER I

FORECAST OF TRAFFIC BETWEEN BANGKOK AND THONBURI

Section 1. Method of Traffic Forecasting

In formulating a proper traffic plan, it is first necessary to estimate the anticipated traffic volume in a proper manner.

Basic data such as OD tables (origin and distination tables), economic statistics and a road improvement plan are necessary for estimating properly the amount of future traffic, but they are completely insufficient at present. For this reason, traffic forecasting in this report has relied largely on our assumption. It will be desirable to make an accurate forecast after conducting a series of a proper traffic survey and making a traffic plan at an early date. We are obliged to forecast traffic with rather insufficient data under the following procedure.

An OD survey, which is performed to determine the movement of vehicular traffic, serves as an important basis to forecast the anticipated volume of traffic. In this survey, all the movements of normal daily vehicular traffic have been checked taking into consideration the type of vehicles, origin, destination, travel time, purpose of travel, load, etc.

However, since no vehicle OD survey has ever been conducted in Bangkok, we had no choice but to rely on the person trip survey on bus passengers conducted in 1965 by the Ministry of Transportation, Thailand, which seems the only available survey.

This survey is rather incomplete for person trip survey, because the purpose of trip was limited only to daily commutation and persons surveyed for the most part were government office people. The data,therefore, was considered not reliable, but we had to consider the OD table as a vehicle OD distribution.

In order to convert this bus passenger OD table to a vehicle OD table, we have multiplied the bus passenger OD table by the ratio of the number of vehicles crossing the Chao Phya River to the number of bus passengers crossing the Chao Phya River. In other words, a vehicle OD distribution is assumed to show substantially the same pattern as that in bus passenger OD table, and the volume of vehicular traffic crossing the Chao Phya River has been adjusted to correspond to actual traffic observations.

The future trips generated by each zone, which is necessary as part of the data to caluculate the future vehicle OD table, has been estimated by multiplying the present trips generated by each zone obtained from the OD table by the rate of population increase in each zone.

For an accurate and proper forecast of trips generated by each zone, it is essential that a regression formula is obtained by adjusting the present trips generated by each zone derived from the OD survey to economic factors of each zone, such as population, number of workers, products, and sales. Applied to the future values of economic factors anticipated from the city planning to this formula, the future trips generated by each zone can be forecast.

While it is necessary to know economic statistics of each zone and city planning, we have relied upon population data only, the most fundamental of the economic statistics, because we were not able to obtain other useful informations. The anticipated volume of the population has not been found from the city planning but from a simple presumption.

On the other hand, we have figured out the total trips of anticipated vehicular traffic in Bangkok and Thonburi by the number of trips per vehicle and anticipated vehicle registrations reported by Dr. Gun Nagamati, Deputy Director General, Department of Road Transportation, Ministry of Communication, Thailand. From the present vehicle OD table and the present total vehicle registrations, we have now calculated the number of trips per vehicle.

In order to properly forecast the volume of future vehicle traffic, we must accurately estimate the anticipated vehicle registrations. In this case, it is desirable to predict the future vehicle registrations by each vehicle type for the reason that both vehicle registrations and the trips vary with the type of vehicle.

The future traffic distribution has been predicted from the above anticipated trips generated by each zone and the total trips using the Entropy method.

It will be necessary to estimate traffic assignment by assigning the anticipated traffic throughout the road network. The road network in which traffic is to be assigned has been considered herein to consist of the existing roadways, the proposed Bangkok-Thonburi bridges and their access roads, for we know little or nothing of future road plan. It should be noted, however, that we have taken into consideration a probable increase in street width.

It will be appreciated that future road traffic cannot be forecast without considering a certain road network. In order to determine whether such a road plan is quite proper or not, it would be an idea to assign OD traffic to some conceivable road network, so that a reliable and accurate selection of a proper road network can be made.

Years predicated are 1975, a few years after the proposed bridges are scheduled to be constructed, and 1990, when the current Bangkok city planning is expected to be completed.

Traffic assignment for 1975 has been arranged for two cases with and without incorporating the proposed Bangkok-Thonburi bridges and their access roads. This is for comparing the former with the latter, in order that the benefits expected from the proposed bridge can be estimated. This comparison is attempted in CHAPTER 2 "Benefit of the Project".

Fig. 1-1 is the flow diagram showing the method of estimating the anticipated traffic between Bangkok and Thonburi.

Most of the data necessary to forecast the anticipated traffic in such a manner as above have been compiled from other data or our assumptions.

Various data for necessary traffic forecasting are herein given for your ready reference :

(1) Present vehicle OD table

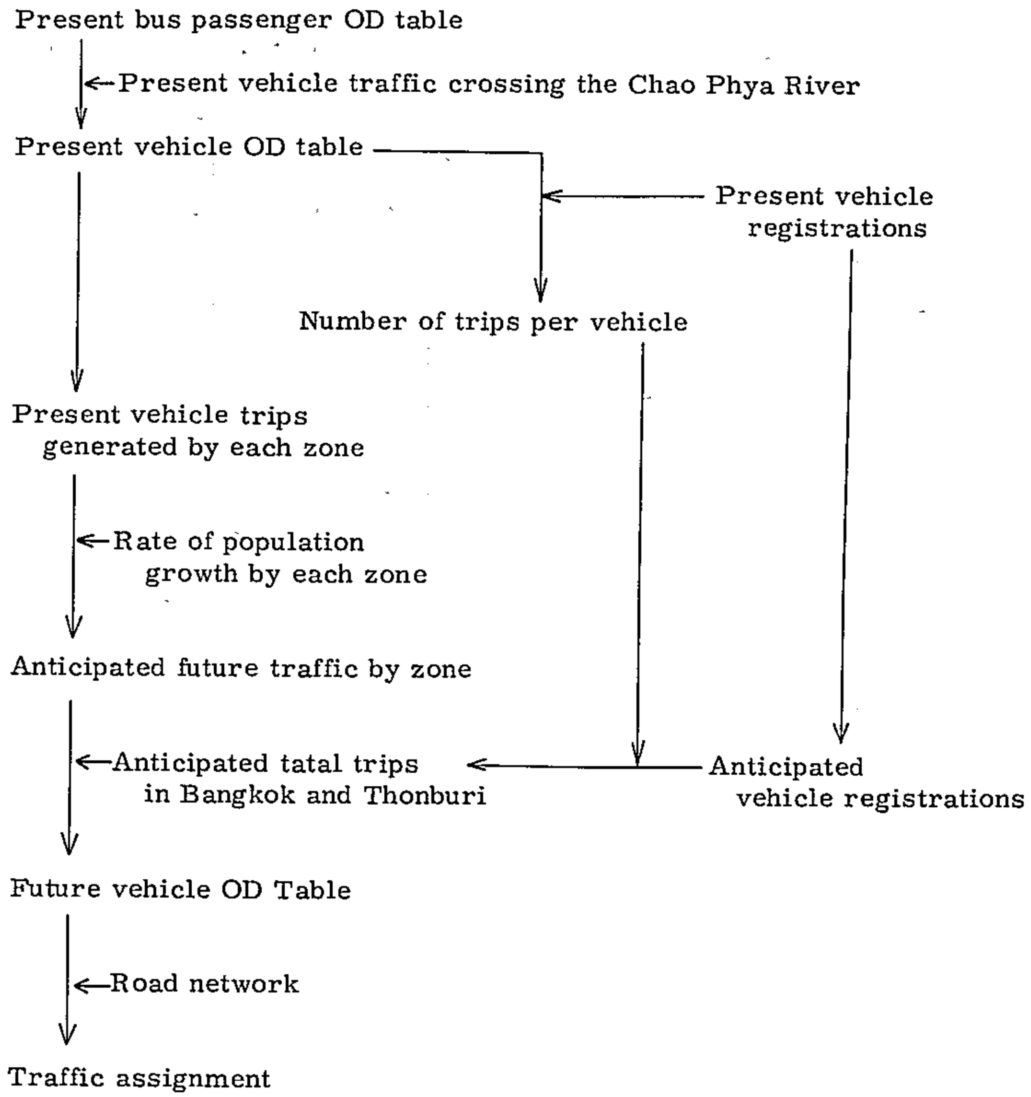
(2) Present and future economic factors of each zone

(3) Future vehicle registrations by type

(4) Future road networks

In order to make results of forecast highly reliable and trustworthy, we feel it will be necessary to re-estimate anticipated traffic volume by performing a more extensive survey and having a new city planning laid out.

Fig. 1-1 Flow Diagram for Traffic Forecast Between Bangkok and Thonburi.



Section 2 Estimated Area and Zoning

Bangkok and Thonburi are two different cities, but they can be considered one and the same city, as they form the nucleus of the Metropolitan area. Therefore, the areas to be estimated herein are Bangkok and Thonburi.

Bangkok and Thonburi, including their suburbs, were divided into 100 zones in the bus passenger OD survey conducted by the Department of Road Transportation, Ministry of Communications, Thailand, in 1965. However, this detailed zoning makes it impractical to provide economic statistics even on the population that serves as one of fundamental economic factors. The zoning for a bridge construction project can be somewhat rougher one. For convenience of predicting future traffic distribution, the zoning has been arranged in unit of Amphur. Amphur Dusit, however, was divided into two areas - one that uses the Krung Thon Bridge and the other the Rama VI Bridge. These two zones have been designated as Zone No. 5 and Zone No. 23.

Refer to table 2-1 and Fig. 2-1 for further information on zoning.

Table 2-1 Comparison of Zones for Forecast and Survey on Bus Passenger

Zone No. for Forecast	Zone Name	Zone No. for Survey on Bus Passenger	Zone Area
1	Bang Tanai	a part of No. 00	Pathum Thani Intersection
2	Bang Mai	a part of No. 20	Rangsit, Don Muang Curve
3	Pak Kred	a part of No. 00	Pathum Thani Intersection
		01	Pathum Thani Intersection along Tivanon Rd.
		02	Pak Kred, Pak Kred Orphan House, Dept. of Irrigation, Praja Song Krao School
		03	Chang Vattana Rd. between Pak Kred Intersection and Water Supply Cannal
		04	Tivanon Rd., Bang-Ka-So Tobacco Factory, International Transmitting Station, T. B. Hospital, Nonburi, Chit-Krai-Pet Street
		a part of No. 05	Ngam-Vong-Van Rd. Railway, Lad Yao Prison
		07	Nonburi Junction
		08	Chang Wat Nonburi, Bang Kwang Prison, Anusorn Vithaya School, Wat Nai Mah, Nonburi Municipal Office
		a part of No. 09	Along River Rd., Nothern Bangkok Tech. School, Pibul Songkran School, Nonburi Girl School, Nothern Bangkok Mech. School, Buri Rangsan Rd. Intersection
4	Bang Khen	a part of no. 05	Ngam-Vang-Van Rd. Reilway, Lad Yao Prison,
		a part of No. 20	Rangsit, Don Muang Curve
		21	Don Muang, Don Muang Market, Phumipol Hospital, Sai-Rup-Sook Rd., Air Force Task Force Hq.
		22	Lak See, Chang Vattana Rd. Water Supply Canal, Internatioanal Transmitting Station
		23	Wat Prasimahathat Area

4	Bang Khen	24	Ram Intra Rd., KM. 2 Army Security Hq, KM. 4 Army Security Hq, KM. 6 Army Security Hq.
		25	Chorke Bua, Sapan Yao, Setaboot School, Minburi
		26	Ram- In-Tra Rd. Intersection, Lam Nok Kwak, Lam Pak Chee Market, Nong Chok
		27	Bang Bua Market, 1st. Ordnance Corps, Tab Boh Aoopatum School, Army Dept. of Science, Dept. of Forestry, Bangkok Silk Mill
		28	University of Agriculture, Ngam Wang Wan Rd. Water Supply Cannal, Ponltny Feed Industry Dept., Ministry of Interior Training Center, Sena Nikon Rd., Satree Waranart School
		29	Lad Pron, Railway Housing
		a part of No. 41	Kuru Sapa Press, Lad Pron Bridge, Sapan Kien
		42	Northern Bus Terminal, Mor Suid Market, Transportation School, Vehicle Inspection Factory
		a part of No. 43	Pabol Yothum Yard, Wat Pai Tan
		a part of No. 44	Tao-Porn-Pem Sup Street, Bangkok-Nonburi Rd., Sian Cemut Co.
		49	Bagsue
5	Dusit	a part of No. 43	Pabol Yothum Yard, Wat Pai Tan
		47	Kiak Kai
		48	Sapan Dang
		a part of No. 49	Bangsue
		a part of No. 54	Makasan Railway Station, Makasan Railway Worker Village
		55	Pratunan
		56	Sisao Makasan
		57	Paya Thai Police Station, Yothi Rd., Women Hospital, Children Hospital, Pra Mongkut Hospital, Army Animal Dept.

5	Dusit	58	Rayathevi Aurupong King Petch
		a part of No. 59	Yos Se, Rong Muang, Chareon Pol, Railway Office
		60	Bang Kra Bue
		61	Nakorn Chaisee Rd.
		62	Ranong 1-2, Padispad
		63	Sapan Kwai, Bang Sue Police Station, Anti T.B. Society
		a part of No. 64	Intamara Rd. (Sai Suthisan)
		a part of No. 65	Hui Kwang
		a part of No. 66	Din Dang, Prom Pan School
		67	Victory Monument, Army T.V. (7) Station
		68	Sanam Pao
		69	Rajavat, Sooko Thai Soi 5, Provincial Electricity Authority, Army Supply Dept.
		70	Sansen, Sang Hee, Suan Sunanta
		71	Paruskwan Palace, Military Police Dept.
		72	Highway Dept., Sanan Na Nang Lerng, Chit Lada Palace
		a part of No. 73	Ministry of Agriculture, Ministry of Communication, Ministry of National Devel., Ministry of Education, Army Cadet School, Police Hq, Army Map. Dept., SEATO, Sala Santithan, Nang Lerng
		a part of No. 74	Bang Khun Prom, Pheves, Sisao
6	Bangkok-Noi	80	Rama 6 Bridge Thonburi Side, Bang Oar, Bang Plad, Krung Thon Bridge Junction
		81	Pron Krung Thon Bridge Junction, Thai Dredit Co., Wat Bang Yu Sai, Bang Khoon Non, Amphur Bangkok Noi, Fichai Junction
		a part of No. 82	Thonburi Railway Station, Siriray, Novy Dock Yard, Wat Aroom, Old Royal Palace, Bangkok Yai Police Station, Navy Police

6	Bangkok-Noi	a part of No. 83	Issara Phap Rd., Royal Engineer 1st. Division, Wat Chinoros, Thawithapisek School, Wat Mai Piren
		a part of No. 84	Southern Bus Terminal, Thonburi Electricity Organization, Bang Sao Thong, Wat Dee Duat, Pa Pra
7	Prana Korn	a part of No. 73	Ministry of Agriculture, Ministry of Communication, Ministry of National Devel., Ministry of Education, Army Cadet School, Police Hq., Army Map. Dept., SEATO, Sala Santithan, Nang Lerng
		a part of No. 74	Bang Khun Pron, Pherves, Sisao
		75	Sanam Luang, Bang Lanpoo , Ta Chang Wang Luang, Ta chang Wang Na, Ta Prachan, Ministry of Justice, Revenue Dept., Royal Grand Palace, Coin Mint., Money Dept., Public Relation Dept., Chana Songkran Polic Station, Thamasart University, Fine Arts Dept.
		a part of No. 76	Central Rajadamneon Ave., Democracy Monument, Samranros Police Station, Bangkok Municipality, Sao Ching Cha, Prison
		a part of No. 79	Grand Palace, Ministry of Commerce, Land Dept., Territorial Defence Dept. Tatian, Saranron Palace, Co-operative Dept.
8	Ponprab	a part of No. 73	Ministry of Agriculture, Ministry of Communication, Ministry of National Devel., Ministry of Education, Army Cadet School, Police Hq, Army Map Dept., SEATO, Sala Santithan, Nang Lerng
		a part of No. 76	Central Raja Ave., Democracy Monument, Sanranros Police Station, Bangkok Municipality, Sao Ching Cha, Prison
		77	22nd. July Circle, Plub Pla Chai Junction, Central Hospital, Warachak
9	Sampantawong	a pert of No. 36	Odeon, Wat Kao, Wat Patoon Kongka, Wat Trimit, Sipaya
		78	Wat Liap M.E.A. Office, Yanaray, Chalernkroong, Wang Burapa, Sanyod (Sapan Lek), Chareon Krung, Song Wad
10	Patumwan	a part of No. 38	Saladang, Chulalongkorn Hospital, Sarakit Street, Royal Sport Club
		a part of No. 39	Lum Pini, Withayu, Signal Corps(Army) , Pre-Military Cadet School
		a part of No. 50	Patum Wan, Samyan, Sapan Lung, Tobacco Monopoly Factory, Hua Lan Pong
		51	Chura

