Report

on the Feasibility Study

of the Bangkok-Thonburi Ring Road Project Part II

Royal Kingdom of Thailand

March 1973

Overseas Technical Cooperation Agency
Government of Japan

Preface

The Government of Japan, in response to the request of the Government of the Royal Kingdom of Thailand, carried out a survey on the Bangkok-Thonburi Ring Road Project, the study being assigned to the Overseas Technical Cooperation Agency.

The Agency, fully aware of the importance of the effect that the completion of the Bangkok-Thonburi Ring Road Project will have on the social and economic development of the Kingdom, despatched a survey team composed of experts on urban transportation problems to Bangkok for a period of about two months, starting from 20 July, 1972. While in Bangkok, the full cooperation of various Government departments made it possible for the survey to be carried out very smoothly. Subsequent works in Japan are now duly completed and this report is the product of the survey.

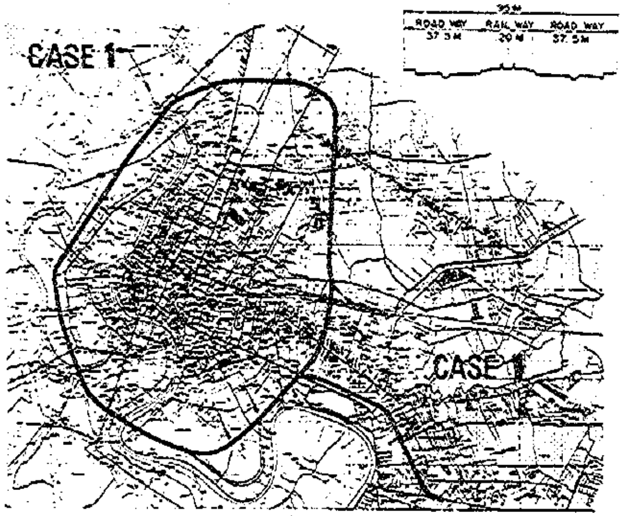
This report covers the route selection, traffic estimation, preliminary structural design and other technical considerations as well as the rough estimation of the construction cost of the Bangkok-Thonburi Ring Road which has been planned to provide relief for the deterioration in traffic situation and impediment in urban function caused by the recent rapid increase in vehicle traffic volume of the Greater Bangkok Metropolitan area.

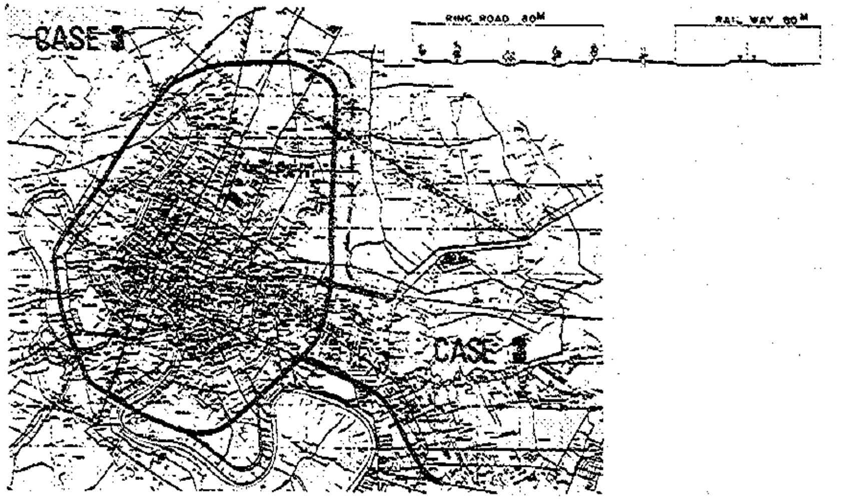
It is our fervent wish that the results of the survey will contribute towards the development of the Greater Bangkok Metropolitan area and towards the promotion of international friendship between Japan and the Royal Kingdom of Thailand.

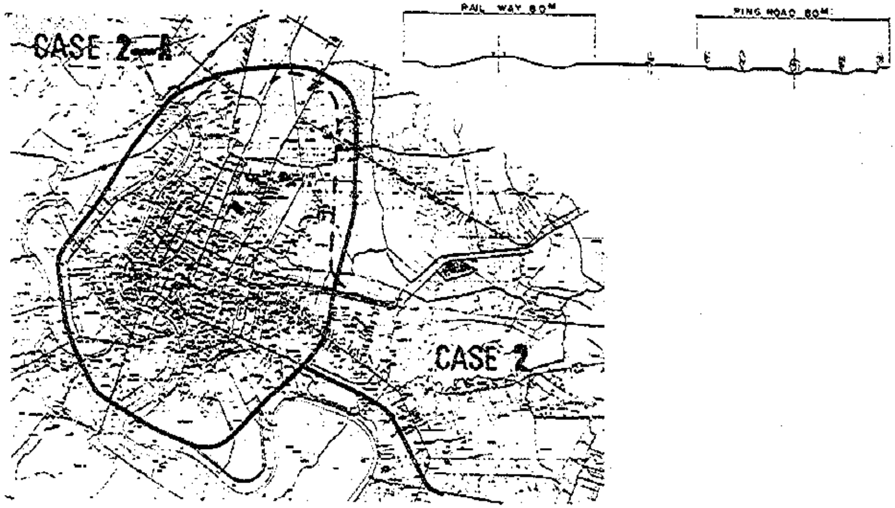
March, 1973

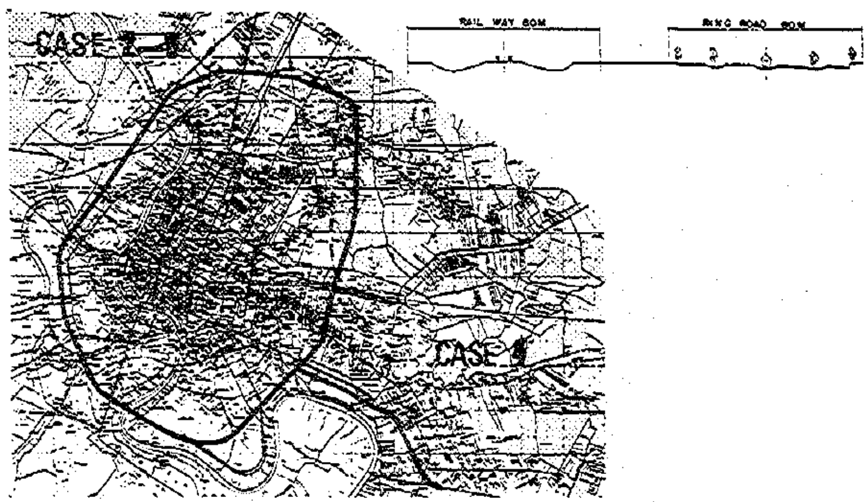
Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency

KEY PLAN


CASE 1
ROAD WAY 37.5M
RAIL WAY 20M
ROAD WAY 37.5M
95M


RING ROAD 80M
RAIL WAY 80M


CASE 2—A
CASE 2
RAIL WAY 80M
RING ROAD 80M


RAIL WAY 80M
RING ROAD 80M

SUMMARY and CONCLUSIONS

1. The road network system in Bangkok is far from adequate to meet the traffic demand, and it is anticipated that the situation will further deteriorate in future. Early steps to improve the traffic situation are therefore absolutely necessary. However, minor steps, such as improvement of existing intersections, expansion of existing roads, or intensification of traffic regulations, will not be sufficient. Construction of new highways is necessary.

2. In the planning of a new urban roadway, the future development plan of the urban area and the trend of future traffic demand in relation to the existing road network are some of the points to be taken into consideration.
The road network system of Bangkok in the suburban area consists basically of linear radial roads, and building-up is developing along the roads. This results in many inconveniences in traffic flow. For example, the district including Din Daeng and Ratchaprarop road suffers from constant traffic congestion due to the concentration of traffic from the suburban area.
To cope with such traffic situation, we are convinced that the proposed Ring Road project is most effective.

3. The proposed Ring Road Part II as well as the Section 5, is an integral portion of the Rachadapisek Ring Road whicl will serve as a collector and distributor road for traffic to and from the densely built-up area of the city, and also as a bypass for through traffic. The Ring Road Part I is in the implementation stage. Unless the Part II as well as the Section 5 is also implemented, the roles of the Rachadapisek Ring Road will not be fulfilled.
From the results of our traffic and economic analysis, a conclusion is reached that the traffic demand for the proposed Ring Road is great and from the economical point of view the project is feasible. It is recommended therefore that the project be implemented as soon as possible.

4. A brief outline of the project is listed up as follows:

Ring Road Part II:

Total Length:	27.59 km
Total Width:	80 m

Section 5:

Total Length: 7.06 km

Total Width: 71 m

Ring Road Part II and Section 5.

Number of traffic lanes	: main roadway	: 6 lanes
	service road	: 4 lanes
Width of traffic lanes	: main roadway	: 3.60 m
	service road	: 3.25 m
Design speed	: main roadway	: 100 km/hr
	service road	: 60 km/hr

5. Estimated traffic volume

Ring Road Part II: (1,000 veh/day)

Section with highest traffic volume :	1975 :	72
	1980 :	93
	1990 :	129
Section with lowest traffic volume :	1975	39
	1980	40
	1990	73
Average for the whole route :	1975	60
	1980	70
	1990	100

Section 5 :

1975	85
1980	93
1990	144

6. Construction cost

The construction costs of the project in 1975 price are estimated as follows:

Cost of land acquisition and demolition :

Ring Road Part II	690	million	bahts
Section 5	370	"	"
Total	1,060	"	"

Cost of construction :

Ring Road Part II	2,160	Million	bahts
Section 5	720	"	"
Total	2,880	"	"

Total for whole project 3,940 Million bahts

7. Estimated benefits

On the completion of the Ring Road Part II and Section 5, the annual benefits for the key years are estimated as follows:

year 1975	:	420	million bahts/year	
1980	:	630	"	"
1990	:	900	"	"

8. Benefit-cost analysis

Assuming the investment of the whole cost in the initial year and a redemption period of 20 years, the results of benefit-cost analysis, as compared to the case of 'without' the Ring Road, are as follows:

Benefit-cost ratio	at discount rate of	10%	is 1.51
"	"	12%	is 1.31
"	"	15%	is 1.09
Internal rate of return			is 16.6%

9. The following schedule of stage construction is suggested for the efficient implementation of the project.

Order of priority of construction

1. Section 5 and Section 6 (Phetchaburi extension - Superhighway)
2. Section 7(a)(1) (Superhighway - Pracharat Road)
3. Section 7(a)(3) (Phetkasem Road - Tachang extension)
4. Section 7(a)(2) & 7(b) (Tachang Extension - Pracharat Road)

10. On the stage construction of the cross section, it is suggested that except for Section 7(a)(1), construction work will start with the high speed main roadway and the construction of the service roads deferred to later date. For Section 7(a)(1) (Superhighway-Pracharat Road), work will start with the service roads first and the main roadway to be continued on completion of the service roads.

11. It is suggested that work on Section 6 and Section 5 be started in 1975 and subsequently, work on a new section be started every year. By this schedule, the first sections will be open to traffic by 1977, the ring, with part of the cross section, completed by 1980, and the project wholly completed by 1984. However, the final schedule should be decided with consideration on the sources of finance, materials and manpower, as well as on popular demand.

12. The traffic analyses are carried out basing on theoretical base year OD matrices, actually surveyed data being unavailable. It is recommended that a review of the results be made when surveyed results are available.

13. Upon implementation of the project, it is recommended that trial embankments be carried out on sample locations before a decision is made on the construction method of earth works.

14. This report is the product of the utmost efforts made within the confine of time and resources, and we are convinced that it will serve as a good basis for the preliminary decision on the project. However, the Ring Road is a large scale project, and a study within confined time at this stage invariably results in many uncertainties to be confirmed in future studies made when more detailed data are available. For example, structures make up a large portion of the estimated construction cost. In this study, the types, methods of construction and cost estimations of structures were decided basing on past data. These assumptions should be verified after ample additional informations are available through boring, soil tests and other field surveys. It is recommended, therefore, that in the implementation stage, sufficient time and effort be appropriated for the re-assessment and re-evaluation of the major items basing on future up-to-date detailed data.

CONTENTS

INTRODUCTION

I-1 General Background

The volume of vehicle traffic in the Bangkok-Thonburi Metropolitan area has been increasing at a tremendous rate for the past few years. On the other hand, the improvement and new construction of roads has not been able to maintain the same high pace. As a result, congestion has become conspicuous in most of the road sections for a large portion of the day.

Many new roads have been included in various future development plans of the Metropolitan area. The Rachadapisek Ring Road, a new loop roadway surrounding the built up portion of the Metropolitan area, has been one of the main new roadways included in the various plans. In late 1971, a contract was awarded by the Highway Department of the Royal Thai Government to a foreign consultant for the preliminary design of the southern portion of the Ring Road. This portion starts from the Tha Phra intersection in Thonburi, curving via the vicinity of the Krung Thep Bridge through the Yannawa orchard district to end at the vicinity of the New Petchaburi-Soi Asok junction. The decision on the northern portion of the Ring Road was deferred pending the outcome of a feasibility study.

I-2 Appointment of Consultants

In early 1972, an application for assistance in the feasibility study of the northern portion of the Ring Road was made by the Royal Thai Government to the Japanese Government. This application was entertained and the onus was placed with the Overseas Technical Cooperation Agency of Japan (OTCA) which is the Japanese Government sponsored organization in the implementation of overseas technical assistance. The Pacific Consultants

International, a general consultants organization in all fields of civil engineering works, was appointed by the OTCA to executive the feasibility study under a contract signed between OTCA and the consultant on 19 July, 1972. Work on the study commenced in Bangkok, Royal Thai Kingdom on the 20th July, 1972. The study period was for a 7-month period from 20 July, 1972 to 28 February, 1973.

I-3 Scope of Work

The Scope of Work as prepared by the Highway Department of the Royal Thai Government and presented to the Japanese Government are quoted as follows:

(6) Scope of Work of Experts
Engineering and Economic Evaluation

1) The Engineer shall examine the site of the proposed route and shall peruse the studies, surveys, plans and sections, reports, soil and subsurface exploration data, traffic studies and all other available information relevant to the project and which has already been prepared or carried out by others.

2) The Engineer shall carry out the necessary traffic and economic studies, additional to those which may be available from others, to determine the appropriate standards for construction and for stage construction not only of the carriageways but of the interchanges along the route.

3) After such examination and studies, the Engineer shall submit twenty copies of an evaluation report (herein-after called 'the evaluation report') which will present an Engineering and Economic evaluation to propose and

justify the recommendations for alignment and stands taking into account the work already done and will propose the methods and principles to be followed by the Engineer in the design of the project, giving details of staff, equipment and timing for the various parts of the work. The report will also highlight difficulties which the Engineer foresees in completing the design or construction, and will suggest Government action that may be required to overcome them. Unless informed in writing to the contrary within four weeks of submission, the Engineer may assume that the proposals contained in his Evaluation Report are accepted by Government.

4) In drawing up his Evaluation Report, the Engineer shall observe the following points:

   a) The standards of design shall be justified in terms of costs and benefits and shall be fully in accordance with generally accepted international practice, taking account the present and potential physical and economic state of development of area and of the country. Where for any reason it appears desirable to depart significantly from such practice, the Engineer shall in his Evaluation Report (or later, as may be appropriate) present sound arguments in support of his decision. These arguments may be based on economic analysis of possible costs and benefits, as well as on engineering or other reasons. The objective at all times shall be to reach an optimum solution to problems within the confines of time and resources available.

b) Part at least of this route will be financed locally, and it is expected that construction may be by contractors already operating in Thailand. The Engineer will use designs and methods which will minimise the use of foreign exchange and which can be readily undertaken by local labour.

c) The Engineer will be expected to take full account of the presence of utilities within or near the Right-of-Way. He will investigate their location, so far as is practicable, and show them on the plans. The design shall allow for the presence of utilities wherever necessary and shall be done in such a way as to minimise their removal or re-location.

5) As a part of the Evaluation Report, the Engineer will:

a) Propose suitable construction lots for approval by the Government.

b) Show the final alignment of the road.

c) Show the general outline of junction designs, with reasons for the type adopted.

d) Give the outline design of the major structures proposed.

e) Give a general report on the major engineering and other decisions taken during the project to date, with supporting arguments, where appropriate, for the decisions taken.

I-4 Conduct of the Study

The excution of the feasibility was carried out by experts from the Pacific Consultants International under the supervision of a Supervisory Committee composing of experts from various departments of the Japanese Government. The study team despatched by the consultants spent variously from one to four months in Bangkok, starting from 20 July, 1972, for fact finding, data collection and discussion with officials of various relevant Departments of the Royal Thai Government. Subsequent works were carried out in the Consultants' Head Office in Tokyo whereby the full support of the whole engineering staff of the consultants as well as the consultants' electronic computer facilities was thrown in. The representatives of the supervisory committee made two separate two-week visits to Bangkok during the study team's working period in Bangkok for confirmation of essential points of decision with the Department of Highways.
A team of two members each from both the Supervisory Committee and the consultants was despatch again to Bangkok in December, 1972 for report and discussion on the intermediate findings of the study. The Supervisory Committee and the study team despatch to Bangkok are of the following composition:

(A) Supervisory Committee

Chairman	1
Highway & Transportation Engineers	3
Economist	1
Structure Engineer	1
Hydrological Engineer	1
Coordinator	1

(B) Study Team of the Pacific Consultants International

Project Manager	1
Deputy Project Manager & Urban Planner	1
Highway Engineer	1
Hydrological Engineer	1
Structural Engineer	1
Transportation Economist	1
Transportation Engineer	1
Soil & Material Engineer	1
Office Manager	1

I-5 Organization of the Study Team

The full list of the study team and Supervisory Committee is as follows:

(A) Supervisory Committee

Chairman:

Mr. Tsutomu Takahashi
Director, Toll Road Div., Road Bureau,
Ministry of Construction, Japan

Highway & Transportation Engineers:

Mr. Shigeru Motoyama
Special Grade Engineer, Toll Road Div., Road Bureau,
Ministry of Construction, Japan

Mr. Hiroyuki Wada
Special Grade Engineer,
Supervisor's Office for Urban Expressway
Public Corporation, City Bureau,
Ministry of Construction, Japan

Mr. Hiroshi Mitani
Deputy Director, Planning Div., Road Bureau,
Ministry of Construction, Japan

Economist:

Mr. Terufusa Hiromatsu
Deputy Manager, Economic Research Department,
Japan Highway Public Corporation

Hydrological Engineer:

Mr. Hiroaki Tamamitsu
Senior Engineer, International Cooperation Office,
Planning Bureau,
Ministry of Construction, Japan

Structural Engineer:

Mr. Osamu Tamaki
Chief, Engineering Div., Metropolitan Expressway
Public Corporation, Tokyo

Coordinator:

Mr. Fumio Higai
Overseas Technical Cooperation Agency

(B) Study Team of Pacific Consultants International

Project Manager:	Yasuo Yanai
Deputy Project Manager & Urban Planner:	Fan Kai-Chang
Highway Engineer:	Takashi Miyakoshi
Hydrological Engineer:	Minoru Shibuya
Structural Engineer:	Yutaka Ishizuka
Transportation Economist:	Teruo Endo
Transportation Engineer:	Tomoyuki Matsumura
Soil & Material Engineer:	Toshinobu Akagi
Office Manager:	Jun Tsuboi

I-6 Assistance from Government Department & Other Bodies in Thailand

In the course of the study, much valuable assistance, advice, opinions, and conveniences were received by the team from various governments departments and public and private bodies in Thailand. We would like to express our appreciation to all, without whom, the study cannot be carried out so smoothly and successfully. A full list will be too long to be included here. So only the major bodies will be mentioned hereunder:

National Economic Development Board
Department of Highways
Department of Town and Country Planning
Department of Police
Department of Land Transport
Department of Harbours
Bangkok Municipality
Office of Metropolitan Traffic Planning
Express Transport Organization (ETO)
ECAFE
Asia Institute of Technology
Chulalongkorn University
Tammasert University
T. P. O' Sullivan & Partners
Thai Engineering Consultants
Japan Trade Centre, Bangkok
Japan Chamber of Trade & Industry, Bangkok Office
Tachang Bridge Construction Office
Nihon Tsuun, Bangkok Office
Embassy of Japan, Bangkok
Japan Overseas Technical Cooperation Agency, Bangkok Office

I-7 Reference Materials

In the study, extensive reference was made of many data, statistical records, reports and essays. A list of these is presented in the appendices.

I-8 The Study Approach

The study period was for only seven months. Over study approach was natural limited to the methods which are physically possible during the seven-month period.

The focus of the study was centred on the Ring Road only. The economic feasibility was considered from the point of whether the project by itself, would be feasible against the benefits that would be derivable through the implementation of the project. The comparison was between 'with' and 'without' the Ring Road. The study on priority was made among various alternative stages of construction of the Ring Road.
No attempt was made of comparative feasibility between the Ring Road and any other competitive transportation projects in a comprehensive transportation plan, as such a study will involved enormous work and is completely out of the scope of this study.

It was not possible to carry out any comprehensive traffic survey, due to shortage of time, and study was limited to analyses of existing data. Data of past Origin-Destination traffic survey was not available. As a result, purely theoretically O - D matrices had to be synthesized and the results checked against existing data of cross section traffic counts.

In cost analysis, the results of the "Road Users Costs in Thailand' (T. P. O' Sullivan & Pastners) were adopted unqualified, with only minor modifications to suit the propose of the Study. No attempt was made to verify the results.

In the case of the engineering part of the study, extensive field reconnaissance was made of the routes of the various proposed alternatives, far beyond what is usually called for in a feasibility study. This is due to the fact that a great part of the routes were proposed through highly built-up area and the cost of demolition was expected to make up a substantial percentage of the construction cost of the project.

Suggestions and advices of the Department of Highways of the Royal Kingdom were sought for in the decision on matters of major importance. Also, for the works carried out in Tokyo, the intermediate findings of the consultant were presented for criticism and advices of the Supervisory Committee during the regular sessions of the Supervisory Committee Meetings.

PART 1

ECONOMIC AND TRAFFIC STUDY

CHAPTER 1. GENERAL

1-1 General Outline

Economically speaking Thailand is relatively developed, compared to its Asian neighbors. Basically an agricultural state, it has been striving on the one hand to diversify and to increase the agricultural products, and on the other to introduce foreign capital investments and aids for the development and advancement of the manufacturing industry. Among other endeavors, an economic development five-year plan was put in effect in 1967. Preceded by a six-year plan enforced in 1961, this is the second of its kind carried in pursuit of the nation's economical mordernization. However, in spite of all the efforts, a downtrend in the growth rate of economy began since the end of the 1960's, after a period of steady growth seen in the earlier part of that decade. This became more pronounced after the year 1970. The cause of this trend is attributed to the fact that in contrast to the rapid growth of imports which reflects industrial development and growth of consumption, exports stangnated, the Vietnam special order decreased, private foreign investments rapidly increased, thus causing the development of unfavorable international balance of payments, and bringing forth an ever growing trade deficit. This is an urgent problem to be solved in order to establish a sound economy.

Fig. 1-1 Per capita national income of Asian nations. (in U.S. dollars) 1970

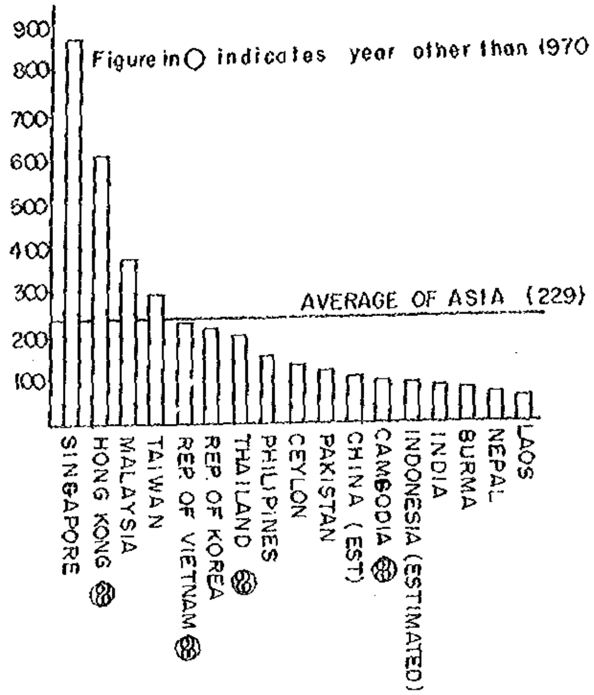


Fig. 1-2 Trend in per capita national income (in bahts)

Year	Central Area		Whole Country	
	Annual income	Index	Annual income	Index
1960	3440	100	2070	100
1961	3530	103	2110	102
1962	3680	107	2210	107
1963	3850	112	2310	112
1964	4030	117	2350	114
1965	4290	125	2480	120
1966	4560	133	2690	130
1967	4850	141	2760	133
1968	5100	148	2900	140
1969	5400	156	3080	149
1970	5550	161	3160	153

Fig. Trend in per capita national income

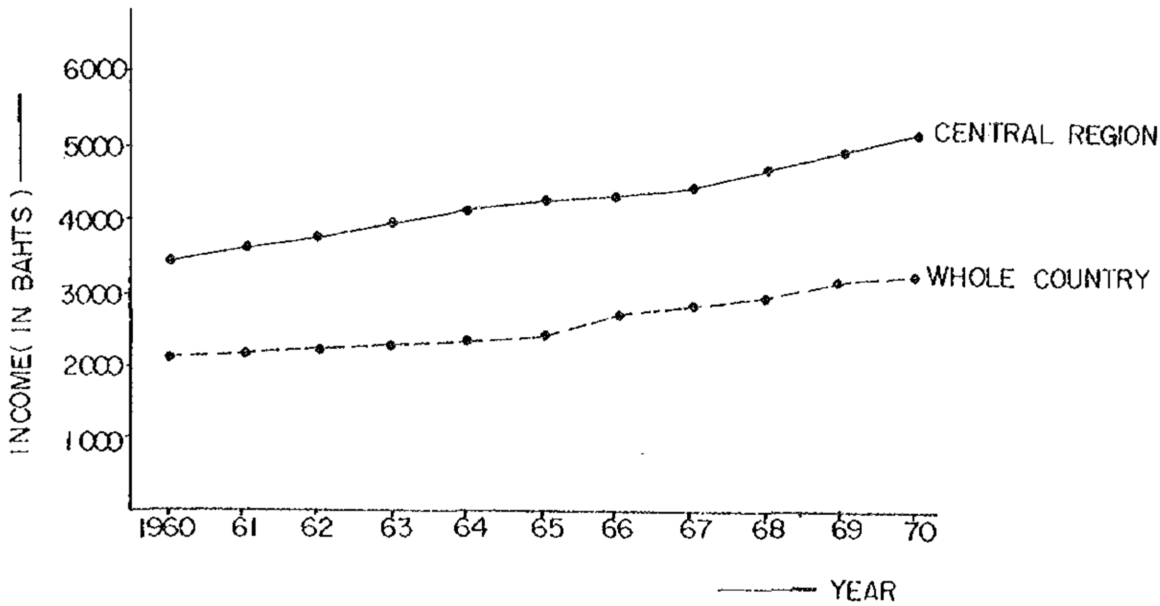


Fig. 1-4 Composition of G.N.P. (1962 value)

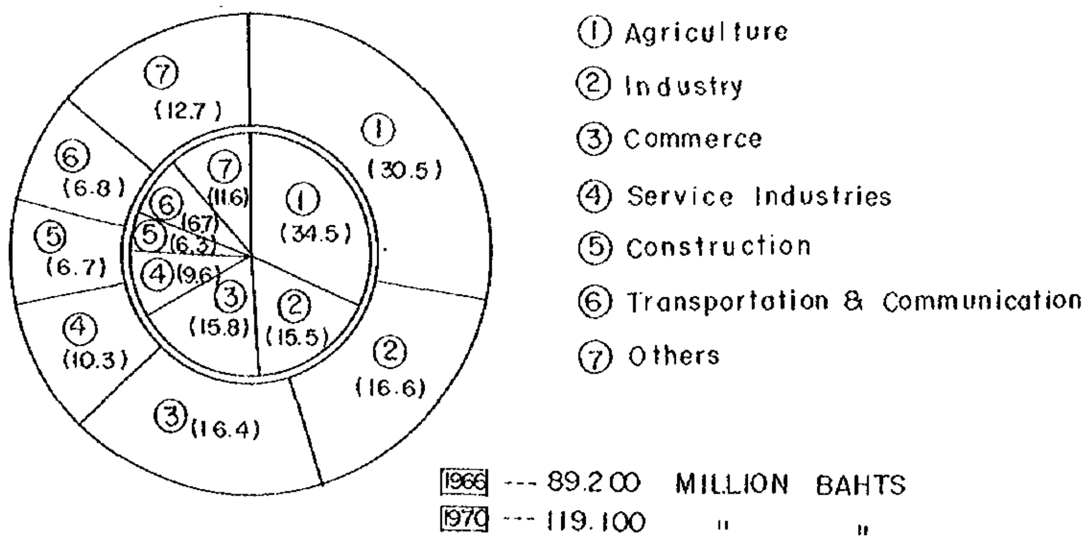


Fig. 1-5 Growth rate of G. N. P. and per capita national income

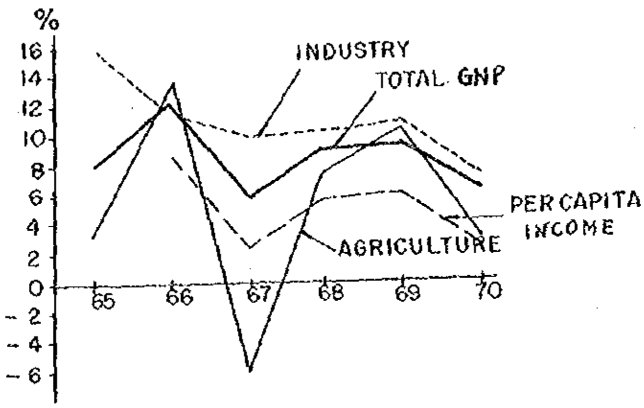


Fig. 1-6 Trend in gross national production of Thailand by industry (based on 1962 price)

(in million baths)

Year / Amount / Industry	1966		1967		1968		1969		1970		1971 (estimated)		1966 - 1970 Average rate of growth
	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%	Amount	%	
Agriculture	30,785	34.5	28,971	30.8	31,091	30.3	34,234	30.5	35,224	30.5	37,300	29.5	5.6
Mining	1,418	1.6	1,630	1.7	1,780	1.7	1,912	1.7	1,984	1.7	2,100	1.7	10.8
Manufacturing	13,795	15.5	15,157	16.1	16,680	16.2	18,456	16.4	19,820	16.6	21,400	16.9	9.9
Contruction	5,604	6.3	6,669	7.1	7,266	7.1	7,599	6.8	8,014	6.7	8,400	6.6	4.3
Power & water services	809	0.9	982	1.0	1,189	1.2	1,428	1.3	1,681	1.4	1,900	1.5	21.9
Transportation & communication	6,013	6.7	6,524	6.9	686.3	6.7	7,638	6.8	8,131	6.8	8,600	6.8	7.8
Commerce	14,133	15.8	15,877	16.9	17,249	16.8	18,819	16.7	19,514	16.4	20,500	16.2	8.8
Banking, insurance & real estate	2,620	2.9	3,068	3.3	3,565	3.5	4,124	3.7	4,749	4.0	5,100	4.1	17.3
Housing	1,931	2.2	2,009	2.1	2,091	2.0	2,187	1.9	2,304	1.9	2,400	1.9	4.4
Administrative & defence services	3,542	4.0	3,827	4.1	4,363	4.3	4,765	4.2	5,366	4.5	5,700	4.5	9.3
Services	8,539	9.6	9,397	10.0	10,441	10.2	11,216	10.0	12,305	10.3	13,000	10.3	9.7
Total	89,190	100.0	94,109	100.0	102,578	100.0	112,378	100.0	119,101	100.0	126,400	100.0	9.5
Index	100		106		115		126		134		142		

Sources: Bank of Thailand monthly bulletin; The Thai National Economic Development Board.

1-2 Geography

1-2-1 The Kingdom

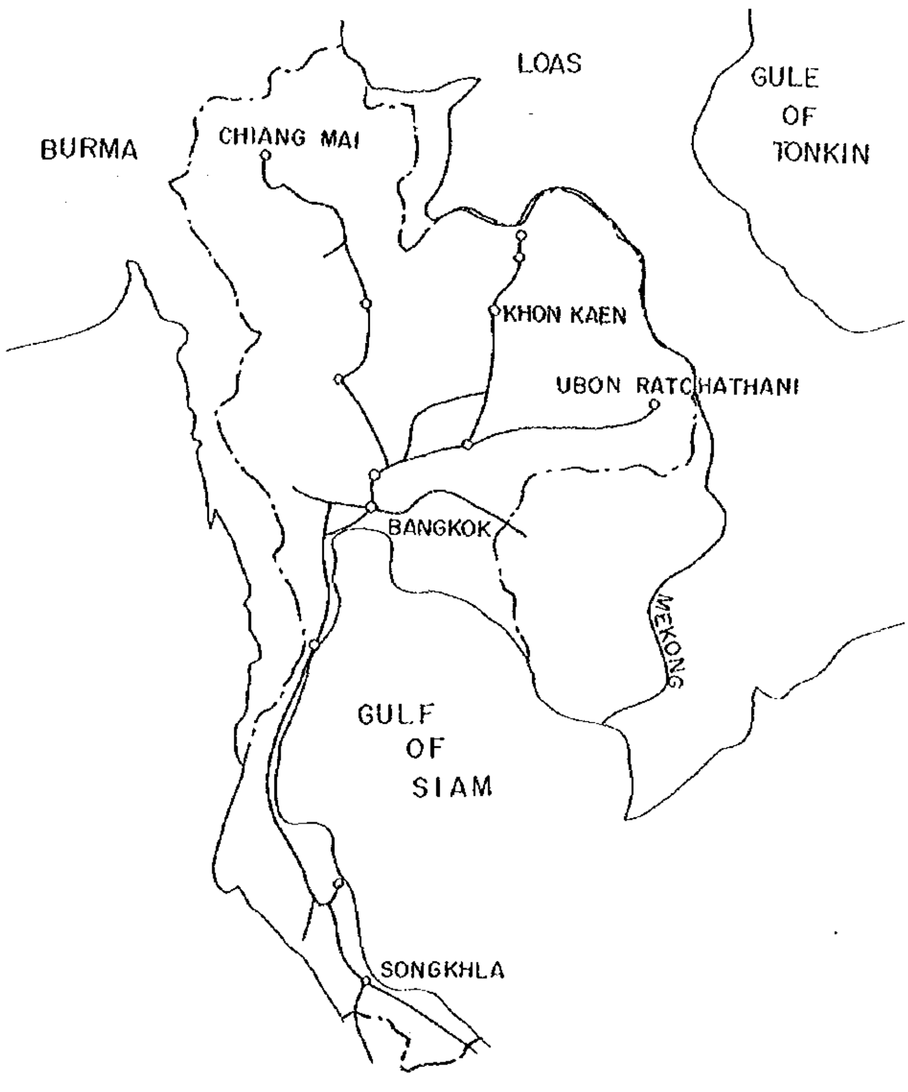
Thailand lies in the central part of Indo-China peninsula. Its neighbours are Burma on the west and northwest, Malaysia on the south, Laos on the east with the Mekong river forming much of the boarder, and Cambodia on the southwest.

Western Thailand contains the Indo-China range which is the extension of the Himalayans. This extends southward, forming the Thanon-Toi-Chai, the Tenasserim, and the Bhukett ranges, and reaches further into the Malay peninsula. Through the central region penetrates the 1,200 km Chao Phraya River which begins in the northern mountains, flows southward across this alluvial delta plain, the rice basket of Thailand, and empties into the Gulf of Siam. In northeastern Thailand stretches the Korat Plateau which is 100 - 200 m above sea level.

1-2-2 The Metropolitan region

Bangkok lies in the vast central alluvial plain formed by the Chao Phraya River, and is situated on the bank of this river near the Gulf of Siam. Its growth as the capital of Thailand dated from 1782, and is also the commercial and cultural center of this nation today. Thonburi is situated across the Chao Phraya River from Bangkok and was formerly the capital before Bangkok took over its place, and now forms part of the Greater Bangkok Metropolitan. All transportation systems of Thailand center at these two cities. Railways and highways networks radiate from Bangkok to all parts of the country. Don Muang International Airport in Bangkok, which is an air center of South East Asia, is the aviation center of Thailand for both domestic and international airways. The seaport of Bangkok, located on the mouth of Chao Phraya River, serves as the main access to Thailand from the sea and the center of seaways linking Bangkok with northern and central parts of Thailand.

Fig. 1-7 Location of Thailand



1-3 Climate

The entire territory of Thailand lies in the tropical monsoon region, with two season in a year, the rainy (May - Nov.) & the dry season (Nov. - Apr.)

However, even during rainy seasons, it is seldom to have rain throughout the day, but, rainfall is received in the form of heavy squalls which only continue for 1 - 2 hours.

Fig. 1-8 Features of local climates

Place	Yearly average tem-perature	Average highest tem-perature	Average lowest tem-perature	Average yearly rainfall	Dry season	Rainy season	Hot season
Chiang Mai (North-ern Region)	21.4 - 28.7°C	35.7°C	13.4°C	1245.6 mm	Nov. - Apr.	May - Oct.	Feb. - May
Bangkok (Central Region)	25.6 - 30.1	34.8	20.2	1469.9	Nov. - Apr.	May - Oct.	Mar. - May
Songkhla (Southen Region)	26.5 - 28.9	33.2	23.8	2231.3	Dec. - Mar.	Apr. - Nov.	Apr. - May

Source: "Economical outline of Thailand, 1972"
Edited by The Bangkok Japanese Chamber of Commerce and Industry.

The above table gives the features of local climates of 3 cities each representing a geographical region. Among these, Bangkok has the highest yearly average temperature and Chiang Mai the lowest.

1-4 Population

With a territory of 514, 000 km^2, Thailand had a population of 34, 152, 000, according to the census of 1970. Since the population was 26, 392, 000 at the 1960 census, it had a population growth of 7, 760, 000 during the last decade.

A considerable population concentration is seen in the region of Bangkok and Thonburi cities which contained 8, 9% of the population at the 1970 census.

Classified by amphoe, Dusit had the highest rate of population growth in the Metropolitan area between 1964 and 1970 of 67. 7%, followed by Bangkhen, Bangna, Phayathai, Samsen. The recent trend in population change is that the highly populated urban center of Bangkok is slowing down in the rate of population growth, whereas such suburban areas as the eastern area (Bangkhen) around Phetchaburi Road, Sukhumwit Road and Rama 4 Road, and the northern area (Dusit) including Pahol Yothin Road, Mittraphap Road and Rama 5 Road increase in a striking pace.

Fig. 1-9 Estimated population of Thailand (By sex)

1960 - 1970

(in persons)

Year	Male	Female	Total	Index
2503 (1960)	13, 221, 000	13, 171, 000	26, 392, 000	1. 00
2504 (1961)	13, 599, 000	13, 569, 000	27, 168, 000	1. 03
2505 (1962)	13, 977, 000	13, 967, 000	27, 944, 000	1. 06
2506 (1963)	14, 355, 000	14, 365, 000	28, 720, 000	1. 09
2507 (1964)	14, 733, 000	14, 763, 000	29, 496, 000	1. 12
2508 (1965)	15, 111, 000	15, 161, 000	30, 272, 000	1. 15
2509 (1966)	15, 489, 000	15, 559, 000	31, 048, 000	1. 18
2510 (1967)	15, 867, 000	15, 957, 000	31, 824, 000	1. 21
2511 (1968)	16, 245, 000	16, 355, 000	32, 600, 000	1. 24
2512 (1969)	16, 623, 000	16, 753, 000	33, 376, 000	1. 27
2513 (1970)	17, 002, 000	17, 150, 000	34, 152, 000	1. 30

Note: Table prepared with an assumed constant growth rate of 3. 1.

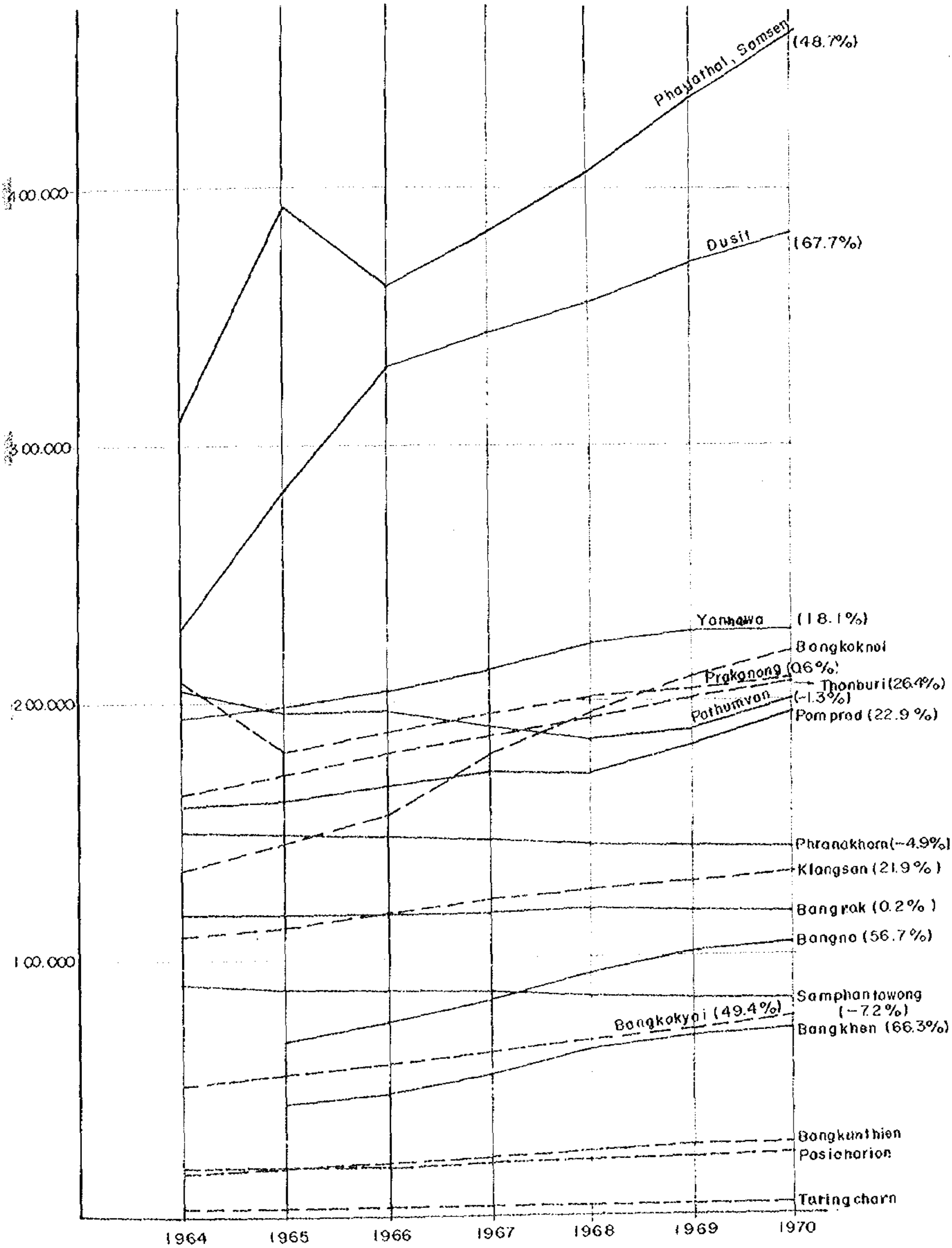
Source: Statistical year Book Thailand.

Fig. 1-10 Area and Population

	Area (Km^2)	Population (1000 persons)	Density (Persons/Km^2)
Bongkok City	124. 7	2, 132	17, 097
Thonburi City	51. 0	919	18, 020
(1) Total	175. 7	3, 051	17, 365
(2) Thailand	514, 000	34, 152	66
Share (1)/(2)	0. 034%	8. 9%	

Source: Statistical year Book Thailand 1970

Fig. 1-11 Trend of population increase in Bangkok by amphoes



CHAPTER 2. ECONOMIC ACTIVITIES

2-1 Primary Industry

2-1-1 Agriculture

During the last decade the relative importance of agriculture among all industries had decreased due to the progress of industrialization and development of the tertiary industry. However a comparison of the total agricultural product and the gross domestic product which were 34,234 million Bahts (based on 1962 price) and 112,378 million Bahts respectively, for the year 1969 shows that agriculture remains still a dominating industry. Rice crop is the staple agricultural product. Though the central region including the Chao Phraya River delta plain remains the biggest rice producing center, total area of rice crop land in other parts of the country surpasses that of this region in recent years. Productivity of the central plain however is greater, so much so that more than half of the rice produced in the country is yielded in this region.

Natural conditions are not very favorable for rice production. The amount of precipitation needed for good yield of tropical rice crop, 1600 - 1800 mm is received only in the peninsular portion and the northeastern area along the Mekong river. Rice culturing in other areas rely much on artificial irrigation and flooding of rivers. In view of this, production of other crops, especially of farm product such as maize, has been encouraged in recent years, and agricultural industry as a whole is thus heading towards diversification.

Table 2-1 Present ratio of land use

(in square kilometers)

	Forest	Lakes and marsh	Agricul- tural land	Others	Total
Area	264,709	2,072	119,308	127,911	514,000
Percent	51.5	0.4	23.2	24.9	100.0%

Breakdowns of agricultural land (in km^2)

	Farm- land	Rice field	Afforesta- tion	Others	Total
Area	105,611	65,424	6,638	7,059	119,308
Percent	88.5	54.8	5.6	5.9	100.0%

Table 2-2 Harvest of agricultural products

(in 1000 metric tons)

Year / Product	1965	1966	1967	1968	1969	1969/ 1965
Unhulled rice	9,217.0	11,845.0	9,594.0	10,772.0	13,346.0	1.45
Rubber	217.4	218.0	220.0	258.8	281.8	1.30
Maize	1,021.3	1,122.0	1,250.0	1,500.0	1,700.0	1.67
Cassava	1,475.0	1,891.7	2,062.5	2,611.5	2,700.0	1.83
Sugar cane	4,480.0	3,827.0	4,526.0	5,846.1	6,740.5	1.50
Green bean	124.8	131.8	122.5	183.8	202.1	1.62
Peanut	130.6	219.9	132.1	157.9	180.5	1.38
Soy bean	19.1	37.9	52.8	44.8	61.2	3.20
Sesame	18.3	19.9	22.7	22.1	22.1	1.21
Coconut	1,170.0	1,069.0	1,074.1	1,098.7	1,111.2	0.95
Castor bean	31.6	41.9	37.6	42.6	42.6	1.35
Rawcotton	59.8	88.8	80.7	131.5	92.2	1.54
Jute	8.7	10.9	7.4	4.4	—	—
Tobacco	75.5	88.4	78.0	85.5	80.0	1.06
Kenaf	528.6	661.4	421.4	316.8	355.0	0.67

Table 2-3 Harvested area and annual crop per hectare by product

(during 1966)

Product	Harvested area (1000 ha.)	Annual crop (1000 ton)	Annual crop per hectare
Rice	6,949	11,845.0	1.70 t/ha
Rubber	373	218.0	0.58
Maize	644	1,122.0	1.74
Sugar cane	160	3,827.0	23.92
Coconut	247	1,069.0	4.32
Peanut	153	219.9	1.44
Raw cotton	79	88.8	1.13
Kenaf	498	661.4	1.33
Cassava	130	1,891.7	14.55

2-1-2 Forestry

About 65 million acres, or 52% of the land of Thailand are covered with forest and pastureland, the majority of which being under state control. Forestry products include yang lumber (a specis of lawan) resin, rattan and bamboo, etc.

Teak is traditionally an important item of Thailands exports. It is a product of the northen region. Its production was about 250 - 330 thousand cu.m. in the middle 1950's, but had declined to 150 thousand cu.m. by 1966, after which slight increased had continued. Such slump in teak production is due to excessive lumbering in the past.

Teak had been the fourth principle item of exports until 1958, following rice, rubber and tin, but had become the seventh since 1961, being out ranked by farm products including maize. About 20,000 cu.m. are exported annually during recent years.

Table 2-4 Trend in annual crop of forestry products

(in. 1000 m^3)

Year / Product	1960	1966	1967	1968	1969
Teak	154	151	182	263	296
Yang	321	535	525	525	471
Other timber	791	1,356	1,622	1,788	1,607
Firewood	1,191	1,296	1,604	1,681	876
Charcoal	629	511	562	451	44

Source: 1) Economical outlook of Thailand, 1972
2) World trade guidebook.

2-1-3 Fishery

Fish is the main source of protein supply for Thai people. Coastal fishery developes over the full extent of the lengthy coastline. While fishing fleets operate mainly in the Gulf of Thailand, they also sail as far as the Gulf of Bengal to find their fishing ground during some seasons of a year.

The annual catch of salt-water fish increased strikingly, approximately 9 times between 1960 and 1969, whereas fresh water fish production which amounts to only less than 10 percent of the total fishery production, showed only a small rate of increase.

Total 2-5 Trend in the quantity of fishery haul

(thousand tons)

Year	1960	1966	1967	1968	1969
Salt-water catch	146	635	762	1,004	1,278
Fresh-water catch	73	85	85	85	92
Total	219	720	848	1,089	1,370

Source: The Fishery Agency, Ministry of Agriculture and Forestry.

*The main salt-water products are mackerel, shark and shrimp.

The main fresh-water products are carp, loach, and eel.

2-1-4 Livestock industry

Domestic animals raised in Thailand include elephants, horses, cattle, buffaloes, hogs, ducks, and chicken. There were 11,000 elephants, 175,000 horses, 5,167,000 bulls, 6,878,000 buffaloes, according to a survey conducted in 1966.

Traditionally a Buddhist country, the Buddhist proscription against killing is taken very seriously in Thailand, and the consumption of animal food began only comparatively recently, while work animals had been kept by farmers since very ancient days.

In the northeastern region where there is extensive grasslands suitable for grazing, cattle and buffaloes have been popularly raised since olden days, and mordern stock farms where breed improvement of beef cattle is being researched are found in Saraburi under foreign aid.

Cattle, buffaloes, hogs, chicken and duck eggs are exported to Hongkong and Singapore during recent years.

2-2 Other Industries

2-2-1 Foreign trade

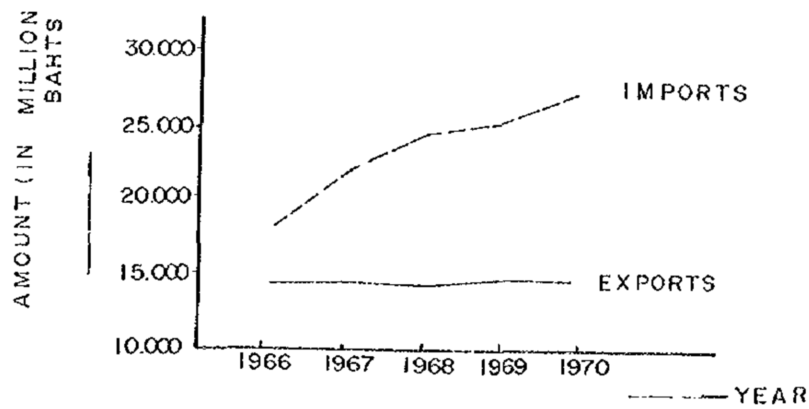
1. Trade balance

Table 2-6 Trade balance of Thailand

(in million Bahts)

Year		1960	1966	1967	1968	1969	1970	1970 Jan - July
Exports	Amount	8,614	14,099	14,166	13,679	14,722	14,786	9,544
	Growth rate (%)	—	63.7	0.5	-3.4	7.6	0.4	—
Imports	Amount	9,622	18,054	22,188	24,103	25,966	27,009	15,085
	Growth rate (%)	—	87.6	22.9	8.6	7.7	4.0	—
Balance		-1,008	-4,405	-8,022	-10,424	-11,244	-12,237	-5,541

Source: Bank of Thailand: Monthly Bulletin



As shown in the above table, foreign trade has been steadily growing. The growth of imports reflecting the industrial development and increase of consumer demand exceeds that of exports, so that trade balance remains contantly in the deficit.

2. Pattern of trade

(i) Exports

Agricultural and forestry products such as rice, crude rubber, maize, and jute are the principle exports items. Japan is the biggest market, which accounted for over 20% for the past several years (1966 - 1970) and, in 1970, 25.5% of Thailands' exports.
This is followed by the United States (14.4%), the Netherlands (8.6%) and Hongkong.

(ii) Imports

Imports include varieties of industrial products such as industrial materials, chemical products, capital goods etc. Japan's share of Thailand imports, even bigger than that of exports, was 37.4% in 1970.
The U.S. was the second major partner with a share of 14.8%, and West Germany the third, sharing 8.5% of of the same.

Fig. 2-1 Breakdown of imports classified by trading partner and by category of product

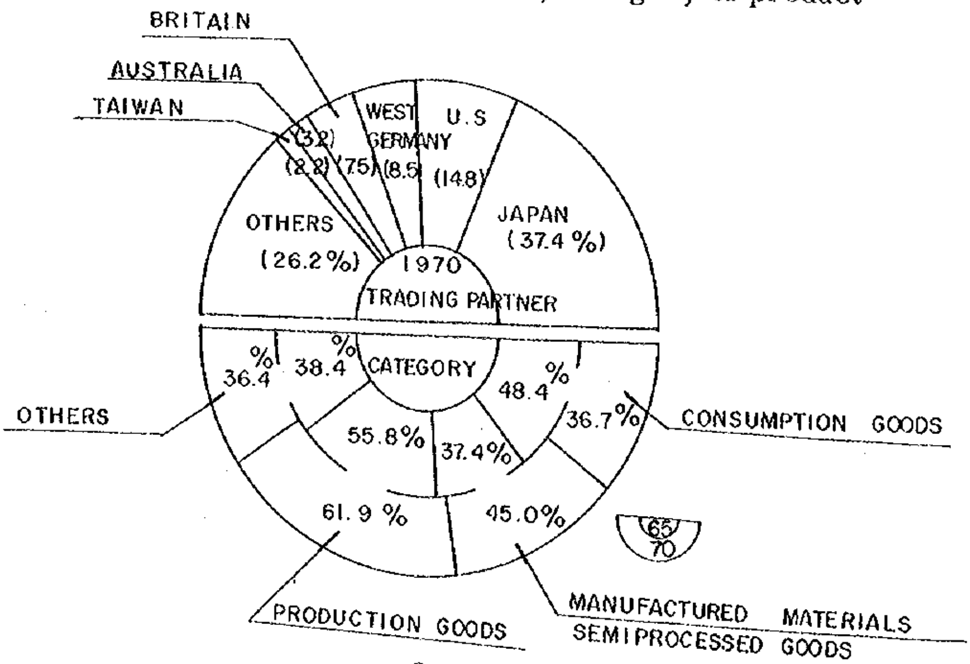


Table 2-7 Trend in annual amount of main imports by commodity

(in million bahts)

Item \ Year	1960	1966	1967	1968	1969	1970
Food stuffs	784	975	1,035	1,109	1,345	1,072
Beverages & tabacco	108	296	313	479	495	303
Materials	143	521	624	623	828	1,379
Mineral oil	1,025	1,873	1,588	1,995	1,829	2,363
Animal & vegetable oil	20	26	37	38	59	38
Chemical products	974	2,141	2,629	2,862	3,319	3,479
Manufactured goods	3,289	5,481	6,393	6,248	6,313	6,356
Machines	2,390	5,800	7,728	8,821	9,426	9,530
Miscellaneous manufactures	—	955	1,217	1,338	1,684	1,298
Others	—	311	479	411	526	1,083
Gold	—	125	145	179	142	108
Total	9,622	18,504	22,188	24,103	25,966	27,009

(Source) Bank of Thailand: Monthly Bulletin

Table 2-8 Trend in annual imports by trading partner

(in million bahts)

Year / Market	1960	1966	1967	1968	1969	1970
Japan	2,463	6,572 (35.5)	8,046 (36.3)	8,274 (34.3)	9,515 (36.6)	10,106 (37.4)
United States	1,605	3,033 (16.4)	3,646 (16.4)	4,512 (18.7)	3,922 (15.1)	4,011 (14.8)
West Germany	811	1,442 (7.8)	1,946 (8.8)	2,021 (8.4)	2,354 (9.1)	2,286 (8.5)
Britain	—	1,516 (8.2)	1,610 (7.3)	1,673 (6.9)	2,034 (7.8)	2,014 (7.5)
Italy	127	349 (1.9)	454 (2.1)	592 (2.5)	597 (2.3)	487 (1.8)
Taiwan	78	393 (2.1)	576 (2.6)	579 (2.4)	617 (2.4)	602 (2.2)
Australia	—	495 (2.7)	598 (2.7)	578 (2.4)	749 (2.9)	851 (3.2)
The Nether-land	462	481 (2.6)	470 (2.1)	456 (1.9)	583 (2.2)	368 (1.4)
Total	9,622	18,504 (100.0)	22,188 (100.0)	24,103 (100.0)	25,966 (100.0)	27,009 (100.0)

Figures in ( ) indicate percent distribution

(Source) Bank of Thailand: Monthly Bulletin.

Table 2-9 Trend in annual amounts of main export items

(in million bahts, thousand tons)

Year / Item	1966		1967		1968		1969		1970		Market of main products
	Amount (price)	Ton	Amount (price)	Ton	Amount (price)	Ton	Amount (price)	Ton	Amount (price)	Ton	
Rice	4,011	1,507	4,653	1,482	3,775	1,068	2,945	1,023	2,522	1,050	Hongkong, Singapore, Malaysia, India, Saudi Arabia.
Crude rubber	1,861	202	1,574	211	1,816	252	2,664	276	2,237	277	Japan, U.S. Britain Malaysia
Maize	1,520	1,218	1,355	1,090	1,556	1,481	1,674	1,476	1,846	1,386	Taiwan Japan
Tin	1,291	17	1,820	26	1,510	24	1,631	23	1,617	22	U.S.A. The Netherland
Teak (in cu.m)	243	49	194	36	169	29	166	29	155	29	U.S. Britain, West-Germany, Italy
Tapioca	644	688	726	781	772	889	876	975	1,221	1,324	The Netherland, West Germany, U.S.A.
Kenaf and jute	1,614	473	866	317	674	289	780	256	719	255	Japan, Belgium, Britain, India.
Others	2,900		2,976		3,407		3,986		4,502		
Total	14,099		14,166		13,679		14,722		14,819		

Source: Bank of Thailand: Monthly Bulletin

Table 2-10 Annual amount of main exports by market

(in million bahts)

Market \ Year	1966	1967	1968	1969	1970
Japan	2,930 (20.8)	3,000 (21.2)	2,874 (21.0)	3,192 (21.7)	3,770 (25.5)
U.S.A.	1,752 (12.4)	2,024 (14.3)	1,789 (13.1)	2,168 (14.7)	1,985 (13.4)
Malaysia	1,166 (8.3)	1,211 (8.6)	1,038 (7.6)	1,079 (7.3)	830 (5.6)
Singapore	1,021 (7.2)	962 (6.7)	1,181 (8.6)	1,154 (7.8)	1,018 (6.9)
The Netherland	373 (2.6)	708 (5.0)	967 (7.1)	1,030 (7.0)	1,276 (8.6)
Hongkong	932 (6.6)	1,084 (7.7)	921 (6.7)	1,156 (7.9)	1,112 (7.5)
India	1,374 (9.8)	763 (5.4)	782 (5.7)	530 (3.6)	102 (0.7)
Britain	521 (3.7)	403 (2.8)	435 (3.1)	406 (2.8)	305 (2.1)
Total	14,099 (100.0)	14,166 (100.0)	13,679 (100.0)	14,722 (100.0)	14,786 (100.0)

2-3 Tourism

2-3-1 Number of tourist

The number of tourist visiting Thailand increased 2.2 times between 1966 and 1970. Especially in 1970, the rate of increase amounted to a high 33% partly due to the influence of the international exposition held in Japan.

However, affected by trade recession in the United States, the pace of growth slacked to 10% in the first season of 1971, compared to the same season of 1970, and in the second season, dropped below the record of the previous year.
The total growth rate for the first two seasons, as a result, barely reached the level of that of the previous year.

Classified by nationality, the greatest number of visitors were citizens of the United States, followed by Malaysian, Japanese, and British in that order. This order has been unchanged since 1968, although the number of visitors from the United States decreased by 5,000 persons in the first half year of 1971 compared to that of 1970, while the number of Malaysian and Japanese visitors remain in the upward trend.

It is noteworthy also that the number of tourists from West Germany which ranked No. 6 in 1970 had become the 4th, next to Japan, in 1971.

2-3-2 Tourism revenue

Tourism revenue increased year by year following the increase of visitors, and recorded 2,175 million Bahts in 1970 (including the 390 million Bahts from R & R of the U.S. military servicemen). Compared to the other foreign exchange earners on the list of exports, this ranked third in amount.

As for average spending per visitor, that of all tourist, excluding military personnel, was 2,800 bahts per person while that of military personnel was 8,800 bahts per person in the same year. The total spending of R & R (the U. S. military personnel) recorded the highest of 460 million bahts in 1969 (26% of the total tourism revenue) and has since then been on a decreasing trend.

Table 2-11 Number of visiting tourists by nationality

(in persons)

Year / Nationality	1966	1967	1968	1969	1970	1970 / 1966	1970 Jan.- June	1971 Jan.- June
U. S. A.	90, 300	89, 486	103, 592	133, 327	159, 216	1.76	72, 785	67, 007
Malaysian	38, 821	46, 712	47, 235	59, 621	105, 037	2.71	50, 022	58, 725
Japanese	14, 935	24, 124	31, 548	42, 872	46, 952	3.14	22, 736	27, 156
British	18, 370	22, 165	26, 434	31, 331	36, 977	2.01	18, 216	17, 529
Australian	9, 045	11, 380	17, 394	22, 247	28, 185	3.12	14, 502	12, 389
West Germans	7, 978	11, 654	15, 084	20, 190	28, 023	3.51	15, 229	18, 583
Indians	5, 392	7, 181	9, 961	11, 957	21, 111	3.91	–	–
French	7, 770	9, 823	10, 443	12, 725	21, 059	2.71	–	–
Laotian	22, 822	35, 690	18, 302	16, 022	20, 155	0.88	–	–
Swiss	4, 050	5, 653	7, 372	8, 143	12, 805	3.16	–	–
Others	65, 634	71, 977	89, 897	111, 349	149, 151	2.27	104, 347	95, 637
Total	285, 117	335, 845	377, 262	469, 784	628, 671	2.20	297, 837	297, 026

Source: T. O. T.: Statistics on Tourism in Thailand.

Note: Number of U. S. Citizens does not include R. & R.

Table 2-12 Tourism revenues

(in million bahts)

Item \ Year	1966	1967	1968	1969	1970
Tourists	618	736	812	1,310	1,784
R & R	136	216	408	460	391
Total	754	952	1,220	1,770	2,175

Note: Recent average stay per person is 4.8 days.

Source: T.O.T: Statistics on Tourism in Thailand.

Table 2-13 Total number of hotel acommodations and average rate of utilization

Item \ Year	1967	1968	1969	1970	1971 Jan./Oct.
Total number of hotel acommodations (rooms)	6,338	7,984	7,984	8,753	8,879
Average rate of utilization	60.5	54.9	56.4	57.6	–

Note: Figure for average rate of utilization of 1970 includes that of first half year only.

Source: T.O.T.

2-4 Future Development Plan

2-4-1 Future Development Plan of the Kingkom

The 'Third National Economic and Social Development Plan' is the fundamental plan for the development of the Kingdom for the period October 1971 - September 1976. The major objectives are as follows:

(i) to restructure the economic system and to promote economic growth.

(ii) to maintain a reasonable level of foreign reserves and price stability and to overcome immediate problems, particularly the decline in the overall economic growth rate.

(iii) to promote economic growth in the rural areas and to reduce the income disparities.

(iv) to promote social justice.

(v) to develop manpower resources and to create employment.

(vi) to promote the role of the private sector in economic development.

(1) Restructuring of the economic system and promotion of economic growth

In the objective, a target is set to increase the GDP at an annual average rate of 7 % per year.
This will result in an average per capital income growth rate of 4.5 % as compared to the 4.02 for the Second Development Plan period. At this rate, the GDP for the year will reach 178.2 billion bahts (in constant 1962 price) or about 1.4 times that of 1871. Table 2-14 gives a

Table 2-14 Gross Domestic Product
(Constant 1962 prices)

(billion baht)

	1971 (estimate)		1976 (target)		Average Annual Growth Rate	
	GDP	%	GDP	%	'67-'71	'72-'76
1. Agriculture	37.3	29.5	47.8	26.8	4.1	5.1
1.1 Crop	26.0	20.5	32.5	18.2	2.7	4.6
1.2 Livestock	3.9	3.1	4.7	2.6	2.7	3.4
1.3 Fishery	4.3	3.4	6.9	3.9	17.3	10.0
1.4 Forestry	3.1	2.5	3.7	2.1	6.5	3.4
2. Mining and Quarrying	2.1	1.7	2.8	1.6	8.1	6.0
3. Industry	21.4	16.9	31.4	17.6	9.2	8.0
3.1 Traditional Industry	6.6	5.2	8.3	4.6	5.1	4.8
3.2 New Industry	14.8	11.7	23.1	13.0	11.4	9.2
4. Construction	8.4	6.6	11.7	6.6	8.4	6.5
5. Electricity and Water Supply	1.9	1.5	3.9	2.2	20.7	15.0
6. Communication and Transportation	8.6	6.8	11.5	6.5	7.5	6.0
7. Trade	20.5	16.2	29.3	16.4	7.7	7.0
8. Banking, Ins. and Real Estate	5.1	4.1	11.0	6.2	14.4	15.0
9. Dwelling	2.4	1.9	2.7	1.5	4.1	2.5
10. Public Admin. and Defense	5.7	4.5	7.6	4.3	10.0	6.0
11. Services	13.0	10.3	18.5	10.3	8.8	7.0
GDP	126.4	100.0	178.2	100.0	7.2	7.0

breakdown of the estimated GDP for the year 1976.

(2) Maintenance of Economic Stability

To achieve this objective the major measures to be adopted are as follows.

(i) Acceleration of export promotion

(ii) Filling the expenditure gap created by the reduction of U.S. military spending.

(iii) Encouragement of foreign investment.

(iv) Maintenance of suitable and stable level of foreign reserves.

(v) Other fiscal and monetary measures.

(3) Promotion of economic growth in rural area and reduction of income disparities

The targets for this objective are:

(i) To improve the standard of living of the rural population while reducing income disparities.

(ii) To provide a basis for reduction of the gap in standard of living and income.

The measures adopted are as follows:

(i) Acceleration of agriculture production at an annual growth rate of 5.1 % and increasing of agricultural expenditure which will be increased in allotment at an annual increase rate of 10 %.

(ii) Incretment of small investment in the rural area, such as ditches and dikes, feeder roads and village development projects as a means to provide more employment opportunities.

(iii) Reduction of population growth rate through the expansion of family planning program, and the promotion of employment opportunities through promotion of industries dependent on agriculture products.

(4) Promotion of social justice

The targets in this objective are as follows:

(i) To diversify Government social services to reach more people.

(ii) To reduce the gap in standard of living.

The measures adopted will be classified into two categories:

(i) Improvement of the standard of living of urban population

The provision of low cost housing and more complete water supply service and the alleviating of such problems as mass transportation, traffic congestion and sewerage disposal will be steps taken in this direction.

(ii) Improvement of the standard of living of rural population

Such measures as the construction of feeder roads, the rural electrification project, and improvement of government health and education services will be some of the measures for this purpose.

(5) The development of manpower and creation of employment

The targets will be as follows:

(i) To reduce the population growth rate from the present 3.0 % to eventually 2.5 % in 1976.

(ii) To provide 2.6 million job opportunities and to maintain urban unemployment rate at about 3.2 %.

(iii) To reduce under employment in the rural area, where 75 % of the labour force is located.

The measures adopted will be:

(i) Family planning

(ii) Provision of employment opportunities through promotion of labour intensive industries in both private and public sectors.

(iii) Expansion of professional training programs

(iv) Extension of support to training course

(v) Dispersal of manpower into the rural areas.

(6) Promotion of the role of private sector in economic development

The target amount of private investment is planned at 131 billion bahts, or 63 % of total investment. This will represent an annual average increase rate of 7.3 %.

The measures adopted towards this objective will be.

(i) Encouragement of business groupings, especially in the priority sectors so that production and marketing can operate efficiently.

(ii) Encouragement of close cooperation between the Government and the private professional groups.

(iii) Encouragement of private investment in business which do not require Government intervention.

(iv) Development of better planning for decision on policy for state enterprises.

(v) Change and improvement of the method of operation of the various Government departments so that private investors will not be hampered by organizational limitations or ineffective administration.

The above is a brief summary of the gist of the Third National Economic and Social Development Plan.
To implement this plan, programs for implementation for different sectors were drawn up. Here a summary of only the development program in the 'Transportation and Communication' sector will be made.

In this sector, the programs drawn up cover all phases of transportation and communication. However, highway development has very high priority and will receive the lion share of the development project for the sector.
Emphasis will be on provicial highway and village roads or feeder roads, and on land transport improvement particularly around the Metropolitan area to reduce traffic congestion in Bangkok.
The construction and maintenance of 5,974 km of national highways, 7,468 km of provicial highways and 12,200 km of tertiary roads and feeder roads is planned in the program.

2-4-2 Future Development Plan of the Metropolitan area.

The latest long term development plan for the Bangkok Metropolitan area is the Revised Report on the Greater Bangkok Plan, by the Department of Town and Country Planning.
Although at the time of this study, the report had not been officially authorized, it can be safely said that the recommendations in the report will form a basis for the development projects of Bangkok area. The plan is basically a revision of the 'Litchfield Plan' (1958), modifying and rectifying the dimensions

planned in the Litchfield Plan, through using up-to-date statistical data. In this sense, the revised Greater Bangkok Plan is much more oriented to suit the existing situation of the Metropolitan. The main points of the plan are summarized as follows.

(1) Area covered in the Plan

The total area covered by the Greater Bangkok Plan is approximately 732 km^2. This includes the municipal areas of Bangkok, Thonburi, Nonthaburi, Samut Prakan and Prapadaeng as well as some parts of the area in the four changwats out of the boundary of the municipalities. This completely covers the whole economic sphere which is formed through the inter-community economic activities centering around the capital.

(2) Population

The Greater Bangkok Plan has planned the future population of the Greater Bangkok area at 6.5 million for the year 1990. This is considerably lower than that derived through trend projection, which as indicated in the report, may even reach 10 million. However, as again pointed out in the report, such an uncheck expansion will result in a very unhealthy situation in the Metropolitan and prompt the sprouting of other deterring factors. Nevertheless, to guide the population towards the planned figure of 6.5 million for the Greater Bangkok area, there is no doubt that considerable efforts are required of the authorities in relevant policy making. Population control policy is being proposed in the report, which policy, through proper guidance, will certainly be effective to keep the population to the planned size.

In this study, an estimation of the population out of the Greater Bangkok area but within the Metropolitan changwats is made, and the results show that in 1990, the total population for the whole area of the four changwats will be 7.2 million, which comes to a population of 700 thousand for the areas out of the Greater Bangkok Plan.

(3) Land use plan

Land use of the Greater Bangkok area is classified into the following regions:

(a) Residential region

A total area of 260 thousand rai or approx. 416 km^2 (57 % of total planned area) is planned as residential area to accommodated a population of 5,810 thousand, or 89 % of the total planned population. The residential area is again reclassed into high density, medium density and low density area with respectively 32 km^2, 224 km^2 and 160 km^2 in area and 1,040 thousand, 3,570 thousand, and 1,200 thousand in population. The remaining 690 thousand in population will be accommodated in commercial areas, military facilities and public institution.

(b) Commercial region

The existing commercial activities are largely carried out in small shopping houses scattered all over the area. In the plan it is proposed that commercial activities be intensified through the construction of more comprehensive shopping centres. A total of 27.7 thousand rai (approx. 44.3 km^2) is planned for commercial region, of which

20,000 rai (32 km^2) will be for shopping centres and 7,000 rai (11.2 km^2) for small shopping areas scattered among residential region.

(c) Industrial region

The area for the industrial region is planned at a labor density of 12 persons per rai (7.5 persons per 1,000 m^2). The total area planned comes to 52,700 rai or 84.3 km^2. Industries will be classified into various types. The pollution-prone industries will be collectively located in industrial estate separated completely from residential areas. Other light industries without fear of pollution will be located at places convenient for the manufacturing and transportation process.
Besides the industrial region in the Greater Bangkok area, a recommendation of establishment of 3 large industrial estates within the Metropolitan sphere, (one each at Nakhon Pathom, Samut Sakorn and Chonburi) is also made.

(d) Government and institutional region

In this category are included the facilities for civil services, military, municipal and international agencies including embassies, hospitals, universities and libraries. An area of 39,452 rai (63.1 km^2) is planned for this purpose and are scattered over the area for the convenience in execution of the functions of the agencies.

(e) Recreation region

In the Greater Bangkok Plan an area of 39,000 rai (62.4 km^2) is planned in this category which includes vacant lands, parks, gardens and playgrounds, which will be divided into 14 different districts. An area of 26,000 rai (41.6 km^2) is also planned within the residential area.

(4) Transportation system

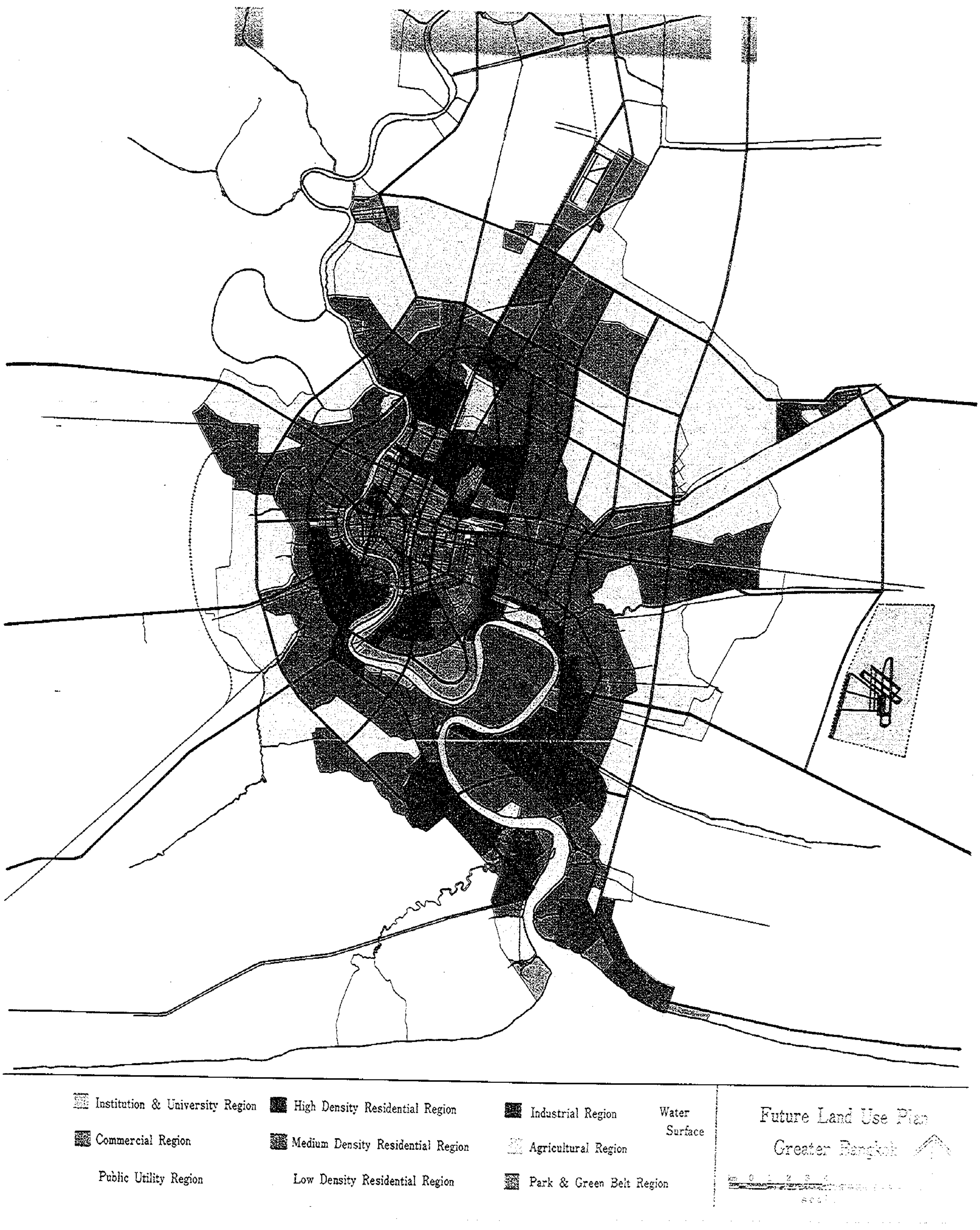
(a) Road system

The 'ring road' is the basic concept in the planning of the future road system in the Greater Bangkok area. Three ring roads are proposed. These are connected by other radial roads and intermediate connecting roads to form a complete net. For the traffic across the Chao Phraya River, three new bridges are proposed, other than the Tachang Bridge or the Sathorn Bridge which are already in the construction or planning stage.

(b) Other transportation system

Total elevation of the railway lines within the Metropolitan area is proposed, a deep-water harbour at Lamchabang is planned, and the early implementation of the planned new international airport is recommended.

Plate No. 2-1 summarizes the "Land use' plan and the transportation system plan in one drawing, and gives an easy visual understand of the plan.



Future Land Use Plan
Greater Bangkok

CHAPTER 3. TRAFFIC ANALYSIS

3-1 General Description of Transportation System in Thailand

3-1-1 Railway

Thailand's railway system is constructed, run and controlled by "The State Railway of Thailand" under the ministry of communication.

The total length of railroads in 1970 was 3,765 km, of which only 90 km (between Bangkok and Ban Phaen) were double track.

The major routes are:

(1) The north bound line between Bangkok and Changmai (751 km)

(2) The north-east bound line connecting Bangkok, Korat and Nongkai (624 km)

(3) The north-east bound line connecting Bangkok, Korat and Ubon (575 km)

(4) The east bound line running from Bangkok to the Thai-Cambodian boader.

(5) The south bound line extending between Bangkok and the Thai-Malaysian border

(6) The west bound line between Bangkok and Nan Tok (210 km)

(7) The west bound line between Bangkok and Suphan Buri (157 km)

There are in total 584 railway stations, and the average distance between stations is 6.5 km.
Capacity of terminal stations except that of Bangkok is estimated to be more than enough at present and will be able to meet a 50% increase of the transportation volume.

The volume of passenger transportation increased with the growth of economy between 1962 and 1968, but had slacked down in the rate of growth in recent years. Freight transportation grew in a similar pattern as that of passenger transportation except for a short interval of stagnation in 1963. The decrease of growth rates is attributed to the rapid development of the highway system. (Table 3-1)

Classified by commodity, petroleum products was the largest item being transported followed by clinker, marl, cement in that order. Whereas sea transportation is most suitable for such bulk and heavy goods as petroleum products, it is not possible in Thailand except along the coastline, and railway transportation is expected to become increasingly important in the future. As shown in the Table 3-2, the volume of items 1 - 4 increased between 1968 and 1970 while that of 5 ~ 10 decreased.

It is anticipated that transportation of bulk and heavy goods will in the future rely on the railway system while the others switch to highway as highway facilities improve. Classified by place of origin and destination, 60% of the goods on the above mentioned table were transported from or to the central region, 20% the northern region. The share of railway transportation among all systems of goods transportation is 10% in the southern region, much higher than the 5% for road transportation. This is probably because long-distance transportation is geographically required and railway transportation is better prepared than road transportation.

Table 3-1 Volume and distance of railway transportation

	Passenger			Goods		
	Person	Person kilo-meter	Average distance of trans-portation	Ton	Ton kilo-meter	Average distance of trans-portation
Unit	Thousand persons	Million person kilometer	Kilometers	Thousand tons	Million ton kilometer	Kilometers
1965	43,914	2,847	64.8	4,435	1,534	393.1
1966	46,024	3,173	68.9	4,694	1,607	385.2
1967	48,108	3,614	75.1	5,236	1,941	413.0
1968	49,729	3,884	79.7	5,462	2,083	420.6
1969	47,326	3,962	83.7	4,829	1,979	453.4
1970	48,190	4,113	85.3	5,131	2,209	470.2

SOURCE : Information Booklet

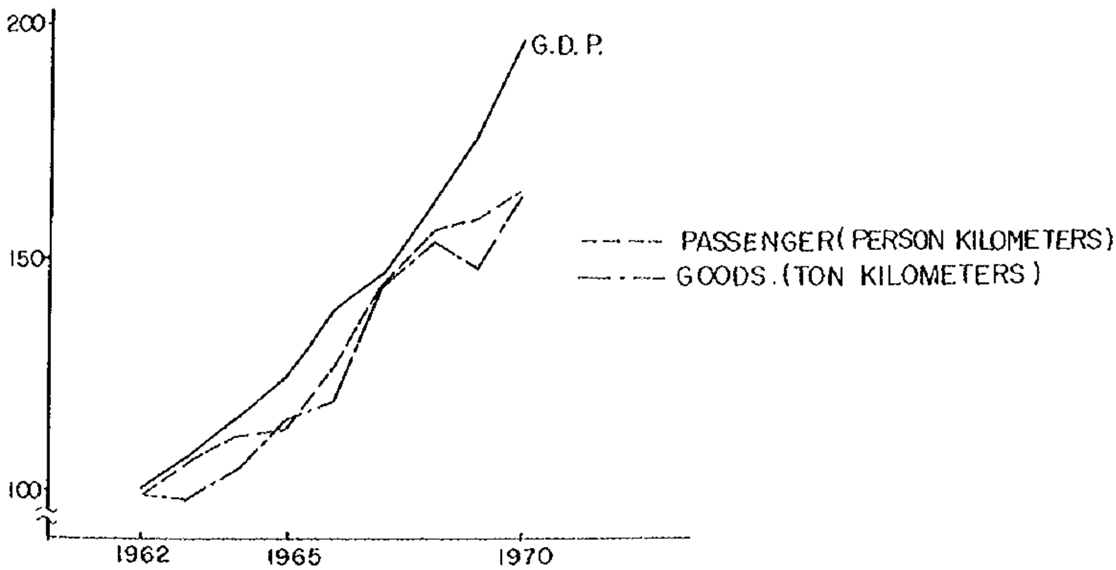


Table 3-2 Breakdown of volume of transportation by item

Year		1968			1970		
Item		Volume (ton)	%	Average distance (km)	Volume (ton)	%	Average distance (km)
1	Petroleum products	566	16.4	574	856	16.7	573
2	Cement	639	11.7	574	647	12.6	533
3	Rice products	420	7.7	563	535	10.4	530
4	Fluorspar	180	3.3	735	245	4.8	744
5	Lumber, logs & poles	292	5.3	531	229	4.5	534
6	Clinker & Marl	1,190	21.8	94	749	14.6	126
7	Maize	175	3.2	425	160	3.1	384
8	Fertilizer	83	1.5	489	68	1.3	473
9	Jute & Kenaf	77	1.2	476	47	0.9	497
10	Livestock	17	0.3	325	16	0.3	373
11	Other	1,833	33.6	–	1,579	30.8	–
	Total	5,462	100.0	420	5,131	100.0	470

Source: Information boo

3-1-2 Air transportation

(1) Domestic air system

Thailand's domestic air transportation system is operated by the Thai Airway Co. There are 27 domestic airports of which 24 are in operation.

Table 3-3 A list of domestic airports in Thailand

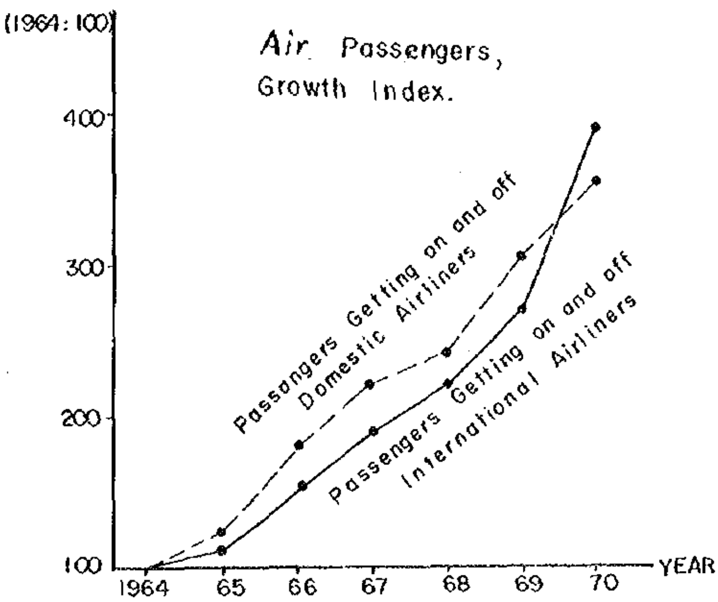
Name of airport	Dimension		Runway		In operation (O)
	Runway(m)	Stopway (m)	Surface	Strength (ton)	
Chiang Mai	2,134x38	275x38, 150x38	Concrete	48.0	O
Chiang Rai	1,475x30	60x30, 60x30	Asphalt	13.6	O
Hua Hin	840x30	360x30, 60x30	"	13.6	O
Khon Kaen	1,500x30	60x60, 60x60	"	13.6	O
Khun Yuam	1,100x45		Laterite & grass	6.8	
Lumpang	1,475x30	60x30, 60x30	Asphalt	13.6	O
Loei	1,200x30	88x30, 50x30	Laterite	19.1	O
Mae Hong Son	1,315x30	30x60	Asphalt	13.6	O
Mae Sariang	1,070x30	60x30, 60x30	Laterite & grass	16.8	O
Mae Sot	1,100x45		"	16.8	O
Nakhon Phanom	200x45		Laterite	16.8	O
Nakhon Sawan	1,200x45		"	16.9	O
Nan	1,400x30		Asphalt	19.1	O
Nong Khai	110x40		Laterite	16.8	O
Pai	700x30		Laterite & grass	6.8	
Pattani	1,400x40		Asphalt	20.2	O
Phitsanulok	1,820x45	60x45, 60x45	"	27.2	O
Phrae	1,200x40			16.8	O
Phuket	1,440x30	60x30, 60x30	Asphalt	13.6	O
Ranong	1,080x30		Laterite	16.8	
Sakon Nakhon	1,400x30	100x50, 100x50	Asphalt	20.2	O
Songkla	1,500x45		"	20.2	O
Tak	1,350x45		Laterite	16.8	O
Ubon	2,743x38	300x38, 300x38	Concrete	11.3	O
Udon	3,048x38	300x38, 300x38	"	11.3	O
Uttaradit	1,520x30	200x30, 200x30	Asphalt	20.2	O
Trang	1,500x30	60x60	"	13.6	O

As seen from the above table showing name, dimension and runway structure of all domestic airports (excluding Don Muang Airport of Bangkok), a considerable number have runways shorter than 1,400 m. About half of these have laterite finished runway which calls for restraint of utilization under bad weather condition, hence resulting in a high rate of flight cancellation. The busiest airway route is that between Bangkok and Chiangmai, with the frequency of 38 flights/week on both ways. The frequency of the air traffic between Bangkok and Songkla is 14 flights/ week. Construction of another 14 airports is now being planned. They include those of Surat Thani, Narathiwat, Surin, Ranong and Lom Sak.

The volume of passenger transported was 200 thousand persons, and 100 million person kilometers in 1970, for an average trip distance of 500 km. The average rate of increase was as high as 20 - 25% during the last 5- 6 years. Such a pace of increase, as illustrated by the graph in Fig. 3-1 is comparable to that of the international airways. Classified by routes, the number of passengers transported between Bangkok and Chiangmai was the largest, being about one third of the total of domestic airlines. The other major routes next to this in volume of passenger transportation are that between Bangkok and Songkla, and that between Chiangmai and Chiang Rai, each flying only about 1/4 of the passengers volume of the Bangkok-Chiangmai route.

As much as 80% of domestic air passenger departed from or destine for Bangkok.

Fig 3-1



(2) International air transportation

Do Muang International Airport, situated 17 km north of Bangkok, is not only the main access of Thailand via air, but also an air centre of southeast Asia. It is on the regular stop of international liners flown by 30 companies, with a total of 30,000 scheduled civilian flights a years. The first flight of Jambo Jet flying here was that of PAA, on Nov. 1, 1971.

The features of Don Muang Airport are given in Table 3-4.

Table 3-4 Features of Don Muang Airport

Item	Dimension
1. Elevation	4 m
2. Runway	
Dimension	3,210 x 60 m 3,000 x 45 m
Strength	34,000 kg
Surface	Concrete
3. Stopway	
Dimension	305 x 60 m 305 x 60 m 305 x 45 m 305 x 45 m
Surface	Asphalt
4. Apron	
Dimension	847 x 110 m
Surface	Concrete
5. Taxiway	
Dimension	24 m

Don Muang Airport is equipped with two 3000 m class runways parallel to each other. Construction of a new airport terminal building which was started in 1969 is now been completed after some delay. This new building is designed to have the departure & arrived lounges twice as big as the previous one, and various other facilities improved. Nevertheless, with a daily total of 200 - 250 international flights and a daily average of 20 domestic flights, together with non-schedule military aircrafts departing and arriving, the hourly number of departing and arriving flights at the peak of a day amount to over 140, and the capacity of the airport itself is already almost saturated. In view of this, the construction of a new international airport at Khlong Nong Ngahao, 30 km east of Bangkok, with a total area of 24 km^2 is being planned.

The annual total number of arriving and departing passengers was 600 thousand persons each, the volume of goods arriving was 10, 000 ton, and that departing was 9, 000 ton. Classified by season, the volume of passenger during April - August was largest, that between November and February was smallest. Classified by airliners, the Thai Airway accounted for 20%, the largest proportion of the total of passengers, followed by JAL (10%), CPA (8%), MSA (7%) and PAA (6%) in that order.

Table 3-5 International Air Traffic of Bangkok Airport

Years Oct. to Sept.	Aircraft		Passengers			Freight (Metric Ton)		
	Total	Increase/ Decrease	In	Out	Increase/ Decrease	In	Out	Increase/ Decrease
1960 1961	19,823		110,662	108,967		1,536.09	1,952.73	
1961 1962	23,783	+18.1%	126,464	129,745	+16.7%	2,694.72	2,070.80	+36.5%
1962 1963	27,135	+14.9%	146,316	149,976	+14.8%	2,118.78	2,388.02	- 5.4%
1963 1964	27,711	+ 2.1%	179,380	174,402	+20.3%	2,100.45	2,521.33	+ 2.5%
1964 1965	28,752	+ 3.8%	182,593	189,121	+ 5.7%	2,388.12	2,796.04	+12.2%
1965 1966	21,697	-24.6%	246,893	248,390	+33.2%	3,358.78	3,920.41	+40.4%
1966 1967	21,894	+ 1.9%	326,439	325,875	+31.8%	4,317.00	4,968.00	+27.6%
1967 1968	26,159	+19.4%	380,171	375,939	+15.8%	6,198.00	6,324.00	+34.9%
1968 1969	25,237	+ 7.9%	462,612	456,930	+21.1%	6,831.58	7,443.78	+14.0%
1969 1970	33,515	+18.6%	621,442	606,097	+33.4%	9,645.99	8,693.79	+28.4%

3-1-3 Coastal waterways

The volume of domestic coastal goods transportation has not been much growing, as seen in the following table.

Table 3-6 Volume of goods handled at harbors (include only coastwise freight)

in 1, 000 tons

Region	1960	1965	1968	1969
Whole Kingdom	902	1, 054	1, 222	1, 236
Port of Bangkok	345	480	592	521
Ports on east coast of southern Thailand	380	431	556	635
Ports on west coast of southern Thailand	91	85	27	28
Other ports	86	58	47	52

This is because navigable coastline are limited to the southern part of Thailand.

The following table gives the volume of coastal goods transportation divided into two parts: goods transported from or to Bangkok and goods transported between other places. The proportion of the former, in volume against the total is greater than 70%.

Table 3-7 Proportion of goods transporten to and from Bangkok against the total of coastal goods transportation

Name of region & port	Total (ton)	Goods to and from Bangkok (ton)			Relative weight of goods to and from Bangkok (%)
		To BKK	From BKK	Sub Total	
Total of Thailand	523.6	128.6	263.3	381.9	72.9
Ports on east coast of southern Thailand	395.5	106.4	261.3	367.7	93.0
Ports on west coast of southern Thailand	57.6	0	0	0	0
Other ports	70.5	22.2	2.0	24.2	34.3
Major ports					
Songkhla	126.9	34.9	84.3	119.2	93.9
Surat Thani	89.5	42.8	38.1	80.9	90.4
NakhornSiThammrat	77.8	5.8	67.1	72.9	93.7
Pattani	67.4	5.6	58.0	63.6	94.4
Kantang	31.5	0	0	0	0
Phuket	26.1	0	0	0	0
Samut Songkram	22.0	—	0.3	0.3	1.4
Chantha Buri	20.3	12.9	0.2	13.1	64.5
Ko Samui	16.7	13.5	3.0	16.5	98.8
Narathiwat	14.9	3.8	10.9	14.7	98.7
Trat	13.7	9.1	1.3	10.4	75.9

Classified by area, 90% of good transportation between ports on the eastern coast of southern Thailand (coastline of the Gulf of Thailand) was with the port of Bangkok on the other end. On the other hand, goods transportation between ports on the western coast (the coast of Indian Ocean) are not connected to the port of Bangkok, since such connection means a long detour route around the Malay Peninsular.
The following table gives the volume of goods transported by coastal vessels, classified into 4 groups of routes.
The volume of goods transported between Bangkok and ports on the southern coastline, which was 70% of the whole, was the largest, followed by that between ports of the southern coast, which was 16%.

Table 3-8 Volume of goods transportation on coastal seaway by routes

Routes	Volume (in 1,000 tons)	%
Bangkok & southern Thailand	184	70
Bangkok & other ports	12	5
Between ports of southern Thailand	43	16
Between other ports	24	9
Total	263	100

Breakdown of the goods transported from & to Bangkok is shown on the following list. The bulk of goods transported to Bangkok involves primary products and that from Bangkok includes essential goods. For the ports on the western coast which have no connection in goods transportation with Bangkok, essential goods are imported from Penang and Singapore.

Table 3-9 Breakdown of goods transportion to and from the port of Bangkok

	To Bangkok		From Bangkok	
	1,000 ton	%	1,000 ton	%
Total	128.6	100	263.3	100
Rice	0	0.0	6.9	2.6
Coconut	18.2	14.1	0.3	0.1
Fishery products	0.4	0.3	4.2	1.6
Other food stuff, and tobacco	4.7	3.6	77.0	29.2
Rubber	13.6	10.6	1.2	0.5
Timber	49.4	38.4	2.6	1.0
Building material	0.7	0.5	88.9	33.7
Machines	1.0	0.8	2.7	1.0
Fuel oils and gasoline	1.2	0.9	55.8	21.2
Chemical fertilizers & chemical products	0.1	0.1	4.6	1.7
Others	39.3	30.7	19.1	7.4

3-1-4 Inland waterways

With the Chao Phraya River penetrating the heart of Thailand, the Mekong River flowing on the east along the border, and a network of khlongs connecting a host of tributaries of these rivers, inland waterways have been the main stay of transportation system in Thailand since early days.
In spite of the development of railway and highway networks, waterways still remain important to-day, and the bulk of this country's goods, including agricultural products, livestock and ponltries, are transported on waterways. Transportation of passengers relies also largely on water. The volume of passengers crossing Chao Phraya River by ferries alone amounts to 160 thousand persons a day. Water buses, water taxi and sampans plying the Chao Phrayer River and network of khlongs connecting with this river are essentially important in the citizen's daily life, as means of commuting and transportation.

There are 4 main routes of waterways connecting Chainat and the Bangkok-Thonburi metropolitan area:-

(1) The westmost route including Suphan, Nakhon Chaisi, and Chai rivers which runs a distance of 310 km between Chainat and Samut Sakhon via Suphan Buri.
This route, being deeper than the others, is especially useful during dry season.

(2) The route next to the first one, imvolving Nai river, and Bang Sai Khlong, runs a distance of 150 km almost parallel to the Chao Phraya River, from Chainat Southward and meets the Chao Phraya at the southern part of Ayuthaya. Even though reported to be deeper than 2 m during dry season, there are apparently shallower places, since siltation is observed at some parts of the course.

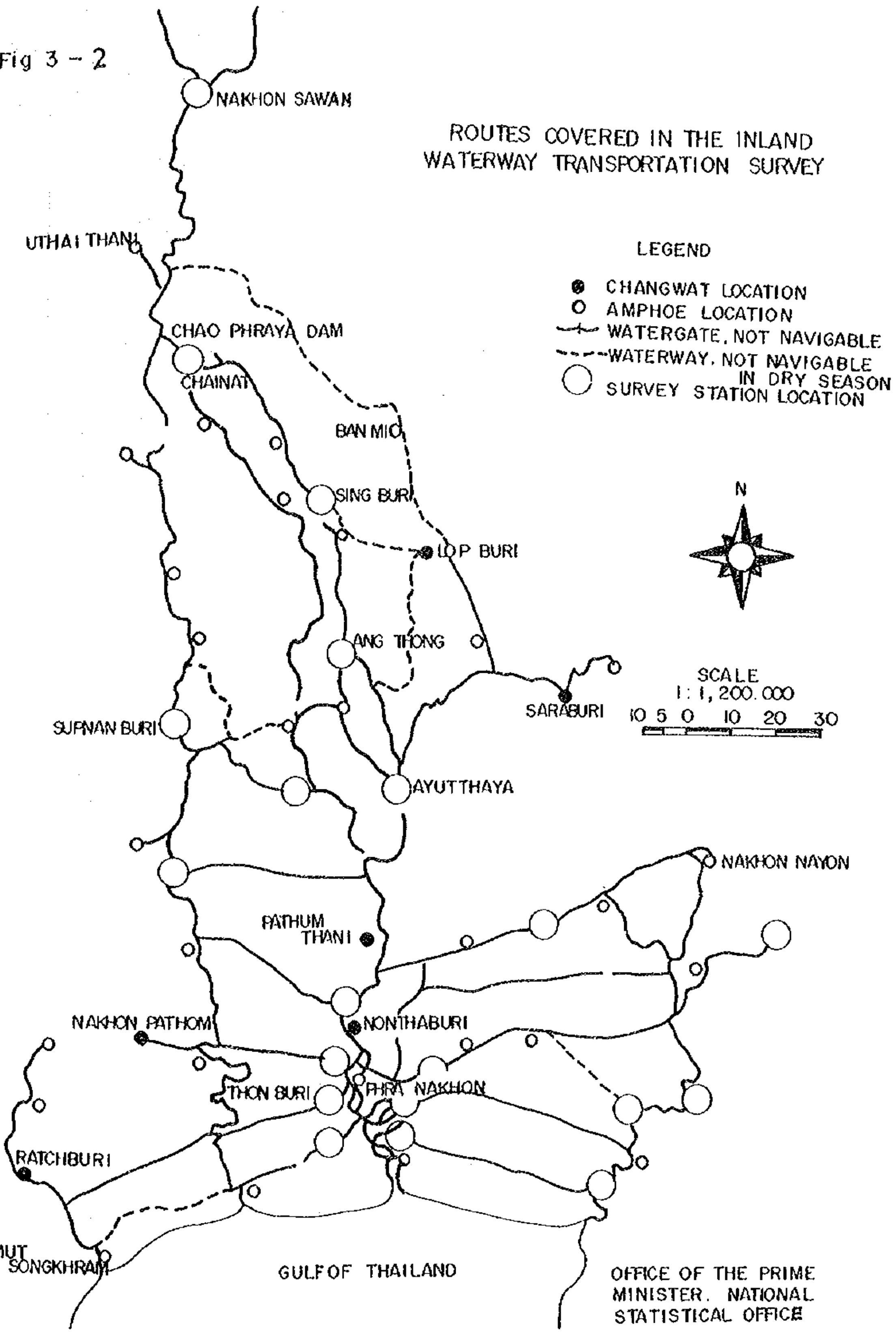
(3) The third route counting from the west, starts from Chainat, runs via Sing Buri, Ayuthaya and straight into Bangkok, is the largest waterway in Thailand. It has a length of 360 km, between the junction of Ping and Wang rivers and the Gulf of Thailand, and carries the largest traffic volume in Thailand.

(4) The eastmost route starts with a detour eastward and turns round to meet Menam Chao Phraya at Ayuthaya. This course involves unnavigable parts during dry season.

In view of the inportance of inland waterways, a "Survey of Inland Waterway Transportation" was conducted in 1963 by the government, headed by the Harbour Dept. and cooperated by N. S. O & N. E. D. B., on 30 sampled days between Oct., 1963 & Oct., 1964 at survey stations located as shown on the Fig. 3-2.

It is known that the total number of vessels navigating the inland waterways counts 26,000, of which 25,000 belong to the central region. Out of this 25,000 vessels, 16,000 were covered by the above survey. The remaining apparently includes those only very occassionally used, and those travelling only within a very confined sphere around the owner's dwelling.

Fig 3 - 2



Source " Survey of Inland Waterway Transportation", Harbour Dept.

Table 3-10 Daily traffic volume on khlongs by season

Survey station	Yearly average (Vessel /day)	Dry season (Jan - May) (Vessel /day)	Rainy season (June - Dec.) (Vessel /day)	Rainy season /Dry season	Proportion of vessels flowing in and out of metro.area (%)
Capital District					
1 Nonthaburi	973	886	1,039	1.17	90.0
2 Wat Suwankiri	680	649	694	1.07	97.8
3 Phasicharoen	246	264	232	0.88	89.6
4 Wat Sai	171	161	179	1.11	89.7
5 Saensaeb	35	36	35	0.97	89.4
6 Phrakhanong	57	50	62	1.24	81.1
7 Samrong	22	22	22	1.00	57.7
Northern District					
8 Ayutthya	336	257	397	1.54	87.9
9 Sena District	174	219	139	0.63	72.5
10 Suphan Buri	82	109	61	0.56	56.9
11 Songphinnong District	119	129	110	0.85	31.7
12 Ang Thong	171	44	268	6.09	73.6
13 Sing Buri	174	66	256	3.88	70.7
14 Chai Nat	243	168	300	1.79	72.7
15 Nakhon Sawan	136	38	210	5.53	77.9
Eastern District					
16 Bangpa Kong	13	15	12	0.80	40.3
17 Chachoengsao	36	35	37	1.06	65.0
18 Bangkhla	19	18	19	1.06	36.6
19 Nakhon Nayok	14	15	14	0.93	26.5
20 Phrachin Buri	21	21	21	1.00	38.3
Average	186	160	205	1.28	

Sourse: Survey of Inland Waterway Transportation, 1963

As seem in the above table showing traffic volume of each survey station, Nonthaburi has the largest average daily traffic volume of 1,000 return trips, followed by Wat Swankiri with 700 return trips, and Chainat with 300 return trips a day.

Classified by season, traffic volume in the rainy season in larger, being 1.28 times of the dry season.

Table 3-11 Traffic volume and transportation volume to and from the metropolitan area by way of khlongs

Place	Traffic volume (thousand vessels per year)		Transportation volume (thousand tons per year)		Loading efficiency (ton/vessel)	
	To	From	To	From	To	From
Total	368.0	351.9	5,668.7	442.4	15.4	1.3
Total excluding Nonthaburi	256.0	238.9	5,612.2	414.6	21.9	1.7
Capital District						
Nonthaburi	112.0	113.0	56.5	27.8	0.5	0.3
Samut Prakarn	5.1	3.0	53.4	8.4	10.4	2.8
Pathum Thani	58.4	54.9	1,505.4	40.4	25.8	0.7
Northern District						
Ayutthya	48.7	51.0	1,134.7	75.5	23.3	1.5
Ang Tong	5.0	5.2	93.4	17.6	18.6	3.4
Sara Buri	5.1	4.0	180.9	6.3	35.1	1.6
Lop Buri	7.2	6.9	235.2	2.8	32.5	0.4
Sing Buri	3.6	3.7	87.8	12.2	24.7	3.3
Chai Nat	3.2	2.8	90.6	6.0	28.1	2.2
Uthai Thani	2.0	1.4	44.5	9.0	22.2	6.5
Nakhon Sawan	9.5	9.1	262.5	8.5	27.7	0.9
Phichit	10.0	6.9	300.0	12.5	30.1	1.8
Phit Sanulok	2.8	2.4	100.0	2.8	35.5	1.2
Eastern District						
Chachoengsao	7.9	7.3	101.3	24.1	12.8	3.3
Nakhon Nayok	0.8	0.5	9.9	0.7	12.3	1.4
Prachin Buri	1.9	1.8	37.7	2.7	19.8	1.5
Western District						
Nakhon Pathom	6.9	6.0	107.1	44.9	15.4	7.5
Samut Sakhon	24.6	21.6	193.2	31.3	13.9	1.5
Samut Songkhram	14.1	13.4	195.8	36.3	7.8	2.7
Ratchaburi	27.1	25.3	645.1	24.5	23.8	1.0
Suphan Buri	8.9	9.2	199.7	30.9	22.5	3.4
Others	3.0	3.2	34.3	16.9	11.6	5.2

The above table shows the volume of goods transported on waterways from and to the metropolitan area. The yearly inflow of goods was 5,670 thousand tons, and the outflow was 440 thousand ton, less than 1/10 of the inflow.
The bulk of goods transported to the metropolitan area via waterways was from Pathun Thani and Ayuthaya areas, the proportion of each against the total influx being 27% and 20% respectively. The average volume of goods transported per vessel was 15 ton for inflowing goods and 1.3 ton for outflowing goods.
Breakdown of inflowing and outflowing goods by commodities are listed on the following table. Among the inflowing goods, building material is the largest in volume, being 50% of the whole, followed by rice with 29%, and maize, with 10% of the same.

Table 3-12 Breakdown of goods transported to and from the metropolitan region by way of khlongs

Item	To		From	
	Volume (thousand ton)	Percent	Volume (thousand ton)	Percent
Total	5,670	100	442	100
Material including building materials	2,809	49.5	77	17.4
Maize	601	10.6	10	2.3
Fruits, vegetable	129	2.3	32	7.2
Rice	1,650	29.1	61	13.8
Other food stuff	219	3.8	46	10.4
Fuels	73	1.3	120	27.2
Fertilizer	15	0.3	26	5.9
Others	174	3.1	70	15.8

3-1-5 Highway

The construction, rehabilitation and maintenance of national and provincial highways and the development of national highway system is under the responsibility of the Department of Highways.

As of 1971, the total length of highway under the control of the Department of Highways and open to traffic came to 17, 105 km, of which 10, 977 km are national highway and 6, 128 km provincial highways. 9, 681 km of the 10, 977 km of national highway are maintained with asphalt surface, and the remaining 1, 296 km maintained with aggregate surface. Of the provincial highways, 1, 781 km are with asphalt surface and the remaining 4, 347 km with aggregate surface. There were in addition, 17, 412 km of highways under construction. The following table shows the trend of increase in length of highway under the Department of Highways.

Table 3-13 Length of highway open to traffic in Thailand (km)

Year	National Highway	Provincial Highway	Total
1964	9, 404	2, 214	11, 681
1965	9, 482	2, 793	12, 275
1966	10, 335	2, 995	13, 330
1967	9, 517	3, 893	13, 410
1968	9, 744	5, 209	14, 953
1969	9, 972	5, 729	15, 701
1970	10, 401	5, 891	16, 292
1971	10, 977	6, 128	17, 105

Bangkok is the hub of the major trunk highways in Thailand. The Highway Route No. 1, by far the most important routes of all, starts from Bangkok and forms the main artery connecting the northern part of the Kingdom, passing Saraburi, Nakhon Sawan, Tak, Lampang (where it branches to Chiang Mai), Chiang Rai to end at the Thai-Laos border. The Route No. 2 branches out to the east from Route No. 1 at Saraburi to form the main route to the northeastern region, passing Nakhon Ratchashima. Khon Kaen to end in Nong Kai, the major border town which is separated from the Laotian capital of Vientien by the Mekong River. The Route No. 3, joins Bangkok with the Southeastern region, passing through Samut Prakan, Rayong, Chantaburi, and terminating in Trat. The Route No. 4 is the main artery to the Southern penisular region, starting from Bangkok and passing through Nakhon Pathom, Petchaburi, Chumpon, Trang, and, at the Thai-Malaysian border, connecting to the Malaysian highway Route No. 1 which runs right up to Singapore. Other highways complement the abovementioned 4 major routes to form a network over the Kingdom.

3-2 Existing Road Network Situation in Bangkok

The present road network system is far from desirable for a metropolitan of three million in population. The expansion of the metropolitan is far too fast for new road construction and road improvement to keep pace with. (Fig. 3- 3). A random survey of road area percentage carried out by the Office of Metropolitan Traffic Planning revealed that only around ten percent of the total area in the surveyed area is roadway. The percentage for the whole metropolitan is probably much lower, as the survey was carried out near the old city centre of Bangkok, where roads exist at a higher density than the districts farther away from the city core. This is a very low percentage as compared to other major cities of the world where an average of over twenty percent is common.

The many waterways, which in former days, served as the main arteries of transportation, have also proved to be great hindrance for a road network. Minor waterways have to be filled up, while major waterways which are preserved, have to be spanned by major structures. The major waterways are shown in Fig. 3-4. By far the most important waterway is the Chao Phraya River which still plays a very important role in transportation of Bangkok. The river forms the natural boundary between the municipalities of Bangkok and Thonburi.
Only four bridges span this great river. The Memorial Bridge joins the old city centres of the tow municipalities and is the most important cross-river bridge. Some six kilometers upstream is the Krung Thon bridge which is next to the Memorial Bridge in importance. To the south, the Krung Thep bridge forms a connection between the Phrachao Taksin Road on the Thonburi side and the Charoen Krung Road on the Bangkok side.

Traffic volume on this bridge is small, due mainly to the poor running condition of the access roads. The RamaVI Bridge is far to the north and serves as the link between Nonthaburi and Thonburi.

The demand of cross-river traffic is beginning to show sign of exceeding the traffic capacity provided by the bridges and provision of new bridges is underway. The Tachange Bridge at present under construction will no doubt greatly relieve the daily traffic congestion on the Memorial Bridge. The Sathorn Bridge to be shortly implemented should further improve the situation of cross-river traffic.

Major khlongs (canals) also form major obstacles in improvement of road network. The old city centre is encircled by Khlong Lot, Khlong Ong Ang-Khlong Pang Lam Phu, and Khlong Phadung Krung Kasem. In this old city district, the three khlongs are well served by bridges which link all major thoroughfares. However, the widths of the carriageways inevitably narrow at the bridges, resulting in certain falling in capacity.

The Khlong SaenSaeb running east-west-wise from Khlong Krung Kasem to the boundary of Amphoe Bang Kapi and then turning northeast therefrom, virtually divides the city of Bangkok into two parts. The east-west section of the khlong is about ten kilometres in distance. However, there are only eight bridges across the waterway. (including the bridge at Wittayu Road which is not yet open to traffic). There is not a bridge across the three-kilometre section from Soi Asok (Soi 21) to Soi Ekkamai (Soi 63). This lack of connection link between Phetchaburi Road and Sukhumwit Road results in unnecessary concentration of traffic and brings about congestion on these two roads. The other khlongs of importance on the

Bangkok side are Khlong Samsen, Khlong Bang Sue, Khlong Bang Khaen, Khlong Lat Phrao, Khlong Prem Prachakon and Khlong Phranakhong. On the Thonburi side, Khlong Bangkok Yai, Khlong Bangkok Noi, Khlong Bang Kruai and Khlong Mon are the major khlongs which require major structures in road construction. However, the problem here is less prominent due to the present-day comparative low demand for cross-river traffic movement.

The road network pattern is basically different between the old city centre (The Amphoes of Phra Nakhon, Pomprap Suttru Phai and Samphanthawong) and the rest of the Metropolitan. As can be seen from Fig. 3-3, the old city centre is densely linked by grid road network running in the east-west and north-south direction. However, the roads are on the whole narrow, and multi-lane roadways are few. Nevertheless, such grid network provide good accessibility to every part within the centre. Beyond this centre core, the network pattern is basically linear. In each direction, two or three trunks roads run parallel from the centre core to the outskirt. These parallel trunk roads are connected to each other by very few connecting links. As a result, movement from one trunk road to another is confined to very limited number of roads. The trunk roads in different directions are seldom connected to each other, and transfer of traffic from one direction to another usually has to take place in the heavily built-up city area.

By far the most important trunk roads are those running in the east-west direction. The Phetchaburi-New Petchaburi Road, the Sukhumwit Road, and the Rama IV Road, are the three trunk roads running in these direction, the Phetchaburi Road starts from the Mission Hospital near Khlong Krung Kasem and runs eastward along Khlong Saen Saep for a distance of about ten kilometres to meet the Soi Phranakhong-Khlong Tan (Soi 71) which runs in a north-south direction. The section east of Soi Nana (Soi 3) is referred to as the New Petchaburi Road. This thoroughfare is comparatively new, and, being sandwiched on both sides by Khlong Saen Saep and Khlong Samsen, development along the road has not extended to any depth, although the strips on both sides of the road are completely opened to business and commercial activities.

The Rama IV Road is the southernmost of the three east-west thoroughfares. It starts from the Bangkok Railway Station to join the Sukhumwit Road at Phrakhanong, about ten kilometres from the starting point. This thoroughfare is important as the distributor and collector road for traffic to and from the Amphoes of Bangrak and Yannawa. Skirting the Port of Bangkok, it also offers the access to the port area through Sunthon Kosa Road and At Narong Road.

The Sukhumwit Road lies between the two above-mentioned roads. The section running east-west, namely from Khlong Krung Kasem to the railway line to the port, is named Rama I Road for the first half and then Ploenchit Road for the other half. The name Sukhumwit Road begins from the east of the railway line, and runs in a southeast direction to Phrakhanong and then southwards to Bangna before branching off into national highways Route No. 3 and Route No. 34. Rama I Road and Ploenchit Road form the axle of the new city centre, where business and commercial concerns are concentrated. The districts on both sides of the Sukhumwit Road are the fastest developed districts in recent years. Business, commercial and international tourist facilities line the road sides, while deep behind the road, residential area sprawl at tremendous pace. South of Phrakhanong, industrial establishments are clustered.

For the sections between Klong Krung Kasem and the Port railway line, the three thoroughfares are connected by the roads

Rama VI, Phayathai, Ratchadamri and Wittayu, which run perpendicular to the three roads. Rama IV Road and Rama I Road are further connected by the Henri Dunnant Road. East of the Port railway line, the lack of connecting roads between the three roads is conspicuous. New Petchaburi Road and Sukhumwit Road are connected by Soi Nana (Soi 3), Soi Asok (Soi 21), Soi Ekkamai (Soi 63), and Soi Phrakhanong-Khlong Tan (Soi 71). The connecting links between Sukhumwit Road and Rama IV Road are Soi Ari (Soi 26), Soi Naphasap (Soi 36), Soi Ban Kluai Tai (Soi 40) and Soi Kluai Nam Thai (Soi 42). Except for Soi Asok, which has a carriageway of four lanes, the other sois are all narrow in width, poor in alignment, and low in traffic capacity.

The most important trunk roads in the north-south direction are the Phahon Yothin Road and the Mittraphap Road (Super-highway). The Phahon Yothin Road, starting from the Victory Monument, extends north-northeast to intersect with Mittaraphap Road at Lat Phrao and continues in the same direction, finally remeeting Mittraphap Road north of the Changwat boundary. The Phahon Yothin Road is continued to the south by the Phaya Thai Road which ends at the Rama IV Road. The Mittraphap Road begins from Din Daeng, and after twice intersecting with the Phahon Yothin Road, extends north as national highway Route No. 1, which is the sole connecting trunk road with the northern changwats. Along both sides of the road, the Phahon Yothin Road is heavily built-up from the Victory monument to the intersection with Pradiphat Road, and moderately built up beyond this point, except at the vicinity of Don Muang, where some concentration is seen near the airport. The Mittraphap Road is a new highway, and development along the road has not taken place to any extent. However, residential development and some industrial development is fast picking up momentum, especially near Din Daeng.

The Rama V Road and the Samsen Road also vertically traverse Dusit Amphoe from the old city centre, and the extension to the north makes up the main link between Bangkok and Nonthaburi. Pradiphat Road link these two roads to Phahon Yothin Road to provide access to the north for the Dusit Amphoe.

The core on the Thonburi side is small and the road network pattern is more simplified. From the Memorial Bridge, the Prachathipak Road extends south to Wong Wian Yai, from which the road is contined by Phra Chao Taksin Road to Phra Pradaeng. East of the Phra Chao Taksin Road, the Charoen Nakhon Road runs along the Chao Phraya River. From Wong Wian Yai, the Inthara Phithak Road runs west until Tha Phra intersection where it branches into Phet Kasem Road to the west and Charan Sanit Wong Road to the north. The Charan Sanit Wong Road ends at Rama VI Bridge and is the major link between Thonburi and Nonthaburi.

Compared to Bangkok, Thonburi is generally less heavily built up. However, development is taking place at a high pace along the Phra Chao Taksin Road and Charan Sanit Wong Road. To the west, heavy concentration is found up to the Tha Phra intersection.

Fig. 3-5 shows the major trunk roads in the twin municipalities. From this, it can be seen that lack of connection between trunk roads to the east and whose to the north is conspicuous. Far beyond the town centre, the Lat Phrao Road and the road via Kitikhachon Studium come under this category. However, the detour is too great for any practical purpose as a bypass. All traffic transfer between the north and the east take place by once passing through the city area. This results in the daily nightmarish traffic congestion at the Din Daeng area and along the Ratchaprarop Road.

Bangkok-Thonburi Ring Road Part II

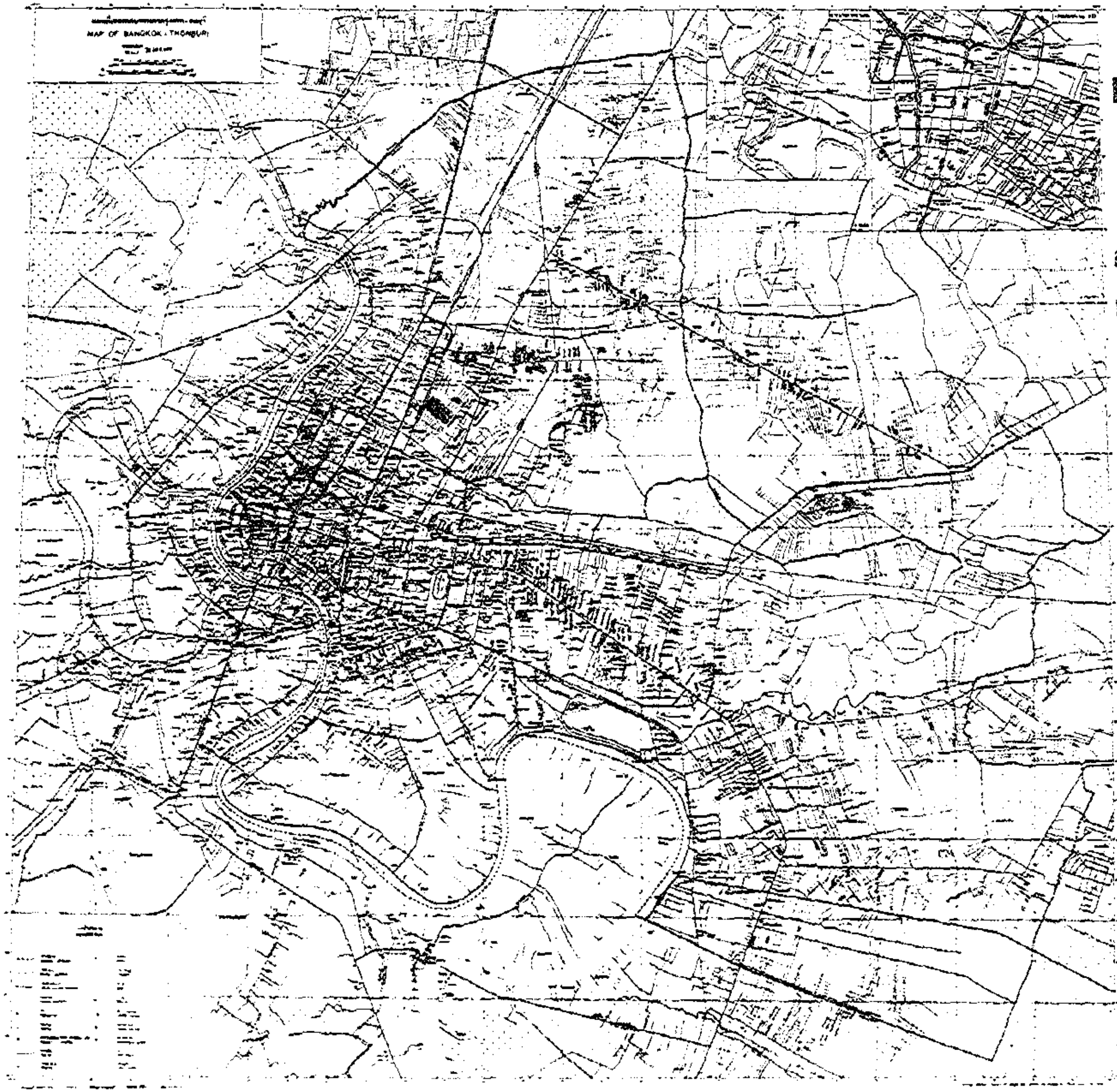
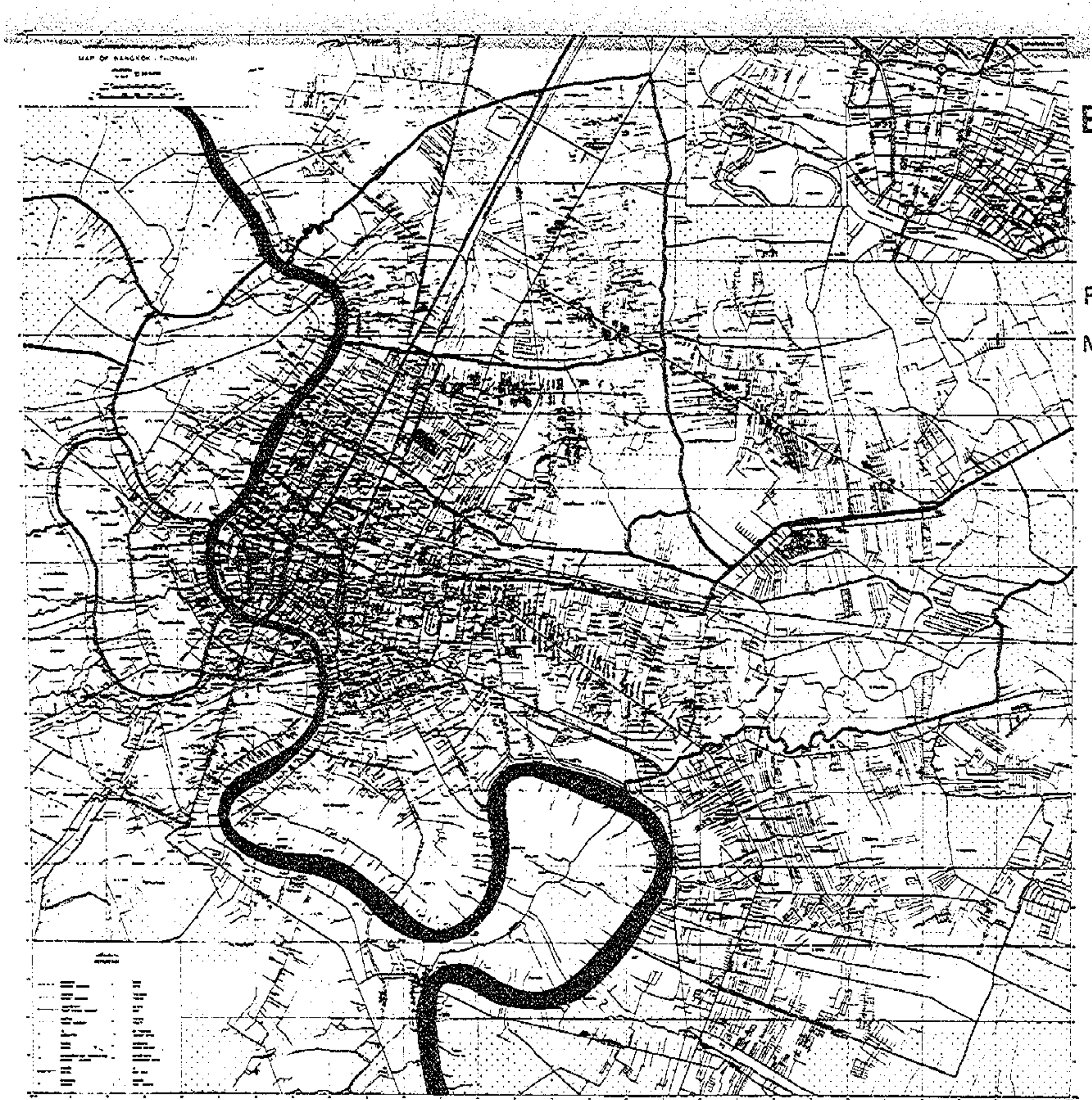


Fig 3-3

Existing Road Network in Bangkok



Bangkok-Thonburi

Ring Road Part II

Fig 3-4

Major Waterways in Bangkok

Bangkok-Thonburi

Ring Road Part II

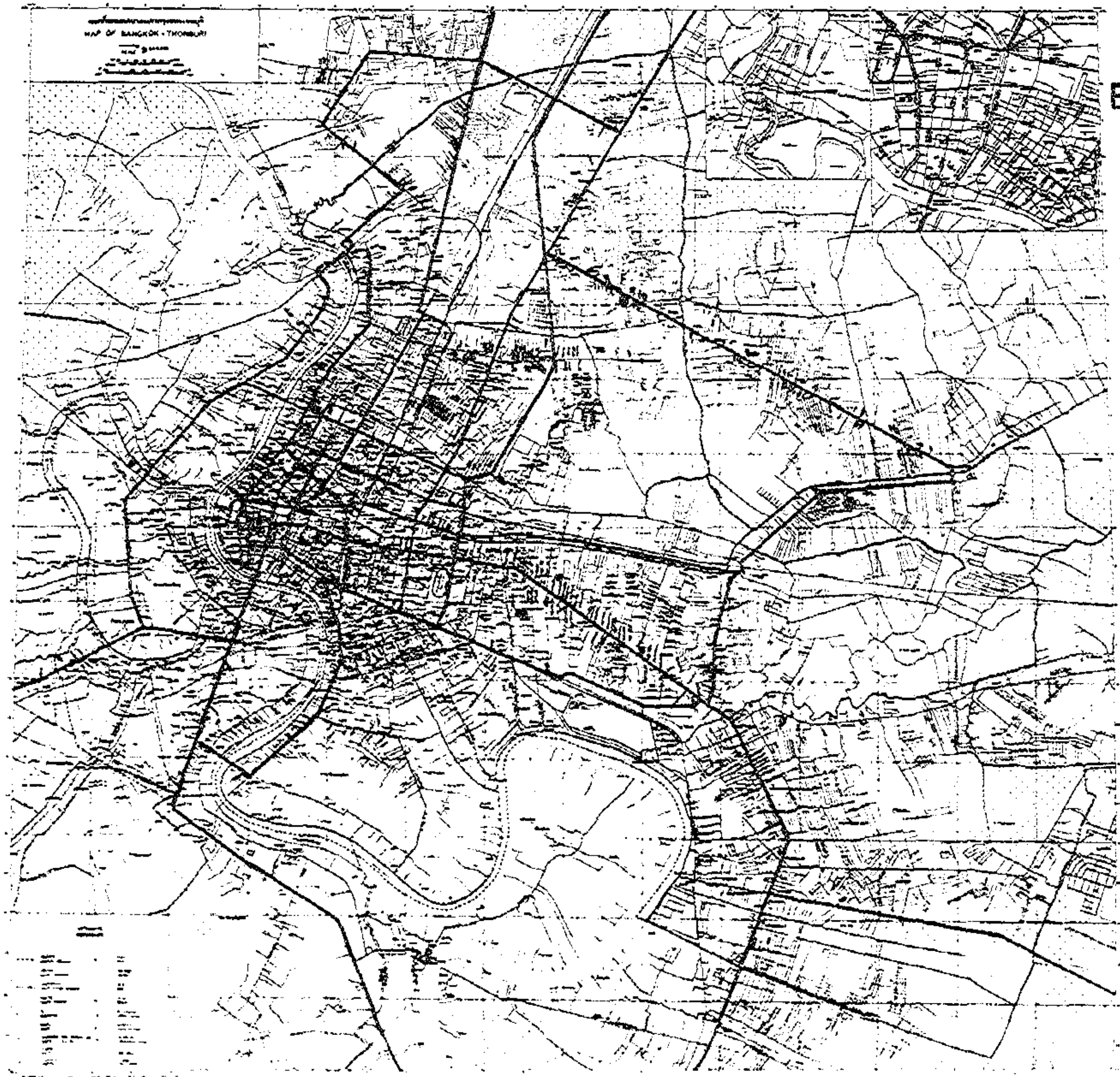


Fig 3-5

Major Trunk Roads in Bangkok

3-3 Analysis of Present Traffic Situation in Bangkok

Congestion is the general impression received from the traffic situation in the city area of the twin municipalities. However, the extent of the congestion cannot be clearly grasped without some actual surveys. The following surveys are the common surveys usually carried out.

(1) Travelling time survey : The actual travel time required for a road section is surveyed through travelling with the traffic stream and recording the time consumed for the road section. In this study, an extensive travel time survey was carried out and the details will be described in subsequent sections.

(2) Cross-section traffic volume survey: A count of the volume of traffic through a road section is made and then analyses carried out regarding the quality and quantity of the traffic volume. A comparison of the traffic volume with the capacity of the carriageway will provide useful information regarding the traffic situation of the road section. In this study, lack of time did not allow our carrying out a traffic count of our own. However, an extensive survey had been carried out by the Office of Metropolitan Traffic Planning. Analyses were carried out with the valuable survey results kindly provided us by the MTP.

(3) Intersection traffic survey : In this survey, the volume of traffic in each direction is counted for the intersection surveyed to establish the pattern of traffic flow at the intersection. In this study, the data of intersections traffic survey were also kindly provided by the MTP.

In the following sections, a description of the traffic situation in the Bangkok-Thonburi municipalities will be made through analyses of the aforesaid survey results.

3-3-1 Travel time survey

In this study, travel time survey was carried out from August 3 to August 16, 1972 for all major roads in the city area of the metropolitan. (Fig. 3-6 to 8). A passenger car was driven through the surveyed route with the main traffic stream, and the running time, stopping time, and reasons for stopping were recorded for every road section. The travel speed and travel time of a road section varies according to the hourly traffic volume which in turn is variable according to the time of the day. To obtain good survey data, it is necessary therefore to carry out as many surveys as possible, spreading the survey time to different time of the day. In the survey for this study, consideration in this regards is taken and endeavours are made to carry out at least two runs for each road section. However, due to lack of time, it was not possible to carry out two runs for some sections of minor importance. As a result, some sections (e.g. the road sections in Dusit Amphoe) were only covered by one survey run. (Fig. 3-9).

Table 3-14 is the summary of the travel time survey. It took a total of 15 hours and 55 minutes to travel a total distance of 371.9 kilometres, which comes to an average travelling speed of 23.4 kilometres per hours. Of the nearly 16 hours of travelling time, a loss time of four hours and nineteen minutes (or 271.1% of travel time) was accounted for by various reasons. The average running time for the same distance was therefore 32.1 kilometres per hour. A breakdown of the stopping time shows that by far the largest percent of loss time was due to traffic signal at intersections. (55.7%). Bangkok is probably conspicuous for its extraordinary length of traffic signal cycle. Especially during the 'rush hour' when most of the traffic signals at major intersections are manually manipulated by traffic policemen, it is not uncommon for vehicles to encounter red traffic signal for a period of from three to five minutes. This results in long waiting queues sometimes several hundred metres long. Sometimes the effect of such long queues are extended to the next intersections where the vehicles are unable to move ahead despite the traffic signals being green because of the waiting queues ahead. It is fortunate that such disturbances are not common, due to the extraordinary length between intersections in Bangkok. The accumulated loss to the national economy due to undue waiting time must be great, and we cannot help but feel that a shorter signal cycle is more beneficiary on the whole. 'Congestion', the next biggest item in loss time (28.6%), includes time loss for stopping at an intersection for more than one traffic signal cycle. This phenomenon is especially conspicuous in the old city centre (China Town) where vehicles move ahead at a 'snail pace' for most of day.

During the whole survey, a total stops of 46 times were made for pedestrian crossing the roads. Although the total loss time was comparatively small, such abrupt crossing of pedestrian at unexpected place are annoying to drivers and cause disruption to the smooth flow of traffic, not to mention the peril of traffic accidents. The non-observation of the pedestrian crossing zones and the disrespect of the pedestrian crossing zones by the drivers render such crossing zones meaningless and result in pedestrians crossing at any place considered convenient. Enforcement of pedestrians crossing the roads only at specified places will greatly help in the smooth flow of the traffic stream. 28 stops were made for buses stopping for boarding and descending passengers. While some were due to insufficient width in carriageway, many were due to bus deivers' failure to pull along the side of the road for passenger loading and unloading. Education of bus drivers in this respect is also important to ensure uninterrupted traffic flow. Other reasons made up about 10% of interruptions during the travel survey and are considerably of less importance compared to the above-mentioned reasons.

Fig. 3-10 shows the average travel time, stopping time and the number of stops for each road section, while Fig. 3-11 shows the average travel speed of each road section as obtained from the survey. On the whole the average travel speed of most of the road sections in the survey area falls between 20 km/hour to 30 km/hour. Most road sections in and around the old city centre recorded an average travel speed of under 20 km/hour. Especially on the two one way streets in the China Town, namely the Yaowarat Road and the Charoen Krung Road, the average travel speed fell below 10 km/hour. The road sections in the Phrakhanong district also recorded extremely low average travel speed. Of the linear trunk roads, the Mittraphap Road and the New Petchaburi Road registered the highest average travel speed. The Mittraphap road, being under partial control, has few interruptions by traffic signals. The section from Din Daeng to the Inthramara intersection average nearly fifty kilometres hourly speed while the section further north could be travelled at over sixty kilometres in average speed. The New Petchaburi Road, by virtue of being less densely built-up on both sides of the road, has a smaller traffic volume, and was able to record an average travel speed of well over 40 km/hour. On the Thonburi side, The section of Charan Sanitwong from Tha Phra junction to the Krung Thon Bridge intersection shows a relatively high average speed, while the rest of the network averaged around or below 30 km/hour.

Table 3-14 Summary of Travel Time Survey

(Survey Carried out during 3rd Aug. - 16 Aug. 1972)

Total Distance Travelled	:	371.9 km
Total Travel Time	:	15 hours 55 min. 15 sec.
Average Travel Speed	:	23.4 km/hr.
Total Stopping Time (543 stops)	:	4 hours 19 min 09 sec. (27.1% of Total Travel Time)
Total Running Time	:	11 hours 36 min. 06 sec
Average Running Speed	:	32.1 km/hr.

Details of Stopping Time

	Reason for Stopping	No. of Stops	Total Stopping Time	%
	Total	543	4 hr. 19 min. 09 sec.	100.0%
1.	Traffic Light	224	2 hr. 24 min. 23 sec.	55.7%
2.	Traffic Accident Ahead	3	1 min. 21 sec.	0.5%
3.	Pedestrian Crossing	46	6 min. 04 sec.	2.3%
4.	Due to Bus Stopping	28	3 min. 37 sec.	1.4%
5.	Vehicle Entering Traffic Stream from side roads	23	2 min. 53 sec.	1.1%
6.	Stop at Police' Direction (for vehicle or Pedestrian)	9	6 min. 36 sec.	2.6%
7.	Congestion	152	1 hr. 14 min. 05 sec.	28.6%
8.	Vehicle Crossing	18	2 min. 47 sec.	1.1%
9.	Weaving at Circus (Rotary)	19	6 min. 43 sec.	2.6%
10.	Construction Work ahead	10	3 min. 20 sec.	1.3%
11.	Railway Crossing	3	5 min. 10 sec.	2.0%
12.	Stopping for Right Turn	8	2 min. 10 sec.	0.8%

Bangkok-Thonburi

Ring Road Part II

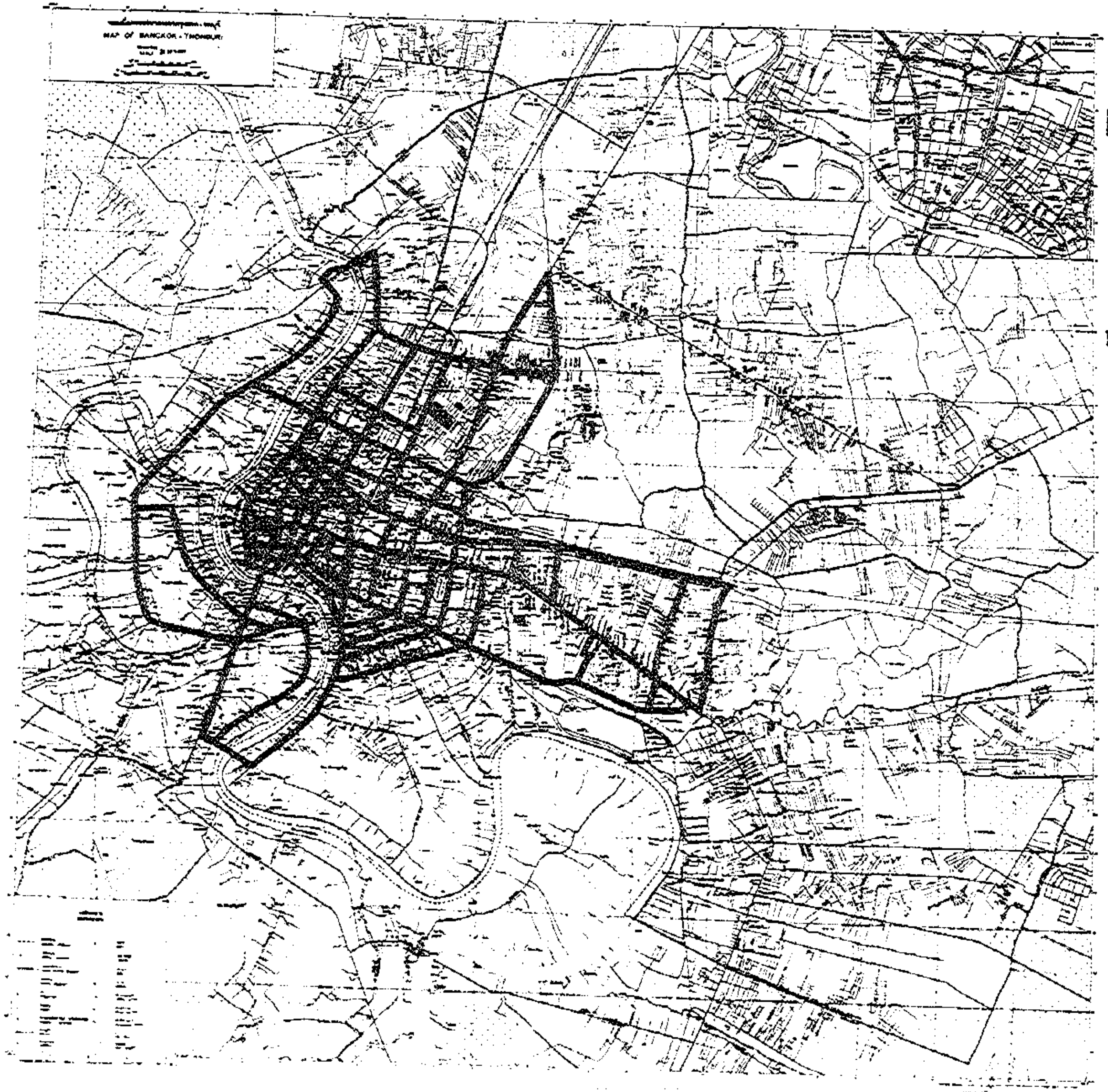


Fig 3-6

Roads Covered in Travel Time Survey

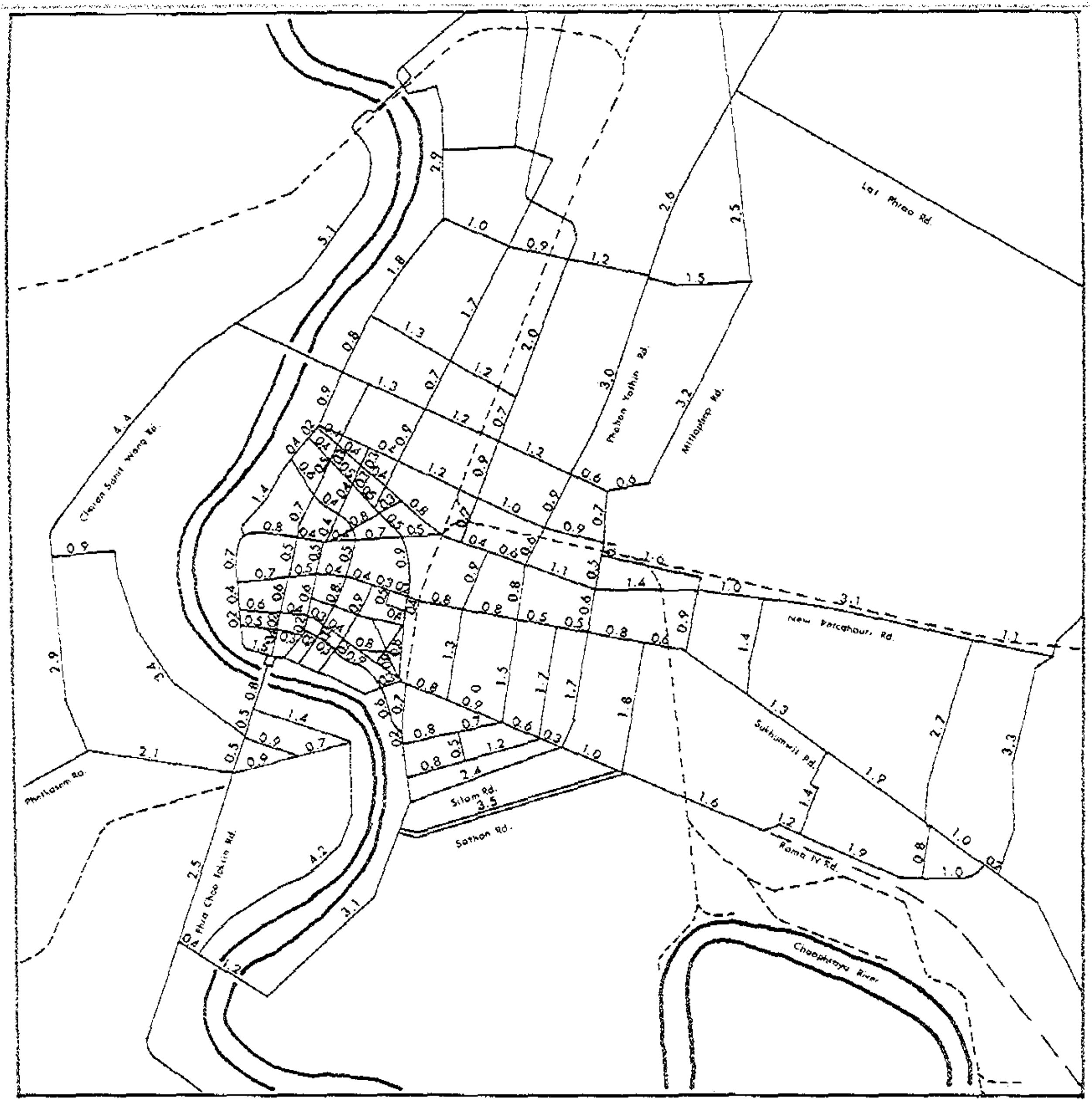
Bangkok-Thonburi

Ring Road Part II

Fig 3-7

Link Distance for Roads

Covered in Travel Time Survey



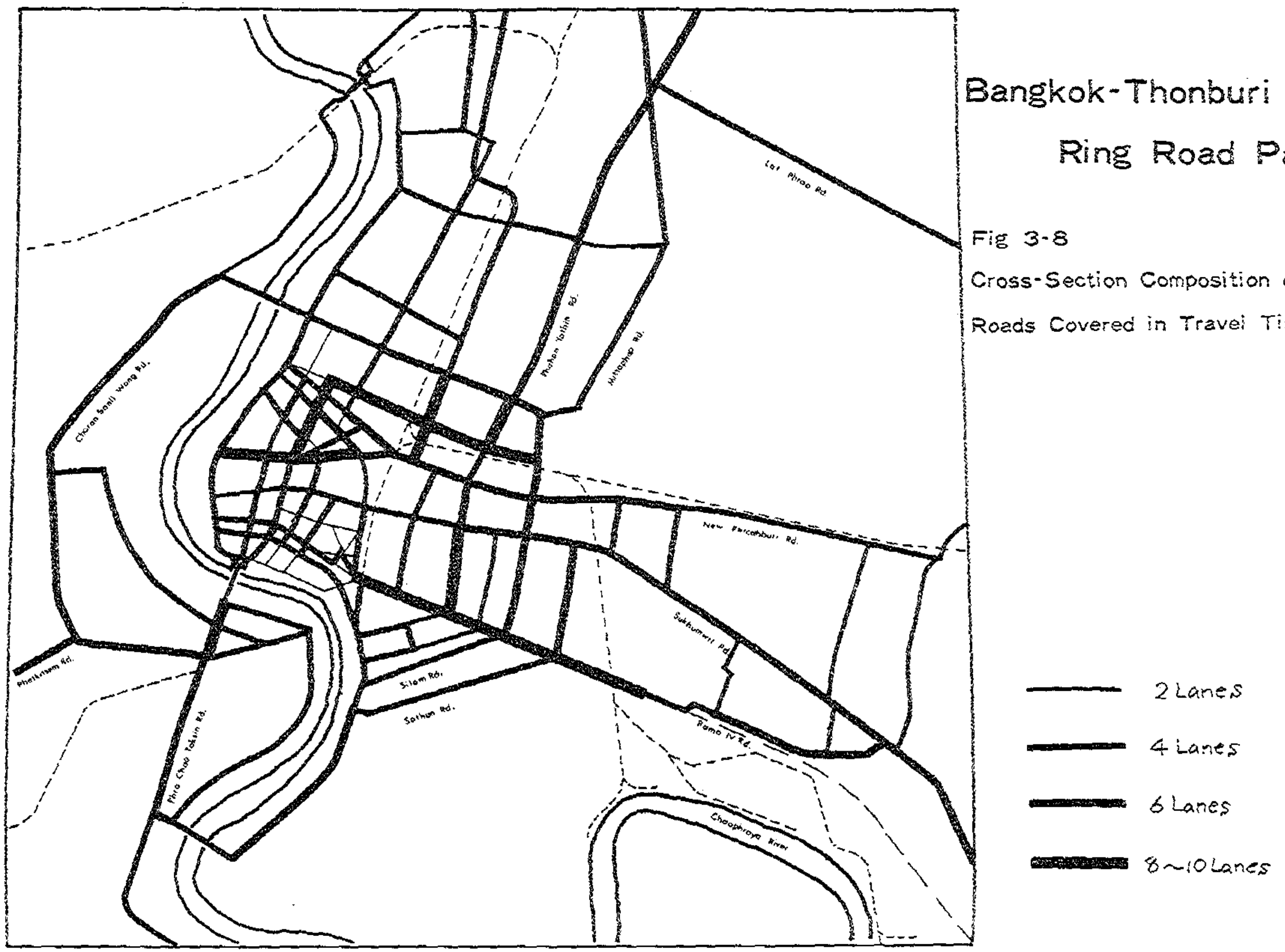
Bangkok-Thonburi

Ring Road Part II

Fig 3-8

Cross-Section Composition of

Roads Covered in Travel Time Survey



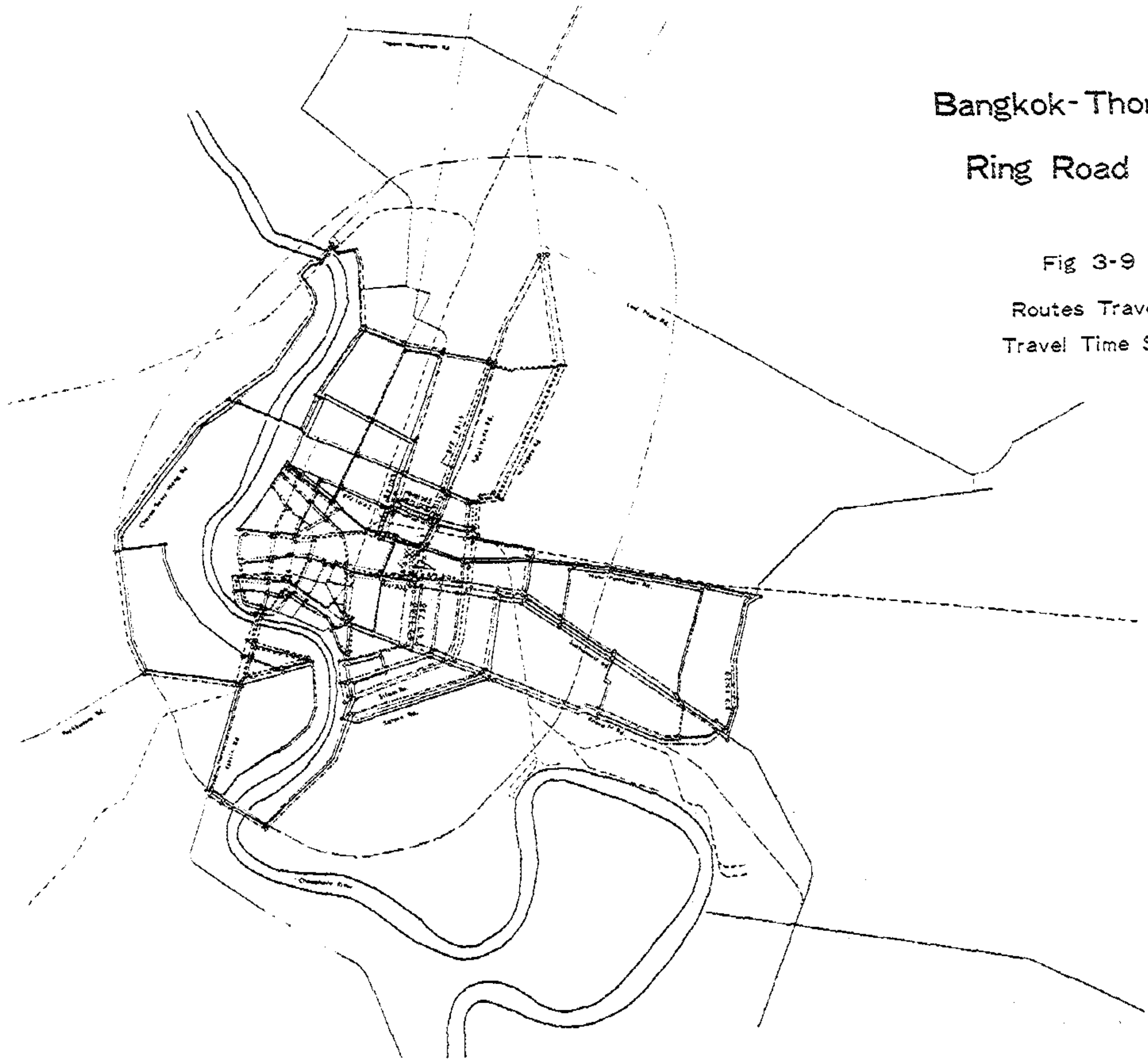
Bangkok-Thonburi

Ring Road Part II

Fig 3-9

Routes Travelled in

Travel Time Survey



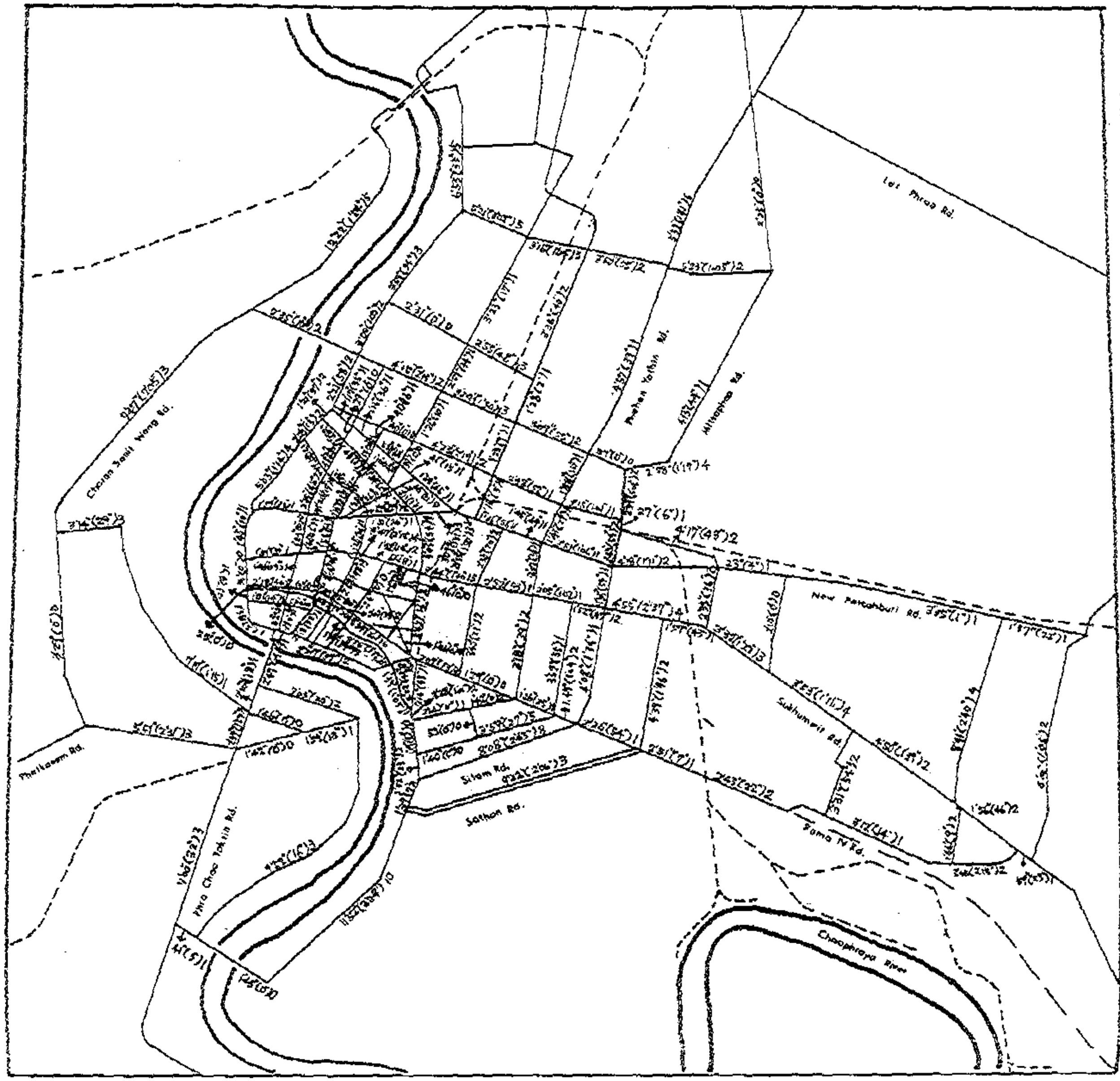
Bangkok-Thonburi Ring Road Part II

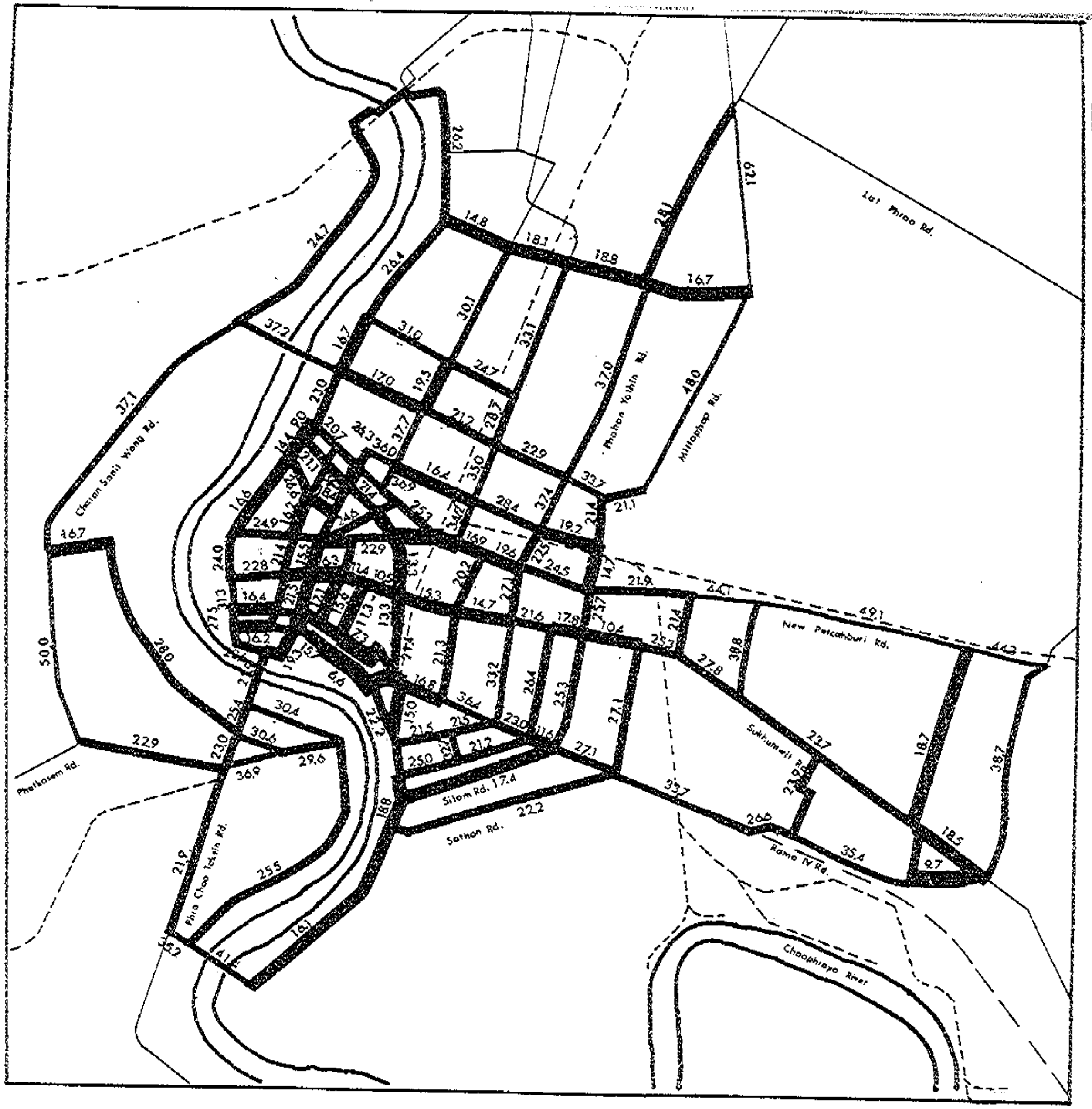
Fig 3-10

Results of Travel Time Survey

Travel Time (Stopping Time) &

No. of Stops





Bangkok-Thonburi
Ring Road Part II

Fig 3-11

Average Travel Speed

0 ~ 10.0 Km/h
10.1 ~ 20.0
20.1 ~ 30.0
30.1 ~ 40.0
40.1 ~ 50.0
50.1 ~

3-3-2 Cross section traffic volume survey:

A comprehensive cross section traffic volume survey was carried cut by the Office of Metropolitan Traffic Planning on thirty three major road sections from 28 January to 8 February, 1972. (Fig. 3 - 12). The survey was for a sixteen-hour period from 6 a.m. to 10 p.m. when hourly traffic classified into 8 classes of vehicle types were counted. Detailed data of the survey together with results of analyses are to be found in the appendices of this report.

(1) The four road sections from the north to the old city centre, namely stations No. 10 (Samsen Rd), No. 11 (Pracha Thipathai Road), No. 12 (Ratchadamnoen Nok Road), and No. 13 (Nakhon Sawan Road), registered almost equal daily traffic volume of around thirty five thousand vehicles. This even distribution of traffic volume on parallel alternative roads indicate that the traffic volumes are nearing the capacity of the roads, which are all utilized to the fullest extent. In reality, except for the Ratchadamnoen Nok Road, which is ten lanes in width, the other three roads are all weak four lane roads, and a traffic volume of thirty five throusand vehicles is almost the upper limit.

(2) Three cross section counts were taken on the most important east-west trunk road, the Sukhumwit Road and its extension up to Khlong Krung Kasem, the first at the vicinity of Soi Ari (Soi 26), the second at Ploenchit Road and the third at Rama I Road. The traffic volume recorded in each case remained at around seventy thousand vehicles per day, indicating that for a total distance of over ten kilometres, there was no conspicuous increase or decrease in traffic volume.

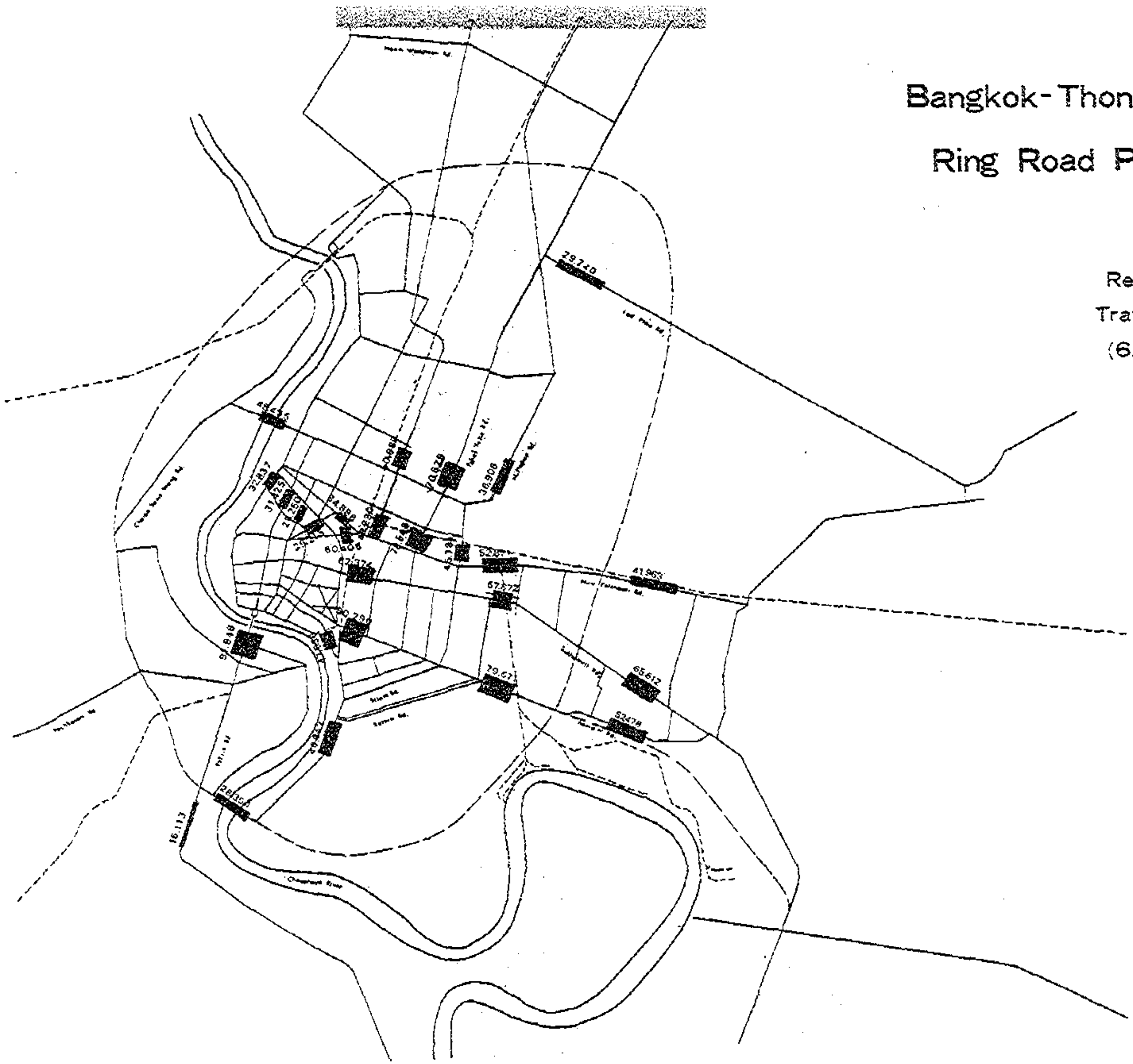
In most city roads, the traffic volume tend to be highest near the city centre, and tapper off proportional to its distance from the city centre. The phenomenon on Sukhumwit Road is therefore extraordinary and is worth special attention. It can easily be seen that this phenomenon is due to the fact that the Sukhumwit Road is loaded up to capacity throughout the whole length and does not allow any increase in traffic volume to any great extent.
The Sukhumwit Road is a weak six lane road where normally only four lanes are fully utilized while the two outermost lanes are usually occupied by parking vehicles. It is difficult to imagine any further increase in traffic without causing total paralysis to the whole road.

(3) The Rama IV Road had a traffic volume of over 100, 000 vehicles per day at the vicinity of the Bangkok Railway Station, but gradually decreased to ninety thousand near Lumpini Park, and then to around sixty thousand at the vicinity of Soi Ari. The New Petchaburi had a traffic volume of slightly under fifty thousand near Soi Klang (Soi 49), but increased as it approached the city centre, to sixty thousand near Soi Nana, and eventually to around seventy thousand at Lan Luang Road. These figures are more normal for a city trunk road, showing that some increase in traffic volume can be tolerated at the end away from the city centre. Unfortunately, due to lack of sufficient connecting link between these roads and the Sukhumwit Road, diversion of traffic from the Sukhumwit Road to these two roads is difficult, and they cannot be of any major help in relieving the congestion on the Sukhumwit Road.

(4) With a traffic volume of about forty thousand per day, the Mittraphap Road (Superhiway) is comparatively under-capacity compared to the Phahon Yothin Road, which runs parallel and is with a traffic volume twice that of the Mittraphap. Here again, diversion is difficult without provision of more connecting links. The Mittraphap, lowly built up along the route, however, has a special purpose of serving as the access road to the airport and the northern regions of the nation.

(5) Soi Rongphayaban and Nang Linchi Road provided the access to the deep southern part of Yannawa Amphoe. Despite the poor condition of alignment and low traffic capacity of these two-lane roads, traffic volumes counted were repectively twenty and thirty thousand vehicles per day. The lack of adequate road network in this area results in heavy concentration of traffic on the limited number of access roads. Considering the future development ear-marked for this district, improvement of the road network is of utmost importance.

(6) The Memorial Bridge, with a daily traffic volume of over one hundred thousand vehicles, accounted for over half the traffic volume across the Chao Phraya River. The Krung Thon Bridge registered a traffic volume of about fifty thousand, which was about a quarter of the total cross river traffic. Despite the favourable condition of being near the new town centre of the Bangrak Amphoe, the Krung Thep Bridge had an unexpectedly low daily traffic of just over thirty thousand. The poor condition of the access roads is the main reason for this low traffic volume, and the improvement of the road network in the Yannawa Amphoe will no doubt be of help in putting this bridge into better use.



Bangkok-Thonburi

Ring Road Part II

Fig 3-12

Results of Cross Section Traffic Count (6. 00a.m.~ 10.00p.m.) (vehicles/16hours)

3-3-3 Intersection traffic stream survey

An intersection traffic stream survey was also carry out by the Office of Metropolitan Traffic Planning in early 1972 on seven intersections, most of which are situated away from the town centre. (Fig. 3-13). A few comments on the traffic pattern of each intersection is given below.

(1) Station No. 1 (Charan Sanitwong - Krung Thon extension intersection)

The major flow at this intersection was the left or right turn traffic from the Charan Sanitwong Road to cross the Krung Thon Bridge, and the north-south through traffic formed only a small percentage. This shows that the characteristic of the Charan Saintwong Road is that of an access road for Thonburi to enter Bangkok. As the densely built up area of Thonburi is much farther to the south of the intersection, it clearly shows that the Charan Sanitwong Road serves as a bypass for traffic to the northern part of Bangkok.

(2) Station No. 2 (Wong Sawan Road-Phibun Songkhram Road intersection)

This is the intersection where the traffic from Nonthaburi branches to Bangkok and Thonburi via Samsen Road and Rama VI Bridge respectively. The survey results show that the major traffic stream is in the direction of the Rama VI Bridge. Coupled with the results of station No. 1 it can easily be deduced that a large portion of the traffic from Nonthaburi to Bangkok travels via Rama VI Bridge-Charan Sanítwong Road-Krung Thon Bridge route, and the percentage of traffic via the Samsen Road is small.