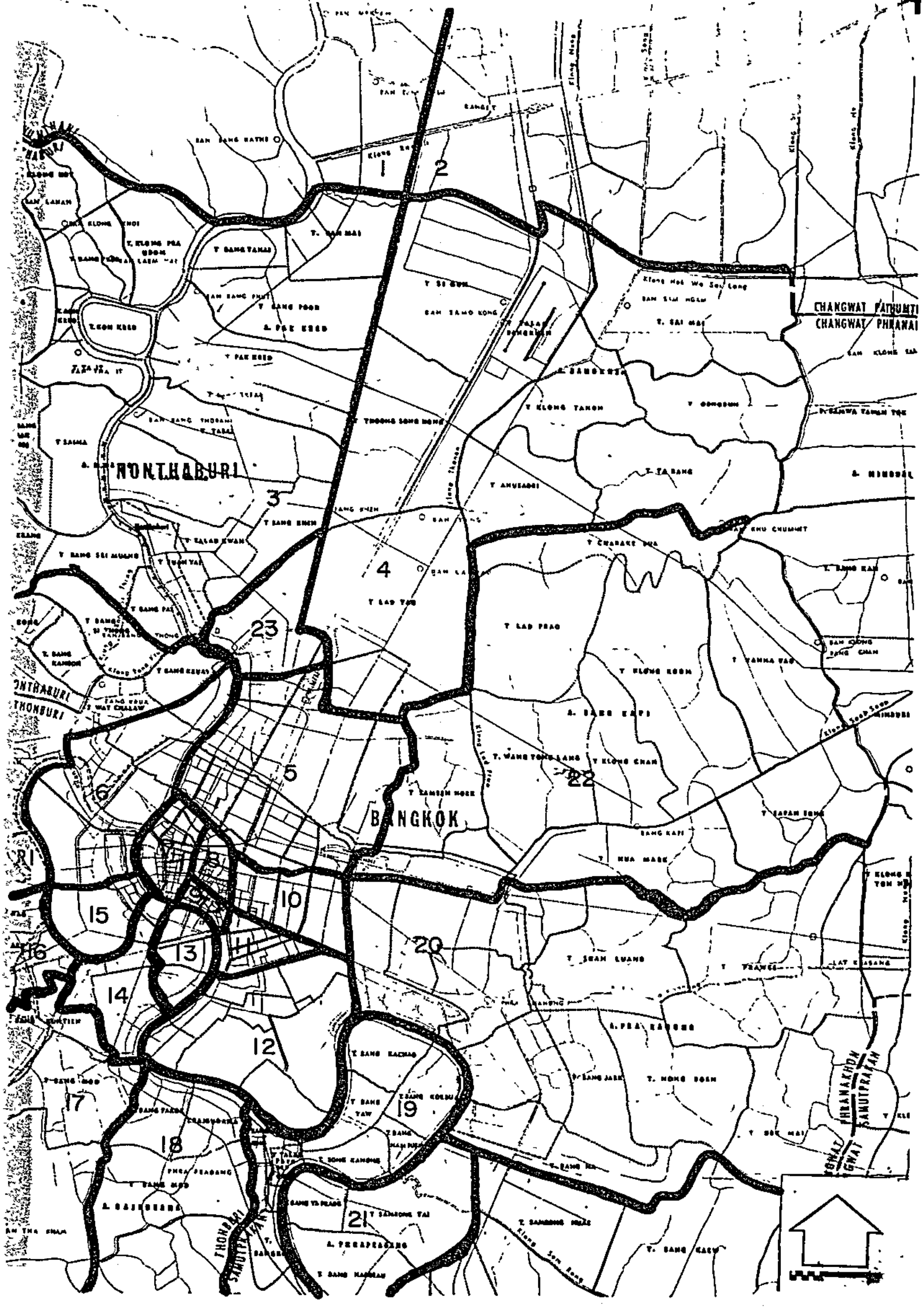
10	Patumwan	52	Police Dept., Royal Sport Club
		a part of No. 53	Rajaprasong, Plinchit, Nana North - South
11	Bang Rak	a part of No. 35	Tobacco Monopoly Factory, Yamawa, Satree See Suriyothai School, Kang Chang Satree School, Wat Don, Bangkok Dock Co.
		a part of No. 36	Odeon, Wat Kao, Wat Patoon Kongka, Wat Trimit, Sipaya
		37	Bang Rak, Silon, Naris Rd., Soi Sap, Surinong
		a part of No. 38	Saladang, Chulalongkorn Hospital, Sarakit Street, Royal Sport Club
12	Yanawa	30	Tanon Tok, Tambol Bangkor Lan, Wat Praya Krai Police Station, Trok Chan Intersection
		31	Trok Chan, Fish Industry Organization, Tonbol Bang Krong, Satu Pradit Rd. Intersection
		32	Chong Non See, Tonbol Pongpan
		a part of No. 33	Standard Vaeuun Oil Co., Phai Metal Industry Co., Shell Oil Co., Chong Non See Factory, Shell Aoopatun School
		34	Torng Maha Make, Technical Institute, Suan Ploo Rd., St. Louis Hospital
		a part of No. 35	Tobacco Monopoly Factory, Yanawa, Satree See Suriyothai School, Kang Chang Satree School, wat Don, Bangkok Dock Co.
13	Klongsarn	a part of No. 90	
		91	
		a part of No. 92	
		a part of No. 93	
14	Thonburi	a part of No. 85	
		a part of No. 86	
		a part of No. 90	
		a part of No. 92	
		a part of No. 93	
		a part of No. 95	
		a part of No. 96	

15	Bangkok-Yai	a part of No. 82	Thonburi Railway Station, Sirirat, Navy Dock Yard, Wat Aroon, Old Royal Palace, Bangkok Yai Police Station, Navy Police
		a part of No. 83	Isara Phap Rd., Royal Engineer 1st. Division, Wat Chinoros, Thawithapisek School, Wat Mai Piren
		a part of No. 84	Southern Bus Terminal, Thonburi Electricity Organization, Bang Sao Thong, Wat Dee Duat, Pa Pra
		a part of No. 85	
		a part of No. 86	
		a part of No. 87	
16	Pharsicharoen	a part of No. 87	
		88	
		89	
		94	
17	Bangkhunthien	a part of No. 95	
		a part of No. 96	
		a part of No. 97	
18	Rajburane	a part of No. 97	
		a part of No. 98	
		a part of No. 99	
19	Prapradong	a part of No. 98	
		a part of No. 99	
20	Prakanong	11	Bang Na, Navel Ordnance Dept., Battery Factory, Glass Factory, Plywood Factory, Seepamit Street, Roong Rueng Street, Sopon Street, Udom Sook Street, Poonavithi Street, Puengme Street
		12	Sai Thip Street, Run Prem Street, Kasan Suwan Street, Amphur Prakanong, Prakanong Police Station, Prakanong Market

20	Prakanong	a part of No. 13	Prakanong Klong Ton Rd., Rama 4 Junction, Wat Tat Tong
		14	Military Fuel Energy Dept., Tanning Factory, Kluey Nam Thai Rd.
		15	Ekamai Rd., Ekamai Rd., Charun Chai Rd., Sethaboat Rd., Tong Lor Rd., Paidee-Madee Rd., Soi Klong, Sang Mookda Rd.
		a part of No. 16	New Petehburi Extension Rd., Asoke Rd., Ekamai Rd.
		17	Pirom Rd., Meteological Dept., Sai Nam Thip Rd., Sai Nam Pueng Rd. Asoke Rd., Sang Chan Rd.
		18	Klong Toey Area
		19	Convent School, Custom Dept., Port Authority of Thailand
		a part of No. 33	Standard Vaeuum Oil Co., Phai Metal Industry Co., Shell Oil Co., Chong Non See Factory, Shell Aoopatum School
		a part of No. 39	Lumpini, Withayu, Signal Corps (Army), Pre-Militaly Cadet, School
		a part of No. 53	Pajaprasong, Plinachit, Nana North-South
21	Samrong Nua	10	Changwat Samut Prakarn, Navel Cadet Acedemy, Choraky, Prapradang Landing Rd., Leprosy Hospital, Santikan Street, Sanrong
22	Bang Kapi	a part of No. 13	Prakanong-Klongton Rd., Rama 4 Junction., Wat Tat Tong
		a part of No. 16	Asoke Rd., Ekamai Rd.
		40	Amphur Bang Kapi, Dom Sakae
		a part of No. 41	Kuru Sapa Press, Rapl Pron Bridge, Sapan Kein
		a part of No. 54	Makasan Railway Station, Makasan Railway Worker Village
		a part of No. 64	Intamara Rd., (Sai Suthisan)
		a part of No. 65	Hui Kwang
		a part of No. 66	Dim Dang, Pron Pan School
23	Bang Sue	a part of No. 06	Krung Thep - Nonburi Rd., Pibul Songkran Rd. Intersection, Wiriya Yothin School, Wat Tang Luang School

23	Bang Sue	a part of No.09	Along River Rd., Northern Bangkok Tech School, Pibul Songkran School, Nonburi Girl School, Northern Bangkok Mech. School, Buri Rangsan Rd. Intersection
		a part of No.44	Tao-Poon-Pen Sup Street, Bangkok-Nonburi Rd., Siam Cemut Co.
		45	Tao-Poon Intersection - Bang Po., Prajarai Wattaya School, Satree See Pichai School
		46	Bang Po., River Side- Rama 6 Bridge

FIG. 2 - 1 ZONING



Section 3 Forecast of Future Total Trips

As a preliminary to estimating the OD tables, it is necessary to predict the total future trips of vehicles in both Bangkok and Thonburi.

We have estimated the total future vehicle registrations in Bangkok and Thonburi from the mean rate of growth shown by the lines in Fig. 3-1, based on the estimation made by Dr. Gun Magamati, Deputy Director General, Department of Road Transportation, Ministry of Communications, Thailand. According to his estimation shown in Fig. 3-1, the anticipated number of vehicle registrations will be 493×10^3 vehicles and 731×10^3 vehicles in 1975 and 1990 respectively.

As will be described in Section 4, the trips of each vehicle are estimated to be 3.92. Assuming this figure remains unchanged in the future, the total trips of vehicles in Bangkok and Thonburi may be calculated as follows :

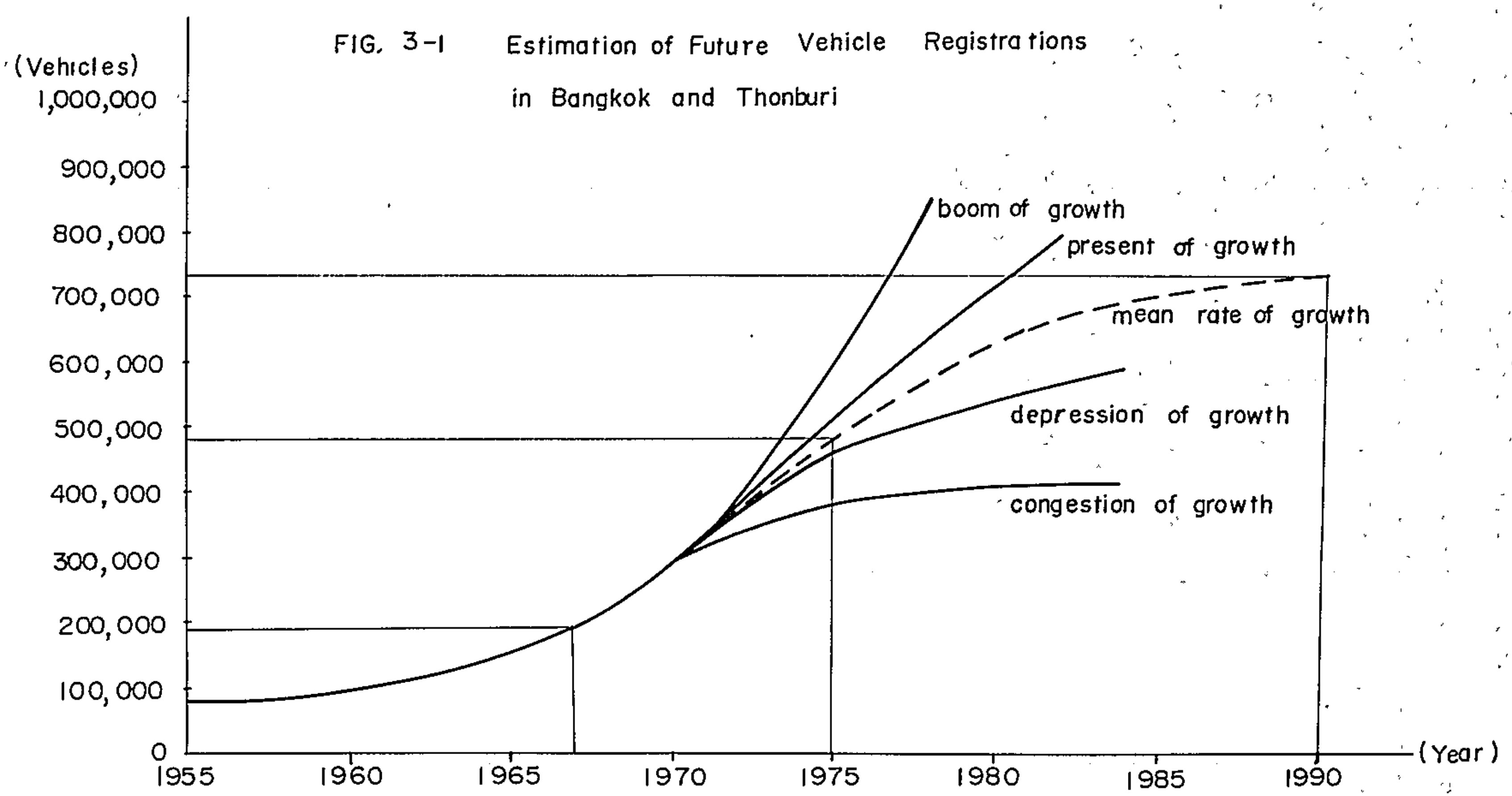
Year 1975

$$493^{(1,000\ \text{veh.})} \times 3.92^{(\text{trips/veh.})} = 1,933^{(1,000\ \text{trips})}$$

Year 1990

$$731^{(1,000\ \text{veh.})} \times 3.92^{(\text{trips/veh.})} = 2,866^{(1,000\ \text{trips})}$$

FIG. 3-1 Estimation of Future Vehicle Registrations in Bangkok and Thonburi



Section 4. Forecast of Anticipated Traffic Distribution

The present OD Table, which provides a basis for estimating the future traffic distribution, has been prepared on the basis of the bus passenger OD survey conducted by the Department of Road Transportation, Ministry of Communications, Thailand, in 1965. This OD table is shown in Table 4-1.

Because the survey was conducted only on from-home-to-office trips, the trip generations of each zone in this OD survey are considered to be roughly proportionate to the population, but the rate of the trip generation to the population in each zone as of 1965 is highly variable as shown in Table 4-2. We assume this is because the number of people sampled in each zone are not in proportion to the population in the same zone. Thus, in such zones as Nos. 16, 17 and 22, where the rate of trip generation is too large in comparison with the population, the trip generation of these zones have been revised to reflect the average rate of trip generation of other zones. With the above points in mind, the present bus passenger OD table has been prepared, as shown in Table 4-3.