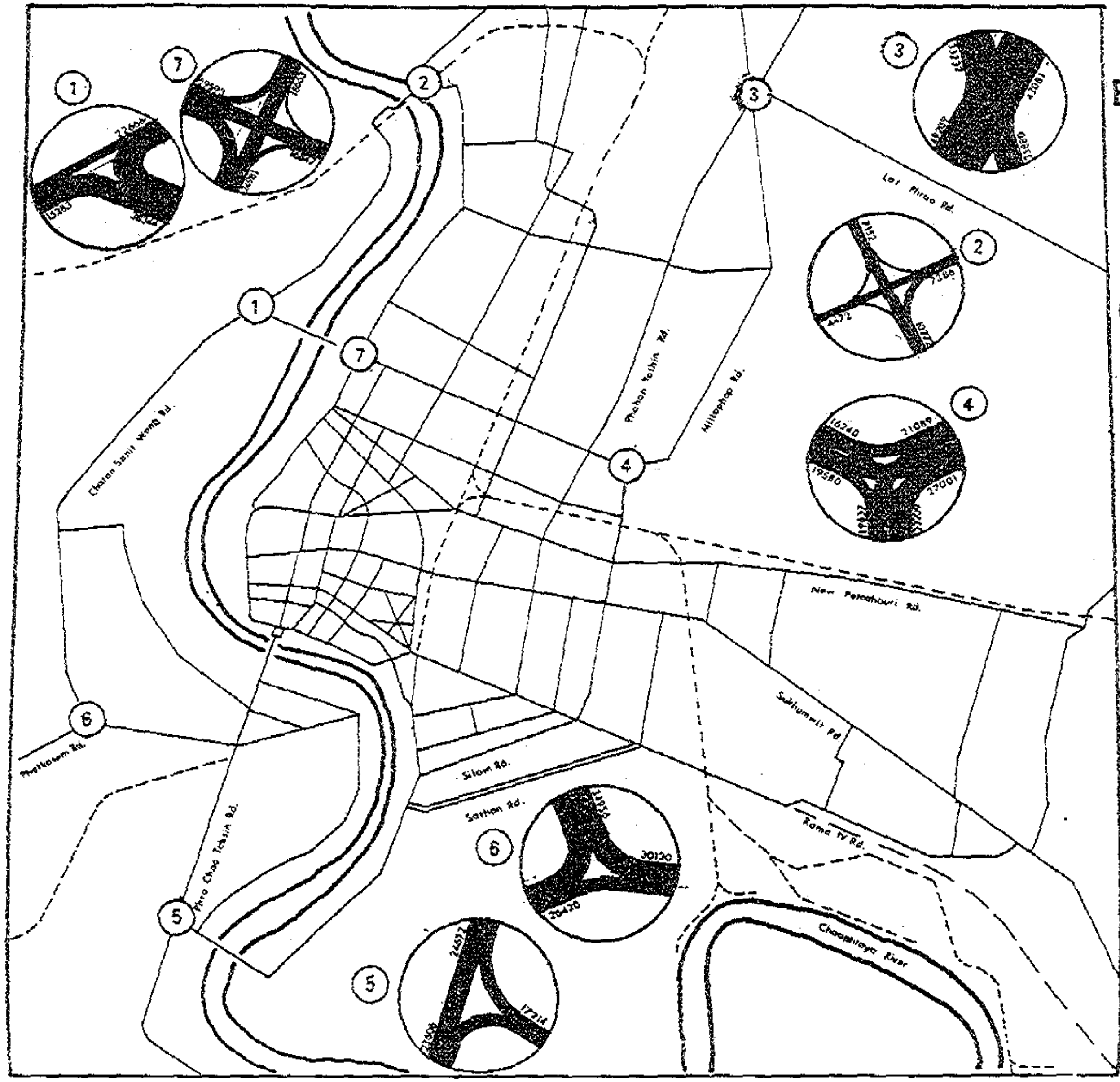
Here again, the northern section of the Charan Sanitwong Road serves as the bypass for traffic from Nonthaburi to Bangkok.

(3) Station No. 3 (Pahol Yothin Road-Mittraphap Road intersection)

At this junction, the traffic from the north branches into either the Pahol Yothin Road or the Mittraphap Road. It is interesting to note that while traffic from either direction of the Mittraphap Road divided almost equally into the two roads after crossing the intercestion, while the major share of the traffic on the Pahol Yothin Road continued ahead along the same road. The fact that the Pahol Yothin was far densely built up than the Mittraphap along the road, thus contributing to the generation of traffic from along the road, was a major reason for this traffic pattern. However, the perennial congestion at Din Daeng, the terminal of Mittraphap Road, certainly did not offer any encouragement to the use of the Mittraphap Road.

(4) Station No. 4 (Din Daeng Junction)

The Mittraphap Road terminates here, where traffic diverges into Ratwithi Road and Ratchaprarop Road. This is the major junction, through which traffic between the northern part and the southeast part of Bangkok mainly traverses, and congestion is a common phenomenon. While traffic was generally heavy in all direction, the Mittraphap Road-Ratchaprarop Road direction formed the major flow. The relief of congestion at this junction is one of the major problems for the improvement of traffic situation in Bangkok.



Bangkok-Thonburi Ring Road Part II

Fig 3-13
Results of Intersection Traffic Stream Survey
(6.00a.m~6.00p.m)

(5) Station No. 5 (Taksin Road-Krung Thep Bridge Extension).

This is the major access to the Krung Thep Bridge. However, survey results showed that the Krung Thep Bridge direction was a minor stream of traffic flow. The poor running condition of Charoen Krung Road, the access to the bridge on the Bangkok side, was no doubt the major reason for the low usage.

(6) Station No. 6 (Samyeak Tha Phra Junction)

The Charan Sanitwong Road and, the Phetkasem Road meet at this point. It is significant that the Charan Sanitwong direction was the major stream for both the traffic from the west and from the town centre of Thonburi. It is evident again, that a large portion of the traffic goes into Bangkok via Krung Thon Bridge.

(7) Station No. 7 (Ratwithi Road-Samsen Road Intersection)

This is an intersection in the town centre and is also the entrance to the Krung Thon Bridge on the west. At this intersection the traffic volume in the southern direction was almost twice that in the east direction, showing that the gravity of the southern direction, which leads to the city centre is greater than the eastern direction. Traffic to Krung Thon Bridge came evenly from all directions.

3-3-4 Origin-destination traffic survey

Another traffic survey that will usually provide very valuable imformations regarding the traffic situation of a region is the origin-destination traffic survey (O-D Survey). In this survey, the starting point and destination of each vehicle trip is verified through either road-side interview of vehicle driver at specific cordon stations, or through requesting the cooperation of a sampled portion of vehicle owners to provide informations regarding their activities at a specific date by answering a prepared questionaire. An analysis of the results of an O-D survey will reveal the pattern of the vehicle owners' desire to travel irrespect of the actual traffic pattern on the existing road network. Provision of future road network to fulfil the actual desired of the owners may be planned.

However, an O-D survey, whether through roadside interview or home interview, and the subsequent analyses, are very costly and time consuming. Moreover, constant survey of the same region at regular interval is necessary in order to obtain the trend of change in travel desire. For these reasons, the availability of complete O-D data is limited to very few countries of high intensity in highway traffic. In Bangkok, no regular O-D survey had been made in the past. A few limited surveys were carried out in the proccess of planning of specific projects. (e.g. O-D survey of Chao Phraya River cross river traffic for the Memorial Bridge Project.) However, such limited data are not sufficient for the overall transportation planning of the Metropolitan. In early 1972, the Office of Metropolitan Traffic Study carried out an overall O-D survey of the whole Metropolitan area. To date, the data are under scrutinization and analysis, and the final results will not be ready for some time to come. Should these data be finally made available, they will be most valuable for any future plans of the Metropolitan road network.

In this study, unfortunately, the full data of the O-D survey carried out by the Office of Metropolitan Traffic Study could not be made available. Through the effort of the Office, however, some parts of the interim results were provide us. They are:

(a) Outbound traffic in car-units per 24 hours (cordon-line 1972)

(b) Outbound traffic-person trips per 24 hours (cordon-line 1972)

Although incomplete, the above data were most valuable as reference materials.

In lieu of the results of actual O-D survey, theoretical O-D matrices were made for the purpose of this study. This was done through first estimating the number of registered vehicles in each zone, and assuming the average number of trips per vehicle to obtain the volume of traffic generated from each zone and then distributing the zone generated traffic volume by the gravity method. The O-D matrices thus obtain were then checked for credibility through comparing the theoretical results with the actual cross-section traffic volumes at specific cordon lines, and also through comparing the general distribution pattern of the vehicle type with the limited data available from the Office of the Metropolitan Traffic Study.

A detailed description of the steps taken for the preparation of the theoretical O-D matrices will be made in the subsequent section.

3-3-5 Theoretical synthesis of present O-D matrices

As mentioned above the only O-D traffic survey carried out for the Metropolitan area was the one made by the Office of Metropolitan Traffic Planning in early 1972. This survey, which covered the Changwats of Phranakhon, Thonburi, Nonthaburi and Samut Prakan, was made for the private passenger traffic, public passenger traffic and goods traffic.

The data of the survey are in the process of being sorted, checked and analysed. The part which covered the outbound traffic had been made available and been made use of in this study. However, analysis for the internal traffic will not be completed in time for this study. For this reason, theoretical O-D matrices had been synthesized and the results checked against the actually surveyed traffic volume of various cross sections for reliability of the theoretical figures.
The steps taken in the establishment of the O-D matrices are as follows:

(1) Zone division

The proposed Ring Road is situated within the Metropolitan boundary, and is shown as the Middle Ring Road in the Greater Bangkok Plan. For this reason it is possible that traffic volume that originates within the ring may make use of the Ring Road as a bypass to circumvent the traffic congestion in the city centre. This was taken into consideration in the process of zone division, and the size of the zones were decided such that unnatural movement of the traffic will not result when the zones are represented by centroids in traffic assignment. Also, correspondence of traffic volume of the zones with zone economic factors is necessary in estimation and analysis of future traffic. Taking these facts into consideration, the zones are divided to coincide with the Amphoe boundary in principle, and subdivided into smaller units where neccessary.

Away from the city centre, the zone boundaries are drawn along the amphoe boundaries at the vicinity of the Ring Road, and along the Changwat boundary for the districts at a distance from the Ring Road. Further away from the Metropolitan sphere, two or more changwats are combined to make one zone wherever the road network pattern allows. As a result, the Changwat of Phranakhon is divided into 30 zones, and the Changwat of Thonburi into 14 zones. The rest of the kingdom is divided into 18 zones, making a total of 62 zones in all. The zoning code list and the zone map are shown respectively in Table 3-15 and Fig. 3-14 - 3-16.

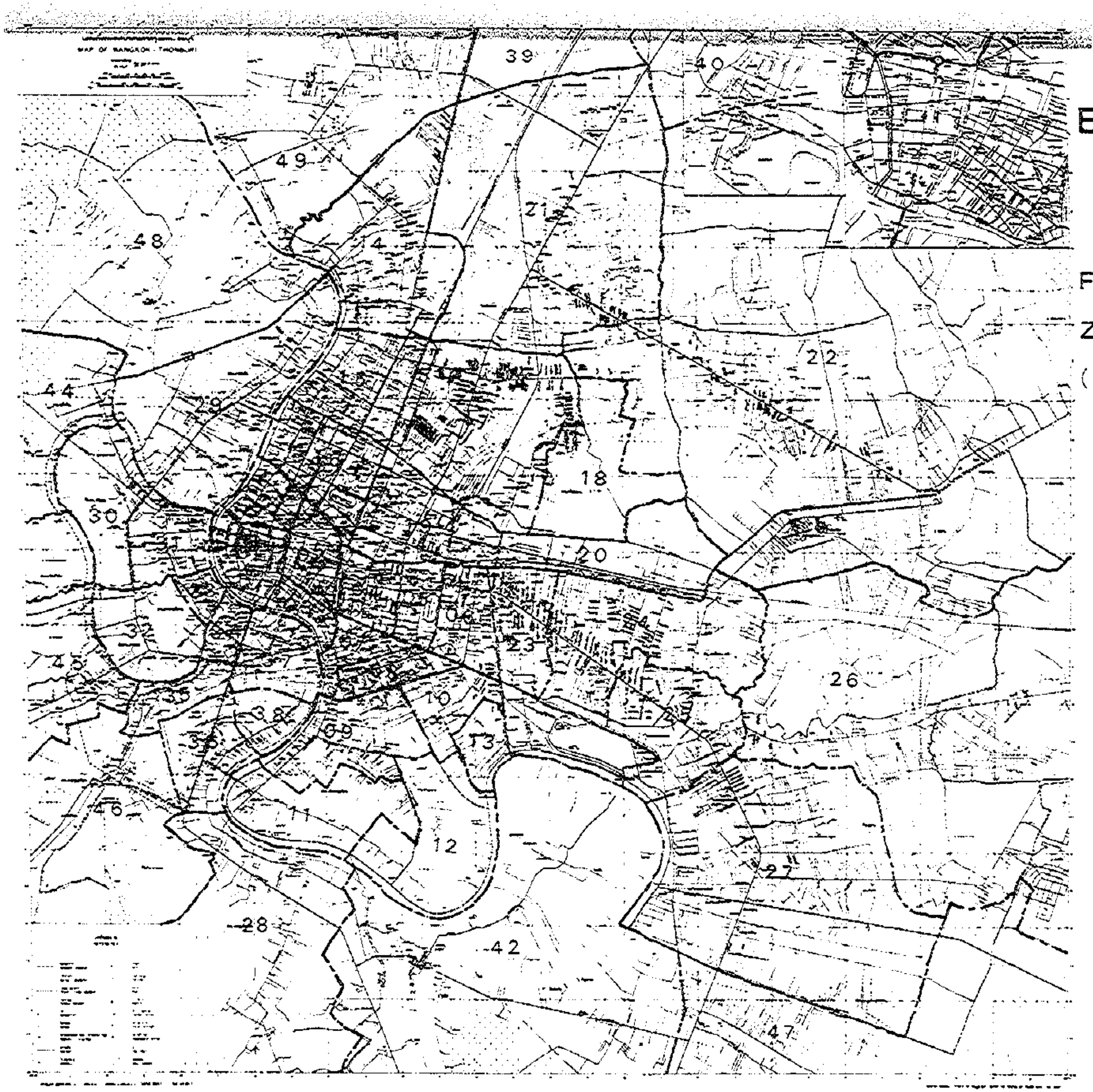
Table 3-15 Zone division

Zone No.	Enclosed area	
01	Amphoe Phra Nakhon	
02	Amphoe Pomprap Sattru Phai	
03	Amphoe Samphanthawong	
04	Pathum Wan	Wang Mai, Rong Muang
05		Pathum Wan
06		Suan Lumpini
07	Bang Rak	Sripraya, Bangrak, Mahapruotaran
08		Sriwong, Silom
09	Amphoe Yannawa	Yannawa, Tung Wad Don, Wad Phraya Kai,
10		Tung Mahamek
11		Bang Kor laem, Bang Klon
12		Bang Pong Prang, Chongnonaree
13		Chongnonaree

Zone No.	Enclosed area	
14	Amphoe Dusit	Bang Suc
15		Tanon Nakornchaisri
16	Amphoe Dust	Vachirapayabarn, Dusit, Suanchitlada, Siyark Mahanark,
17	Amphoe Phraya Tai	Sam Sen nai
18		Huay Kwang
19		Tung Phraya Tai, Petchburi, Tanon Phraya Tai, Makasan,
20		Bang Kapi
21	Amphoe Bang Khen	Lad Yao
22	Amphoe Bang Kapi	
23	Amphoe Phra Khanong	Klong Toey
24		Klong Ton
25		Phra Khanong
26		Suan Luang, Prawes, Nong Born, Dok mai,
27		Bang Jark, Bang Na,
28	Amphoe Rat Burana	
29	Amphoe Bangkok Noi	Bang Or, Bang Plad, Bang Yee Khan, Bang Bamru, Siriraj
30		Bang Khur Non, Bang Khur Sri
31		Buan chang Lor, Siriraj
32	Amphoe Bangkok Yai	Wat Tah Phra
33		Wat Aroon

Zone No.	Enclosed area	
34	Amphoe Muang	Wat Kalaya, Hiranruchee
35		Bang Yee Ruer, Talare Plu.
36		BuKhalo
37	Amphoe Klon San	Klon San, Klong Ton Srai, Somdej Chao Phraya,
38		Bang Lampu-lang
39	Amphoe Bang Khen	Sri Gun, Thoong Song Hong, Talad Bang Khen,
40		Sai Mai, Kling Tanon, Or Ngenn, Anusaowari, TaRoeng
41	Amphoe Min Buri, Amphoe Nang Chog, Amphoe Lad Krabang,	
42	Phra Pradaeng	Sang Kanong, Bang Kasorp, Bang, Korbua, Bang Ka Chao, Bang Nam Pueng, Bang Pueng, Talad, Bang Yor, Bang Kru, Bang Jark
	Amphoe Muang	Nah Kluer, Nai Klong Bang Pla-Kod, Laem Fah Pah, Klong Bang Pla-Kod
43	Amphoe Amphoe Bang Plee	Bang Plee Yai, Bang Chalong, Bang Pla, Bang Sao Tong, RaJathewa, Nong Prue Srisa Charak Nai, Srisa Charak Yai
	Amphoe Bang Bor Amphoe Muang	Bang Poo
44	Amphoe Taling Chan	
45	Amphoe Phasi Charoen, Amphoe Nong Khaem	
46	Amphoe Bang Khun Thien	

Zone No.	Enclosed area	
47	Phra Pradaeng	Bang Yah Praeg, Bang Hang Hua Suor, Samrong Tai
	Amphoe Muang	Bang Prong, Pak Nam, Bang Duam, Samrong Nueh, Bang Muang, Tai Baan, Bang Poo Mai, Praeg Sa, Bang Kaew
48	Amphoe Srai Noi, Amphoe Bang Yai, Amphoe Bang Kreuy, Amphoe Bang Bua Tong, Amphoe Pak Kred	
49	Amphoe Muang	Shai Mar, Bangrak Nai, Bang Krang, Bang Pai, Bang Sri Muang, Bang Kasor, Tah Srai, Talad Kwan, Bang Khen, Suan Yai
50	Samut Sakhon	
51	Ratchaburi, Samut Songkhram	
52	Kanchanaburi	
53	Nakhon Pathom, Suphan Buri	
54	Pathum Thani, Pra Nakhon Si Ayutthaya, Ang Thong, Sing Buri	
55	Lop Buri, Saraburi	
56	Nakhon Nayok, Prachin Buri	
57	Chachoengsao	
58	Chon Buri, Rayong, Chanthaburi, Trat	
59	Phetchaburi, Prachuap Khiri Khan, Chumphon, Ranong, Surat Thani, Phangnga, Krabi, Nakhon Si Thammarat, Phuket, Trang, Phatthalung, Satun, Songkhla, Pattani, Yala, Narathiwat	
60	Chiang Rai, Mae Hong Son, Nan, Chiang Mai, Lamphum, Lampang, Phrae	



Bangkok-Thonburi

Ring Road Part II

Fig 3-14

Zone Division

(Bongkok-Thonburi

Municipal District

Bangkok-Thonburi

Ring Road Part II

Fig 3-15

Zone Division (Metropolitan Area)

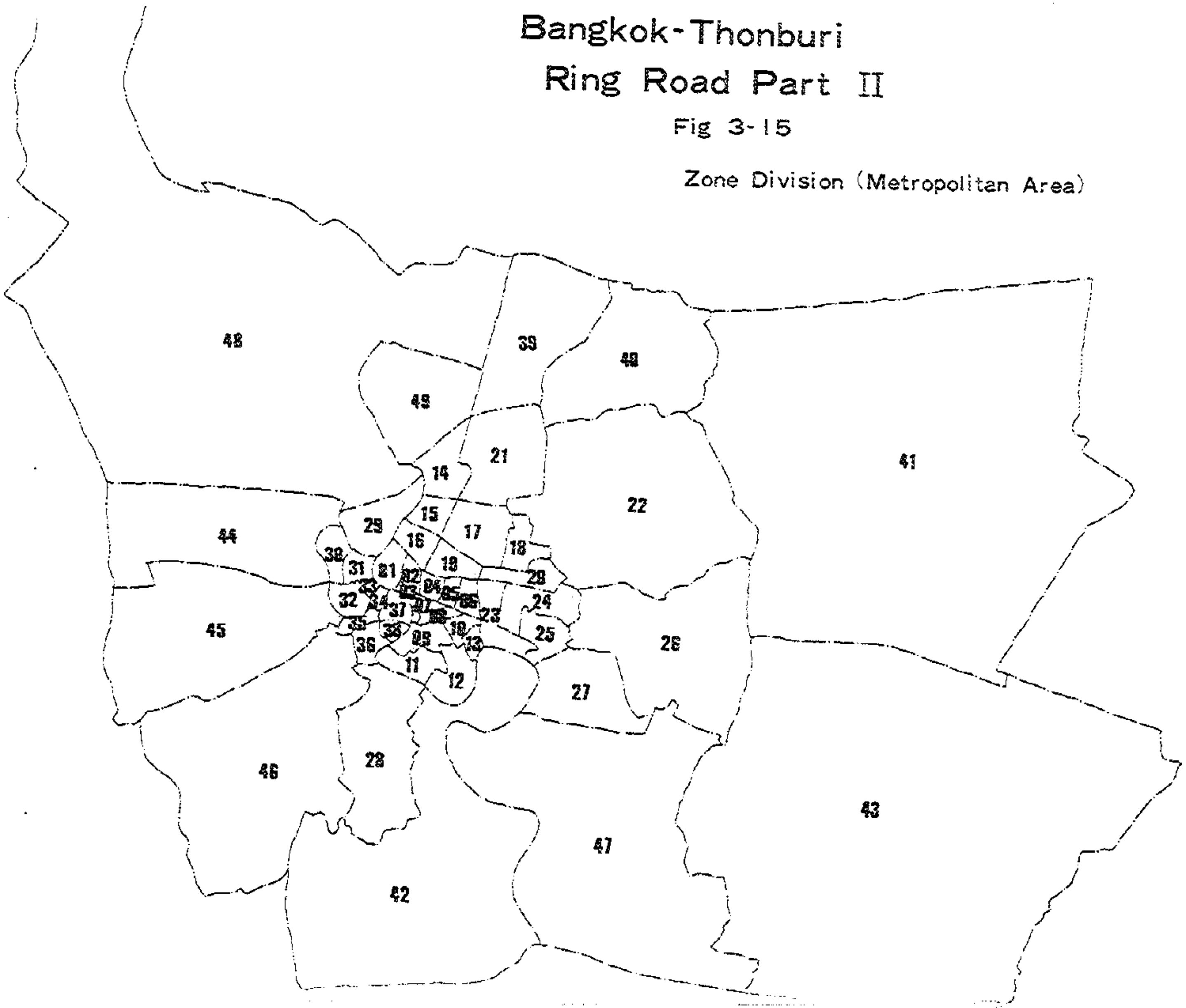
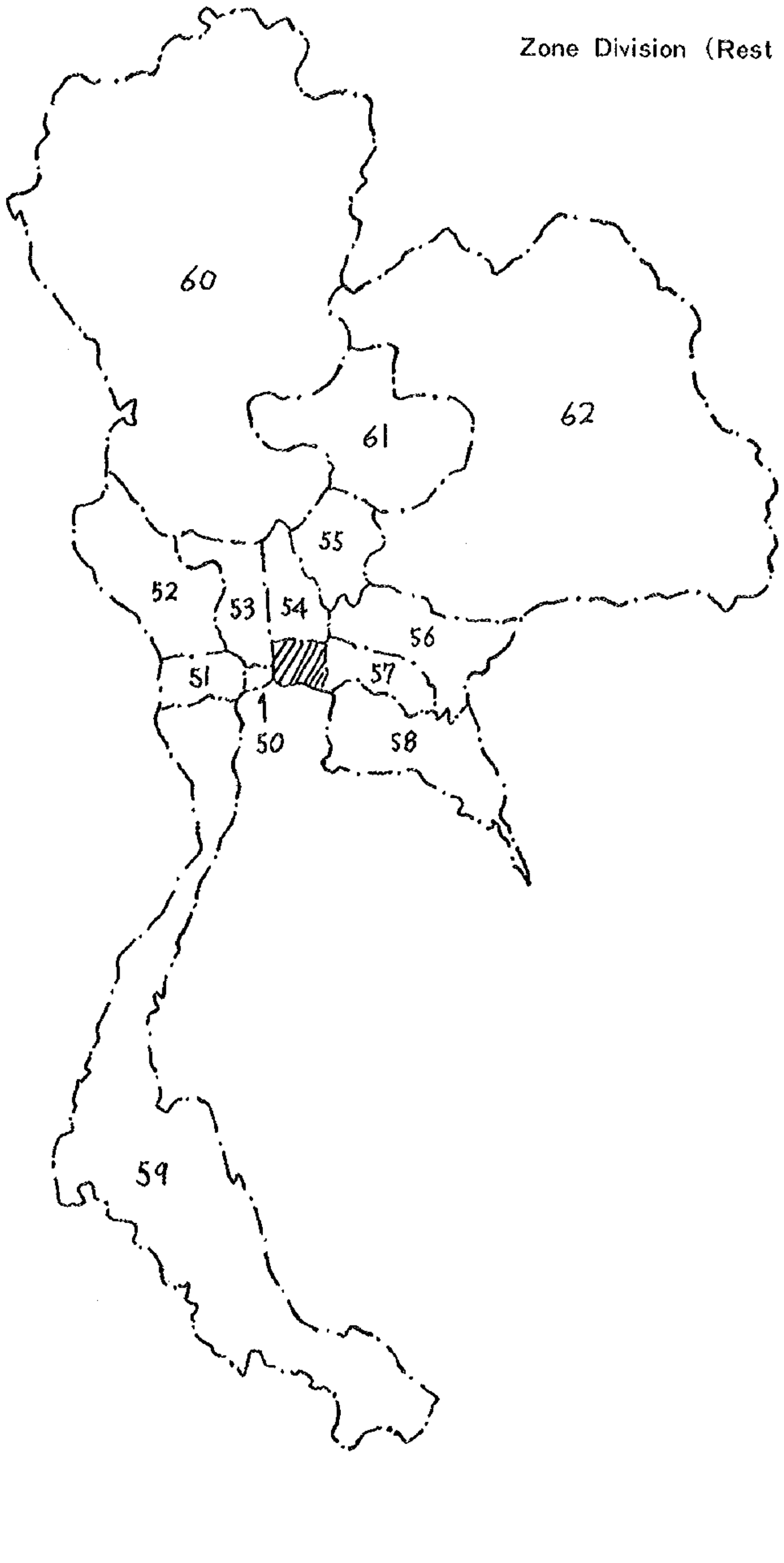


Fig 3-16

Zone Division (Rest of Kingdom)



Zone No.	Enclosed area
61	Phetchaburi, Phichit, Chaiyaphum
62	Nong Khai, Loei, Udon Thani, Kalasin, Sakon Nakhon, Khon Kaen, Maha Sarakham, Roi Et, Nakhon Phanom, Ubon Ratchathani, Nakhon Ratchasima, Buri Ram, Surin, Si Sa Ket

(2) Estimation of the registered number of vehicles for the traffic zones

The data on the registered number of vehicles which were available to us were the figures by Changwats for the past years. To estimate the generated traffic volume of the traffic zones, an estimation of the registered number of vehicles for the traffic zones was first carried out.

Of all the statistical data for the Metropolitan area, most were only figures by Changwats, and the only figures which were broken down into Amphoe level are the population statistics for the past years. In the estimation of present registered number of vehicles, it was assumed that the rate of vehicle ownership for the whole of the twin capital Changwats was uniform and the registered number of vehicles for the Amphoes were distributed in the proportion of the population of the Amphoes. Where Amphoes are further divided into smaller zones the registered number of vehicles were further divided in proportion to the area of the zones to the whole Amphoe. However, minor adjustments were made, where the degree of development in an Amphoe varies very greatly from zone to zone.

(3) The estimation of average number of trips per vehicle

In the traffic survey carried out by the Office of Metropolitan Traffic Study the traffic volume was classified into the three following vehicle types. (1) private passenger traffic, (2) public passenger traffic and (3) goods traffic. In this study, for facilitation of future coordination, the O-D matrices were classified into the same three vehicle types. To estimate the daily average number of trips per vehicle, the results of the O-D surveys carried out in Japan for the major cities in 1965 and 1968 by the City Bureau, Ministry of Construction, Japan, were used as reference.
In Japan, the daily average number of trips per vehicle in the years 1965 and 1968 for cities over 1,000,000 in population are as shown in Tables 3-16 and 3-17.

Table 3-16 Average number of trips per vehicle in Japan, 1965
(For cities over 1,000,000 in population)

Type of vehicle	Trip/day
Passenger vehicles	14.8
Goods vehicles	5.6
All vehicles	8.0

Table 3-17 Average number of trips per vehicle in Japan, 1968
(For cities with population 1,000,000 - 3,000,000)

Type of vehicles		Trip/day
Passenger sedan	Private owned	3.7
	Company owned	5.3
	Business	69.3
Bus	Private	6.9
	Public	11.9
Goods vehicles		5.4
All vehicles		7.2

The analysis results of Japan cannot be adopted outright for application in Bangkok but some modifications have to be made to suit the actual local conditions. In general it can be said that due to the extensive provision of mass transportation system in the major cities in Japan (commuting trains, subway trains, tram cars or monorail) the average number of trips per vehicle tends to be lower as compared to Bangkok where road transport is the absolute major means of transportation. Unfortunately, this reasoning cannot be verified with emperical figures. In this study, we have therefore assumed an increase of about fifty percent for private passenger vehicle, buses and goods vehicle. The situation is different for public passenger cars in Japan, there being a general shortage of taxis in major cities, resulting in an abnormally high number of average trips per vehicle. (Statistical data show that public passenger vehicles made up 2.5% of the total registered number of vehicles in the cities of over

1, 000, 000 in population in Japan while the same for Bangkok is 7.4%). For this reason, it is reasonable to assume that the average number of trips in Bangkok should be much lower. In this study, we have assumed a figure about forty percent lower than the average in Japan.
With the above assumptions, the figures adopted for Bangkok are as shown in Table 3-18. The resultant average number of trip for all vehicles in 8.5 trips per day, which figure being slightly higher than the average for the major cities in Japan which was 8.0 for the year 1965 and 7.2 for 1968.
Before the above assumed average daily number of trips per vehicle is put into practical use, a check is made by calculating the total number of vehicle-kilometres and comparing the figures with the actually surveyed cross-section vehicle composition. The average trip length per vehicle by types of vehicle for the major cities in Japan are adopted in the calculation and the resultant composition of total vehicle-kilomeres obtained. It is assumed that this will represent the vehicle type composition for cross section traffic volume.
In comparison with the actual cross section traffic composition, it was found that while the compositions of the private passenger vehicles and buses are very close to the actually surveyed figures, the composition for the public passenger vehicles is lower than surveyed figures while that for goods vehicles higher than surveyed cross section composition. The share of goods traffic for the

cross section traffic volume is only 4.6% according to the MTP cross section traffic count. This is unduly low, considering the fact that goods vehicle has a share of 15% of the registered number of vehicles. It is due to the fact that many light trucks being used as mini-buses, all light truck traffic are being categorized as mini-bus traffic. Under this assumption, then a comparison has to be made of the total of public passenger traffic (which includes mini-bus traffic) and goods traffic. In this case, the calculated share is 47%, which is fairly closed to the actually surveyed share of 44.8%.

Table 3-18 Estimated average number of trips per vehicle in Bangkok

<table>
<tr><th colspan="2" rowspan="2"></th><th rowspan="2">Private Passenger Vehicle</th><th colspan="3">Public Vehicle</th><th rowspan="2">Goods Vehicle</th><th rowspan="2">Total</th></tr>
<tr><th>Passenger Sedan</th><th>Buses</th><th>Total</th></tr>
<tr><td rowspan="4">Registered number of vehicles</td><td>Bangkok Thonburi</td><td>218,637</td><td>21,611</td><td>4,871</td><td>26,482</td><td>41,587</td><td>286,706</td></tr>
<tr><td>Nonthaburi</td><td>1,906</td><td>140</td><td>200</td><td>340</td><td>924</td><td>3,170</td></tr>
<tr><td>Samut Prakhan</td><td>1,857</td><td>58</td><td>300</td><td>358</td><td>851</td><td>3,066</td></tr>
<tr><td>Total</td><td>222,400</td><td>21,809</td><td>5,371</td><td>27,180</td><td>43,362</td><td>292,942</td></tr>
<tr><td colspan="2" rowspan="4">Trip per Vehicle Trips/day</td><td>5.6</td><td>40.0</td><td>20.0</td><td></td><td>7.0</td><td></td></tr>
<tr><td>5.6</td><td colspan="3">35.0</td><td>7.0</td><td></td></tr>
<tr><td colspan="4">8.8</td><td>7.0</td><td></td></tr>
<tr><td colspan="4">8.5</td><td></td><td></td></tr>
</table>

(4) Estimation of zone generated traffic volume

The zone registered number of vehicles for the year 1970 and the average number of trips per vehicle per day were established as shown in the above-mentioned sections (1) and (2). The zone generated traffic volume was then derived through the multiplication of the figures.
The total generated traffic volume for the Metropolitan Changwats of Bangkok, Thonburi, Nonthaburi and Samut Parakan are summed up as follows:

Total generated traffic volumes by type of vehicles
(year 1970)

Private Passenger Traffic	1, 245, 440
Public Passenger Traffic	951, 300
Goods Traffic	303, 534
Total	2, 500, 274

(5) Estimation of distributed traffic volume

The traffic distribution between zones is estimated through the use of the gravity model, with the travel time between zone centroids as the resistance factor.
The general formula of the gravity model method is as follows:

$$Tij = Ti \times Tj \times \frac{k}{Di^{n}j}$$

whereby Tij : Distributed traffic volume between zones i and j

Ti, Tj : Zone generated traffic volumes for zones i and j

Dij : Resistance factor between zones i and j (travel time between i and j) n, k : empirical coefficient

The travel time between zones (D_{ij}) was established through a route search by the computer for the shortest route between zones centroids in travel time. The empirical coefficient was obtained through the regressive analysis of the outbound traffic volume surveyed by the Office of the Metropolitan Traffic Study. The results of the regression calculation are as follows :

	n	k
Private passenger traffic	1.64367	0.24305×10^{-4}
Public passenger traffic	1.26255	0.14179×10^{-6}
Goods traffic	1.73565	0.44722×10^{-4}

The resultant O-D matrices for the year 1970 as prepared through the above mentioned method are as in Table 3-19 - 3-21.

(6) Verification of the theoretical O-D matrices for 1970

A check of whether the theoretical O-D matrices do represent the actual traffic situation is made through comparison of cross section traffic volumes at suitable cordon lines. The cordon line that is most easily comparable is that drawn across the Chao Phraya River. Table 3-22 shows the cross river traffic volume carried out in several previous surveys against the theoretical cross river traffic volume for 1970 as estimated in this study. The table clearly shows that while there were some minor fluctuations between surveys due probably to the difference in months of the surveys carried out, the cross river movement remained at an almost constant volume of between 175,000 and 195,000/24 hours for the period 1969 to 1972. While the other road sections showed an annual increase of 10 to 15% in traffic

A. PRIVATE PASSENGER TRAFFIC-1970

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
01	10,103	3,713	1,603	656	371	490	444	436	407	129	355	294	70	1,172	403	1,343
02		18,186	1,880	2,791	905	930	762	630	572	160	447	348	87	935	419	758
03			6,566	319	191	249	851	520	433	109	289	209	54	422	186	351
04				4,293	1,134	701	259	325	199	81	158	128	41	327	171	264
05					2,329	2,017	208	342	164	98	132	132	47	252	127	167
06						5,061	258	521	263	296	319	368	123	439	216	263
07							3,768	1,324	793	325	323	159	56	209	92	143
08								4,775	1,056	380	459	314	140	275	128	166
09									2,489	180	1,398	567	121	261	111	154
10										1,662	127	359	113	116	52	59
11											4,808	1,418	103	285	118	150
12												7,965	484	276	116	133
13													607	20	30	33
14														16,967	5,605	1,961
15															4,913	715
16																4,159

	17	18	19	20	21	22	23	24	25	26	27	28	29
01	701	334	778	432	337	303	111	257	67	719	245	364	1,161
02	895	404	1,438	649	475	367	183	237	94	903	309	305	839
03	330	158	366	209	158	149	56	78	39	395	185	185	387
04	465	190	1,448	364	206	153	109	127	44	361	131	91	280
05	454	219	1,821	549	219	151	179	176	51	384	132	67	206
06	770	385	1,315	1,680	432	368	894	601	132	836	289	306	312
07	257	120	342	177	122	107	50	67	33	305	105	89	171
08	404	209	557	341	219	173	96	122	61	506	173	109	206
09	296	160	285	215	160	143	58	80	44	413	140	105	198
10	155	89	140	152	89	83	52	66	40	290	99	40	78
11	301	171	234	199	165	161	52	77	43	448	153	111	204
12	320	193	213	256	184	199	73	105	63	622	212	106	168
13	88	51	69	83	50	50	25	33	21	164	56	24	65
14	4,565	1,029	624	503	1,332	620	111	166	80	943	319	257	1,918
15	4,498	542	338	242	825	267	52	76	31	382	132	102	686
16	766	301	550	283	312	184	62	87	37	400	136	131	4,406
17	14,658	2,340	1,378	811	5,380	773	171	237	99	1,031	351	199	888
18		13,513	450	419	1,701	447	92	132	58	626	212	132	390
19			4,043	1,062	518	287	197	223	74	627	215	129	549
20				3,736	452	551	1,078	747	164	1,031	356	109	349
21					2,564	615	96	133	56	580	197	103	389
22						1,835	105	127	143	1,273	433	112	266
23							318	111	61	319	113	28	36
24								688	213	620	212	43	111
25									561	871	296	21	59
26										22,179	2,211	261	578
27											5,921	88	296
28												3,391	338
29													8,671

	30	31	32	33	34	35	36	37	38	39	40	41	42
01	255	190	388	32	393	440	246	687	153	173	208	411	44
02	216	148	279	51	217	329	533	159	105	206	242	168	39
03	106	97	202	39	217	229	390	366	75	84	102	206	22
04	70	42	75	14	59	89	142	114	30	89	98	176	32
05	54	30	53	10	39	62	99	77	23	92	92	154	9
06	81	47	80	15	56	91	149	115	37	162	161	270	36
07	53	43	82	15	67	94	152	129	33	61	70	138	12
08	66	51	90	17	68	106	169	137	40	100	130	204	35
09	65	49	87	17	64	102	162	131	41	81	94	183	35
10	25	18	30	6	21	35	56	43	15	43	48	89	6
11	71	50	85	16	57	99	157	121	43	89	109	221	37
12	68	46	75	14	48	88	139	103	43	102	124	257	37
13	15	10	17	3	12	20	32	26	9	26	29	56	4
14	412	162	160	36	116	212	333	244	90	518	503	835	41
15	156	57	74	14	69	86	137	101	36	248	213	323	36
16	371	111	108	22	80	124	202	159	49	138	149	252	39
17	241	92	134	26	89	169	256	189	66	859	600	793	32
18	120	69	74	14	46	87	137	98	38	439	351	502	19
19	130	59	101	20	73	123	196	155	46	183	136	289	16
20	101	48	80	15	33	93	148	112	39	180	182	305	17
21	114	46	71	13	45	83	130	95	36	1,011	472	506	17
22	95	47	74	14	44	87	136	100	41	290	290	488	21
23	23	12	21	4	14	24	38	29	10	41	41	73	4
24	31	18	31	6	20	36	57	43	16	61	65	114	7
25	17	9	15	3	9	17	27	20	8	28	32	58	3
26	205	110	175	33	105	204	320	235	102	327	393	806	47
27	69	37	60	11	36	69	108	80	35	110	132	267	16
28	196	142	308	48	193	358	1,630	399	281	62	85	178	347
29	2,435	594	521	109	194	359	480	371	325	190	210	395	51
30	4,884	660	454	99	142	257	336	213	72	63	76	155	29
31		3,317	329	352	201	164	267	182	52	27	35	77	18
32			5,312	56	327	927	826	584	172	41	53	113	34
33				736	136	63	110	76	18	8	10	22	6
34					2,518	373	657	480	78	25	31	66	19
35						5,441	947	671	140	48	62	134	40
36							9,471	1,358	509	15	91	209	110
37								7,956	562	55	71	153	43
38									5,837	23	33	77	26
39										1,218	923	516	11
40											4,814	1,386	15
41												12,228	38
42													33

	43	44	45	46	47	48	49	50	51	52
01	110	296	952	551	39	55	76	139	118	88
02	125	266	796	491	44	58	84	80	41	10
03	58	123	483	282	19	26	36	51	94	10
04	50	93	238	155	18	23	34	39	21	6
05	47	73	177	117	37	22	33	30	26	26
06	92	121	281	191	36	39	59	31	21	5
07	41	68	234	147	15	18	25	41	10	5
08	65	90	287	187	23	28	40	10	26	5
09	59	88	279	181	21	25	34	41	10	5
10	34	38	107	71	14	13	18	0	5	0
11	72	103	298	202	25	30	39	0	0	0
12	94	104	285	200	33	35	44	0	0	0
13	22	23	63	44	8	8	11	0	0	0
14	166	522	689	488	55	186	331	5	36	10
15	65	183	272	188	22	62	110	10	10	5
16	63	379	348	225	22	42	63	46	40	5
17	158	322	533	378	55	138	243	127	67	21
18	102	176	301	218	34	85	139	5	5	0
19	81	158	342	225	29	47	66	31	77	5
20	116	142	292	202	44	46	67	0	0	0
21	91	162	276	197	32	104	209	0	5	0
22	186	158	304	224	67	81	114	10	10	12
23	32	33	75	55	12	11	15	21	21	5
24	59	51	114	79	25	17	23	0	0	0
25	41	26	56	39	22	9	11	31	21	15
26	613	340	705	514	252	119	146	10	5	5
27	510	114	237	122	358	40	50	5	0	0
28	50	234	675	1,741	16	44	29	3	5	0
29	97	1,222	1,449	811	33	132	105	52	56	10
30	38	635	963	331	12	48	35	0	0	0
31	20	235	587	223	7	22	15	0	5	0
32	31	250	2,105	129	10	29	19	42	36	10
33	6	51	121	70	2	6	4	10	0	0
34	17	109	496	253	6	15	11	16	15	0
35	36	217	1,239	481	12	32	22	138	57	10
36	55	301	1,499	1,416	18	50	34	10	0	0
37	39	215	1,029	547	13	36	25	35	10	5
38	18	83	338	351	8	17	31	21	15	5
39	65	98	168	122	59	147	168	5	23	5
40	81	126	238	161	26	179	131	0	0	0
41	285	283	493	371	62	191	177	0	5	15
42	10	40	172	190	3	8	5	5	5	5
43	485	72	138	108	69	27	30	15	10	5
44		1,886	658	325	30	61	77	0	0	0
45			6,755	1,046	61	91	111	168	77	30
46				5,145	47	69	80	10	21	0
47					56	11	7	0	0	0
48						197	337	10	10	10
49							759	10	8	0
50								5	0	0
51									0	0
52										0

	53	54	55	56	57	58	59	60	61	62		T.E
01	298	463	149	47	28	114	56	30	10	10		46,189
02	490	381	105	44	44	384	30	39	10	88		65,004
03	150	142	35	15	20	124	36	5	5	30		27,388
04	41	96	42	5	12	64	0	20	5	10		22,144
05	104	165	50	22	8	126	10	10	0	41		17,466
06	67	155	20	0	20	100	0	0	5	20		28,040
07	73	76	10	20	8	32	5	15	0	5		12,387
08	77	118	5	19	0	129	0	25	2	10		22,061
09	40	101	20	12	37	54	15	5	0	30		16,097
10	10	16	0	0	0	16	0	10	0	0		8,178
11	0	0	0	0	0	0	0	0	0	0		19,820
12	0	0	0	0	0	0	0	0	0	0		25,868
13	0	0	0	0	0	0	0	0	0	0		4,681
14	67	219	75	21	3	40	15	30	5	50		69,719
15	46	75	20	20	6	34	10	5	0	5		29,117
16	113	177	47	20	8	109	10	20	5	34		26,120
17	150	650	165	33	48	185	37	95	20	95		65,291
18	5	51	25	0	4	4	0	0	5	5		37,698
19	123	200	48	10	34	167	5	27	0	29		27,665
20	5	29	0	0	21	30	0	0	5	5		23,302
21	5	82	20	5	7	0	5	10	5	10		24,487
22	30	320	82	35	22	109	5	35	5	54		21,895
23	31	131	12	15	18	150	0	0	0	25		6,674
24	0	12	2	5	0	12	0	0	0	0		6,596
25	106	197	35	28	56	134	15	30	5	13		5,527
26	30	0	0	4	0	0	5	5	0	10		68,202
27	5	24	0	4	31	148	0	0	0	4		22,253
28	5	24	0	14	0	6	0	0	0	0		17,792
29	138	138	43	15	10	16	10	5	0	10		43,030
30	5	5	0	0	3	0	0	0	0	0		20,281
31	0	0	0	0	0	0	0	0	0	0		12,529
32	130	51	24	9	6	24	10	15	0	0		21,565
33	0	0	0	0	0	0	0	0	0	0		3,384
34	42	10	15	0	0	24	5	0	0	0		11,096
35	197	117	25	5	4	24	15	10	2	25		21,299
36	16	13	5	0	8	16	0	5	0	15		35,120
37	15	16	10	0	10	16	5	0	0	0		27,122
38	34	70	30	5	0	48	0	0	0	5		16,213
39	83	1,494	165	38	45	105	51	50	5	90		13,186
40	5	10	0	0	3	4	0	0	0	15		18,108
41	23	42	20	8	43	39	0	5	0	12		38,498
42	25	5	10	0	8	20	0	0	0	15		1,834
43	0	7	5	0	12	87	5	0	0	0		5,565
44	0	4	0	0	0	2	0	0	0	0		13,257
45	141	66	15	5	0	16	25	0	0	0		37,190
46	21	27	10	5	4	8	10	0	0	0		25,484
47	0	25	10	0	12	64	10	0	0	25		2,069
48	10	249	22	10	3	4	5	17	3	10		3,617
49	52	264	52	0	20	16	5	5	0	14		5,517
50	10	12	15	0	4	21	0	10	0	5		1,422
51	0	24	20	0	0	13	5	0	0	5		1,094
52	0	5	0	0	0	0	0	0	5	0		362
53	10	33	5	0	0	47	0	0	0	15		2,838
54		683	15	10	7	5	5	20	0	15		6,844
55			0	0	6	8	5	0	0	0		1,515
56				0	0	4	0	0	0	0		512
57					7	0	0	0	0	0		607
58						4	10	13	5	6		3,073
59							0	10	0	10		460
60								5	0	0		591
61									0	0		116
62										6		855
												1,132,378

6. PUBLIC PASSENGER TRAFFIC—1970

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
01	5852	2909	1296	529	319	512	447	456	389	143	374	356	80	1214	444	1105
02		11,173	1,637	2050	829	917	750	661	545	182	476	431	99	1,093	496	769
03			3,612	319	213	283	692	486	377	116	293	251	60	508	227	375
04				2212	769	580	255	312	190	84	165	257	43	384	195	267
05					1,302	1,271	209	316	161	97	146	161	48	309	153	203
06						2824	252	477	255	249	238	339	111	522	252	288
07							1,999	918	554	120	297	224	57	274	123	169
08								2,547	721	294	407	333	120	354	161	199
09									3,268	151	879	482	98	309	134	169
10										745	725	304	225	348	66	73
11											2,464	1,058	94	358	150	179
12												1,375	339	384	162	179
13													335	88	39	41
14														11,530	3751	1653
15															2815	631
16																2411
17																
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	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
01	809	421	715	430	337	319	325	153	78	792	280	325	988	266	202	375
02	1,053	522	1251	631	131	385	196	224	106	961	349	299	653	247	180	316
03	419	218	374	227	174	167	69	83	48	451	160	176	389	125	111	210
04	498	228	986	318	195	154	102	109	48	399	144	93	278	83	53	90
05	483	252	1,154	491	223	155	150	139	52	403	144	73	217	68	41	67
06	796	430	998	1,121	375	298	567	395	120	819	293	116	330	108	63	102
07	339	167	326	186	133	122	57	67	39	344	122	93	193	68	55	97
08	472	262	493	319	216	186	99	113	61	536	192	115	233	85	65	108
09	337	195	265	204	155	350	67	74	46	431	153	103	206	77	58	96
10	185	111	137	347	86	88	50	57	39	295	105	44	90	33	24	38
11	368	221	244	210	172	182	67	78	50	505	178	118	227	89	63	101
12	474	266	249	219	206	235	85	109	74	714	252	125	235	94	64	101
13	105	64	70	77	50	53	25	29	21	171	60	26	53	20	14	22
14	3818	1,121	666	545	1,096	643	140	182	102	1,127	396	285	1,628	463	200	212
15	3135	568	349	256	629	276	64	83	45	462	165	115	612	172	74	97
16	794	357	498	287	294	204	73	90	46	473	167	138	2,523	331	122	128
17	9253	2085	1,218	777	3,153	746	192	234	119	1,151	419	230	690	287	129	187
18		6537	475	431	1,207	458	111	139	73	752	265	137	437	155	72	107
19			2271	770	421	276	172	181	77	640	277	132	496	143	74	172
20				3,947	367	452	613	441	137	928	332	113	337	114	60	95
21					1,326	489	91	112	57	573	202	103	350	170	55	82
22						2598	102	148	129	1,177	416	121	267	111	59	80
23							196	347	56	308	112	32	86	30	17	28
24								316	132	536	193	43	109	39	23	36
25									281	627	232	25	60	22	33	20
26										13338	1,842	293	636	255	145	238
27											3178	103	224	90	51	71
28												1,704	347	203	144	280
29													5,111	1,594	535	517
30														2549	508	406
31															3642	297
32																2594
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01	23	339	126	593	633	197	290	227	414	59	157	258	839	491	59
02	63	260	356	580	511	168	239	263	468	56	179	218	746	472	70
03	42	200	238	350	366	108	104	119	217	32	85	119	436	265	32
04	18	62	105	184	132	50	59	104	174	18	69	85	232	152	27
05	13	18	75	122	95	39	102	99	160	15	65	72	161	124	27
06	20	60	120	185	146	69	175	172	276	25	176	149	292	200	52
07	19	75	184	174	151	52	76	83	318	18	62	70	233	149	24
08	22	75	122	197	153	67	118	125	214	23	92	92	268	191	36
09	19	67	132	174	141	56	92	104	188	21	33	84	260	174	31
10	8	25	44	69	53	25	52	59	98	10	18	39	111	77	20
11	20	66	118	182	142	61	109	129	245	26	102	104	299	205	39
12	20	64	119	182	137	67	133	168	301	29	135	116	317	227	53
13	4	14	24	39	30	13	33	35	62	4	29	24	62	47	11
14	48	147	232	417	315	142	533	524	841	65	248	458	722	515	30
15	19	63	133	175	134	58	249	223	332	25	98	167	292	204	35
16	27	91	146	232	186	73	157	162	274	28	95	230	318	231	36
17	37	119	226	337	257	111	223	388	391	52	234	311	583	416	88
18	23	66	125	182	143	67	128	356	271	32	135	182	349	231	59
19	24	82	143	222	181	70	188	183	284	27	111	143	332	272	43
20	19	61	111	171	132	57	182	185	300	25	143	129	286	201	59
21	36	51	97	148	111	51	655	370	426	24	115	137	263	190	43
22	38	52	105	159	112	58	227	295	201	30	223	149	309	234	87
23	7	17	32	50	38	16	28	49	81	8	43	34	82	57	18
24	9	23	41	64	46	20	62	66	132	10	67	46	109	77	29
25	4	12	23	35	27	12	35	39	70	6	57	26	64	46	28
26	43	130	252	391	289	142	385	470	974	72	703	339	745	560	302
27	15	48	90	137	102	50	136	164	321	28	194	119	761	196	321
28	43	172	326	1334	363	262	77	91	186	212	69	206	714	1147	25
29	111	260	402	543	427	129	202	221	390	26	135	869	1263	605	50
30	80	147	273	346	244	101	77	99	173	42	58	475	835	342	21
31	223	183	181	284	203	76	37	45	89	28	33	195	515	227	12
32	59	283	229	224	536	131	51	65	123	18	48	228	1613	398	17
33	293	102	68	109	86	25	11	20	25	8	5	46	120	71	3
34		1212	372	547	413	101	32	38	72	28	27	102	423	232	10
35			2547	833	616	129	61	77	351	56	56	209	1009	462	21
36				3283	1015	603	97	137	229	132	65	288	1261	1558	31
37					1264	551	21	86	165	60	21	209	893	595	23
38						3423	35	44	83	30	32	25	361	337	11
39							181	658	470	38	87	98	184	137	32
40								2555	1345	23	118	173	232	178	42
41									2594	51	340	251	475	382	90
42										42	19	49	116	192	6
43											186	85	176	140	92
44												1328	689	361	30
45													5507	1175	63
46														3815	19
47															85
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	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	T.P.
01	96	95	36	25	26	16	691	0	10	19	31	10	10	0	10	35145
02	165	108	41	5	0	15	50	10	70	4	64	0	10	0	153	45546
03	49	49	15	20	0	104	16	9	0	0	44	0	0	0	0	20870
04	41	43	5	5	0	10	404	0	0	0	57	0	45	10	0	16722
05	39	42	0	5	0	5	24	0	0	0	45	0	6	0	10	13339
06	69	73	10	0	0	16	49	5	0	4	16	0	0	0	0	21406
07	34	34	0	0	0	0	9	0	0	0	8	0	0	0	6	13252
08	53	52	0	6	0	0	20	5	0	0	8	0	0	0	0	16836
09	43	43	10	0	0	10	15	0	0	0	4	0	0	0	0	12291
10	23	24	5	0	0	0	0	0	0	0	0	0	0	0	5	6186
11	55	53	0	0	0	0	0	0	0	0	0	0	0	0	0	14996
12	66	64	0	0	0	0	0	0	0	0	0	0	0	0	0	19616
13	14	14	0	0	0	0	0	0	0	0	0	0	0	0	0	3538
14	284	343	5	10	0	16	13	0	0	0	4	0	0	5	0	50062
15	100	120	0	0	5	10	22	0	0	0	1	0	0	0	35	22183
16	73	77	10	5	0	25	51	10	9	10	4	10	0	0	0	20240
17	227	266	10	0	0	26	161	20	6	7	8	5	0	0	0	50018
18	142	161	0	0	0	5	5	0	0	0	1	0	0	0	0	28651
19	71	77	0	10	0	0	18	5	0	4	12	5	0	0	0	21236
20	75	78	0	0	0	5	0	0	0	0	4	0	0	0	0	17752
21	133	178	0	16	0	0	150	50	90	67	0	0	50	30	170	18439
22	126	125	0	0	0	0	20	0	4	14	8	0	0	0	5	16769
23	20	21	16	5	0	26	0	0	5	1	20	0	0	0	0	5310
24	27	28	0	0	0	0	5	0	0	0	8	0	0	0	0	6182
25	17	17	10	0	0	0	40	0	4	91	287	0	0	0	5	4277
26	209	192	0	0	0	0	5	0	0	1	4	0	0	0	0	51861
27	73	67	0	0	0	0	0	0	0	0	20	0	0	0	0	16935
28	78	37	0	10	0	31	0	0	0	0	6	0	0	0	0	13201
29	216	116	10	0	5	21	14	5	8	0	0	0	0	0	10	32338
30	88	45	0	5	0	0	0	0	0	0	0	0	0	0	0	15036
31	43	22	0	0	0	0	0	0	0	0	0	0	0	0	0	9253
32	57	27	83	140	36	214	33	0	0	0	4	114	5	0	5	15920
33	11	6	6	0	0	0	0	0	0	0	0	0	0	0	0	2476
34	32	16	5	0	0	5	0	0	0	0	0	0	0	0	0	8250
35	66	31	26	10	0	52	0	5	0	4	0	5	0	0	0	15895
36	99	48	0	0	0	0	4	2	0	0	0	0	0	0	0	26112
37	71	35	0	0	0	5	0	0	0	0	0	0	10	0	0	20176
38	36	17	0	0	0	0	24	0	0	0	16	0	10	0	0	12127
39	189	157	0	0	0	0	326	15	0	14	4	35	10	0	55	10411
40	172	137	0	0	0	0	10	0	0	0	0	0	0	0	0	14189
41	262	196	0	10	0	0	0	5	0	14	6	0	0	0	0	29330
42	21	9	0	0	0	10	4	0	0	0	0	0	0	0	5	2191
43	55	16	0	0	0	0	0	5	0	17	8	0	0	0	0	6793
44	122	57	0	0	0	0	0	0	0	0	0	0	0	0	0	11371
45	207	96	51	25	0	57	0	0	0	0	0	0	0	0	0	32001
46	160	72	0	0	0	5	4	0	0	0	0	0	0	0	0	22169
47	19	17	0	0	0	0	5	0	0	0	8	0	0	0	0	2567
48	412	218	0	0	0	0	40	18	0	0	0	0	0	0	0	5385
49		462	0	0	0	10	23	5	0	0	7	0	0	0	0	4846
50			21	0	0	0	5	0	0	0	0	0	0	0	0	395
51				0	0	5	15	0	0	14	0	0	0	0	0	316
52					0	0	0	0	0	0	0	0	0	0	0	72
53						0	5	10	10	0	0	0	0	0	5	264
54							70	0	0	0	10	0	0	0	0	2520
55								0	0	10	10	0	0	0	0	195
56									0	0	0	0	0	0	0	207
57										6	0	0	0	0	0	313
58											0	0	0	0	0	237
59												0	0	0	0	164
60													5	0	0	160
61														0	0	65
62															8	169
																894910

C. GOODS TRAFFIC—1970

	01	02	03	04	05	06	07	08	09	10	11	12	13	14
01	3220	517	231	31	52	69	60	60	53	18	49	35	11	148
02		5613	270	407	134	137	104	90	84	25	70	46	15	123
03			2033	52	29	36	130	80	64	18	45	28	10	56
04				1484	190	113	38	50	29	14	25	17	7	45
05					962	356	31	55	24	17	21	18	8	35
06						2013	35	83	39	52	35	43	22	60
07							1271	216	123	21	52	27	10	27
08								1743	168	69	76	45	25	36
09									770	78	220	76	20	32
10										581	21	56	87	17
11											1600	214	18	38
12												2,507	63	32
13													307	10
14														5722

	15	16	17	18	19	20	21	22	23	24	25	26	27	28
01	55	207	94	41	120	66	55	45	3	28	8	80	34	55
02	60	172	127	52	242	112	77	64	6	49	14	139	42	52
03	27	59	48	21	62	35	28	25	1	15	6	57	21	31
04	25	43	69	25	267	66	38	27	4	27	7	57	21	15
05	20	34	70	31	351	102	46	21	6	38	7	57	21	11
06	32	42	118	55	248	321	83	53	34	134	20	127	46	17
07	13	22	36	15	57	29	23	18	1	13	4	43	15	11
08	18	27	60	28	98	69	39	29	3	25	8	76	27	18
09	15	22	41	20	45	34	25	20	1	14	6	53	18	15
10	8	10	24	13	25	29	13	14	1	14	6	43	15	6
11	17	24	45	24	39	32	25	24	1	14	6	62	22	17
12	15	18	42	24	31	38	28	28	1	15	8	80	23	14
13	6	6	14	8	13	15	10	8	1	7	3	25	8	4
14	871	301	661	132	94	76	223	91	5	28	10	120	42	36
15	1,286	120	753	77	57	41	157	43	1	14	4	55	20	16
16		1,452	122	43	101	49	59	31	1	17	6	57	21	21
17			4,774	340	237	136	1,054	127	6	46	14	116	52	30
18				3,555	69	61	302	69	3	21	7	83	29	16
19					1,628	211	105	52	7	50	11	99	36	23
20						1,509	90	97	43	174	25	161	57	18
21							1,191	120	4	29	8	92	32	18
22								1,588	3	35	20	178	62	16
23									4	34	1	10	4	1
24										363	41	126	46	8
25											162	111	42	3
26												6,670	316	35
27													1,849	12
28														1,249

	29	30	31	32	33	34	35	36	37	38	39	40
01	171	31	23	19	33	55	60	101	86	20	11	31
02	141	59	18	36	8	34	47	74	54	12	15	47
03	62	15	13	28	6	32	34	57	48	10	6	37
04	45	10	5	10	2	8	33	20	14	4	7	17
05	33	6	4	7	2	6	9	14	10	3	7	15
06	50	13	6	11	2	8	34	21	15	5	11	21
07	26	7	5	11	2	9	13	21	16	4	4	11
08	32	9	7	12	3	10	35	24	18	5	7	18
09	28	8	6	11	2	9	14	22	17	5	6	13
10	12	4	2	4	1	3	5	9	6	2	3	7
11	31	10	7	12	2	9	56	23	17	6	6	15
12	25	8	5	9	2	6	11	18	12	5	6	17
13	8	2	2	3	1	2	3	5	4	1	1	4
14	283	59	19	19	5	15	27	42	29	11	34	73
15	113	23	7	10	2	7	12	19	13	5	18	35
16	826	59	16	15	4	12	19	30	23	7	10	24
17	137	34	12	18	4	12	22	35	24	9	63	97
18	55	26	6	9	2	6	11	17	12	5	79	53
19	97	21	8	15	3	12	19	30	23	7	14	31
20	59	26	7	12	3	8	14	23	17	6	14	29
21	70	19	7	11	2	8	14	21	15	6	88	85
22	41	14	7	11	2	7	33	21	16	7	20	41
23	2	1	0	1	0	0	1	1	1	0	0	1
24	21	6	3	5	1	4	6	10	8	3	6	11
25	7	2	1	2	0	1	2	3	3	1	1	4
26	80	27	14	23	5	15	27	43	32	14	20	52
27	28	9	5	8	2	5	10	15	11	5	7	18
28	55	31	21	19	8	34	57	288	66	50	4	11
29	3,044	413	90	78	18	29	55	73	55	20	13	32
30		1,719	99	67	17	21	38	46	29	16	4	11
31			1,138	15	59	29	22	36	22	7	2	5
32				1,698	8	48	141	120	78	17	3	8
33					266	24	10	18	31	3	1	2
34						913	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
35							1,665	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
36								3,041	[illegible]	[illegible]	[illegible]	[illegible]
37									2,552	[illegible]	[illegible]	[illegible]
38										1,616	[illegible]	[illegible]
39											83	[illegible]
40												1,623

	41	42	43	44	45	46	47	48	49	50
01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
02	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
04	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
06	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
07	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
08	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
09	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	52	1	1	31	51	40	1	13	25	0
20	52	1	1	26	40	33	1	14	21	0
21	92	3	1	31	40	34	1	33	81	0
22	61	1	3	23	36	30	3	20	32	0
23	2	0	0	1	2	2	0	1	1	55
24	21	1	1	10	18	15	1	6	11	0
25	7	0	0	4	6	5	1	2	3	10
26	113	3	2	48	79	67	10	28	39	0
27	36	1	7	17	27	23	15	9	14	0
28	25	25	1	39	118	288	1	11	8	10
29	62	3	1	231	203	99	1	38	34	63
30	23	1	0	113	130	57	0	13	11	0
31	12	1	0	41	77	35	0	6	5	0
32	18	3	0	46	344	70	0	7	6	42
33	4	0	0	10	18	13	0	1	1	0
34	11	1	0	21	23	45	0	4	4	10
35	20	3	0	38	132	80	0	8	7	73
36	33	7	1	53	210	258	1	14	14	0
37	25	3	0	39	144	94	0	11	8	41
38	13	1	0	15	49	64	0	6	4	10
39	36	0	0	7	9	8	0	18	24	21
40	156	1	1	18	25	21	1	32	38	0
41	3,347	2	3	39	57	48	3	14	46	0
42		1	0	3	7	13	0	1	3	29
43			1	1	1	1	0	1	1	20
44				1,033	129	70	1	22	17	0
45					2,229	186	1	21	20	213
46						2,342	1	24	16	52
47							1	1	1	10
48								273	139	10
49									1,067	0
50										6

	51	52	53	54	55	56	57	58	59	60	61	62	T.E
01	124	0	316	336	142	10	30	92	26	41	10	31	11,034
02	41	10	83	67	60	22	32	83	10	22	22	32	15,798
03	76	31	51	127	40	0	16	33	41	40	0	0	6,596
04	42	0	34	52	49	0	44	35	0	10	10	0	5,370
05	0	0	21	73	10	8	8	82	10	0	0	50	1,200
06	0	0	21	20	10	0	0	0	10	0	0	0	6,855
07	25	30	51	27	0	0	0	43	10	0	0	20	4,185
08	10	0	10	0	10	0	0	8	0	10	0	0	5,410
09	52	31	72	119	10	20	36	110	42	0	0	22	3,729
10	0	0	10	0	0	0	8	8	0	0	0	10	3,981
11	0	0	0	0	0	0	0	0	0	0	0	0	4,855
12	0	0	20	20	9	0	6	8	0	0	0	32	6,217
13	0	0	0	0	0	0	0	0	0	0	0	0	1,140
14	65	0	65	347	134	30	18	79	20	22	10	57	16,384
15	10	10	21	55	49	0	11	50	0	22	0	12	2,041
16	65	0	114	166	57	30	22	40	31	0	0	10	6,293
17	10	10	42	243	107	29	41	166	10	7	10	70	15,769
18	0	0	0	0	0	0	0	0	0	0	0	0	9,205
19	10	0	34	67	30	10	19	40	0	0	0	20	6,731
20	0	0	24	17	12	0	6	18	0	0	0	0	5,676
21	0	0	0	70	9	10	6	0	0	0	0	0	5,933
22	0	10	10	121	80	22	6	48	10	25	0	30	5,276
23	52	10	145	504	20	52	36	166	21	0	0	30	1,301
24	0	0	0	10	0	0	0	7	0	0	0	0	1,979
25	42	0	31	144	20	0	38	123	21	12	0	18	1,254
26	10	0	0	10	0	0	0	8	0	10	0	21	16,526
27	10	0	0	46	24	0	38	174	0	0	0	0	5,338
28	21	21	33	17	0	0	0	25	20	10	0	17	4,364
29	200	0	63	84	29	0	31	8	10	10	9	18	10,650
30	0	0	0	0	0	0	0	0	0	0	0	0	5,031
31	0	0	0	0	0	0	0	0	0	0	0	0	3,305
32	44	0	104	25	20	7	6	8	50	0	0	20	5,240
33	0	0	0	0	0	0	0	0	0	0	0	0	837
34	0	0	0	0	25	0	0	8	0	0	0	0	2,766
35	52	10	45	110	40	10	11	8	52	0	0	0	5,278
36	10	0	107	25	10	0	0	0	0	0	0	0	8,650
37	0	10	10	0	0	0	0	8	0	0	0	0	6,725
38	0	0	34	20	10	0	0	17	0	0	0	0	3,951
39	0	0	56	946	372	114	52	90	0	60	0	363	2,694
40	0	0	0	10	0	0	0	7	0	0	0	0	1,564
41	24	0	30	83	119	6	137	16	0	12	0	12	9,235
42	53	0	99	56	23	0	78	1,484	0	22	12	192	2,348
43	10	0	24	58	0	22	126	560	0	10	0	46	923
44	0	0	0	10	0	11	0	0	0	0	0	0	3,748
45	659	62	1,027	67	10	22	0	51	146	21	0	12	9,921
46	20	10	104	10	0	0	0	16	0	10	0	20	1,352
47	0	0	21	30	22	11	72	754	0	44	12	175	1,215
48	0	0	24	131	9	9	6	26	0	44	0	89	3,700
49	24	0	44	410	117	34	33	27	10	44	0	62	1,929
50	0	10	0	30	40	0	0	26	0	0	0	10	1,180
51	0	0	12	132	22	0	0	33	0	10	0	33	1,979
52		0	0	0	0	0	0	0	0	0	0	0	245
53			10	80	41	0	22	55	0	0	0	33	3,254
54				224	128	10	42	62	10	12	25	87	8,827
55					20	0	26	87	10	9	0	10	2,072
56						0	0	10	0	0	0	0	489
57							13	29	0	0	0	0	1,101
58								6	26	29	0	0	4901
59									0	0	0	22	668
60										0	0	10	578
61											0	0	120
62												12	1,507
													310570

volume, the cross river traffic volume did not show any marked increase from year to year. This is evidently due to the fact that the bridges across the river, especially the Memorial Bridge, had traffic volumes nearing the capacity of the bridges, and increase in traffic volumes were physically almost impossible. The estimated cross river traffic volume fell squarely within the range of past survey results, showing that as far as cross river movements are concerned, the theoretical O-D matrices made a very good representation.

Several other cordon lines were also drawn at several cross sections within the municipality area.

While, as different from the cross river traffic, direct comparisons are difficult, due to difference in year, as well as existence of local or intra-zonal movement in actual survey results. However, endeavours had been made to convert the figures into the same level.

The results of all the comparisons shows that the estimated cross section traffic volumes fairly represented the actual traffic situation for the various cordon lines, and the computed O-D matrices for 1970 may be adopted with quite high degree of reliability.

Table 3-22 Comparison of traffic movements across the Chao Phraya River

(a) Surveyed traffic volume in March 1969 (Sathorn Bridge Feasibility Study Report)

i) Memorial bridge (March 12)	74,618	vehicle/12 hours (700 to 1900 hr.)
ii) Krung Thon bridge (March 11)	27,196	"
iii) Krung Thep bridge (March 18)	17,657	"

iv) Rama VI bridge (March 19) — 6,501 vehicle 12 hours (700 to 1900 hr.)

Total for 12 hours 125,972 vehicles

Conversion into Total for 24 hours 192,649 vehicles (x1.5293*)

*the conversion rate vehicles per 24 hr/vehicles per 12 hr = 1.5293 was derived from the 24 hour survey carried out for the Memorial Bridge Report for the three bridges of Krung Thon, Memorial and Krung Thep.

(b) Surveyed traffic volume in May/June 1971 (Memorial bridge report)

i)	Memorial bridge (28 May-2 June)	81,885 vehicles/24 hours		
ii)	Krung Thon bridge (26 May)	52,322	"	
iii)	Krung Thep bridge (29 May)	28,534	"	
	sub-total	162,741	"	
iv)	Rama VI bridge (estimated)*	11,450	"	(6.6%)
	Total for 24 hours	174,242	"	

(c) Surveyed traffic volume in February, 1972 (Office of Metropolitan Traffic Planning)

i)	Memorial bridge (8 February)	72,204 veh/16 hours (0600-2200 hr.)	
ii)	Krung Thon bridge (7 February)	41,645	"
iii)	Krung Thep bridge (8 February)	23,890	"

iv)	Rama VI bridge (7 February)	12,324 veh/16 hours (0600-2200 hr)
	Total for 16 hours	150,063 "
	Conversion into total for 24 hours	179,941 vehicles (x 1.1991)*

* the conversion rate of 1.1991 was derived from the 24 hour survey for the Memorial Bridge Report.

(d) Estimated traffic volume for the year 1970 (This study)

i)	Memorial bridge	80,875 vehicles per 24 hr.
ii)	Krung Thon bridge & Rama VI bridge	61,154 "
iii)	Krung Thep bridge	34,448 "
	Total for 24 hours	176,377 vehicles

(7) The limitations of the theoretical O-D matrices

The purpose of a theoretical present O-D matrices is to produce, through theoretical calculations, a traffic pattern which will represent as close as possible, the actual traffic pattern which existed in the year under study.

In this study, checks with result of other traffic surveys have been made to show that the O-D matrices do show good representation of certain traffic phenomenon at specific points, and the O-D matrices were adopted as practical. However, theoretical calculations are made with assumptions, and the products of such calculations naturally have their short comings.

In the calculations made in this study, due to lack of data, assumption have to be brief, and the zone generated traffic volume was assumed to be proportional to the population. Such a method usually results in the uniformity of generated traffic pattern for all zones. An analysis of the variation from zone of land use, zone average income, zone rate of vehicle ownership, or other peculiarities in economic activities would have produced a more favorable outcome, if it had been possible.

In the calculation of traffic distribution, again the gravity model is applied uniformly for each single type of vehicle. This again could have been improved if different models were made applicable for different trip purpose (business, shopping, commuting etc.) provided sufficient data are available.

Although the screen section traffic volume of the theoretical O-D matrices (which is an accumulation of individual zone pair traffic volume) had been checked and found to be close to the actually surveyed volume, it is not impossible that the pattern of distribution may be quite different from the actual pattern. This has to be always borne in mind and the O-D matrices should be treated more as a reference in lieu of surveyed O-D matrices and should not be treated as infallible substitutes. However, we can also safely assume that allowing for some deviation in the pattern of distribution, the assigned traffic volume can represent a fairly good picture of the traffic situation on the road network in Bangkok.

As soon as the survey data of the Office of Metropolitan Traffic Planning are available, a check of the theoretical results against the surveyed results is necessary, and necessary rectification made if deviation results in conspicuous distortion of the actual traffic pattern.

3-4 Estimation of Future O-D Matrices

3-4-1 Future zone generated traffic volume

The future zone generated traffic volume of Bangkok was also estimated through forecasting the future registered number of vehicles in the relevant zones.

(1) Forecast of future registered number of vehicles in the Metropolitan area

In the forecast of the future number of vehicles in the Metropolitan area, an attempt was first made with analysis of the correlation between rate of ownership and average per capita income. However, it was found that the results were unfavourable, and the future number of vehicles were eventually estimated through trend projection.

(a) The trend of vehicle registration in the Metropolitan area

The number of vehicles registered in the 4 Changwats of the Metropolitan area are as in Table 3-23 (i) - (iv).

Table 3-23 Registered number of vehicles (1965 - 1970)

(i) Bangkok and Thonburi

	1965	1966	1967	1968	1969	1970
Private passenger	45,338	78,584	101,579	116,969	164,968	218,637
Public passenger	17,542	18,205	18,820	18,896	24,411	26,482
Goods	19,081	28,142	30,991	34,961	36,521	41,587
Total	81,961	124,931	151,390	170,826	225,900	286,706
Vehicle/ 1,000 persons	28.3	41.6	48.3	52.6	66.8	81.5

(ii) Nonthaburi

	1965	1966	1967	1968	1969	1970
Private passenger	714	809	1,036	1,218	1,511	1,906
Public passenger	206	213	238	283	321	340
Goods	446	577	635	628	892	924
Total	1,366	1,599	1,909	2,129	2,724	3,170
Vehicle /1,000 persons	—	—	—	—	—	12.5

(iii) Samut Prakan

	1965	1966	1967	1968	1969	1970
Private passenger	568	569	969	940	703	1,857
Public passenger	210	204	137	194	426	358
Goods	319	319	357	433	1,407	851
Total	1,097	1,092	1,463	1,567	2,536	3,066
Vehicle /1,000 persons	—	—	—	—	—	9.4

(iv) Total of four Changwats

	1965	1966	1967	1968	1969	1970
Private passenger	46,620	79,962	103,584	119,127	167,182	222,400
Public passenger	17,958	18,622	19,195	19,373	25,158	27,180
Goods	19,846	29,083	31,983	36,022	38,820	43,362
Total	84,424	127,622	154,762	174,522	231,160	292,442
Vehicle /1,000 persons	—	—	—	—	—	71.5

(b) Per capita national income

The past statistics of per capita national income for the Kingkom and the Central Region are as in Table 3-24. The per capita national income for the Central Region was 5,550 bahts/year, which is about 1.8 times the national average of 3,160 bahts/year.
The increase by 1.29 times for Central Region from 1965 to 1970 was also slightly higher than the national figure of 1.27.

Table 3-24 Trend of increase in per capita national income (Baht/year)

	Central area	Whole Kingdom
1965	4,290	2,480
1966	4,560	2,690
1967	4,850	2,760
1968	5,100	2,900
1969	5,400	3,080
1970	5,550	3,160
1970/1965	1.29	1.27

(c) Correlation between rate of vehicle registration and average per capita national income

The correlation between the rate of vehicle registration and average per capita national income for the metropolitan region may be graphically shown as below. (Fig. 3-17)

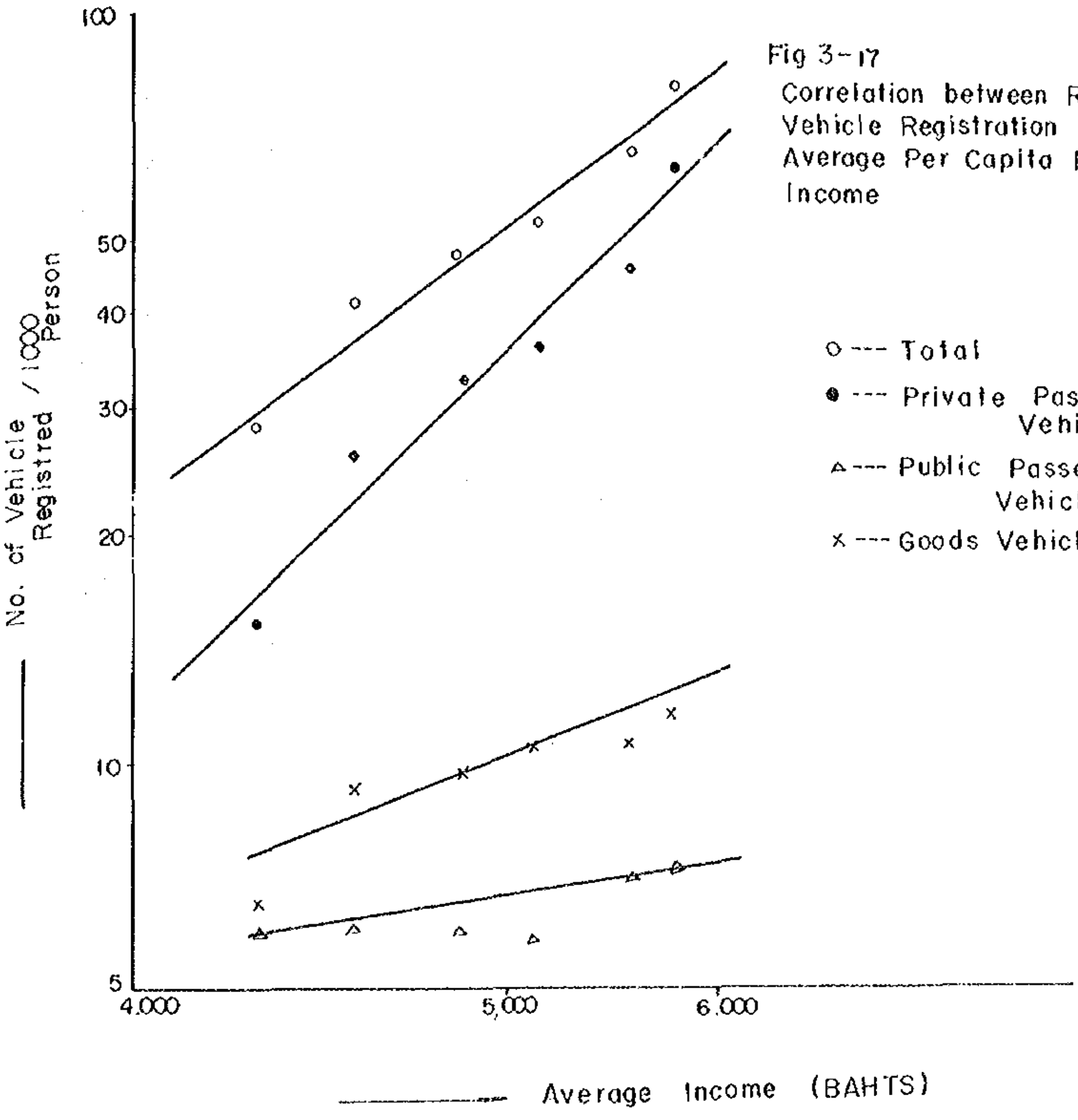


Fig 3-17
Correlation between Rate of Vehicle Registration and Average Per Capita National Income

The points in the graph show rather good correlation, and the following equations are obtained through regression.

Private passenger vehicle : $Y = 1.5^{-16} \cdot X^{4.79}$ (R = 0.982)

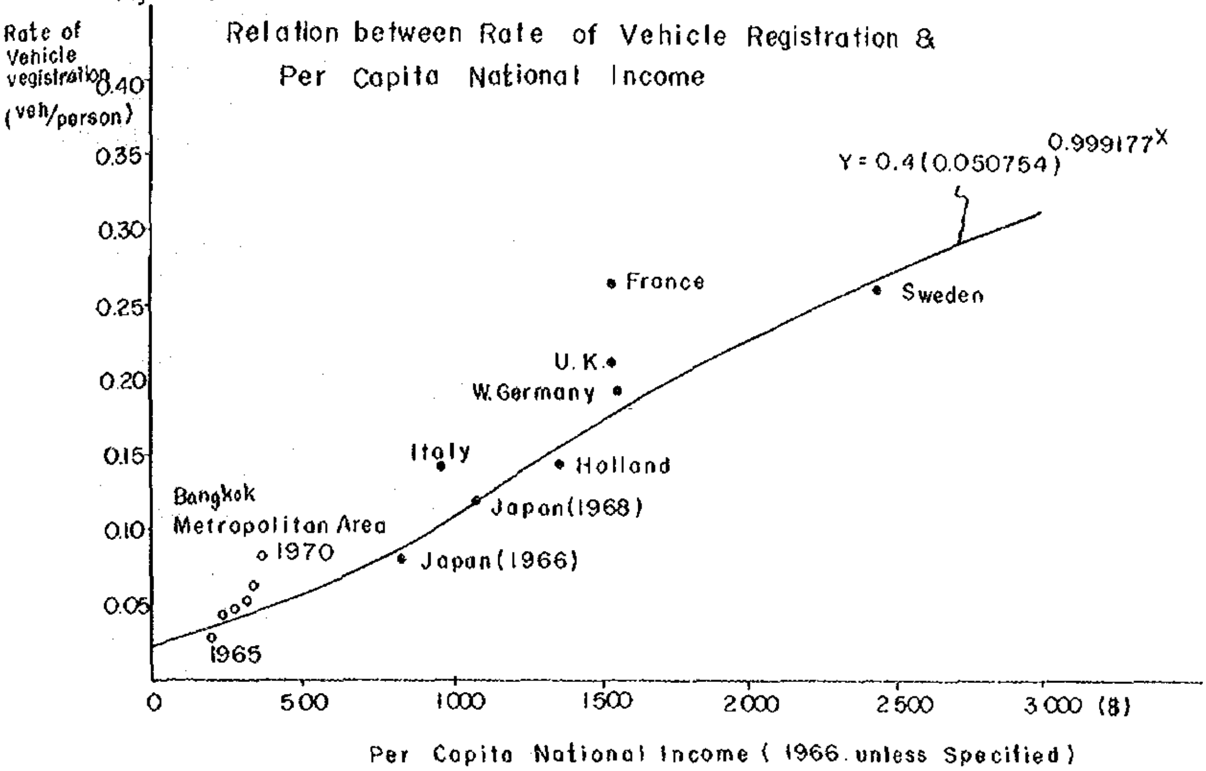
Public passenger vehicle : $Y = 1.5^{-2} \cdot X^{0.81}$ (R = 0.735)

Goods vehicle : $Y = 1.05^{-6} \cdot X^{1.9}$ (R = 0.908)

All vehicles : $Y = 6.8^{-11} \cdot X^{3.66}$ (R = 0.982)

The average per capita national income in the year 1990 for the Metropolitan area was estimated at 13, 100 baht/year.
When this figure is adopted in the equation obtained, an unrealistically high rate of vehicle registration of 1740 veh/1000 population would be derived, showing that the correlationship could not be adopted for the forecast of future registered number of vehicles.
It is found that the past rate of ownership of vehicles for the Metropolitan area had been exceptionally high despite a rather low per capita national income.
An analysis of the rate of ownership of various west European nations and Japan against that of Thailand (1965 - 1970) was made and the results are as in Fig. 3-18. It is evident that while there are some ups and downs, a general trend was followed in relation to the per capita national income.
However, the figures for the Metropolitan area were far above the general trend, and a projection of the past trend would be unrealistic. The adoption of the correlation was thus abandoned.

Fig 3-18



(d) Forecast through trend projection

A trend projection of the registored number of vehicles was made for the 4 Metropolitan Changwats and the results are as in Table 3-25.

Table 3-25 Estimated future registered number of vehicles by trend projection

(i) Bangkok & Thonburi

	Correlation equation	Estimated number of vehicles, 1990
Private passenger vehicle	Y=32600X - 64020420 (R=0.980)	859,350
Public passenger vehicle	Y=1810X - 3541010 (R=0.904)	57,670
Goods vehicle	Y=4045X - 7926750 (R=0.971)	126,865
Total		1,043,885

X : year

(ii) Nonthaburi

	Correlation equation	Estimated number of vehicles, 1990
Private passenger vehicle	Y=236X - 462460 (R=0.980)	7,230
Public passenger vehicle	Y=29.7X - 58140 (R=0.983)	912
Goods vehicle	Y=95.1X - 186400 (R=0.952)	2,943
Total		11,085

(iii) Samut Prakan

	Correlation equation	Estimated number of vehicles, 1990
Private passenger vehicle	Y=195X - 382330 (R=0.752)	5,760
Public passenger vehicle	Y=41.8X - 81980 (R=0.702)	1,138
Goods vehicle	Y=171.4X - 336670 (R=0.733)	4,562
Total		11,460

(iv) Total of 4 Changwats

	Correlation equation	Estimated number of vehicles, 1990
Private passenger vehicle	Y=33030X - 64863750 (R=0.979)	872,340
Public passenger vehicle	Y=1880X - 3681590 (R=0.904)	59,720
Goods vehicle	Y=4310X - 8443930 (R=0.978)	134,370
Total	Y=39230X - 77001270 (R=0.983)	1,066,430

The estimated registered number of vehicles for the 4 Changwats in the Metropolitan area in 1990 is about 1,066 thousand vehicles. On the other hand, the "Greater Bangkok Plan" has an estimated population of 6.5 million for the Greater Bangkok area. Together with the regions excluded from the greater Bangkok area, the total population for the 4 Changwats in 1990 is estimated at 7.2 million. The average rate of vehicle registration is 150 vehicle per 1000 population, which is about 2 times the present rate of ownership. The figure is quite high as compared to that of other western European nations when the average per capita national income is taken into consideration. (Table 3-26). However, considering that this is a comparison between figures for a region (the Metropolitan area) against the national average rate of vehicle registration for all other nations, and that the present rate is already above that of the general trend of other nations, this cannot be considered an overestimate. In want of other better methods of analysis available against existing data, these rather sophisticated figures are adopted as the estimated future registered number of vehicles for the Metropolitan area.

Table 3-26 Comparison of vehicle registration situation

	Rate of Vehicle Ownership (vehicle /person)	Per capita national income ($)	Registered No. of Vehicles (1,000 veh.)	Population (1, 000 persons)
France	0, 262	1,542	12, 965	49, 400
W. Germany	0. 189	1,574	10, 881	57, 485
Italy	0. 136	944	7, 047	51, 859
Netherland	0. 141	1, 362	1, 756	12, 455
Sweden	0. 259	2, 392	2, 024	7, 808
Switzerland	0. 182	2, 077	1, 104	6, 050
U. K.	0. 207	1, 515	11, 350	54, 953
Canada	0. 348	1, 979	6, 926	19, 919
U. S. A.	0. 471	3, 154	92, 843	196, 920
Japan, 1966	0. 081	791	8, 015	98, 865
Japan, 1968	0. 115	1, 077	11, 690	101, 408
Metropolitan area Thailand, 1990	0. 150	655	1, 066	7, 200

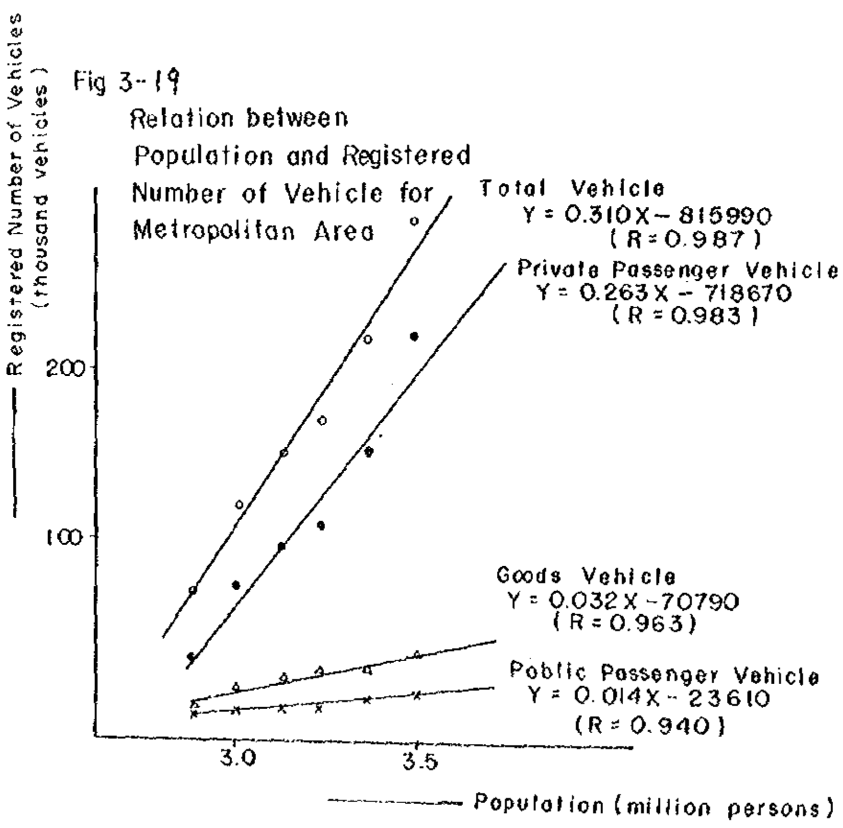
all figures for 1966 unless stated otherwise

(2) Estimation of future zone registered number of vehicles

The total future registered number of vehicles for the whole Metropolitan area had been estimated. For the calculation of zone generated traffic volume, it is necessary to break this total into zone future registered number of vehicles. The relation between population and registered number of vehicles for the Metropolitan area is graphically as in Fig. 3-19.

It can be seen that for a sufficiently large district, the two show very good correlation. When the district is further divided into smaller zones, the same relation may not necessary apply. However, in this study, there were insufficient data for an analysis of the interzonal difference in charactiristics, and a bold assumption was made that the number of vehicles was distributed proportional to the zone population. The 1,066 thousand vehicles was thus allocated to the zones by types of vehicles in proportion to the future estimated zone population, which totals 720 million for the 4 Metropolitan Changwats and 650 million for the Greater Bangkok area.

Fig 3-19 Relation between Population and Registered Number of Vehicle for Metropolitan Area



(3) Future average number of trips per vehicle

The average number of trips per vehicle vary according to the level of economic activities and social activities of the society. It is difficult to estimate the trend of change of the average number of trip in relation to an increase in the rate of vehicle ownership.

An increase in private passenger vehicles will result in the increase of idle vehicles and consequently a decrease in average number of trips on one hand, but also in the increase of short-distance trip on the other. Increase in economic activities tends to increase the trip length of goods vehicle trip, thus reducing the average number of trips, but this may be offset by an improvement in the efficiency in the use of the vehicles through rationalization and better planning.

Past data for Japan shows that the general trend is towards a gradual decrease in the average number of trips per vehicle, although the decrease is by no means significant and may be neglected over a short period. In this study, in want of a substantial argument for or against a decrease in the average number of trips per vehicle in Bangkok, the same figures for 1970 was adopted for 1990.

(4) Establishment of future zone generated traffic volume

The zone generated traffic volume by types of vehicles for the year 1990 was obtained by a multiplication of the zone registered number of vehicles by the average number of trips per vehicle for each type of vehicle.

The zone generated traffic volume for the years 1975 and 1980 were subsequently obtained through interpolation.

3-4-2 Establishment of future O-D matrices

The future traffic distribution was also computed with the gravity model method, applying the same values for the paraments n and k as that for the 1970 traffic analysis. The future interzonal travel time (Dij) for the different years were separately derived with consideration for the future improvement and new construction to the road network in Bangkok. As the future generated traffic volumes for the external zones were not established, the future internal-external and external-external zonal traffic was derived through proportional increase of the existing interzonal traffic volume with the growth factor of registered number of vehicles for the relevant zones. The future O-D matrices thus obtained are shown in Tables 3-27 - 3-35.

D. PRIVATE PASSENGER TRAFFIC—1975

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
01	11934	5044	1959	967	528	689	559	526	517	354	475	407	88	3791	609	2066
02		29154	2722	4830	1506	1529	1130	868	843	223	510	472	126	1659	722	1664
03			8557	517	268	370	1191	661	577	137	316	256	71	675	295	592
04				8047	2055	1267	417	500	372	125	210	228	66	637	329	518
05					4062	3506	322	508	258	144	271	251	73	476	237	357
06						8735	365	767	410	137	286	620	188	873	103	497
07							5221	3740	1187	161	331	253	76	319	654	241
08								6009	1611	479	510	388	186	445	203	270
09									3570	244	1684	759	174	418	189	267
10										2315	176	452	554	188	83	97
11											1899	1606	200	412	168	220
12												10010	647	503	211	230
13													1145	119	52	57
14														35068	11437	4071
15															9930	3469
16																8687

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
01	988	441	1105	552	422	423	146	213	92	309	826	655	3161	2022	671	658
02	1473	636	2390	970	780	610	283	375	187	454	1232	637	2165	1175	434	545
03	490	220	550	281	260	238	78	118	56	128	560	350	847	455	198	360
04	836	321	2624	698	414	283	183	220	77	211	603	209	693	328	129	163
05	815	358	3203	871	484	277	294	287	87	207	636	162	196	224	81	111
06	1338	746	2341	2656	839	585	1463	1015	224	451	1495	277	749	319	138	181
07	396	172	531	219	211	175	71	118	50	144	497	246	385	199	94	206
08	598	295	829	459	363	279	136	223	88	231	854	346	135	221	133	290
09	468	252	419	309	286	253	87	153	69	207	701	578	454	228	169	405
10	232	109	209	245	350	361	87	171	60	136	546	130	162	77	48	91
11	399	346	308	374	246	329	119	228	97	212	260	1022	598	346	218	862
12	566	455	385	886	409	557	290	545	200	466	1861	756	549	305	183	497
13	139	155	108	207	94	125	77	151	49	105	452	420	99	57	31	74
14	8667	1840	1282	923	3049	1187	199	309	150	564	1438	638	5041	1107	473	456
15	8463	960	636	445	1244	455	92	140	64	230	598	251	1764	385	161	167
16	1164	542	1050	515	669	427	112	162	70	241	610	326	11659	931	340	283
17	25672	3857	2411	1527	10538	1224	283	439	175	577	1554	458	2150	602	263	293
18		17822	741	1826	3117	1214	342	661	213	560	1683	351	890	290	139	185
19			2095	1691	1016	528	323	379	127	340	1005	295	1326	526	209	218
20				5125	1167	987	1621	1572	300	556	1932	326	798	324	139	182
21					5669	1154	197	312	126	447	1107	292	1061	560	242	232
22						7060	216	393	239	4166	2082	361	745	281	139	204
23							496	1118	109	165	636	95	115	76	32	55
24								1121	365	375	1180	178	265	115	50	101
25									1002	463	1029	87	123	53	25	49
26										3952	3751	297	412	193	92	165
27											11629	920	1154	501	263	508
28												5142	846	480	294	918
29													15319	4122	1348	953
30														7946	1103	668
31															5736	503
32																7148

	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
01	168	208	626	1239	1215	265	305	310	661	67	123	1365	1653	2046	13	132
02	146	524	538	1039	980	308	311	371	899	69	64	951	1614	1053	59	132
03	95	411	340	682	306	201	118	142	349	35	73	381	881	561	27	56
04	42	136	160	300	266	120	141	167	369	24	71	287	531	351	27	50
05	29	85	109	227	220	101	150	155	351	18	66	157	384	272	25	48
06	43	123	176	382	361	169	763	316	680	34	134	302	644	469	65	85
07	41	146	196	500	674	314	87	108	258	24	66	183	543	388	81	34
08	57	203	277	693	917	426	139	167	388	35	87	213	763	546	34	50
09	74	274	372	1039	1361	633	122	158	361	50	84	223	961	878	32	50
10	20	59	88	196	206	98	62	92	207	14	48	78	283	214	20	27
11	71	231	903	2611	570	437	120	202	470	76	109	321	1547	1450	42	62
12	60	175	525	1212	412	274	195	319	770	71	168	307	1392	1863	70	80
13	11	32	78	167	105	50	43	70	155	13	36	53	221	192	15	17
14	123	279	410	746	589	211	1487	1316	1547	87	251	1074	3234	1435	84	151
15	43	116	164	302	242	66	479	437	602	32	97	367	643	437	34	148
16	80	193	241	455	388	119	249	276	603	39	58	745	911	553	31	101
17	37	199	291	535	454	214	1421	1103	1491	52	125	605	1169	806	80	307
18	38	97	189	374	253	120	686	830	1210	46	190	322	735	610	74	178
19	57	172	247	410	391	182	900	305	664	35	116	165	740	500	43	92
20	41	106	185	378	294	140	360	476	941	39	162	315	659	557	69	104
21	63	111	203	330	283	136	1696	1040	1030	41	154	546	874	528	56	260
22	42	101	207	389	273	136	493	1183	3924	53	102	322	813	661	99	183
23	11	29	55	115	80	38	69	109	221	11	45	74	188	160	20	24
24	18	48	105	220	147	70	123	199	400	21	81	116	344	294	36	42
25	8	24	50	101	69	34	56	99	241	11	57	56	176	148	27	22
26	34	81	167	316	223	109	221	497	2131	42	512	211	651	531	125	101
27	97	214	521	1035	695	330	545	865	2463	118	1257	540	1501	1583	879	234
28	97	293	948	2330	606	396	186	242	608	470	136	168	2270	4161	49	98
29	276	363	159	1026	738	230	570	613	1157	98	189	2691	2569	1422	64	241
30	199	717	500	637	392	134	280	293	465	52	84	1494	1501	777	28	115
31	136	326	350	420	291	95	137	147	227	29	43	687	938	465	15	57
32	105	162	6019	2705	829	281	240	162	329	63	70	519	3409	1239	25	63
33	1261	263	99	197	117	42	56	42	73	10	35	148	245	353	6	17
34		3169	442	910	321	151	62	34	165	25	35	169	725	442	13	29
35			5292	2925	799	295	125	118	330	64	71	409	2436	1301	25	59
36				12390	1613	797	190	216	602	133	132	557	2981	2957	49	94
37					12113	609	129	174	431	53	92	350	1512	935	34	64
38						8019	63	85	216	31	45	129	627	582	17	28
39							1987	1403	580	27	90	312	538	333	31	323
40								7129	1638	36	154	337	651	138	52	266
41									13178	98	1310	529	1418	1323	155	301
42										38	23	55	221	288	7	15
43											112	95	312	249	60	50
44												1070	1898	780	32	164
45													13210	6027	109	295
46														7029	88	382
47															66	15
48																426

	49	50	51	52	53	54	55	56	57	58	59	60	61	62		T.X
01	188	259	220	164	551	813	240	88	52	213	104	56	18	18		66320
02	183	162	83	21	385	367	213	90	26	372	62	80	21	179		107176
03	76	95	176	18	281	267	66	28	38	232	67	10	10	18		39376
04	70	83	45	11	87	202	88	11	25	136	0	42	11	21		10902
05	67	21	55	55	220	223	106	46	17	266	21	24	0	87		31085
06	119	66	45	11	141	325	42	0	42	213	0	0	11	42		49740
07	43	80	20	10	143	150	20	39	15	441	10	29	0	10		26944
08	67	20	50	10	148	228	10	36	0	248	0	49	4	20		33161
09	63	87	21	11	127	213	42	25	25	115	38	11	0	63		29011
10	29	0	10	0	20	31	0	0	0	31	0	70	0	0		12436
11	80	0	0	0	0	0	0	0	0	0	0	0	0	0		33163
12	98	0	0	0	0	0	0	0	0	0	0	0	0	0		43516
13	21	0	0	0	0	0	0	0	0	0	0	0	0	0		8286
14	731	11	83	22	154	476	172	48	7	92	35	69	11	115		112978
15	239	22	22	11	105	172	45	49	14	77	22	11	0	11		58023
16	139	105	91	11	256	403	106	45	18	227	22	45	11	77		55952
17	491	202	144	45	322	1414	353	70	102	398	80	203	43	203		118056
18	265	11	11	0	11	105	53	0	8	8	0	0	11	11		66309
19	132	150	162	11	260	423	102	21	71	353	11	57	0	62		49737
20	147	0	0	0	11	60	0	0	45	62	0	0	11	11		41450
21	479	0	11	0	11	395	48	11	17	0	11	24	11	24		51811
22	230	24	21	28	70	738	189	81	50	252	11	61	11	125		45594
23	31	45	45	11	66	276	88	32	38	316	0	0	0	53		12436
24	56	0	0	0	0	28	4	11	0	28	0	0	0	0		16584
25	28	66	45	32	224	416	74	59	119	916	32	53	11	28		10359
26	116	21	11	11	20	0	0	8	0	0	11	21	0	21		31085
27	279	11	0	0	11	57	0	8	73	316	0	0	0	8		130560
28	119	11	11	0	11	55	0	32	0	8	0	0	0	0		37301
29	344	115	123	22	305	305	25	34	22	35	22	11	0	22		91185
30	167	0	0	0	11	11	0	0	7	0	0	0	0	0		41441
31	83	0	0	0	0	0	0	0	0	0	0	0	0	0		21838
32	88	92	18	22	284	112	52	20	53	52	22	32	0	0		47194
33	24	25	0	0	0	0	0	0	0	0	0	0	0	0		8286
34	39	32	29	0	85	20	29	0	0	49	10	0	0	0		18654
35	80	284	118	21	405	241	52	10	8	49	31	21	0	52		37303
36	123	21	0	0	35	27	10	0	17	34	0	10	0	31		62172
37	83	73	21	10	31	34	21	0	21	34	10	0	0	0		17674
38	35	12	31	10	69	143	62	10	0	98	0	0	0	10		26941
39	333	11	35	11	175	3170	349	80	95	223	108	166	11	190		21876
40	253	0	0	0	11	21	0	0	7	8	0	0	0	31		33156
41	315	0	10	31	46	84	41	17	87	78	0	10	0	24		62171
42	18	10	10	10	52	10	20	0	35	41	0	0	0	29		3256
43	52	31	20	10	0	14	10	0	24	176	10	0	0	0		9294
44	253	0	0	0	0	7	0	0	0	4	0	0	0	0		24869
45	372	361	167	61	302	143	32	11	0	35	55	0	0	0		82898
46	216	21	45	0	15	56	21	11	8	17	21	0	0	0		55945
47	18	0	0	0	0	50	20	0	24	129	20	0	0	50		3447
48	658	21	21	21	31	495	25	21	6	8	10	35	18	21		7780
49	1838	25	20	0	129	618	129	0	49	39	13	13	0	35		12916
50		30	0	0	18	22	28	0	7	39	0	18	0	10		2878
51			0	0	0	45	38	0	0	24	10	0	0	10		2240
52				0	0	10	0	0	0	0	0	0	10	0		745
53					18	62	10	0	0	88	0	0	0	28		5866
54						340	28	28	13	10	10	38	0	28		14185
55							0	0	15	15	10	0	0	0		3192
56								0	0	7	0	0	0	0		1073
57									13	0	0	0	0	0		1268
58										7	18	21	10	11		6369
59											0	18	0	18		947
60												10	0	0		1238
61													0	0		214
62														0		1807
																2153366

8. PUBLIC PASSENGER TRAFFIC-1975

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62		T.S
01	1272	2,555	1007	549	350	469	361	359	325	311	314	305	64	1,226	144	1,117	748	361	661	362	242	303	105	140	64	213	663	605	1,295	1,022	413	417	110	400	421	770	755	218	210	238	433	87	152	612	566	629	63	322	182	70	62	66	115	1,756	0	25	48	28	25	25	0	25		35651
02		11,952	3,548	2,278	930	1,015	736	616	549	169	399	369	98	1,334	589	1,047	1,177	543	1,107	644	535	442	200	249	104	318	1,021	448	1,435	778	313	424	123	372	440	728	145	232	239	281	603	99	228	531	1,075	704	50	135	200	105	33	0	39	132	37	185	11	108	0	32	0	402		56276
03			3016	343	231	277	602	400	335	95	218	202	52	550	244	403	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		20511
04				2558	697	669	240	302	200	83	147	171	46	469	245	342	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		20548
05					1539	1,487	216	311	172	95	129	189	50	400	195	263	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		16244
06						3269	259	466	270	244	210	417	115	669	321	371	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		25970
07							1,812	792	549	104	231	188	52	311	137	192	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		11069
08								2087	643	242	302	269	105	387	175	214	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		17321
09									1,231	136	315	424	94	364	355	199	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		15355
10										617	132	249	200	169	71	78	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		6512
11											1,686	184	109	353	147	178	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		17328
12												3,514	295	452	292	207	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		22718
13													315	102	43	48	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		4340
14														16,418	5,284	2,353	4,965	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		74685
15															3,924	890	4,035	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		30308
16																3,434	1,033	133	447	353	424	308	87	115	53	187	559	244	1,665	577	251	223	69	150	207	564	314	319	185	210	420	59	143	353	629	391	55	302	150	35	14	0	98	211	35	0	35	33	35	0	0	0		29358
17																	11,001	2,311	1,143	959	1,168	633	210	286	127	421	1,308	372	1,504	483	242	269	77	181	283	487	417	220	833	722	986	59	318	396	900	617	123	281	468	27	0	0	0	10	436	55	0	20	21	14	0	0		61703
18																		6,758	524	993	1,188	156	218	367	134	375	1,259	276	689	251	134	183	11	92	182	333	238	126	433	531	778	21	255	220	574	454	105	173	286	0	0	0	0	0	21	0	0	0	0	0	0	0		34614
19																			2,687	834	395	346	186	213	60	223	718	713	838	354	164	175	50	138	321	268	126	200	[illegible]	213	421	52	351	259	510	342	62	90	134	0	27	0	0	14	0	0	33	21	0	0	0	0		25979
20																				1,935	395	545	612	602	147	315	1,303	220	535	228	112	141	36	95	251	283	227	119	213	231	340	33	189	183	414	357	83	95	145	0	0	0	13	0	0	0	0	0	0	0	0	0		21628
21																					1,950	609	120	122	24	265	763	203	657	318	171	168	50	87	160	252	217	115	788	528	577	55	181	276	545	339	71	190	350	0	45	0	0	427	143	256	190	0	0	143	85	482		27063
22																						2,736	134	287	132	1,634	1,334	250	528	217	116	157	38	83	168	297	216	115	304	658	1,645	71	416	195	551	435	119	160	221	0	0	0	9	55	0	11	39	22	0	0	0	14		23804
23																							197	378	55	95	402	69	133	60	29	45	10	25	48	91	67	35	49	74	143	15	56	48	134	109	25	24	35	43	14	0	69	0	0	14	11	53	0	0	0	0		6,472
24																								375	139	185	654	112	185	84	42	73	15	36	78	150	106	56	78	120	228	27	93	69	217	176	41	36	55	0	0	0	0	14	0	0	0	22	0	0	0	0		3644
25																									265	197	518	56	90	41	21	36	8	18	39	71	52	27	38	63	139	14	66	34	115	92	29	21	28	27	0	0	0	108	0	11	245	770	0	0	0	14		5,432
26																										1,406	1,884	196	328	146	77	120	28	63	327	228	165	86	150	302	1032	55	448	127	421	330	127	91	118	0	0	0	0	13	0	0	11	11	0	0	0	0		16239
27																											7,024	665	958	435	246	417	95	216	448	825	585	313	417	652	1534	169	1,257	375	1,365	1,085	806	242	321	0	0	0	0	0	0	0	0	55	0	0	0	0		68,195
28																												1,505	550	308	197	479	69	181	517	1,121	384	755	534	176	395	358	167	245	1,105	1,656	64	91	122	0	28	0	37	0	0	0	0	0	0	0	0	0		19592
29																													6,262	1,963	781	610	190	263	539	736	556	213	381	426	759	129	258	1,147	1,527	881	97	217	329	21	0	10	43	28	10	17	0	0	0	0	0	21		47,635
30																														2,800	577	400	127	153	536	440	281	320	190	209	328	69	119	629	863	437	45	106	152	0	14	0	0	0	0	0	0	0	0	0	0	0		23,535
31																															1,925	302	328	197	241	501	221	87	504	115	174	42	67	325	566	301	25	59	88	0	0	0	0	0	0	0	0	0	0	0	0	0		12,983
32																																2,387	76	265	2,205	1,285	507	209	105	123	231	16	97	256	1,540	645	38	63	92	227	392	106	574	90	0	0	0	11	305	14	0	11		21,627
33																																	550	137	76	139	107	39	42	36	59	14	24	83	165	105	10	98	28	0	0	0	0	0	0	0	0	0	0	0	0	0		4,341
34																																		1,200	269	504	414	118	50	62	123	38	52	311	426	265	20	32	45	13	0	0	11	0	0	0	0	0	0	0	0	0		9,728
35																																			2,064	1,435	518	727	101	122	246	81	104	232	1,254	707	41	63	91	69	27	0	136	0	13	0	11	0	13	0	0	0		19,495
36																																				4,651	958	525	153	196	427	154	167	321	1,593	1,445	73	98	139	0	0	0	0	8	4	0	0	0	0	0	0	0		32,475
37																																					4,127	526	109	141	311	74	130	217	909	573	52	70	97	0	0	0	10	0	0	0	0	0	0	21	0	0		24,906
38																																						2,950	57	76	165	45	70	94	427	366	28	34	46	0	0	0	0	52	0	0	0	35	0	21	0	0		14,069
39																																							774	641	360	36	113	168	356	224	43	214	253	0	0	0	0	875	41	0	38	31	41	27	0	148		12,985
40																																								2,482	897	50	189	159	444	300	69	200	224	0	0	0	6	27	0	0	0	0	0	0	0	0		17,321
41																																									5,020	119	1,068	294	890	682	174	245	295	0	27	0	0	0	13	0	36	15	0	0	0	0		32,477
42																																										64	49	57	215	265	16	27	35	0	0	0	31	11	0	0	0	0	0	0	0	14		3,780
43																																											584	106	370	286	111	81	98	0	0	0	0	0	14	0	49	24	0	0	0	0		10,674
44																																												393	843	389	39	113	183	0	0	0	0	0	0	0	0	0	0	0	0	0		12957
45																																													5,347	2,733	139	249	344	139	69	0	154	0	0	0	0	0	0	0	0	0		43,298
46																																														2,677	108	158	207	0	0	0	13	41	0	0	0	0	0	0	0	0		29223
47																																															107	28	35	0	0	0	0	14	0	0	0	24	0	0	0	0		3994
48																																																295	477	0	0	0	0	101	66	0	0	0	0	0	0	0		6251
49																																																	1,221	0	0	0	32	76	37	0	0	22	0	0	0	0		10359
50																																																		28	0	0	0	18	0	0	0	0	0	0	0	0		1,106
51																																																			0	0	38	56	0	0	52	0	0	0	0	0		965
52																																																				0	9	0	0	0	0	0	0	0	0	0		196
53																																																					0	18	38	38	0	0	0	0	0	16		2071
54																																																						262	0	0	0	38	0	0	0	0		6936
55																																																							0	0	38	38	0	0	0	0		573
56																																																								0	0	0	0	0	0	0		557
57																																																									22	0	0	0	0	0		900
58																																																										0	0	0	0	0		1,943
59																																																											0	0	0	0		447
60																																																												28	0	0		434
61																																																													0	0		126
62																																																														29		1,292
																																																															1,135,094

F. GOODS TRAFFIC—1975

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
01	3516	665	261	175	79	90	31	70	66	21	67	50	13	210	37	297	125	52	363	80
02		8,243	364	673	203	203	144	120	115	34	81	62	20	195	92	227	190	76	363	154
03			2,469	73	39	50	161	97	81	21	49	31	11	83	39	87	64	27	84	63
04				2397	307	179	55	70	43	18	31	29	11	76	43	74	111	39	421	95
05					1543	551	45	77	36	24	27	35	13	59	32	53	115	99	561	150
06						3,146	50	115	57	71	43	58	32	102	55	73	189	99	369	466
07							1,660	272	116	25	59	35	13	41	20	34	52	21	81	39
08								2,122	218	83	84	56	32	55	28	39	84	39	136	26
09									1,098	36	274	105	28	53	25	36	62	31	61	46
10										106	29	71	113	75	13	15	35	27	35	42
11											1,809	259	36	65	24	34	59	49	50	63
12												3,241	112	60	28	31	74	93	57	130
13													419	12	8	10	21	24	20	38
14														10,742	1,611	567	1,356	218	161	128
15															3,443	224	1,299	127	97	69
16																2,747	214	73	374	84
17																	2,792	529	372	244
18																		5,254	105	284
19																			2,586	311
20																				7,082

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
01	22	69	7	35	11	46	95	92	501	286	81	84	22	95	88	167	153	34	24	48	101
02	325	99	15	69	20	78	353	99	318	168	50	67	20	62	76	139	109	36	27	59	161
03	81	34	4	21	7	29	70	53	126	54	24	48	14	55	60	97	90	28	10	21	57
04	66	45	10	41	10	35	74	31	101	45	15	20	6	17	22	39	31	18	13	25	61
05	81	45	17	57	13	36	84	25	74	31	11	14		11	15	32	27	13	13	24	62
06	140	55	88	202	31	78	159	42	111	45	17	24	6	17	25	53	45	22	22	49	119
07	36	28	4	21	81	35	34	28	4	21	1	24	63	38	55	28	11	27	6	20	26
08	60	45	1	42	13	39	115	55	64	32	17	41	8	29	42	104	126	63	11	25	67
09	43	36	4	27	8	32	85	85	63	31	21	55	10	38	55	151	105	94	10	23	57
10	25	21	6	34	8	24	78	21	25	11	7	14	3	8	14	33	31	15	6	34	315
11	11	52	3	65	14	16	134	171	22	53	31	137	33	36	157	118	35	73	10	31	76
12	63	84	15	99	27	71	244	112	76	42	22	67	8	24	78	176	53	36	15	16	113
13	17	21	4	32	7	18	69	20	15	8	4	11	1	6	13	28	15	8	4	11	27
14	459	161	6	16	17	83	162	84	696	141	53	53	35	34	53	91	66	25	116	185	232
15	295	70	4	24	8	36	74	36	269	53	20	21	6	15	22	18	29	11	41	67	99
16	312	66	6	29	10	39	83	49	2,036	141	46	39	13	28	36	66	52	17	28	42	101
17	1,691	192	14	74	22	94	195	49	314	83	32	36	10	25	41	71	55	26	123	169	231
18	510	185	17	116	27	88	207	48	119	36	16	22	4	11	25	18	29	15	56	122	193
19	183	90	20	37	18	62	140	48	287	83	28	31	8	25	34	62	53	27	28	50	120
20	218	169	108	344	45	99	284	52	129	49	20	27	6	15	29	59	42	22	31	77	165
21	2,313	200	11	63	18	80	160	48	175	80	35	35	10	17	34	52	42	21	190	176	182
22		2,365	13	74	32	327	300	53	135	12	20	31	1	15	34	60	41	22	42	172	605
23			22	88	6	10	31	6	10	1	1	3	0	1	3	6	4	1	1	6	11
24				549	86	72	200	32	46	20	8	17	3	8	20	39	25	13	13	35	77
25					286	70	132	11	15	7	3	6	1	3	7	13	8	4	4	13	32
26						1,509	602	46	71	31	14	27	6	13	28	52	35	20	20	74	346
27							11,063	173	148	63	31	62	13	31	70	131	84	43	41	120	370
28								1,859	129	71	42	144	15	45	161	386	91	66	15	34	90
29									4,595	662	192	139	42	53	119	153	101	36	49	91	186
30										2,596	157	95	31	31	27	92	50	18	24	43	73
31											1,854	64	112	43	49	55	34	11	11	21	35
32												2,250	15	64	1,037	409	105	38	13	24	53
33													584	41	35	29	20	6	4	7	13
34														1,260	69	135	97	24	6	11	28
35															1,701	193	115	45	11	22	56
36																3,851	223	118	15	36	101
37																	3,574	104	16	25	71
38																		2,355	5	14	38
39																			203	123	49
40																				2,299	231
41																					3,959

	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	T.E
01	32	10	262	205	158	11	41	43	110	210	0	535	579	241	17	59	155	125	70	17	53	14,779
02	36	14	185	223	178	17	46	49	0	76	18	155	323	111	11	59	154	18	41	41	59	24,019
03	18	6	73	119	92	8	18	20	106	136	53	87	204	69	0	28	56	70	69	0	0	8,768
04	13	6	55	70	57	8	17	18	41	81	0	66	59	95	0	85	67	0	20	20	0	8,769
05	10	6	38	52	45	8	12	17	0	0	0	41	141	20	15	15	158	20	0	0	97	6,932
06	17	13	57	85	71	17	29	31	0	0	6	39	39	20	0	0	0	20	0	0	0	11,081
07	70	85	42	7	17	43	33	6	34	73	61	6	11	11	0	38	18	91	337	0	0	6,806
08	18	8	41	105	92	10	17	17	0	17	0	17	0	18	0	0	14	0	18	0	0	7,392
09	25	7	39	127	137	8	15	14	241	101	60	139	230	20	39	70	213	81	0	0	42	6,467
10	8	4	15	38	36	6	8	7	0	0	0	18	0	0	0	14	14	0	0	0	16	3,053
11	43	30	84	220	258	13	21	20	0	0	0	0	0	0	0	0	0	0	0	0	0	7,390
12	36	14	55	167	183	20	24	23	39	0	0	38	38	0	0	31	15	0	0	0	59	10,092
13	7	3	11	31	34	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,851
14	41	20	182	206	161	22	137	169	21	137	0	137	726	280	63	36	167	42	46	21	120	31,881
15	17	8	61	83	69	10	49	62	21	21	21	43	169	162	0	29	102	0	46	0	25	12,922
16	21	3	118	122	90	10	34	35	64	114	0	237	343	118	21	16	83	61	0	0	21	12,469
17	31	20	118	147	125	24	102	125	50	17	12	69	398	176	48	67	272	12	11	17	729	26,330
18	22	15	55	87	99	21	55	62	20	0	0	0	0	0	0	0	0	0	0	0	0	14,780
19	20	11	97	105	87	14	34	35	0	20	0	66	129	57	20	36	77	0	0	0	39	11,081
20	22	15	63	93	93	22	35	38	0	0	0	66	32	21	0	31	35	0	0	0	0	9,226
21	22	14	115	122	50	18	94	133	0	0	0	0	150	20	21	33	0	0	0	0	0	13,548
22	27	36	60	101	101	31	53	52	0	0	21	21	258	169	16	33	101	21	53	0	63	10,172
23	3	1	6	8	10	3	3	3	106	101	20	261	973	39	101	70	328	41	0	0	57	2,772
24	13	8	27	53	56	13	15	13	0	0	0	0	21	0	0	0	14	0	0	0	0	3,696
25	4	4	8	20	20	7	6	6	20	81	0	60	276	39	0	73	238	41	24	0	35	2,308
26	22	50	42	87	87	42	38	27	0	20	0	0	20	0	0	0	15	0	20	0	39	6,929
27	55	106	88	216	225	262	66	60	0	20	0	0	90	48	0	0	342	0	0	0	0	29,107
28	273	11	90	288	713	14	29	27	21	43	43	27	35	0	0	35	52	42	21	0	35	8,312
29	52	12	554	349	231	20	78	85	127	402	0	127	149	59	0	22	12	20	20	18	36	20,226
30	27	7	300	159	123	8	36	43	0	0	0	0	0	0	0	0	0	0	0	0	0	9,234
31	14	3	126	118	76	4	15	20	0	0	0	0	0	0	0	0	0	0	0	0	0	5,514
32	24	6	98	175	206	7	23	21	84	87	0	207	50	39	14	13	15	99	0	0	39	9,737
33	6	3	27	24	25	3	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	1,845
34	16	3	35	99	74	4	10	10	18	0	0	0	0	45	0	0	14	0	0	0	0	1,160
35	36	7	83	351	234	8	20	21	137	98	18	84	205	76	16	21	15	98	0	0	0	8,311
36	74	11	106	437	319	34	31	31	0	20	0	203	48	20	0	0	0	0	0	0	0	13,853
37	28	7	63	199	159	10	21	20	16	20	20	20	0	0	0	0	15	0	0	0	0	10,623
38	18	4	24	88	104	6	10	10	18	0	0	65	36	18	0	0	31	0	0	0	0	6,008
39	7	4	34	38	28	6	59	46	43	0	0	167	1,834	725	220	103	174	0	116	0	311	5,550
40	18	13	62	78	63	13	27	35	0	0	0	0	16	0	0	0	14	0	0	0	0	2,352
41	52	125	104	179	172	49	85	62	0	0	0	55	153	213	11	325	25	0	22	0	22	14,688
42	154	7	38	102	168	7	17	14	49	125	0	241	136	56	0	150	3,516	0	53	29	468	6,623
43		46	10	22	22	11	8	7	49	24	0	52	141	0	53	307	1,365	0	74	0	112	2,953
44			563	326	360	11	67	78	0	0	0	0	18	0	20	0	6	0	6	0	0	5,548
45				3,275	931	28	77	73	417	1,292	122	2,013	122	20	43	0	99	255	41	0	24	18,478
46					2,575	28	97	50	101	39	20	192	20	0	0	0	31	0	29	0	39	12,168
47						50	10	5	24	0	0	52	33	53	22	175	1,837	0	108	29	422	3,891
48							583	337	23	0	0	52	290	20	20	13	56	0	95	0	192	3,979
49								1,511	0	45	0	83	763	218	63	24	50	18	63	0	115	6,609
50									0	0	17	0	45	66	0	0	62	0	0	0	17	2,243
51										0	0	20	183	26	0	0	55	0	17	0	55	3,792
52											0	0	0	0	0	0	0	0	0	0	0	168
53												12	132	57	0	36	90	0	0	0	21	6,236
54													357	210	17	69	402	37	20	11	143	16,937
55														37	0	42	143	17	35	0	17	3,880
56															0	0	17	0	0	0	0	955
57																21	48	0	0	0	0	2,191
58																	10	62	45	0	0	10,223
59																		0	0	0	35	1,257
60																			0	0	17	1,128
61																				0	0	233
62																					20	3,058
																						534,820

G. PRIVATE PASSENGER TRAFFIC—1980

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
01	10357	5,966	1,680	1,076	598	776	538	300	563	178	548	135	99	2065	725	2475
02		10897	3072	6,759	7,156	2180	1,392	1081	1,110	329	752	641	181	2,109	1062	2365
03			7332	603	373	410	1,091	624	620	155	340	259	18	261	316	692
04				11,247	2980	1,607	512	608	467	182	231	309	95	927	493	784
05					5996	5,134	603	631	357	218	245	350	106	714	365	557
06						12762	455	949	587	659	407	885	276	1235	622	773
07							5,512	1,836	1,429	210	447	298	97	447	707	319
08								6290	1,686	609	612	455	230	559	265	356
09									4897	354	2,321	1022	746	657	281	403
10										3291	260	650	639	291	133	135
11											6,598	2318	286	603	253	335
12												13286	903	722	314	343
13													1,683	179	80	90
14														60,402	18,392	6521
15															16253	2,422
16																14,436

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
01	1,111	498	3282	636	655	522	161	232	104	356	932	771	1082	2267	777	771
02	2094	893	3510	1,412	1235	559	402	519	210	662	1,751	955	3203	3,746	636	808
03	543	211	630	318	321	265	87	326	60	199	617	403	983	524	223	416
04	1,190	456	3851	874	658	147	252	305	109	309	857	312	1036	487	188	238
05	1,191	378	4831	1312	795	451	431	423	123	314	939	249	762	328	132	168
06	1961	1099	3525	3991	1,372	951	2339	1,445	328	680	2206	427	1,151	189	200	276
07	493	216	682	316	293	238	88	140	62	161	616	319	500	258	120	266
08	741	361	1,056	582	600	376	167	266	108	291	1057	447	564	284	171	374
09	665	369	655	451	452	396	123	210	98	391	1000	660	676	337	246	598
10	354	288	323	335	252	270	132	251	90	211	832	207	258	122	74	143
11	531	498	451	549	355	519	169	316	137	398	1,383	1,532	882	515	321	1,280
12	794	927	553	1,186	640	862	405	739	281	672	2621	1,107	808	445	265	722
13	206	231	164	314	156	203	113	216	73	160	669	160	154	80	66	113
14	13084	2791	1824	1,128	5151	2002	300	454	227	883	2194	1,015	3981	1,742	735	713
15	13,149	1501	1011	708	3032	390	144	211	101	370	939	409	2908	623	258	269
16	2292	851	1681	827	1,170	727	174	246	111	369	1,011	538	19,132	1,518	547	459
17	37,655	5,769	3636	2310	17,374	2010	436	589	259	881	2,314	710	3325	925	399	447
18		26564	1,123	2776	5215	2003	504	951	316	857	2,587	546	1,383	445	211	283
19			10989	2615	1,712	682	486	556	193	529	1,527	469	2096	827	325	343
20				8,396	2005	1655	2,440	2,303	452	864	2941	517	1263	504	216	264
21					10,445	2515	323	600	209	760	1,841	514	1833	857	412	398
22						12830	351	624	391	2,027	3,137	629	1295	483	234	346
23							775	1634	161	251	939	117	269	115	49	83
24								1,555	522	552	1701	266	396	169	73	150
25									1,477	703	1,530	133	190	81	38	76
26										6,185	5,747	470	707	305	146	259
27											62378	1,438	1,798	774	403	781
28												8802	1373	771	469	1,473
29													24920	6,629	2142	1,526
30														12677	1242	1063
31															8949	390
32																11,315

	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
01	182	816	683	1,315	1,359	301	337	372	675	69	123	3,484	1,900	3,193	45
02	200	765	743	1,453	1,355	447	435	518	1,169	90	209	1,312	2,360	1,532	36
03	101	473	362	246	762	237	127	153	339	35	21	107	990	629	27
04	59	395	220	423	367	175	207	232	508	31	92	356	716	512	35
05	41	329	155	329	311	150	217	225	473	25	88	281	517	407	35
06	62	385	251	557	510	251	382	158	925	45	176	428	969	701	74
07	49	186	237	613	818	399	165	129	281	28	62	218	686	489	24
08	69	258	332	346	1096	540	168	202	434	39	95	253	962	685	38
09	101	329	512	1,453	1833	913	171	220	493	66	108	305	1,401	1267	42
10	28	90	129	293	298	150	91	137	288	20	66	115	431	330	28
11	98	342	1249	3671	783	631	173	283	617	39	139	444	2261	2111	55
12	81	249	710	1,667	650	368	270	141	927	91	211	414	1876	1,658	90
13	15	48	141	242	147	74	63	102	211	17	49	76	337	268	21
14	179	426	598	1,106	850	319	2232	1978	7373	120	343	3,568	2,751	1,256	118
15	64	185	245	463	363	137	741	616	871	46	136	552	1,029	694	49
16	120	309	364	700	681	188	386	427	875	66	139	1,128	1,464	885	49
17	108	298	414	776	640	318	2080	1,617	1,552	84	301	864	1,371	1,215	109
18	55	146	272	515	357	179	1,009	1,221	1,662	63	256	461	1,117	924	101
19	64	268	316	610	568	277	447	454	921	49	158	678	1,155	769	62
20	57	164	270	560	426	213	510	710	1,332	55	221	459	1,019	856	94
21	99	186	323	535	445	224	3100	1,701	1,575	62	231	868	1,474	868	85
22	64	167	326	623	426	223	801	1,922	5,965	80	596	508	1,359	1,098	150
23	15	43	78	167	112	56	99	153	300	15	59	105	261	239	27
24	24	69	146	308	202	102	175	281	578	27	165	160	503	428	48
25	13	35	71	146	97	49	83	144	329	14	76	80	267	223	36
26	48	125	244	472	321	168	339	749	3,094	59	704	309	1,009	819	175
27	139	368	748	1,508	990	507	804	1,305	3391	160	1,693	774	2808	2395	1200
28	144	459	1,415	3,536	896	619	286	368	865	665	189	699	3,426	6,539	70
29	409	570	1,133	1,560	1,091	337	872	939	1,649	139	265	4021	4,102	2,244	92
30	293	339	741	560	560	209	424	414	658	71	116	2211	2,355	1,214	41
31	3072	504	512	626	421	144	207	221	338	41	60	1,007	1,459	720	21
32	154	721	8931	4066	1217	434	215	244	462	87	97	766	5,337	1,931	35
33	2526	379	336	274	200	60	72	59	94	13	20	203	354	221	7
34		5,782	663	1,345	1,046	231	91	109	225	35	68	273	1,114	676	17
35			7,162	4099	1093	424	175	207	433	84	91	561	3,552	1,889	34
36				17,385	2246	1,168	272	351	801	176	132	780	1,417	4,362	64
37					16502	1,161	179	239	554	70	136	477	2,181	1,343	43
38						12069	92	126	294	43	60	185	956	885	22
39							2,883	2038	787	35	119	440	894	496	42
40								10,350	2229	49	204	473	973	651	70
41									16849	123	1634	694	1,973	1,554	195
42										48	25	70	305	396	8
43											698	123	424	337	73
44												1,470	2,764	1,131	42
45													21133	9,862	150
46														10,731	172
47															83

	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	T.E
01	129	119	305	260	195	658	1,019	308	101	62	252	123	61	22	22	68,411
02	164	221	223	115	28	479	625	294	123	39	332	24	109	26	245	149,178
03	53	70	132	203	22	330	332	77	34	45	273	89	11	11	22	38759
04	63	85	116	63	15	122	286	126	15	36	190	0	60	15	31	57,359
05	60	84	31	50	50	266	266	122	62	24	305	31	31	0	94	45,005
06	109	118	92	63	15	200	462	60	0	60	298	9	0	15	60	72,447
07	36	46	99	25	13	178	186	25	49	70	175	13	36	0	13	30,849
08	55	70	24	63	13	185	284	13	46	0	311	0	60	6	24	38,109
09	62	76	119	29	15	174	560	57	35	35	155	43	15	0	87	40,136
10	36	39	0	14	0	28	45	0	0	0	45	0	28	0	0	16,725
11	76	96	0	0	0	0	0	0	0	0	0	0	0	0	0	46,493
12	98	110	0	0	0	0	0	0	0	0	0	0	0	0	0	59,188
13	22	27	0	0	0	0	0	0	0	0	0	0	0	0	0	12078
14	601	949	17	120	34	274	731	252	70	10	134	50	101	37	168	219,505
15	203	321	34	34	17	155	252	57	67	21	115	34	17	0	17	92,309
16	139	188	155	136	17	382	592	160	69	28	339	34	69	17	115	89,241
17	352	623	388	204	64	458	2,015	504	101	147	566	113	290	62	290	176,258
18	234	337	15	15	0	15	153	76	0	13	13	0	0	15	15	98,995
19	122	169	218	234	15	374	608	146	31	104	508	15	83	0	88	74,853
20	135	190	0	0	0	15	88	0	0	64	91	0	0	15	15	62,710
21	379	679	0	18	0	18	298	73	18	25	0	18	36	18	36	87,418
22	266	326	36	36	43	306	1,138	293	125	76	388	18	125	18	192	70,696
23	29	39	63	63	13	301	350	126	45	108	427	0	0	0	74	18,115
24	53	69	0	0	0	0	38	7	17	0	38	0	0	0	0	23,533
25	29	35	92	63	45	326	545	105	84	167	1,319	45	90	15	39	15,096
26	136	153	21	10	10	21	0	0	8	0	0	10	10	0	20	47,746
27	307	357	15	0	0	15	73	0	13	104	451	0	0	0	13	194,302
28	134	158	17	17	0	17	80	0	46	0	14	0	0	0	0	52,918
29	328	456	169	182	32	449	449	140	49	32	52	32	17	0	32	143,000
30	151	218	0	0	0	17	17	0	0	10	0	0	0	0	0	63,961
31	77	108	0	17	0	0	0	0	0	0	0	0	0	0	0	38,024
32	85	115	134	115	32	446	164	77	29	20	77	32	48	0	0	64,583
33	21	28	35	0	0	0	0	0	0	0	0	0	0	0	0	11,460
34	39	50	46	43	0	120	29	43	0	0	69	14	0	0	0	27,774
35	74	97	392	167	29	559	332	71	14	11	69	43	29	0	71	52,544
36	119	151	29	0	0	46	38	15	0	24	46	0	15	0	43	88,758
37	78	98	99	28	14	42	45	28	0	28	45	14	0	0	0	65,224
38	36	45	53	43	15	98	202	87	15	0	137	0	0	0	15	39,853
39	411	420	15	69	15	248	4,445	491	113	134	312	153	150	15	269	36,229
40	344	321	0	0	0	17	32	0	0	10	13	0	0	0	48	45,294
41	365	374	0	14	41	62	113	55	22	116	105	0	14	0	32	82,765
42	18	20	14	14	14	67	14	27	0	22	55	0	0	0	41	4,382
43	60	60	62	35	18	0	20	14	0	53	291	18	0	0	0	12,309
44	206	309	0	0	0	0	11	0	0	0	6	0	0	0	0	35,041
45	393	483	518	238	92	434	203	46	15	0	49	77	0	0	0	121,936
46	242	277	31	64	0	64	83	31	15	13	25	31	0	0	0	83,905
47	20	21	0	0	0	0	67	27	0	32	174	27	0	0	67	4,641
48	491	741	29	29	29	29	728	49	29	10	13	15	50	27	29	10,000
49		2020	29	24	0	153	774	153	0	62	48	15	15	0	42	15,599
50			13	0	0	25	31	38	0	10	53	0	25	0	13	4,066
51				0	0	0	60	50	0	0	32	13	0	0	13	3,084
52					0	0	13	0	0	0	0	0	0	13	0	983
53						25	83	13	0	0	118	0	0	0	38	7,995
54							458	38	25	18	43	13	50	0	38	15,993
55								0	0	21	21	13	0	0	0	4,439
56									0	0	10	0	0	0	0	1,498
57										18	0	0	0	0	0	1,852
58											10	25	32	13	15	8,877
59												0	25	0	25	1,296
60													13	0	0	1,734
61														0	0	342
62															0	2,511
																3124086

II PUBLIC PASSENGER TRAFFIC–1980

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22
01	1050	2865	978	530	400	633	381	350	358	132	351	333	24	1417	529	1340	851	491	723	423	426	356
02		15863	1654	3039	1247	1359	878	777	713	237	325	501	132	1012	822	1476	1519	864	1933	883	780	621
03			2651	319	232	304	580	365	357	109	234	211	57	612	219	469	455	262	411	230	227	193
04				3513	1226	913	314	363	265	118	197	224	82	676	350	490	793	403	1610	473	374	270
05					2089	2017	258	371	227	134	172	246	69	552	276	375	795	449	1693	647	433	276
06						1434	308	554	354	346	280	543	355	921	454	528	1273	868	1625	1610	724	545
07							1891	826	633	129	270	216	62	375	171	211	395	229	413	214	197	162
08								2118	739	306	354	301	325	462	217	267	554	316	592	351	308	249
09									1564	186	923	335	323	186	213	276	474	318	382	270	266	244
10										518	154	337	284	232	105	118	262	239	197	211	353	164
11											2208	1005	145	479	204	239	444	428	298	329	252	318
12												4800	385	598	262	276	622	749	379	646	398	517
13													428	141	63	69	153	128	102	361	91	116
14														22946	7596	3408	6859	2239	1222	955	2519	1233
15															5806	1326	5733	3351	648	463	1393	197
16																5151	6477	736	945	515	662	162
17																	15012	3753	2012	1336	6199	1194
18																		13093	867	1618	2538	1295
19																			3832	1183	843	504
20																				2752	903	794
21																					3364	949
22																						4096

	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
01	120	153	71	426	611	476	2131	1201	483	500	126	473	472	872	841	258	237	267	459	102	190	693
02	269	319	137	750	1166	620	2001	1072	472	598	151	519	578	1037	973	412	316	372	753	139	311	708
03	67	88	43	248	430	265	659	319	171	286	71	288	272	505	501	399	302	123	246	56	115	231
04	160	165	84	326	525	204	654	312	144	181	46	143	176	312	276	154	140	157	312	48	130	220
05	220	211	73	333	563	374	515	231	109	137	35	302	333	256	239	134	146	157	300	42	121	169
06	827	599	168	672	1194	290	776	344	164	218	53	146	780	417	382	214	249	300	560	70	242	256
07	61	90	42	217	400	207	367	169	99	192	39	132	181	406	494	277	83	101	203	43	99	137
08	108	156	66	325	627	277	414	210	133	255	53	174	241	533	633	356	123	148	291	59	139	158
09	80	118	57	315	561	431	644	224	165	310	66	225	312	753	874	491	118	150	305	61	141	171
10	74	120	49	214	438	130	169	91	69	103	22	64	97	196	392	108	64	94	182	29	88	71
11	106	169	78	412	760	708	570	323	211	636	67	269	617	1606	472	382	123	193	385	119	183	239
12	227	354	148	616	1357	605	561	316	199	445	63	178	455	952	392	281	192	360	580	122	280	248
13	59	95	36	154	329	106	112	53	36	74	13	35	76	159	98	56	43	67	121	22	62	44
14	230	311	160	1049	1504	715	4316	1351	559	568	150	349	514	892	703	321	1228	1182	1387	192	511	676
15	109	143	71	444	650	295	1653	434	209	224	57	153	216	381	395	140	435	427	564	77	207	326
16	125	160	76	455	679	360	6930	848	364	333	91	223	288	515	434	126	260	297	560	87	207	559
17	266	373	171	5008	1515	525	2132	685	339	385	93	255	375	658	552	309	3124	976	1213	150	447	536
18	354	568	216	1072	1739	463	1162	419	223	288	62	157	289	535	374	210	695	857	1189	120	127	356
19	260	283	109	543	885	307	1210	501	238	255	56	190	248	444	410	230	226	293	547	34	217	360
20	851	799	202	767	1396	316	774	326	161	206	45	123	206	391	395	172	293	402	703	37	270	253
21	138	244	109	687	962	311	1015	486	260	263	69	133	232	371	331	175	1159	777	802	83	277	406
22	393	297	186	4068	1619	379	784	319	169	235	50	122	234	420	297	168	430	930	2465	106	609	276
23	267	490	73	235	463	93	188	84	41	64	13	35	63	123	88	49	67	101	181	22	76	66
24		465	178	428	720	150	249	112	55	89	16	49	95	193	134	36	102	155	276	35	120	86
25			351	463	559	78	125	56	29	50	10	25	50	95	67	38	50	84	174	20	84	55
26				5821	3759	482	788	357	188	301	63	155	297	540	382	217	351	710	2286	133	1093	301
27					16610	792	1151	318	294	505	102	258	507	944	657	371	477	742	1698	202	1485	430
28						2761	805	445	284	706	91	262	731	1562	522	373	386	245	518	519	239	362
29							9215	2860	1031	907	251	385	716	3033	760	369	533	596	1001	369	374	1613
30								4049	827	588	161	221	462	610	391	175	263	290	428	98	171	875
31									2745	442	427	281	329	414	298	126	141	157	227	60	95	449
32										3577	99	391	3063	1820	703	308	148	174	308	313	313	378
33											652	182	94	175	133	50	53	45	70	20	32	104
34												1253	370	705	567	172	70	85	162	49	76	155
35													2951	1894	669	312	133	160	305	112	141	308
36														6216	1253	731	204	262	536	214	231	131
37															5676	718	141	183	382	702	178	284
38																1277	80	105	217	66	101	132
39																	1033	857	455	52	158	224
40																		3313	1134	71	260	253
41																			5996	157	1421	372
42																				94	71	81
43																					437	148
44																						529

	45–62	T.E.
01–62	[illegible]	[illegible]
		1552382

I. GOODS TRAFFIC—1980

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21
01	2498	685	218	130	73	92	64	63	64	22	67	18	27	218	83	319	327	55	168	63	84
02		10122	374	780	253	252	160	128	137	11	99	11	46	245	119	321	235	94	459	193	162
03			2993	16	41	50	141	87	77	21	16	32	22	83	61	91	64	27	87	43	43
04				3265	391	228	62	80	53	24	39	35	25	97	57	99	141	50	556	125	91
05					1961	717	50	85	45	29	31	42	39	76	43	71	147	60	129	155	113
06						4058	56	129	70	91	55	105	80	133	73	98	239	127	508	608	195
07							1671	265	185	28	62	35	27	46	22	39	57	21	92	43	39
08								2079	231	90	91	57	71	62	32	46	92	43	154	85	71
09									1263	15	325	119	70	56	31	48	74	38	84	57	57
10										902	38	65	294	32	17	20	43	35	46	56	35
11											7198	301	94	69	32	45	73	62	64	81	56
12												3563	276	73	35	39	90	102	70	158	91
13													2296	43	21	25	56	62	49	102	48
14														14318	2203	780	1506	288	214	172	657
15															4819	335	1336	171	132	95	433
16																3889	787	95	238	115	166
17																	9926	682	494	318	2636
18																		6845	139	375	720
19																			3445	414	262
20																				2282	311
21																					3528

	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
01	61	6	34	11	48	23	94	532	300	85	90	22	99	88	166	161	39	34	43	80	87
02	131	15	81	24	99	189	125	469	214	66	87	24	85	92	169	137	49	[illegible]	[illegible]	[illegible]	[illegible]
03	35	3	20	7	29	69	53	130	67	25	50	13	60	45	97	92	32	[illegible]	[illegible]	[illegible]	[illegible]
04	62	11	49	13	46	95	41	133	60	26	27	7	22	28	50	39	21	[illegible]	[illegible]	[illegible]	[illegible]
05	61	18	70	15	46	106	32	98	41	14	20	6	15	20	39	35	20	[illegible]	[illegible]	[illegible]	[illegible]
06	132	97	219	39	102	255	55	147	59	21	31	7	21	32	67	57	32	[illegible]	[illegible]	[illegible]	[illegible]
07	31	3	22	7	27	69	41	63	31	13	31	6	22	31	77	98	55	[illegible]	[illegible]	[illegible]	[illegible]
08	63	7	45	13	45	126	60	74	36	20	48	8	34	46	113	145	81	[illegible]	[illegible]	[illegible]	[illegible]
09	48	4	31	10	39	105	104	80	38	27	70	13	18	66	181	228	233	[illegible]	[illegible]	[illegible]	[illegible]
10	36	6	47	11	31	99	27	34	15	8	16	4	11	57	38	39	22	[illegible]	[illegible]	[illegible]	[illegible]
11	70	7	53	17	59	168	214	120	69	39	179	11	46	190	550	100	101	18	32	78	140
12	106	15	113	51	91	290	133	95	52	28	84	10	29	91	207	61	53	27	46	108	132
13	64	11	83	20	55	183	56	63	22	11	31	4	13	34	70	41	24	15	28	61	52
14	238	10	67	22	111	213	101	919	192	71	73	20	45	61	118	85	36	221	209	246	140
15	104	6	31	11	52	99	49	317	74	27	29	7	21	29	55	39	17	80	78	109	60
16	97	7	38	13	55	112	67	2863	197	63	55	15	38	48	81	70	25	41	49	113	74
17	266	15	91	28	123	249	85	419	109	42	45	13	34	50	90	71	41	228	188	245	106
18	259	20	144	34	136	267	63	161	49	21	29	6	15	31	69	38	22	104	136	202	76
19	177	21	97	24	83	383	63	295	131	38	42	11	34	43	80	70	41	52	55	126	70
20	241	120	435	57	134	372	69	175	67	25	36	8	21	38	76	56	34	59	87	175	76
21	304	14	85	25	113	224	66	255	116	50	52	14	24	45	71	59	35	385	213	206	83
22	3592	14	101	13	1043	436	73	167	60	28	43	8	21	45	81	57	35	83	207	656	94
23		21	91	6	11	35	6	11	4	1	3	0	1	3	1	4	3	3	6	11	6
24			657	78	98	248	39	62	35	10	22	4	10	24	46	31	16	22	38	78	61
25				344	90	164	14	21	8	4	8	1	4	8	17	11	7	7	14	34	15
26					2046	792	60	98	41	18	36	7	18	36	67	46	29	36	85	374	76
27						14174	158	199	83	39	83	15	39	87	168	108	64	74	132	385	182
28							2388	174	95	56	195	18	60	202	491	119	99	28	36	92	890
29								6973	916	263	193	55	71	155	200	136	50	94	106	203	182
30									3703	213	132	39	42	99	120	67	28	45	49	76	92
31										2496	88	141	57	63	71	45	17	20	24	36	50
32											3125	20	88	1345	539	143	57	22	27	57	119
33												689	57	18	36	25	8	8	7	11	17
34													1677	87	175	126	31	10	13	28	46
35														2054	603	314	64	20	24	56	122
36															4838	283	171	28	39	101	216
37																4092	150	18	28	74	98
38																	3402	11	17	46	73
39																		535	195	74	35
40																			2185	210	49
41																				3518	130
42																					1263

	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	T.R
01	13	185	185	164	28	32	39	164	215	0	525	665	281	20	60	352	151	81	20	62	13867
02	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	25467
03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7935
04	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11206
05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8854
06	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14353
07	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6183
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14	35	174	242	213	71	148	206	29	186	0	186	993	384	63	52	222	57	63	29	164	12486
15	15	67	99	95	32	55	76	29	29	29	50	360	141	0	41	114	0	63	0	35	17651
16	15	147	143	125	34	38	43	90	188	0	339	480	165	29	64	116	90	0	0	28	12763
17	31	102	169	164	73	106	146	83	27	27	111	640	281	17	108	137	27	18	27	209	34357
18	28	52	101	139	66	59	74	27	0	0	0	0	0	0	0	0	0	0	0	0	19319
19	20	91	123	136	46	35	12	0	27	0	90	176	78	27	50	105	0	0	0	52	14594
20	27	60	106	127	70	39	46	0	0	0	63	45	32	0	17	48	0	0	0	0	12234
21	28	116	154	129	62	109	171	0	0	0	0	217	28	31	18	0	0	0	0	0	16821
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23	3	4	8	10	6	3	3	141	134	25	377	1296	52	134	92	427	50	0	0	77	3529
24	14	24	59	71	39	17	18	0	0	0	0	27	0	0	0	20	9	0	0	0	4569
25	7	6	22	26	21	6	7	27	109	0	80	371	52	0	98	318	55	31	0	46	2957
26	90	41	102	116	127	35	32	0	18	0	0	18	0	0	9	15	0	18	0	38	9305
27	186	83	252	297	808	70	70	0	27	0	0	122	63	0	48	456	0	0	0	0	37871
28	20	84	332	935	43	31	31	29	60	60	31	49	0	0	0	31	57	29	0	49	11209
29	29	542	419	319	62	87	105	175	557	0	176	234	81	0	31	22	28	26	25	50	27724
30	13	291	237	169	27	41	49	0	0	0	0	0	0	0	0	0	0	0	0	0	12388
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34	6	34	155	98	11	10	11	25	0	0	0	0	63	0	0	20	0	0	0	0	5153
35	11	76	163	298	24	21	24	181	129	25	111	272	99	75	28	20	129	0	0	0	10324
36	20	98	470	671	45	32	35	0	25	0	267	63	25	0	0	0	0	0	0	0	17361
37	14	59	231	202	31	22	24	101	0	25	25	0	0	0	0	20	0	0	0	0	13781
38	8	27	119	160	18	13	13	25	0	0	85	50	25	0	0	43	0	0	0	0	9284
39	11	45	63	53	22	90	77	55	0	0	221	2437	959	296	134	232	0	155	0	414	8635
40	20	50	77	77	38	71	56	0	0	0	0	27	0	0	0	18	0	0	0	0	7533
41	176	80	168	183	113	76	66	0	57	0	71	195	280	11	416	34	0	28	0	28	11192
42	78	88	298	556	56	43	51	69	181	0	336	190	78	0	265	5029	0	74	41	651	11701
43	109	13	35	39	45	13	11	69	34	0	81	196	0	71	427	1897	0	34	0	355	4464
44		385	274	153	27	52	69	0	0	0	0	24	0	27	0	0	0	0	0	0	4931
45			3385	1099	74	74	78	637	2033	165	3301	165	27	59	0	136	459	56	0	32	22280
46				3451	81	62	62	136	53	27	272	27	0	0	0	42	0	27	0	53	16680
47					637	21	22	34	0	0	71	162	74	38	242	2544	0	150	41	592	7948
48						525	335	27	0	0	63	353	24	24	17	69	0	116	0	234	4270
49							1642	0	63	0	116	1033	307	90	35	71	27	116	0	162	7769
50								0	0	24	0	70	92	6	0	60	0	0	0	21	3080
51									0	0	28	260	52	0	0	77	0	24	0	77	5373
52										0	0	0	0	0	0	0	0	0	0	0	619
53											21	186	95	0	52	127	0	0	0	31	6708
54												519	297	24	98	144	24	28	59	202	14778
55													24	0	60	202	24	21	0	24	5260
56														0	0	24	0	0	0	0	1309
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60																		0	0	24	1506
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J. PRIVATE PASSENGER TRAFFIC–1990

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01	11554	2349	1876	3436	801	1036	659	605	749	232	678	563	133	2221	996	3415
02		65286	3961	10650	3392	3420	2020	3543	1833	508	1158	983	281	3854	1737	3823
03			8224	813	435	550	1314	356	826	209	444	350	105	1013	475	963
04				16084	4721	2897	759	985	714	287	459	486	153	1516	811	1295
05					9614	8218	595	918	585	347	355	549	174	1169	601	921
06						20101	669	1376	928	1037	638	1354	442	2022	1022	1277
07							2539	2147	2092	301	643	427	141	664	304	483
08								8249	2435	861	868	643	333	829	393	532
09									2774	553	3626	1590	393	1065	466	665
10										5037	399	993	1315	468	213	251
11											10454	3339	448	972	410	565
12												20304	1435	1161	507	554
13													2705	295	137	150
14														101452	30632	11040
15															27439	4310
16																24636

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01	1487	661	3326	851	918	725	221	316	139	473	1245	3068	5572	3247	1058	1054
02	3276	3397	5452	2232	2034	1568	630	832	330	1039	2221	1517	5124	2810	1018	1296
03	725	323	853	426	418	363	116	371	81	262	822	552	1310	717	304	568
04	3904	734	6223	3407	1107	748	439	495	375	496	1392	518	1695	892	307	391
05	3954	844	2395	2111	1337	755	689	690	204	503	1509	413	1246	539	286	274
06	3135	1756	5680	6413	2307	3590	3417	2360	576	1092	3543	706	1880	802	325	451
07	722	335	1009	468	449	361	130	210	91	265	903	483	749	388	181	400
08	1072	531	1513	846	760	568	241	392	157	420	1530	665	974	423	232	553
09	1061	533	1054	721	157	659	196	343	157	480	1597	1443	1103	553	402	976
10	554	451	511	596	416	442	206	400	161	332	1305	335	412	195	119	228
11	899	781	714	865	652	851	266	507	217	626	2172	2419	1415	830	514	2055
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13	330	370	263	505	259	340	181	351	116	256	1078	308	252	132	76	186
14	21449	4582	3007	2355	8890	3451	491	760	374	1460	3522	1723	13381	2907	1228	1194
15	21516	7470	3622	3172	5250	3364	237	354	167	613	1555	691	4881	1054	431	452
16	3788	1408	2799	3375	2037	1260	267	417	165	647	1681	921	32331	2580	924	770
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21					18512	3737	545	861	353	1287	3116	895	3156	1484	706	653
22						27537	589	1068	659	11830	5789	1086	2205	833	399	591
23							1155	2670	759	402	1509	242	440	189	80	134
24								2598	858	904	2792	449	662	286	122	252
25									2390	4135	2472	221	312	134	62	125
26										9982	9281	781	1162	503	238	420
27											10169	2377	2958	1280	661	1285
28												15025	2325	1313	791	2452
29													41688	11151	3574	2552
30														21442	2922	1788
31															11903	1317
32																18930

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04	97	315	346	672	580	271	330	370	774	48	141	605	1259	825	53	97
05	69	204	244	524	490	239	346	358	722	39	136	427	935	657	63	92
06	102	293	392	874	802	396	610	727	1411	67	273	650	1567	1127	112	167
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10	45	139	196	454	469	232	143	214	431	29	98	169	692	319	41	53
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14	304	694	959	1796	1368	517	3664	3242	3422	188	345	2441	4575	2899	182	911
15	109	300	395	755	582	221	1218	1112	1373	73	217	862	1715	1151	74	321
16	206	504	591	1147	944	307	636	708	1385	88	220	1772	2454	1423	77	220
17	179	470	648	1231	1007	503	3331	2582	3000	127	466	3313	2873	1939	167	610
18	90	230	424	867	563	284	1616	1946	2547	95	395	700	1809	1497	153	357
19	140	423	500	976	900	441	718	727	1415	74	245	1037	1883	1246	94	388
20	97	260	424	892	672	339	819	1137	2015	83	342	701	1658	1387	144	213
21	174	309	532	892	736	372	5227	2858	2541	98	374	1389	2514	1504	136	610
22	113	274	635	1032	699	368	1344	3213	9594	126	565	868	2302	1847	238	426
23	25	69	123	263	176	88	158	251	458	27	91	160	456	385	41	46
24	42	111	232	500	323	164	286	456	826	41	165	248	832	703	73	83
25	21	56	112	232	153	78	133	231	505	22	118	120	434	360	56	45
26	80	197	382	748	504	266	545	1198	1530	90	1093	473	1639	1320	266	210
27	230	584	1175	2397	1560	804	1292	2089	5219	264	2622	1183	4695	3868	1833	472
28	246	750	2292	5789	1456	1014	477	606	1368	3039	303	1096	5725	10851	109	231
29	693	920	1816	2521	1751	578	1428	1533	2583	214	419	6254	6346	5693	144	337
30	500	550	1193	1585	897	339	699	728	1035	112	183	3454	3920	2006	81	262
31	1813	812	819	1011	679	231	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
32	260	1165	14316	6594	1957	703	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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01	241	419	356	265	897	1392	421	111	85	313	168	91	31	31		86819
02	356	333	171	42	788	253	437	185	59	264	129	152	42	365		230981
03	94	153	281	29	451	426	105	45	50	371	106	15	15	29		48128
04	137	176	95	22	186	437	192	22	59	291	0	91	22	46		91439
05	136	46	119	115	465	471	228	100	30	574	46	16	0	186		72187
06	241	141	95	22	305	706	91	0	91	435	0	0	22	91		115496
07	67	141	35	17	252	265	35	69	26	249	13	52	0	17		43318
08	102	34	88	17	262	402	17	61	0	440	0	85	3	32		53081
09	122	179	43	22	262	438	87	57	52	235	66	22	0	130		69565
10	62	0	21	0	42	66	0	0	0	66	0	42	0	0		28874
11	155	0	0	0	0	0	0	0	0	0	0	0	0	0		37185
12	186	0	0	0	0	0	0	0	0	0	0	0	0	0		91441
13	43	0	0	0	0	0	0	0	0	0	0	0	0	0		19248
14	1583	27	190	53	354	1159	398	111	15	211	80	358	27	265		365233
15	536	53	53	27	245	399	106	106	32	191	53	27	0	27		153989
16	314	246	214	27	606	949	252	108	43	536	53	108	27	182		149114
17	3012	598	315	59	706	3105	776	155	225	871	174	447	94	443		283931
18	549	24	24	0	24	234	116	0	18	18	0	0	24	24		158814
19	277	332	360	24	575	935	224	40	160	781	24	126	0	136		180311
20	309	0	0	0	24	136	0	0	98	140	0	0	24	24		101050
21	3161	0	29	0	29	480	118	29	41	0	29	59	29	59		149184
22	554	57	57	69	171	1827	469	200	126	623	28	200	28	398		170927
23	63	95	95	22	111	596	192	69	83	682	0	0	0	113		28672
24	113	0	0	0	0	59	10	25	0	59	0	0	0	0		38494
25	57	161	95	69	483	896	160	121	255	1974	69	137	22	59		24063
26	249	27	13	13	27	0	0	10	0	0	13	13	0	25		77005
27	581	24	0	0	24	112	0	18	160	694	0	0	0	18		312798
28	265	87	22	0	27	125	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		56243
29	757	265	286	50	204	704	220	22	50	81	50	25	0	50		235944
30	365	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		105869
31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		62564
32	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		105820
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38	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		62559
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42	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		6815
43	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		18645
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45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		202132
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52				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		1496
53					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		12130
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55							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		6242
56								[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		2268
57									[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		2662
58										[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		13374
59											[illegible]	[illegible]	[illegible]	[illegible]		1521
60												[illegible]	[illegible]	[illegible]		2636
61													[illegible]	[illegible]		583
62														[illegible]		3861
																6973731

K. PUBLIC PASSENGER TRAFFIC—1990

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
01	2178	2729	463	612	389	519	305	290	344	123	330	342	73	1,438	539	1,376	834	405	262	437
02		10,665	1672	4,308	1,672	1,820	1014	826	945	303	680	615	176	2521	1351	2083	2117	981	2621	1197
03			2022	386	239	311	514	323	360	108	231	207	59	650	297	503	466	225	431	231
04				4,813	1,687	1,256	374	423	360	155	263	295	85	967	503	713	1,095	470	2241	668
05					2890	2,367	309	434	309	319	231	328	95	794	399	547	1,102	526	2654	906
06						6,314	368	648	454	461	375	722	216	1,374	657	770	1,761	1,015	2269	2337
07							1,974	840	750	548	312	248	78	469	214	304	473	225	501	259
08								2160	855	339	400	344	147	563	266	332	651	362	701	416
09									2,117	244	1221	703	169	692	307	398	654	368	528	374
10										3,173	491	431	378	323	147	165	349	269	266	284
11											7853	1,292	195	668	281	353	595	481	405	445
12												5,622	514	830	365	398	829	841	510	872
13													596	206	97	98	211	209	144	225
14														34,674	11,065	5,583	9908	2,333	1,761	1,394
15															8,803	2027	8,327	1,417	949	690
16																7,938	2,162	911	1,394	764
17																	20,860	4,403	2880	1,816
18																		12,951	1,028	1953
19																			5,421	1,661
20																				3905

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
01	457	389	116	155	63	245	243	487	2152	1226	482	501	130	452	444	836	193	246
02	1341	927	358	414	128	591	1854	875	2279	1505	654	823	221	682	746	1,868	1270	538
03	257	238	69	92	43	148	521	284	697	372	181	204	81	288	267	508	498	397
04	561	416	206	235	85	265	860	297	934	451	204	256	69	192	231	423	370	267
05	654	427	302	305	98	273	925	253	739	335	155	195	52	137	178	349	323	181
06	1092	840	1134	861	224	549	1966	423	1,112	496	236	333	78	197	280	567	634	288
07	259	223	77	312	48	153	671	262	456	237	123	237	50	155	210	479	578	323
08	393	325	175	183	74	224	874	343	503	258	162	307	66	199	272	615	731	406
09	398	322	108	169	76	255	920	622	631	321	235	479	97	302	413	1015	1,862	654
10	221	244	99	167	62	169	696	102	260	127	81	137	34	83	123	256	249	140
11	368	476	141	235	102	326	1215	998	792	455	298	876	97	273	836	2114	615	498
12	578	767	298	490	192	533	2159	847	801	441	273	609	90	231	584	1,246	605	367
13	139	161	61	137	49	127	545	155	161	84	52	106	18	48	101	204	133	74
14	3969	1594	329	466	224	897	2593	1089	6450	1749	834	843	231	491	714	1,266	990	448
15	2205	808	157	216	99	381	1,126	451	2485	561	312	335	88	216	302	543	431	197
16	1056	755	381	242	106	395	1,181	554	10594	1301	556	501	141	318	407	761	617	249
17	9391	1859	393	536	230	829	2509	769	3062	995	456	549	146	316	503	899	742	411
18	3371	1688	417	692	248	742	2426	521	1433	514	269	347	77	179	326	616	426	239
19	1288	788	363	412	148	449	1476	452	1756	745	340	366	98	260	335	612	557	312
20	1,382	3243	1183	1166	274	637	2337	468	1826	482	232	297	70	168	277	638	416	234
21	5222	1604	266	384	161	616	1737	496	1592	771	407	409	112	196	339	552	456	258
22		7088	295	477	279	3,716	2989	617	1260	518	232	374	83	183	349	698	415	252
23			365	701	97	192	760	139	269	120	59	90	20	48	84	165	118	66
24				697	248	365	1240	227	372	169	83	147	29	70	139	274	189	106
25					455	368	945	112	174	78	41	70	14	31	66	126	67	49
26						2853	3737	417	672	307	160	253	65	125	235	435	304	172
27							32966	1382	1,975	899	503	858	181	414	806	1533	1,051	594
28								4243	1219	682	428	1,060	141	374	1,000	2241	739	525
29									13,735	4309	1684	1340	385	542	1035	1,460	1,061	433
30										6854	1215	676	259	316	647	872	550	246
31											4078	654	652	399	455	585	416	175
32												5237	353	545	1239	2549	972	427
33													1030	262	134	255	192	73
34														2323	483	939	746	227
35															3,468	2,491	868	406
36																8,334	1,650	959
37																	7,478	941
38																		5,604

	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53
01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
02	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
04	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
06	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
07	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
08	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
09	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
32	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
33	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
34	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
36	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
37	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
38	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
39	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
40		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
41			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
42				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
43					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
44						[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
45							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
46								[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
47									[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
48										[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
49											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
50												[illegible]	[illegible]	[illegible]	[illegible]
51													[illegible]	[illegible]	[illegible]
52														[illegible]	[illegible]
53															[illegible]

	54	55	56	57	58	59	60	61	62		T, E
01	3298	0	48	91	53	45	48	0	48		36,286
02	220	43	307	18	280	0	43	0	671		96,879
03	218	0	0	0	209	0	9	0	0		20,396
04	2275	0	0	0	321	0	253	56	0		38,359
05	131	0	0	0	255	0	0	0	56		30,210
06	277	28	0	22	90	0	0	0	0		48,437
07	45	0	0	0	41	0	0	0	0		18,159
08	101	25	0	0	39	0	0	0	0		22,392
09	84	0	0	0	22	0	0	0	0		26,253
10	0	0	0	0	0	0	0	0	21		12,306
11	0	0	0	0	0	0	0	0	0		30,274
12	0	0	0	0	0	0	0	0	0		38,356
13	0	0	0	0	0	0	0	0	0		8082
14	269	0	0	0	24	0	0	31	0		153,371
15	134	0	0	0	24	0	0	0	91		64,578
16	312	60	0	60	24	50	0	0	0		62,576
17	918	115	0	41	46	28	0	0	0		119,105
18	28	0	0	0	22	0	0	0	0		66,603
19	274	28	0	22	69	28	0	0	0		50,470
20	0	0	0	0	22	0	0	0	0		42,379
21	953	318	573	426	0	0	318	190	1081		62,583
22	125	0	25	85	50	0	0	0	31		54,494
23	0	0	28	22	112	0	0	0	0		12,306
24	29	0	0	0	48	0	0	0	0		16,331
25	225	0	22	532	1,613	0	0	0	28		10,079
26	22	0	0	18	18	0	0	0	0		32,298
27	0	0	0	0	135	0	0	0	0		131,220
28	0	0	0	0	0	0	0	0	0		40,354
29	63	29	48	0	0	0	0	0	59		96,907
30	0	0	0	0	0	0	0	0	0		44,411
31	0	0	0	0	0	0	0	0	0		26,245
32	223	0	0	0	24	669	29	0	29		44,419
33	0	0	0	0	0	0	0	0	0		8087
34	0	0	0	0	0	0	0	0	0		15,163
35	0	28	0	22	0	28	0	0	0		34,308
36	22	0	0	0	0	0	0	0	0		58,521
37	0	0	0	0	0	0	0	0	0		42,383
38	433	0	0	0	88	0	0	0	0		26,248
39	1837	84	0	78	22	84	56	0	309		24,225
40	57	0	0	0	0	0	0	0	0		32,303
41	0	27	0	74	32	0	0	0	0		57,466
42	25	0	0	0	0	0	0	0	32		6,156
43	0	32	0	108	50	0	0	0	0		23,026
44	0	0	0	0	0	0	0	0	0		22,160
45	0	0	0	0	0	0	0	0	0		84,766
46	22	0	0	0	0	0	0	0	0		56,516
47	32	0	0	0	50	0	0	0	0		8638
48	239	108	0	0	0	0	0	0	0		12,006
49	139	29	0	0	42	0	0	0	0		19,944
50	43	0	0	0	0	0	0	0	0		2,282
51	123	0	0	115	0	0	0	0	0		2,049
52	0	0	0	0	0	0	0	0	0		396
53	41	83	83	0	0	0	0	0	41		4,347
54	574	0	0	0	83	0	0	0	0		14,180
55		0	0	83	83	0	0	0	0		1,203
56			0	0	0	0	0	0	0		1,334
57				49	0	0	0	0	0		1,898
58					0	0	0	0	0		3,971
59						0	0	0	0		945
60							41	0	0		879
61								0	0		277
62									66		2,635
											2,126,228

I GOODS TRAFFIC—1990

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
01	2911	819	771	164	90	115	73	30	80	27	81	57	36	279	109	409	157	64	220	102
02		11683	446	1355	374	374	720	182	206	59	147	101	76	362	179	445	344	137	687	286
03			7044	95	50	61	167	97	97	24	57	38	31	195	53	115	80	34	108	53
04				4655	592	346	87	111	83	35	60	53	43	150	86	155	233	79	856	189
05					2971	1055	70	119	67	43	50	62	50	119	67	112	221	91	1113	295
06						6048	37	116	100	133	83	155	136	206	115	153	363	194	373	924
07							2048	330	256	36	85	46	42	64	32	56	78	34	127	59
08								2565	310	119	122	76	111	87	16	66	127	59	214	116
09									3917	67	190	176	120	104	50	76	115	57	130	88
10										1285	55	122	490	49	25	31	64	50	67	81
11											3270	441	160	108	50	70	141	92	99	122
12												5166	455	112	53	60	133	151	104	235
13													4437	27	38	45	95	106	84	178
14														22915	3534	1260	2351	449	336	270
15															7750	530	2217	269	207	148
16																6341	452	154	329	183
17																	15302	1036	755	186
18																		10375	711	571
19																			5269	636
20																				6260

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
01	109	81	8	43	14	57	119	122	668	378	109	115	26	122	108	141	186	43	28	55
02	258	203	25	132	35	146	279	191	612	322	92	139	35	126	136	179	195	66	45	104
03	56	43	4	24	6	35	84	69	362	84	31	61	17	74	69	81	109	36	11	24
04	146	98	18	77	20	70	146	66	206	92	31	41	11	31	42	53	56	29	22	18
05	181	98	31	109	22	71	162	52	151	63	21	29	8	22	29	42	50	27	24	46
06	311	209	164	365	60	157	380	88	227	92	32	49	11	32	48	70	83	43	42	94
07	56	45	6	33	10	35	94	60	88	43	18	40	8	31	42	73	227	61	19	22
08	104	74	11	62	18	60	172	87	104	50	27	66	13	45	63	105	185	99	17	36
09	91	74	7	48	15	59	161	167	125	60	41	133	20	71	93	185	325	178	11	36
10	55	56	10	64	15	46	148	42	49	22	13	27	6	17	25	38	53	28	10	27
11	88	109	13	85	25	88	255	342	185	106	62	279	21	69	284	550	151	137	18	56
12	127	165	27	112	46	134	434	211	114	77	42	129	14	42	133	204	88	69	25	78
13	87	119	21	347	35	98	321	101	76	38	20	55	8	22	56	81	63	34	18	56
14	1065	393	18	93	35	176	337	188	1513	307	113	116	31	69	104	125	125	49	231	358
15	218	171	30	50	17	83	158	81	602	139	43	48	13	32	46	57	57	22	84	141
16	273	160	13	62	20	88	178	115	4602	337	101	88	25	59	74	94	102	35	43	88
17	1235	171	27	344	43	189	384	139	650	169	61	77	20	50	76	92	99	53	231	328
18	1154	113	32	224	52	179	412	102	219	77	37	46	10	22	48	62	53	28	103	238
19	621	203	36	151	36	126	281	104	459	174	59	67	17	50	66	84	101	53	52	98
20	503	385	206	679	90	206	575	112	273	105	41	57	13	32	57	77	80	43	59	153
21	5969	512	25	140	41	185	363	113	119	190	85	84	22	38	71	26	82	48	417	393
22		6006	25	164	71	1674	623	123	272	99	46	71	14	34	69	83	84	16	90	379
23			39	162	10	20	59	10	18	7	3	6	1	3	6	7	7	4	4	11
24				1043	125	153	389	66	97	41	15	35	6	15	36	49	45	24	22	67
25					502	149	256	22	32	14	6	13	3	6	13	17	15	8	7	24
26						3151	1232	97	154	64	29	56	11	27	53	66	65	38	38	150
27							27074	259	312	439	62	130	24	59	130	171	153	84	27	234
28								4099	286	160	92	325	32	95	321	515	179	131	29	67
29									13010	1435	414	307	68	109	237	207	193	69	97	189
30										5900	337	291	62	83	153	126	97	38	46	87
31											3924	141	227	88	97	76	64	24	21	42
32												5019	31	136	2082	575	209	78	82	49
33													1020	80	29	38	36	11	8	13
34														2484	130	179	178	41	10	21
35															3053	613	203	85	18	41
36																3328	279	160	18	43
37																	6152	192	35	45
38																		4176	10	25
39																			3654	238
40																				1400

	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	T.R
01	101	67	20	290	251	200	4	49	50	211	316	0	808	658	363	25	27	235	195	105	25	80	15989
02	248	115	45	314	107	310	10	85	82	0	141	35	286	230	207	76	111	286	35	76	76	231	52641
03	55	36	13	81	139	112	3	21	21	155	190	77	127	391	101	0	41	83	102	101	0	0	8881
04	111	41	21	98	137	116	1	34	34	78	156	0	127	195	163	0	165	137	0	38	38	0	16871
05	102	34	20	69	99	91	1	32	32	0	0	0	78	274	38	29	29	308	38	0	0	186	33314
06	192	57	39	102	165	154	10	56	51	0	0	0	77	76	36	0	0	0	38	0	0	0	21319
07	52	31	13	46	106	97	3	17	15	0	60	29	148	223	0	0	0	125	29	0	0	57	7993
08	83	46	20	56	155	141	1	25	24	0	29	0	29	0	28	0	0	72	0	28	0	0	9772
09	88	77	21	67	223	255	6	27	25	448	188	112	259	427	36	21	130	396	151	0	0	80	11550
10	57	25	14	27	73	70	1	17	14	0	0	0	34	0	0	0	28	28	0	0	0	35	5324
11	123	133	31	111	409	493	8	38	36	0	0	0	0	0	0	0	0	0	0	0	0	0	13324
12	168	105	12	90	291	332	11	42	38	23	0	0	69	69	0	0	21	26	0	0	0	111	10856
13	120	57	29	46	151	171	8	29	27	0	0	0	0	0	0	0	0	0	0	0	0	0	13354
14	410	139	65	346	426	346	11	288	347	43	281	0	281	1495	580	130	78	342	87	95	43	246	67504
15	185	60	29	133	175	151	7	108	129	43	43	43	91	242	213	0	60	217	0	95	0	52	28418
16	186	74	31	294	260	200	7	73	74	136	284	0	498	727	249	43	97	175	136	0	0	43	27586
17	399	102	61	399	288	253	14	203	239	120	39	39	168	938	413	112	156	641	39	27	39	395	52386
18	328	73	53	99	172	183	13	111	122	38	0	0	0	0	0	0	0	0	0	0	0	0	29311
19	204	67	36	176	219	179	8	67	70	0	38	0	130	259	115	36	73	154	0	0	0	22	22201
20	289	73	57	116	181	196	14	73	76	0	0	0	91	55	46	0	24	70	0	0	0	0	18654
21	354	84	56	236	276	209	13	215	295	0	0	0	0	335	43	48	28	0	0	0	0	0	21533
22	1172	95	131	123	221	225	21	120	112	0	0	45	66	564	372	102	28	224	46	116	0	115	23972
23	21	7	4	8	15	18	1	6	6	206	195	38	547	1887	76	195	134	622	78	0	0	112	5329
24	129	41	28	46	102	112	8	31	31	0	0	0	0	41	0	0	0	28	0	0	0	0	7101
25	55	15	14	15	38	41	4	11	10	38	158	0	116	539	76	0	143	462	78	45	0	67	4418
26	606	74	169	76	172	176	27	64	53	0	22	0	0	22	0	0	0	38	0	22	0	45	14206
27	631	179	358	161	433	461	164	133	116	0	39	0	0	178	92	0	70	659	0	0	0	0	57,737
28	152	920	35	372	594	1511	10	62	55	43	90	90	56	73	0	0	0	108	85	43	0	73	17,760
29	335	179	51	1068	227	500	13	167	175	263	833	0	263	350	320	0	46	34	42	42	38	76	43512
30	130	91	25	575	410	265	6	77	83	0	0	0	0	0	0	0	0	0	0	0	0	0	19,539
31	62	49	13	239	242	150	3	36	39	0	0	0	0	0	0	0	0	0	0	0	0	0	21,545
32	95	116	21	190	1004	418	4	43	43	172	179	0	427	102	81	28	25	32	204	0	0	81	19534
33	20	17	4	53	64	52	1	11	11	0	0	0	0	0	0	0	0	0	0	0	0	0	3550
34	15	43	10	64	192	148	3	20	18	35	0	0	0	0	90	0	0	28	0	0	0	0	2,997
35	83	115	20	143	672	449	6	38	36	258	183	35	258	389	141	35	39	28	183	0	0	0	15101
36	101	153	24	125	515	661	6	36	36	0	36	0	385	91	36	0	0	0	0	0	0	0	14554
37	108	85	24	105	363	284	6	38	35	143	0	35	35	0	0	0	0	28	0	0	0	0	18654
38	63	59	14	43	172	205	3	20	18	36	0	0	122	71	36	0	0	82	0	0	0	0	11543
39	87	22	16	57	71	55	3	133	85	78	0	0	322	3549	1396	428	195	337	0	225	0	603	10632
40	388	55	41	313	248	123	10	150	104	0	0	0	0	38	0	0	0	27	0	0	0	0	21913
41	5926	136	347	109	292	293	27	146	112	0	80	0	99	273	392	20	534	46	0	35	0	39	21689
42		791	34	166	323	542	7	52	42	108	286	0	532	301	123	0	420	2979	0	358	64	1032	12596
43			255	31	74	74	11	29	22	108	55	0	329	311	0	138	676	3909	0	53	0	246	2565
44				936	555	294	2	122	140	0	0	0	0	34	0	36	0	0	0	0	0	0	5269
45					5294	1847	37	150	139	834	2583	244	4203	264	35	87	0	200	573	83	0	48	35906
46						5235	18	115	93	199	77	38	358	35	0	0	0	62	0	38	0	37	24267
47							18	6	6	53	0	0	112	361	118	59	396	4032	0	237	64	938	6761
48								1368	658	33	0	0	92	517	35	35	24	101	0	169	0	313	7258
49									2869	0	92	0	159	1575	449	130	50	104	38	169	0	238	12848
50										0	0	32	0	57	129	0	0	84	0	0	0	32	4332
51											0	0	39	363	71	0	0	105	0	32	0	168	7390
52												0	0	34	0	0	0	0	0	0	0	0	893
53													32	253	133	0	21	125	0	0	0	42	12292
54														724	414	32	136	280	32	39	81	281	21452
55															32	0	84	281	32	29	0	37	1594
56																0	0	32	0	0	0	0	1969
57																	42	91	0	0	0	0	1469
58																		20	84	94	0	0	22625
59																			0	0	0	31	2396
60																				0	0	32	2190
61																					0	6	168
62																						39	5217
																							1032926

3-5 Estimation of Traffic Volume on the Ring Road

The future O-D matrices having been established in the previous section, the assignment of the inter-zonal traffic volume to the road network will provide the future traffic on the Ring Road as well as the other road sections in the network.