Table 4-1 Bus Passenger OD Table

No. 1

O \ D	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
00					2				3	4		6						1		
01					12															
02					4				8	5		1					1	1		
03					1							1								
04			1					1	7	6										
05	1				1				5	1		1						1		
06					1		7	1	13	11		5							3	1
07					1				2	8										
08			6		10	1	1	6	57	19	1	11	3				1	1	3	3
09									4	10	1	2	2							1
10									1	6	167	598	347	3		8	1	6	9	14
11							1		1	2	9	333	26	34	5	22	3	25	8	10
12		1	2				1			4	17	167	66	96	10	81	2	50	14	11
13					1		1			2	4	20	19	32	7	40	4	24	4	7
14											1	2	4	10	1	21		1	5	7
15										4		3	9	26		31	1	16	7	
16												2	1	1		6	1	2	1	
17							1				1	3	2	14	1	10	2	13	6	10
18									1	5	1	23	7	12	5	7	2	15	13	29
19									1	1				1		1		1	4	4
20																		1		
21	1								4	6	1	3	5		1	9		4	3	
22									2											
23																		1		
24																				
25										1		5	1						1	

No. 2

O \ D	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
26												1	1							
27																				
28		1			2	2	6		11		1	11	2	1		4		2	3	4
29									1	3	2	2	3		1	1		1	2	3
30					1	1				6	1	3	1		3			1	5	6
31							1			3	2	3	5		2	2		3	13	8
32										1	1	3	1		4	1		1	2	3
33																				
34					1		3				3	3	4	2	5	4	2	3	19	8
35							3		2	2	12	17	8	2		9		5	23	10
36							1		1	3	2		3		1	2		2	2	2
37							1		1	1	4	12	5	2		4	2	5	9	5
38							1						1	1	1	1		3	5	2
39										8	2	1	12	3	1	5	7	6	42	9
40									1		1	7	2	1		6		2	3	3
41																				
42									1	2		1	1	1						
43									2									1	1	
44										1						1				1
45							13	1	7	8		1	2			2			2	
46			2				10		15	18		5	3		1	1			2	1
47					1				5	1						1		1		
48									1	3								2		
49			1		2		22	2	2	14	1	10	1	1		1	3	3	6	2
50			1		1				1	3	1	16	17	3	2	20	4	15	14	4
51											1	1	1	1		1	1	3		1
52							1						2	1		5		1	2	2
53										1		2	6	1		3		7	1	1
54										1	4	2	7	1		4	19	5	8	5
55							1			1		2	5	2		9	14	6	4	3
56			1				2			1		1				2			1	3
57									1	1	1	2	5			3	1	2	4	4
58			1						2	12	2	17	6	2	2	8	4	16	4	6
59							2		1	3	3	3	8	1		4	2	6	6	1

No. 3

O \ D	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
60			1				7	1	11	23	2	6	9	2	3	2	1	5	13	18
61										1		4			2	4	2	3	5	2
62			2				1		2	10	1	4	1	1	2	4	2	4	4	5
63							1		3	5	2	2	5		2	4	1	3	1	5
64			1				1		1	6	2	6	6	1	3	5	2	4	11	8
65			3				3		5	6	15	22	18	7	2	18	1	15	69	27
66			1				4			8		14	21	3		9	1	11	26	15
67							1		1	3		1	3			1		2	3	2
68										4	3	4	1			3	7		3	4
69					2		5		8	6	2	30	14		2	6	5	8	19	16
70			2		3		4	1	12	13	2	5	5		1	7	2	5	5	4
71							1			1		2	2			3		3	3	2
72										1					1	2		2		1
73							2	1	2			5	3	2		9		6	8	3
74			1				2		6	8		4	4	2		4	1	2	3	5
75			6		7	2	6	1	29	44	2	11	6	1		8	7	8	9	9
76					1		2			5	2	10	9	1	1	4	1	8	4	7
77													1			4			2	1
78										3	2	5	5		1	9		10	7	4
79									2	7	1	4	6			1		4	2	3
80							1		4	5			7		1	3		1	5	6
81					1		6		6	8	3	9	9	1	1	9	2	3	9	1
82							3	1	2	10	4	18	8		2	5	1	4	8	6
83					1							4	5			1		3	2	3
84							1		2	2	1	5	2			1		1	1	6
85					1	1			3	8		6	4		1	5	1	6	7	7
86					2	2	2		6	8	2	21	12	3	1	10	1	4	81	4
87							1		1	7		6	4	1			1	3	3	2
88								1	7	4		3	5	1		4	1	4	12	4
89										5		2			2	1		1		
90			3				7		2	12	5	23	26	5	1	13	1	7	31	11
91			2				2		2	7	11	9	14	1		11	3	6	16	11
92						1			2	3	1	2	2			1	1		2	3

No. 4

D / θ	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
93					1				1	4	1	6		1	1	2		1	5	3
94										1	2	2	4			1		1	2	
95			2			1	1		6	2	2	75	27	1	2	3	3	1	31	5
96									1	1		1	3		1	1	1		4	3
97						1	2			3	7	84	5						4	2
98			2			1				4	35	236	24	1	2	1		9	37	6
99											1	29	1							
Total		2	41		60	13	145	17	291	442	358	1,992	885	290	87	513	128	423	691	423

O \ D	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
00		27							2	1							1	3	1
01		1		2					1						1				1
02		8		1				2	1	1					8	2	1	2	2
03				1											1	1			
04										1					1				
05		5						2	21	6							2	1	1
06										2					4	1	11	4	
07																		1	
08		8		1					7	7				1	4	7	6	14	1
09				1				1	1			1			2	2	2	1	
10		4		2				1	8	5	1	3		1	17	7	19	23	11
11		2	1			1			4	2		4		2	13	11	17	19	4
12		5	1	4				3	6	11	4	4		6	25	32	68	97	18
13		2		2		1			4	4	2	2		3	4	12	16	25	13
14		1										1		3	8	5	4	5	5
15		3		1					1	2				1	6	11	17	14	11
16				1						1		1		1	2			8	
17						1			1	1		2			5	8	11	16	4
18		1							2	3	1	3	1	17	15	16	41	30	16
19											2	1	1	5	4	5	16	7	5
20		52		3					1	7									
21	5	583	29	84		8		19	171	157		2			9	4	23	11	2
22		10		41		1		2	1	2					2			1	
23		4		18		1		8	4	4									
24		1		9		3			2	1									
25		1		4	2	22				2							1	1	
26		1				1												2	
27		6		16				2	9	9					1				
28	2	598	5	60		5	1	21	109	91	3	1			11	17	14	57	2
29	1	25		5				4	19	53		1		2	5	5	9	7	1
30				1					2	1	8	106	1	7	20	279	97	108	10
31		3				1			3	1	5	29	3	13	36	159	75	101	15
32		1										4	1	9	10	17	9	17	2
33								1						2	2		1	3	

No. 6

O \ D	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
34		3		1					3	2	6	21	4	27	34	65	33	71	8
35		1		1				1	2	3	22	61		12	31	210	140	271	31
36				2					5	11	5	14		3	10	43	150	169	72
37		2		1				1	1	7	18	56	3	5	9	94	163	321	171
38															1	5	8	30	7
39		2		1				3	6	5	1	9	3	36	38	53	32	50	27
40		4		1		3			1	9				1	2	5	6	10	
41				1						2							2		
42				3					3	10					2	2	2	3	
43		38	1	2				4	2	17					2	1	3	8	
44									1	1					3	2	4	1	
45		4								2					3	2	5	1	1
46		7		1				4	8	11		1	1		16	6	18	15	2
47		1		1		1		3	1	8		1		1	10	1	3	4	2
48		8		4		1			1	10				1	3	1	1	2	
49		24		3				3	5	28	1	2			17	5	11	24	
50		4		4		2			13	39	1	4	2	26	49	25	135	119	63
51									1	1		1			3	3	13	11	4
52		1							1	2				5	12	8	6	14	7
53									3			1		2	7	12	4	13	4
54		3		1		1		1	4	5		1	1	2	17	12	15	12	5
55				2				1	5	10	1	3		2	17	9	12	10	4
56		1		2				1		8		3			5	15	7	9	5
57		2		1				1	2	12	4			2	12	9	38	33	1
58	1	6		3				7	7	24	1	7	1	1	19	10	43	33	15
59		1		1		1			1	15	2	2		7	19	9	52	67	27
60		7		4				5	14	16	2	1		2	48	12	33	57	10
61								1	1	3					3	5	4	8	2
62		4						3	2	20		1		2	9	9	14	20	4
63		7		4				3	16	40		1			19	3	16	16	2
64		13		1				2	6	22	3	2	2	2	13	8	18	23	9
65		57		3	1			5	26	24	12	7	2	3	32	37	99	82	19
66	1	16		2					10	35	5	4	1	2	13	34	59	62	3

O \ D	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
67		3		5				3	7	23		2		4	13	9	35	20	4
68		4						2	5	19		2		3	5	1	5	16	7
69		11						4	20	21	3	1		3	44	11	43	98	12
70		4		3		1		3	7	15	4	5		1	13	13	36	58	8
71								2		1					3	3	15	17	
72		5				1		3	3	4			1		4	1	15	20	8
73		4				3		1	5	30	2	4		9	20	10	48	35	12
74		1		4				2	6	11	2	2		1	14	7	32	26	2
75	1	14		3				14	28	48	23	16	1	15	67	43	73	77	16
76		5		2				2	10	18	1	3		15	33	12	32	44	17
77									3	26		1		1	6	5	46	55	29
78		1		2					9	44	2	16	1	5	17	42	167	212	77
79								2	7	34	5	1		6	21	11	31	21	11
80		3		3		1		2	3	9	2		1	2	14	6	50	27	3
81		3		2				6	1	10	1	2	1		8	6	35	21	
82		3		1				1	4	7	2	5		1	16	16	25	43	2
83		2		1					1	3		1			4	5	11	4	
84				2				3	4	4		3		1	9	10	9	6	
85		2		1				4	6	8		2		1	26	12	29	16	5
86		9	1	2		3		2	12	17	24	3			25	29	59	47	12
87		1		1		2			6	3		2		1	8	7	17	19	3
88		6							16	2	4	2			10	13	40	25	4
89		1							2	1	1				1	2	3	1	
90		8		7			1	11	15	28	16	11			68	24	65	65	20
91		3							7	17	3	13			17	30	69	71	9
92		2	1	2				2	5	3	4	2		2	8	8	·24	9	6
93		1				1			2	4	3	3		1	1	19	22	24	2
94									1	3					2	1	4	6	
95		8	1	1					9	9	6	2			12	11	26	35	4
96		1		1				2	1			1			4	11	15	19	
97			1					1	1		1	4			4	11	12	20	1
98		18		1		1			11	5	12	9			17	34	30	60	8
99																			
Total	11	1,679	41	351	3	67	2	187	748	1,228	232	486	32	289	1,208	1,739	2,730	3,420	912

No. 8

O \ D	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
00	1			1					1		3	2	1			6			
01								1	6		1					1		2	
02	3	1					5	1	3	1	3	4	2	1		3	1	3	
03							1												
04							1		3			1	1						1
05	1			1					4	2	7	2	1	1		6	1	3	
06	1			3		2	6	13	29	15	41	5	7	3	1	2	3	7	9
07	1						2	2	4		4		2		1	4			
08	7	2	1	1			11	11	27	8	29	15	11	3	4	19	6	3	4
09		1	1				1	4	11	1	3	3		2	1	2	1	4	1
10	10	1		2				3	1		8	31	9	19	5	41	3	6	4
11	10	2	2					1		1	1	46	8	15	34	16	18	10	
12	35	7	1	7	1			5	4		21	123	32	52	44	105	37	17	16
13	16	7	1					1	4	2	8	40	18	12	7	36	12	3	3
14	3								1		1	14	2	1	2	3	10	2	1
15	16	6			1					1	8	36	11	13	9	13	27	6	4
16	1	2										7	4	1	1	21	9	6	1
17	4	2		1								27	10	6	5	5	8	2	2
18	37	4		11							7	50	14	10	2	30	6	11	8
19	8									1	1	7	2	5	1	4	1	6	1
20							1				1	2	1			1		1	
21	9	1		32	3		1		2	44	31	44	4	5	2	2	7	8	39
22									1	1	2	1				1			
23	1											2	4						
24			1											1		1			
25	2			1							6	1			1	6	4	1	
26																14	1		
27		1						1	1		3	2							
28	4	2	2	12	8		2	3	12	26	138	50	13	8	1	25	10	17	15
29	6	2	17	10	4			1	9	5	30	12	12	7	1	14	6	22	17
30	13	5		2				3		1	3	14	6	4	6	14	11	4	5
31	19						1	1	2	1	2	22	11	7	3	9	4	6	3
32	6									1	1	5	5	1	1	4	1		
33														1					

O \ D	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
34	43	2	1	3					2	2	3	22	5	7	3	12	15	11	8
35	39	6	1	1				3	2	1	9	43	14	13	10	31	25	18	13
36	11			1				3	3	1	4	111	27	6	1	22	4	21	10
37	16	2		7				3	3	3	7	47	27	10	4	22	8	5	13
38	4	1										14	1	1	1	1	1	3	2
39	38	2		2				4	1		5	85	18	28	8	45	14	23	25
40	4	3	6	2					2		21	19	5	5	2	431	8	7	3
41	1				3					1	1	1						3	1
42	1	1	1		1			1	7	2	12	2		1	2		1	7	1
43	1	1	1	2	3				2	7	6	14	3	5		2	3	6	6
44									7	1	7	1	3	2				1	
45	8		1		1	1	5	12	80	18	37	7	15			6	1	6	1
46	4	1	2		1	4	6	13	109	13	60	26	12	6	3	10	15	16	16
47	6			2	1	1	3	2	7	9	33	3	4	1	5	2	1	8	5
48	5		2	1	2			1	34	1	22	1		1	1	1	1	3	
49	4	2	7	4	4	3	6	20	128	61	140	27	13	3	3	49	8	41	18
50	43	12		15	1		1	4	2	1	18	175	72	17	17	110	19	58	34
51	3								1		1	15	4	1	1	2	1	6	3
52	8		3									9	3	3	1	6	2	7	9
53	10	1							2		2	18	9	3	4	7	6	4	2
54	10	9		6				1	4		18	48	6	11	7	439	31	22	16
55	18	39	2	3	2				1		6	21	13	9	2	37	2	21	14
56	5				3				2	1	4	11	8	1	1	34	3	12	7
57		4	1		1			3	2	1	15	35	8	9	3	178	28	24	70
58	9	8	2	1	1			3	3	4	21	49	62	25	3	59	44	74	52
59	13			1				2	3	1	8	76	14	7	9	40	5	16	7
60	30	4	1	2	2	3	5	19	158	17	93	50	68	16	13	34	15	21	16
61	5	1	2	1					17	2	5	4	10	6	5	11	7	8	6
62	6	8	8	7	18			5	29	19	84	28	21	9	4	33	10	22	20
63	11	1	2	2	8			5	38	21	35	41	17	7	4	8	5	29	23
64	16	1	1	3	17			2	10	21	18	39	17	14	8	15	25	30	27
65	46	14	4	7	12			9	13	34	163	102	19	113	25	76	216	61	64
66	31	5	8	3	6	3	1	11	12	9	73	53	20	55	12	165	90	41	59
67	5		1					3	2	3	6	31	15	11	2	33	9	14	9

O \ D	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
68	10	1	2	1	2				11	2	3	30	8	6	2	10	5	27	21
69	23	15	2	3	1	1	1	9	35	26	254	62	43	28	7	120	43	49	45
70	10	2		5	3	1	5	12	47	11	45	47	53	8	6	27	6	28	25
71	7			1	1				2	3	11	16	19	5		30	6	8	12
72	1	4		1	1				2	2	12	11	14	4	2	8	8	10	16
73	5	1	1	2				3	1	7	21	66	14	9	7	49	19	22	17
74	1		4	1		1	2	4	8	6	23	35	16	3	5	18	2	5	4
75	32	4	6	8	1	2	20	23	29	17	63	107	74	40	15	56	28	30	48
76	16	1	3	2			1	4	7	3	40	42	43	17	4	21	14	15	7
77	5							3	1		2	46	9	5		7	1	7	1
78	13	2		1				4		3	28	140	24	11	1	22	15	10	11
79	11	1		2	1				2	2	10	41	15	3	1	12	6	1	6
80	3		3	1				8	30	4	22	56	14	5	4	23	4	28	25
81	2	1	2	8			1	8	6	3	26	31	5	9	4	23	11	12	17
82	5	2	3	3	1			11	5	2	40	44	13	7	9	61	8	10	16
83	5	2		1			1	3	1		10	22	8	9	4	4	3	3	2
84	5		1	1						1	5	18	8	5	3	12		2	3
85	8	2	4	1				4	4	2	19	31	22	23	14	18	6	9	6
86	17	5	2	8		2		16	21	14	40	65	21	14	9	34	40	13	16
87	5		2						3	2	4	18	8	4	4	12	3	3	3
88	9	9		2				5	1	4	13	37	21	13	7	8	12	4	11
89			1					2			3	4	2	4		1		1	
90	20	4	4	19	2		2	18	18	20	37	114	65	23	17	43	21	16	19
91	13	6	5	12	2			6	11	6	24	59	19	15	13	22	11	8	23
92	6		7		1		2	2	7	4	6	44	19	7	5	5	7	9	4
93	4	1	3	3				3	2	3	7	11	4	6	5	6	1	4	1
94	1	2			1			1	1		6	1	1	2		15	3	1	6
95	5	2		5			1	9	14	13	39	46	13	14	11	30	36	5	19
96	3							2			4	7	2	1		1		2	2
97	8								5	4	1	8	2	10	7	6	3	1	3
98	6	3		7				3	8	6	7	36	21	16	12	14	6	11	9
99												1							
Total	927	244	138	258	121	24	95	343	1093	535	2125	3092	1318	919	474	3047	1138	1153	1099

O \ D	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
00	3	2	1		1							1	5		3	2		12	3
01	3		1		1										1	1		4	5
02	8	5	10		2					2	1	1	12	1	10	11	8	23	8
03										1	1		1		1		1		
04	2	1	4										4		1	2	6	4	2
05	13		1			9				3	1	1	7		3	3	1	6	11
06	16	6	32		4	5			2	4		9	35	7	13	32	27	51	29
07	6	2	2										12	2	3	2	1	3	2
08	18	18	28		8	4				1	1	6	48	1	20	28	61	119	21
09	2	2	2			2			1		2	2	9			2	7	16	3
10	46	20	3						2	2	4	1	13	1	13	12	8	63	16
11	49	45	3		6	2			4	1	5	6	11	5	19	14	13	24	32
12	116	93	21		15	8			3	3	1	14	42	6	38	69	29	81	70
13	42	29	3		5	2			2	1	2	2	24	1	14	23	19	27	37
14	5	3			1	1					1	2	2	1	7	8		3	3
15	42	35	3		3	5			1	1	1	1	11	1	9	20	8	26	20
16	11	3			3				2	1	1		4		1	3	2	3	5
17	31	28			5	1			1			1	7	1	6	10	7	12	21
18	63	43	5		6	3		1	1	4	5	4	14	6	12	8	11	18	39
19	13	7			4	1			1			4	3	2	4	1	1	6	8
20	18	1	1							1							2	1	5
21	52	19	26		9	99	1	1	6	60	20	5	18	1	16	36	11	226	39
22	1					2					2	1	2		5	2		2	
23	1					1							1			3	1		2
24	2										1								
25	4	1								1		1	4			3		9	
26															2				
27	2	1				1							5	1	2	5	3	3	
28	77	43	15	5	10	59		1		24	12	19	21	3	21	43	29	122	46
29	71	17	3		12	22	1	1	6	14	24	4	18	7	22	39	8	40	22
30	63	26	2		1	2			3		4	6	14	2	18	23	2	30	33
31	24	26	4			1		1	3		2	1	5	2	10	23	4	38	30
32	5	4	1						1				8		2	2	4	6	4

No. 12

O \ D	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
33	1				1								1				1	2	
34	50	18	3		4	1		3	1			5	10	3	6	26	6	40	21
35	106	33	8		3	3			1	2	5	3	14	2	19	27	10	79	41
36	72	19	5		2	4	1		2	6	2	5	23	1	6	35	20	27	18
37	68	46	23		3	7.				3	1	3	32	4	53	25	17	65	30
38	5	1			1	1				1					3	3	2	4	7
39	138	34	7		9	3		1	6	11	9	8	14	9	15	37	6	58	40
40	11	8	4		4	3		4	2	2	1	6	4		5	13	3	13	10
41	2	3			1					1			1		2	4		3	1
42	8	3			9	3					3		3	1	2	4	2	6	5
43	17	1	3		6	6		1	2	3	5	1	4	3	6	13	1	8	9
44	3	2	3		2	1							8	1	2		4	13	1
45	16	9	18		12	3		1	1		3	7	37	4	7	27	28	69	24
46	34	19	82	1	5	12			2	5	1	6	90	7	16	69	83	137	48
47	19	4	21		10	7				2	3	11	22	3	5	16	25	26	7
48	13	4	6		9	3		1	1			9	6	2	4	14	8	12	12
49	68	43	44		115	14		2	4	4	3	57	52	30	50	80	48	76	85
50	216	167	6		16	16			4	15	7	3	39	4	56	78	27	82	61
51	20	7	1		7				1		1		5	1	4	2	1	8	6
52	40	14	3		10	1			1		1	4	3	1	2	2	2	9	12
53	31	11	1		1	1			1	3		2	4	1	9	11	2	7	11
54	63	37	10		18	5		4	16	9	5	5	17	6	14	21	10	32	21
55	109	20	9		18	3		1	6	3	3	13	14	17	16	42	9	19	28
56	78	12	1		7	6		1	2		6	4	13	6	5	21	3	23	13
57	117	16	6		26	6		3	7	11	8	16	33	51	27	53	12	37	32
58	273	53	16		40	18		1	7	13	13	9	83	58	78	136	33	104	111
59	61	185	2		3	2			3		2	4	19	2	34	78	31	73	113
60	117	34	44		16	26		1	4	20	4	63	200	12	65	97	153	232	90
61	22	15	17	2	3	4			2	3	2	26	18	3	8	15	14	24	17
62	148	26	19	1	39	27	2	1	6	11	10	53	41	30	41	60	35	79	84
63	89	31	25		25	9		2	8	19	31	5	51	11	23	39	26	66	40
64	73	21	17		19	59	4	11	6	18	10	13	40	2	21	55	22	72	60
65	105	68	28	1	35	85	5	17	443	164	27	87	127	32	85	265	89	206	295

O \ D	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
66	119	68	24		21	35	2	12	52	65	24	80	63	23	49	115	38	89	140
67	57	11	7		18	16		7	25	1	11	12	33	12	11	34	11	37	44
68	85	14	4		13	20		1	3	22	105	2	15	9	11	19	10	18	30
69	126	42	53		48	16	1	8	29	34	8	79	80	53	74	175	76	155	195
70	122	22	32	1	23	13		3	3	12	2	22	106	18	73	94	139	192	68
71	34	5	3		2				7	5	3	14	20	16	24	19	15	20	18
72	49	13	3		17	4		1		2	4	11	25	18	12	44	14	25	40
73	98	82	8		14	9			9	5	5	21	42	14	34	184	54	118	174
74	53	41	24		10	7			4	4	4	9	62	2	26	151	52	174	62
75	298	130	61	1	25	14	1		2	6	7	23	200	21	80	276	231	477	259
76	100	109	4		24	16		1	6	6	10	33	47	6	42	228	46	145	175
77	51	105	4		4	15			2	1		2	14	1	16	94	20	19	62
78	121	244	4		8	22			1	1	7	8	22	1	37	156	37	89	132
79	56	55	6		4	12			1	1	2	5	21	2	22	73	45	115	73
80	70	16	8	1	9	4		1	2	14	3	29	111	18	41	57	79	92	42
81	47	27	18		8	7		1	4	4		7	67	6	19	61	101	130	70
82	67	40	21		8	7		2	3	4	5	5	46	3	27	92	101	114	140
83	28	22	4		4	1				3		6	31	1	6	20	25	66	38
84	18	35	4		1	2			3	4	1	3	10	1	13	21	11	43	30
85	53	39	5		9	1			4	2	4	8	61	2	33	85	72	88	87
86	60	80	26		17	17		3	3	6	9	8	131	8	36	57	126	300	107
87	32	32	4		8				1	2	4	2	14	2	15	31	15	56	37
88	19	28	2		4	5				1	2	8	27	1	11	32	11	96	49
89	5	13			1						1	1	5		2	13	2	22	9
90	114	89	35	1	19	21		3	3	5	4	17	122	7	41	175	85	269	189
91	63	47	22		7	14		2	2		4	6	40	1	32	67	54	215	89
92	37	34	3		4	4			2	2		7	23	1	14	43	17	34	45
93	23	13	3		3	4			2			4	10		7	22	7	48	22
94	10	8	1		1	1				1	3	3	6		4	19	6	18	8
95	41	36	52		4	17		1	3	9	9	21	190	3	19	69	143	445	42
96	17	12	1		5							1	5	1	7	34	7	33	24
97	10	6	6			1		1				3	12		5	19	8	19	17
98	34	28	9	3	4	3		1	2	2	2	3	20	1	29	39	12	101	53
99																1			1
obscure																		1	
Total	5,104	2,990	1,064	17	922	877	18	108	758	677	500	983	3069	610	1,847	4,417	2,680	6,552	4,440

No. 14

O \ D	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
00		2	2																
01		1	1	1	1									1					
02		2	4				2		3	2				1	3				
03																			
04			2																
05	1	2	3			1				1				1		1			
06	9	7	17	1	3	2	1	1	1	2				2	2				
07			1	1						1									
08	4	12	25	7	4	3			4	1	3			4	5				
09	2	3	3	1	1	1	1		3	1				3					
10	6	122	23		1	4	1		9	4	1			22	7	2	2		
11	13	15	33		1	1	2		6	2	1			8	4	1			
12	20	55	104		2	9	3	1	10	7	4		1	7	10	4	1	1	3
13	10	20	18	2	2	1	2		6	2				3	3		1	1	
14		5	4	1	1				1									1	
15	5	11	27			2	2	1	1	5	1			2	3			1	
16		4	2				1							1					
17	3	14	15			1	1		2	1				2	1	1			
18	5	18	21	1		2	1		3	15				5	1				2
19	7	9	6	1		1			2	1	1			2	2				
20			3																
21	14	36	17	3	3	1	1		7	4				2	4	4	1		
22			1						1										
23									5						1				
24									1										
25	1			1		1													
26																			
27		3	3						1					1					
28	11	25	25	3	5	6	2	4	9	12	1			10	3	9	2	5	3
29	4	16	14	1			1		4	3	1			5	1				1
30	4	41	24	1	2	3	1		6	3				6	6	8			
31	7	39	25	1	2	2	2		7	1	3			5	6	3	1	1	1
32		4	3	1		1	1		1	1					2	1		1	

No. 15

O \ D	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
33	1																		
34	4	22	18			1		1	5	8	1			4	6			4	1
35	13	60	36	3	2	1		2	8	10	2			6	14	5	4	4	3
36	14	37	29	4	1			1	4	8	6			7	1	1		3	1
37	10	75	35	6	3				7	12	4			6	4	4	3	3	1
38	3	1	1			2				3				1			1		
39	11	16	21		1	1		1	5	6	1			5	3	1		2	
40	2	7	5						2	3					2				
41		1							1					1					
42		1	2											1	1				
43	3	3	3											2	1				1
44			5							1									
45	2	12	19	2	2			1	4	1					1				2
46	14	28	43	12	5	6	1		4	13				7	4	1			
47	3	6	9	8		1	3		3	5	1			8	1				
48		9	11	1					1	4				2	5			1	
49	11	66	25	4	1	5	5		7	11	1			9	5	4		4	
50	64	78	60	4	3	1	6	2	10	14	1		1	27	12	4		2	2
51	8	3	9	1			1			3				2	2				
52	4	15	9				1		1	2				1	2				1
53	4	6	12				1		1	2				1	1				
54	3	43	52			4	1		5					2	1	1			1
55	1	9	31	1	1	2			3	3	1			2		3		1	
56		3	5	1		1			5	1				1		1		1	
57	2	20	11	6	2	2			6	7	1			6	6	1	1	4	1
58	10	27	88	8			2	1	9	8	2			7	11	2	1	1	
59	29	53	41	8	1	1	4		7	3				8	5	2	1	1	
60	11	53	33	34	7	8	3	3	23	11	3			28	16	1			1
61	1	17	14	7	1				1	2				2	3	2			
62	2	43	33	4	1		4	1	7	1				5	2			2	1
63	4	17	37	5	1	1			11	4				12	3			1	
64	10	38	29		2	5	4		4	5			1	9	2	1			1
65	51	168	290	18	5	19	2	2	8	15	7	1	2	34	31	6	6	4	3

No. 16

O \ D	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
66	19	58	88	7	1	8	6	3	30	14	4	1		16	16	18	3	7	
67	3	19	31	5	2	1	2	2	7	2				3	5	1			
68	3	13	18	2	1	1	1		2	2				6	2	1		1	
69	15	91	88	19	10	4	4		25	14	3		1	10	7	5	2	4	2
70	9	60	69	59	13	12	5	2	18	44	2			24	10	3		2	1
71	1	6	5	7	3		2		2		1			1	3	1			
72	6	20	12	7			1		2	2						2			
73	28	46	77	14	4	15	2		14	5	1			21	2	11			2
74	7	46	76	5	5	8	3	1	24	18				22	7	2		2	
75	24	148	245	33	11	14	11	5	30	44	5			56	43	4			8
76	14	73	93	2	3	6	13	5	10	23	3			43	10			1	1
77	44	28	21	4	1	2	3	1	2	4				18	3	11			
78	61	103	80	3	1	9	17	3	16	19	4			145	54	9		2	1
79	3	34	16	5	2	1	8		4	25	1			12	18	2			2
80		42	42	78	35	20	21	4	21	10				18	13	3			
81	5	57	51	26	70	107	70	19	52	22	1			49	18	6	2	1	2
82	13	108	157	11	61	145	283	33	131	31	7		1	113	42	7		2	2
83	3	27	41	3	26	46	124	3	54	7	4			51	21	4	2	1	
84	4	32	55		22	56	86	10	22	33	6			49	16	2	1	1	
85	14	106	126	6	25	96	210	7	58	61	4			148	22	15	1	2	
86	19	186	196	3	9	30	29	3	55	372	6	1	1	235	106	17	3	5	57
87	13	42	68	1	7	18	12	14	18	47	37	4	2	71	36	15	1	4	3
88	22	128	120	2	4	17	8	11	15	17	155	35	18	138	17	9	1	3	9
89	4	13	25	1	2	3	2	3	11	3	20	3	4	18	10	1		1	
90	37	234	254	15	33	56	175	17	78	181	16	4	2	328	174	117	9	3	42
91	24	100	162	3	12	15	49	5	39	71	5	3	2	306	273	40	18	4	31
92	17	45	50		4	9	7	1	12	14				102	15	52	4		2
93	9	28	35	3	1	3	14	2	17	40	1			69	27	205	1	1	2
94	3	19	25		1	10	2	3	9	62	11			17	11	1		2	1
95	17	173	148	2	2	6	10	5	34	157	4			147	83	24	6	6	17
96	2	20	32		2	1	12		16	20	2			48	23	42		1	16
97	6	28	19	1	1	3	3	1	7	10	1			40	16	29	7		3
-98	11	64	80	3	1	16		1	21	13	41		1	317	21	6	50		1
99			3								17			1	1			1	
Total	881	3600	4100	494	442	841	1258	186	1103	1622	409	52	37	2941	1334	739	137	106	295

No. 17

D / O	96	97	98	99		Total	
00						104	
01						50	
02						198	
03						11	
04						52	
05			1			146	
06						532	
07						70	
08	1	1	3			800	
09			1			137	
10	1	3	101			1,918	
11	1	3	9			1,065	
12	5	2	13			2,204	
13	3		5			737	
14						174	
15	2		1			566	
16						128	
17	1	1				359	
18		2	5			780	
19	1		1			182	
20						88	
21	1					2,115	
22						87	
23						62	
24						23	
25			2			91	
26			1			24	
27						82	
28	8		3			2,091	
29	2		1			716	
30	11	13	8			1,127	
31	2		4			863	
32			1			166	
33			1			18	
34	5		1			752	
35	3	4	15			1,659	
36	2	1	2			1,098	
37	9	1	4			1,657	
38	1					136	
39	3					1,148	
40	2					702	
41						37	
42		1				126	
43			4			250	
44	1					83	
45			1			566	
46		1	2			1,223	
47		1	2			371	
48			1			253	
49	3	1	5			1,667	
50	1	6	6			2,298	

No. 18

O \ D	96	97	98	99		Total	
51		2				180	
52						261	
53						258	
54	1	2	1			1,174	
55	2					708	
56	1		1			381	
57	3		2			1,065	
58		3	7			1,963	
59			7			1,230	
60		4	8			2,378	
61						386	
62	2	2	3			1,287	
63	1	1				1,016	
64	2					1,083	
65	5	2	3			4,445	
66	8	1	7			2,351	
67	1	1				722	
68	2		2			677	
69	5	2	5			2,730	
70	3	2	13			1,880	
71	1		1			418	
72						502	
73	2	1	6			1,590	
74		4	2			1,207	
75	2	5	9			4,007	
76	4	4	5			1,803	
77	1		2			822	
78	2		7			2,352	
79	1					921	
80	2		8			1,303	
81	8	2	6			1,485	
82	2	10	6			2,288	
83	1	3	4			809	
84			1			733	
85	2	7	1			1,799	
86		7	5			3,030	
87	2		1			841	
88	1	2				1,352	
89		1				240	
90	26	20	46			4,016	
91	3	16	9			2,444	
92	6	26				867	
93	3	59	2			863	
94	2		6			345	
95	8	14	7			2,583	
96	2	29	5			515	
97	6	63	179			752	
98	28	36	286	4		2,075	
99		4	6	2		69	
obscure						1	
Total	220	376	878	7		100,000	

Table 4-2 Rate of Trips Generated by Each Zone to Population

ZONE NO.	1	2	3	4	5	6	7	8	9	10	11	12
A; Number of trip generation	102	47	1,314	6,654	26,468	4,610	6,977	2,259	2,879	3,255	3,879	3,766
B; Popuration	-	-	-	43,988	605,174	145,677	149,896	162,611	89,863	179,408	118,363	198,124
A/B	-	-	-	0.0151	0.0441	0.0317	0.0465	0.0139	0.0322	0.0181	0.0328	0.0190
ZONE NO	13	14	15	16	17	18	19	20	21	22	23	Total
A, Number of trip generation	6,544	5,251	4,431	2,763	2,019	1,426	1,319	6,921	1,932	5,764	Included in zone No. 5	94,440*
B; Popuration	114,376	173,197	56,064	19,981	19,806	-	-	244,042	-	64,709		2,385,279
A/B	0.0571	0.0303	0.0774	0.138	0.111	-	-	0.0283	-	0 0890	-	0.0396

* ZONE NOS. 1, 2, 3, 18, 19 and 21 are not included.