3-5-1 Methodology

In this study, the quantity-volume (Q-V) traffic simulation method is adopted for the traffic assignment. The bench mark travel speed of each road section varies according to the geometric structure and the environmental conditions of the road section. The bench mark speed can only be maintained when the traffic volume is low. With the increase in traffic volume, the travel speed begins to fall until it reaches the maximum possible volume for the road section, beyond which a decrease of traffic capacity will occur. The relation between travel speed and traffic volume is generally a curve. This principal is adopted in Q-V traffic simulation. Network as well as the road traffic capacity at the bench mark speed is set. However, for the facility in actual calculation, the Q-V curve is simplified into a linear form as shown in Fig. 3-20. In this figure, the speed 'V_1' is the bench mark speed of the road section, and the capacity 'Q_1' is the maximum capacity of the road section when the bench mark speed may be maintained. Capacity 'Q_2' is the maximum possible capacity of the road section and speed 'V_2' the speed estimated at the maximum possible capacity. The distributed traffic volume of each zone-pair is divided into many partial fractions and assignment made to the road network, each fraction at a time. At the initial assignment, the bench mark speed is used. After the first assignment, the travel speed of each road section is calculated basing on the traffic volume of the first assignment. This process is reiterated until all distributed volumes are assignment to the network. In the selection of the optimum route, the travel time of all road sections are calculated and the route with the shortest travel time selected as the best route.

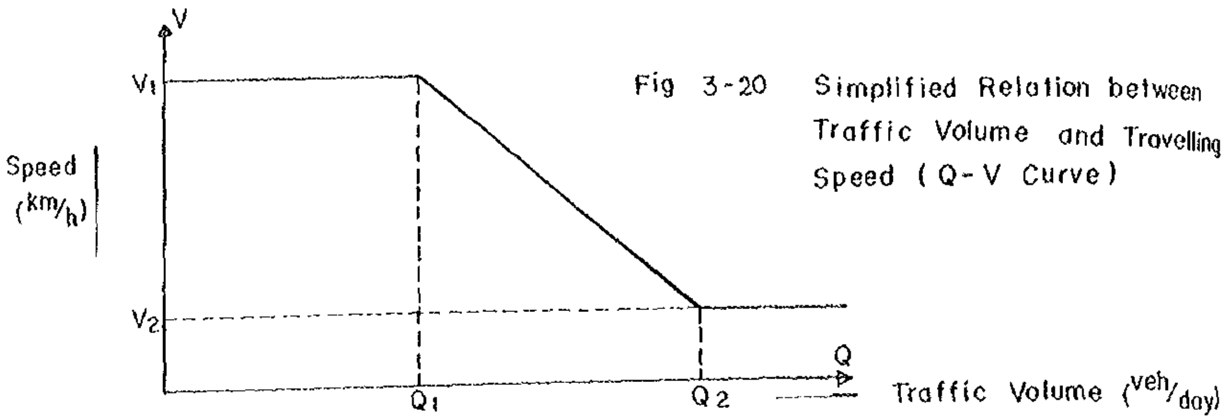


Fig 3-20 Simplified Relation between Traffic Volume and Travelling Speed (Q-V Curve)

3-5-2 Establishment of the relevant road network

Traffic assignment will be made for all the years at which O-D matrices have been established. Needless to said, the running conditions will be different for the various years as it can be expected that constant improvement will be made to the existing road network to increase the running speed and traffic capacity of the road sections. Also, as years pass by, construction of new roads can also be expected.

It will not be practical to put all road sections of the existing road network into the relevant road network used in traffic assignment, as many of these are local roads serving mainly short-distance local traffic. In the decision of the relevant network, therefore, only the roads section which cater for interzonal traffic are selected. Along this line, the relevant road network for 1970 was decided as in Fig. 3-21.

Bangkok-Thonburi

Ring Road Part II

Fig 3-21

Relevant Road Network, 1970

For the year 1975, the several addition which are made are limited to the projects which are at present under construction (such as the Tha Chang Bridge, the Asok-Din Daeng Municipal Road) or in the design stage (the Ring Road Part I, the River-side Municipal Road etc.).

The decision on the relevant road network for 1980 and 1990 is more difficult. Although in the "Greater Bangkok Plain, (which is not officially authorized), a future highway network plan is included, the programme of completion of the new roads is neither shown in the report nor has it been drawn up by any relevant departments. However, being the only existing plan available, the relevant road network has to be decided basing on the "Greater Bangkok Plan'.

A brief study is made, and an assumption made of the roads which will be completed if they are implemented without delay and with the maximum efficiency by the year 1990. This forms the 'optimum road network' relevant to the traffic assignment in this study, and the network contains a majority of the roads planned in the 'Greater Bangkok Plan'. For the year 1980, only minor additions are made to the 1975 relevant road network.

Even though the road network for 1990 thus screened is considerable reduced in number of new roads, it is still difficult to envisage that all the new roads included will be duly completed, since their completion by 1990 will probably call for a sharp increase in the annual budget alloted for new road construction, not to mention that the man power and mechanical power capable of undertaking the construction work will probably be greatly strained. Also, many of the new roads in the network are further away from the town centre than the Ring Road under study. In an analysis for the Ring Road, it will be unnatural to assume that the roads that are planned further away than the Ring Road should be completed earlier than the Ring Road. A second network for 1980 and 1990 is therefore set whereby it is assumed that the new roads outside of the Ring Road will not be completed by 1990. (The normal network).

Traffic assignment in this study, was made for both the two cases of road networks for 1990. However, for subsequent economic analyses, only the latter case, where new roads outside of the Ring Road were omitted, was taken into consideration.

3-5-3 Setting of Q-V conditions for the relevant road networks

All the junctions (nodes) and road sections between junctions (links) are coded for the purpose of computer calculation. There are in total 184 nodes and 301 links. . (Fig. 3-22 to 24)

The links are classified into 15 road classification and the Q-V condition for each class of road set. (Table 3-36). The distance of each link is also provided. The full list of all nodes and links are as in Table 3-37. In the assignment, the traffic volume was assigned by 10 stages, and the percentage of traffic volume assigned at each stage was at follows:

Stage	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Percent of traffic volume	20	15	15	10	10	10	5	5	5	5

Table 3-36 Q-V Condition by road classification

Road Classification			(V_1) km/h	Q_1 Capacity Veh/day	(V_2) km/h	Q_2 Capacity Veh/day
1	Type No. 1	2 Lanes	45	5,500	20	15,000
2	Type No. 2	4 Lanes	50	26,000	10	110,000
3	Type No. 3	4 Lanes	60	27,000	15	65,000
4	Type No. 4	6 Lanes	55	36,000	20	80,000
5	Type No. 5	6 Lanes	55	35,500	25	71,000
6	Type No. 6	6 Lanes	60	37,000	20	83,000
7	Type No. 7	6 Lanes	65	38,000	20	85,000
8	Type No. 8	8 Lanes	60	48,000	30	96,000
9	Type No. 9	8 Lanes	60	52,000	20	120,000
10	Type No. 10	10 Lanes	50	65,000	25	130,000
11	Ring road	6 Lanes	100	49,000	30	98,000
12	Urban planning road	4 Lanes	70	27,000	30	54,000
13	Express way	4 Lanes	100	32,000	30	64,000
14	Express way	2 Lanes	100	6,500	30	13,000
15	Type No. 11	4 Lanes	40	22,500	5	45,000

Bangkok-Thonburi

Ring Road Part II

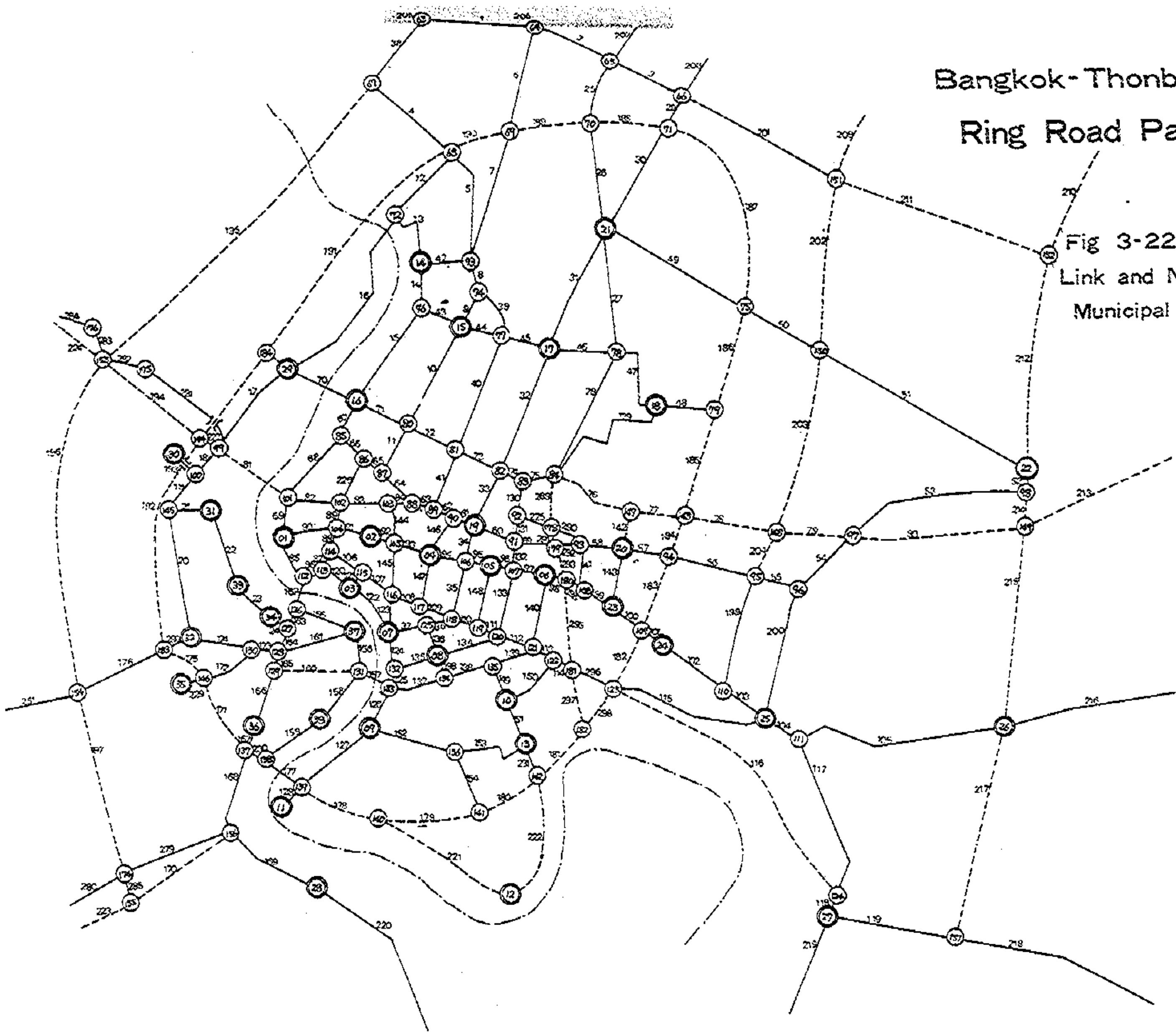
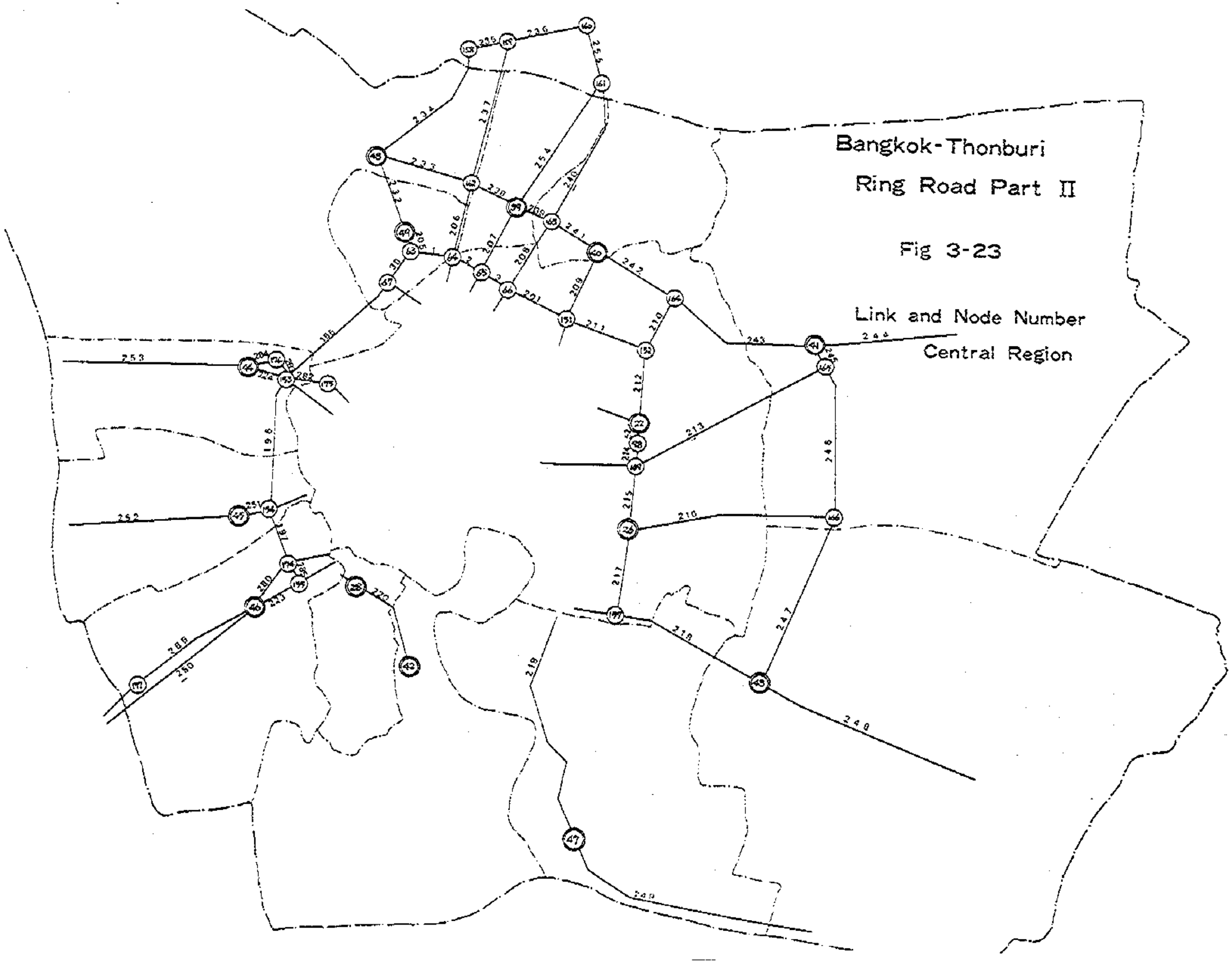


Fig 3-22
Link and Node Number-
Municipal Region



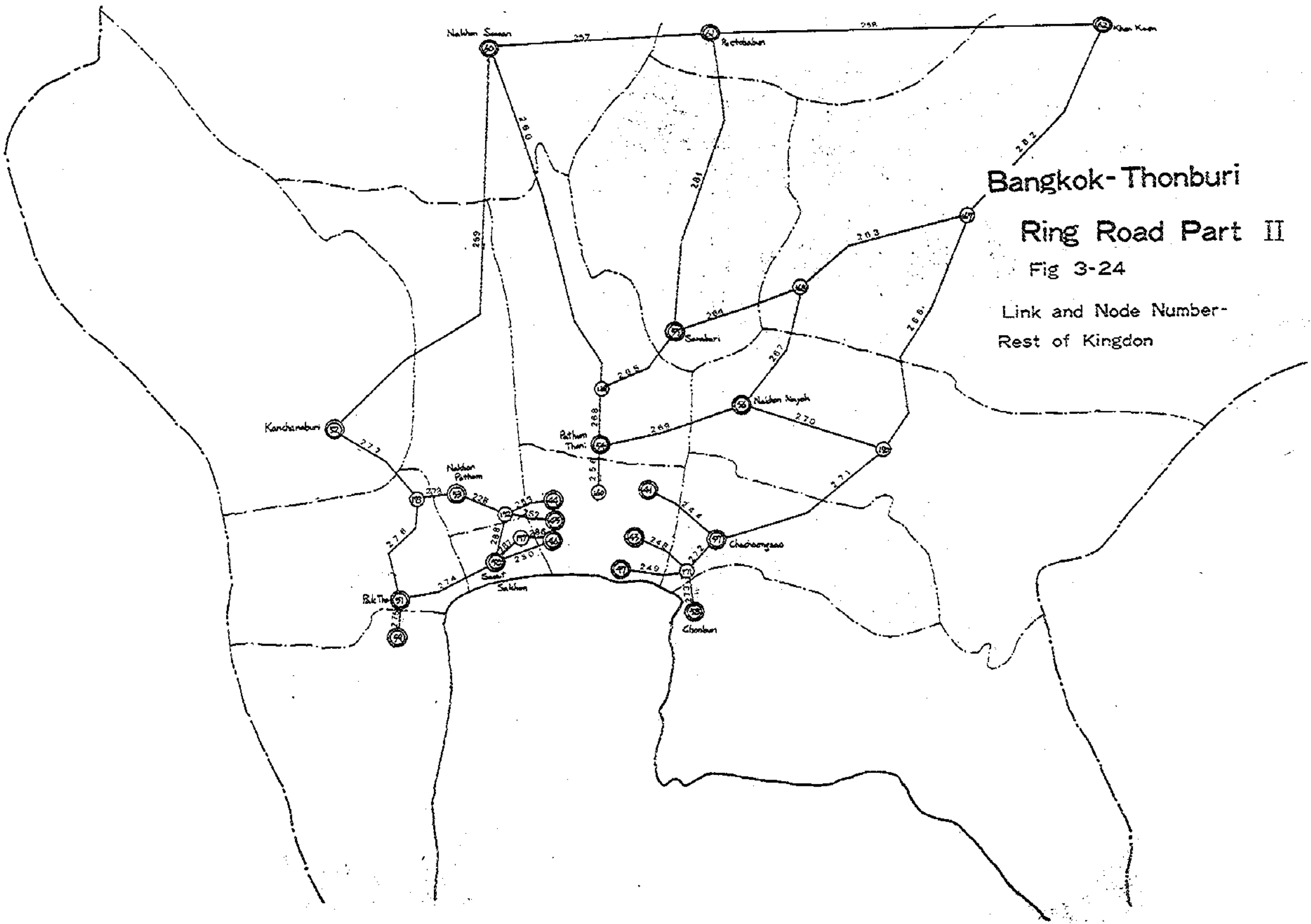
Bangkok-Thonburi

Ring Road Part II

Fig 3-23

Link and Node Number

Central Region



Bangkok-Thonburi

Ring Road Part II

Fig 3-24

Link and Node Number-
Rest of Kingdon

Fig. 3-37 List of nodes and links

Link No.	Node-pair	Distance	Type	Link No.	Node-pair	Distance	Type
1	63-64	2.5	1	23	33-34	1.7	2
2	64-65	1.9	1	24	34-127	0.5	2
3	65-66	1.8	1	25	65-70	1.6	13
4	67-68	2.4	1	26	70-21	2.3	13
5	68-73	2.6	1	27	21-78	2.5	13
6	64-69	2.7	3	28	78-84	3.2	13
7	69-73	3.0	3	29	66-71	0.9	3
8	73-74	0.7	2	30	71-21	2.6	3
9	74-15	0.8	3	31	21-17	2.6	7
10	15-80	2.4	3	32	17-82	3.0	7
11	80-87	1.3	3	33	82-19	1.5	8
12	68-72	1.8	1	34	19-106	0.8	4
13	72-14	1.9	1	35	106-118	1.5	8
14	14-76	1.0	1	36	118-125	0.7	3
15	76-16	2.6	2	37	125-07	0.8	3
16	72-29	5.1	1	38	63-67	2.1	1
17	29-99	2.1	6	39	74-77	1.1	3
18	99-100	0.8	6	40	77-81	2.7	3
19	100-145	1.5	6	41	81-89	1.6	8
20	145-32	2.9	6	42	14-73	1.1	1
21	145-31	0.9	2	43	76-15	1.0	2
22	31-33	1.2	2	44	77-17	0.9	1

Link No.	Node-pair	Distance	Type	Link No.	Node-pair	Distance	Type
45	77-17	1.2	3	67	85-16	0.9	3
46	17-78	1.5	1	68	85-101	2.0	3
47	78-18	2.1	1	69	101-01	0.7	2
48	18-79	1.3	1	70	29-16	1.6	2
49	21-75	3.5	3	71	16-80	1.3	2
50	75-150	1.9	3	72	80-81	1.2	6
51	150-22	5.3	3	73	81-82	1.2	6
52	22-98	0.5	3	74	82-83	0.6	6
53	98-97	4.2	3	75	83-84	0.6	3
54	97-96	1.7	3	76	84-147	1.9	3
55	96-95	1.1	3	77	147-143	1.2	12
56	95-94	2.2	3	78	143-148	2.1	12
57	94-20	0.9	3	79	148-97	1.7	12
58	20-93	1.0	6	80	97-149	3.9	12
59	93-91	1.4	6	81	99-101	1.7	6
60	91-19	1.1	6	82	101-102	1.2	9
61	19-90	0.6	6	83	102-103	1.1	6
62	90-89	0.4	6	84	103-88	0.5	6
63	89-88	0.3	6	85	01-112	0.3	2
64	88-87	1.1	7	86	112-113	0.6	3
65	87-86	0.4	3	87	113-114	0.3	3
66	86-85	0.8	2	88	114-104	0.6	3

Link No.	Node-pair	Distance	Type	Link No.	Node-pair	Distance	Type
89	104-102	0.5	3	111	119-120	0.3	8
90	01-104	1.2	1	112	120-121	1.0	8
91	104-02	0.8	3	113	121-122	0.5	9
92	02-105	0.5	2	114	122-123	1.5	9
93	105-4	0.8	3	115	123-25	3.7	6
94	04-106	0.8	3	116	123-124	7.4	11
95	106-05	0.5	6	117	111-124	4.0	6
96	05-107	0.5	6	118	124-27	0.5	6
97	107-06	0.8	6	119	27-157	3.0	3
98	06-108	0.6	7	120	113-03	0.5	4
99	108-23	1.1	7	121	03-115	1.2	2
100	23-109	0.8	7	122	03-07	1.7	4
101	109-24	0.6	7	123	116-07	1.0	2
102	24-110	1.8	7	124	07-132	0.8	3
103	110-25	1.2	6	125	132-133	0.4	3
104	25-111	0.9	6	126	133-09	1.0	6
105	111-26	4.8	3	127	09-139	2.1	6
106	114-115	0.7	2	128	139-11	0.6	6
107	115-116	1.0	2	129	18-84	3.5	1
108	116-117	0.9	8	130	83-92	0.8	6
109	117-118	0.9	8	131	92-91	0.5	15
110	118-119	0.6	8	132	91-107	0.6	6

Link No.	Node-pair	Distance	Type	Link No.	Node-pair	Distance	Type
133	107-120	1.7	6	155	126-37	1.4	2
134	120-08	1.4	3	156	37-131	1.1	2
135	08-132	1.0	3	157	131-133	0.7	6
136	125-08	0.7	3	158	131-38	1.1	2
137	133-134	1.4	3	159	38-138	2.0	2
138	134-135	1.3	3	160	129-131	1.8	6
139	135-121	0.8	3	161	128-37	1.6	3
140	121-06	1.8	5	162	112-126	0.8	2
141-	108-93	0.9	2	163	126-127	0.5	8
142	20-147	0.8	3	164	127-128	0.5	8
143	20-23	1.4	2	165	128-129	0.4	6
144	103-105	0.9	1	166	129-36	1.5	6
145	105-116	1.2	3	167	36-137	0.6	6
146	90-04	0.9	2	168	137-156	2.0	12
147	04-117	1.3	3	169	156-28	2.3	12
148	05-119	1.7	2	170	156-155	2.8	13
149	135-110	0.8	1	171	137-146	1.9	11
150	10-122	1.3	1	172	146-130	1.3	12
151	10-13	1.1	1	173	130-128	0.7	6
152	09-136	2.0	2	174	130-32	1.4	6
153	136-13	1.9	1	175	32-146	1.0	11
154	136-141	1.5	1	176	32-154	2.8	6

Link No.	Node-pair	Distance	Type	Link No.	Node-pair	Distance	Type
177	138-139	1.2	3	199	95-110	2.7	2
178	139-140	1.9	11	200	96-25	3.3	2
179	140-141	2.3	11	201	66-151	3.9	12
180	141-142	1.6	11	202	151-150	3.8	12
181	142-123	2.7	11	203	150-148	4.3	12
182	123-109	1.6	11	204	148-95	1.1	12
183	109-94	1.7	11	205	63-49	1.2	1
184	94-143	1.0	11	206	64-162	4.6	3
185	143-79	2.5	11	207	65-39	4.5	13
186	79-75	2.4	11	208	66-163	4.7	3
187	75-71	4.9	11	209	151-40	4.5	12
188	71-70	1.8	11	210	152-164	3.6	12
189	70-69	1.8	11	211	151-152	5.0	12
190	69-68	1.3	11	212	152-22	4.8	12
191	68-144	8.6	11	213	149-165	12.3	12
192	144-145	1.9	11	214	98-149	0.8	12
193	30-100	0.7	3	215	149-26	4.7	12
194	144-153	2.8	13	216	26-166	12.1	3
195	153-67	8.7	12	217	26-157	5.0	12
196	153-154	7.8	12	218	157-43	9.3	3
197	154-155	4.9	12	219	27-47	6.5	3
198	08-134	0.5	3	220	28-42	6.0	12

Link No.	Node-pair	Distance	Type	Link No.	Node-pair	Distance	Type
221	140-12	3.5	11	243	164-41	9.8	1
222	12-142	3.2	11	244	41-57	37.2	14
223	155-46	2.9	13	245	41-165	1.2	12
224	153-44	2.0	13	246	165-166	9.6	12
225	92-93	1.6	1	247	166-43	10.5	12
226	86-102	1.1	10	248	43-171	31.3	14
227	99-144	0.5	6	249	47-171	47.4	14
229	53-172	25.4	14	250	46-50	22.6	13
229	35-146	0.5	12	251	154-45	1.6	3
230	137-138	0.4	6	252	45-172	17.2	3
231	13-142	0.8	1	253	44-172	17.4	13
232	48-49	4.9	1	254	39-161	9.2	13
233	48-162	6.0	1	255	160-161	3.5	3
234	48-158	9.5	1	256	160-54	1.8	14
235	158-159	2.3	1	257	60-61	165.4	14
236	159-160	4.8	1	258	61-62	224.6	14
237	159-162	5.0	3	259	52-60	245.7	14
238	162-39	3.0	1	260	60-169	189.2	14
239	39-163	2.3	1	261	61-55	230.5	14
240	161-163	9.5	3	262	62-167	187.8	14
241	163-40	3.2	1	263	167-168	81.2	14
242	40-164	5.2	1	264	168-55	57.3	14

Link No.	Node-pair	Distance	Type	Link No.	Node-pair	Distance	Type
265	55-169	59.7	14	284	176-44	1.1	1
266	167-170	119.1	14	285	155-174	1.0	12
267	168-56	58.3	14	286	46-177	12.3	2
268	169-54	21.4	14	287	177-50	12.3	2
269	54-56	58.6	14	298	50-172	24.8	2
270	56-170	65.2	14	289	84-178	1.5	2
271	170-57	86.2	14	290	178-93	0.7	1
272	57-171	18.3	14	291	178-179	0.4	2
273	171-58	22.7	14	292	179-93	0.5	6
274	50-51	55.8	13	293	180-179	1.0	2
275	51-59	10.4	13	294	180-108	0.3	7
276	51-173	60.5	14	295	180-181	2.6	2
277	173-52	51.2	14	296	181-123	1.0	9
278	173-53	19.1	14	297	181-182	1.5	2
279	156-174	2.6	2	298	182-123	1.4	11
280	174-46	2.9	2	299	183-32	0.5	6
281	99-175	1.8	1	300	144-184	2.4	11
282	175-153	1.8	1	301	184-29	0.6	2
283	153-176	1.1	1				

3-5-4 Results of traffic assignment

Traffic assignment were made for the years 1975, 1980, 1990 both for 'with' and 'without' the Ring Road. For the year 1990, the assignment for both the 'optimum network' and the 'normal network' were caried out. The results of the assignments are graphically shown in Fig. 3-25 - Fig. 3-32.

Various cases where only part of the Ring Road Part II were completed was also assumed and assignment made. These are shown in Fig. 3-33 - Fig. 3-35 for reference.

It can be seen from the results of the traffic assignment that the traffic volume on the Ring Road reach the requirement for a six lane highway in all cases from as early as 1975. Purely from the traffic point of view, the total construction of the whole Ring Road from the initial stage is necessary.

Also, the traffic volumes on other road sections are also, as expected, very heavy, and by 1990, most of them will have surpassed the capacity of the roads. Early steps to improve the existing road network are also matters of emergency.

3-5-5 Intersection traffic stream analysis

In the assignment, analysis for the traffic stream at interchanges of the Ring Road were also made. The results for the 1990 are as in Fig. 3-36 - Fig. 3-37. It will be seen that at most intersection planned with diamond interchanges, the traffic volume will reach the capacity of the intersections, and appropriate channelization at the interchanges will be required to increase the capacity at interchanges. Total grade separation of these intersections, however, cannot be recommended, as these intersections are within the built-up area, and despite the enormous cost required for grade separation, the effectiveness is dubious without coordination with all other intersections in the city.

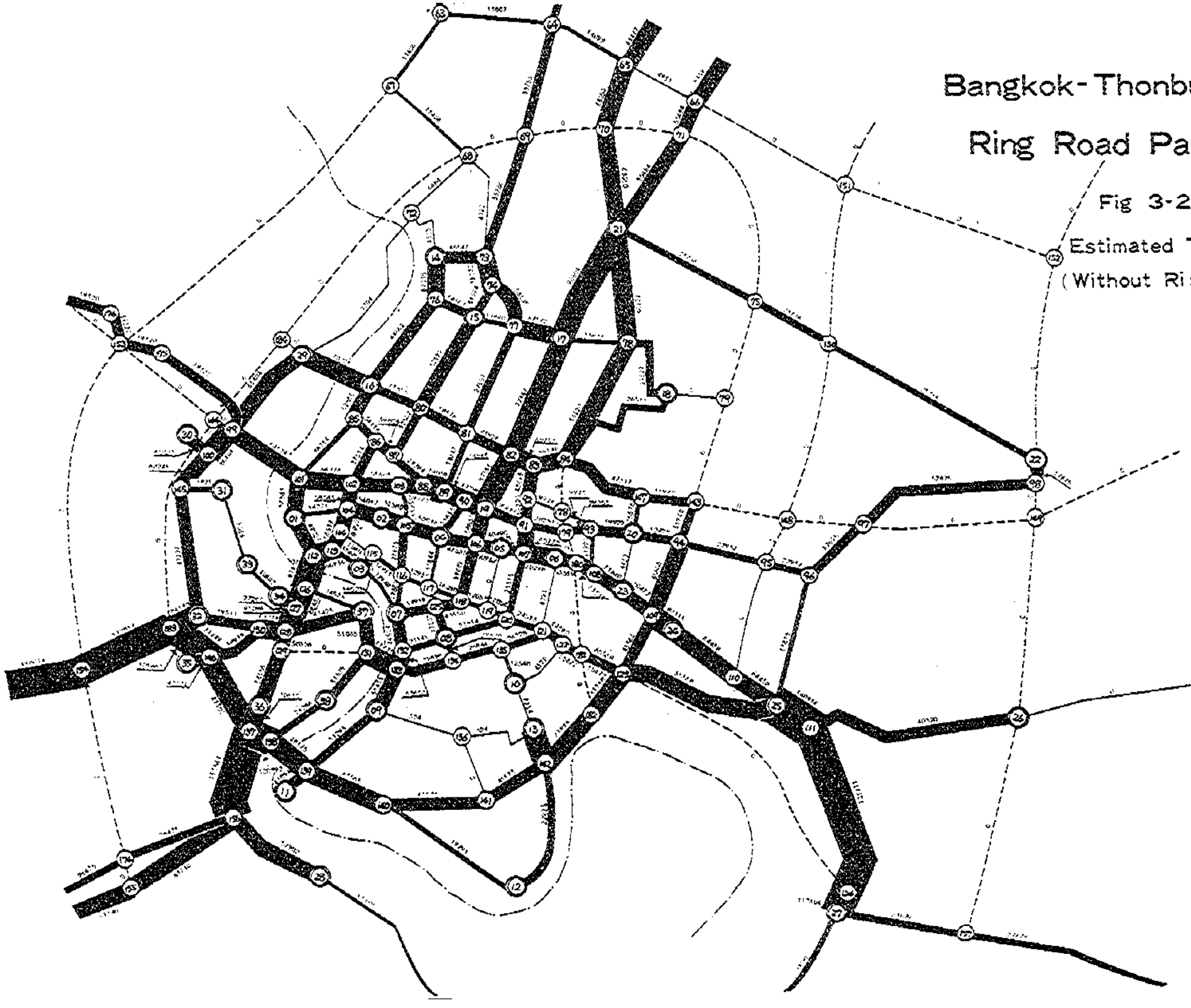
Bangkok-Thonburi

Ring Road Part II

Fig 3-25

Estimated Traffic Flow, 1975

(Without Ring Road)

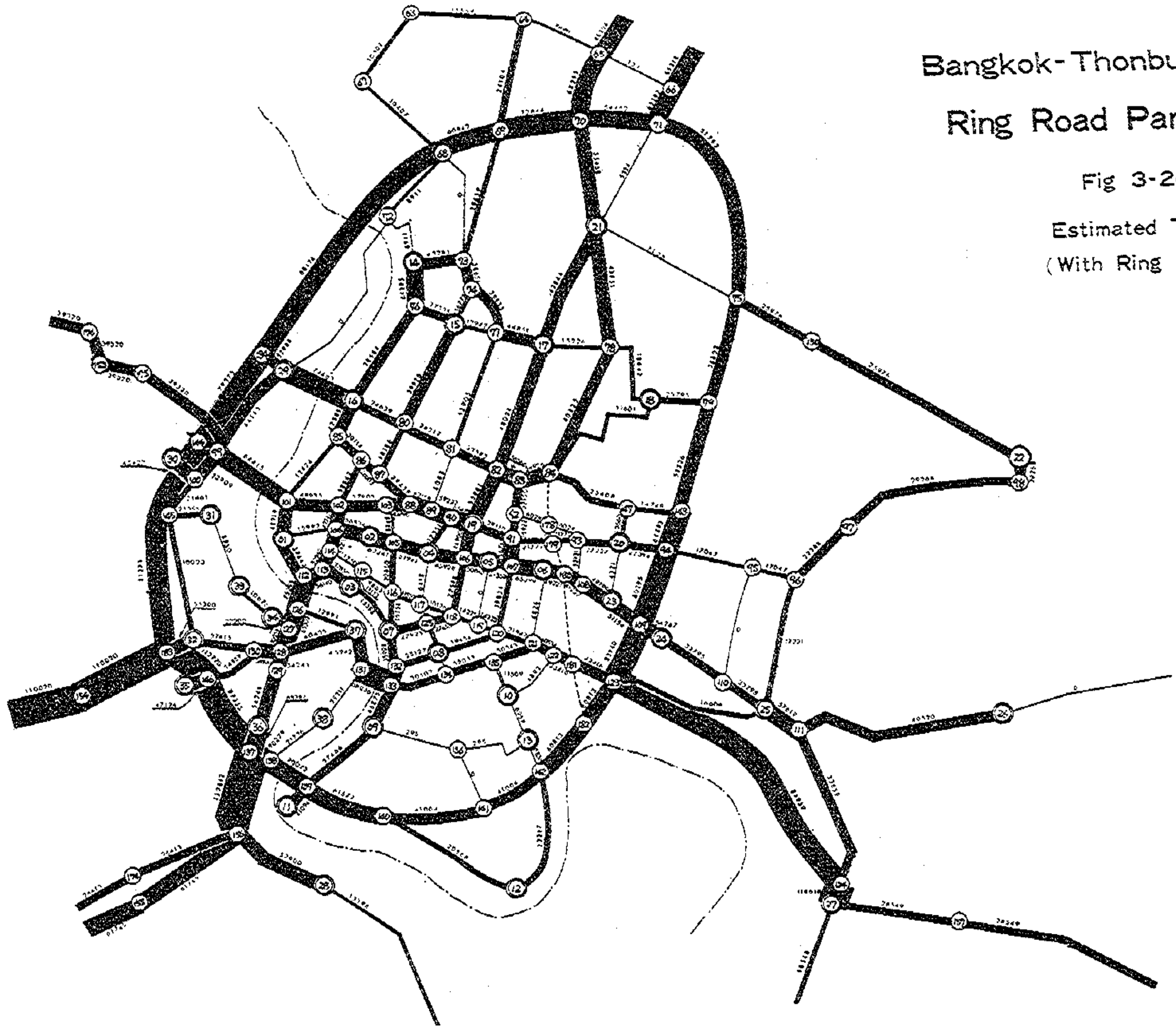


Bangkok-Thonburi

Ring Road Part II

Fig 3-26

Estimated Traffic Flow, 1975
(With Ring Road)



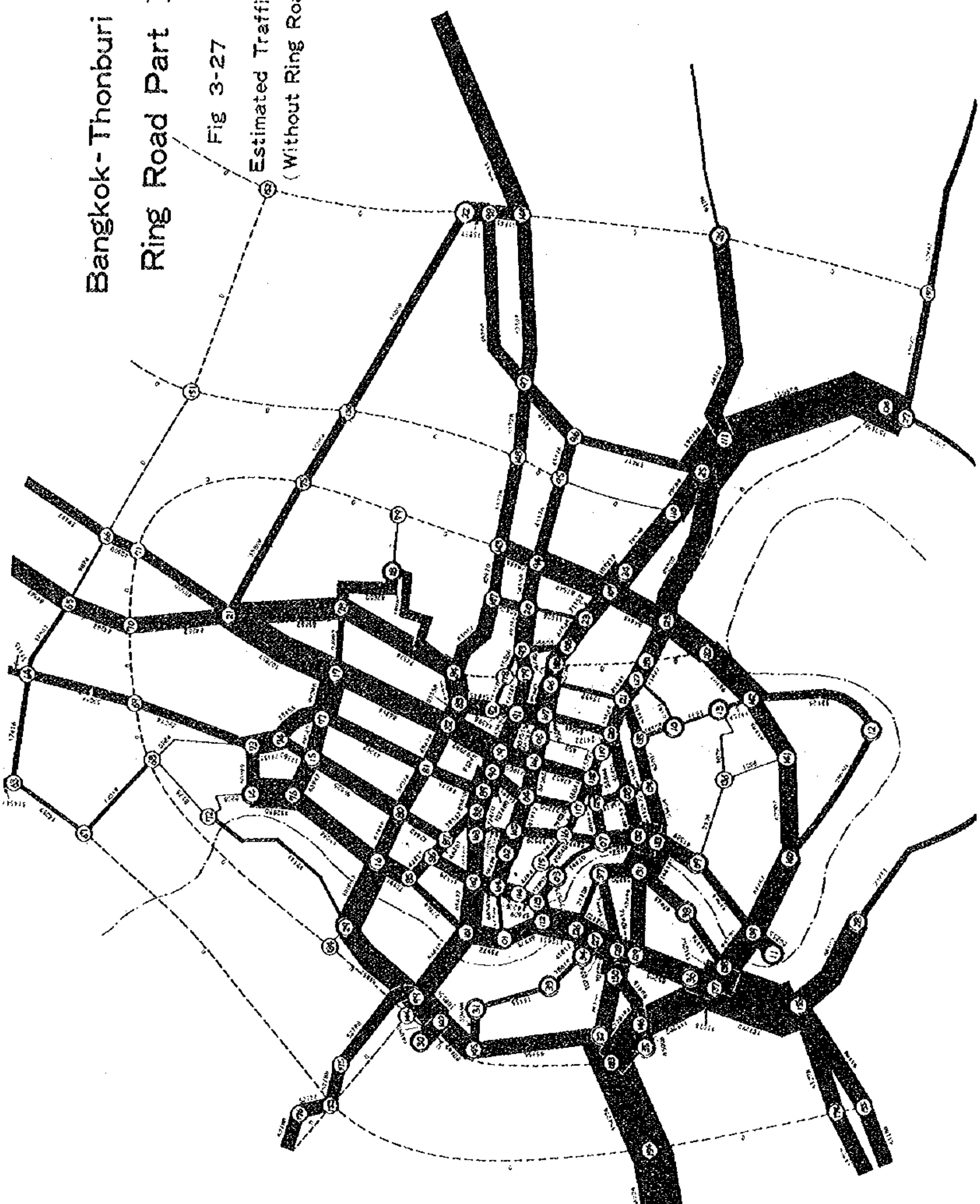
Bangkok - Thonburi

Ring Road Part II

Fig 3-27

Estimated Traffic Flow, 1980

(Without Ring Road)

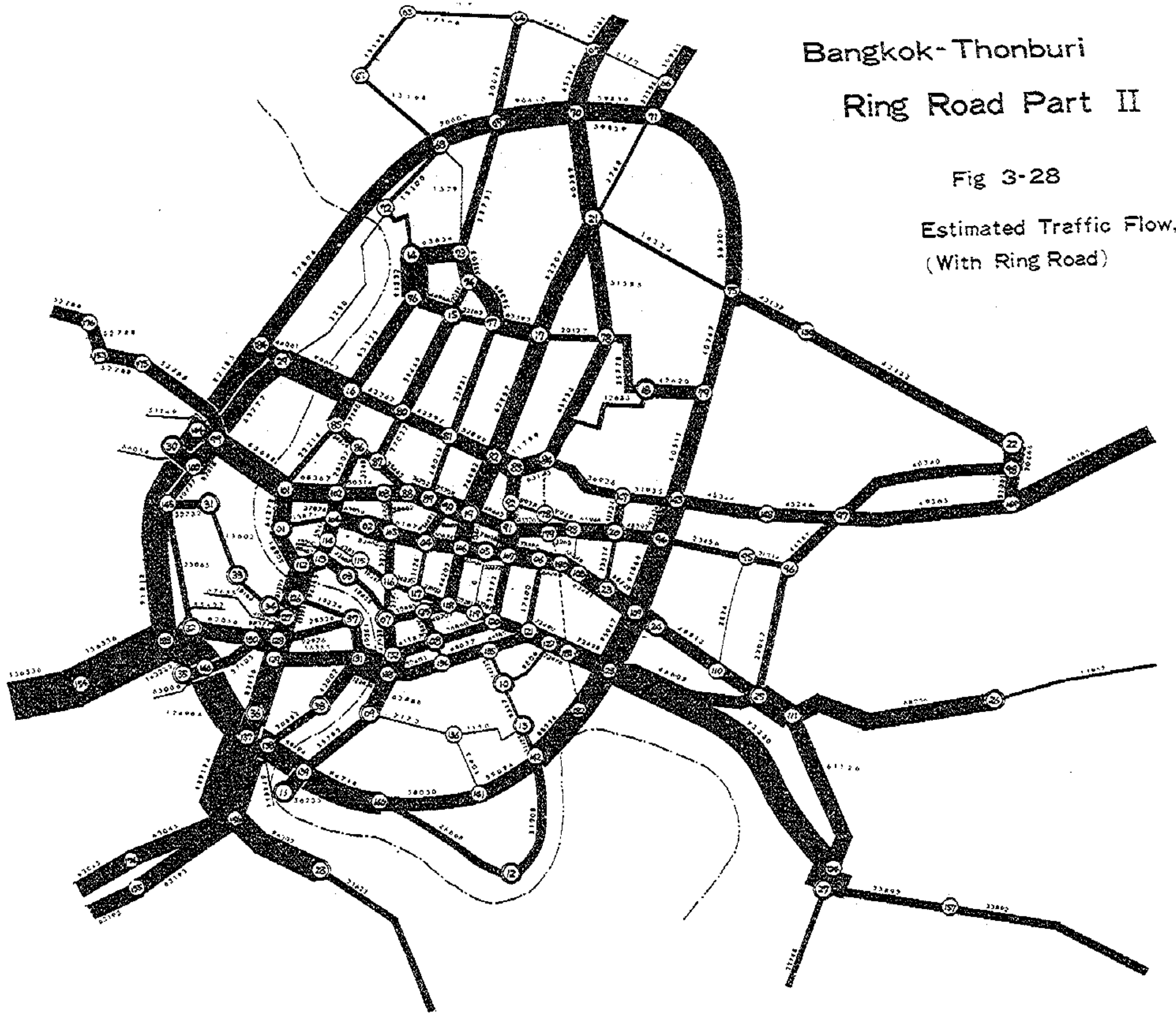


Bangkok-Thonburi

Ring Road Part II

Fig 3-28

Estimated Traffic Flow, 1980
(With Ring Road)

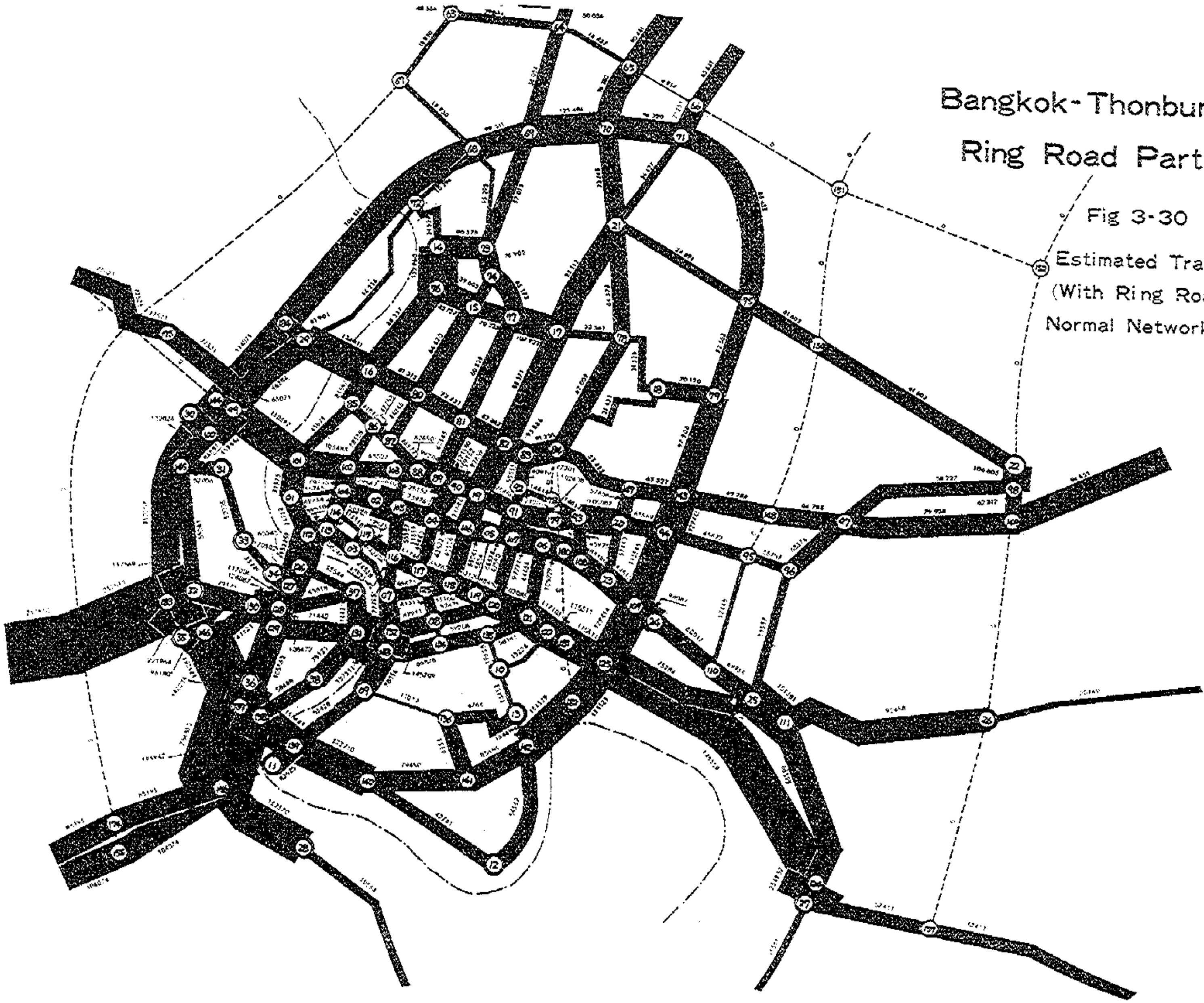


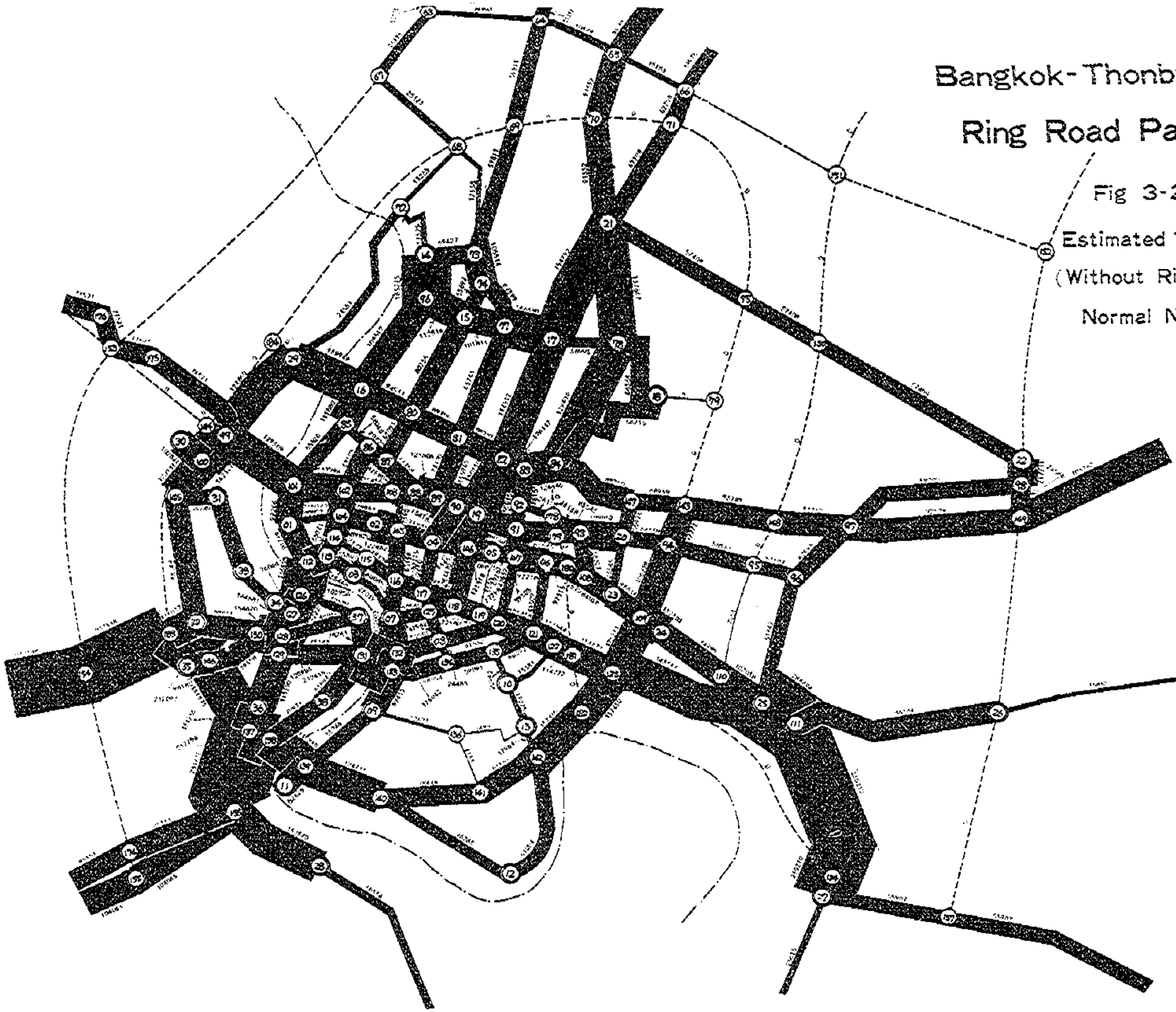
Bangkok-Thonburi

Ring Road Part II

Fig 3-30

Estimated Traffic Flow, 1990
(With Ring Road,
Normal Network)





Bangkok-Thonburi

Ring Road Part II

Fig 3-29

Estimated Traffic Flow, 1990

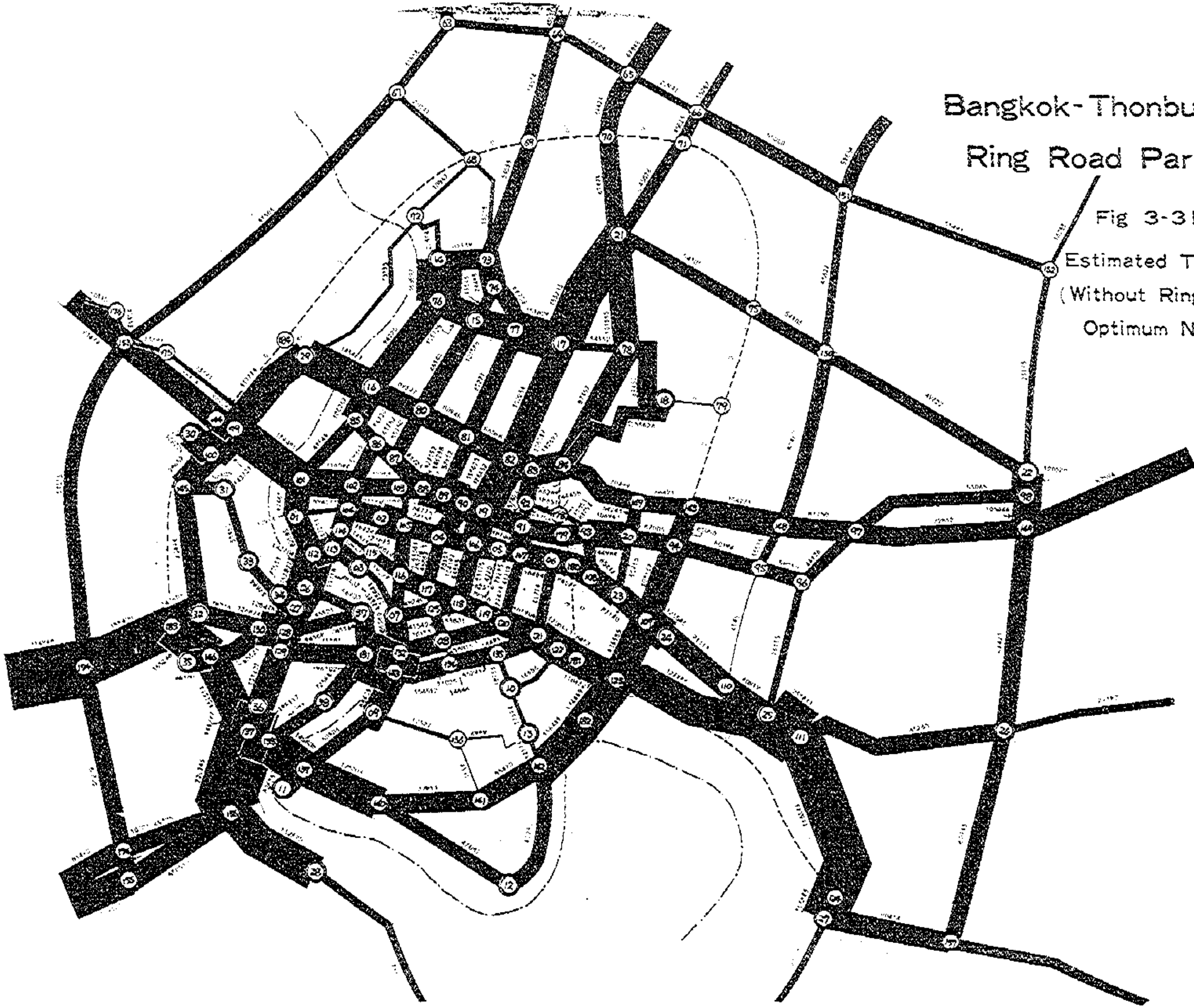
(Without Ring Road, Normal Network)

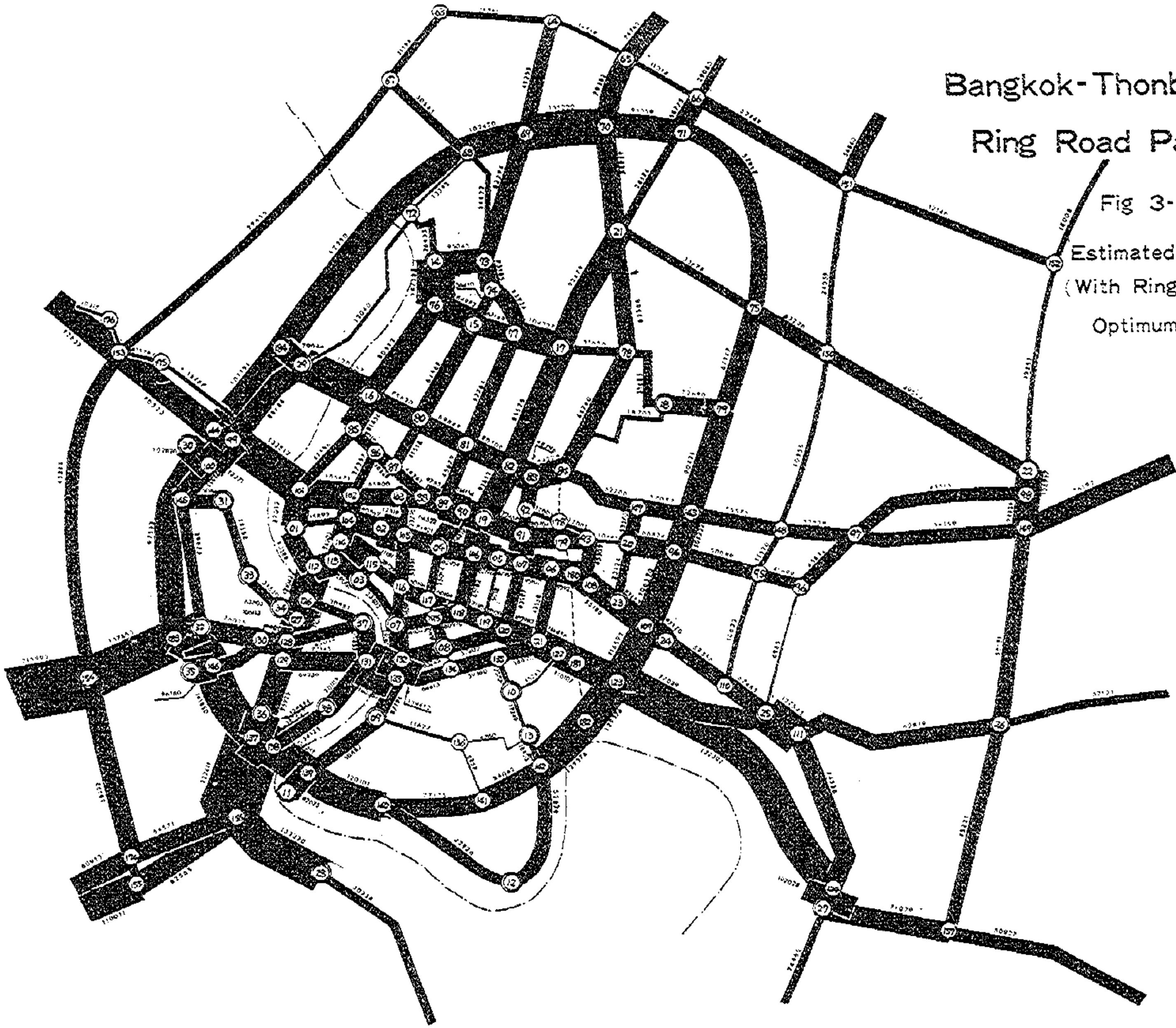
Bangkok-Thonburi Ring Road Part II

Fig 3-31

Estimated Traffic Flow, 1990

(Without Ring Road, Optimum Network)





Bangkok-Thonburi

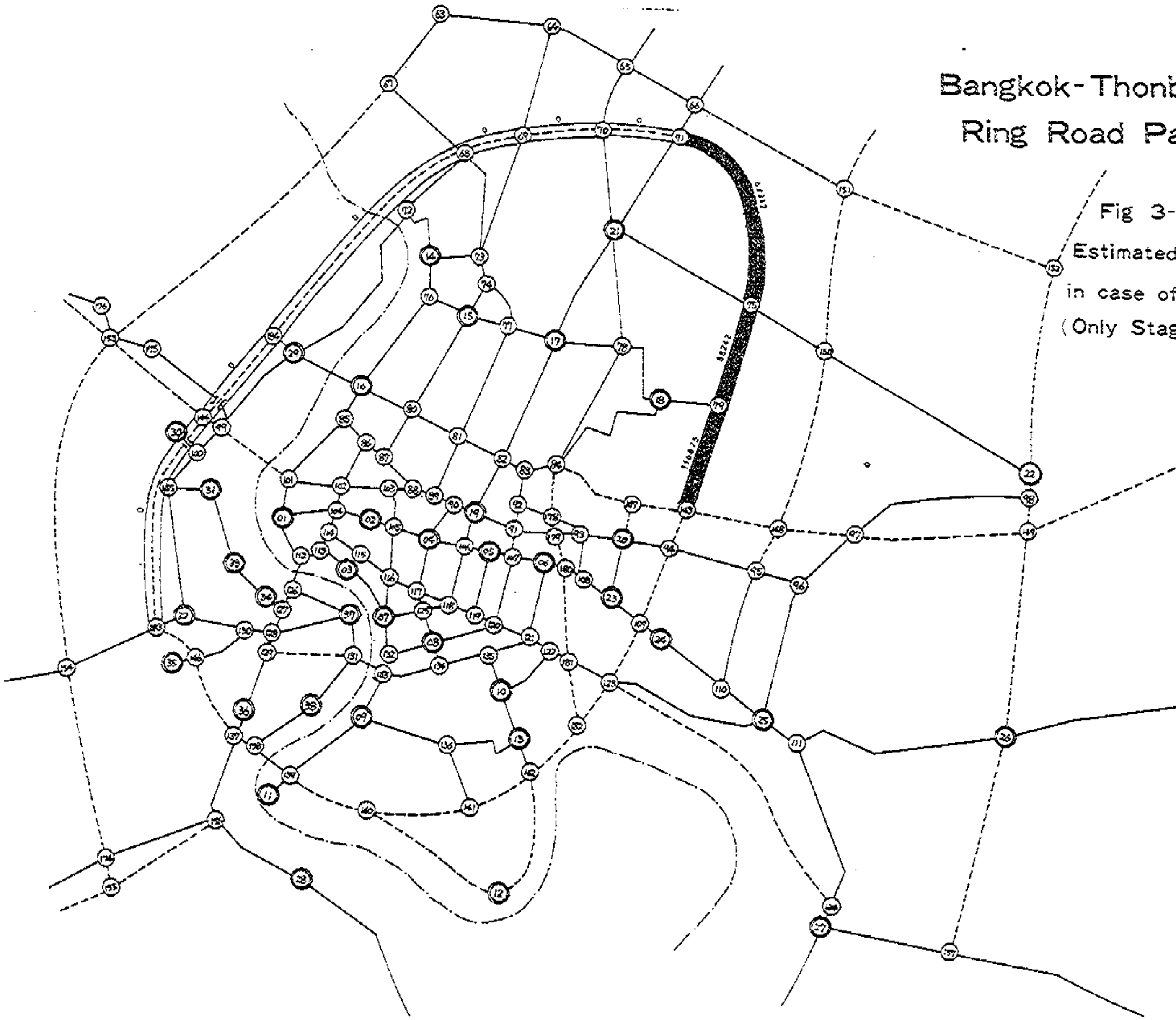
Ring Road Part II

Fig 3-32

Estimated Traffic Flow, 1990
(With Ring Road,
Optimum Network)

Bangkok-Thonburi Ring Road Part II

Fig 3-33
Estimated Traffic Flow, 1990
in case of Stage Construction.
(Only Stage 1 being Completed)
vehicles/day



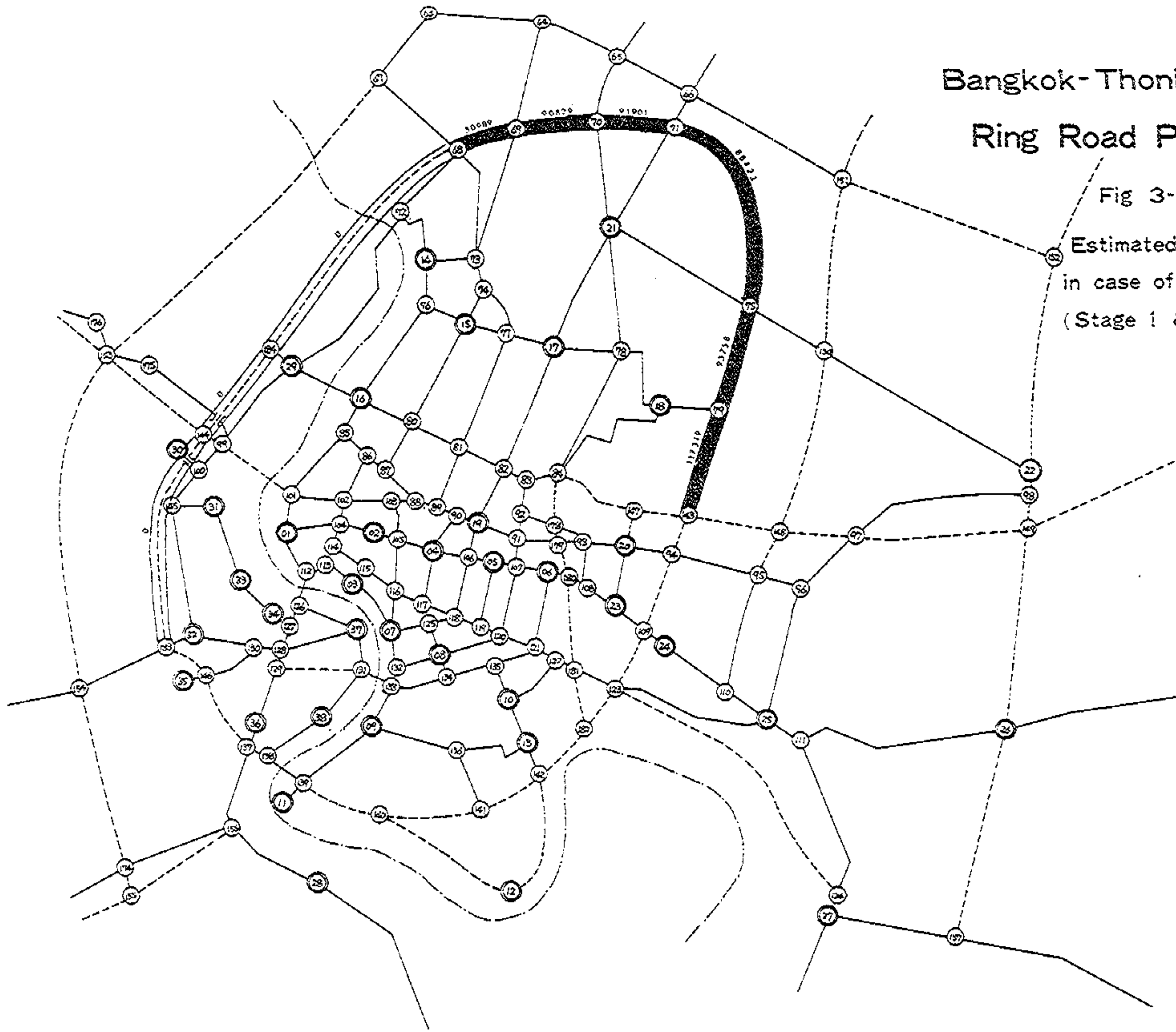
Bangkok-Thonburi

Ring Road Part II

Fig 3-34

Estimated Traffic Flow, 1990
in case of Stage Construction
(Stage 1 & 2 being completed)

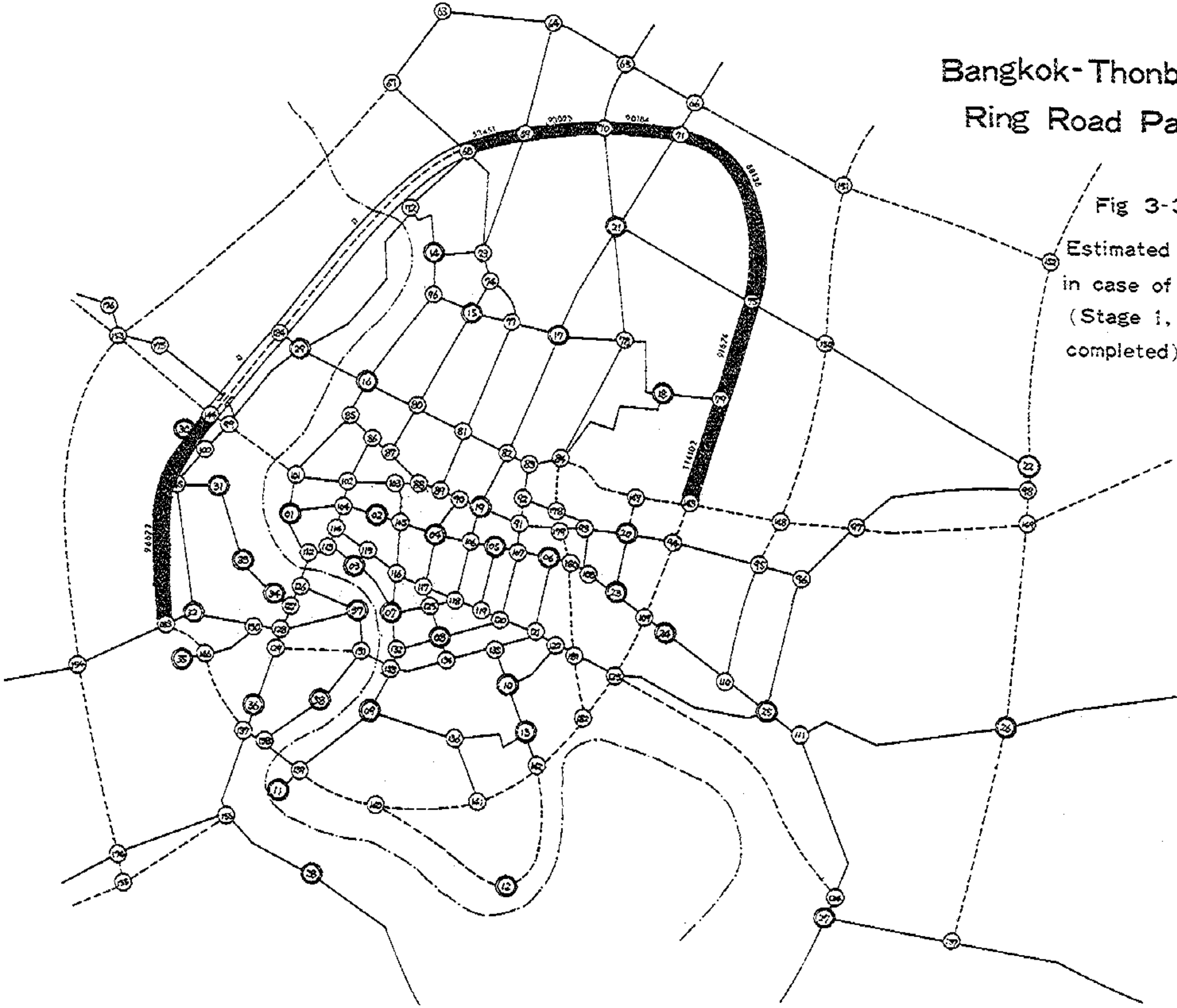
vehicles/day



Bangkok-Thonburi Ring Road Part II

Fig 3-35

Estimated Traffic Flow, 1990 in case of Stage Construction (Stage 1, 2 & 3 being completed) vehicles/day



Estimated Intersection

Traffic Stream, 1990

(Normal Network)

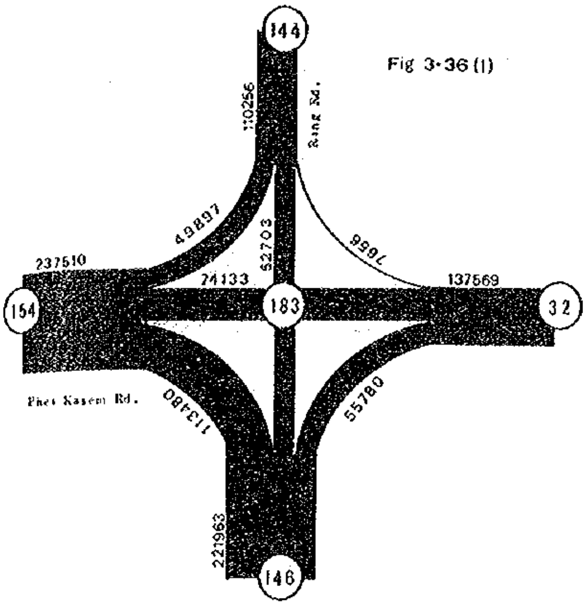
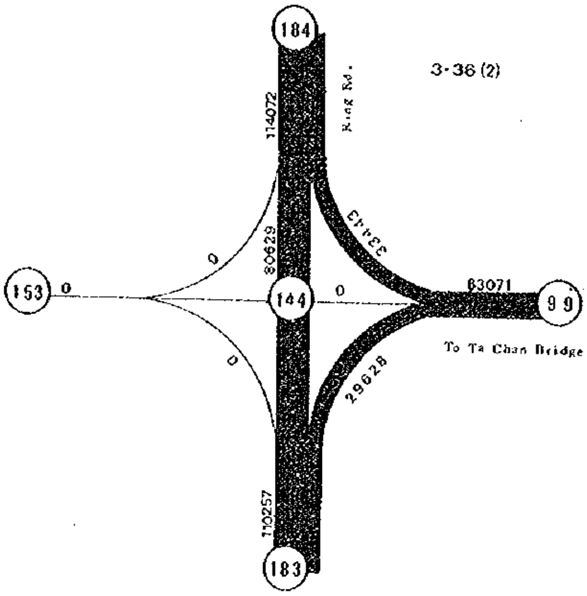
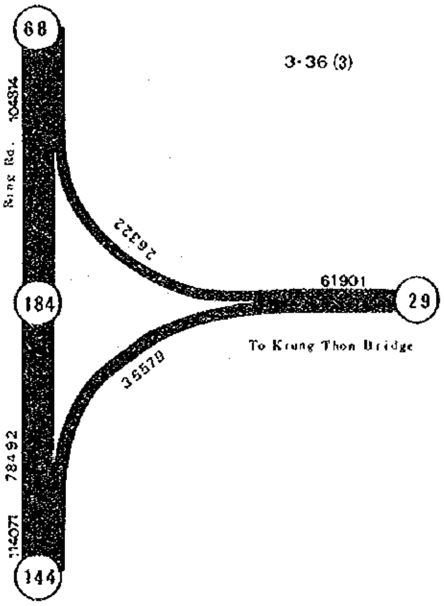


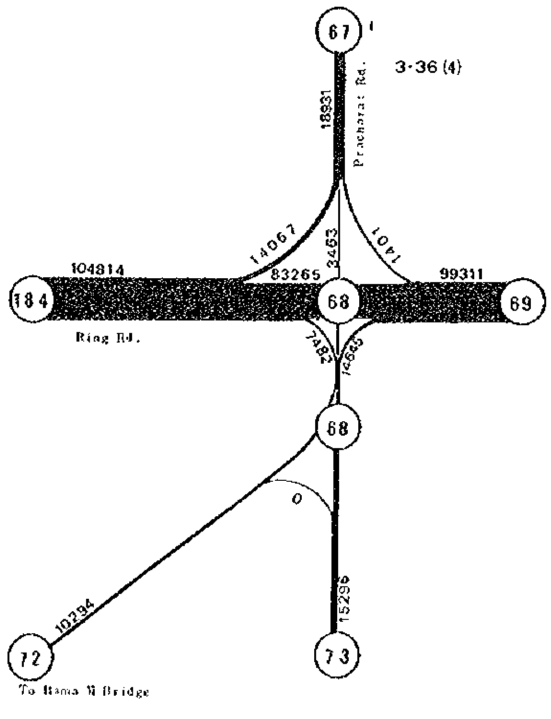
Fig 3-36 (1)



3-36 (2)



3-36 (3)



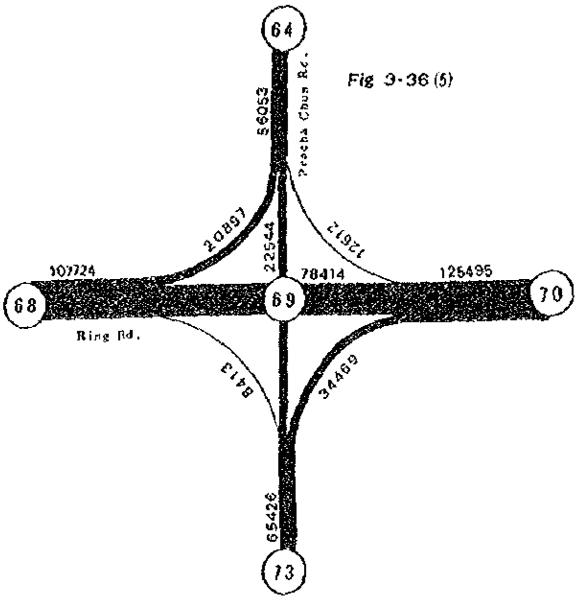
3-36 (4)

Estimated Intersection

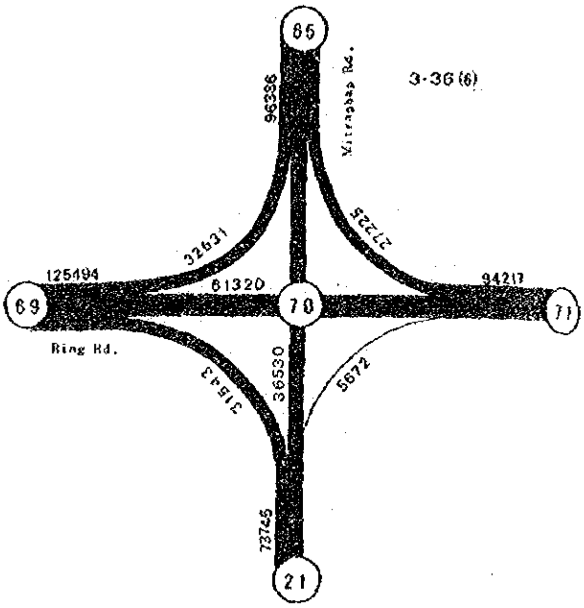
Traffic Stream, 1990

(Normal Network)

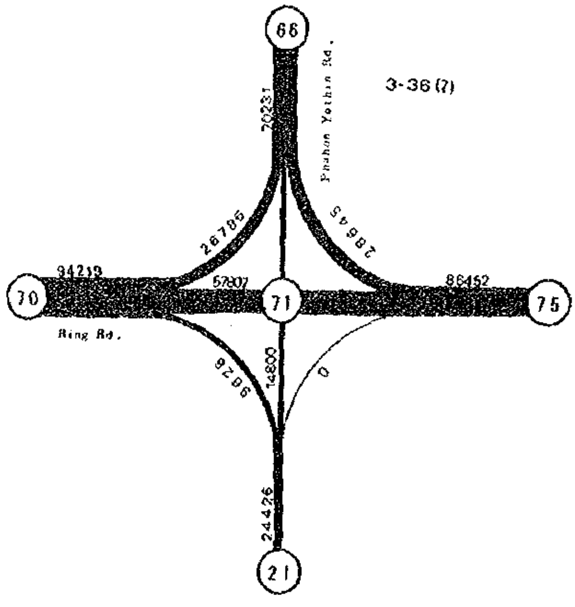
Fig 3-36 (5)



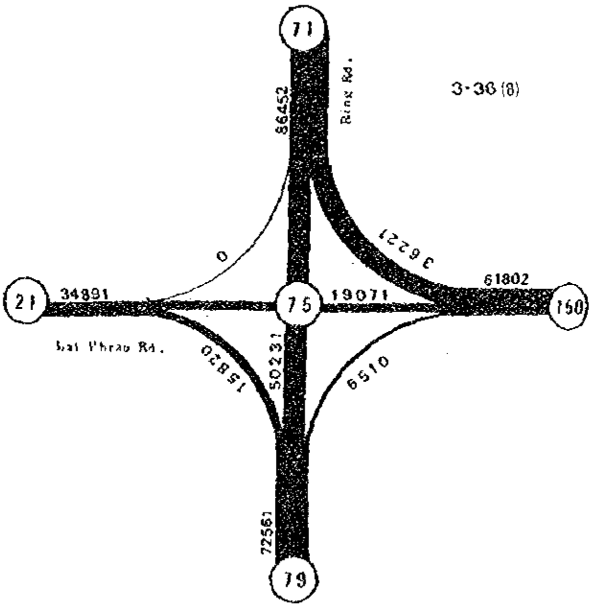
3-36 (6)



3-36 (7)



3-36 (8)

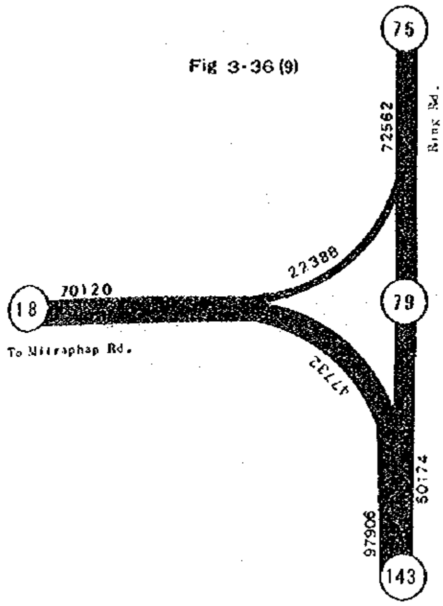


Estimated Intersection

Traffic Stream, 1990

(Normal Network)

Fig 3-36 (9)



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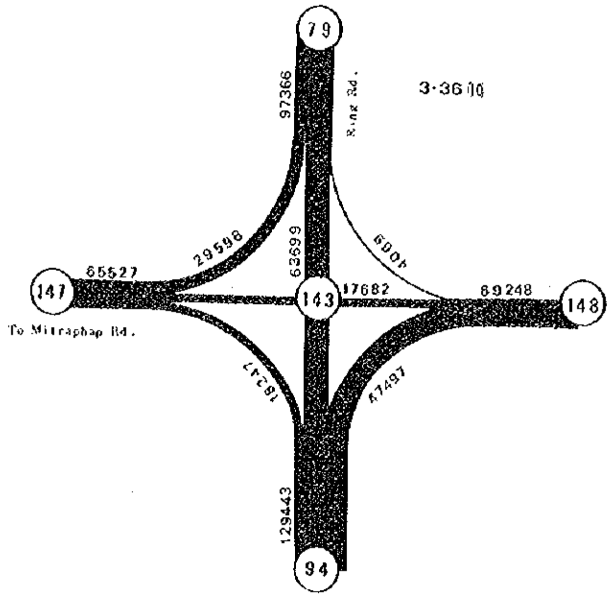

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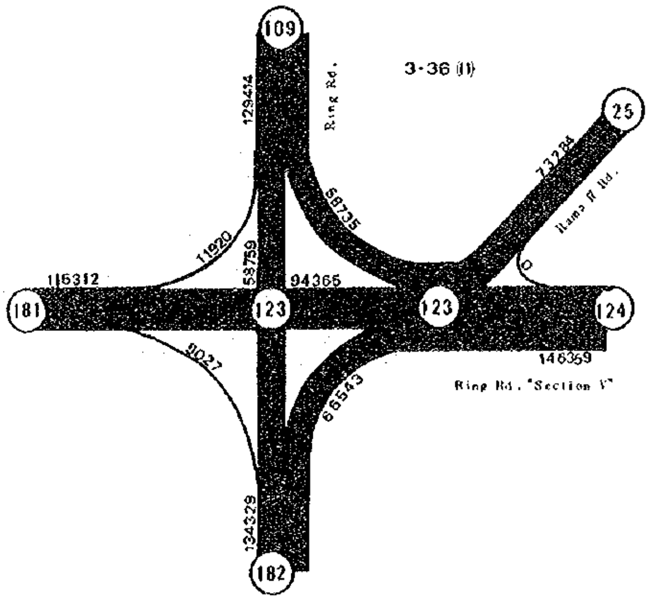
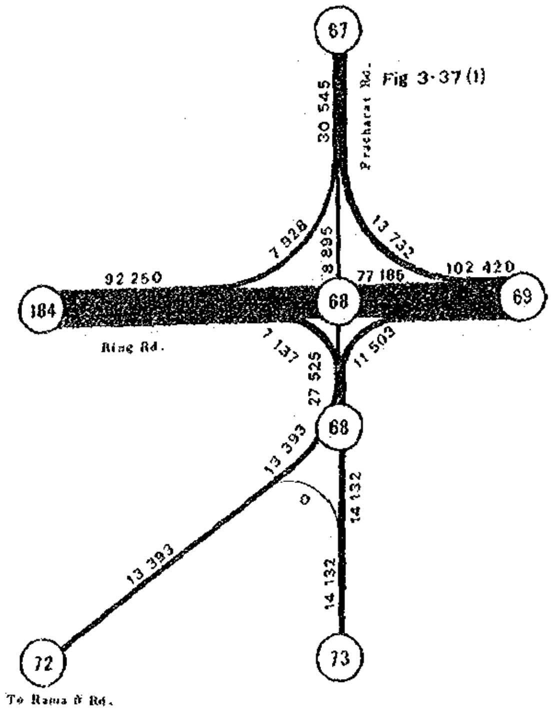


Estimated Intersection

Traffic Stream, 1990

(Optimum Network)

Fig 3-37 (1)



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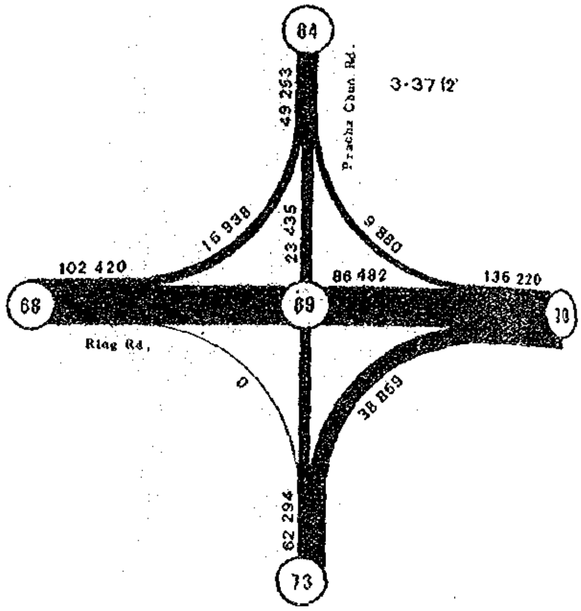

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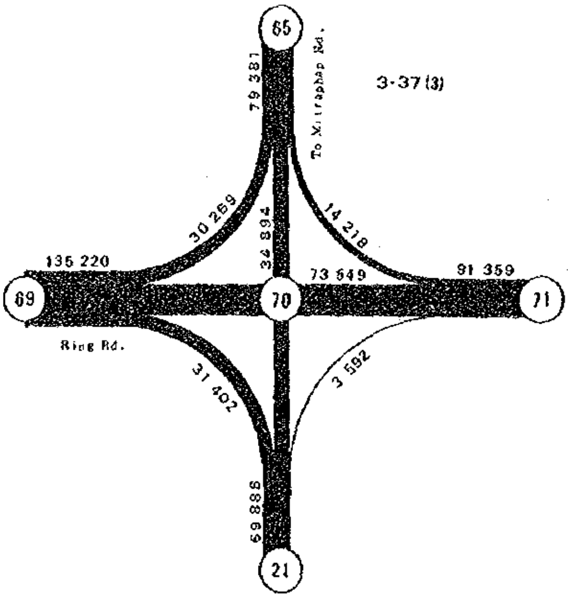

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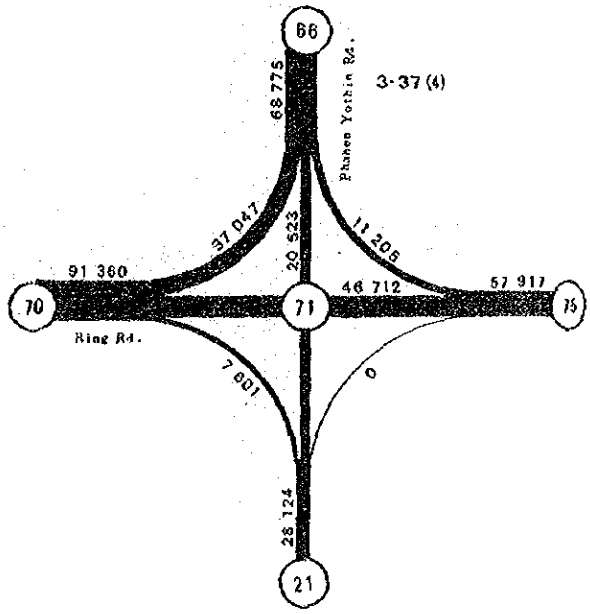
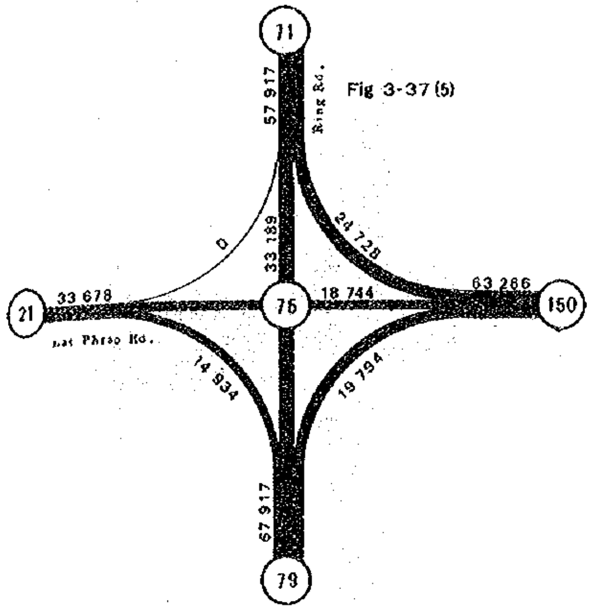


Estimated Intersection

Traffic Stream, 1990

(Optimum Network)

Fig 3-37 (5)



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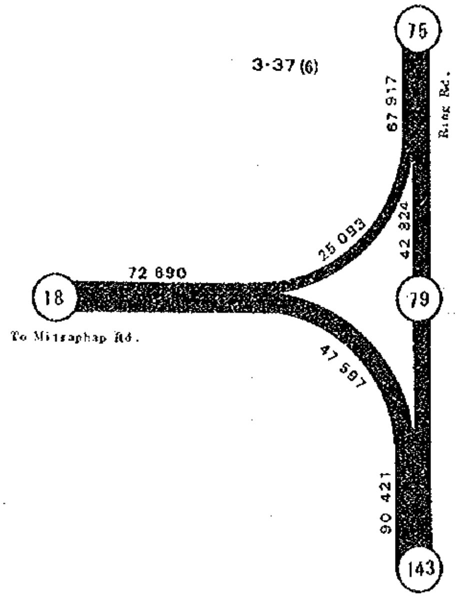

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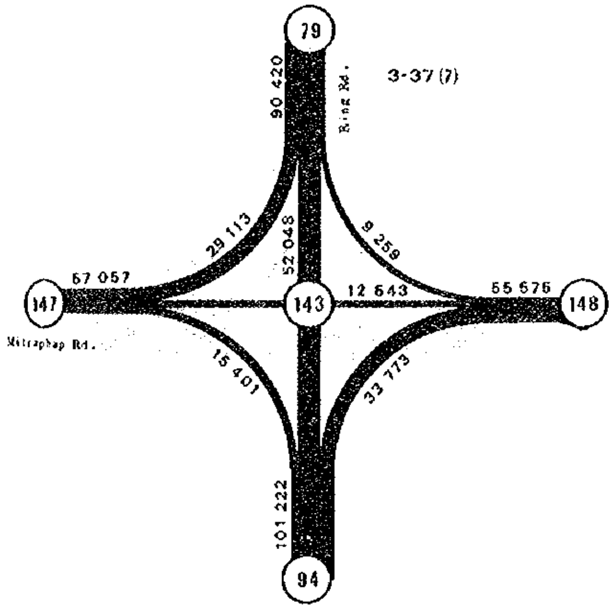

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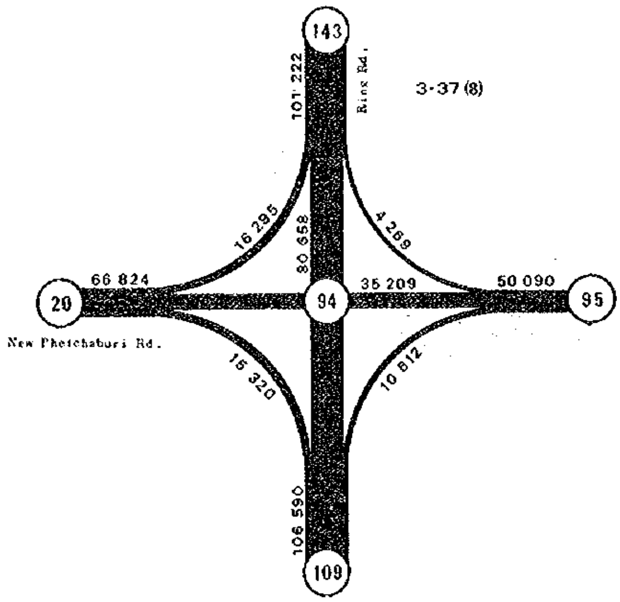
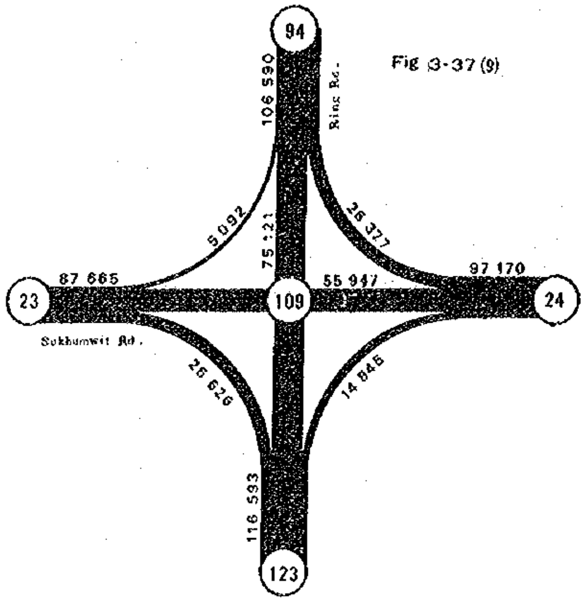


Estimated Intersection

Traffic Stream, 1990

(Optimum Network)

Fig 3-37 (9)



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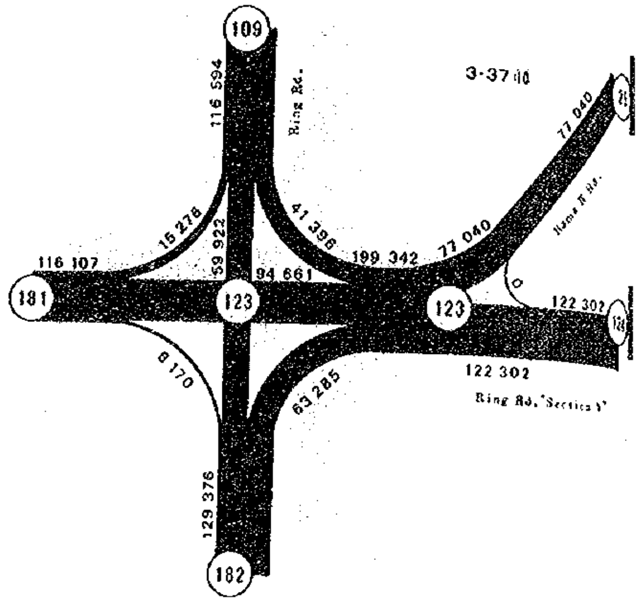

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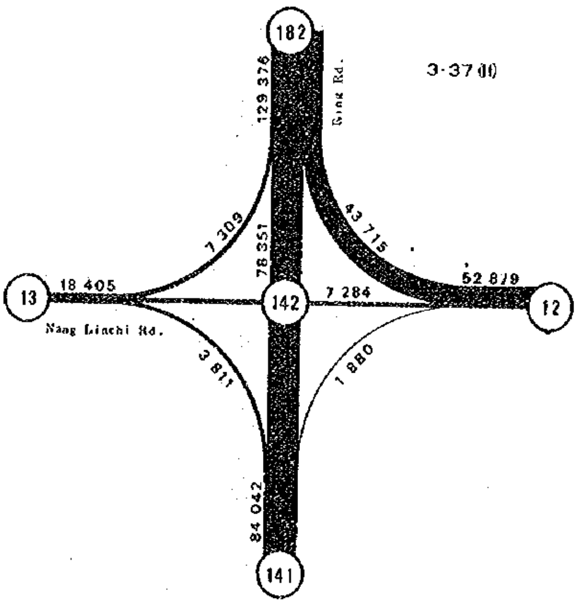

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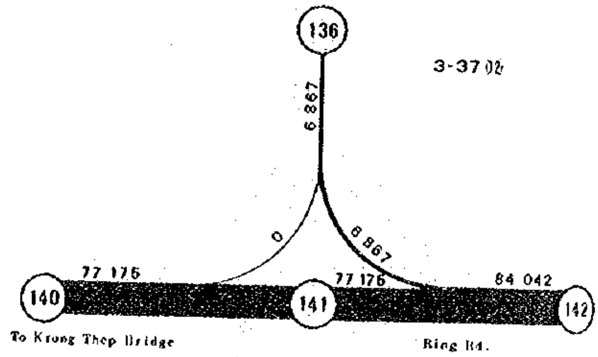
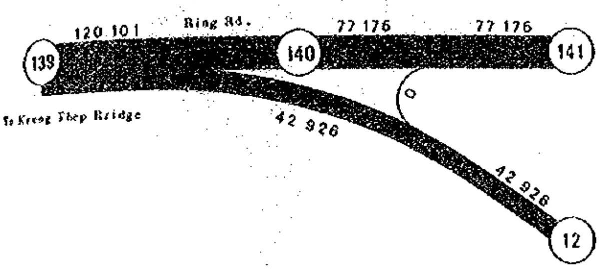


Estimated Intersection

Traffic Stream, 1990

(Optimum Network)

Fig 3-37 (3)



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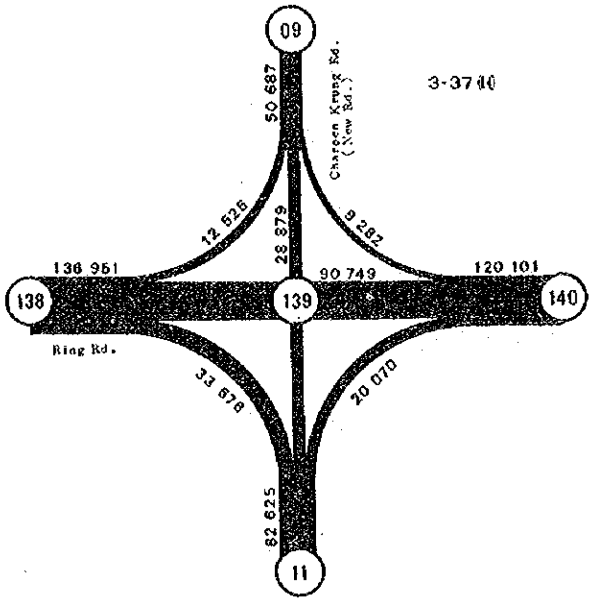

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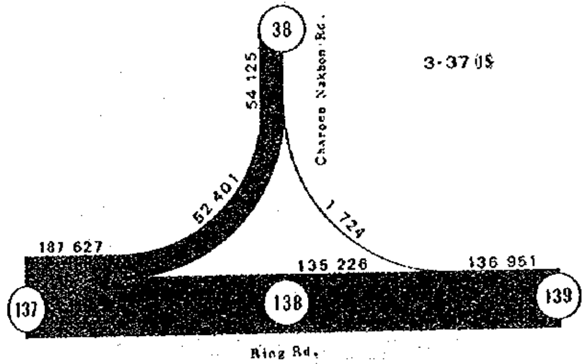

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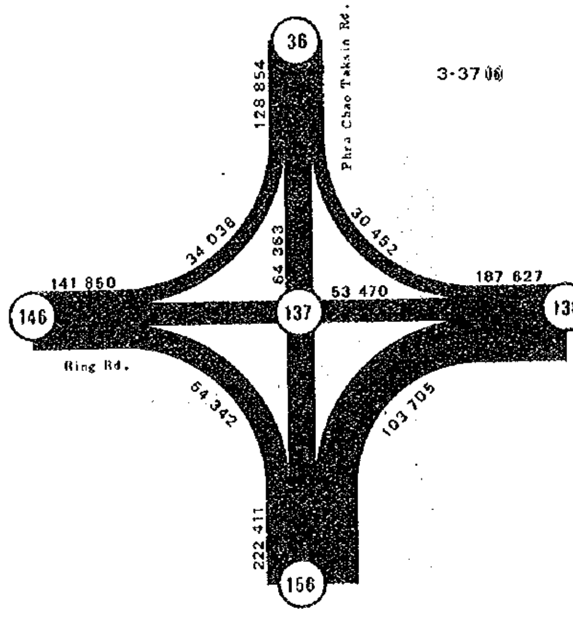
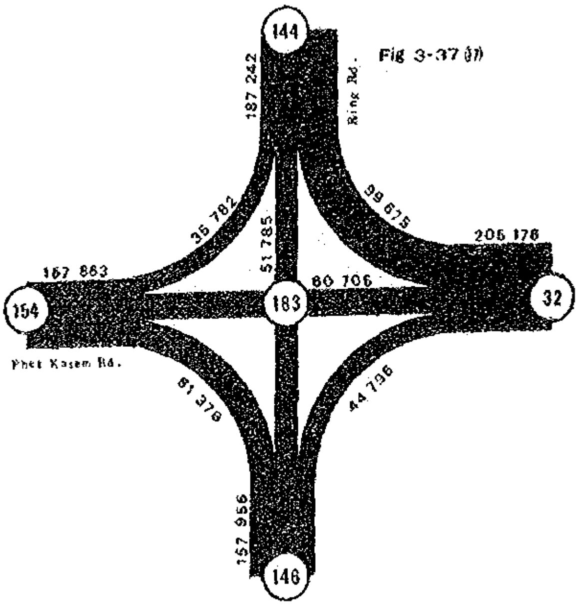
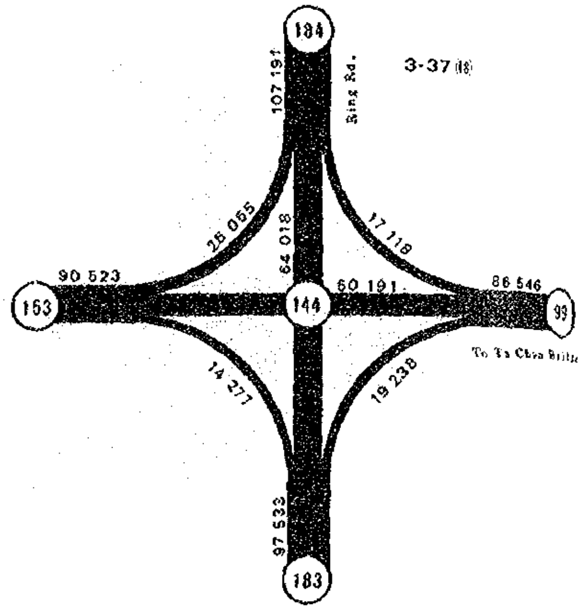


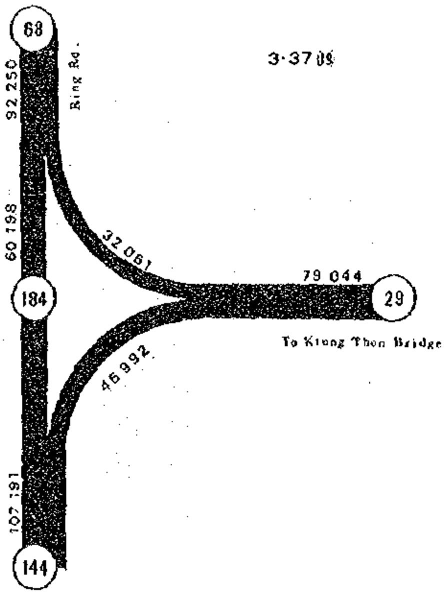
Estimated Intersection

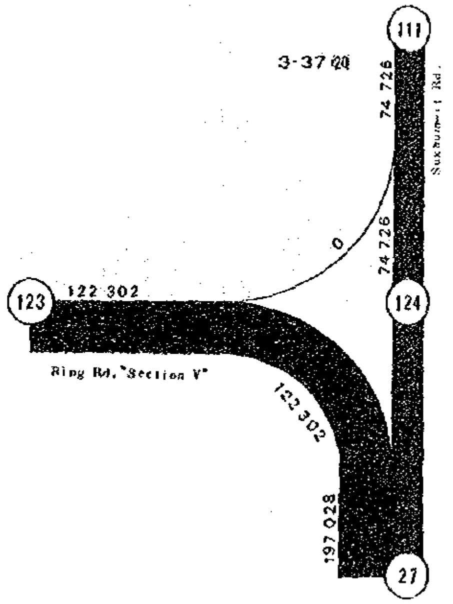
Traffic Stream, 1990

(Optimum Network)









CHAPTER 4. ECONOMIC ANALYSIS

4-1 Introduction

4-1-1 About economic analysis

Economic analysis is necessary in new highway construction to determine the economic viability or feasibility of the project. There are many methods of analysis commonly in use. The following are a few of the most commonly adopted methods.

(1) Equivalent uniform annual cost method

This is a method whereby all investment costs and all annual expenses are combined into one single annual sum that is equivalent to all disbursement for the whole analysis period if distributed evenly over the period. In examining more than one alternatives, the one with the lowest equivalent uniform annual cost is the most economical. If the value is converted into the present worth, then the answer derived will be the same as that obtained by the present worth of costs method.

(2) Present worth of cost method

In this method, all investment costs and all annual expenses are combined into a single sum converted into present worth, representing the totals sum necessary at the initial year to finance the total disbursements over the analysis period. The one with the lowest present worth is the most economical of the alternatives compared.

(3) Equivalent uniform annual net return method

This is a method whereby an income factor or benefit factor is added to the equivalent uniform annual cost method. The result of the analysis shows the amount by which the equivalent uniform annual income is more or less than the equivalent uniform annual cost. The alternative which has the greatest equivalent uniform annual net return is the one economically most feasible.

(4) Net present value method

In this method, the difference between the present worths of outward cash flows and inward flows of incomes or benefits is computed. It is the same in principle as the present worth of costs method, except that the factor of annual income is included. The alternative with the greatest net present values is considered economically most feasible.

(5) Benefit/cost ratio method

The benefit/cost ratio is the ratio between the equivalent annual benefit (or its present worth) and the equivalent uniform annual cost (or its present worth). An alternative with a benefit/cost ratio higher than 1.0 is economically feasible, and of the alternatives compared, the one with the greatest benefit/cost ratio has the highest economic preference.

(6) Internal rate of return method

In this method, the discount rate which will produce an equal value for both the negative costs and the positive incomes or benefits is computed. Usually, in highway projects, two or more alternatives are compared to determine the differential benefits. The higher the internal rate of return the greater the economy of the alternative is indicated.

Although there are many methods in economic analysis, no single method may be considered absolutely advantageous over the other methods as each method has its limitations and its advantages when applied to different types of projects. For this reason, in many cases, more than one method are adopted in order to provide more field for making a final decision.

In all the above-mentioned methods, there is a common objective of comparing the future stream of costs and incomes/benefits in such a way that for the analysis period the results will indicated the probable net return on the proposed investment, or the most economical alternative for producing the returns. It is evident therefore, that in such an analysis, the analysis of the costs and incomes/benefits for the project is necessary. A description will be made of the cost and benefits analysis to be adopted in this study in the subsequent sections.

4-1-2 The general concept of economic analysis in the study

In the economic analysis of a project within a comprehensive transportation system plan, the usual practice will be to evaluate the economic viability, feasibility, or priority vis-a-vis other projects, mutually exclusive or inclusive. This will involve the analysis of all projects under contemplation. However, such an analysis will be entirely out of the scope of this study, whereby the target is set only at the Ring Road. The short period of time allowed for the study will in any way rule out the possibility of probing into so deep an analysis. The analysis here, therefore, will involve only the evaluation of the feasibility of the Ring Road as against the case of 'without' the Ring Road.
The relative feasibility of the Ring Road project in comparison to other transportation projects will have to be left pending a study at a higher level.

The problem left for this study, will therefore boil down to only answering the question, whether it is worthwhile to implement the Ring Road project. A simple way to answer this question will be as follows.

Assume a most pessimistic case, whereby the minimum of benefits is taken into consideration, and the investment of the whole route for the complete cross section of the road carried out right from the beginning. (This is usually an uneconomical way of investment.) On evaluation, if it is found that such an investments pays (or is feasible), then any accruement of unaccounted-for benefits, and any savings on the method of investment will further enhanced the feasibility of the project. This method is adopted to ascertain that the Ring Road project is feasible even under the most pessimistic conditions, and then the evaluation for a suggested more realistic schedule of investment also made.

4-2 Cost Analysis

In the economic analysis of a new highway project, the cost involved may be largely classified into the following three categories:

i) Initial investment costs
ii) Maintenance and management expenses
iii) Road users costs

Full description of the above items will be offered in the ensuing sections.

(1) Initial investment cost

The main items in this category are the costs involved in the construction of the proposed road. They are the cost of land acquisition, the cost of construction, the other miscellaneous cost related to the implementation of the project. When any reinvestments are planned during the analysis period, the costs of reinvestment are also taken into consideration.
The costs in this category are directly related to the engineering aspects of the project, and are usually computed during the cost of the engineering study of the project. In this study, the engineering aspects of the proposed road discussion are made in details in Part II of this report. The cost estimated in the engineering study are then adopted in the economic evaluation.

(2) Maintenance and management expenses

This item includes the disbursements involved annually during the analysis period to keep the highway in good operating condition. They are the costs of repairs, improvements, maintenance, management of the road during the analysis period.
In the case of a toll road, the direct and indirect costs

involved in the operation of the toll system are also included. In this study, the expenses are estimated in the engineering study and the results adopted in economic analysis.

(3) Road users costs

These are the costs involved by the road users in the course of using the new road. The major items are the vehicle operating costs and the time value of the vehicles and the passengers. However, these items are seldom taken up independently as the costs of the project. Rather, comparisons are made between these cost involved in the case 'with' and the case 'without' the proposed project, and the saving in costs computed as benefits of the new project.

The operating cost of a vehicle is composed of many items. These items may be roughly classified under the following five headings:

(a) Distance elements: The body, the mechanical and the electrical components, consumption of gasoline and oils, tyres, depreciation and others.

(b) Time elements: Accidents, depreciation, insurance, licence, interest, parking and others.

(c) Ownership elements: Garage, property tax, vestcharge and others.

(d) Commercial elements: Operators wages and benefits, overheads, business taxes and others.

(e) Value of travel time of vehicle occupants

These elements vary in cost according to the conditions of the country, the prices of the component items, the rate of duty and taxes of the country, as well as the alignment,

road surface condition, gradient and other geometric conditions of the road being used. Careful detailed analyses are necessary to establish the per unit operating cost of a vehicle in a district or a road under study.
The consulting engineers T. P. O. Sullivan & Partner had, in early 1971, carried out a very comprehensive analysis of the operating cost of vehicles in Thailand, and the results are presented in the report "Road User Costs in Thailand".

In this report the road user costs at different travelling speed were analysed by vehicle types and class of roads.
The vehicle type and the road class classifications are as follows:

(a) Vehicle type:

i) Car
ii) Light Bus
iii) Light truck
iv) Heavy bus
v) Heavy truck

(b) Class of road:

i) First class road: well paved roads
ii) Second class road: well engineered and maintained laterite road.
iii) Third class road: Earth road and inferior laterite road.

As the report was based on data for rural roads, modifications have to be made for the application of the results to urban road networks. In a subsequent report on "Memorial Bridge" also by the said T. P. O Sullivan & Partners, the consultants had duly made modifications to establish the costs applicable to Bangkok.

The study made was very detail, and it was concluded that the findings could be adopted to this study without qualification. However, the classification of vehicles in this study is different from that of the said cost analysis, and the findings had to be modified to suit the purpose of this study.

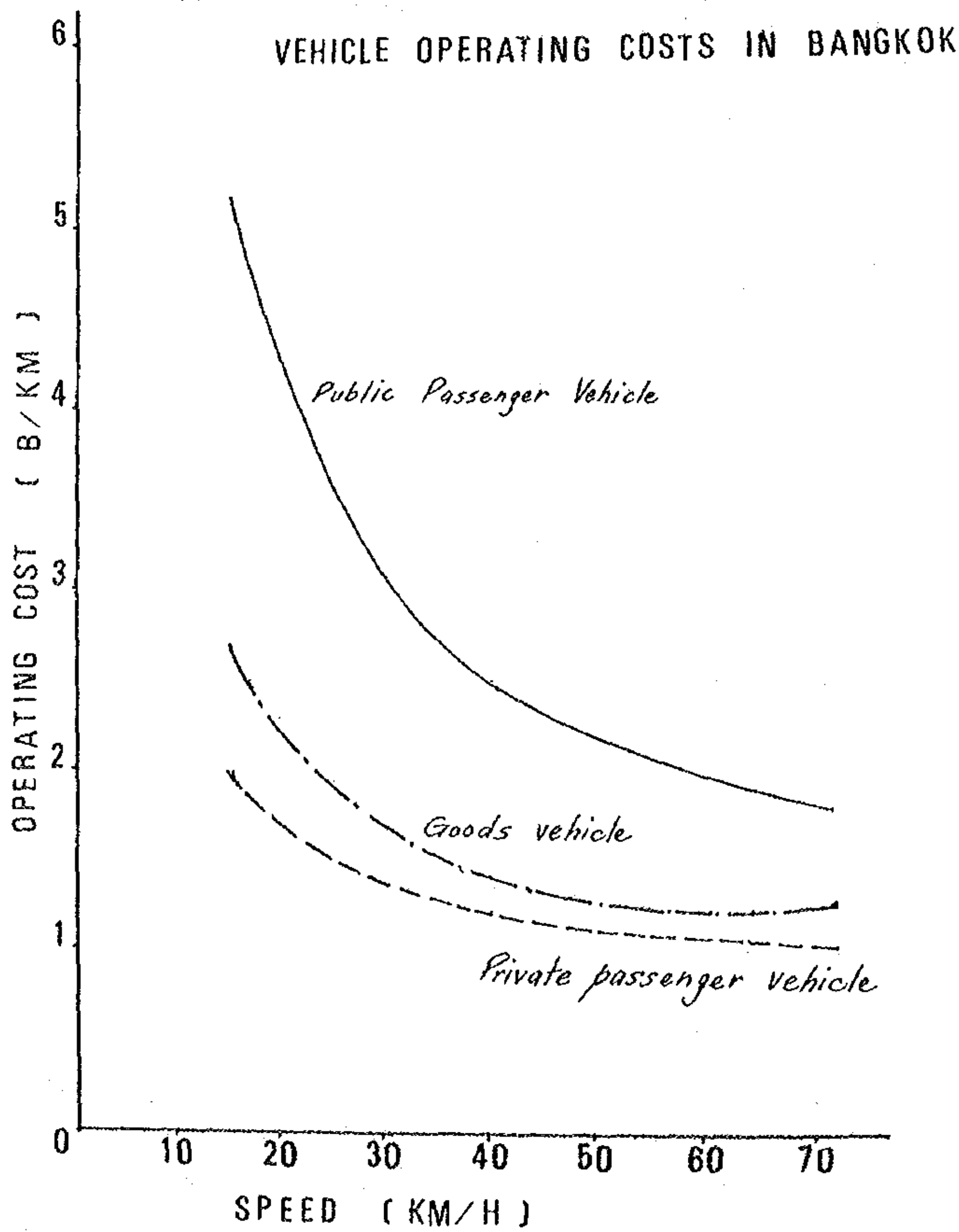
The final vehicle sperating costs as adopted in this study are shown in Table 4-1, and Fig. 4-1 is a graphical representation of the same.

Table 4-1 1970 vehicle operating costs in Bangkok with leisure time unvalued

Speed Km.p.h.	*Operating cost in Baht/Km		
	Vehicle Type		
	Private passenger vehicle (Weighted)	Public passenger vehicle (Weighted)	Goods vehicle (Weighted)
16	1.953	5.101	2.676
20	1.713	4.257	2.286
25	1.520	3.560	1.946
30	1.386	3.082	1.704
36	1.275	2.678	1.509
40	1.217	2.475	1.415
64	1.079	1.889	1.225
72	1.064	1.803	1.235

* Passenger time values included.

FIG 4-1


VEHICLE OPERATING COSTS IN BANGKOK
OPERATING COST (B/KM)
6
5
4
3
2
1
0
10
20
30
40
50
60
70
SPEED (KM/H)
Public Passenger Vehicle
Goods vehicle
Private passenger vehicle

4-3 Benefit Analysis

The c ompletion of a new transportation project will bring about various economic benefits to the community, some readily quantifiable, others so very interrelated to ther factors of economic activities that the methods for quantification will be highly sophisticated and the credibility of the outcomes dubious. In this study, following the general concept of evaluating the 'minimum' benefits, only the factors which are easily quantifiable will be computed, while other economic benefits narrated qualitatively.

4-3-1 Computation of quantifiable benefits

The most readily quantifiable item of all benefits will be the saving of the road users cost, which includes both the operating cost of the vehicles and the time value of the occupants. This comes from two general streams.
The one is the saving of time and cost by the vehicles diverted to the new highway as compared to the conventional route, and this is usually referred to as the direct benefit. The other is the saving of time and cost by the remaining vehicles on the existing road network, which, through the diversion of part of the traffic to the new route, enjoys some relieve in traffic congestion, and will be able to provide traffic with a better service. This is usually termed the indirect benefit.
In this study, the total saving at different year of all traffic on the whole network, covering both the direct at the indirect benefit, can be computed on one calculation by comparing the total road users cost 'with' and 'without' the Ring Road.
This will be done through multiplication of the total vehicle-kilometer in each case with the unit road user cost for the

respective case. Table 4-2 shows the total travel time and travel distance of the whole network in various years under different conditions and Table 4-3 summarizes the benefits of these cases.

The annual benefit derived from the Ring Road in 1975, if the whole route were completed in that year, would have come to 425.0 million bahts. The same for 1980 and 1990 (normal network) are respectively 630.8 million and 898.2 bahts. This respresents an increase to 1.48 and 2.11 times the benefit in 1975. The increase in traffic volume, as compared to 1975, are estimated at 1.41 and 2.13 times for 1980 and 1990 respectively. The growth rate in benefit is almost parallel to that in traffic volume. This shows that the increase in traffic volume is the main factor in the increase in benefits, and that the deterioration in traffic congestion is but a minor factor, if any contribution is made at all.

The benefits for the intermediate years and subsequent years are derived through linear interpolation and extrapolation, and the year by year benefits are shown in Table 4-4 and Fig. 4-2.

One of the possible programmes for stage construction is discussed in Chapter 7, whereby only a portion of the Ring Road will be available for traffic at the initial stage. In this case, the benefit in 1975 will have been reduced to 118.8 million. A table of annual benefits according to the stage construction programme, which calls for the opening of the first stage in 1977, will be as shown in Table 4-5, and the graphical presentation as in Fig. 4-3.

Table 4-2 Summary of total daily travel time & travel distance in whole network

Year	Road Network	Total Travel Time (vehicle-minute)				Total Travel Distance (vehicle kilometer)			
		Vehicle Type				Vehicle Type			
		Private Passenger Vehicle	Public Passenger Vehicle	Goods Vehicle	Total	Private Passenger Vehicle	Public Passenger Vehicle	Goods Vehicle	Total
1975	Without Ring Road	12,031,611	7,447,021	4,915,767	24,394,399	10,635,262	6,442,567	5,506,268	22,584,097
	With Ring Road	10,987,804	6,732,209	4,634,676	22,354,689	10,595,440	6,425,555	5,510,868	22,531,863
1980	Without R. R.	16,871,332	9,993,619	6,711,406	33,576,357	14,472,187	8,356,261	7,393,494	30,222,397
	With R. R	15,163,346	8,883,196	6,346,824	30,393,366	14,475,410	8,369,098	7,374,891	30,219,399
1990	Without R. R. (optimum network)	29,190,454	15,383,922	11,199,027	55,773,403	23,270,565	11,950,587	11,132,808	46,353,960
	With R. R. (optimum network)	26,336,066	13,743,973	10,659,542	50,739,581	22,689,535	11,880,891	11,077,439	45,647,865
	Without R. R. (normal network)	32,277,331	16,891,052	11,868,578	61,036,961	22,916,740	11,934,640	11,115,702	45,967,082
	With R. R, (normal network)	28,926,131	14,950,720	11,209,696	55,086,547	22,962,210	11,966,480	11,107,642	46,036,332

Table 4-3 Benefits through saving in vehicle operating cost

Year		Without Ring Road				With Ring Road				Benefits	
		Private passenger vehicle	Public passenger vehicle	Goods vehicle	Total	Private passenger vehicle	Public passenger vehicle	Goods vehicle	Total	Baht/day	Million baht /year
1975	Unit operating cost (Baht/km)	1.142	2.184	1.229	—	1.115	2.055	1.234	—		
	Total operating cost (Baht/day)	12,145,469	14,070,566	6,767,203	32,983,238	11,813,916	13,204,515	6,800,411	31,818,842	1,164,395	425.0
1980	Unit cost	1.151	2.226	1.228	—	1.118	2.072	1.232	—		
	Total cost	16,657,487	18,601,037	9,079,769	44,338,293	16,183,508	17,340,771	9,085,866	42,610,145	1,728,148	630.8
1990 (optimum network)	Unit cost	1.172	2.314	1.260	—	1.150	2.184	1.238	—		
	Total cost	27,273,102	27,653,658	14,027,338	68,954,098	26,092,965	25,947,866	13,713,869	65,754,700	3,199,398	1,167.8
1990 (normal network)	Unit cost	1.202	2.416	1.287	—	1.173	2.280	1.261	—		
	Total cost	27.545,921	28,834,090	14,305,908	70,685,920	26,934,672	27,283,574	14,006,737	68,224,983	2,460,937	898.2

Table 4-4 Annual benefits

Year	Annual benefits (million bahts)
1975	425.0
76	466.2
77	507.3
78	548.5
79	589.6
80	630.8
81	657.5
82	684.3
83	711.0
84	737.8
85	764.5
86	791.2
87	818.0
88	844.7
89	871.5
90	898.2
91	924.9
92	951.7
93	978.4
94	1,005.2
95	1,031.9
96	1,058.6
97	1,085.4
98	1,112.1
99	1,138.9
2000	1,165.6

Fig 4-2 Annual Benefits

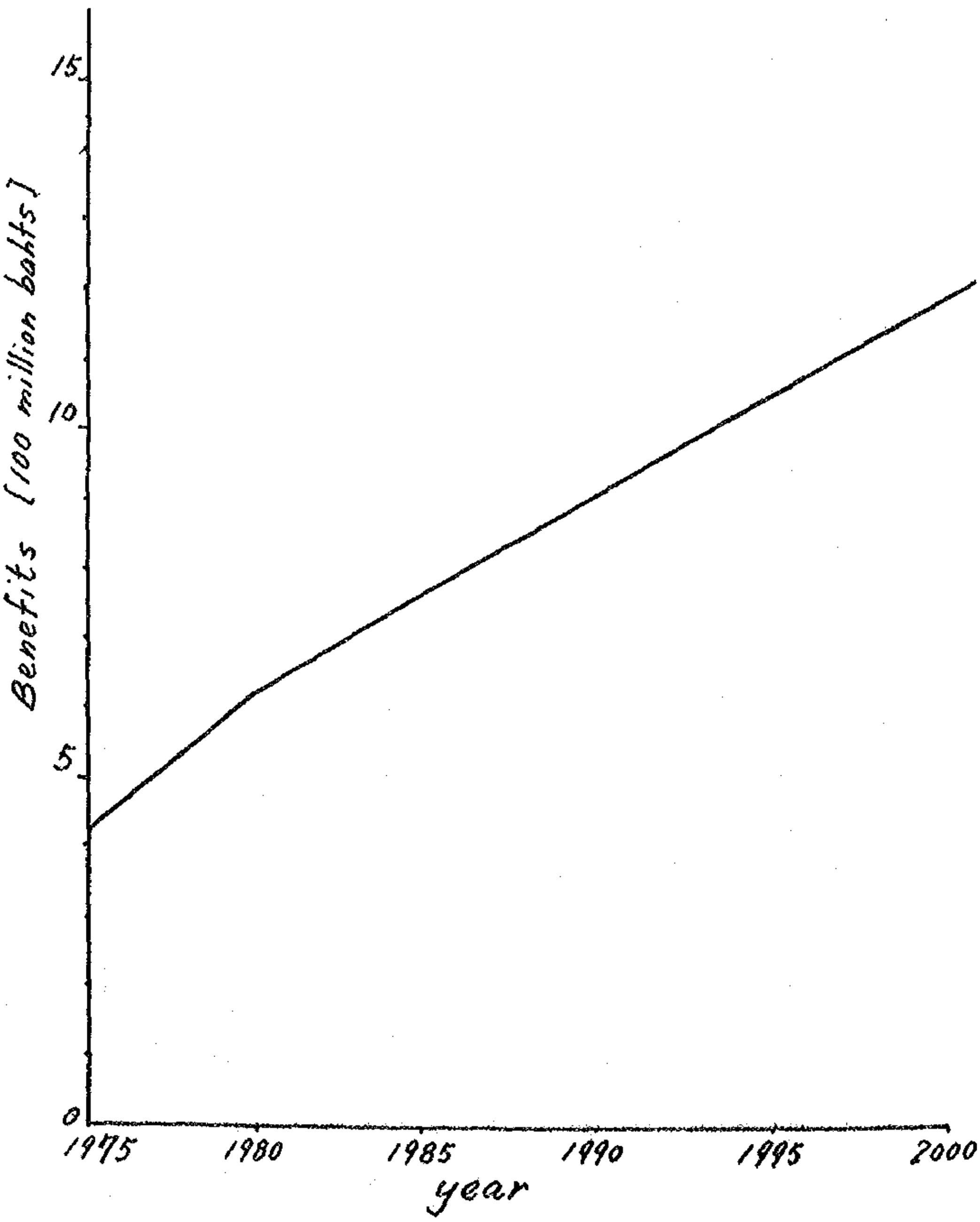
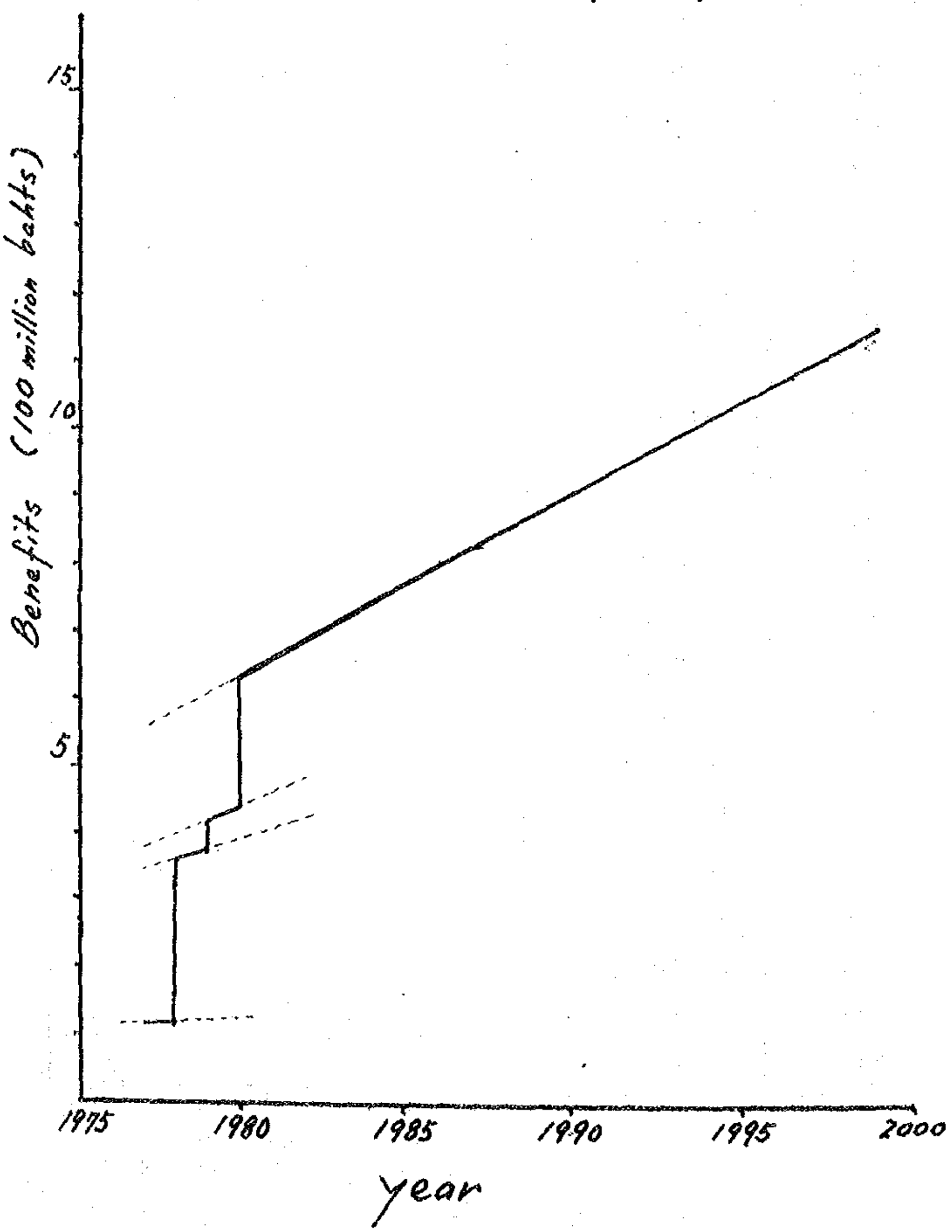


Table 4-5 Annual benefit in case of stage construction

Year	Benefit	Remarks
1975	–	
76	–	acquisition & construction
77	120.2	Completion of 1st section
78	361.7	" 2nd "
79	421.1	" 3rd "
80	630.8	Ring completed
81	657.5	
82	684.3	
83	711.0	
84	737.8	Project completed
85	764.5	
86	791.2	
87	818.0	
88	844.7	
89	871.5	
90	898.2	
91	924.9	
92	951.7	
93	978.4	
94	1,005.2	
95	1,031.9	
96	1,058.6	
97	1,085.4	
98	1,112.1	
99	1,138.9	
2000	1,165.6	

Fig 4-3 Increase in Annual Benefits in case of stage construction



4-3-2 Other economic effects

The completion of a new road will not only result in the benefits enjoyed by the vehicles within the road network through saving in time and cost, but will also bring about many other economic effects to the community. The quantification of these is difficult without a thorough analysis into the economic structure of the community, or without more detail data. Only brief comments on these economic effects will be made below.

(1) Intensification of land use

The building up of a city develops along transportation route, whatever the mode of the transportation.
Where land transportation facilities are not available, residence and commerce will take place along a waterway. When a railway line is built, building up will begin centering around a railway station. When a new road is completed, development activities will sprout along the route.
A major part of the Ring Road is planned to traverse through regions where economic activities are limited to agriculture. The completion of the Ring Road will no doubt serve as a catalyst to stimulate more intensified economic activities along the route. Residential areas, commercial areas, and industries can be expected to hang to the new road. However, it is difficult to assess quantitatively the effects of such anticipated development, nor can the pace of development be forecast. However, an indication may be seen from the building up which followed the completion of the Mittraphap Road and the New Phetchaburi Road extension. Fig. 4-4 shows the trend of building up in Bangkok since the beginning of this century.

It is seen that within a short span of seven decades, the the city area has expanded by more than 10 times, increasing at a pace of more than 3 times every thirty years. Centering around the old city centre, the expansion has been in all directions, the east being the most prominent. The two news roads of Mittraphap and New Phetchaburi came into the picture after 1958. The development along these two roads within a short span of time was most phenomenal, as can be seen from the state of building up in the 1967 map. The railway line which runs along the New Phetchaburi extension, however, forms a barrier and development along this road does not go into any depth beyond the railway line. From the figures, the lack of development on the north-eastern portion of Bangkok is most conspicuous. Despite the region's relative nearness to the city center (as compared to Don Muang, Bangna or even to Bangsu region), the lack of transportation facilities is fatal. The Lat Phrao Road is the only major trunk road within this region, and the route of Lat Phrao Road certainly does not contribute towards a rapid access to the city center. The Ring Road, which is proposed to run right through the heart of this 'desert' region in a north-south direction, will no doubt contribute greatly to the future development of the region.

(2) Effect of reduction in traffic accidents

Lack of sufficient data bars the possibility of making a comparison of the rate of vehicle accident on an expressway as against that on an ordinary roadway, and it will be rash to conclude that a road as the Ring Road will be safer than other roads, However, the appearance of the Ring Road will reduce the congestion on the whole road network, and will, indirectly contribute to the safety on these existing roads.

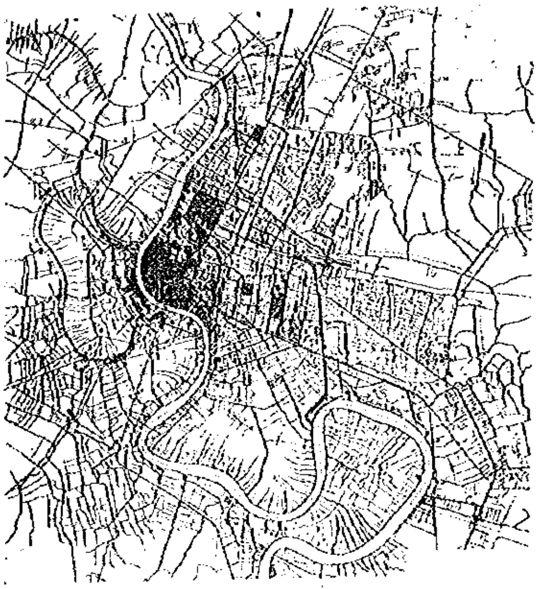
(3) Rationalization of goods transportation

Heavy goods vehicles are at present curbed from entering the Municipal boundaries from six in the morning to nine in the evening. The vehicles from upcountry will have to wait outside the boundaries for the daily lifting of the restriction, resulting in undue waste of time.
The completion of the Ring Road will enable these heavy trucks to come into the city area during daylight hours without making major disturbance to the traffic of the existing road network. This will indirectly contribute to the future rationalization of goods transpotation in and out of Bangkok.

(4) Others

There are as doubt many other indirect benefits as a result of the completion of the new road, since the improvement of the transportation system will not only stimulate economic activities but will also indirectly provide incentive to cultural, civic, sports and recreational activities.
Such unquantifiable benefits to the community shall also be a major consideration in making a decision towards the implementation of the Ring Road.

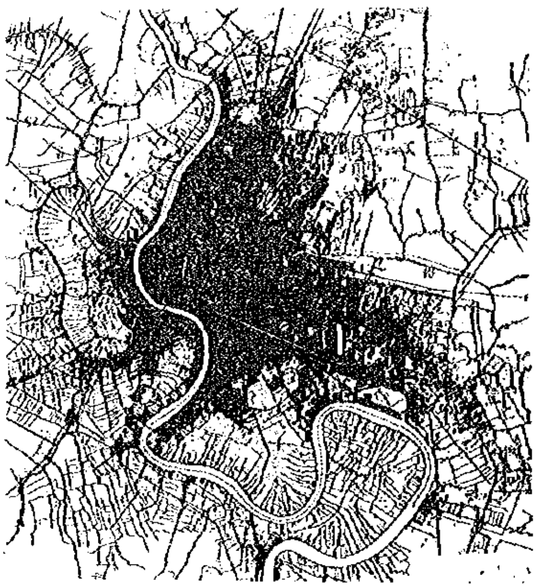
Fig 4-4 Trend of Building Up in Bangkok



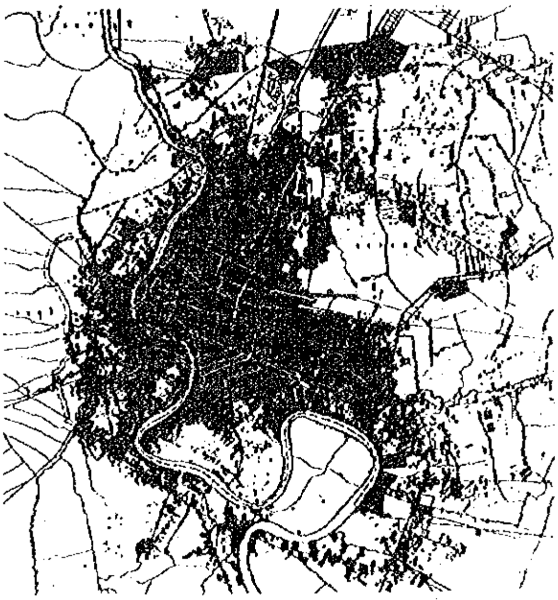
year: 1900 Estimated area 13.3km²

year: 1936 Estimated area 43.2km²

year: 1958 Estimated area 96.4km²



year: 1967 Estimated area 141.5km²



4-4 Cost-Benefit Analysis

As has been mentioned before, in the cost-benefit analysis here, the sole purpose is to study the feasibility of the investment on the Ring Road as against the quantifiable benefits that may be expected of the Ring Road. Calculation will be made of both the benefit-cost ratio and the internal rate of return when the whole investment is made in the initial year, for the best alternative routes decided in Chapter 7.

(a) Construction cost

The construction costs are estimated in Chapter 7, and the summary is given below:

(i) Ring Road Part II

Cost of land acquisition and demolition		
	693.3	million bahts (1975 value)
Cost of construction		
	2,165.0	"
Total	2,858.3	"

(ii) Section 5 (excluding junction with Ring Road)

Cost of land acquisition & demolition		
	177.8	million bahts
Cost of construction	566.7	"
Total	744.5	"

(iii) Junction of Section 5 with Ring Road

Cost of land acquisition & demolition		
	195.0	million bahts
Cost of construction	150.0	"
Total	345.0	"

(iv) Whole Project

Cost of land acquisition & demolition

	1,066.1	million bahts (1975 value)
Cost of construction	2,881.7	"
Total	3,947.8	"

(b) Maintenance cost

The annual maintenance cost are estimated as follows:

(i)	Ring Road Part II	10.8	million bahts/year (1975 value)
(ii)	Section 5	2.8	"
(iii)	Junction of Section 5 with Ring Road	1.5	"
(iv)	Total	15.1	"

(c) Benefits

The benefit are as shown in Table 4-4 in the preceding section.

(d) Benefit-cost ratio

Benefits-cost ratio are calculated under the following conditions

(i) Discount rates : three cases were considered, which are 10%, 12%, and 15%

(ii) Redemption period 20 years

Under the above mentioned conditions, the accumulated discounted costs and benefits are as in table 4-6.
Basing on the above results, benefit-cost ratios and the internal rates of return are calculated and the results are as below.

(i) at discount rate of 10%	benefit-cost ratio = 1.51	
(ii) at discount rate of 12%	benefit cost ratio = 1.31	
(iii) at discount rate of 15%	benefit cost ratio = 1.09	
(iv) internal rate of return		16.6%

The results show that, even with the most unpractical method of investing the whole construction cost of 3,947.8 million bahts at the initial year, the accumulated benefits in in 20 years at a high discount rate of 15% will pay off the invested amount. Taking the Ring Road project by itself, the conclusion will therefore be that the project is economically viable. From the traffic analysis, the trafic demand fully justify the implementation of the project from the traffic point of view. It is recommended therefore that the Ring Road project is necessary and economically feasible and, to provided early relieve to the situation of vehicle traffic congestion in Bangkok, the project should be implemented at an early date.

Table 4-6 Annual Discounted Benefits and Maintenance Cost

Unit: million baht

Year	Construction Cost (1975 price)	Benefits				Maintenance Cost			
		Current price	1975 price			Current price	1975 price		
			10%	12%	15%		10%	12%	15%
1975	3,947.8	425.0	425.0	425.0	425.0	15.1	15.1	15.1	15.1
76		466.2	423.8	416.2	405.4	"	13.7	13.5	13.1
77		507.3	419.3	404.4	383.6	"	12.5	12.0	11.4
78		548.5	412.1	390.4	360.6	"	11.3	10.7	10.0
79		589.6	402.7	374.7	337.1	"	10.3	9.6	8.6
80		630.8	391.7	357.9	313.6	"	9.4	8.6	7.5
81		657.5	371.1	333.1	284.3	"	8.5	7.7	6.5
82		684.3	351.2	309.5	257.3	"	7.7	6.8	5.7
83		711.0	331.7	287.2	232.4	"	7.0	6.1	4.9
84		737.8	312.9	266.1	209.7	"	6.4	5.4	4.3
85		764.5	294.7	246.1	189.0	"	5.8	4.9	3.7
86		791.2	277.3	227.5	170.1	"	5.3	4.3	3.2
87		818.0	260.6	210.0	152.9	"	4.8	3.9	2.8
88		844.7	244.7	193.6	137.3	"	4.4	3.5	2.5
89		871.5	229.5	178.3	123.2	"	4.0	3.1	2.1
90		898.2	215.0	160.4	110.4	"	3.6	2.8	1.9
91		924.9	201.3	150.9	98.8	"	3.3	2.5	1.6
92		951.7	188.3	138.6	88.4	"	3.0	2.2	1.4
93		978.4	176.0	127.2	9.1	"	2.7	2.0	1.2
1994		1,005.2	164.4	116.7	70.6	15.1	2.5	1.8	1.1
Total for 20 years	3,947.8		6,093.3	5,313.8	4,428.8	302.0	141.3	126.5	108.6
1995		1,031.9	53.4	107.0	63.0	15.1	2.3	1.6	0.9
96		1,058.6	143.0	98.0	56.2	"	2.1	1.4	0.8
97		1,085.4	133.3	89.7	50.1	"	1.9	1.2	0.7
98		1,112.1	124.2	82.1	44.7	"	1.7	1.1	0.6
1999		1,138.9	115.6	67.0	39.8	15.1	1.6	1.0	0.5
Total for 25 years	3,947.8		6,762.8	5,757.6	4,682.6	377.5	150.9	132.8	112.1

(e) Benefit-cost ratio under stage construction

The investment of the whole 3,947.8 million baht in one year is not practical, as this will increase the budget for the highway projects by many times and will adversely affect other highway projects. Moreover, a construction work of such a scale at such a short time will require concentrated supply of man-power and materials, which will be beyond the capacity of existing supplies. Technically, it will also be practically impossible to safely carry out such a construction work. A suggestion as one of the practical methods of stage construction is made in Chapter 7. Here the economic analysis is made in the case that the suggested stage construction schedule is implemented.

(i) Construction cost

The annual allotment of investment amount as well as the accumulated amount will be as in table 4-7.

(ii) Benefits

According to the schedule, the benefits will not be produced until 1977, when part of the Ring Road is completed. The benefits for the first several years will be considerably lower than that which available when the whole project is completed, and the accumlated benefits will be as in table 4-8.

(iii) Maintenance cost

The annual maintenance cost will be as shown in table 4-9.

(iv) The results of the economic analysis are as follows:

a) at discount rate of 10% benefit cost ratio = 1.54

b) at discount rate of 12% benefit cost ratio = 1.33

c) at discount rate of 15% benefit cost ratio = 1.09

d) Internal rate of return = 16.4%

Construction by stage, whereby the Ring Road will be partially in operation 1977, is more practical. The feasibilily of the project also remains unchange despite the fact that the benefit for the first year will not be available until 1977, and the first year amount will be reduced to one-fourth.

Table 4-7 Annual Allotment in Construction Cost in case of Stage Construction.

unit: million baht

No. of year after operation	Year	Annual Investment	Discounted Value		
			10%	12%	15%
–	1974	551.6	551.6	551.6	551.6
–	1975	610.9	610.9	610.9	610.9
–	1976	441.5	401.4	394.2	383.9
1	77	518.5	428.5	413.3	392.1
2	78	489.4	367.7	348.3	321.8
3	79	353.0	241.1	224.3	201.8
4	80	351.0	217.9	199.2	174.5
5	81	363.8	205.4	184.3	157.3
6	82	194.0	99.6	87.7	72.9
7	83	75.0	35.0	30.3	24.5
	Total	3,948.7	3,159.1	3,044.2	2,891.3

Table 4-8 Annual Benefits in case of Stage Construction

unit: million baht

No. of year after operation	Year	Annual Investment	Discounted Value		
			10%	12%	15%
1	1977	120.2	99.3	95.8	90.9
2	78	361.7	271.8	257.5	237.8
3	79	421.1	287.6	267.6	240.8
4	80	630.8	391.7	357.9	313.6
5	81	657.5	371.1	333.1	284.3
6	82	684.3	351.2	309.5	257.3
7	83	711.0	331.7	287.2	232.4
8	84	737.8	312.9	266.1	209.7
9	85	764.5	294.7	246.1	189.0
10	86	791.2	277.3	227.5	170.1
11	87	818.0	260.6	210.0	152.9
12	88	844.7	244.7	193.6	137.3
13	89	871.5	229.5	178.3	123.2
14	90	898.2	215.0	160.4	110.4
15	91	924.9	201.3	150.9	98.8
16	92	951.7	188.3	138.6	88.4
17	93	978.4	176.0	127.2	79.1
18	94	1,005.2	164.4	116.7	70.6
19	95	1,031.9	153.4	107.0	63.0
20	96	1,058.6	143.0	98.0	56.2
	Total		4,965.5	4,129.0	3,205.8

Table 4-9 Annual Maintenance Cost in case of Stage Construction

unit: million baht

No.of years after operation	Year	Annual Maintenance Cost	Discounted Value		
			10%	12%	15%
0	1976	1.4	1.3	1.2	1.2
1	77	3.7	3.1	2.9	2.8
2	78	6.2	4.7	4.4	4.1
3	79	8.7	5.9	5.5	5.0
4	80	10.4	6.5	5.9	5.2
5	81	12.2	6.9	6.2	5.3
6	82	13.0	6.7	5.9	4.9
7	83	14.4	6.7	5.8	4.7
8	84	15.1	6.4	5.4	4.3
9	85	"	5.8	4.9	3.7
10	86	"	5.3	4.3	3.2
11	87	"	4.8	3.9	2.8
12	88	"	4.4	3.5	2.5
13	89	"	4.0	3.1	2.1
14	90	"	3.6	2.8	1.9
15	91	"	3.3	2.5	1.6
16	92	"	3.0	2.2	1.4
17	93	"	2.7	2.0	1.2
18	94	"	2.5	1.8	1.1
19	95	"	2.3	1.6	0.9
20	96	"	2.1	1.4	0.8
	Total		92.0	77.2	60.7

PART 2

ENGINEERING STUDY

CHAPTER 5. SOILS INVESTIGATIONS

5-1 Introduction

This chapter presents the results of a preliminary study for general subsurface conditions, foundations and pavement for the proposed Ring Road Project, Part II, in Bangkok, Thailand. This study consists of literature survey, interviews of engineers in this area and field reconnaissance, but includes no exploratory borings nor laboratory testing specifically conducted for this project.

In the Bangkok area a wealth of information is available concerning its general geology and subsurface characteristics. The results of a comprehensive study are also available on the engineering properties of the subsurface soils, particularly of the Bangkok clay which is now well known for its low strength and high compressibility.

Much of the information useful for this preliminary study was derived from published data and incorporated in this report. A bibliography relative to this subject is compiled and included in the appendices.

5-2 Geology

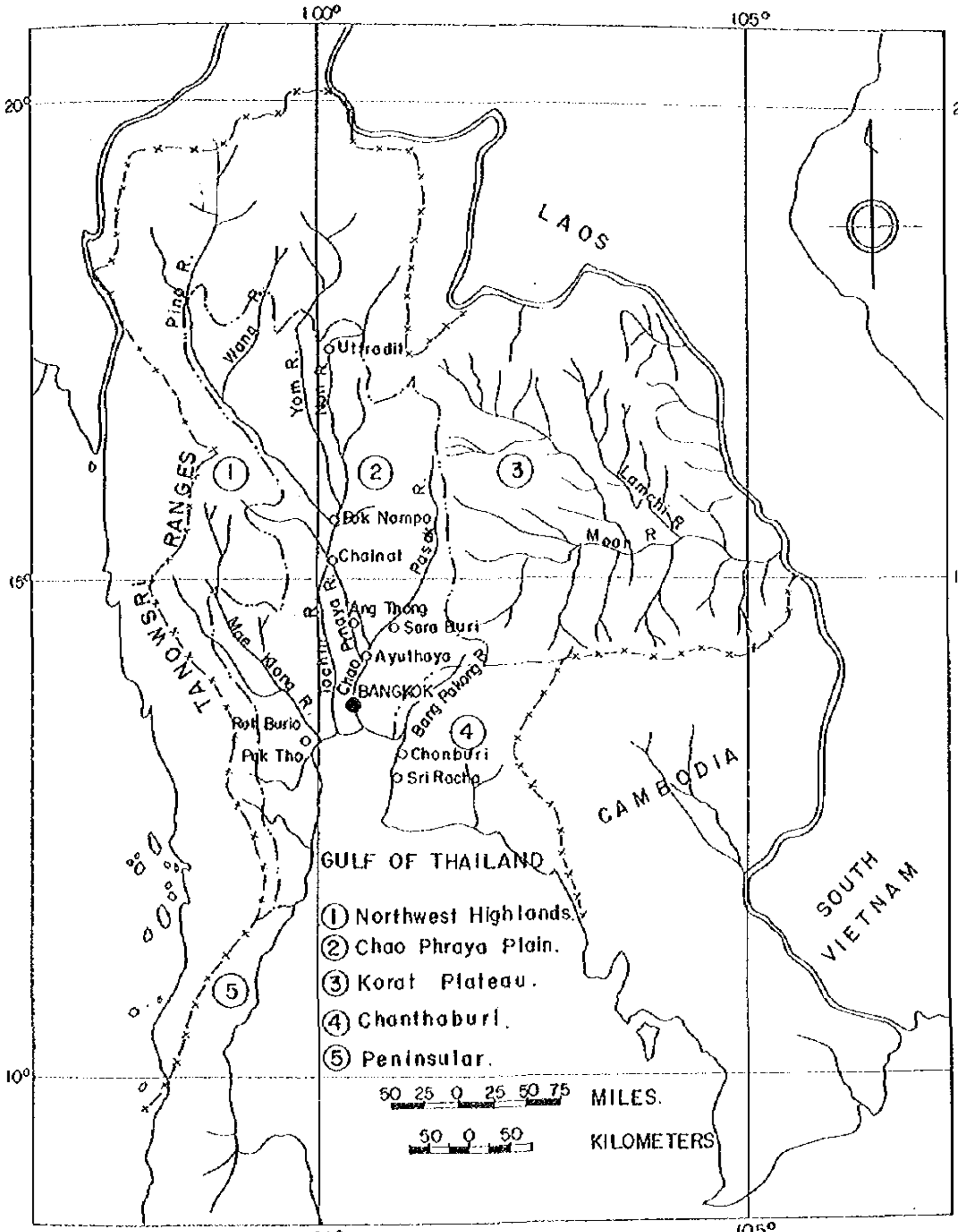
Bangkok is located on the bank of Chao Phraya River, some 20 km north of its estuary to the Gulf of Thailand. This river with many tributaries is the main drainage of the Northwest Highlands and the Chao Phraya Plain, Fig. 5-1. It is a basin filled with marine and alluvial deposits, forming an extremely flat plain about 300 km long and 100 km wide, and being completely surrounded by highlands except on the south.

It is considered that the depression of the Chao Phraya Basin is the result of the late Tertiary structural movements of the earth crust. The earlier shore of the gulf could have been as far north as Uttradit, 250 km away from the present one (Muktabhant, et al 1963).

It is speculated that, in the last 20,000 years, the rate of rise in sea level generally exceeded the rate of deposition from Chao Phraya River and invasion of the sea over the land occurred until 8,000 to 4,000 years ago, during which time the marine clays were deposited. Then land building began and an extensive deltaic plain has been formed. The marine clays were subjected to wetting and drying cycles from tidal movement of approximately ± 1.0 m during emergence of the land, and then built up above mean sea level by the terrestrial deposition of silt and clay size particles in the annual flood waters (Cox, 1968).

The alluvial deposits thus accumulated gradually moved the shore southward, presently at an annual rate of 4 to 5 m and formed a very flat plain; + 18 m near Chainat at the head of the delta, +4 m at Ayuthaya and in the average + 1.80 m (1.0 to 2.0m) in Bangkok all above the mean sea level.

The situation described as above is best illustrated by geologic sections through and across Chao Phraya Delta, Figs. 5-2 and 5-3.



(Muktabhant et al, 1967)

FIG. 5-1 Physiographic Provinces of Thailand

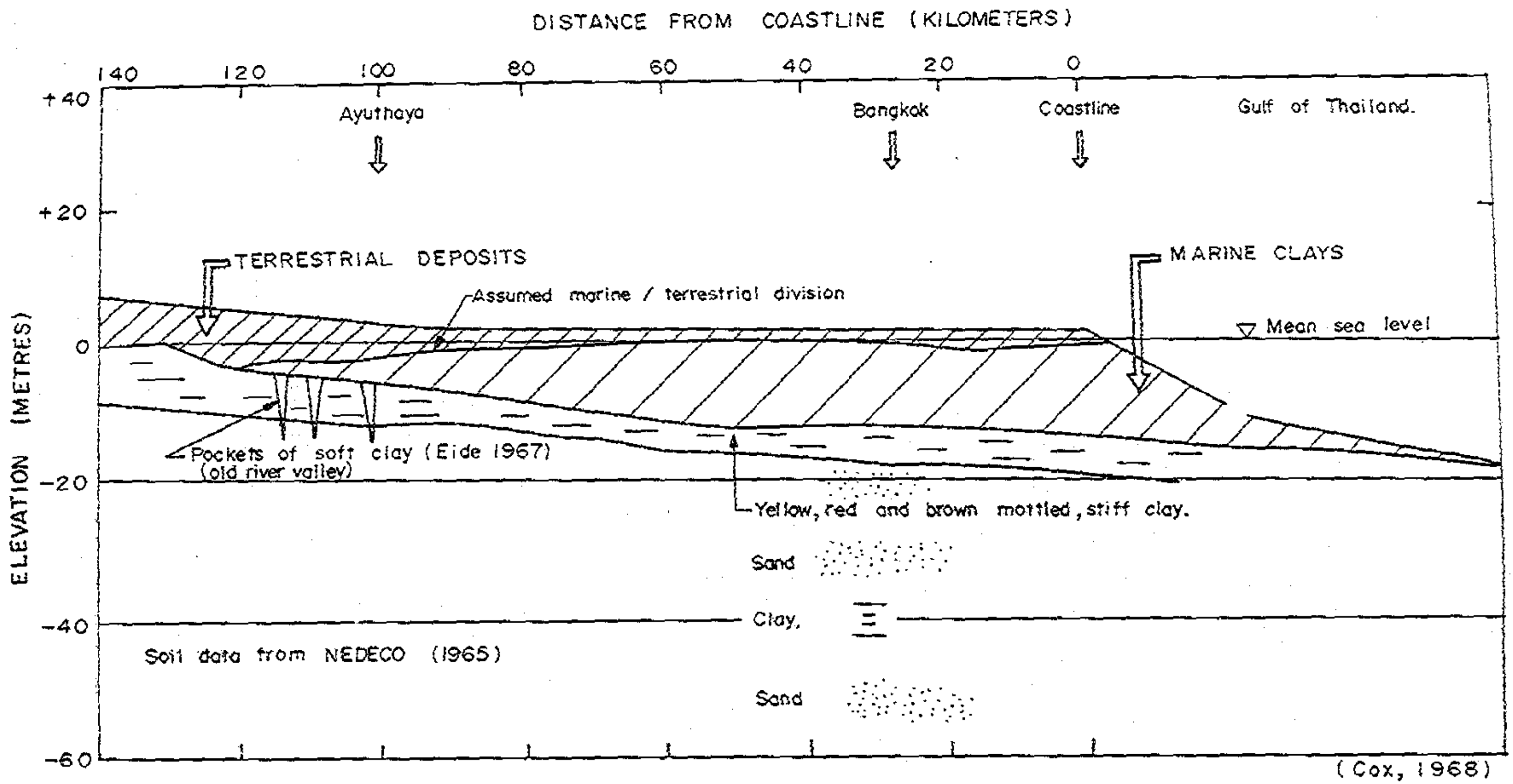


FIG.5-2 CROSS SECTION THROUGH CHAO PHRAYA DELTA, THAILAND.

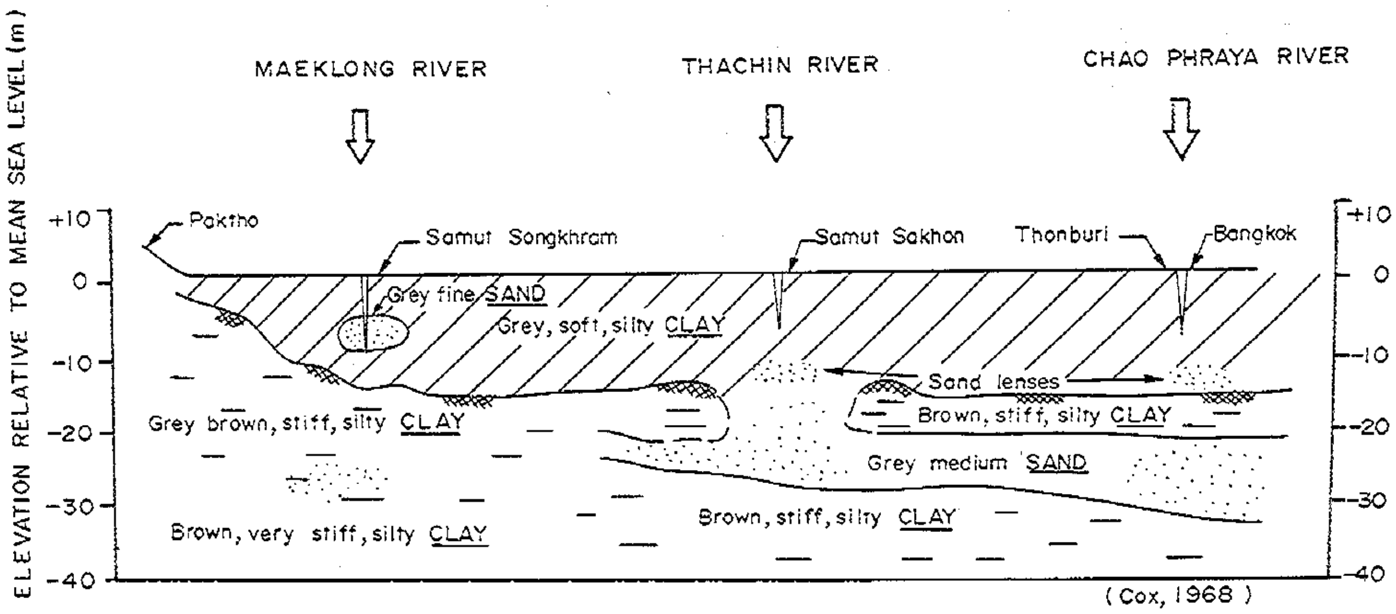


FIG. 5-3 CROSS SECTION ACROSS CHAO PHRAYA DELTA, THAILAND.

5-3 Subsurface Conditions

The general subsurface conditions of Bangkok area are illustrated typically by three soil profiles, each covering the distances of 6 to 17 kilometers (Muktabhant, 1967). The first profile, Fig. 5-5, is along Pahol Yothin Highway, approximately north-south, while Figs. 5-6 and 5-7 show soil profiles approximately in the east-west direction. Their approximate locations are indicated in the area plan, Fig. 5-4.

For engineering purposes, the soil profile in Bangkok can generally be divided into four layers and described as follows:

(1) A weathered crust of 2 $\pm$ 1 m, usually composed of mottled gray-brown clay having cracks due to alternate cycles of wetting and drying. In some areas, miscellaneous fill, generally clayey, is encountered. The water table is at El. + 1.0 to 1.5 m above M.S.L.

(2) Very soft to medium dark gray clay, referred to as the soft Bangkok clay, that usually extends to El. -12$\pm$2m.

(3) Stiff to hard, gray and yellow brown, clay of variable thickness.

(4) Dense sand and gravel layers, with some sandy clay, that occur alternately at El. -22$\pm$2m to an indeterminate depth of at least 300 m. (Moh, et al 1969).

Near the bank of Chao Phraya River, a thick deposit of loose clayey sand may underlie the soft Bangkok clay.

In the upper 200 m of the deposits, six separate confined aquifers have been identified at depths of approximately 35, 65, 85, 115, 150 and 200 m. The ones at 85 m and 150 m are most heavily used at the present time. These aquifers consist of poorly sorted mixtures of fine sand, coarse sand and gravel, and are of great areal extent having an average thickness of about 20 m (Camp, Dresser and Mckee, 1969).

Some evidences of subsidence and the possibility of future general subsidence in the Bangkok area have been pointed out in view of extensive deep-well pumping now under way in this area (Brand, et al, 1971).