Table 4-3 Present Bus Passenger OD Table (Revised)

O \ D	1	2	3	4	5	6	7	8	9	10	11	12
1	0	0	7	33	22	0	16	3	2	3	4	0
2	0	0	0	34	9	0	2	2	0	0	0	0
3	0	0	138	80	454	17	278	44	22	63	37	22
4	1	4	43	2,640	1,951	29	733	191	148	240	199	67
5	3	0	127	1,254	10,312	308	3,675	1,218	916	1,620	1,238	495
6	0	0	48	114	1,165	589	845	184	95	209	188	66
7	0	0	79	271	2,060	96	1,784	498	333	523	345	238
8	0	0	2	80	649	24	446	252	119	235	187	55
9	0	0	3	83	597	21	351	162	242	377	572	90
10	0	0	4	87	938	14	372	191	186	490	423	157
11	0	0	5	66	794	18	325	115	327	451	1,078	318
12	0	0	9	38	583	17	338	106	278	248	945	725
13	0	0	19	168	1,023	224	1,189	280	401	351	302	155
14	0	0	20	115	953	151	992	203	316	269	219	102
15	0	0	15	90	781	427	824	173	239	210	146	80
16	0	0	6	23	141	26	192	46	87	57	44	16
17	0	0	3	37	282	5	238	25	70	30	30	11
18	0	0	3	19	136	9	133	39	63	57	73	16
19	0	0	3	32	135	8	84	33	53	60	63	37
20	0	0	19	128	1,618	28	761	289	283	868	631	264
21	0	0	4	26	152	3	102	18	132	73	52	25
22	0	0	6	154	1,313	18	413	160	121	229	152	61
23	1	0	64	122	1,096	31	532	121	58	108	62	35
Total	5	4	627	5,694	27,164	2,063	14,625	4,353	4,491	6,771	6,990	3,085

O \ D	13	14	15	16	17	18	19	20	21	22	23	Total
1	0	0	0	0	0	0	1	6	0	3	2	102
2	0	0	0	0	0	0	0	0	0	0	0	47
3	16	7	9	3	0	2	2	39	1	19	61	1, 314
4	40	55	39	9	8	6	10	104	4	83	50	6, 654
5	285	231	215	49	22	40	40	789	27	934	210	24, 008
6	245	148	439	12	7	15	12	122	5	58	44	4, 610
7	181	91	105	9	7	14	10	158	4	80	91	6, 977
8	56	31	26	2	2	4	4	51	1	23	10	2, 259
9	203	32	35	11	2	3	6	57	3	20	9	2, 879
10	45	23	23	3	2	9	6	175	4	90	13	3, 255
11	37	42	25	16	7	10	10	156	11	57	11	3, 879
12	45	50	27	13	11	23	16	210	13	48	18	3, 766
13	1, 081	406	343	39	38	54	36	314	16	60	45	6, 544
14	582	560	338	16	29	115	6	187	3	44	31	5, 251
15	403	242	547	19	11	16	4	126	3	47	28	4, 431
16	118	47	53	111	2	2	1	29	1	13	7	1, 022
17	87	63	38	4	11	12	2	50	1	7	4	1, 010
18	171	77	20	15	8	175	186	145	20	3	6	1, 424
19	225	59	18	29	10	91	128	218	23	8	2	1, 319
20	63	51	51	12	9	20	24	1, 462	34	283	23	6, 921
21	29	10	10	1	0	37	68	992	167	25	6	1, 932
22	35	33	22	7	3	3	3	192	8	352	14	3, 299
23	18	17	21	0	1	2	2	42	0	9	118	2, 460
Total	3, 965	2, 275	2, 404	380	196	653	577	5, 629	349	2, 266	803	95, 363

Table 4-4 has been obtained by comparing the ratio of the volumes of the bus passenger trafic crossing the Chao Phya River, over each bridge, which was derived on the assumption that the OD traffic volume flow through the minimum path, with the ratio of the volumes of vehicle traffic obtained from the field observations by the General Engineering Company in 1967.

Table 4-4 Comparison of Bus Passenger versus Vehicle Traffic Crossing the Chao Phya River

Traffic Volume \ Bridge		Memorial	K. Thon	K. Thep	Rama VI	Total	Ratio
Vehicle	Number	105,400	27,060	22,200	5,380	160,040	7.72
	Ratio	0.658	0.169	0.139	0.034	1.000	
Bus Passenger	Number	14,278	3,270	2,942	241	20,731	1.00
	Ratio	0.688	0.158	0.142	0.012	1.000	

According to Table 4-4, the ratio of the vehicular traffic passing over each existing bridge almost equals that of bus passengers with the exception of Rama VI Bridge. Thus the bus passenger OD distribution given in Table 4-3 may be considered to show vehicle OD distribution. But to convert the bus passenger OD table to vehicular table, the figure must be multiplied by the ratio of 7.72, for the volume of vehicular traffic crossing these bridges is 160,040 vehicles, while that of bus passengers amounts to 20,731 persons. Therefore, the total trips of the present vehicles will become :

Total trips of bus passengers x 7.72
= 95,363 x 7.72
=736,202 trips

On the other hand, since the number of vehicle registrations in 1967 is given in Fig. 3-1 as 188,000 vehicles, the average trips of each vehicle in 1967 can be expressed by

$$\frac{736,202 \text{ trips}}{188,000 \text{ veh.}} = 3.92 \text{ trips/veh.}$$

The above is the basis which we have used to form the anticipated total number of trips of vehicles given in Section 3.

It is now necessary to find the vehicle trips generated by each zone in both 1975 and 1990. Though the Entropy Method permits the calculation of trip generation completely independent of the trip attraction, we can normally consider both of the above traffic volumes to be almost equal each other. We shall simply use hereinafter a term "trip generation" as the sum of trip generation and attraction.

The anticipated trip generation has been predicated as follows :

(1) Estimate the population increase in each zone from 1965 to 1975 and 1990 in proportion to that from 1960 to 1965, and estimate the trips generated by each zone in 1975 and 1990 in the same proportion as the above population increase with the exception of followings (2) to (4).

(2) The population increase in each zone will stop at the time, when the population density goes up to the maximum determined from the viewpoint of land use and the position of each zone. The said maximum population density is shown in the column "Maximum Population Density" of Table 4-7.

(3) Where population increase is insignificant during years 1960 and 1965, the population growth in these zones are expected to show little or no increase taking into account such factors as population density and land use. These zones are Nos. 7, 8, 9 and 10.

(4) Since the greater effects of development can be expected on Zone No. 6 with the construction of the proposed bridge, we have doubled the annual average population increase between years 1960 and 1965 from 9.9% to 19.8%.

(5) Where the rate of population increase is not known, the annual average population increase in whole Bangkok and Thonburi of 4.3% have been applied. These zones are Nos. 1, 2, 3, 18, 19 and 21.

On the other hand, the total population in urban area as cumulated by zone may differ from the estimated value of the entire urban area. Thus, first find it and then revise the increase in population of each zone by the said value as control total.

The following describes this point in more detail.

The movement of population in Bangkok and Thonburi between the years of 1956 and 1966 is shown in Table 4-5. As can be noted from the table, the population in Bangkok has increased to a considerable extent between years 1964 and 1965 as its municipal area has been doubled approximately in 1965. To predict population of newly added municipal area, based on the rate of population increase in 1960 through 1964, then,

$$\text{Population of municipal area newly added to Bangkok} = \text{Population of both Bangkok and Thonburi as of 1965} - \text{Population of Bangkok and Thonburi as of 1964.} \times \text{Annual average rate of population increase during 1960 - 1964.}$$

$$= 2,407,585 - 2,173,124 \times \left(\frac{2,173,724}{1,800,678}\right)^{1/4}$$

$$= 129,728$$

This is the population as of 1965 and the population as of 1960 can be computed as follows;

$$\text{Population of municipal area newly added to Bangkok as of 1960} = \frac{129,728}{(\text{Annual average rate of population increase during 1960-1964})^5}$$

$$= \frac{129,728}{\left(\frac{2,173,724}{1,800,678}\right)^{5/4}} = 102,460$$

Hence, the total population of Bangkok and Thonburi including newly added urban areas as of 1960 is

$$1,800,678 + 102,460 = 1,903,138$$

As can be seen from Table 4-6, since the population in the Metropolitan area totaled 567,332 persons in 1960, the ratio of population in Bangkok and Thonburi to that in whole Metropolitan area can be computed as follows :

$$\frac{1,903,138}{2,567,332} = 0.741$$

On the other hand, the Greater Bangkok Plan estimates the population of the Metropolitan area to run into 6,300,000 in 1990, showing annual average rate of population increase of 3.19 per cent. Based on the said population increase rate, the population of the Metropolitan area as of 1975 will be 4,120,000 persons. Assuming that the rate of population in Bangkok and Thonburi to that in whole Metropolitan area does not vary in 1975 and 1990, the total population of these two cities will be as follows :

1975 : 4,120,000 persons x 0.741 = 3,150,000 persons
1990 :. 6,300,000 persons x 0.741 = 4,670,000 persons

If the increased portion of people of each zone as found from the rate of population increase in each zone during years 1960 and 1965 is revised using the above control total, i.e., 3,150,000 as of 1975 and 4,670,000 as of 1990, it is now possible to obtain the population of each zones as of 1975 and 1990, and the ratio of the population in 1975 and 1990 to that in 1965, as shown in Table 4-7. Also if these multiples are multiplied by the trip generation of bus passengers, the trips generated by each zone both in 1975 and 1990 can be found as given in Table 4-8.

However, because trip generation occuring due to the existence of port facilities in Zone No. 20 can not be overlooked in any way, we have doubled the bus passenger trip generation in 1965.

Table 4-5 Populations in Bangkok and Thonburi Municipal Areas

Year / Municipality	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
Bangkok	1, 127, 923	1, 204, 874	1, 286, 422	1, 369, 036	1, 419, 492	1, 492, 593	1, 548, 047	1, 632, 127	1, 669, 246	1, 874, 178	1, 936, 539
Thonburi	302, 728	319, 909	336, 039	356, 535	381, 186	405, 641	435, 351	474, 754	504, 478	533, 407	563, 818
Total	1, 430, 651	1, 524, 803	1, 622, 461	1, 725, 571	1, 800, 678	1, 898, 234	1, 983, 398	2, 106, 881	2, 173, 724	2, 407, 585	2, 500, 357

Table 4-6 Population in Metropolitan Area in 1960

Changwat	Population
Pranakhon	1, 577, 003
Thonburi	559, 432
Nonthaburi	196, 196
Samutprakan	234, 701
Total	2, 567, 332

Table 4-7. Movement and Prediction of Population in Bangkok and Thonburi by Each Zone (1)

Zone No.	Population in 1960	1965 Population	1965 Area (km2)	1965 Population Density (person/ha)	Annual Average Rate of Population Increase 1/5 (1965/1960)	Maximum Population Density (person/ha)
1						
2						
3						
4		44,384	30.50	14.4		300
5	408,201	610,621	33.39	181.0	1.083	300
6	91,000	146,988	23.00	63.0	1.198	500
7	148,996	151,245	4.54	330.0	1.000	
8	161,645	164,074	2.34	695.0	1.000	
9	87,186	90,672	1.10	815.0	1.008	
10	177,186	181,023	7.67	233.0	1.002	
11	110,250	119,428	3.69	320.0	1.015	400
12	160,281	199,907	23.64	84.0	1.049	300
13	88,401	115,405	6.00	191.0	1.101	500
14	130,979	174,756	9.00	192.0	1.057	500
15	41,392	56,569	6.00	93.5	1.062	500
16	14,676	20,162			1.064	
17	10,988	19,984			1.125	
18						
19						
20	142,744	246,238	95.84	25.4	1.113	300
21						
22		65,291	35.85	18.0		300
23						
Total		2,406,747				

Table 4-7. Movement and Prediction of Population on Bangkok and Thonburi by Each Zone (2)

Zone No.	Population in 1965	1975			Rate of Population Increase Adjusted by Control Total (1975/1965)
		Rate of Population Increase (1975/1965)	Population	Population Adjusted by Control Total	
1					1.234
2					1.234
3					1.234
4	44,384	1.234	54,770	47,044	1.058
5	610,621	2.240	1,367,791	804,594	1.315
6	146,988	6.200	1,150,000	403,941	2.750
7	151,245	1.000	151,245	151,245	1.000
8	164,074	1.000	164,074	164,074	1.000
9	90,672	1.000	90,672	90,672	1.000
10	181,023	1.000	181,023	181,023	1.000
11	119,428	1.161	138,656	124,354	1.041
12	199,907	1.614	322,650	231,351	1.155
13	115,405	2.600	300,000	162,695	1.410
14	174,756	1.740	304,075	207,885	1.189
15	56,569	1,803	101,994	68,206	1.227
16	20,162	1.860	37,501	24,604	1.220
17	19,984	3.250	64,948	31,503	1.575
18					1.234
19					1.234
20	246,238	3.241	798,057	387,604	1.574
21					1.234
22	65,291	1.234	80,569	69,205	1.060
23					1.315
Total	2,406,747		5,308,025	3,150,000	

Table 4-7. Movement and Prediction of Population on Bangkok and Thonburi by Each Zone (3)

Zone No.	Population in 1965	1990			Rate of Population Increase Adjusted by Control Total (1990/1965)
		Rate of Population Increase (1990/1965)	Population	Population Adjusted by Control Total	
1					2.865
2					2.865
3					2.865
4	44,384	2.865	127,160	61,282	1.381
5	610,621	7.35	4,488,064	1,459,202	2.390
6	146,988	91.8	1,150,000	536,527	3.660
7	151,245	1.000	151,245	151,245	1.000
8	164,074	1.000	164,074	164,074	1.000
9	90,672	1.000	90,672	90,672	1.000
10	181,023	1.000	181,023	181,023	1.000
11	119,428	1.45	147,600	128,485	1.072
12	199,907	3.31	661,692	307,829	1.534
13	115,405	11.1	300,000	187,096	1.624
14	174,756	4.00	450,000	250,912	1.440
15	56,569	4.50	254,561	101,327	1.790
16	20,162	4.71	94,963	37,108	1.840
17	19,984	19.0	379,696	93,382	4.660
18					2.865
19					2.865
20	246,238	23.6	2,875,200	829,687	3.370
21					2.865
22	65,291	2.865	187,059	90,149	1.385
23					2.390
Total	2,406,747		11,703,009	4,670,000	

Table 4-8. Trips Generated by the Each Zone Both in 1975 and 1990

Zone No.	Trip Generation in 1965	1975			1990		
		Multiple 1975/1965	Trip Generation	Composition Rate	Multiple 1990/1965	Trip Generation	Composition Rate
1	107	1.234	132	0.00055	2.865	307	0.00083
2	51	1.234	63	0.00026	2.865	146	0.00040
3	1,941	1.234	2,395	0.01000	2.865	5,561	0.01511
4	12,348	1.058	13,064	0.05453	1.381	17,053	0.04632
5	51,172	1.315	67,291	0.28089	2.390	122,301	0.33223
6	6,673	2.750	18,351	0.07660	3.660	24,423	0.06634
7	21,602	1.000	21,602	0.09017	1.000	21,602	0.05868
8	6,612	1.000	6,612	0.02760	1.000	6,612	0.01796
9	7,370	1.000	7,370	0.03076	1.000	7,370	0.02002
10	10,026	1.000	10,026	0.04185	1.000	10,026	0.02724
11	10,869	1.041	11,315	0.04723	1.672	18,173	0.04937
12	6,851	1.155	7,913	0.03303	1.534	10,509	0.02855
13	10,509	1.410	14,818	0.06185	1.625	17,077	0.04639
14	7,526	1.189	8,948	0.03735	1.440	10,837	0.02944
15	6,835	1.227	8,387	0.03501	1.790	12,235	0.03324
16	1,402	1.220	1,710	0.00714	1.840	2,580	0.00701
17	1,200	1.575	1,890	0.00789	4.660	5,592	0.01519
18	2,077	1.234	2,563	0.01070	2.865	5,951	0.01617
19	1,896	1.234	2,340	0.00977	2.865	5,432	0.01476
20	12,550	1.574	19,766	0.08251	3.370	42,294	0.11489
21	2,281	1.234	2,815	0.01175	2.865	6,535	0.01775
22	5,565	1.060	5,899	0.02462	1.385	7,708	0.02094
23	3,263	1.315	4,291	0.01791	2.390	7,799	0.02119
Total	190,726	--	239,561	1.00000	--	368,123	1.00000

Now the trips generated by each zone have been obtained. At this point, it should be noted that, since the trips generation, when the Entropy Method is applied, could mean only relative largeness of each zone, it is not required to convert trip generation of bus passengers shown in Table 4-8 to that of vehicles. In this case, however, it is necessary to find the ratio of trip generation of each zone, to that of all zones, just as shown in the right-hand side column of each year in Table 4-8.

Before proceeding further, a brief description of the Entropy method is presented in order to promote a better understanding.

The Entropy method employs the maximum likelihood method in the probability theory to obtain the most likely transition probability in the whole of OD pairs, based on the concept that the OD distribution can be interpreted from the viewpoint of probability,so that OD distribution may be estimated from the above most likely transition probability.

Hence, the following definition can be drawn:

$$U_i = \sum_j x_{ij}$$

$$V_j = \sum_i x_{ij}$$

$$T = \sum_i U_i = \sum_j V_j = \sum_{ij} x_{ij}$$

$$u_i = U_i / T$$

$$v_j = V_j / T$$

where x_{ij} represents the traffic volume from the zone i to the zone j.

$x_{ij} = U_i p_{ij}$, i.e. $x_{ij} = Tu_i p_{ij}$ is drawn using transition probability p_{ij}, and the following formulas can be written;

$$\sum_j p_{ij} = 1$$

$$\sum_i u_i p_{ij} = v_j$$

The joint probability P, which is obtained when distributing total trips T to all the OD pairs by as much as x_{ij}, can be considered as the product of the number of combinations, in which T are distributed to each OD pair ij by as much as x_{ij} respectively, and probability, in which fundamental probability p'_{ij} occurs on each OD pair ij by x_{ij} times respectively, where p'_{ij} is the probability in which the traffic occurs from the zone i to the zone j.

Hence,

$$P = \frac{T!}{x_{11}!x_{12}! \cdots\cdots x_{ij}! \cdots\cdots} (p'_{11})^{x_{11}} (p'_{12})^{x_{12}} \cdots\cdots (p'_{ij})^{x_{ij}} \cdots\cdots$$

Let us now assume the following gravity model;

$$p'_{ij} = \alpha u_i v_j t_{ij}^{-\gamma}$$

where t_{ij} is the time required, or distance, from the zone i to the zone j.

If the Sterling's formula is used, omitting the constant numbers having no bearing with p_{ij}, P is modified as objective function R.

$$R = -\Sigma\Sigma u_i p_{ij} \log p_{ij} - \gamma\Sigma\Sigma u_i p_{ij} \log t_{ij} \cdots\cdots (4-1)$$

The first term of the right side in this equation is no other than the entropy generally used in the information theory. Making P as maximum is equivalent to making R as maximum. Thus, we might as well find p_{ij} that can make R as maximum.

Since it is impossible to obtain a solution in the form of the explicit function, it should be derived by convergent computation.

The Lagrange's function of the equation (4-1) can be expressed with the undetermined coefficient μ_i and λ_j as follows;

$$F = H - \gamma \Sigma\Sigma u_i p_{ij} \log t_{ij} + \Sigma \lambda_j (\sum_i u_i - v_j) + \mu_i (\sum_j p_{ij} - 1)$$

Therefore

$$\frac{\partial F}{\partial p_{ij}} = - u_i(1 + \log p_{ij}) - \gamma u_i \log t_{ij} + \lambda_j u_i + \mu_i = 0$$

Hence

$$p_{ij} = t_{ij}^{-\gamma} \exp (-1 + \lambda_j + \frac{\mu_i}{u_i})$$

And

$$\frac{\partial F}{\partial \mu_i} = \sum_j p_{ij} - 1 = 0$$

$$\frac{\partial F}{\partial \lambda_j} = \sum_i u_i p_{ij} - v_j = 0$$

Now take α_i and β_j as defined as follows:

$$\exp\left(\frac{\mu_i}{u_i}\right) = \alpha_i$$

$$\exp(\lambda_j) = \beta_j$$

Then

$$p_{ij} = \alpha_i \; \beta_j \; e^{-1} t_{ij}^{-\gamma} \quad \cdots\cdots\cdots\cdots \quad (4\text{-}2)$$

$$\alpha_i = \frac{e}{\sum_j \beta_j t_{ij}^{-\gamma}} \quad \cdots\cdots\cdots\cdots \quad (4\text{-}3)$$

$$\beta_j = \frac{ev_i}{\sum_i u_i \; \alpha_i t_{ij}^{-\gamma}} \quad \cdots\cdots\cdots\cdots \quad (4\text{-}4)$$

Of the above 3 equations, numerical calculus are performed in the following manner:

(1) Assume β_j in Eq. (4-3), and figure out α_i.

(2) Find β_j by substituting the value of α_i in the Eq. (4-4).

(3) Obtain the value of α_i by substituting β_j in the Eq. (4-3).

(4) Repeat the above step until the figure comes within the permissible error range and then find the values of α_i and β_j.

(5) By using α_i and β_j obtained in (4) above, now calculate p_{ij} from Eq. (4-2).

The afore-mentioned is the outline of the Entropy method using gravity model.

By the Entropy method, in addition to the relative trip generation of each zone, it is necessary to decide the constant γ that represents the effects of the time required to travel from one zone to another. We have used the value of 1.1 by applying the gravity model to the bus passenger OD table. We have considered distance between zones instead of time required for the traffic between zones. Distance between zones is shown on Table 4-9.

As described, while OD distribution probability may be drawn from the above input data, using a digtal computer, OD tables can be obtained by multiplying this value by the total number of trips derived in Section 3.

Table 4-10 through 4-11 show both the OD tables in the years 1975 and 1990, which are given in trigonometric form.

Table 4-9. Distance between Zones

O \ D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	1.0	28.3	10.4	19.5	23.2	31.8	27.7	29.2	28.7	29.8	37.8	39.0	35.8	36.7	36.6	39.1	39.7	42.5	44.9	34.2	43.6	21.2	18.5
2		1.0	19.9	9.8	23.7	26.4	32.1	29.0	30.7	27.0	29.0	34.1	34.1	35.1	31.7	33.8	36.7	38.3	44.6	34.7	41.0	25.1	35.4
3			0.1	8.5	12.0	15.0	16.9	16.7	16.5	18.9	24.2	29.2	26.4	27.0	28.3	24.2	30.3	32.9	40.0	28.3	40.2	23.4	6.4
4				0.5	11.3	25.0	17.1	16.6	25.2	20.0	22.1	27.2	24.5	25.1	25.4	28.9	26.9	30.0	40.0	27.0	35.0	16.2	24.9
5					15.4	10.0	6.0	5.9	10.0	6.5	12.2	17.4	11.7	8.3	12.1	15.4	10.5	24.7	25.0	15.2	20.6	14.0	2.8
6						2.2	5.9	10.0	10.0	11.6	13.0	16.4	5.8	6.7	3.1	6.5	7.7	16.9	23.7	10.0	10.0	18.0	16.0
7							3.1	3.6	5.0	7.8	7.7	10.5	4.4	4.4	4.1	7.1	7.5	13.2	20.0	14.2	23.0	16.0	7.0
8								2.8	4.8	3.8	6.0	11.2	5.3	6.3	6.5	7.0	10.2	13.1	18.8	10.5	21.0	14.0	10.5
9									2.1	2.7	2.4	5.7	3.7	4.1	5.4	6.0	10.3	9.1	15.0	14.2	18.9	21.0	14.0
10										2.5	3.1	6.5	8.6	9.1	7.7	10.2	12.0	14.2	17.8	7.5	14.4	14.0	12.0
11											1.9	4.1	8.4	8.6	9.7	12.1	9.2	12.1	15.0	11.6	21.6	20.4	17.7
12												0.6	12.4	9.4	13.4	16.0	10.6	9.1	15.8	15.5	26.5	25.5	15.5
13													1.6	2.2	3.4	4.9	5.3	7.9	13.7	19.6	26.1	23.2	15.4
14														1.6	3.8	5.4	2.9	5.4	12.2	20.6	28.1	24.4	17.6
15															1.1	3.2	6.9	12.2	19.0	20.5	27.0	25.0	18.5
16																0.1	10.0	11.1	16.9	22.8	29.2	28.3	19.8
17																	2.7	3.7	10.0	19.5	30.5	28.0	22.6
18																		0.1	5.5	21.7	28.1	36.2	22.1
19																			0.1	17.5	35.0	36.2	28.9
20																				1.8	6.5	21.2	24.1
21																					0.1	28.6	26.1
22																						2.8	13.0
23																							1.3

Table 4-10 Vehicle OD Table in 1975

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1	82	2	44	128	714	128	148	44	50	66	66	42	78	44	42	8	14	10	10	148	10	128	42	2,130
2		18	10	128	328	74	60	20	22	34	42	24	38	22	24	4	6	6	4	58	6	50	10	1,018
3			13,054	1,128	5,243	1,036	904	288	324	391	387	208	388	223	200	44	64	46	36	644	40	405	484	38,645
4				72,871	32,071	3,383	5,107	1,664	1,162	2,104	2,449	1,284	2,416	1,384	1,290	206	416	288	212	3,881	264	3,475	622	210,804
5					245,409	62,963	109,795	35,269	21,828	49,211	31,988	14,264	36,998	31,758	19,811	2,804	7,966	2,429	2,407	49,599	3,217	27,721	46,743	1,085,945
6						42,065	28,258	4,988	5,516	6,574	7,536	3,846	20,228	10,156	22,388	1,830	2,830	932	645	19,862	1,800	5,312	1,736	296,161
7							28,511	15,254	11,752	10,114	13,330	6,245	27,250	16,034	16,364	1,651	2,897	1,216	773	13,427	716	6,012	4,286	348,615
8								3,171	3,876	7,036	5,531	1,834	7,002	3,406	3,108	528	652	386	261	5,902	250	2,196	866	106,703
9									5,321	11,330	16,758	4,264	11,498	6,042	4,216	692	712	638	370	4,682	310	1,554	698	118,936
10										8,654	17,750	5,180	6,382	3,528	4,004	542	846	549	430	13,263	586	3,408	1,160	161,796
11											19,759	11,174	8,510	4,878	4,036	583	1,472	851	675	10,666	488	2,926	982	182,597
12												30,489	3,654	2,916	1,864	284	830	767	420	5,110	256	1,508	750	127,702
13													29,124	24,144	14,124	1,744	2,982	1,502	823	6,616	438	2,806	1,264	239,133
14														10,082	7,354	922	3,406	1,343	550	3,686	238	1,562	642	144,402
15															13,578	1,548	1,240	518	319	3,500	234	1,436	574	135,350
16																6,467	152	106	67	574	40	232	98	27,594
17																	598	662	222	1,272	70	436	158	30,501
18																		13,722	336	884	60	257	127	41,357
19																			13,833	1,124	48	258	95	37,751
20																				81,773	3,609	5,540	1,382	318,985
21																					16,132	361	114	45,419
22																						13,111	1,390	95,195
23																							2,513	69,249
Total																								1,932,989

Table 4-11 Vehicle OD Table in 1990

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1	254	6	120	246	1,782	244	214	64	74	94	156	82	138	80	92	16	54	26	24	394	28	236	98	4,776
2		58	28	250	836	144	88	30	34	50	100	46	70	40	52	8	28	14	12	186	14	94	24	2,270
3			31,269	1,913	11,511	1,747	1,159	370	428	490	797	357	603	350	383	84	232	110	88	1,518	94	664	994	86,578
4				87,498	49,856	4,038	4,636	1,508	1,088	1,868	3,570	1,564	2,654	1,540	1,748	278	1,070	493	357	6,480	445	4,037	904	265,539
5					493,909	97,310	129,041	41,378	26,469	56,562	60,353	22,486	52,621	45,727	34,760	4,894	26,487	5,368	5,253	107,218	7,003	41,685	87,959	1,904,377
6						49,924	25,504	4,494	5,136	5,804	10,920	4,656	22,092	11,228	30,164	2,452	7,228	1,581	1,081	32,971	3,009	6,134	2,508	380,293
7							19,568	10,452	8,322	6,789	14,687	5,750	22,633	13,482	16,768	1,682	5,626	1,569	985	16,949	910	5,280	4,709	336,371
8								2,169	2,740	4,714	6,084	1,686	5,806	2,860	3,180	538	1,262	498	332	7,437	317	1,924	948	102,960
9									3,888	7,846	19,050	4,050	9,852	5,242	4,456	728	1,428	849	487	6,098	406	1,408	790	114,757
10										5,680	19,126	4,664	5,184	2,902	4,012	540	1,606	693	536	16,373	729	2,926	1,246	156,114
11											34,948	16,514	11,346	6,586	6,638	956	4,588	1,762	1,379	21,616	995	4,126	1,732	282,977
12												37,648	4,070	3,288	2,562	386	2,162	1,327	718	8,652	438	1,778	1,104	163,636
13													29,272	24,566	17,514	2,150	7,006	2,345	1,269	10,108	673	2,982	1,682	265,908
14														10,386	9,230	1,152	8,102	2,123	859	5,700	370	1,680	864	168,743
15															20,769	2,356	3,593	997	607	6,595	445	1,882	942	190,514
16																9,785	438	203	127	1,077	74	302	160	40,171
17																	3,287	2,414	802	4,542	254	1,084	492	87,072
18																		33,272	804	2,097	144	424	262	92,647
19																			32,729	2,634	112	421	194	84,539
20																				189,866	8,440	8,948	2,792	658,557
21																					38,002	587	234	101,725
22																						14,731	1,956	120,020
23																							4,422	121,438
Total																								2,865,991

Section 5. Estimation of Traffic Assignment

This section deals with the problem of just how the OD traffic distribution predicted in Section 4 will flow and how great the anticipated volume of traffic might be in each section of the road network.

While a number of various methods have hitherto been introduced to estimate the traffic assignment. The traffic has been assumed in this report to flow via the route which offers the shortest travelling time between zones. We have devided traffic assignment into several times for convenience and the OD traffic shown in the OD table is assigned through the shortest route in any desired volume.

The running speed will change according to the traffic volume of each road section that might increase on each time of assignment, and the shortest route is determined by the speed thus changed. Then the volume of traffic is added to the shortest route thus determined, until the entire OD traffic volume is assigned.

At this point, a problem arises with regard to the relationship between the traffic volume and travel time, and the relationship between the traffic volume and the running speed (the so-called QV equation) may generally be expressed by a linear equation.

$$V = AQ + B$$

where

V = Running speed

Q = Traffic volume

A, B = Constants determined for each roadway

This relationship is plotted in Fig. 5-1 (1). If the traffic volume increases from Q to Q', the running speed will decrease from V to V'. On the other hand, the relationship between the running speed and running time is computed from the formula

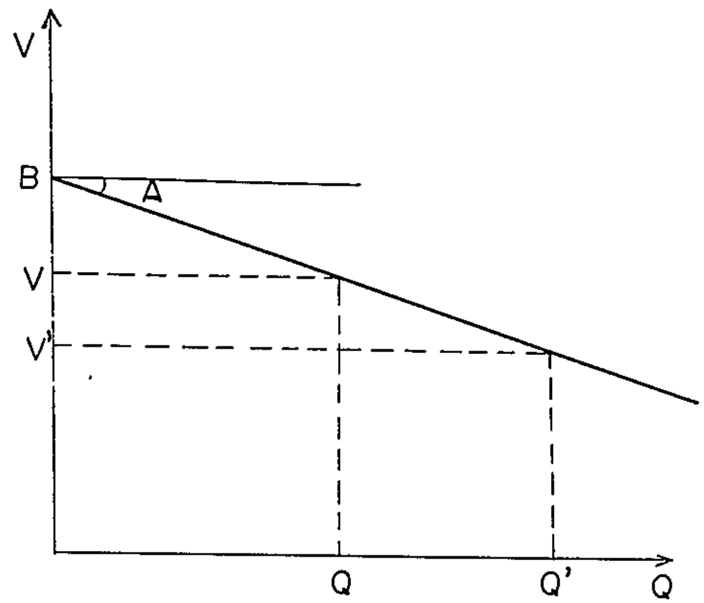
$$T = \frac{L}{V}$$

where

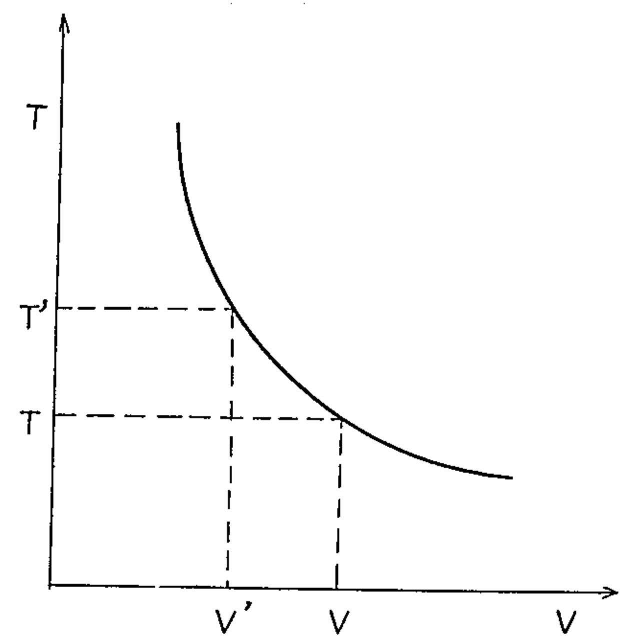
T = Running time

L = Distance

This relationship is plotted in Fig. 5-1 (2). If the running speed decreases from V to V', the running time increase from T to T'. Therefore, with an increase in the volume of traffic, the running time will also increase.



(1) Relationship between Traffic Volume Q and Runing Speed V



(2) Relationship between Runing Speed V and Runing Time T

FIG. 5-1

The followings describe the computer programming actually employed to make necessary computation.

(1) The actual road network, when fed to the computer, will appear as a network consisting of links and nodes. Each link in this case represents a section of road and each node an intersection. The serial numbers are given to all nodes. It is necessary to feed the computer with the node numbers of both ends, the relationship between the traffic volume and the running speed (so-called QV equation) and length of each link, as input data in regard to each link. Also fed thereinto are OD traffic volume and traffic generating nodes. A traffic generating node is considered as a point, to which are centered various points, where the actual traffic is generated or attracted in a zone.