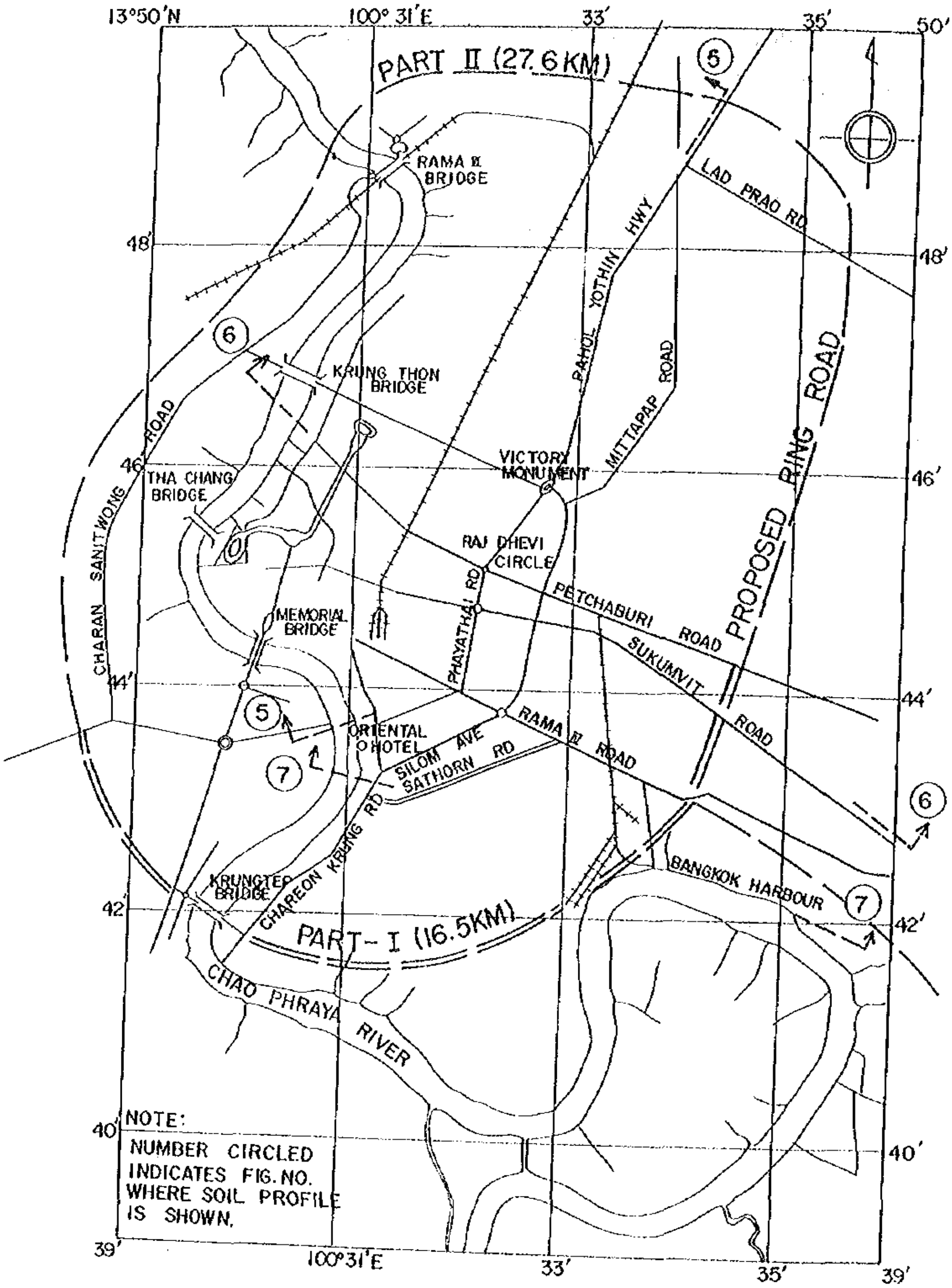


FIG. 5-4 LOCATION MAP OF BANGKOK AREA.

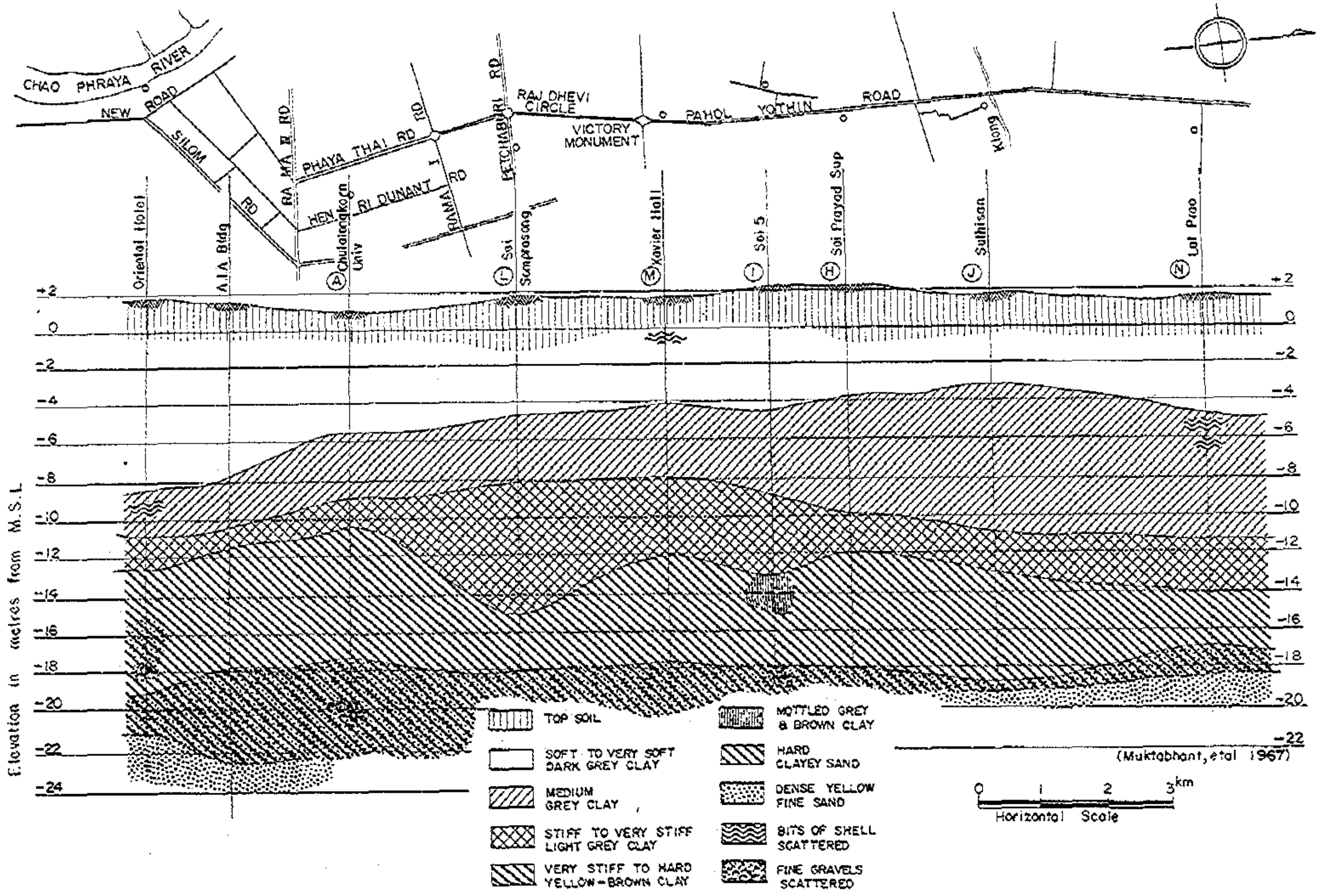


FIG.5-5 SOIL PROFILE ALONG PAHOL YOTIN HIGHWAY

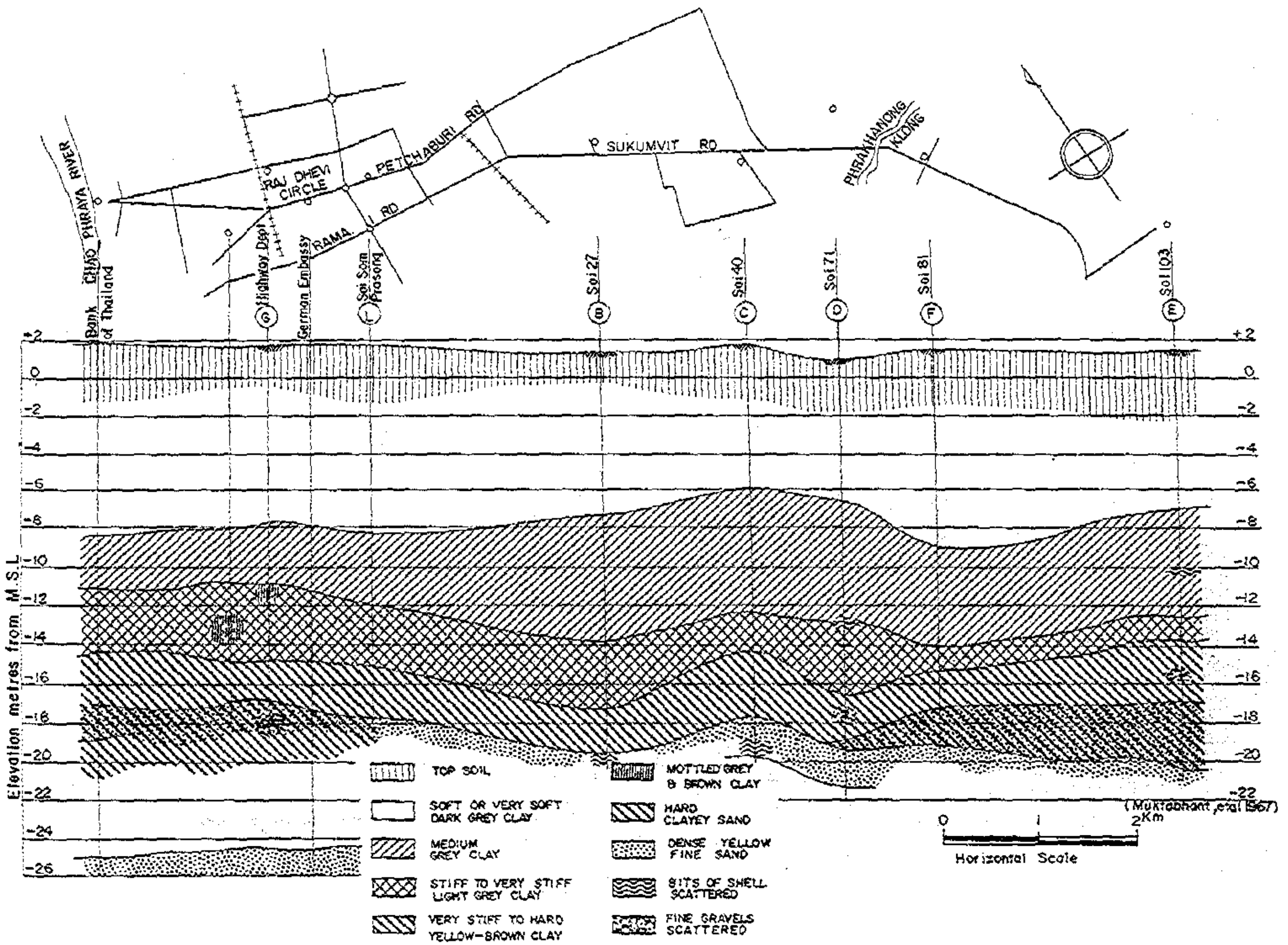


FIG. 5-6 SOIL PROFILE ALONG SUKUMVIT ROAD

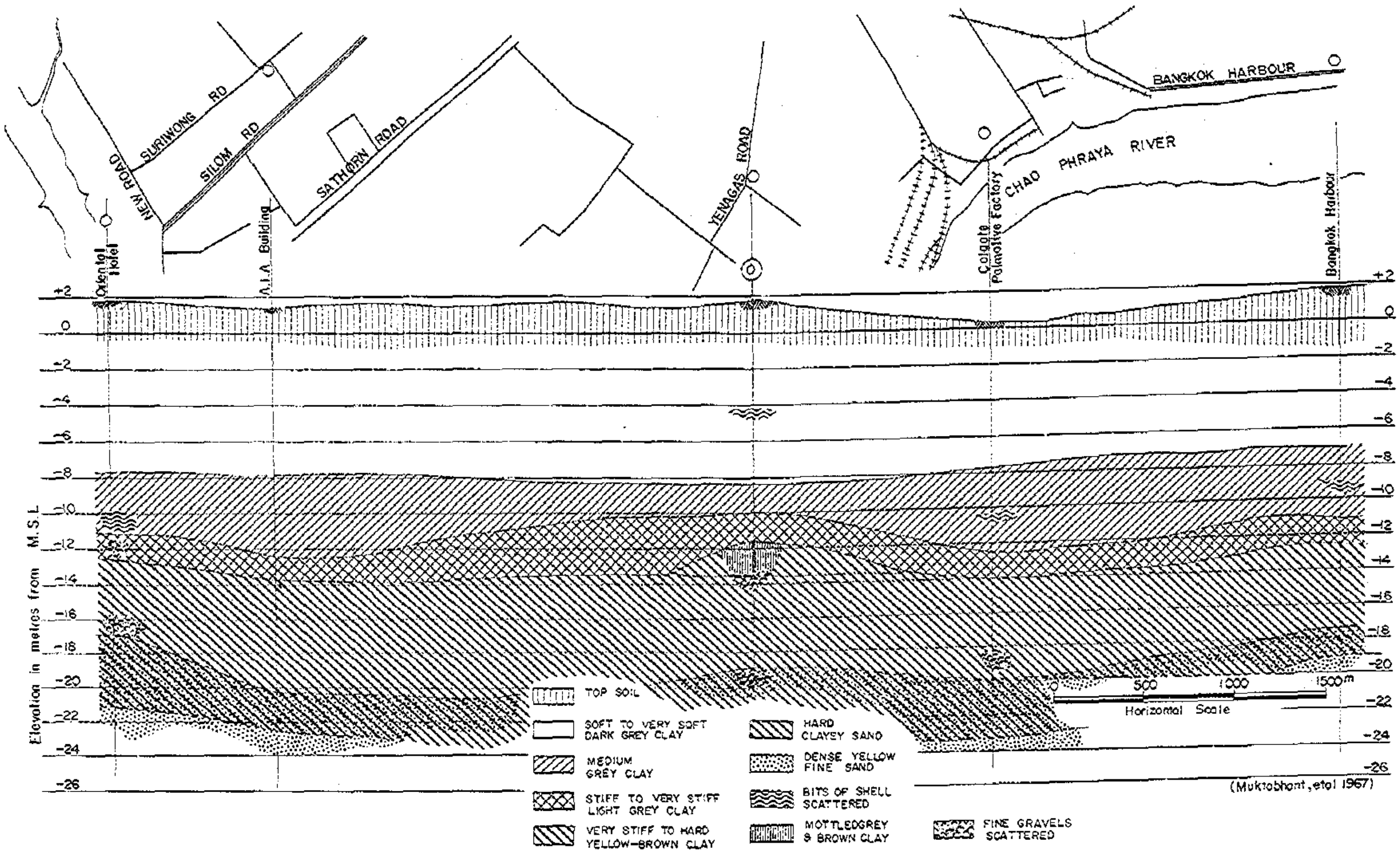


FIG.5-7 SOIL PROFILE ALONG THE ALIGNMENT OF ORIENTAL HOTEL AND BANGKOK HARBOUR

5-4 Engineering Properties of Subsurface Soils

5-4-1 Soft Bangkok clay, layers (1) and (2)

(1) Physical properties:

Bangkok clay is primarily a normally consolidated marine clay which occurs as a fairly homogeneous and isotropic deposit, but contains some fine sand and silt lenses and occasional shell fragments. Typical physical properties of this clay is summarized in Table 5-1. The clay is composed, in decreasing order of abundance, of quartz, feldspar and the clay minerals of montmorillonite, illite and kaolinite.

(2) Strength characteristics:

Some typical undrained strength data are shown versus depth in Fig. 5-8 and 5-9. Fig. 5-8 summarizes the results of unconfined compression tests and field vane shear tests from nine exploratory borings. These holes are located widely, covering the City of Bangkok fairly well. In the upper 4 to 6 m of the Bangkok clay, linear relationships between depths and undrained shear strength do not hold as generally indicated for greater depths by Figs 5-8 and 5-9. This weathered crust is thought to be due to desiccation, ion exchange reactions and weathering of clay minerals by leaching water. A set of shear strength parameters for Bangkok clay is shown in Table 5-2, which also includes typical strength envelopes in terms of total and effective stresses.

(3) Compressibility characteristics:

The Bangkok clay has not been subjected to a greater vertical stress than the existing overburden pressures, but appears slightly overconsolidated throughout the depth, Fig. 5-10. This overconsolidation is considered to be due to the pronounced secondary consolidation of the sediments after

deposition as the clay has high plasticity and appreciable organic contents, the rate of secondary consolidation being quite large. Some typical e-log p curves are indicated in Fig. 5-11.
The coefficient of consolidation, c_v, determined from routine oedometer tests varies from 0.5 to 2.0 x 10^{-4} cm^2/sec.
It appears however that, below a consolidation pressure of approximately 15 t/m^2, the coefficient is primarily governed by the stress history of the clay, being higher in the range of 5 to 18 x 10^{-4} m^2/sec.

5-4-2 Stiff to hard Bangkok clay, layer (3)

This zone consists of an overconsolidated clay having a maximum past pressure in the neighborhood of 45 t/m^2. Overconsolidation of the clay has in general been attributed to desiccation. Typical physical properties of the stiff Bangkok clay is summarized also in Table 5-1. Two series of shear strength parameters are indicated below, which suggests that this clay possesses similar shear parameters as those of the overlying soft clay.

Series	Total Stress		Effective Stress	
	c(tsm)	ϕ(deg.)	$\bar{c}$(tsm)	$\bar{\phi}$(deg.)
I	5.0	13.3	2.8	22.5
II	7.1	12.2	4.5	21.7

(Nelson, et al, 1970)

This zone offers fairly high resistance against driving and even the upper portion has been commonly utilized as a bearing stratum for medium sized buildings in this area.

According to the results of 15 borings (Muktabhant, 1967), the standard penetration resistance (N-values) ranges from 6 to more than 50, averaging about 25, and the unconfined compressive strength varies from 12 to 53 t/m^2.

5-4-3 Dense sand and gravel, layer (4)

The hard clay is underlain normally by strata of yellow dense fine sand at an elevation between -20 and -24, M. S. L. The top boundary is not always clearly defined but usually encountered in a transition stage of yellow brown clayey sand.

This zone is capable of supporting piles and caissons for large heavy structures.

Table 5-1 Typical physical properties of Bangkok Clay

	Soft Bangkok Clay Layers (1) and (2)	Stiff Bangkok Clay Layer (3)
Color	Dark gray	Mottled brown and grey
Consistency	Very soft to Medium	Stiff
Natural Water Content	50 - 88 (60 - 70)	20 - 30
Liquid Limit	55 - 95 (75)	53 - 65 (59)
Plastic Limit	23 - 33 (28)	21 - 24 (23)
Plasticity Index	20 - 60 (47)	32 - 42 (37)
Liquidity Index	0.7 - 1.0 (0.85)	0.1
% Finer than 2 μ	40	44
Activity	0.6 - 1.1 (0.8)	0.83
Soluble Salt Content (gr/liter)	1.5 - 15 (2.5 - 10)	5.6
Organic Matter (%)	1 - 5 (3)	0.8
Specific Gravity	2.65 - 2.75 (2.70)	2.74
Wet Density (t/m2): Above 2±1 m depth	1.65 - 1.80 (1.74)	-
Wet Density (t/m2): Below 2±1 m depth	1.45 - 1.75 (1.65)	-
Dry Density	0.84 - 1.13 (1.13)	1.61
Void Ratio	1.4 - 2.2	(less than 1)
Sensitivity	3 - 7 (5)	1.3
Main Reference	Ladd, et al (1971)	Nelson, et al (1970)

Note: Numbers in parentheses indicate representative values.

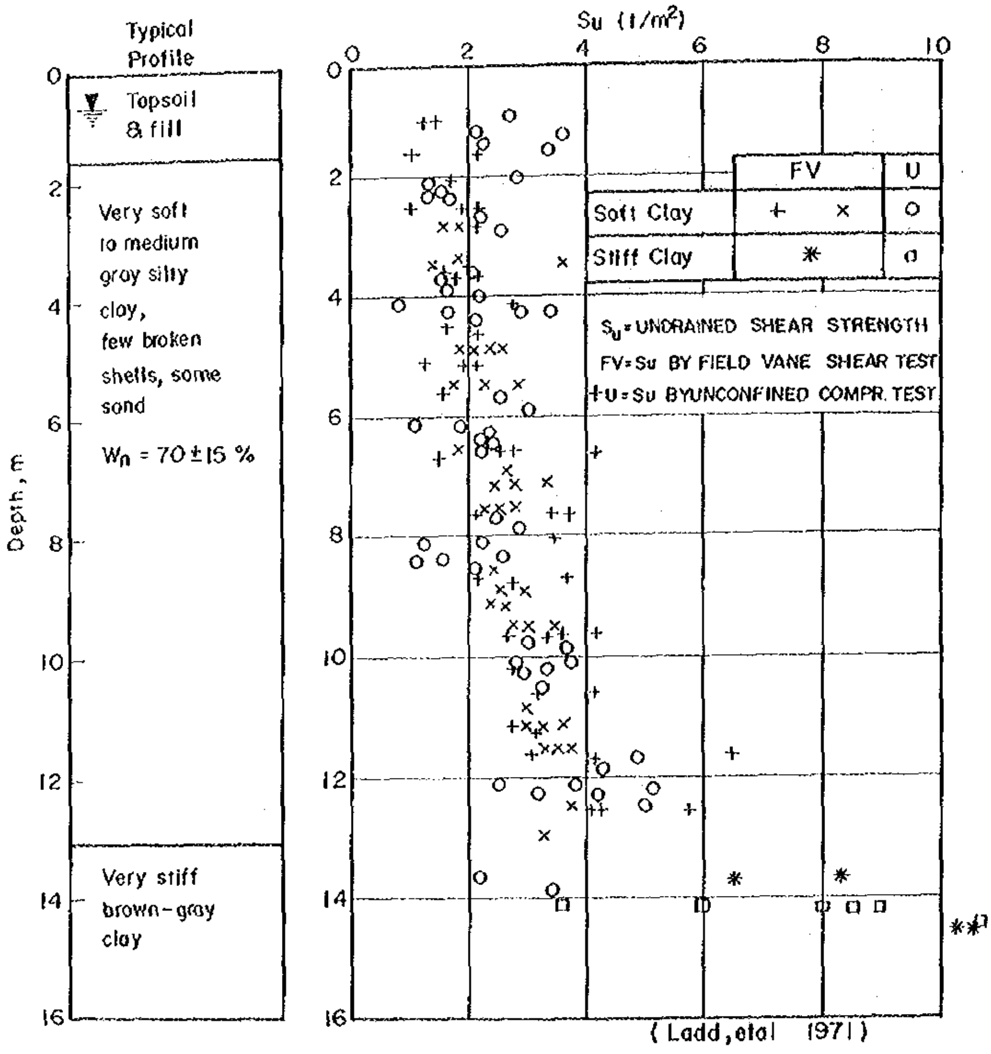


FIG. 5-8 TYPICAL FIELD VANE AND UNCONFINED STRENGTH DATA ON BANGKOK CLAY.

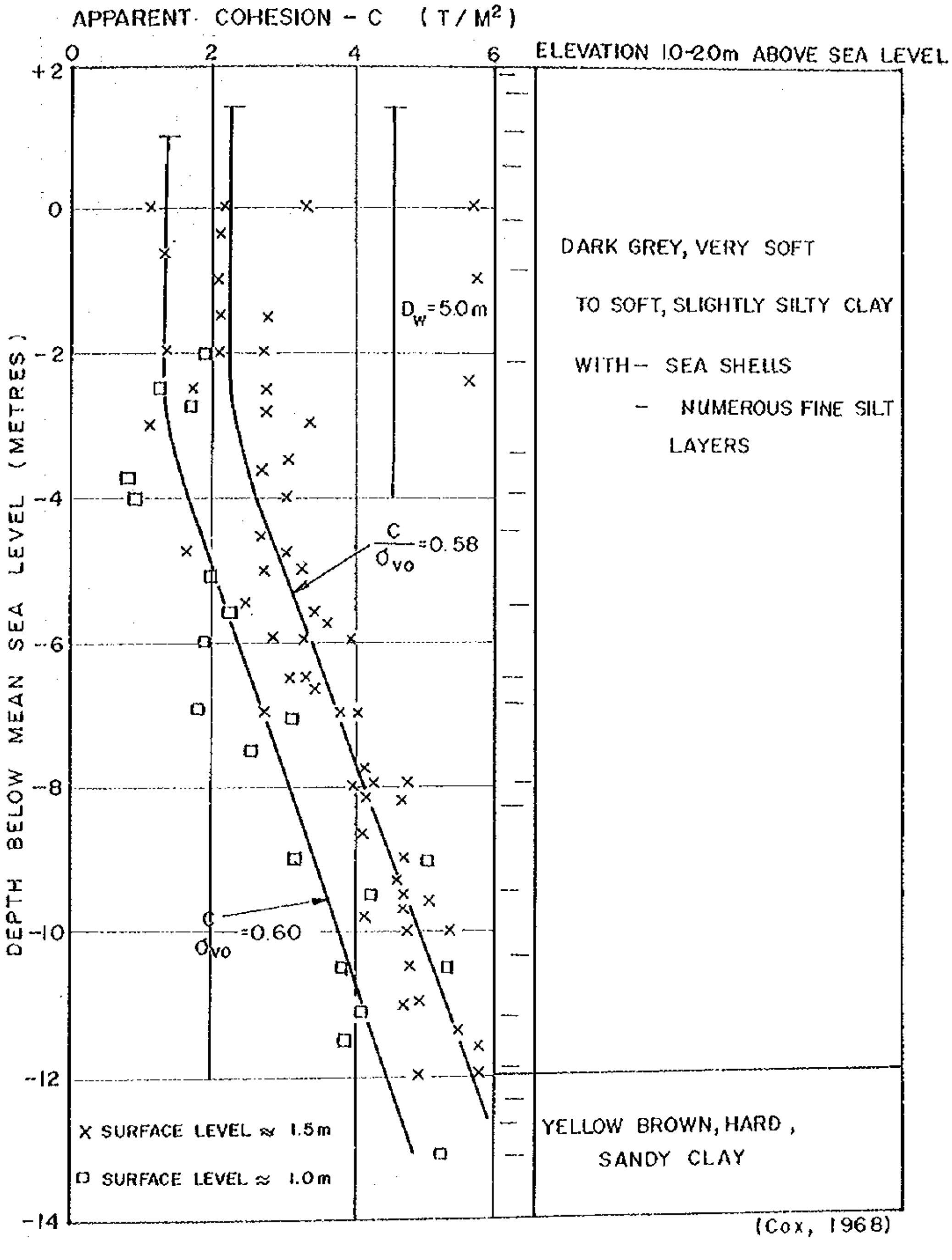
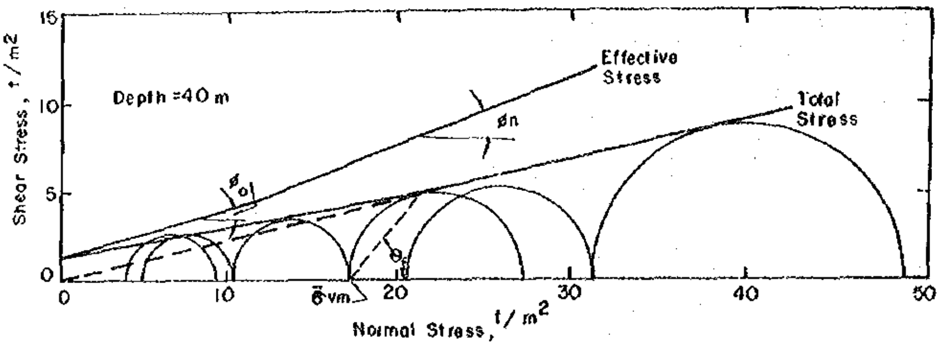


FIG. 5-9 SHEAR STRENGTH PROFILES FOR BANGKOK CLAY.

Table 5-2 Shear Strength Parameters for Bangkok Clay (Moh, et al 1969)

Depth metres	$\bar{\sigma}_{vm}$ ton/sqm	Total Stresses c ton/sqm	Total Stresses ϕ_n degrees	Total Stresses ϕ_o degrees	Effective Stresses $\bar{c}$ ton/sqm	Effective Stresses $\bar{\phi}_n$ degrees	Effective Stresses $\bar{\phi}_o$ degrees
1.1	27.7	0.6	13	–	0.5	20	–
1.5	25.6	2.0	11	9	1.8	18	13
2.5	24.6	0.8	11	10	0.7	20	19
4.0	17.5	1.4	13	9	1.5	21	16
5.3	0	0	11	–	0	20	–
10.5 – 11.7	6.1	6.1	15	10	3.7	24	20



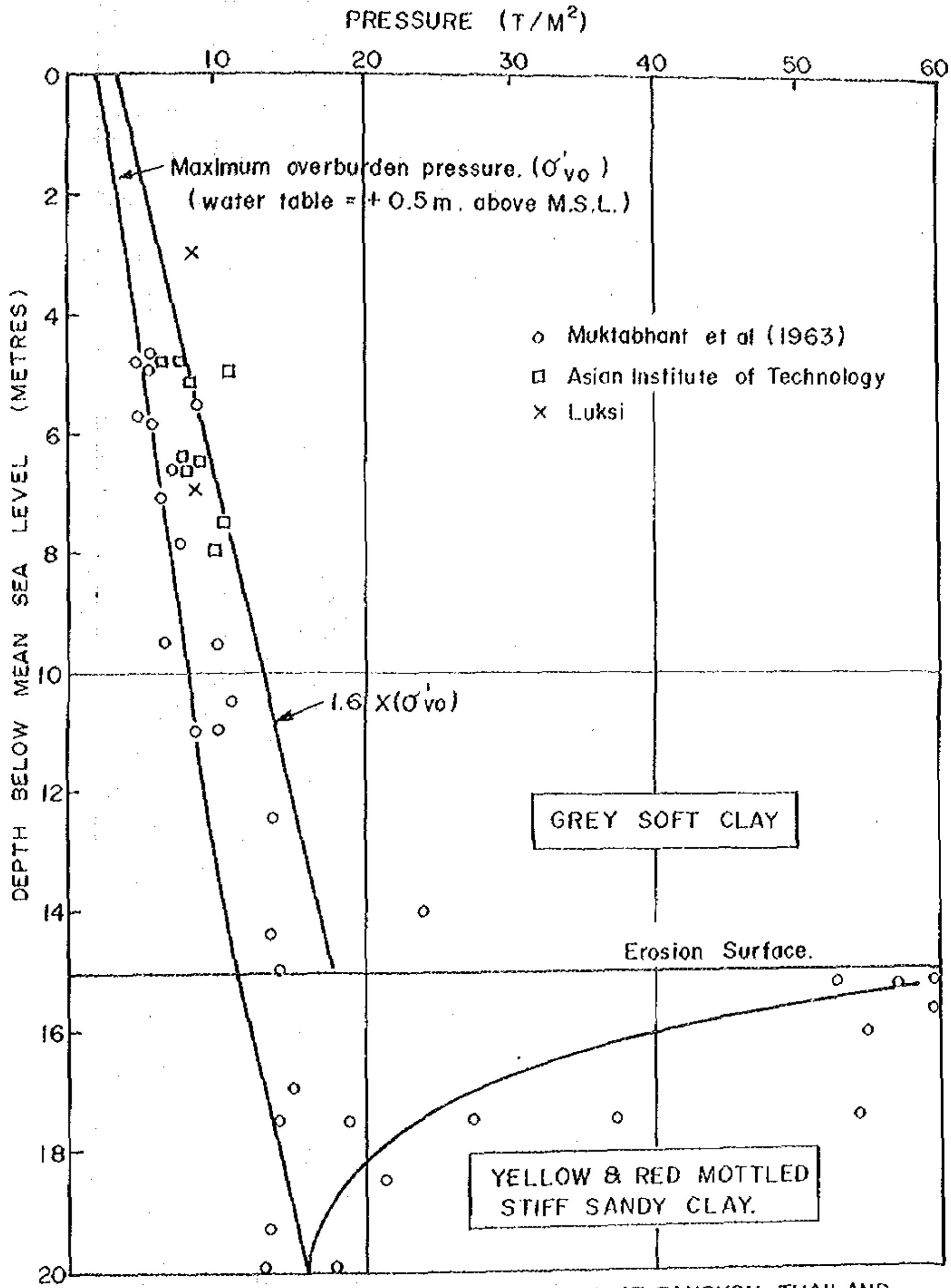


FIG. 5-10 CRITICAL PRESSURE PROFILE AT BANGKOK, THAILAND.
(Cox, 1968)

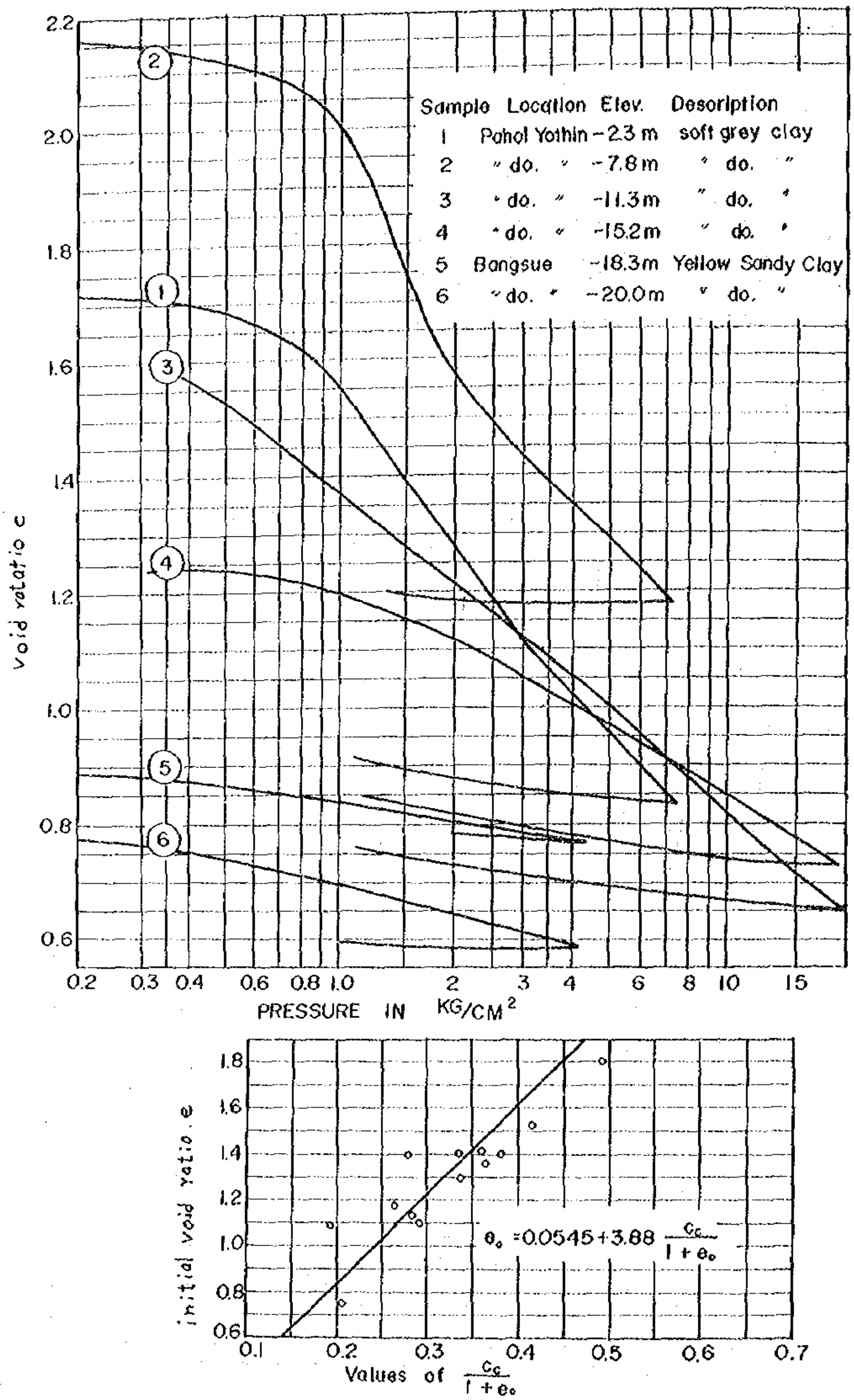


FIG. 5-11 TYPICAL RESULTS OF CONSOLIDATION TESTS ON BANGKCK CLAY

5-5 Engineering Problems

5-5-1 Embankment stability

Because of the extremely soft and highly compressible nature of the Bangkok clay, it poses a serious threat to stability of even low embankments which are only a few meters in height, and makes it difficult to predict their settlement behavior on the basis of laboratory test results. Although the stability and settlement of embankments are inseparable in nature for a soft clay such as the Bangkok clay, each subject is treated separately herein.

In connection with the Bangkok-Sri Racha Highway project, Eide (1967) had analysed several failures of trial embankments and found that recalculation of these slides based on the conventional Swedish circle method employing vane shear strength yeilded an average factor of safety of 1.5. A safety factor as large as 2.0 was calculated for a failure which extended from the embankment to a side borrow pit. Cox (1968) pointed out that the conventional slope analysis did not take into account horizontal forces between embankment and natural soils, and inclusion of these forces would indicate a factor of safety close to unity at failure.

Considerable lateral stresses are developed by arching in the embankment during settlement and act outwards from the center toward the toe. Fissures and slickensides noted in the Bangkok clay could also result in a lower in-situ shear strength than is measured by either laboratory compression tests or field vane shear tests.

Undrained strength analyses may, however, have a factor to make the results too conservative when appreciable consolidation takes place during construction. In the Thonburi-Paktho Highway project, vane shear tests were carried out before and after construction in the weathered crust beneath the trial embankment. It was revealed that the vane shear strength in this crust had increased from its initial value of 1.2 t/m^2 to an average value of 2.2 t/m^2 in several months. For this project three large trial embankments were constructed with extensive instrumentation a few years before the highway construction began in 1970, Table 5-3. The embankments which were deliberately built to failure for a stability study failed when the height reached 2.6 m on a coconut plantation field and 4.2 m on a rice field (Cox, 1970). Another embankment failure was reported near Bangkok when it was built to a height as low as 1.6 m.

Brand (1971) gave an interesting account for an embankment failure which took place some 20 km north of Bangkok. Concrete piles, 15 m long and 30 by 40 cm in cross-section, were driven in an attempt to improve the marginal stability of a retaining wall for a roadway embankment located along a canal, and two days after pile driving the embankment slid into the canal together with the wall and piles. This failure was attributed to excess porewater pressures developed in the soft Bangkok clay due to pile driving.

5-5-2 Embankment settlement

Chandrangsu (1967) reports his experience in 1939 about the embankment construction of Sukhumvit Highway in the Bangkok area: the actual quantity of material dumped to form embankment of about 1 m in height was twice as much as the quantity calculated from the cross-section. He recalls similar excessive settlements observed during road construction in the vicinity of the city including the Bangkok-Don Muang Highway and pointed out that the settlements were far greater than those due to elastic compression and consolidation of the soil layers underneath.

According to Eide (1967), a 3 m high railway embankment located 6 km south of Ayuthaya, settled 2.5m. (It was first built as a single track some 65 years ago and then expanded to a double track about 15 years ago). His investigation showed that only 1.2 m of the total settlement was due to consolidation and the remaining 1.3 m due to shear deformation in the form of plastic flow in the clay at constant water content.
He also estimated the settlement during construction was 0.7 to 0.8 m. At this location it was found that the soft Bangkok clay filled an old river bed being about 14 m deep. Therefore, the condition may be considered comparable to that in the Bangkok area.

Construction difficulty was encountered in a section near Bangkok (Circeo, 1968) when low fills experienced settlements over 30% of their heights in one year period. The most critical section, only 1.5 m high, settled a total of about 1 m during the construction period of 1.5 years.

Table 5-3 summarizes the results of an extensive trial embankment program constructed for the Thonburi-Paktho Highway project (Cox, 1971). The locations of test sites are given in Fig. 5-12 and some of the settlement data are shown in Figs. 5-13 and 5-14. It is to be noted that settlements for a relatively short period are sizable and the rates of secondary consolidation very considerable.

As shown in Table 5-3, a 4.2 m high embankment settled 1.8 m for a period of 3.7 years and was only 2.4 m above the ground level as of February, 1971. It was also found that the pore pressure parameters, μ and A, depended upon the over-consolidation ratio of the silty clay beneath the embankment.

At high stress levels μ varied from 0.4 to 0.5 in the weathered crust to 0.8 below this zone. The coefficient A_f at similar stress levels varied from -0.2 to +0.6 in the weathered crust to 0.8 below this zone and correlated well with the laboratory test results for Bangkok clay (Cox, 1968).

In addition to the fact that large shear flows make settlement predictons next to impossible, presence of thin lenses of silt and sand in the soft Bangkok clay complicates the settlement rates considerably.

The actual settlements, however, do not always exceed the predicted ones. In connection with the Bangkok-Sri Racha Highway project (N. G. I., 1967), a trial embankment of 1.7 m in height was constructed near Bangkok. The settlement was calculated to be on the order of 1 m, approximately 20 cm of which should occur during the first year. As it turned out, however, the settlements actually measured, were only 7 cm in the first few months and practically no more settlements were observed for the subsequent six months. It was reasoned that the average embankment load 3.3 t/m^2 was very close to, but still too small to exceed the critical load (apparent pre-consolidation load) and the Bangkok clay behave as an over-consolidated clay, although it was normally consolidated in terms of its stress history.

All the indications are, therefore, that the values from laboratory results should not be applied directly to field cases. Forecasting settlement and its rate for the soft Bangkok clay is still at present such a complex and unsubstantiated process that it is much safer to make the use of empirical, observed time-settlement relationships on a similar subsurface condition with similar loading than to estimate them by analytical means alone. In this regard, it is highly recommended for the proposed Ring Road project that at least one trial embankment be constructed at each representative site as early as possible and such relations be established for the most economical construction.

5-5-3 Embankment materials

Most of the roads and highways in this area have been constructed on low embankments consisting of topsoil scooped from roadside borrows within the right of way, which in turn serve as canal or ditch after completion of roadways. The current practice does not necessarily follow this traditional method, however, due to increasing cost and difficulty in land acquisition and construction requirement for better embankment material. In the Ring Road project, which is proposed in most part through highly developed urban areas, it is expected that practically all the embankment materials will have to be brought in from other sources located a considerable distance away from the project site.

The Bangkok clay at shallow depths is generally classified as A-7-5 or A-7-6 in terms of the AASHO classification system and possesses poor to fair compaction characteristics. The optimum moisture content ranges from 18 to 28%, the modified AASHO maximum density from 1.4 to 1.8 t/m^3 and the CBR value from 1 to 7. However, the water content in situ is usually so high that it is difficult to attain such compaction in the field, and the surfacial soil in general must therefore be classified as poor to very poor embankment material. This highly plastic heavy clay, after compaction, may attain a maximum wet in-situ density of about 2.3 t/m^3, and does not dry up to the optimum moisture content except the top 20 cm or so.

Lateritic soils and river sand are now often used for embankment construction in this area. The available data on lateritic soils from the Saraburi area indicate the modified AASHO maximum dry density of 1.94 to 2.17 t/m^3 at the optimum moisture content of 4 to 12% with the 4 day-soaked values of CBR ranging from 4 to 87. Lateritic soils available in the Paktho-Ratburi-Kanchanaburi area also show good compaction characteristics; the modified AASHO maximum dry density of 2.05 to 2.30 t/m^3 at the optimum moisture content of 7.6 to 10.6% with CBR varying from 15 to 94. The lateritic soils possess excellent compactability responding well to higher compaction efforts, but the test results scatter considerably even if the soils are from the same source.

River sand, fine to medium in grain size, is dredged in quantities from Chao Phraya River near Bang Pa-in, Ayuthaya and Ang Thong, and may be transported by barges to the Bangkok area. Medium to coarse sand may be found in the river bed of Mae Klong River near Ratburi and upstream of it. Typically, the maximum dry density is 1.68 t/m^3 and the optimum moisture content around 17% on the average.
The design CBR value of the river sand used for the Don Muang-Saraburi Highway was 15.

Although gravel is not available in this area, limestone and andesite are quarried and crushed commercially. There are a number of rock quarries within a 100 km radius of the project site; the Ratburi Highland foothill areas to the west, the Saraburi area to the north and the Cholburi area to the south-east. In testing these rocks, the percentage of wear in the L.A. abraision tests ranges roughly between 20 and 40%.

Rice husk ash has been used as lightweight embankment material in Thailand on approach embankments of railway and highway bridges. Most rice mills are equipped with steam engines using rice husk as fuel, and the resulting ash may be found in adequate quantities at scattered locations. Laboratory tests indicate that the rice husk ash is composed chemically of silicon dioxide (about 90%) and the dry density under repeated loading is on the order of 0.8 t/m^3 showing high frictional resistance but no cohesion (Williams, et al, 1971), and that effective compaction may also be attained by mixing clay with lime and the ash (Lazaro et al, 1971). According to the results of a field test (General Engineering Co., 1967), the ash stabilized with 6% of hydrated lime showed the maximum dry density of 0.64 t/m^3 at the optimum moisture content of 90% and it was suggested that the maximum wet density in-situ may reach 1.35 t/m^3.

5-5-4 Deep foundations

The Bangkok clay is so soft and compressible that the building code permits no shallow foundations designed for a pressure more than 2.0 t/m^2 in the Bangkok area. In consequence, practically all structures require deep foundations which transfer the loading to the more competent, less compressible underlying bearing strata.

In addition to extensive use of timber piling, composite piles used to be popular for relatively light loading and consisted of a timber pile section driven into the clay and the reinforced concrete section above the groundwater level. For instance, steel towers for the power transmission lines in the vicinity of Bangkok rest on composite piles consisting typically of a 16 m wood section and a precast concrete section, 40 cm square and about 4 m long. These were considered as friction piles and designed for 20 to 25 tons per pile (Miller, 1963).

Reinforced concrete piles are extensively used in this area, and are typically 25 to 35 cm square and up to 26 m in length with design capacity of 20 to 45 tons per pile. In the recently completed portion of the Asian Highway which starts 52 km north of Bangkok, for example, bridge piers are supported mainly by two types of reinforced concrete piles; 35 cm square solid piles designed for 30 to 45 tons per pile, and octagonal hollow piles with the inside diameter of 38 cm and the wall thickness of 10 cm designed for 55 to 110 tons per pile (Holmberg, 1970).

Cast-in-place concrete piles and piers of various types have also been frequently used. One of the most notable cases is the Thachang Bridge which is to be completed in 1974. The main piers are supported by cast-in-place, reinforced concrete piers, 1.5 m in diameter, 45 m in length and designed for 430 tons per pier. The other bridge piers and abutments are founded on prestressed concrete piles, about 25 m in length. These piles are 40 cm octangonal and 35 cm square with the design load ranging from 40 to 60 tons per pile. The Bangkok Noi Bridge, also presently under construction, employs prestressed concrete piles, 35 cm square, 24 m long and designed for 40 tons per pile.

Caissons have been used for bridges across Chao Phraya River. The main piers of the Memorial Bridge and the Rama VI Bridge were constructed under compressed air, while those of the other two, Krung Thep and Krung Thon on open caissons (Prakobyantrakich, 1963)

Fig. 5-15 shows a representative boring log for the location of each crossing as well as its foundation level.

According to a recent investigation (O'Sullivan, 1971), the caissons of the Memorial Bridge which were constructed in 1932 were actually founded at EL. -28.7 and EL. -29.7, M.S.L., on the Thonburi side and the Bangkok side, respectively. It was pointed out that only 0.4 m of river bed remains at the point of maximum scour around the base of the Thonburi pier and the scour rate could be as high as 0.5 m per year. It is to be noted that the Thonburi pier is located on the outside of the meander, resting in alternate layers of stiff silty clay and silty sand with trace of clay which indicate standard penetration resistance ranging from 20 to 30.

5-5-5 Approach embankment

In the Bangkok area, evidences of excessive differential settlements are observed at practically every connection between the bridge abutment and the approach embankment, characterized by damages of various degrees caused in side-walks and railings at the end of the bridge. Although the pavement in such transition is usually covered by thick asphalt overlays, the design vertical curve has been so badly impaired that vehicles approaching a bridge have to slow down in order to avoid possible driving hazards, or at least unpleasant feeling of bumps every time they get on and off the bridge.

In an attempt to cope with this problem, two schemes have been employed for some of the recent highways constructed to a higher standard. These measures consist of the use of relief piling beneath the approach embankment and the use of light-weight fill material for the embankment after preloading.

In a test fill program for the Bangkok-Sri Racha Highway project, sand drains, 20 cm in diameter, were installed to depths ranging from 3 to 13 m beneath a 2.1 to 2.3 m high embankment which was built on a stratum of the Bangkok clay, 14.5 m in thickness. Where the sand drains were deepest, it settled as much as 1.3 m in a period of 15 months but was still settling at a rate of 3 cm a month. It was concluded that the sand drains were generally effective to accelerate the settlement, but not effective enough to limit its rate to a tolerable level within the expected construction period. The use of relief piling was then recommended for bridge approaches in this project.

Also in the Asian Highway project, relief piles were employed for bridge approaches in areas where the soft Bangkok clay was present. The purpose of relief piling is to minimize differential settlements between the embankment and the bridge abutment and also to increase stability of such relatively high embankment.

The piles put into use were 20 to 30 cm diameter timber piles for pile length less than 16 m, and 22 cm square prestressed concrete piles for lengths greater than 16 m. Fig. 5-16 gives typical cross-sections showing the relief piling for the Asian Highway designed by KAMPSAX in 1968.

To take the maximum advantage of the preloading effect, it appears very effective to replace a heavy fill material after an adequate preloading period by a lightweight material such as rice husk ash, which has been discussed as an embankment material in Section 5-5-3. The rice husk ash has been used apparently successfully on approach embankments to railway bridges on the Eastern Line and the high approaches to the Rama VI Bridge. The Department of Highways has also used this material at least on three bridge approaches before it was decided to employ the combined scheme of sand preloading and lime-stabilized rice husk ash for the Thonburi-Paktho Highway presently under construction. This scheme is reported to have been successful in reducing post-construction settlements of the approach embankments.

Besides these two methods, stabilization by means of sand compaction piles or chemico-lime piles (consisting of quick lime) would also prove to be effective to reduce the settlements. It is recommended, therefore, to include such treatment in the trial embankment program to verify their effectiveness.

Table 5-3 Summary of Trial Embankment Results
Thonburi-Pak Tho Highway (Cox, 1971)

Site	Station	Section No.	Information Required	Height (m)	Maximum Pressure (t/m^2)	Start of Construction (settlement Period to Feb. 71)(yrs)	Immediate Settlement (cm)	Settlement to Feb. 71 (cm)	Settlement Rate -cm/cycle of 0.1 1 yr(secondary coefficient-C_r	Maximum Lateral Movement (cm)
1	54 + 800	1	Stability and settlement	4.20	7.22	15/6/67(3.7)	30.0	168	—	12.4
2	63 + 600 (Rice Field)	1	Stability	4.70 (Failure)	7.31	11/6/69	34.2	—	—	9.0
		2	Settlement	0.97	1.65	1/6/69(1.7)	2.0	7	7.2 (0.005)	0.8
		3A	Settlement	2.45	4.21	5/9/69(1.5)	8.2	47	55.0 (0.038)	3.5
		3B	Settlement	1.38	2.31	9/8/69(1.6)	1.7	13	16.5 (0.011)	1.0
		3C	Settlement	0.75	1.21	28/8/69(1.5)	1.0	4	2.4 (0.002)	0.4
3	13 + 700 (Old coconut plantation)	1	Stability	2.64 (Failure)	4.96	4/9/69	25.0	—	—	8.5
		3A(a)	Settlement	1.83	3.29	19/11/69(1.3)	8.4	45	51.0 (0.040)	4.0
		3A(b)	Settlement	1.93	3.30	19/11/69(1.3)	8.6	43	51.0 (0.040)	5.0
		3B	Settlement	1.09	1.57	12/11/69(1.3)	2.2	18	22.5 (0.017)	1.2
		3C	Settlement	0.70	1.17	3/11/69 (1.4)	1.3	8	8.5 (0.006)	0.4

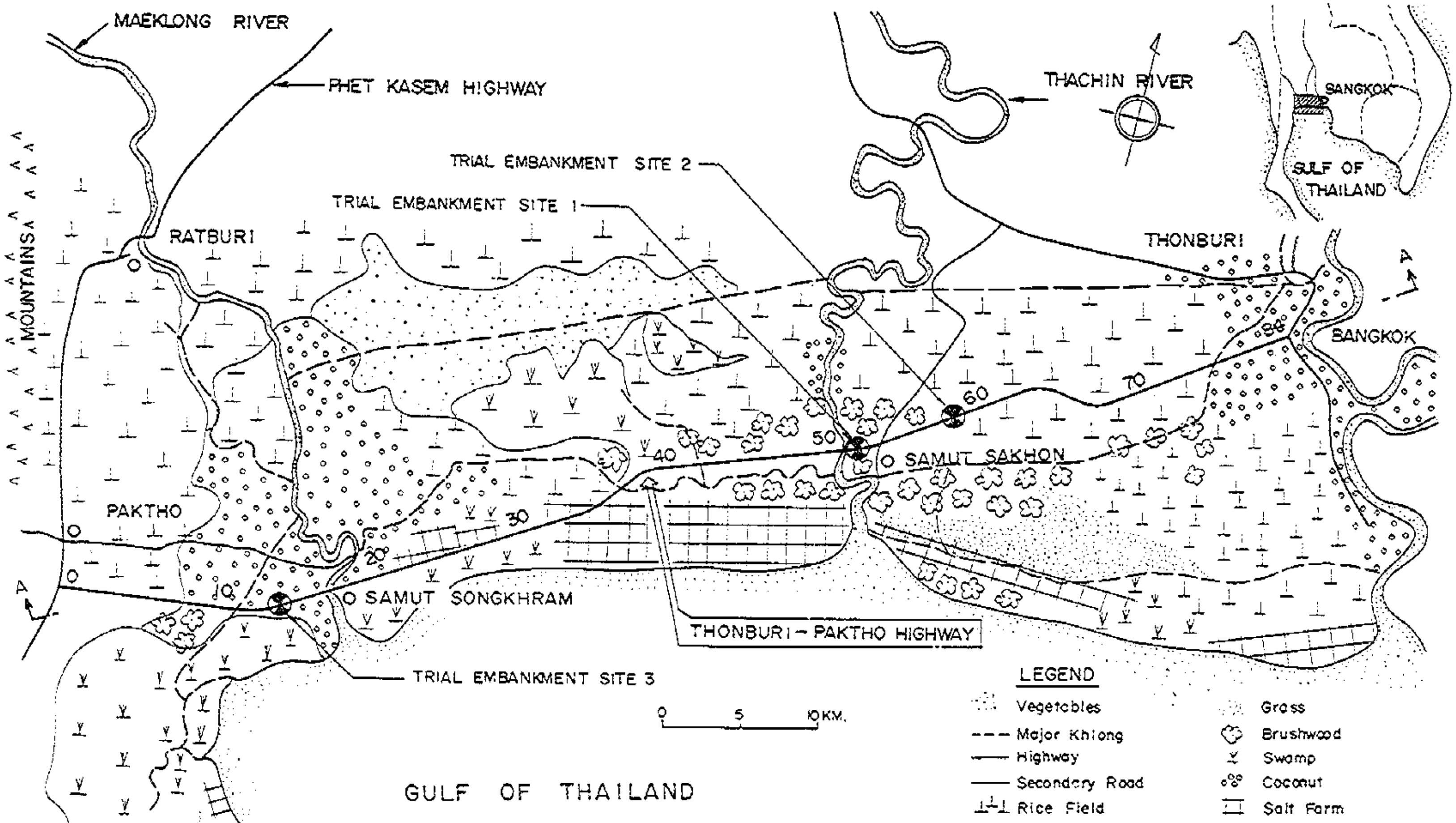
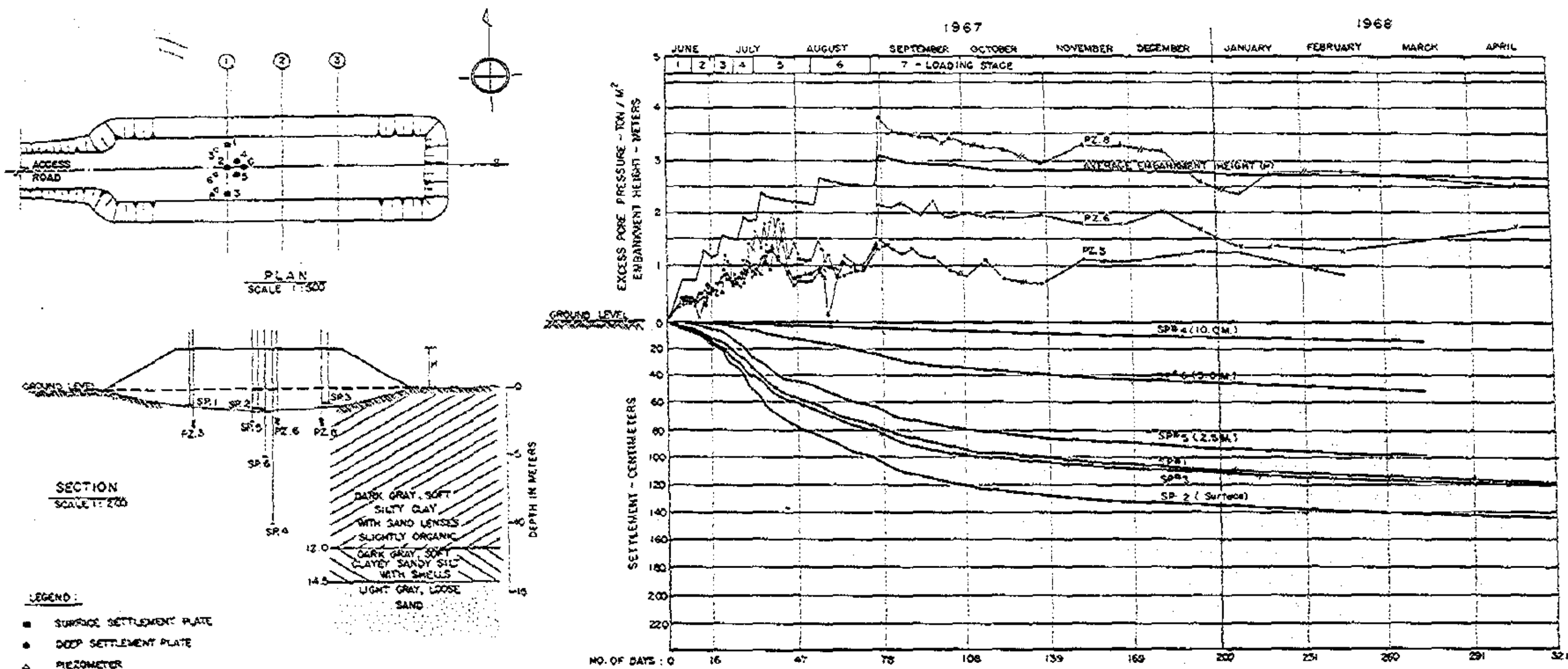


FIG 5–12 LOCATION MAP OF TRIAL EMBANKMENTS, THONBURI – PAKTHO HIGHWAY

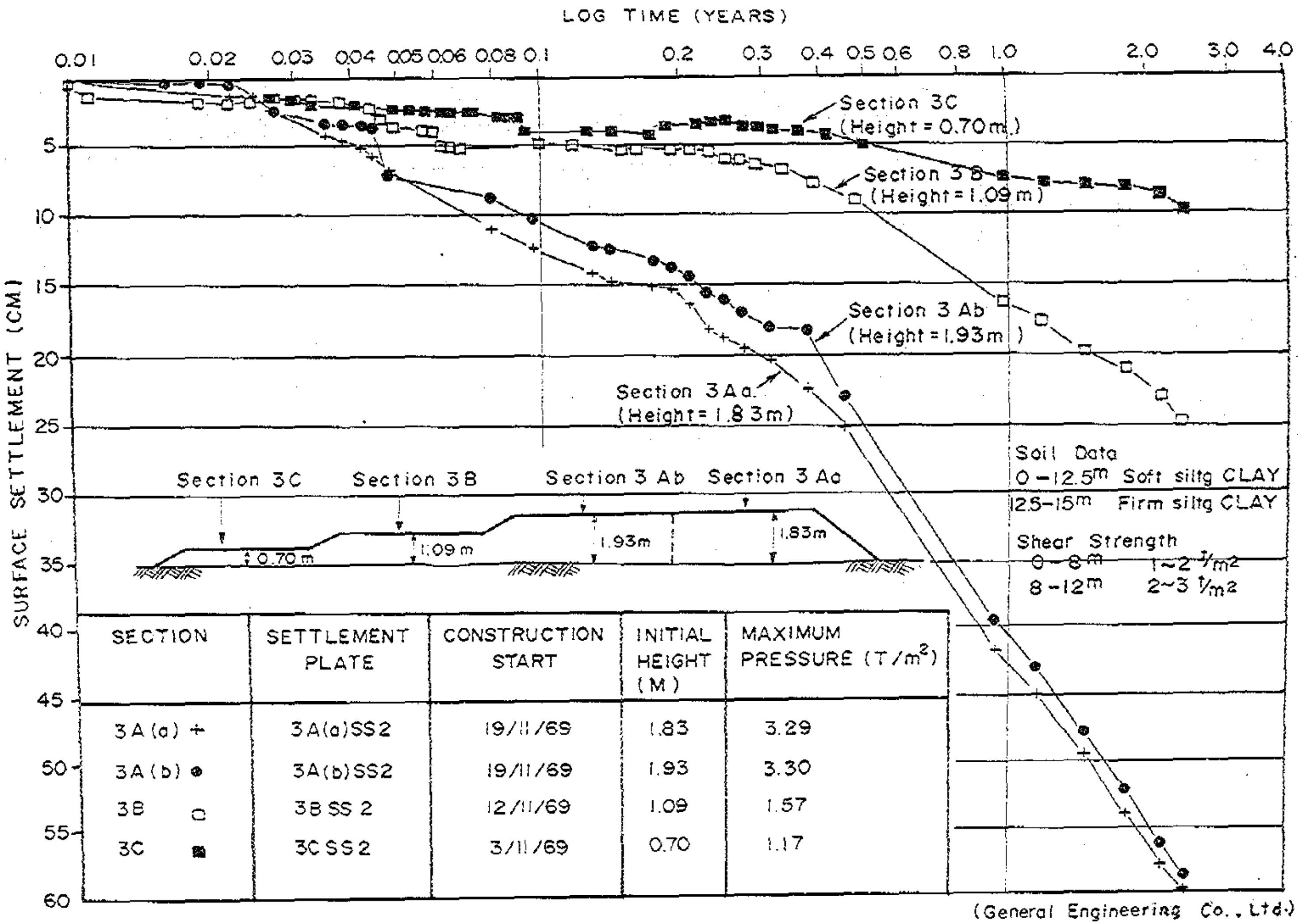
(General Engineering Co.,Ltd)



NOTE : 1 DAY = mm.

FIG. 5-13 SETTLEMENTS AND POREPRESSURES
TRIAL EMBANKMENT, SITE 1
THONBURI - PAK THO HIGHWAY PROJECT

(General Engineering Co., Ltd.)



SECTION	SETTLEMENT PLATE	CONSTRUCTION START	INITIAL HEIGHT (M)	MAXIMUM PRESSURE (T/m^2)
3A (a) +	3A(a)SS2	19/11/69	1.83	3.29
3A (b) ●	3A(b)SS2	19/11/69	1.93	3.30
3B □	3B SS 2	12/11/69	1.09	1.57
3C ■	3C SS 2	3/11/69	0.70	1.17

(General Engineering Co., Ltd.)

FIG. 5–14 SURFACE SETTLEMENT, TRIAL EMBANKMENT SITE 3, THONBURI — PAKTHO HIGHWAY

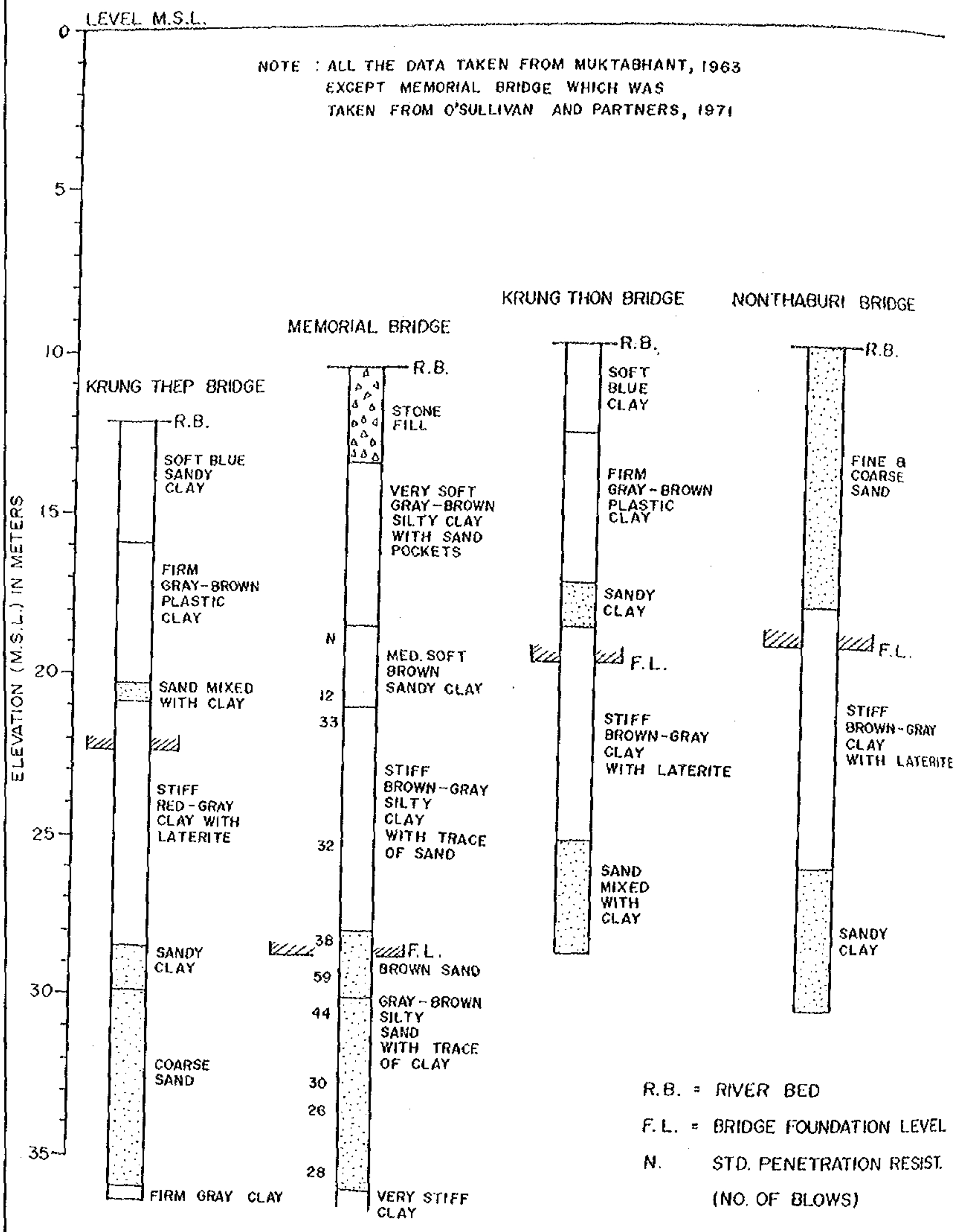


FIG. 5-15 BORING LOGS AT MAJOR RIVER CROSSINGS

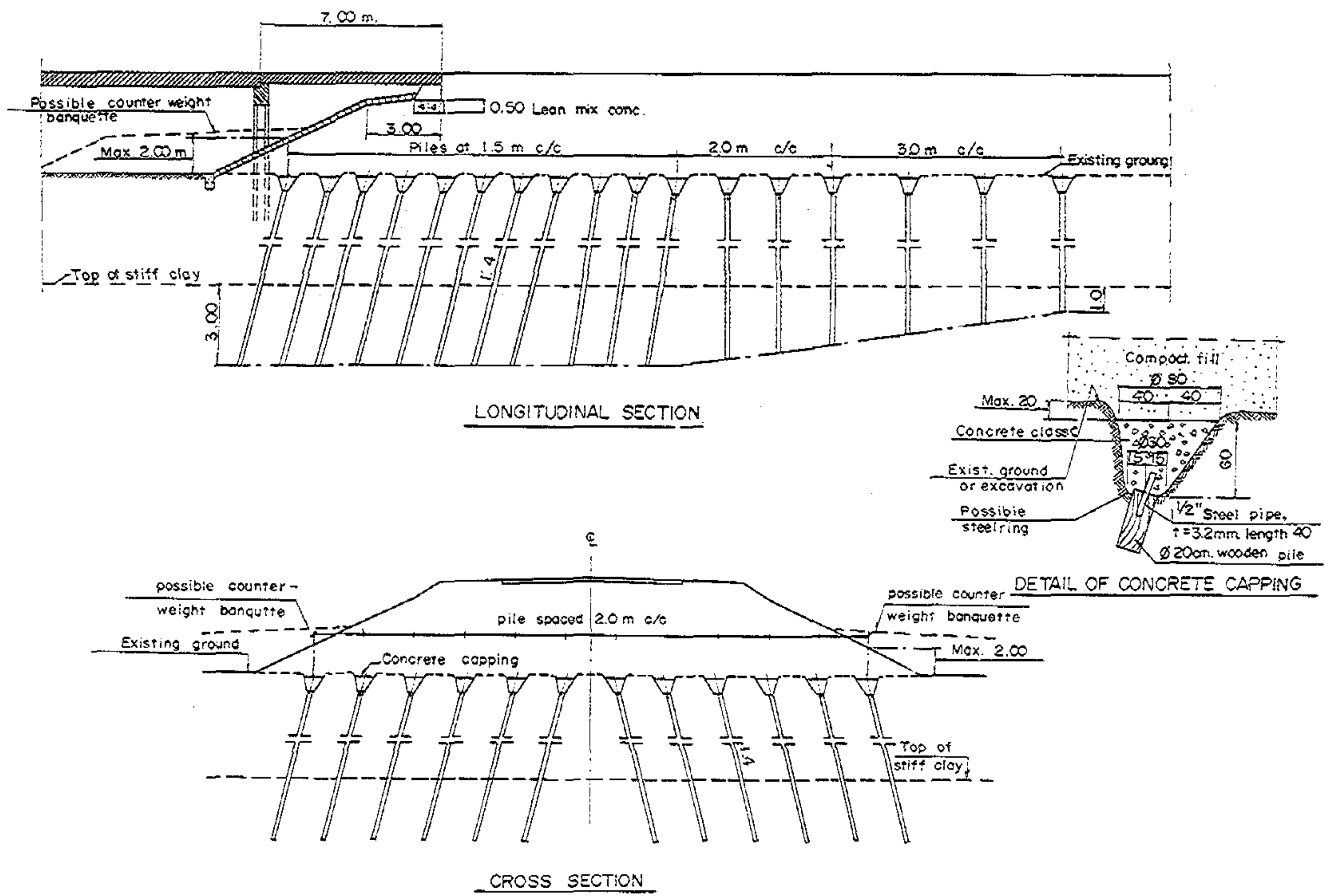


FIG. 5-16 RELIEF PILING (KAMPSAX , 1968)

5-6 Pavement

As of 1971 the Department of Highways had under its reponsibility a total of 17, 105 km of highways open to traffic; 10, 977 km of National Highways and 6, 128 km of Provincial Highways. The surface type of these highways are tabulated as follows:

	National Highway	Provincial Highway
Asphalt paved	9,571	1,770
Concrete paved	110	11
Unpaved	1,296	4,347
Total	10,977	6,128

As shown above the overwhelming majority of the highways in Thailand are surfaced with asphalt pavement. In the Bangkok area, however, concrete pavement appears to be predominant for heavily-travelled arterials and city streets within and near the city limits. It is noted that even on these roads, asphalt is applied to intersections, approaches to structures and shoulders. Both asphalt and cement are produced in abundance in Thailand and local contractors have experience in both types of pavement.

Typical cross sections of pavement structures are given in "Highways in Thailand, 1971" published by the Department of Highways and the ones for primary highways are shown in Fig. 5-17 (a) and (b). The concrete pavements in the Bangkok area are typically 23 cm in thickness; but the asphalt pavement throughout the country is mostly only 5 cm in thickness underlain by various undercourses. It is to be noted that the 23 cm thick concrete pavement and the 5 cm thick asphalt pavement on undercourses such as shown in Fig. 5-17 (a) and (b) are not comparable in terms of stability and durability; the former is far more competent than the latter. As a matter of fact, in the Bangkok area the asphalt pavement breaks down relatively easily due to heavy traffic or floods which often submerge the pavement section during the rainy season. It is by this reason that the asphat pavement is generally believed in Thailand to be of inferior quality requiring constant maintenance as compared with the concrete pavement.

The 23 cm concrete pavement of the Super Highway to Don Muang Airport, for instance, is in excellent shape except approaches to bridges. The concrete pavement of the original two lanes of National Highway No. 4 between Thonburi and Nakorn Pathom shows poor performance manifested by numerous cracks and unpleasant gaps at almost every joint of concrete slabs due probably to pumping. The additional two lanes of No. 4, now almost complete, are paved with asphalt surface of 10 cm in thickness, which is believed to be one of the first thick flexible pavements in Thailand. Also under construction is a 1.5 km section of Suksawat Road in Thonburi with a 12 cm thick surface of asphalt concrete with a pavement section of 50 cm in total, placed on a 65 cm subgrade of compacted sand.

Properly designed and constructed surfaces of the asphalt concrete pavements are capable of carrying almost unlimited volumes of traffic, provided only that they are supported by adequate foundations. The majority of these surfaces may be expected to have an economic life of 20 years or more.
It is also true that concrete surfaces are sometimes economical because of their low cost of maintenance and their relative permanency.

While each type has its merits and demerits for the conditions prevailing in the Bangkok area, the particularly important points to be considered are as follows:

1. Where considerable post-construction settlements are expected, it is easier to apply corrective measures to asphalt surfaces.

2. Stage construction is possible for asphalt pavement to reduce the initial cost and

3. For foundation conditions in which soft clay and high ground-water prevail, pumping may take place beneath concrete pavement.

Our preliminary designs of both type, concrete and asphalt, are shown in Fig. 17 (c) and (d), respectively. These are based on preliminary traffic volumes and soils data and are considered for comparison of the construction cost of each type.

The minimum thickness of the subgrade, i. e., a compacted sand embankment is tentatively indicated to be on the order of 100 cm and will have to be finalized when more soil data of the weathered crust at shallow depths are obtained.
A subbase of soil aggregate will consist of laterite mixed with sand and a base course of crushed stone will be of limestone or andesite crushed to the specified grading.

The preliminary cost estimate of a pavement section above subgrade would be roughly as follows:

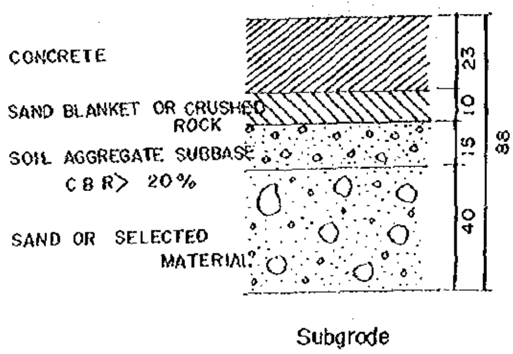
Concrete Pavement

	Thickness (m)		Unit Cost ($Baht/m^3$)		Cost ($Baht/m^2$)
Surface Course	0.23	x	900	=	207
Base Course	0.15	x	240	=	36
Subbase Course	0.15	x	144	=	22
Total	0.53				265

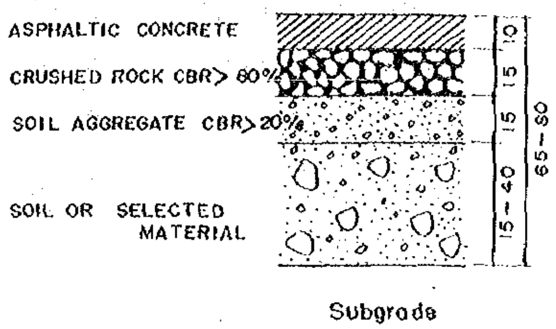
Asphalt Pavement

	Thickness (m)		Unit Cost (Baht/m^3)		Cost (Baht/m^2)
Surface Course	0.10	x	850	=	85
Base Course	0.15	x	650	=	97
Subbase Course	0.25	x	144	=	36
Total	0.50				218

As shown above, this preliminary comparison indicates that the concrete pavement is 22% more expensive than the asphalt in terms of the cost per square meter. As more accurate traffic data firm up, stage construction may become a possibility in which, for instance, a 6 cm surface is placed initially and another 4 cm layer laid several years after the opening of the Ring Road, which would be an additional economic merit.
At this preliminary stage, however, no further elaboration of cost estimate is justified because of the lack of essential data.



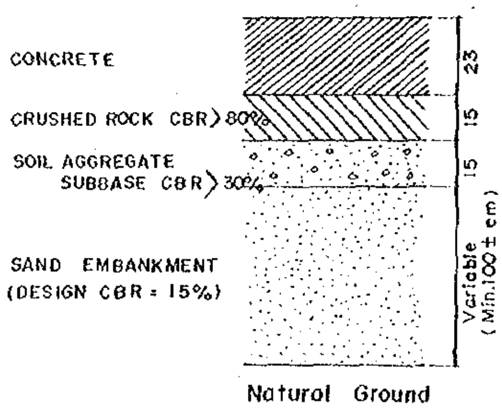
(a) Rigid Pavement



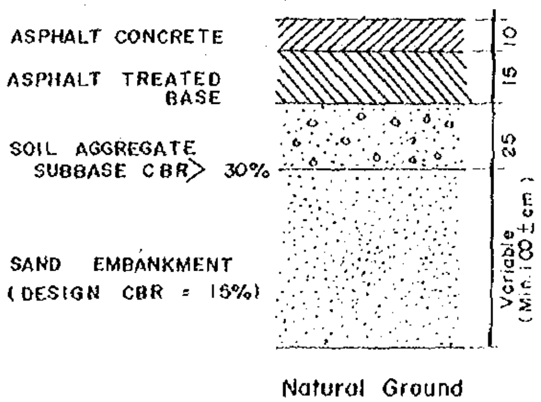
(b) Flexible Pavement

(A) TYPICAL PAVEMENT STRUCTURES FOR PRIMARY HIGHWAYS

(Department of Highway)



(c) Concrete Pavement



(d) Asphalt Pavement

(B) PROPOSED PAVEMENT DESIGN

(Unit : Cm.).

FIG. 5-17 PAVEMENT SECTIONS

5-7 Summary and Conclusions

1. The project area is situated in the vast flat alluvial plain of Chao Phraya River and the subsurface condition appears to be fairly uniform. The area is mantled with a deposit of soft Bangkok clay, typically 12 to 16 m in thickness. The top few meters are in general slightly stiffer, forming a weathered crust. Beneath this deposit exists a layer of stiff to hard clay, several meters thick, and at a depth of 21 to 25 m, is underlain by dense sand and gravel strata with some sandy clay extending to undetermined depths. Groundwater level is generally encountered close to the ground surface.

2. The Bangkok clay is a normally consolidated, sensitive clay with a consistency of "very soft to soft" and with a high compressibility and a high rate of secondary consolidation. This clay appears to be slightly overconsolidated throughout the depth and the "critical load" due to this effect is of great engineering significance in terms of stability and settlement problems.

3. Because of its extremely low strength and high compressibility, it has been found almost impossible to evaluate reliably the stability and settlement of an embankment founded on the Bangkok clay by means of the conventional design analyses alone.

4. It is urgently recommended, therefore, that at least one prototype trial embankment be constructed at a representative site at an earliest practicable time. Settlement plates, piezometers and surface stakes should be installed beneath and around the embankment, and field measurements be taken regularly until construction starts.

Only with such field data would it be possible to predict with reasonable accuracy the performance of the embankment on a similar subsurface condition and to make an economical design of the highway embankment in the project area.
It should be kept in mind that more trial embankments may be called for should the detailed exploration reveal different subsurface conditions.

5. It is recommended that embankment be built by imported river sand rather than utilizing the in-situ surface clay along the proposed route. The embankment, in most part, will have to be compacted so as to form a competent subgrade for pavement section. Approach embankments for structures will have to be pile-supported, or to consist of lightweight fill material such as lime-stabilized rice husk ash after sufficient preloading. Or else, the foundation soil has to be treated by some special methods prior to construction of approach embankments to minimize the settlements.

6. It is recommended that embankment be constructed in stages and field measurements for stability and settlement be maintained at close intervals of distance during construction. Maintenance of such measurements will have to be included in the special provisions for the construction specification.

7. It is our preliminary feeling that the embankment height should be limited to 2 to 3 m to lessen post-construction settlements and also to minimize the possibility of failure which might result in property damages in developed areas.

8. An adequate supply of satisfactory embankment materials and aggregates in the form of crushed stone is available within a reasonable distance from the project area.

9. No particular difficulty is anticipated for deep foundations; large-diameter, cast-in-place, reinforced concrete piers for the major river crossing, and precast reinforced concrete piles or prestressed concrete piles for other structures are recommended.

10. The asphalt concrete pavement, properly designed and constructed, will require no major resurfacing for a design life of at least 20 years. Because of its economy and flexibility the asphalt concrete surface appears more attractive than concrete pavements.

CHAPTER 6. HYDROLOGICAL INVESTIGATIONS

6-1 General Description

6-1-1 Topography

The proposed Bangkok - Thonburi Ring Road traverses an extremely flat plain located in the delta formed by the Chao Phraya River. The project area is situated about 50 river kilometers north of the Gulf of Thailand.

The topography is characterized by a low-level ground formation interlaced with many waterways. The natural ground elevations in the project area are in the order of 0.5 meters to 1.5 meters with a maximum of about 2 meters above local mean sea level. (Mean sea level at Bangkok Bar is set at 35.0 meters.)

In some places along the Chao Phraya River, natural leeves can be observed with low-lying marshy areas behind them. In addition to these topographic characteristics, there are many artificial ponds which are the remains of past borrow pits.

The rainfall runoff water in the project area is drained through natural streams or khlongs to the Chao Phraya River, however, water accumulates and forms marshes in some low-lying areas.

The proposed alignment of the Ring Road Part II, surrounds the northern outskirt of the Bangkok - Thonburi metropolitan area. On the west side of the Chao Phraya River, the alignment passes a forest of palm trees alongside the existing Charan Sanitwong Road.

The alignment on this portion is set on comparatively high elevations, and therefore, no major drainage problems are anticipated. On the east side of the Chao Phraya River, the alignment traverses a newly developed residential area, paddy fields and marshes. Some special drainage considerations will be needed in designing this section of the road.

6-1-2 Climate

The climate of Thailand is governed mainly by monsoons. Air streams flowing from the south-west from mid-May to September and from the north-east during the months of November to February are the typical monsoons of Thailand.

Three well-defined seasons arise as a consequence of these prevailing winds: The "Rainy Season" extending from May to September: The "Dry Season" which includes November, January and February, and "Transition Seasons", covering October, March and April.

The rainfall during the rainy season in Bangkok presents some regularities. For example, it generally starts raining in the late afternoon or in the evening with strong showers usually coupled with thunderstorms. The rainfall is characterized by high intensity, short duration storms. About 80% of the total yearly rainfall is recorded during the rainy season.

Whenever typhoon rains overlap with monsoons during the rainy season, large floods, caused by the Chao Phraya River, usually occur on the delta area.

Table 6-1 summarizes the climatic conditions in Bangkok, including temperature, relative humidity, evaporation, days of rain and rainfall, and wind velocities.

Table 6-1 Climatic conditions in Bangkok

Months	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Temperature, °C												
High	33.3	33.9	35.0	36.1	35.0	33.9	33.3	33.3	32.8	32.8	31.7	31.7
Low	18.9	21.1	22.8	24.4	24.4	24.4	24.4	24.4	23.9	23.9	21.6	19.4
Avg.	26.2	28.0	29.3	30.1	29.7	29.0	28.5	28.4	28.1	27.7	26.9	25.6
Temperature, °F												
High	92	93	95	97	95	93	92	92	91	91	89	89
Low	66	70	73	76	76	76	76	76	75	75	71	87
Avg.	79	82	85	86	85	84	83	83	82	82	80	78
Relative Humidity percent	71.4	74.1	73.6	74.3	78.6	79.4	79.4	80.1	82.1	82.7	79.3	73.5
Evaporation,												
millimeter	185	169	195	170	140	141	130	119	100	125	153	182
inches	7.3	6.7	7.7	6.7	5.5	5.6	5.1	4.7	3.9	4.9	6.0	7.2
Days of Rain, per month	1	3	4	6	17	18	19	19	21	17	7	3
Average Rainfall,*												
millimeters	8	31	35	84	179	163	176	187	313	245	53	6
inches	0.3	1.2	1.4	3.3	7.1	6.4	6.9	7.4	12.3	9.7	2.1	0.3
Wind Velocities,												
Max., Km/hr	47	61	58	97	122	76	76	72	83	72	54	50
Avg., Km/hr	7	13	13	11.5	8.5	7	6.5	7	7	6.5	6	3.5

*Mean annual rainfall = 1,482 millimeters (58.4 inches). Period of record = 2480 to 2509 (1937 to 1966).

6-1-3 Soil and Ground Water

Sub-surface soil conditions in the project area are relatively uniform. A soft clay layer, called Bangkok dark heavy clay, is widely found in the ground top stratum. This layer is from two to three meters thick and beneath it, a soft gray clay and brown stiff clay layers are observed. Below 20 meters, the clay is increasingly mixed with sand and gravel.

The ground water level in Bangkok is very close to the surface during the rainy season. Even during extreme dry seasons, ground water is rarely more than a meter below the surface. The average elevation of ground water level varies approximately from 35.5 to 36.0 meters while the natural ground elevations range from 35.5 to 36.5 meters.