(2) First, using the QV equation, compute the running speed and running time of each link on which traffic volume is zero. Then, derive a certain traffic generating node at random and select a minimum path leading to the each attracting node.

(3) Assign a part of OD traffic from the said generating node through the minimum path given in step (2) and then compute the new running speed and running time of each link, using the QV equation. It can be determined freely how much percentage of the OD traffic is assigned here.

(4) Derive a certin another traffic generating node at random and select a minimum path leading to the each attracting node. And assign a part of OD traffic (the same percentage as in the step (3)) from this generating node through the minimum path determined from the running time of each link given in the step (3). Then, compute the new running speed and running time of each link.

(5) The step (4) should be repeated until such time as all the traffic generating nodes are selected.

(6) Repeat computations given in the steps (4) and (5) and discontinue to do so when the entire OD traffic has been completely assigned. It is not necessary to divide the OD traffic volume equally at each time of repetition of computation given in the steps (4) and (5).

(7) The amount of traffic through each link, link running time and traffic volumes at crossings to each direction can be obtained as output data.

Needless to say, in this method of traffic assignment, the presence and absence of certain roads will give delicate effects on the assigned volume of traffic of other roads.

For this reason, it is necessary to consider all the projected routes; otherwise, the traffic volume in one section of road cannot be estimated accurately. The above remark particularly is applied to routes that are in competition with others. In order to find the volume of traffic passing over the first Bangkok - Thonburi Bridge in Ta Chang-Wangn Na, we have included in the road network the second Bangkok - Thonburi Bridge linking the Sathon or Silom Road. This road network is shown in Fig. 5-2. The number of lanes of each link, which must be determined prior to formulating a QV equation, is just as shown on Table 5-1. In this table, the street widening is anticipated to some extent to meet the increasing traffic volume, particularly in 1990. The constants A and B given in the QV equation have been drawn, based on the actual observations in Japan.

Table 5-1. The Number of Lanes of Each Link

Link No.	1975	1990	Link No.	1975	1990
1	2	2	19	4	4
2	2	2	20	4	4
3	2	2	21	6	10
4	8	8	22	6	10
5	8	8	23	4	4
6	2	2	24	6	8
7	8	8	25	6	6
8	4	4	26	6	8
9	4	6	27	8	10
10	2	2	28	10	10
11	4	4	29	4	6
12	8	8	30	8	8
13	4	4	31	10	10
14	2	2	32	8	10
15	6	6	33	4	8
16	6	6	34	16	16
17	6	6	35	14	14
18	10	10	36	4	4

Link No.	1975	1990	Link No.	1975	1990
37	4	4	69	2	2
38	4	4	70	2	2
39	4	6	71	2	2
40	4	4	72	2	2
41	4	8	73	4	4
42	6	8	74	6	6
43	6	8	75	2	2
44	4	8	76	4	4
45	4	4	77	2	2
46	4	8	78	4	4
47	6	8	79	2	2
48	6	8	80	2	2
49	2	2	81	6	6
50	4	4	82	4	4
51	12	12	83	6	10
52	4	4	84	6	6
53	4	6	85	6	8
54	4	4	86	8	8
55	4	6	87	4	4
56	4	4	88	4	4
57	4	6	89	4	4
58	4	6	90	6	8
59	4	6	91	6	8
60	2	4	92	6	6
61	2	4	93	6	6
62	2	4	94	6	6
63	2	2	95	6	6
64	4	4	96	6	6
65	2	2	97	6	6
66	4	6	98	4	4
67	4	4	99	4	4
68	4	4			

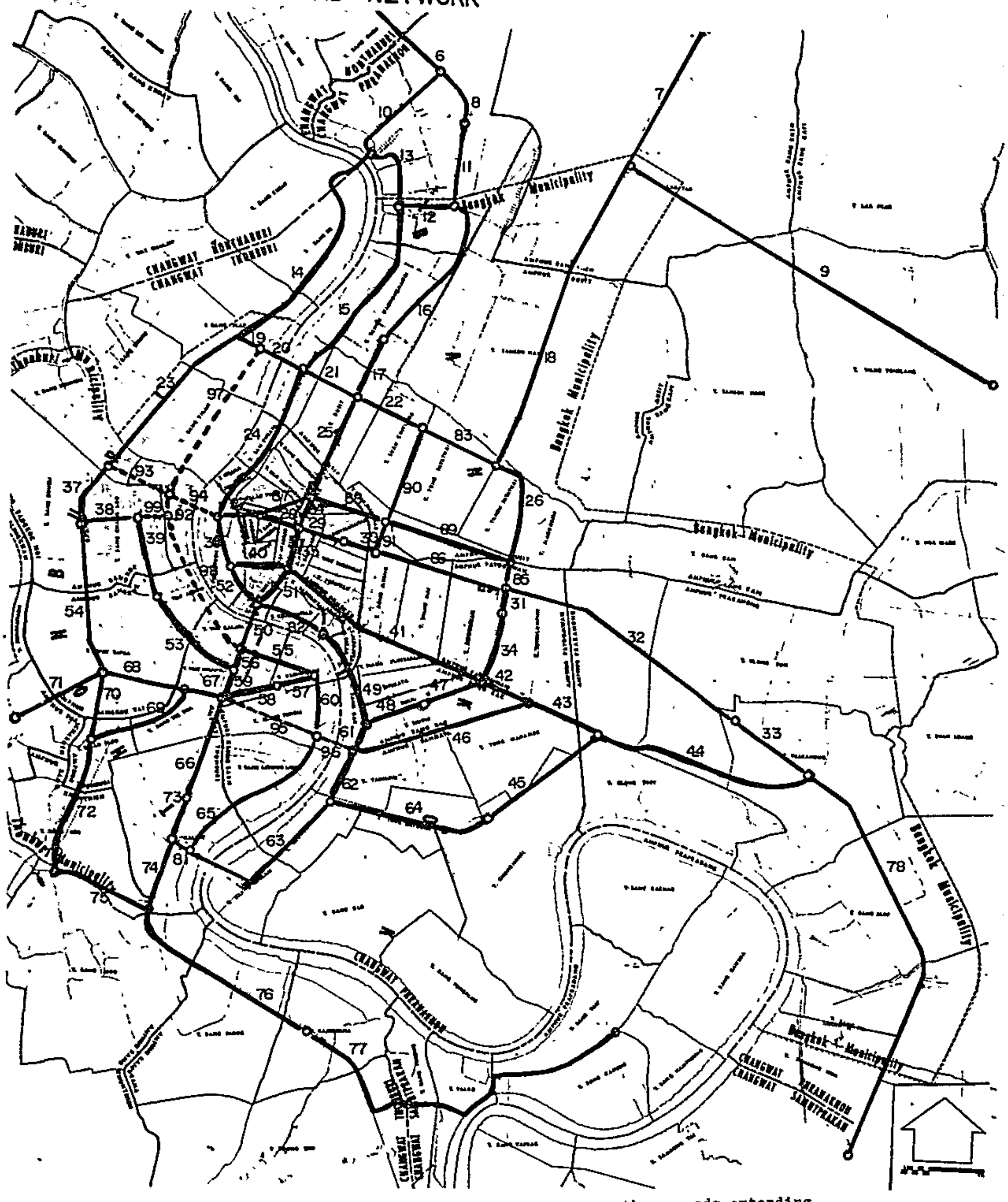
In computing the traffic assignment with a digital computer, OD traffic volume is devided into four equal volumes. While traffic between Bangkok and Thonburi in 1990 is expected to be too large for an exact computation to be handled by the combined traffic-carrying capacity of this road network, traffic assignment has nevertheless been carried out to ascertain as to how large the traffic volume of the proposed bridge will be when a certain period of time has passed after the completion of the bridge.

Of the results of assignment computations, part of the traffic between Bangkok and Thonburi area are indicated in Table 5-2 alongside the 1967 figure for purposes of comparison. All results are also given in Fig. 5-3 through 5-5.

Table 5-2. Traffic between Bangkok and Thonburi

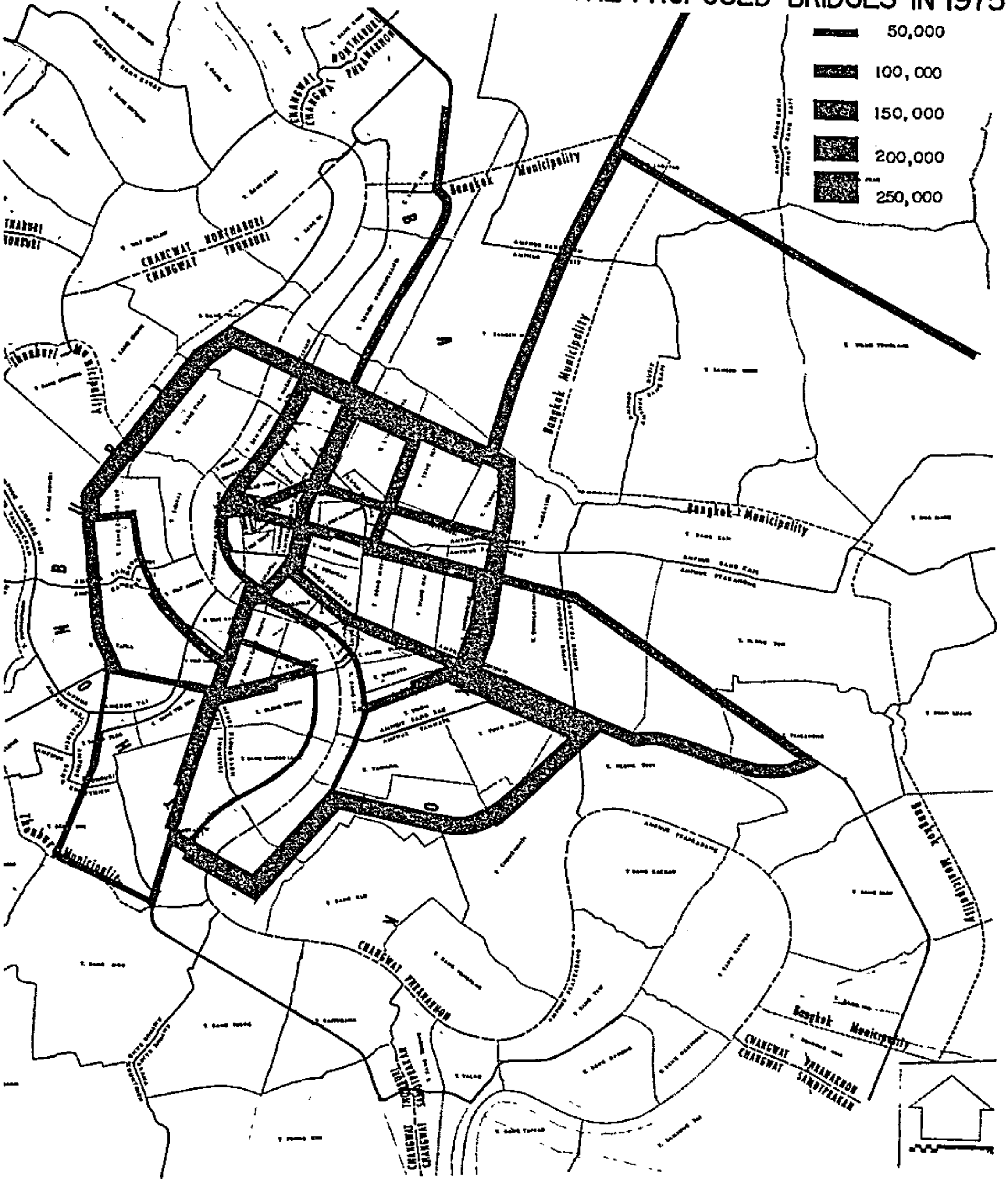
Link No.	Bridge	1967	1975		1990
			Not Including the Proposed Bridges and their Access Roads	Including the Proposed Bridges and their Access Roads	
14	Rama VI	5,380	21,020	24,565	35,757
20	K. Thon	27,060	150,017	73,356	104,151
50	Memorial	105,400	133,131	112,455	114,527
63	K. Thep	22,200	142,987	61,538	79,855
94	First	--	--	91,384	134,854
96	Second	--	--	83,857	132,929
Total		160,040	447,155	447,155	602,073

FIG. 5 - 2 ROAD NETWORK



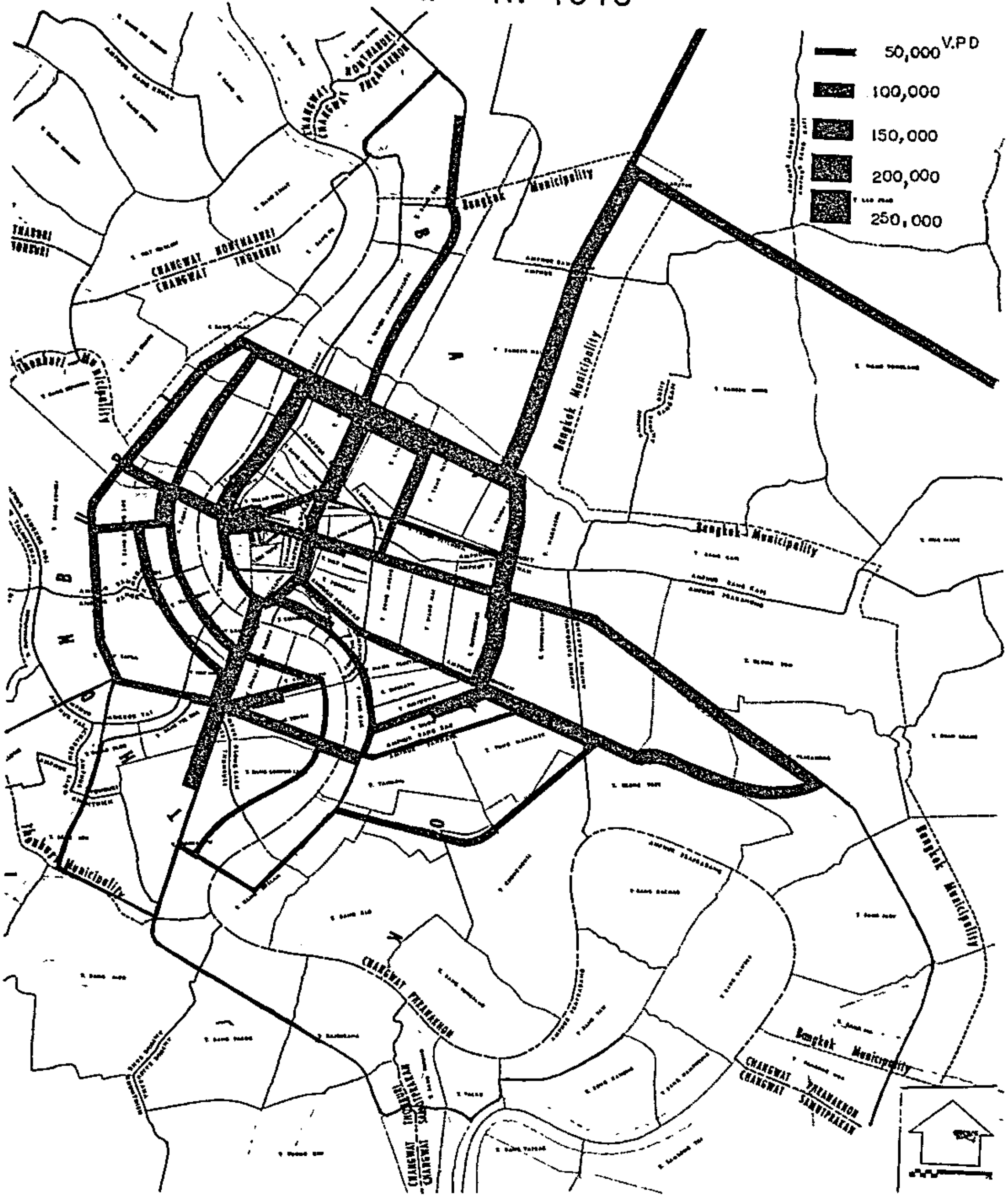
Note: For convenience of computations, two or three roads extending in the same direction are shown as one roadway. Since a main emphasis is placed on the forecasting of traffic volume on the bridge and its access roads, there may be slight inaccuracy on the traffic volume of other roads.

FIG. 5-3 TRAFFIC FLOW EXCLUDING THE PROPOSED BRIDGES IN 1975



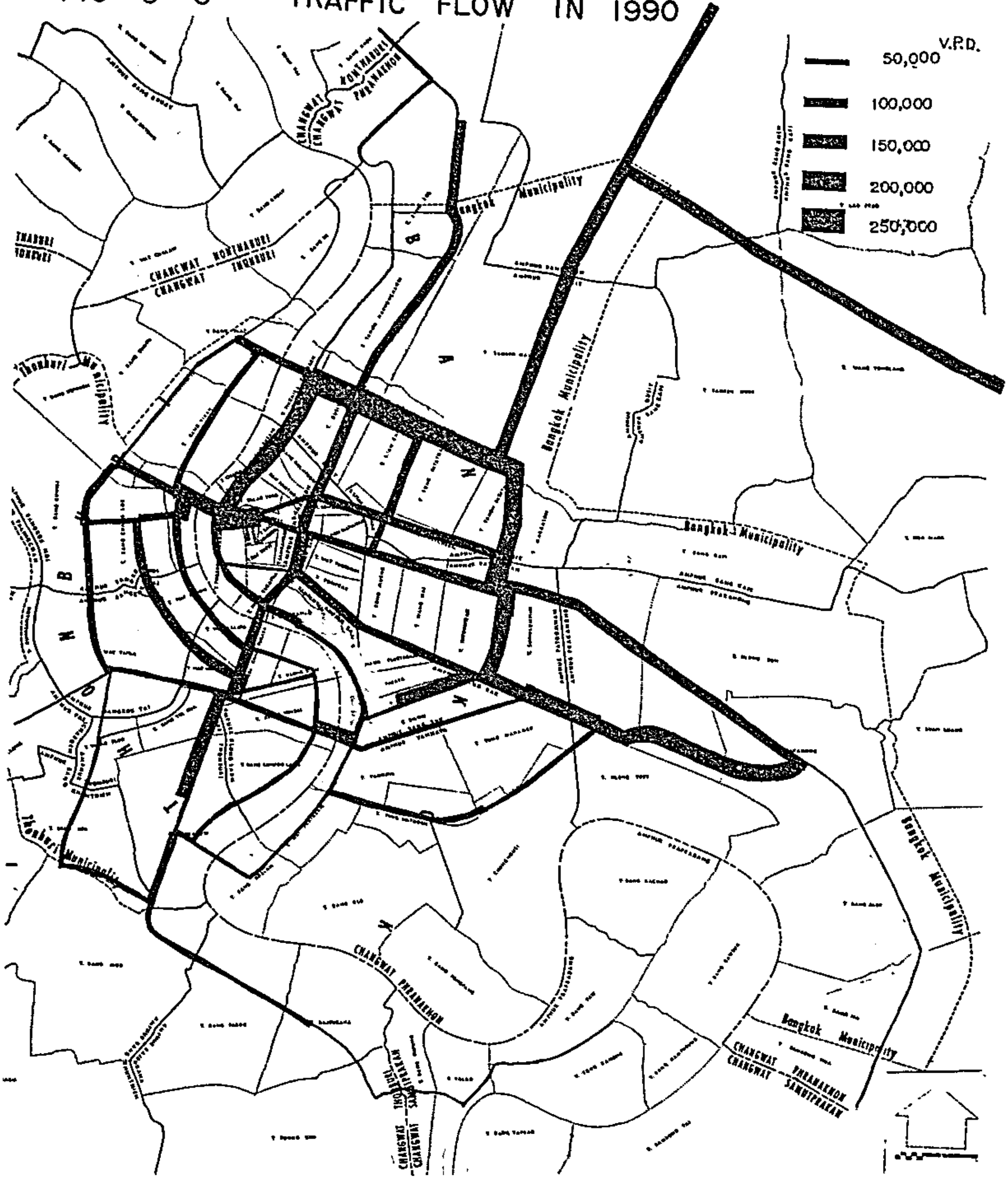
Note: For convenience of computations, two or three roads extending in the same direction are shown as one roadway. Since a main emphasis is placed on the forecasting of traffic volume on the bridge and its access roads, there may be slight inaccuracy on the traffic volume of other roads.

FIG 5 — 4 TRAFFIC FLOW IN 1975



Note: For convenience of computations, two or three roads extending in the same direction are shown as one roadway. Since a main emphasis is placed on the forecasting of traffic volume on the bridge and its access roads, there may be slight inaccuracy in the traffic volume of other roads.

FIG 5-5 TRAFFIC FLOW IN 1990



Note: For convenience of computations, two or three roads extending in the same direction are shown as one roadway. Since a main emphasis is placed on the forecasting of traffic volume on the bridge and its access roads, there may be slight inaccuracy in the traffic volume of other roads.

CHAPTER II

BENEFITS OF THE PROJECT

Section 1. Types of Benefits and Unit Cost

The investment on roads produces various economic effects such as shown on Table 1-1.

Table 1-1. The Economic Effects of Investment on Road

<table>
<tr><td rowspan="11">Economic Effects (broad sense)</td><td rowspan="9">Economic effects (narrow sense)</td><td rowspan="5">Direct effects</td><td>Saving in running cost</td></tr>
<tr><td>Reduction in travelling time</td></tr>
<tr><td>Less fatigue and increased comfort</td></tr>
<tr><td>Reduction in Traffic accidents</td></tr>
<tr><td>Saving in packing and crating costs</td></tr>
<tr><td rowspan="4">Indirect effects (external economy)</td><td>Rationalization of product and transport planning</td></tr>
<tr><td>Greater industrial development</td></tr>
<tr><td>Development of natural resources</td></tr>
<tr><td>Market expansion</td></tr>
<tr><td rowspan="2">External ill-effects on economy</td><td colspan="2">Reduction in agricultural products due to the change of farm-land into right-of-way and the division of farm-land</td></tr>
<tr><td colspan="2">Increase in social loss due to destruction of cultural assets and public nuisance</td></tr>
</table>

It, however, is very difficult to measure these effects in teams of monetary value except the effects of saving in running cost and reduction of travelling time. Therefore, these two effects only are taken into consideration in general cases. This report confines its scope of economic effects to saving in running cost and time benefit.

The term "cost saving" used herein is difined as a saving in travel costs and the "time benefit" as the reduction of travelling time, expressed in terms of time unit cost.

The CHAPTER II deals with the computation of benefits using the results of traffic assignment as calculated in CHAPTER I. The total number of vehicles have only been estimated as traffic to be assigned to each road section, but inasmuch as the amount of benefit might vary with each type of vehicle involved, the average composition of vehicle types for 1975 and 1990 have been estimated by adding the composition rate of Samlors to that of passenger cars observed in 1967 by the General Engineering Company on the traffic passing over the existing four bridges.

We have worked out benefit unit costs by multiplying the composition of the types of vehicles passing over the bridges by time unit cost of each type of vehicle or by travel cost. The present and future compositions of vehicle types are given in Table 1-2.

Table 1-2. Composition of Types of Vehicles Passing Through the Existing and Proposed Bangkok-Thonburi Bridges

Year	Bridge	Types of Vehicles					
		Passenger Car	Sumlor	Bus	Track	Motor Cycle	Total
	Memorial	59,400 54.1	9,280 8.4	9,700 8.8	6,720 6.1	24,850 22.6	109,950 100.0
	Krung Thon	18,100 64.7	1,715 6.1	1,665 5.9	4,120 14.6	2,600 9.2	28,200 100.0
1967	Krung Thep	11,140 45.0	1,950 7.9	1,200 4.8	1,410 25.8	4,100 16.5	24,800 100.0
	Rama VI	3,230 54.6	123 2.1	775 13.1	1,252 21.2	533 9.0	5,913 100.0
	Total	91,870 54.4	13,068 7.7	13,340 7.9	18,502 11.0	32,083 19.0	168,863 100.0
1975	Total	277,684 62.1	-- --	35,325 7.9	49,187 11.0	84,959 19.0	447,155 100.0
1990	Total	373,887 62.1	-- --	47,564 7.9	66,228 11.0	114,394 19.0	602,073 100.0

Upper position : Number of vehicles

Lower position: Percentage

Section 2. Time Benefits

The average time unit cost of all types of vehicles has been worked out by multiplying the future composition of the types of vehicles by the time unit cost of each type of vehicle which is shown on Table 2-1. The time unit cost in Thailand in the said table has been derived by revising the Nihon Doro Kodan's (Japan Highway Public Corporation's) standard unit cost by the different of national income per person. The time unit cost of motorcycle is reduced to just one-half of the time unit cost of a mini passenger car.

Table 2-1. Time Unit Cost (฿/min)

Type of Vehicles	Time Unit Cost in Japan	(1)Time Unit Cost in Thailand	(2)Composition of the Vehicle Type	(1) x (2)
Passenger car	0.306	0.047	0.621	0.029
Bus	0.927	0.141	0.079	0.011
Truck	0.454	0.069	0.110	0.008
Motorcycle	0.077	0.012	0.190	0.002
Total	--	--	1.000	0.050

The traffic passing the first Bangkok-Thonburi bridge is a part of the traffic between Bangkok and Thonburi. Table 2-2 shows the value of reduction in running time per vehicle of each zone pair, in 1975. Then, multiplying the value shown in Table 2-2 by the traffic volume of each zone pair passing the first bridge, we can obtain the total reduction in running time as shown in Table 2-3. Therefore, total saving in time by the bridge will be 800,713 min.veh./day, which is obtained by totaling the values of all zone pairs. The total time benefit can be found by multiplying the foregoing total time saving by the average time unit cost of 0.050฿/min. per vehicle given on Table 2-1.

Time benefit for 1975

= saving in travel time x time unit cost

= 800,713 min.veh./day x 0.050฿/min.veh.

= 40,036฿/day

Table 2-2. Reduction in Running Time per Vehicle Passing the First Bangkok-Thonburi Bridge

O \ D	6	13	14	15	16	17	18	19
1								
2								
3								
4	1.5							
5	6.3	1.8	2.4	4.0	4.0	2.0	2.0	2.4
7	10.6	4.3	5.2	8.7	8.3	4.8	4.8	4.8
8	9.5			2.4	2.4	1.8	1.8	1.8
9	5.2							
10	5.2							
11	4.8							
12	4.8							
20	4.0							
21	3.2							
22								
23								

Table 2-3. Total Reduction in Running Time Passing the First Bangkok-Thonburi Bridge

O \ D	6	13	14	15	16	17	18	19	Total
1									
2									
3									
4	2,538								2,538
5	198,337	33,298	38,110	39,624	5,608	7,966	2,430	2,408	327,781
7	149,767	58,588	41,688	71,183	6,856	6,955	2,918	1,858	339,813
8	23,693			3,730	634	587	347	236	29,227
9	14,342								14,342
10	17,092								17,092
11	18,086								18,086
12	9,230								9,230
20	39,724								39,724
21	2,880								2,880
22									
23									
Total	375,689	91,886	79,798	114,537	13,098	15,508	5,695	4,502	800,713

Section 3. Cost Saving

The running unit cost is necessary to compute saving in running cost.

Since the running cost of vehicle varies with the running speed of each vehicle, the running speed has been chassified into four classes such as shown on the Table 3-1, while the running speed of each road section has been derived from the traffic assignment given in Section 5 of CHAPTER I.

The Table 3-1 has been obtained in consideration of following points:

(1) The Table 3-1 has been derived from Nihon Doro Kodan's (Japan Highway Public Corporation's) data except the rows "Motorcycle" and "Heavily congested street".

(2) Since there are road sections where the running speed is limited to less than 20km/hr. and such case is not included in the Nihon Doro Kodan's data, a row "Heavily congested street" has been specially provided in the table, and the running unit cost of each vehicle type at the standard speed of 15 km/hr. has been obtained on the assumption that the increase of running cost is proportional to the decrease of running speed.

(3) The running cost of motorcycle is assumed to be one-fourth of that of mini passenger car.

And then, multiplying the running cost of each speed, shown on Table 3-1 by the future composition of vehicle types, it is possible to forecast the average running cost at each speed. The result of the computation is shown on Table 3-2.

Table 3-1. Running Unit Cost

Vehicle Type	Road Condition	Standard Speed (km/hr.)	Travel Cost (฿ /km)
Passenger car	Improved road	45	0.843
	Ordinary Street	35	1.039
	Congested street	25	1.167
	Heavily congested street	15	1.618
Mini passenger car	Improved road	45	0.536
	Ordinary street	35	0.655
	Congested street	25	0.637
	Heavily congested street	15	0.635
Bus	Improved road	45	3.385
	Ordinary street	35	4.433
	Congested street	25	4.808
	Heavily congested street	15	6.586
Truck	Improved road	45	2.667
	Ordinary street	35	3.640
	Congested street	25	3.841
	Heavily congested street	15	4.564
Motorcycle	Improved road	45	0.134
	Ordinary street	35	0.164
	Congested street	25	0.159
	Heavily congested street	15	0.159

Table 3-2. Average Running Unit Cost at Each Speed

Vehicle Type	A: Composition Rate of Vehicle Types	Speed (km/hr)	B: Running Cost (฿ /km. veh)	A x B (฿ /km)
Passenger Car	0.621	45	0.843	0.524
		35	1.039	0.645
		25	1.167	0.725
		15	1.618	1.005
Bus	0.079	45	3.385	0.267
		35	4.433	0.350
		25	4.808	0.380
		15	6.586	0.520
Truck	0.110	45	2.667	0.293
		35	3.640	0.400
		25	3.841	0.423
		15	4.564	0.502
Motorcycle	0.190	45	0.134	0.025
		35	0.164	0.031
		25	0.159	0.030
		15	0.159	0.030
Average	1.000	45	--	1.109
		35	--	1.426
		25	--	1.558
		15	--	2.057

Now, it is necessary to find the total running cost in 1975 based on the above running unit cost for cases with and without the first and second Bangkok-Thonburi Bridges and their access roads.

First, in case including the proposed bridges and their access roads, the number of vehicles of zone pairs whose trafic is assigned over the first bridge is multiplied by the length of each road section used by the above traffic and then the products are totaled by standard speed. In addition, we again multiply the figures thus totaled by the running unit costs according to speed and total of such figures will provide predication of total running cost of the traffic using the first bridge.

On the other hand, we can estimate the total running cost by the similar calculation regarding to the above zone pairs in case that the proposed bridges and their access roads are not included. The results of these compulations are shown in Table 3-3.

Table 3-3. Running Costs

Case		Not Including the Proposed Bridges and their access Roads		Including the Proposed Bridges and their access Roads	
Standard Speed (km/h)	(a) Unit Running Cost	(b) Road Length x No. of Vehicles	(a) x (b) Running Costs	(c) Road Length x No. of Vehicles	(a) x (c) Running Costs
45	1,109	5,909	6,553	6,858	7,606
35	1,426	5,104	7,278	5,584	7,963
25	1,558	53,882	83,948	50,237	78,269
15	2,057	69,682	143,336	31,343	64,473
Total	--	--	241,115	--	158,311

Therefore,

Cost Saving in 1975

= Running cost not including the proposed bridges and their access roads

- Running cost including the proposed bridges and their access roads

= 241,115 (฿/day) - 158,311 (฿/day)

= 82,804 (฿/day)

Section 4. Benefits of the Project

The sum of the benefits obtained in Section 2 and Section 3 is the total amount of benefits, i. e.

40 + 83 = 123 (1,000฿/day)

Since this value is the amount of daily benefits estimated to accrue therefrom, it is necessary to convert this figure into annual benefit amount.

Annual benefit in 1975

= 123 x 365 = 44,895 (1,000฿/year)

While the anticipated annual benefit expected to accrue will be proportionate to an increase in the traffic volume over the first bridge.

Therefore,

Annual benefit in 1990

$$= \text{benefit for 1975} \times \frac{\text{traffic volume over the bridge in 1990}}{\text{traffic volume over the bridge in 1975}}$$

$$= 44,895 \times \frac{134,854}{91,384}$$

= 66,252 (1,000฿/year)

CHAPTER III

COMPARISON BETWEEN BENEFITS AND COSTS

A comparison is made between the costs and benefits.

In regard to construction, maintenance and operation costs, refer to CHAPTER II, Section 4 and CHAPTER III, Section 3 and Section 4 of "FEASIBILITY REPORT" compiled separately.

Assuming the project cost is invested in its entirety in 1974, and its interest in 8 per cent annum, the cost and benefit in 'n' number of years are calculated on the basis of evaluation at the first year of use, namely, that in 1975 as follows:

the first Bangkok-Thonburi Bridge and related costs ('n' number of years)

$$430,000 \times 10^3 \times 1.08 + 1,806 \times 10^3 \times \sum_{i=1}^{n} (1.08)^{-i+1}$$

the first Bangkok-Thonburi Bridge and related benefits ('n' number of years)

$$= \sum_{i=1}^{n} B_i (1.08)^{-i+1}$$

where the benefit in 'i' th year is 'B_i'.

Let it be assumed that the life of the bridge is 50 years, the ratio of the cost to benefit for these 50 years can be obtained by

$$\frac{\text{the first Bangkok-Thonburi Bridge and related benefits}}{\text{the first Bangkok-Thonburi Bridge and related costs}}$$

$$= \frac{509,394\ (1,000฿)}{481,659\ (1,000฿)} = 1.06$$

Therefore, judging from the value indicated above, it can be said that the present proposed bridge construction project is adequately compensated when considered from the standpoint of national economy. Years till the benefits to equal the invested capital will be as follows:

$$n = 13.76$$

It is now clear that the invested capital can be depreciated in a relatively short period of time when viewed from the standpoint of national economy.