Under these conditions, there exist many waterlogged areas throughout the year.

According to existing records at Bangkok Bar, the mean sea level is 35.03 meters. The maximum and minimum sea levels have been recorded at 36.86 and 33.37 meter respectively.

These water heights closely influence the ground water height in the project area.

6-2 Floods in the Project Area

6-2-1 General

There are two different types of floods in the project area, internal floods and external floods.

Internal floods are observed everywhere in the metropolitan area after heavy rainfalls during the rainy season. They are caused mainly by the fact that the existing drainage system cannot accommodate the rapidly accumulated runoff resulting from high-intensity storms.

External floods are caused by high flood waters from the Chao Phraya River. During the rainy season, high flood waters of the Chao Phraya River are sometimes swelled by high tides and overflow the river banks.

The external floods are more extensive than the internal floods.

6-2-2 Internal floods

The existing drainage facilities in the metropolitan area are not very effective. Because of the extreme flatness and low elevation of the topography as well as the high water level in the khlongs and rivers that receive the discharge runoff from the storm sewer networks, it is quite difficult to maintain the necessary hydraulic gradient to accommodate the expected discharge under the gravity flow drainage system now employed.

Shortly after a high intensity storm, excess surface runoff water slowly moves to low points and sumps where it accumulates and stagnates for several days. Roads constructed in these areas are generally overtopped by this type of flood.

Due to the lack of available data, the design water height for internal floods could not be exactly determined. However, from local information collected during site surveys, a flood height of 36.2 meters can be expected for the Part I portion of the Ring Road alignment. Taking the general slope of the Chao Phraya delta as 1 : 25,000 in the project area, this flood height of 36.2 meters can be projected and estimated at 36.3 and 36.5 meters for the southern portion and northern portion of the Part II alignment respectively.

Considering that the average ground level is about 36.0 meters and that the total monthly rainfall in the rain season is in the order or 300 millimeters, the internal flood heights thus obtained are considered to be reliable and adoptable.

Although internal flood heights are generally lower than those of external floods, they do occur more frequently during the year and for comparatively longer durations.

The Bangkok municipality is now starting to implement a program for the improvement of the drainage system in the Bangkok - Thonburi metropolitan area. After this scheme is completed, internal floods will be drastically eliminated in the developed portion of the project area.

Under these circumstances, the proposed Ring Road, if designed to cope with external floods, will be quite adequate to handle internal floods.

6-2-3 External floods

There are two major factors which decide the extent of floods in the lower reaches of the Chao Phraya River.
The first is the accumulated quantity of water collected by its many upstream tributaries. The second is represented by the tidal influence in the Gulf of Thailand, as the average ground

elevation in the project area is only about one meter above mean sea level. In the past, external floods were observed when high concentrations of sea water appeared in the river discharge.

Geographically, the river basin occupies most of the northern part of the country and also a large area of the central part, totalling 162,000 Km^2 which constitutes about 31% of the whole area of the Kingdom of Thailand.

In the northern part of the country, mountain ranges form four principal basins which are drained off by the Ping, Wang, Yom and Nam Rivers.

These rivers come into concurrence at their lower reaches forming the Chao Phraya River.

The general river slope near Pak Nam Poh, where the four north tributaries join, is about 1:7,000, with ground level at Pak Nam Poh being about +23.50 meters above mean sea level.

It gradually flattens to 1:10,000 at Ayuttaya, and then further still until it reaches 1:25,000 at Bangkok with practically no slope at all at its intersection with the sea coast.

As Thailand has seasonal rains, the rise and fall of its rivers usually correspond to them. In general, most rivers have their first peak in May or June. During this part of the year, their waters rise about 2 - 3 meters above minimum levels for a period lasting 7 - 21 days, receding thereafter by 1 - 2 meters during July or thereabouts. The second peak follows and builds up gradually reaching its maximum at the end of August or beginning of September, usually overflowing the banks for a short period, then gradually subsiding to the normal minimum level by the end of November or beginning of December.

Fig. 6-1 shows the discharge hydrograph of the Chao Phraya River.

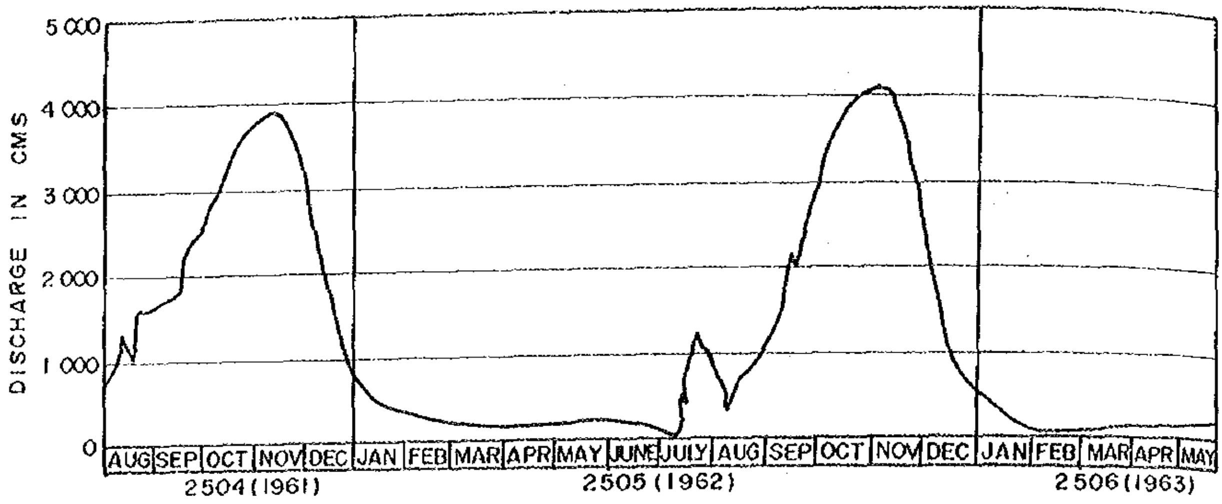


Fig. 6-1 Discharge hydrograph of Chao Phraya River at mouth

The hydraulic grade line in the lower reaches of the Chao Phraya River is very much influenced by tides. In the wet monsoon season, the location where the river flow begins to be noticeably affected by tides is in the vicinity of 75 kilometers upstream from its mouth. In the dry season, this location shifts further up river to about 160 kilometers near Pamok. Fig. 6-2 shows water-level gradients for the Chao Phraya River in its lower reaches.

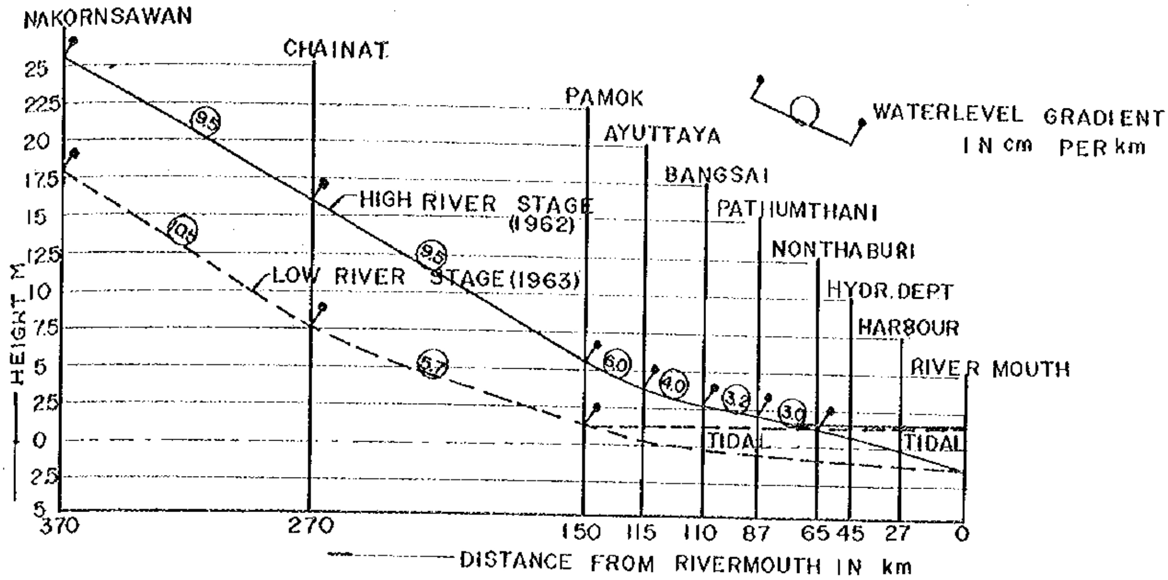


Fig. 6-2 Water-level gradients of Chao Phraya River

During the rainy season, the Chao Phraya's main channel is insufficient to accommodate the total discharge coming from its upstream tributaries. As a result, the excess discharge overflows its embankments downstream from the Chao Phraya Dam.

The flood waters spread over the Chao Phraya delta and find their way south and finally flow into the Gulf of Thailand. In Fig. 6-3, the Pamok water-levels are plotted against the Nakorn Sawan discharge. The curve of this figure clearly shows the limited discharge capacity of the main channel. Flooding starts when the discharge at Nakorn Sawan has attained a value of about 1400 m^3/sec.

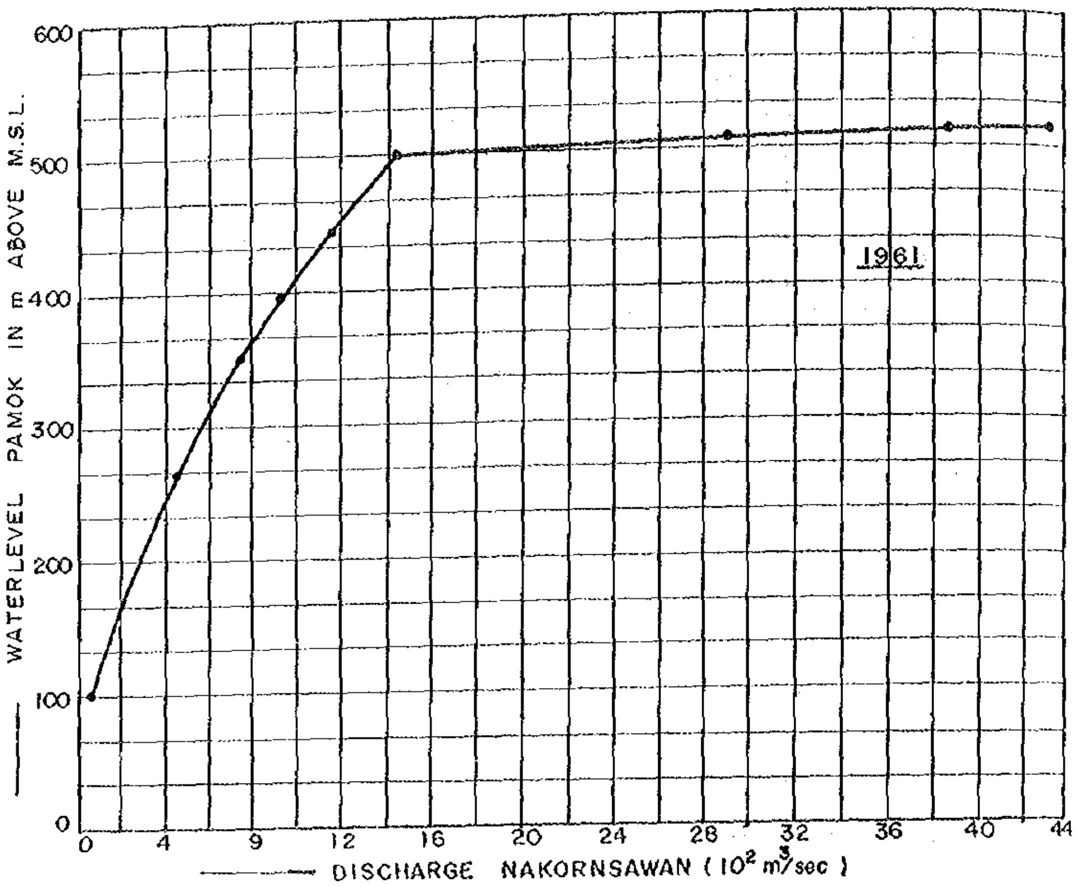


Fig. 6-3 Water-levels at Pamok vs. discharges at Nakorn Sawan

Before the Chao Phraya Dam was completed in 1957, there were many serious floods in the Bangkok-Thonburi metropolitan area. At present, an irrigation scheme, "The Greater Chao Phraya Project" has been completed, and Bumipol Dam on the Ping River, the most important tributary, has been opened. Another dam, the Sirikit Dam was newly completed on the Nam River, the second largest tributary.

Therefore, flooding is no longer a serious problem in the project area, however, the danger still exists in the event of extremely large flows.

The Royal Irrigation Department conducted extensive studies on flood heights and calculated the future expected flows and their recurrences at Bangkok. These values are shown in Table 6-2.

Table 6-2 Estimated present flood expectancy at Bangkok

Expected Recurrence (Frequency in Years)	Flows at Chainat, (Cubic Meters per Second)	Expected Flood Level at Bangkok	
		Meters Above Mean Sea Level	Elevation, City Datum (MSL=35.03)
100	4,700	1.80	36.83
50	4,500	1.77	36.80
25	4,200	1.75	36.78
10	3,700	1.72	36.75
5	3,300	1.70	36.73

These flood heights are expected at the Memorial Bridge site in the southern portion of the Ring Road, Part II. At the Rama VI Bridge site in the northern portion of the proposed highway, flows 0.20 meters above the listed heights are expected based on data from past observations.

6-3 Considerations and Recommendations

6-3-1 General

As stated in the previous sections, the project area is under the influence of internal and external floods.
The proposed Ring Road has to be designed properly so as to meet all-weather road specifications. In order to attain the above purpose, we must consider the proposed profile grade of the Ring Road, necessary river crossings and surface drainage systems within the right of way.

6-3-2 Profile grade

Requirements for an all-weather road call for the pavement surface to be always above the expected high flood level. Moreover, for long flood durations, the adverse effects that prolonged water contact will have upon the supporting strength of the subgrade or pavement materials must be carefully considered.

In determining the proposed vertical alignment, the following information must be taken into consideration.

(a) High water levels for a 50-year external flood frequency are 36.80 at the Memorial Bridge site and 37.00 at the Rama VI Bridge site.
These heights are hereby defined as high flood levels.

(b) The peak water level for the expected internal flood is in the order of 36.3 m to 36.5 m.
The height will be defined as average water level, as it stands for a comparatively long duration.

(c) Due to the very soft and thick clay layers of the subsurface soil in the project area, severe settlement of the highway embankment is expected. During recent observations, 40 cm - 70 cm of settlement in a highway section between Thonburi and Paktho and 20 cm - 25 cm in the Don Muang - Saraburi Highway, were recorded during their construction stages.

Under such soil conditions, low highway embankments are desirable in order to avoid excess settlement and decrease the quantity of borrow material for economical construction.

(d) The total thickness of pavement material is estimated at approximately 50 cm. (Please refer to the pavement section, Chapter 5.)

(e) Newly constructed highways are generally graded to elevations of 37.0 meters - 38.0 meters in the project areas. They are working properly as all-weather roads.

After careful examination, the recommended relationships between the high flood level, average water level and the roadway were determined as shown in Fig. 6-4.

The height at the edge of the outside traffic lane has a freeboard of 50 cm above the high flood level. A freeboard of 50 cm above the outside edge of the travelled way is considered to be adequate for the specialized conditions existing in the delta area.

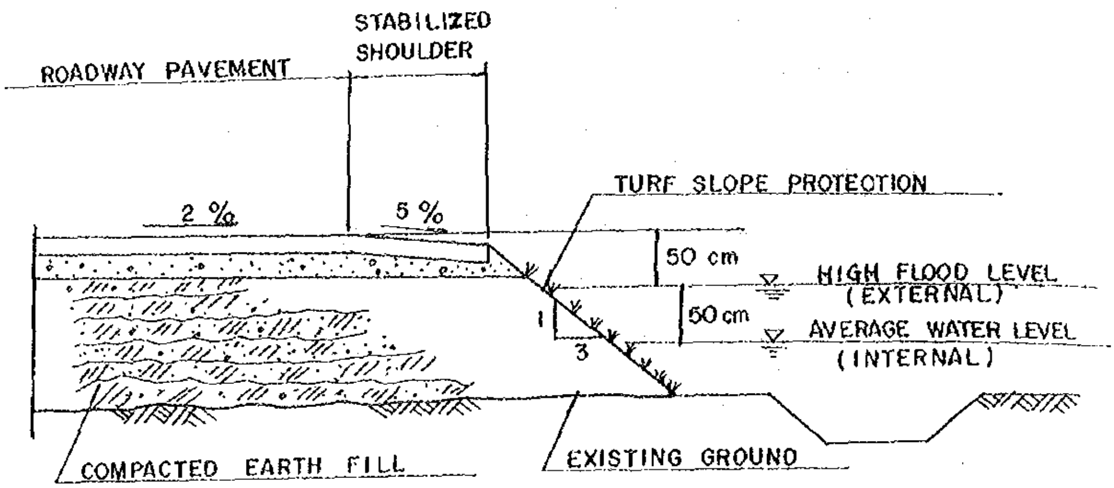


Fig. 6-4 Relation between flood levels and roadway

Because of its extreme flatness, the delta area has a high capability for storing flood waters.

For this reason, the high level of a 100-year recurrence frequency flood, is only 3 cm above the 50-year high flood level previously determined.

Therefore, if properly and periodically maintained, the proposed freeboard should be sufficient to cope with anticipated floods. If the road formation level is set at the center of the traffic lane, the proposed formation elevations thus obtained will range from 37.5 to 37.7 meters.

6-3-3 River crossings and surface drainage system

After careful alignment studies, a bridge site for the Chao Phraya River crossing was proposed at about 1 kilometer upstream from the existing Rama VI Bridge. However, as the crossing site is on the meandering portion of the river, the effect of scour on the proposed bridge foundations should be further studied during subsequent and more detailed investigation.

After considering the facts that no river training works are provided and that the existing Rama VI bridge is working properly, the total length of the proposed bridge may be determined based on the existing river width and the total length of the existing Rama VI bridge.

The streams which will be crossed by the Ring Road are mostly khlongs. According to information obtained from the Harbour Department, a vertical clearance of 3.5 m above high water level and a horizontal clearance of 30 m are required in crossing the khlongs used for combined irrigation-navigation purposes. For the smaller khlongs, the span length and clearance will be decided according to detailed surveys on their present condition.

As the proposed Ring Road alignment will be set so as not to interfere with flood flows, no special structures to equalize the flood levels on each side of the highway will be provided. An appropriate surface drainage system within the right of way shall be provided. In designing the roadway and roadside drainage system, a 5 years frequency storm in conjunction with the rational formula will be suitably employed in calculating run-off. The rainfall intensity-duration-frequency curves, in Fig. 6-5 which were developed for the Bangkok metropolitan drainage study, will be utilized for the above purpose. The close cooperation with the Bangkok metropolitan drainage scheme shall be considered essential in the detailed design stage.

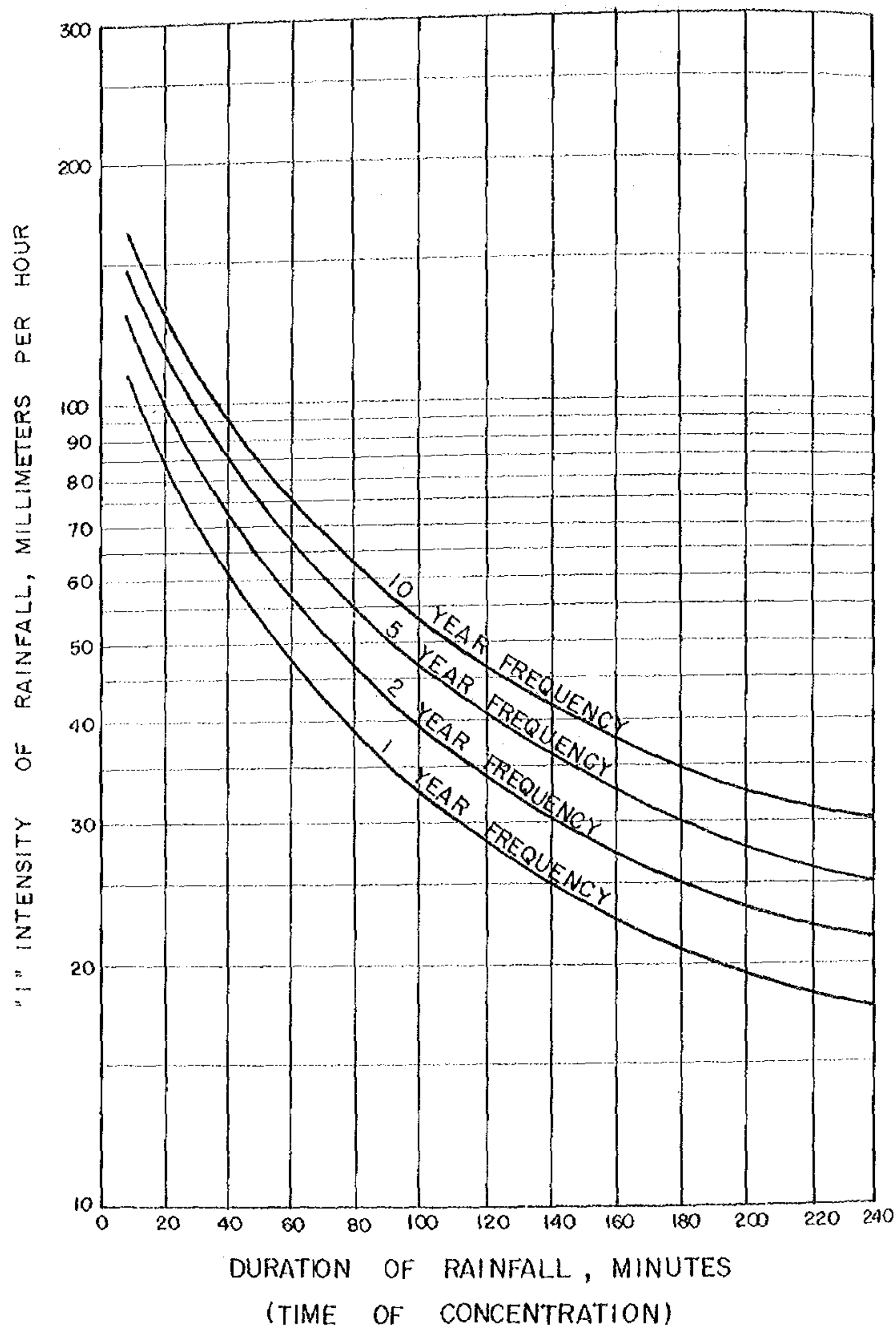


Fig. 6-5 Rainfall intensity-durations curves

CHAPTER 7. HIGHWAY ENGINEERING

7-1 Introduction

Bangkok, the capital of the Royal Kingdom of Thailand, is a fast expanding city, which, together with Thonburi, has a present population of well over three million. In twenty years time, it is anticipated that the population will grow to over six million.

The Ring Road as planned by the Department of Highways, is a ring running at a distance of from seven to ten kilometers from the city centre, and has a total length of about 45 kilometers.

The role of the Ring Road may briefly be summarized as follows.

(a) To serve as a collector and distributor road for the urban traffic.

The commercial and business activities in Bangkok are scattered over a large area. The Ring Road will serve as a collector and distributor for various subcentres, thus reducing unneccessary through passing of traffic across the undestined area.

(b) To serve as a bypass for through traffic

The existing highway system of Bangkok is such that the major part of the through traffic in all directions will have to transverse the city centre of Bangkok, adding to the congestion of the city road network.
While the percentage of through traffic in a big city is generally small, the absolute number of vehicles will be considerable, and the construction of a bypass warranted.

(c) To serve as a control for unplanned sprawl of city growth.

Without a properly planned guidance, a city tends to sprawl in all directions in its growth. This phenomenon is also seen in Bangkok, especially in the eastern and north-eastern direction, where growth of residents along any available existing roads is at a rapid rate. A Ring Road will serve as a check and control for such sprawling.

In this study, full consideration for the roll of the Ring Road is made in the process of selection of the route so that the final choice will be able to dispense its function most efficiently.

7-2 Base Data

a) Aerial photographs

The aerial photographs, prepared in 1971, in the scale of 1 : 6, 000, supplied by the Department of Highways, were used in the selection of the route. Any new building constructions or developments were confirmed during field investigation trips, and the aerial photographs duly modified.

b) Unit price of land

The unit price of land as officially evaluated by the Land Department of the Municipalities of Bangkok and Thonburi were adopted in the calculation of cost of right-of-way.

However, as the unit price was not obtained for the whole route, some portions were evaluated through deduction by comparison with other known portions of similar condition.

In the case of cost of demolition, it can be anticipated that the actual cost will vary case by case, and in the calculation in this study, a standard cost is assumed and applied to all buildings. In this case, the buildings are classified into either concrete structure or wooden structures, and the standard demolition cost including compensation per m^2 applied.

7-3 Design Standard

7-3-1 General

The Ring Road was planned as full controlled access with access permitted only at designated intersections.

The design criteria for Ring Road is shown as follows, where desirable standards and minimum requirement are indicated based on the AASHO standard, and the Japanese Standard for Geometric Design of Highway used as reference.

7-3-2 Design criteria for Ring Road

		Main roadway		Service road
1.	Design speed	100	km/hr	60
2.	Minimum Radius of Horizontal Curve			
	Through roadway (desirable)	700	m	200
	Through roadway (absolute min.)	400	m	120
	Ramps (desirable)			
	1-lane	50	m	
	2-lane	60	m	
	Ramps (absolute minimum)			
	1-lane	40	m	
	2-lane	50	m	
3.	Maximum Superelevation	8	%	
4.	Maximum profile grade			
	Through roadway	4	%	5%
	Ramps	6	%	
5.	Minimum Vertical clearance			
	Ring Road over highway	5.0	m	
	Ring Road over railway	5.1	m	
	Minimum free-board over major khlong	3.5	m	
	" minor khlong (Chapter 6)	varies		

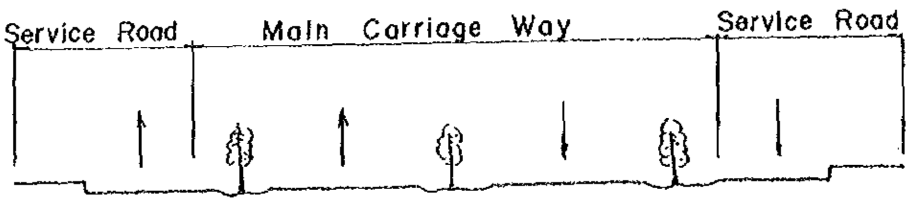
6.	Sight Distance		
	Through roadway	160 m	75
	Ramps	50 m	
7.	Vertical curve radius		
	Convex: Desirable	9,000 m	2,000
	Minimum	6,500 m	1,400
	Concave: Desirable	4,500 m	1,500
	Minimum	3,000 m	1,000
8.	Cross Section Elements for Roadway		
	Traffic lane	3.60 m	3.25
	Left shoulder		
	Roadway	2.50 m	
	Viaduct	1.50 m	
	Right shoulder		
	Roadway	1.00 m	
	Viaduct	1.00 m	
9.	Median		
	Except on viaduct	6.00 - 10.0 m	
	on viaduct	varies	
10.	Drainage		
	a. Design flood frequency	50 years	
	b. Design storm frequency		
	Pipe culvert	25 years	
	Box culvert	25 years	
	Short span bridge	50 years	
	Long span bridge	50 years	

7-3-3 Additional explanations on design criteria

1) Cross section composition

The estimated traffic volumes for the Ring Road are as shown in Fig. 3-25 - Fig. 3-35. Besides this volume, an additional 30% of intrazonal traffic is also expected when the area along the highway is fully developed.

The cross section composition of the Ring Road should be such that the road will offer adequate service to the traffic, and will be able to play the roles as described previously. For this purpose, the composition of the cross-section is decided where the main roadway is provided in the centre to cater for high speed through traffic, and service or frontage roads provided on both sides with stopping lanes and sidewalks, to serve the users along the road, and also to serve as distributor and collector connecting roads for the main roadway.



2) Design speed

a) Main roadway

The speed at which vehicles can travel safety and comfortably on a road is variable according to conditions of the climate, the traffic volume as well as the highway structure.

In the case of the proposed Ring Road, the alignment is across flat terrain, and sufficiently great curvature is planned for the curves sections. However, due to the many elevated sections across major roads, klongs or railway line at an average interval of about 2 kilometers, the profile is rather undulating. It is undeniable that for this reason, there is some lack of harmony between the profile and alignment. As a remedy, endeavours are made to secure as much of lateral allowance along the traffic lane as possible, and to maintain sufficient sight distance at all points. With these considerations, the main roadway is planned at a design speed of 100 km per hour.

b) Service road

From the point of structures, service roads have a smalles number of elevated sections, and the harmony between alignment and profile is maintained.

With the purpose of serving the area along the highway, the service roads, intersecting with other roads at grade, provided with stopping & parking facilities, and being uncontrolled for the access, cater for traffic of varied characteristics. The service road also serve as access ramps to the main roadway. For this purpose, the design speed for the service road is planned at a normal u rban city-road speed of 60 km/h.

3) Width of shoulder

The left shoulder of the roadway is planned at 2.5 m wide, to permit emergency stopping of all vehicles. However, at bridge or elevated roads of more than 50 m in length, the width of the shoulder is reduced to 1.5 m, which will only permit stopping for light vehicles such as passenger sedans.

For the bridge of section 7b across the Chao Phraya River, (the substitute for Rama VI Bridge), the shoulder in planned at 2.5 m, in order that dual direction traffic may be served even if only one half of the bridge is constructed during stage construction.
The right shoulder is planned at 1.0 m to secure sufficient lateral allowance for flowing traffic.

4) Median

The width of the median should be sufficiently provided to allow free and safe flow of high-speed traffic travelling in opposite direction. A minimum of 3 m will be sufficient for this purpose, although in this case the separator will have to be of mounted-up type with kerb stone.
A wide median will reduced psychological resistance to vehicle drivers and thus increase capacity of the inner traffic lanes. Taking the characteristics of the Metropolitan into consideration, the median for the Ring Road is planned at 10 metres.

7-4 Required Number of Traffic Lanes for Ring Road

The design traffic capacity per traffic lane may be calculated from the following formula.

$$C_D = C_b \times R \times B$$

where C_D = Design traffic capacity (vehicle per hour per lane)

C_b = Basic traffic capacity (vehicle per hour per lane) = 2, 000

R = Total modifying coefficient = Re x Rc x Rt x Ri

Re = Modifying coefficient for width of traffic lane.

R_c = " " for lateral clearance

Rt = " " for heavy vehicle composition.

Ri = " " for roadside obstruction.

In the case of the Ring Road, the width of a traffic lane is planned at 3. 6 m, sufficient lateral clearance as well as amply wide median is provided, and the conditions along the route are planned such that no obstruction to traffic flow will exist. The modifying coefficient are thus adopted as follows.

Re = Rc = Ri = 1. 0

The modifying coefficient for heavy vehicle composition is calculated as follows.

$$Rt = \frac{100}{100 - Pt + Et.\ Pt}$$

where Pt = Composition of heavy vehicle (%)

Et = Equivalent standard vehicle unit per heavy vehicle.

In this study, the composition of heavy vehicles is estimated to be no more than 15%. At an equivalent factor of 2. 0, Ri will be 0. 87.

B = Modifying coefficient for planned service level.

The modifying coefficient for planned service level differs according to the relation between the possible traffic capacity and the planned peak-hour volume of the target year. From the existing traffic situation on the present road network, it is difficult to assume a high level of service for the proposed Ring Road. For calculation of the maximum capacity, the coefficient is assumed at 1.0.

With the above-mentioned figures, the design traffic capacity per traffic lane can be calculated as follows.

C_D = 2,000 x 0.87 x 1.0 = 1,740 veh/hour per lane.

This hourly traffic volume is converted into daily traffic volume with the following calculation:

$$ADT = \frac{D.H.V.}{K \times D} = \frac{C_D \times N}{K \times D}$$

Where ADT = Design average daily traffic (veh/day)

D.H.V. = Design hourly traffic volume in one direction.

K = Ratio of 30th hour traffic volume in both directions to ADT = 0.09
(In the city area of Bangkok, the peak hour ratio of traffic volume to daily traffic volume is rather low as can be seen from the results of cross section traffic counts. However, considering that the major part Ring Road traverses through the suburban district, thus resulting in possible concertration of traffic during commuting hours, the k value is set at a comparatively high 0.09)

D = Ratio of major directional traffic flow to total flow at 30th hour = 0.60

N = Number of traffic lane in one direction.

The design average daily traffic capacity for a six-lane highway can thus be calculated as follows:

$$A.D.T = \frac{1,740 \times 3}{0.09 \times 0.60} = 98,000 \text{ vehicles/day}$$

The same calculation for a four lane highway will result in a design capacity of 76, 000 veh/day. From the estimated traffic volume for target year of 1990, it is evident that a six-lane main roadway is required of all sections of the Ring Road.

As for the service roads which cater mainly for localized intrazonal traffic, it is seen that some sections may suffice with 2 traffic lanes. However, as stopping and parking will be allowable on the service roads, it is decided that 2 lanes in each direction for a total of 4 traffic lanes should be planned for the service roads through the whole section.

The results of traffic assignment shows the that by 1990, some small sections of the Ring Road have traffic demand slightly exceeding the capacity. However, with the anticipation that some portion of the traffic volume may simultaneously utilize the service road, a six-lane main roadway will be adequate, and expansion of the roadway to 8 lanes cannot be easily justified.

7-5 Route Selection for the Ring Road Part II.

7-5-1 Outline

The route selection was made mainly from the aerial photographs supplied by the Department of Highways and supplemented with extensive field investigation trips.

The investigations in this study alone is not sufficient in the decision of the best routes for certain minor portions, and it is suggested that in the preliminary design, comparison of alternatives for some localized section should further be made in detail.

The alternative studies made for various sections of the Ring Road Part II are described in details in the subsequent paragraphs.

7-5-2 Section 6, 7a (1)

(Section 6 : Phetchaburi Road - Pahol Yothin Road - Mittraphap Road

Section 7a(1) : Mittraphap Road - Pracharat Road)

(1) Status quo

(a) Along the vicinity of the proposed route for Section 6 of the Ring Road Part II, the Railway Department had in the past secured a strip of land of 80 m in width with the plan of connecting the Northern and the Northeastern Railway Line in the future. Along this strip of railway right-of-way, building up have been in progress.
For the region between Phetchaburi Road and Pahol Yothin Road, some paddi fields are still in existence on the Phetchaburi side. Along Inthrama Road and Lat Phrao Road, which will meet the proposed route about perpendicularly, the building up is prominent in a ribbon shape, showing conspicuous sprawl phenomenon. Also, in the district of Ban Tambon Lat Yao,

large scale housing estate development is at present underway and building up in progress although the district in not conveniently accessible from any major roads.

(b) Along the section from Pahol Yothin Road to Krung Thep-Nonthaburi Road are found the Mittraphap Road which connects the town centre of Bangkok with Don Muang International Airport and the Northern regions of the Kingkom, and also the Northern and Northeastern Railway Line which runs generally parallel to the Mittraphap Road. In the district lying between the Mittraphap Road and Prachachun Road, construction of concrete structure housing units is going on at a rapid rate centering around Chon Niwet Road. In this new residential district, schools and other public facilities are also well provided in a well planned pattern.

(2) Basic concept in the selection of alternative routes.

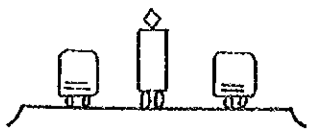
The Ban Tambon Lat Yao and Chon Niwet Districts are undergoing development throughout an extensive area.
In order to maintain harmony between the Ring Road and the newly developed district, the proposed route has to be selected at the vicinity of the boundary between newly developed and old housing estates in order that the new high-class residential area will not be disrupted by any new road construction.
For this section, with the relation with the railway right-of-way taken into due consideration, 4 alternative routes are selected for comparative study, two of which propose making use of the railway right-of-way and the remaining two are unrelated to the railway right-of-way.

The conclusion reached from the comparative study is that alternative 2A, a route unrelated to the railway right-of-way and running about 0.6 - 1.0 km to the east of the right-of-way is the best route.

(3) The route of alternative 1 (case 1)

(a) Location and form

In this alternative, the Ring Road will utilize the railway right-of-way, leaving only 20 m of the 80 m in width for future railway use in the centre, and having the Ring Road on both sides of the railway. This will locate the Ring Road at about 1.5 km to the east of the Mittraphap Road and about 2.0 km to the west of Khlong Lat Phrao. However, considering the existing state of building-up of the environment, a road further to the east is considered more desirable.



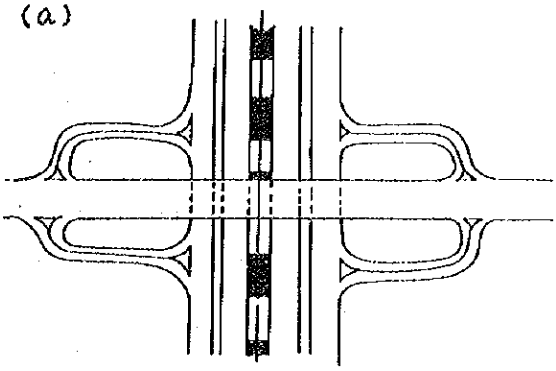
(b) Relation with future railway line

i) Traffic management

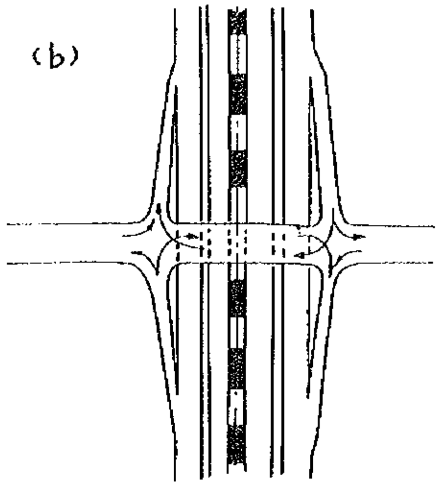
Many problems on traffic management are expected due to the future existence of a railway line in the middle of the highway. To eliminate most of these problems, the elevation of the whole railway line is considered necessary. The reasons are as follows: If the railway line were to be constructed at ground level, then the high-speed main roadway of the Ring Road will also have to be at ground level at intersections with other roads.

At these intersections, grade separation is necessary to maintain the function of the Ring Road, by way of elevating the intersecting roads. In this case, connection between the Ring Road and the intersecting roads will have to be effected with a full clover leaf type interchange or an elevated diamond interchange. This results in increase in cost of construction or land acquisition. Also, traffic regulation will have to be carried out at the crest of elevated part of the elevated intersecting road or at the terminal part of the slope, both being undesirable for safe traffic operation. (Fig. a, Fig. b)

(a)

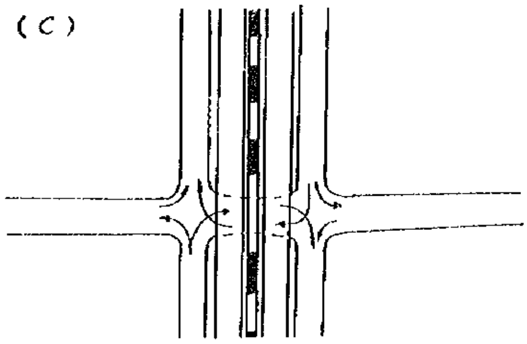


(b)



If only the high-speed main roadway of the Ring Road is elevated at intersection, leaving the railway line at ground level, then traffic may be regulated with a ground level diamond interchange. In this case, however, undesirable interruption of smooth flow of traffic on the intersecting road by the at grade railway crossing is anticipated. (Fig. c)

(C)



ii) Interchange structure of Ring Road

The starting point of section 6 of the Ring Road Part II is decided by the terminating point of the Ring Road Part I presently in the design stage. The railway line will confluent with the Ring Road at the southern part of section 6, coming in from the southeast.

For the profile, the eastern half of the main roadway will therefore overcross the railway line at the confluence point. For the alignment, to reduce the crossing angle at the confluence point, the Ring Road will be swayed into a gradual S shape. This results in increase in land acquisition and is also undesirable for smooth traffic flow.

Again, at the vicinity of the Mittraphap Road, the proposed railway line will swing out to merge with the existing Northern and the Northeastern Railway line, and the inner lanes of the Ring Road will again have to cross with the railway line with grade separation.

At this point, the Ring Road is to be connected to the Mittraphap Road with a partial cloves leaf type interchange, and the service road, which serves as the collecting and distributing road, will overpass the Mittraphap Road.

As a result, in order that the railway line will pass the inner roadway of the Ring Road at a two storey level, the overpassing of the railway line has to be completed before reaching the interchange.

A structure as this, where the angle of crossing is small, and where railway crossing of the loops of the interchange is unavoidable, is with very complicated positioning of the abutments. In this case, it is not posible to limit the railway line to within the right-of-way already procured, and some new acquisition of land for the railway is necessary.

iii) Relation with the width of existing right-of-way

With 20 m of the existing 80 m of railway right-of-way reserved for the future railway line, the Ring Road will be able to purchase the remaining 60 m from the Railway Department. This width will be insufficient to fulfil the planned cross-section for the Ring Road and an additional 15 m in width has to be acquired.

From the existing land use along the right-of-way, it is planned that for the section from Phetchaburi Road to Lat Phrao Road, the expansion will be to the east side of the existing railway right-of-way and for the section from Lat Phrao Road to Mittraphap Road the expansion will be to the west (or south) side of the existing right-of-way.

If it is decided that the Ring Road is to be planned within the available 60 m in width without any new acquisition, then it is necessary to reduce the width of separators and the sidewalks, resulting in certain lowering in efficiency of the Ring Road.

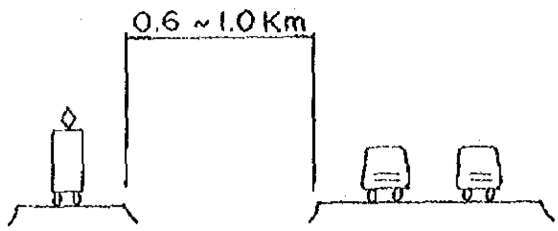
(c) The geometric structure of the Ring Road

This alternative is the shortest route of all the alternatives under comparison. However, as mentioned in (ii) above, there are some problem in alignment and profile. Also, as continuous elevation will be necessary for the section from Mittraphap Road to Khlong Prem Prachakon, it becomes an expensive alternative despite being the shortest route.

(4) The route of alternative 2A (case 2A)

(a) Location and form

In this alternative, the route is proposed at 0.6 - 1.0 km to the east (or north) of the existing railway right-of-way, with a width of 80 m. From the existing situation of the building up of the environing district, the alternative is considered most desirable, as it will serve also as the main trunk road for the newly developed residential estate in Ban Tambon Lat Yao.



(b) Relation with future railway line.

The Ring Road will be connected to the Mittraphap Road with an interchange. At the intersection point between the Mittraphap Road and the furture railway line, it will therefore not be possible to elevated the Mittraphap Road to cross the railway, but the railway will have to overpass the Mittraphap Road. From the point of maximum gradient allowable to the railway, it will be necessary for the railway to be elevated continuously across both the Pahal Yothin Road and the Mittraphap Road.

(c) The geometric structure of the Ring Road

This alternative is the longest of all the alternative routes under comparison. Large curvatures are planned for the curve sections, and, as the distance between intersecting existing road is longer than other alternatives, the distance between points of change in profile is consequently long enough for efficient traffic operation.

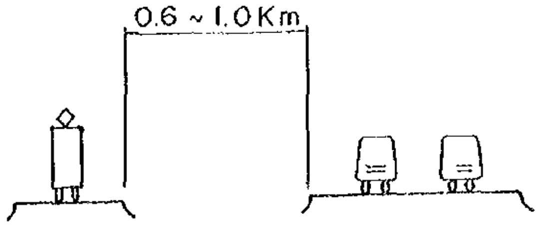
(d) Position of intersecting point between Mittraphap Road and the Ring Road

After field reconnaisance, the intersection is planned at the open space between existing buildings such as Mazda Automobile factory, Pepsi Cola factory, District Police Department and Press Office. A tower for high tension wire stands on the extension of this route in the Chon Niwet District and further detail investigations will be necessary to decide the final route.

(5) The route of alternative 2B (case 2B)

(a) Location and form

For the section from Phetchaburi Road to Lat Phrao Road, the route for this alternative is the same as that for alternative 2A. Beyond Lat Phrao Road, the Ring Road intersects with the future railway line and runs to the south of it.



(b) Relation with the future Railway Line

i) Intersection between the railway and Mittraphap Road

As the Ring Road will be connected to the Mittraphap Road with an interchange, and future railway line will have to overpass the Mittraphap Road for the same reason as in case 2A.

ii) Intersection between the railway and the service road of the Ring Road.

The Ring Road will intersect with the future railway line at the vicinity of Sta. No. 85 and Sta. No. 115. At these intersections, the service roads will intersect with the railway at grade, resulting in reduction in efficiency as compared with other alternatives. Especially at the vicinity of Sta. No. 115, the service roads will intersect with both the future railway line and the existing northern railway line, and the role of the service roads as the distributor and collectors will thus be greatly impeded.

(c) The geometric structure of the Ring Road

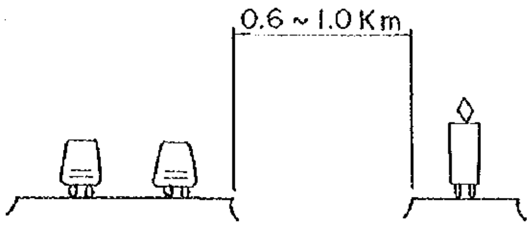
Large curvature is planned for the alignment of the route. However, for the section between Lat Phrao Road and the existing Northern Railway Line, there are four grade-separated intersections for a distance of about 4.5 kilometer, resulting in undulation in the profile. The distance between Pahol Yothin Road and Mittraphap Road is only 300 m, being the shortest of all the alternative routes, and weaving within such a short distance between the service roads and the high-speed lanes of the Ring Road is not particularly desirable from the traffic point of view.

Also, two consecutive elevated parts will have to the planned for the crossing of the Mittraphap Road and the Northern Railway Line. The improvement of the profile by combining these two elevated parts into one single structure will result in lengthening of the bridge and consequent increase in construction cost.

(6) The route of alternative 3 (case 3)

(a) Location and form

In this alternative it is proposed that the whole 80 m of the railway right-of-way be used by the Ring Road and a new right-of-way of also 80 m in width acquired and compensated to the Railway Department at 0.6 - 1.0 km to the east (or north) of the existing right-of-way.



(b) Relation with the future railway line

i) Intersection with the Mittraphap Road

Here again, the railway line will have to overpass the Mittraphap Road, as the later will be connected to the Ring Road with an interchange. From the maximum grade allowable to the railway, the position of the intersection will have to be 1.0 km north of the point of intersection between the Ring Road and the Northern Railway Line. For this reason the whole curve section of the railway has to be moved to about 1.0 km north of the existing railway right of way.

ii) Intersection with the service road of the Ring Road

With the moving of the future railway line to the east, the intersection at the vicinity of Phetchaburi Road is eliminated.

On the other hand, at the intersection point between the Ring Road and the Northern Railway Line, the Ring Road will also have to cross the future railway line at the same time, resulting in more interruption of vehicle traffic at the railway crossing than Alternative 2A.

(c) Geometric structure of the Ring Road

Due to the removal of the railway line, the number of elevated sections of the Ring Road is reduced to the same as that for Alternative 2A. Moreover, the length of the elevated structure is short and large curvature can easily be planned for the alignment.

7-5-3 Section 7a(2), 7(b)

(Pracharat Road - Tachang Bridge Extension)

(1) Status quo

On the Bangkok side of this section, along the route of the proposed Ring Road, schools and wats are dotted sporadically over the region. Especially at the vicinity of Phibun Songkham Road, besides schools and wats, small-scale factories and residential houses are also widely scattered. The Thonburi side is mainly orchards and agriculture land.

(2) The location of the new bridge across Chao Phraya River

The existing bridge across the Chao Phraya River, the Rama VI Bridge, is of only two lanes in width, and the geometric structure of the access road is of low standard. The existing Rama VI Bridge will therefore not be sufficient to play the role as part of the Ring Road.

A new location for a bridge is chosen with due considerations that the construction will not cause disruption to the schools, wats or factories along the Phibun Songkham Road and that the alignment will avoid running over the thermal power station on the Thonburi side. The final proposed site of the bridge is chosen at some 900 m up-stream of the existing Rama VI Bridge.

(3) The position of intersecting point between the Ring Road and the Southern Railway Line

The point where the Ring Road intersects with the Southern Railway Line is chosen in the orchard region so that the angle of intersection will not be too acute. For the section from the intersection of Tachang extension, considering the existence of wats and residential areas within this region, the proposed route is chosen as far to the west as possible, avoiding any high concrete buildings in the vicinity.

(4) The stage construction of the new cross-river bridge and traffic handling.

The new bridge across the Chao Phraya River will be of about 300 m in span, and, together with the approach on both sides, will form a bridge of about 1.0 km in length. The construction cost for the bridge will be high and the time required for the construction will be long. It is therefore planned that service roads will not cross the river, but will end at the river banks, with provision for U-turn under the bridge.

As for the width of the roadway across the river, it is planned that the width of one half of the roadway (3 lanes) should be sufficient to accomodate traffic for 4 lanes with some sacrifice in width of each traffic lane, and that only the outer half of the roadway will be constructed first, leaving the inner half to be constructed at a later stage. The part completed first will thus be able to accommodate traffic of 2 lanes in each direction. The second half will be constructed as a second independent bridge. To avoid adverse effects to the abutments of the first bridge, and to provide sufficient clearance for upper structure construction work, it is planned that the two bridge structures be constructed 15 m apart.

7-5-4 Section 7a(3)
(Tachang Extension - Phetkasem Road)

(1) Status Quo

The Tachang Bridge at present under construction will be extended west to intersect with the existing Charan Sanitwong Road and the proposed Ring Road and eventually extended further to the west.

The Ring Road is planned to meet the Tachang extension with an interchange. The proposed route for the Ring Road is chosen at about 300 - 500 west of the Charan Sanitwong Road. This will come to about 300 - 500 m to the east of Khlong Bangkok Yai. Around this region are sporadic existence of wats and schools.

(2) Selection of route

In the vicinity of the Khlong Bangkok Noi, the Tachang Extension and the Southern Railway Line, along the general region of the proposed route, are found such wats as Wat Bankunnom, Wat Pen etc., and the section from Khlong Mon to Phetkasem Road is dotted sporadically with schools and wats. With these wat and schools as control points, the route is finally chosen some 300 - 500 to the west of Charan Sanitwong Road.

The Part I of the Ring Road will initially end at the Tha Phra Junction. However, it is planned that on completion of the whole ring, the Ring Road will intersect with Phetkasem Road at some 350 m west of the Tha Phra Junction.

7-6 Route Selection for Section 5

7-6-1 Status Quo

At the vicinity of the junction between Rama IV Road and the Ring Road Part I, the Rama IV Road branches into Sunthon Kosa Road which leads to the Port area and the through road which meets the Sukhumvit Road before turning south to the Pattaya direction. At this branching point, the Rama IV, with a 8 lane roadway on the west, abruptly reduces to 4 traffic lanes on the east. Moreover, the alignment takes a sharp S shape at this point, and the maintenance of adequate sight distance is difficult.

The Rama IV Road meets the Shukhumvit Road at the vicinity of Soi 69, near which, the Soi 71 (Phrakhanong-Khlong Tan) is the major link connecting the Sukhumvit Road to the Phetchaburi Road and to Lat Phrao Road to the north.

7-6-2 Basic concept in the selection of alternative routes

(1) Type of alternative routes

An estimated 200 thousand vehicles per day is forecast for the year 1990 for the Rama IV Road and the Section 5 in total. Four alternative routes were chosen for comparative study and alternative 2, which proposes the overall utilization of the Khlong Toei, is considered the best alternative. The four alternatives are:

alternative 1 : Improvement and expansion of the existing Rama IV Road

alternative 2 : Overall utilization of the Khlong Toei

alternative 3 : Utilization of the northern bank of the Khlong Toei.

alternative 4 : A route south of the Khlong Toei running through the port area.

(2) Cross section composition

The cross section composition of the Section 5 is proposed to be the same as the Ring Road with high-speed roadway in the centre and service roads on both sides, because the results of traffic analysis shows that some 65 % of the traffic on Section 5 will directly flow into the Ring Road.

(3) Type of connection with the Ring Road

As the majority of the traffic on Section 5 will use the Ring Road, and the traffic volume at the point of connection will be heavy, purely from the point of traffic treatment, it is desirable to have the Section 5 connected directly to the Ring Road with some sort of full interchange. However, the connecting point is within heavily built-up area, where cost of land and compensation for building demolition will be high. The construction of a full interchange (such as a 3 level Y-type junction or a trumpet-type interchange) from the initial stage will be very costly, and it is more desirable that stage construction be considered, and the full structure carried out at a later stage when traffic situation necessitates. In this case one of the methods that may be adopted is the reconstruction or improvement of the access roads in the vicinity and the control and regulation of traffic (e.g. enforcement of one way traffic etc.) so that these access roads may serve the purpose of a cloves-leaf type interchange.

In the case that a full interchange will eventually be constructed, the types that may be adopted are the 3-level Y-type junction and the single-trumpet-type interchange. Of the two types, the Section 4 of Ring Road Part I being to be elevated, considering the ease in stage construction and the low cost of construction in the initial stage, it can be said that the 3-level Y-type junction is more preferable.

(4) Connection with national highway route No. 34 at the Eastern End.

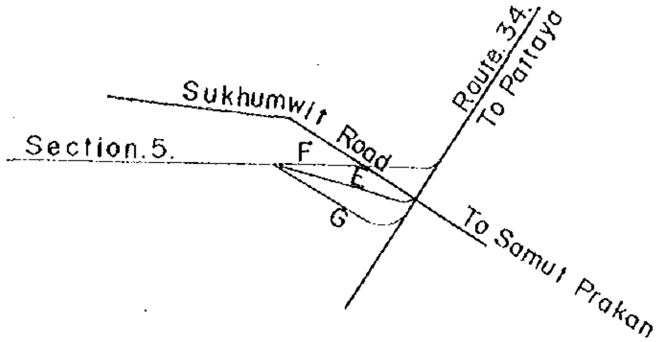
As previously mentioned, 4 alternative routes are considered for the western half of Section 5 from Sta. No. 0 to Sta. No. 35 From Sta. No. 35 to Sta. No. 50, due to the existence of schools and the Bangkok Oil Refimery, only one route is proposed in between Chao Phraya River and Sukhumvit Road. For the eastern terminal of the Section 5 at around Sta. No. 70, three alternatives as shown in the following sketch are studied.

The first route (route F) is that the route chosen for Sta. No. 35 - Sta. No. 50 be extended in a straight line to fly over Sukhumvit Road and then connected directly to National Highway Route No. 34.

The second route (route G) connects the Section 5 to the minor road which leads to the River. In this case, a flyover at the intersection with the Sukhumvit Road will be necessary for smooth traffic flow.

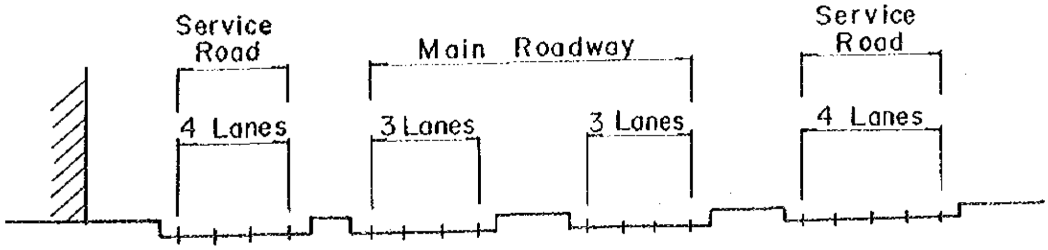
The third route (route E) puts section 5 directly into the existing intersection. In this case, improvement in channelization of the existing intersection will be absolutely necessary. Also, the traffic lanes joining Route 34 and the Section 5 will have to be elevated. However, as the elevated lanes will be a curve, there is physical limit in securing the length of accelerating and decelerating lane. For this reason, the design speed of the Section 5 will have to be sacrified to 40 - 60 km/hr.

Traffic analysis shows that about 65% of the traffic entering the Section 5 at this point will be from Route 34. To maintain the function of Section 5 as a high-speed highway, it can be said that route F is most preferable. However, a decision on this will have to be made together with consideration on the role to be assignment to Section 5, and further study in this respect is most necessary.



7-6-3 Alternative 1. (The Improvement and Expansion of the Existing Rama IV Road)

This alternative calls for the expansion of a section of the existing Rama IV Road which is, at this section, with 4 traffic lanes. As the number of lanes required for the Ring Road with service road is 10 traffic lanes, the expansion will result in a 14 lane highway. (Figure below).

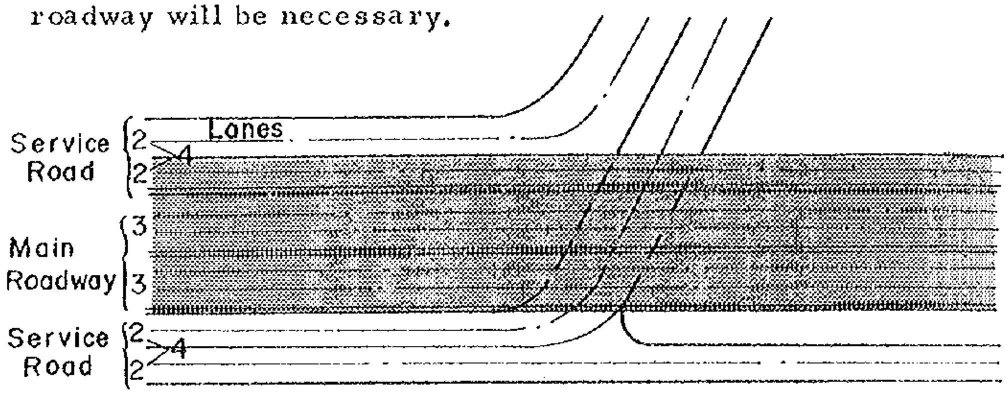


The width of the roadway will thus come to about 100 m. However, due to the reasons described below, such a plan is not practical from the points of traffic operation and construction cost.

(i) The ground level of the existing Rama IV Road does not reach the level planned for the cross-section of the Ring Road. Due to the existance of building on both side of the existing road, it will not be possible to raise the ground level.

(ii) During construction, traffic on the existing road will suffer great inconvenience. Also, heavy burden will be put on the Sukhumwit Road which will be the detour route.

(iii) At Station No. 15 (in the vicinity of Posteri Anuson School), the Ring Road will diverge from the Rama IV Road. For this reason, the elevation of the 6-lane high-speed roadway will be necessary.



(iv) At present it is possible for vehicle and pedestrians to cross the Rama IV Road at places with traffic light control. However, as the high-speed lanes will be separated with separators, crossing of vehicles will not be possible. As for pedestrians, pedestrian-crossing bridges of over 100 meters will have to be provided, and this will be greatly inconvenient.

(v) The expansion of one side of the existing road will be adversary aesthetically.

(vi) Both sides of the existing road are densely lined with concrete-structure buildings of over 3 storeys. The cost of land here will be around 3,000 baht/m^2 or about 6 times that along Khlong Toei, which is at around 500 baht/m^2. The cost of demolition will also be more than 5 times costlier. Together with the construction of the bridge at Station No.51, the total construction cost will be extremely high.

The alignment from Station No.0 to No.5 will be of a S-shape curve, and will not be desirable from the point of safety in operation.

(viii) The future connection with the Ring Road Section 4 will necessarily be of the trumpet-type, as the Y-type direct junction will not be possible.

7-6-4 Alternative 2 (The full use of the Khlong Toei)

In this alternative, Khlong Toei will be reclaimed and used as the roadway, and residents on both sides of the Khlong will be removed.

The Khlong Toei is highly polluted, and is serving no other purpose than as an outlet for the sewerage of the vicinity, and as an unloading point for construction materials such as sand and gravel. It is possible therefore, to make use of the full width of 70 m which includes the width of the existing roads on both sides of the khlong. A waterway of 7 m in width will be left in the middle for drainage purpose. In this alternative, large quantity of fill material will be required for the reclamation of the khlong. The cost of land acquisition and demolition will be much lower than that of other alternatives. The alignment of the route will be extended to the city center through Rama IV Road in a straight line. It is also superior in the connection of the existing built up area to the port area. This alternative is most desirable from every aspect.

7-6-5 Alternative 3 (Route on the northern bank of Khlong Toei)

In this alternative, the route will run over schools, Military Pharmaceutical building as well as Leather Tanning Organization, and the acquisition and reparation of these facilities will remain a big problem.

Moreover, as the route will be flanked on the southern side by Khlong Toei, development effect cannot be too greatly expected, resulting in a delay in the improvement of Khlong Toei and the clearing of the low standard residents along the Khlong.

The route is about 150 m away from Rama IV Road and the cost of land will be about 1500 baht/m^2, or 3 times that for the Khlong Toei route.

7-6-6 Alternative 4 (Route through the port area)

This alternative calls for the expansion of At Narong Road and extending the route east, running parallel to Khlong Toei at about 300 m away. The route will branch out from Rama IV Road at an angle of about 60°, run in a straight line for about 300 m, and again turn at 60° angle to return to a parallel course with the Khlong Toei.

Along this route are lined many 3 storey shophouse-cum-residential buildings, and the demolition of these buildings will be necessary in road expansion work. When the route is eventually connected to the Ring Road through an interchange, the elevated section will have to be sufficiently long to allow clearance with the Rama IV Road, resulting in increase in construction cost.

Also, the Rama IV Road will be connected to the Ring Road with a split diamond type interchange. As heavy traffic volume is anticipated at this junction, traffic control will remain a problem.

The route from Station 10 to Station 30 will greatly reduce the available land for the port, and at this section, the rerouting of the railway line is necessary. This will result in the necessity for a new railway bridge across Khlong Phra. The cost for such rerouting will be high, and the problem of the effective use of the land in relation to the trunk road remains to be solved.

The alignment of the route will be a continuation of curves to avoid factories, Wat Saphra and Bangkok Oil Refinery, on both sides of Khlong Phra.

7-7 Interchange

7-7-1 The location of interchanges

For the connection between the Ring Road or Section 5 with other existing or future roads, full interchanges are planned for interchanges with the future East-West Highway, the Mittraphap Road (Super Highway) and the Tachang Extension, Y-shaped direction junction planned for junction between Section 5 and Section 4, and direct junction for the terminal of Section 5 at National Highway Route No. 34. Diamond interchanges are planned for all other connections from the point of economy.

The full list of interchanges are as follows:

(1) Ring Road Part II

1)	Phetchaburi Road	diamond interchange
2)	Future Din Daeng Road extension	diamond interchange (left turn ramps only)
3)	Future East-West Highway	full clover leaf - type interchange
4)	Future town planning Road	diamond interchange
5)	Lat Phrao Road	"
6)	Pahol Yothin Road	"
7)	Mittraphap Road (Super Highway)	partial clover leaf type interchange
8)	Prachachun Road	diamond interchange
9)	Pracharat Road	"
10)	Phibun Songkhram Road	half diamond interchange
11)	Tachang Extension	full clover leaf type interchange

12)	Bangkok Noi Taling Chan Road	diamond interchange
13)	Phet Kasem Road	"

(2) Section 5

1)	Rama IV Road and Section 4	Y-shape direct junction
2)	Soi Paknan (Khlong Phrakhanong)	diamond interchange
3)	Soi 54	"
4)	Sukhumwit Road	half diamond interchange
5)	Route 34	direction junction

The average distance between interchange is about 2 kilometers.

Consideration has to be provided that there is a limit to the capability of service to right-turning traffic in the case of a diamong interchange. Also, to enable efficient functioning of the Ring Road, it should be ensured that traffic on other roads should have easy access to the service road (frontage road) of the Ring Road.

Half-clover leaf type interchanges may be considered in place of diamond interchanges. However, in this case, right turning will still occur for traffic on the low standard roads. The full clover-type interchange provides separation for the major traffic stream direction. In this case, large area of land will be necessary and the cost of land acquisition and construction will be high. The adoption of the full clover leaf type will therefore have to made with consideration for the future land use of the vicinity.

In this study, the main roadway of the Ring Road is planned to intersect all other roads with grade separation, and the role of collection and distribution left to the service road. In this case, it is necessary that proper control of access from the service road to the main roadway or vice versa be made, to provide separation for through traffic and in or out going traffic.

7-7-2 Interchange with future East-West Highway

(1) Location

The Ring Road is planned to be connected to the future East-West Highway with a full interchange.
The position of the interchange has to be selected so that sufficient length of speed-change lane can be secure after the Ring Road, having crossed the Phetchaburi Road and the future railway line, reaches the ground level.
Again, near this point the future Din Daeng Road is expected to run parallel to the Khlong Samsen, and provision for the access of this road into the Ring Road has to be made.
With all these points taken into consideration, it is proposed that the full interchange should be planned at 0.8 - 1.0 km north of the Phetchaburi Road.

(2) Type

The future railway line will cross the Ring Road near the interchange, and the future East-West Highway will cross the Ring Road as an elevated section. Under such conditions, full service to all directions should be provided with a double trumpet type or a full clover leaf type interchange.
A double trumpet type interchange will require the crossing of the Ring Road with a bridge, and will also require bigger area. For this reason, it is considered that a full-clover-

leaf type is suitable. In this case, the service roads will fully serve the purpose of collecting and distributing traffic to and from the high-speed traffic lanes.

7-7-3 Interchange with the Mittraphap Road (Super Highway)

(1) Location

The Super Highway is the main trunk road of Bangkok connecting the town centre of Bangkok with the Don Muang Airport and further north with the north and northeastern regions of the Kingdom.
The interchange is planned at about 2 km south of the intersection between Super Highway and Ngan Wongwan Road. At the later intersection, grade separation is being planned to replace the existing at grade junction.
At about 2 km south of the proposed interchange, the Mittraphap Road crosses with the Pahol Yothin Road at grade.
Grade separation construction work is at present underway.

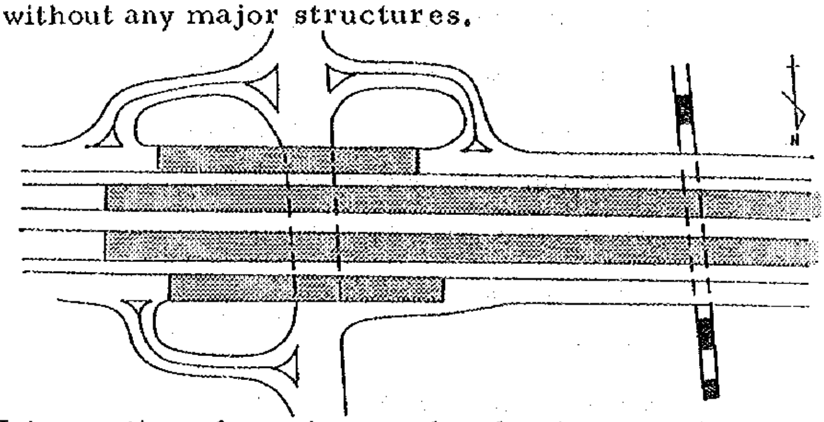
(2) Type

The Super Highway is under improvement to become a controlled access highway eventually rid of traffic lights. The interchange with the Super Highway will have therefore to be such that proper channelization between the two highways is possible. It is proposed that a clover-leaf type interchange, whereby all main traffic streams be guided into loops, be adopted. In this case, two basic types of in and out flow are considered, and the type (a) where the service roads serve as the collector and distributor roads is considered more desirable.

(a) Collector and distributor road type

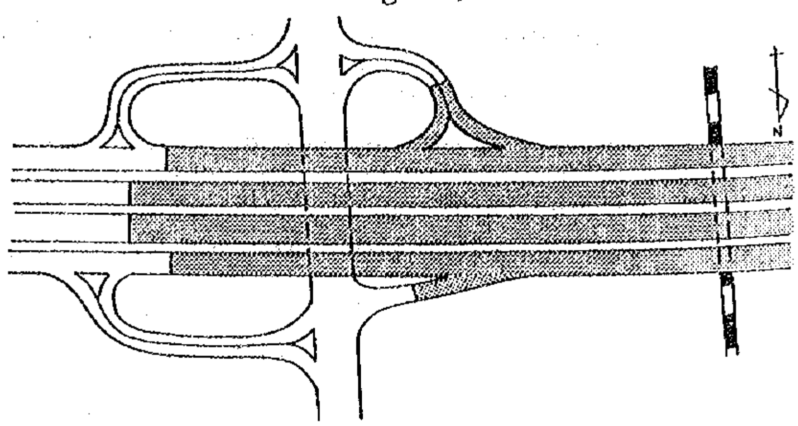
(i) Intersection of the service road with the railway line at grade

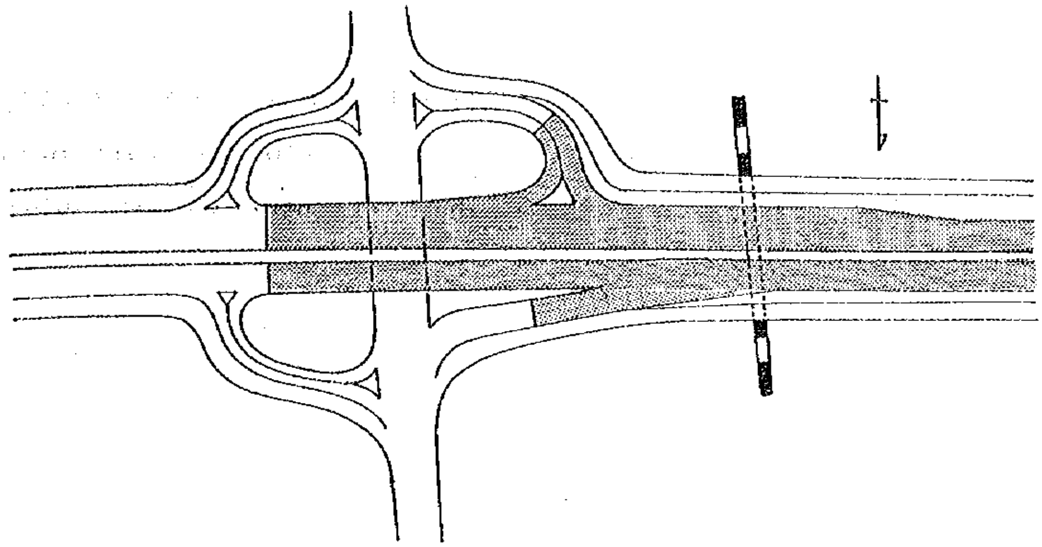
In this type the service roads play the role of collector and distributor roads for the high speed traffic lanes but will cross the Northern and Northeastern Railway at grade. During stage construction, work will start with the service road and weaving occurs on the elevated section of the service road. However, construction cost will be very low, and the whole interchange can be constructed with only earth work without any major structures.



(ii) Intersection of service road and railway with grade separation

Basically this is the same type as (i), with the difference that the service roads also cross the railway lines with grade separation. On this type, some ramps of the interchange are bridge structures, and the construction cost is higher.





(b) Direct access type

The in and out flow traffic will make access to the service road directly from the high speed traffic lanes in this type. When the traffic volume is heavy, this type will considerably lower the capacity of the highway. Also, as the service roads are discontinued at the interchange, the construction of the main roadway will have be carried out together with the interchange during stage construction.

7-7-4 Interchange with Tachang Extension

(1) Location

The extension of the Tachang is at present planned to stop at the Charan Sanitwong Road, but will eventually be extended further west. The interchange with the Ring Road will be planned at the orchard district with the Ring Road running at ground level.

(2) Type

The interchange adopted here will be a full clover-leaf type with the service road serving as collector and distributor road, the same as that for the intersection with the future East-West Highway.

7-8 Structures

7-8-1 Criteria for design of structures

(i) Design load H20-S16-44 (AASHO)

(ii) Allowable stress

Substructures:

Factory made piles

concrete	84 kg/cm^2
reinforcing bar	1,400 kg/cm^2
prestressed concrete	350 kg/cm^2

Others: in accordance to Thailand Industrial Standard

(iii) Clearance limit

Railway : 5.100 m (from top of rail)

Highway : 5.000 m

Khlong : Navigation clearance : H. W. L. + 3.500m
Navigation channel : 30.0 m

Major rivers: Navigation clearance: H. W. L. + 5.500m
Navigation channel : 60.0 m

(The figures for khlongs will be a guiding standard. In principal, the clearance for existing bridges will be adopted).

(iv) Specification :
1) The Standard of the Americal Association of State Highway Officials (ASSHO)
2) Thailand Industrial Standard
3) The Standard of the Thai Department of Highways.

7-8-2 The decision on type of bridge

(1) Superstructure

(a) New bridge across Chao Phraya River (New Rama VI Bridge)

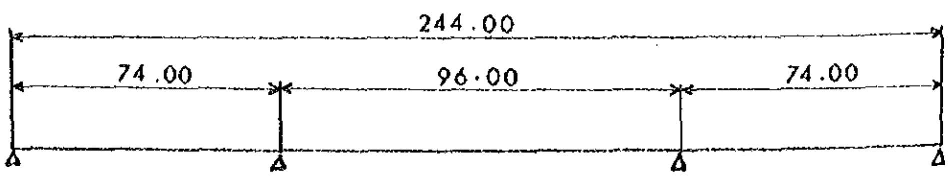
The decision on the type of superstructure for the new bridge across Chao Phraya River (the New Rama VI Bridge), is made basing on findings on the span, clearance, and width of navigation channel for the existing Rama VI Bridge, and a conclusion is reached that a centre span of at least 100 m, and a clearance of MSL + 11.500 m will be sufficient.

The location chosen for the new bridge is highly sensitive to tide movement, and the difference in water level between high and low tide is great. The velocity of water flow is estimated at a maximum of 2.5 m/sec. All these were taken into consideration in the study.

Two different types were chosen as alternatives for study, the one being of prestressed concrete (D & W construction method) bridge, and the other being continuous box girder metal bridge.

(i) Three-span PC bridge (D & W construction method)

The span division is as below.

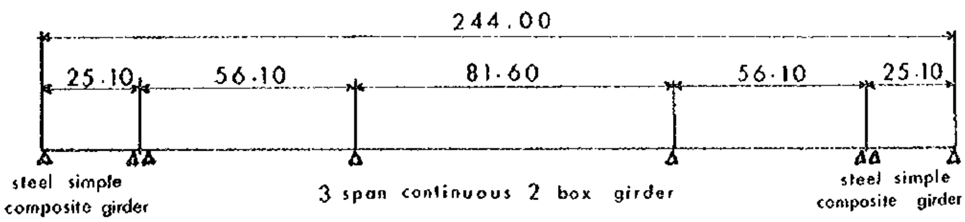


3 span continuous PC bridge

In the D & W construction method, construction work will be carried out in cantilever fashion and will not cause any impediment to traffic on the river during construction. Also, maintenance work after completion will be easier and cheaper than that for a metal bridge. The construction work will be a repetition of simple routine steps and the training for skilled workers will be easier than that for a metal bridge. However, there is a demerit that the construction period will be longer than that for a metal bridge.

(ii) Three-span continuous two-box-girder metal bridge

The span division will be as follows:



In the case of the three-span continuous two-box-girder metal bridge, there is an advantage that the level of profile will be lower by 3.4 m (due to difference in height of the wagon mould during construction and in height of supporting point) and the length of the bridge will be shorter than a PC bridge. The construction period is shorter, and there are less technical problems in construction. Construction work will be carried out by the floating crane method.

(iii) Choice of type

From the comparative study of the above alternatives, it is considered that P. C. bridge is more advantageous from points of engineering and construction cost, and further works are carried out with the P. C. bridge.

(iv) Approach to the bridge

From the points of economy, ease in erection and speed in construction, the PC composite I-girder is adopted for the superstructure of the approach section. Also, to avoid excess settlement of the embankment for the approach, the bridge of the approach is extended until it reaches a height of 1.0 - 1.5 m above ground level, where it is continued with earth work.

(b) Superstructure for elevated section and for bridges over khlongs

For the superstructure of elevated sections of the roadway and for bridge over khlongs, the PC pre-tension girder type is adopted where the span is from 10.0 to 21.0 m, and reinforced concrete slab bridge adopted where the span is below 10.0 m.
For span of over 21.0 m, the post-tension composite I-girder is adopted. The dimensions are as below.

(i) Reinforced concrete slab girder = 5.0m - 10.0m

length of girder (m)	5.0	6.0	7.0	8.0	9.0	10.0
height of girder (cm)	30	34	36	39	42	45

(ii) Prestressed concrete box girder = 10.0m - 21.0m

length of girder (m)	12.0	14.0	16.0	18.0	20.0	21.0
height of girder (cm)	50	60	70	70	70	75

(c) Span division and clearance of major khlongs

A survey of the span division and clearance of existing bridges over major khlongs were carried out.
In this study, in principle, the same span division and clearance is to be adopted for bridges over the same khlongs and situated near the existing bridges.
The following are the results of the survey.

Dimension of Existing Bridges over khlongs

Unit : m

Section	Name of Khlong	Span Division	Clear-ance	Type of Superstructure
6	Bang Sue	13.80	2.70	PC
7a	Prem Prachakon	23.00	5.20	RC cantilever
7a	"	20.50	2.20	Railway bridge
7a	"	15.0 + 12.0 + 15.0	6.00	PC
7a	Bangkhen Mai	6.0 + 8.5 + 6.0	4.10	PC Slab
7a	Bangkok Noi	20.0 + 20.0 + 20.0	6.60	RC hollow girder
7a	Mon	12.00 + 16.00 + 12.0	4.20	RC Slab
7a	"	10.0 + 10.0 + 10.0	3.00	"
5	Phrakhanong	12.30 + 12.30 + 12.30	7.00	RC
5	"	12.20 + 16.00 + 12.20	3.60	RC

With reference to the above table, and with due consideration for the conditions of the site of proposed bridge, the dimensions of the proposed bridges for the Ring Road are decided as follows:

Unit : m

Section	Name of Khlong	Span Division	Clear-ance	Type of Superstructure
6	Bang Sue	20.0 + 20.0 + 20.0	3.60	PC
7a	Prem Prachakon	16.0 + 16.0 + 16.0	5.00	PC
7a	Prapa	10.0 + 10.0 + 10.0	3.00	RC
7a	Bangkhen Mai	10.0 + 10.0 + 10.0	3.00	RC
7a	Bangkok Noi	20.0 + 20.0 + 20.0	5.00	PC
7a	Mon	10.0 + 10.0 + 10.0	3.00	RC
5	Phrakhanong	20.00 + 20.00 + 20.00	3.60	PC hollow girder

(2) Type of Substructure

(a) New Rama VI Bridge

As no detailed soil survey was carried out at the proposed site of the New Rama VI Bridge, data of the soil profile was not available, and in this study, a deduction was made from the soil profile of four other existing bridges across the Chao Phraya River. From these data, it is found that the four existing bridges are supporting on the 'stiff brown-gray clay with laterite stratum' at a depth of 20 - 24 m, and that the soil profiles are similar in all cases. (Fig. 5-15) It can be deduced therefore that the soil profile at New Rama VI Bridge site will also be of similar formation.

However, the report on the Memorial Bridge (T. P. O-Sullivan 1971), states that scouring is found due to meandering of the river, and that a founding level of -29.700 m M. S. L. was indicated. The river shows the same meandering about 500 m upstream of the proposed site, and the possibility of scouring on the right bank cannot be ignored. In this study, we have therefore planned the supporting stratum at the "sandy clay, course sand' layer at around -30.0 m M. S. L. Confirmation of this assumption at the design stage through detail soil investigation is of course necessary.

For the study on the substructure of the New Rama VI Bridge, studies are made for the two general types of (i) Caisson foundation and (ii) pile foundation.

(i) Caisson foundation

The four existing bridges across the Chao Phraya River (Krung Thep, Krung Thon, Memorial, and Nonthaburi) are all with caisson foundation at a supporting level of about M. S. L. -22.0 m.

The caisson foundation is widely adopted in construction of bridges with great spans for its high stability and high bearing power. On the other hand, the construction cost is high and the construction period required is longer. In the case of the New Rama VI Bridge, where the depth is around 15 - 20 m and the speed of water flow at 1.0 - 2.5 m/sec., there may be problem in construction whether with build-island method or floating method. Also, with the supporting stratum at below M. S. L. -30 m, there may be difficulties sinking the caisson through the stiff clay layer. (at M. S. L. -22 - -27 m).

(ii) Pile foundation

Pile foundation may be classified into cast-in-place large diameter reinforced concrete pile and large diameter steel piles. The use of steel piles will incur the problem of availability of the material. In this study, consideration is made of only the cast-in-place reinforced concrete pile.

From the condition of the construction site, availability of equipments, construction cost, and length of piles required, it is considered that the reverse circulation drill construction method is most desirable. This method is also adopted in the construction work of the Tachang Bridge with success. The reverse circulation drill method multi-pile type, with diameter of pile of 1.5 m, is therefore recommended for adoption for the New Rama VI Bridge. The allowable bearing power for a 1.5 m diameter pile will be 430 tons/pile.

(b) Substructure for elevated sections and for bridges over khlongs.

Rigid frame pier is adopted as the substructure for the elevated section of Ring Road, using reinforced concrete pile or prestressed concrete pile as foundation pile. For the bridges over khlongs, the pile-bed type pier is adopted, whereby the substructure is unified with the foundation pile. The pile used will be reinforced concrete pile. The dimension of piles are as follows.

Type of pile	Dimension	Bearing power (ton/pile)
Reinforced concrete pile	25 cm x 25 cm	20
"	35 cm x 35 cm	45
Prestressed concrete pile	35 cm x 35 cm	60
"	40 cm octagonal	70

(length of above piles = 20 - 24 m)

7-9 Estimation of Construction Cost

7-9-1 Conditions for the estimation of construction cost.

The estimation of construction is carried out under the following conditions.

(1) The estimation is made at 1975 value, with an assumption of increase in labour and material cost from the present level at 3.5 % per annum.

(2) The unit cost also includes the following items.

(a)	Overhead cost for contractor	20 %
(b)	Cost of temporary road, lighting, pedestrian bridge, repairs of existing facilities, insurance, etc.	10 %
(c)	Cost of design, survey and supervision	10 %
(d)	Contingency	10 %

7-9-2 Unit cost

The unit cost used in estimation are as follows.

(1) Earth work

(a)	Ring Road :	Service road	20,000 baht/m
		Main roadway	18,000 baht/m
(b)	Section 5 :	Service road	19,500 baht/m
		Main roadway	48,700 baht/m

(2) Bridge

(a)	Reinforced concrete slab bridge (10 m span)	3,500 baht/m
(b)	Prestressed concrete bridge (20 m span)	5,800 baht/m
(c)	New Rama VI Bridge	19,600 baht/m

Details of Unit Cost for Earth Works & Road Works

	Item	Unit	Unit Cost (baht)
1.	Clearing & Grubbing	m^2	3
2.	Excavation	m^3	32
3.	Embankment	m^3	77
4.	Drainage A (cross pipe)	m	660
5.	Drainage B (∅ 100)	m	1,500
6.	Asphalt Surfacing	m^2	35
7.	Asphalt Binder Course	m^2	50
8.	Asphalt Stabilized Base	m^2	97
9.	Sub-base Course	m^2	36
10.	Curb Stone	m	170
11.	Guard Rail	m	400
12.	Main Strip	m	400
13.	Side Strip	m	350
14.	Pedestrain Walkway	m	250

Details of Unit Cost for Grade Separation Structures

	Item	Unit	Unit Cost (baht)
	SUPEP-STRUCTURE		
1.	Class A Concrete	m^3	810
2.	Class B Concrete	m^3	520
3.	Form Work	m^2	200
4.	Falsework	m^2	98
5.	P. C. Cable 12.7 mm	ton	53,000
6.	Reinforcing Bar	ton	6,400
7.	Bearing	each	600
8.	Erection of Girders	ton	812
9.	Drainage	each	150
10.	Expansion Joint	m	3,510
11.	Curb	m	630
12.	Pavement	ton	330
	SUB-STRUCTURE		
13.	Class C Concrete	m^3	930
14.	Form Work	m^2	220
15.	Falsework	each	50,000
16.	Reinforcing Bar	ton	9,000
17.	P. C. Pile	each	8,860
18.	Excavation and Backfill	m^3	100
19.	Load Testpiece Pile	each	35,000

Estimation of Construction Cost

Ring Road Part II, Case 1 L = 26.69 Km | Ring Road Part II, Case 2A L=27.59 Km | Thousand bahts

	Case 1: Section A Petchaburi - Superhighway	Case 1: Section B Superhighway - Pracharat Road	Case 1: Section C Pracharat Road - Tachang Ext.	Case 1: Section D Tachang Ext. - Phetkasem	Case 1: Total	Case 2A: Section A Petchaburi - Superhighway	Case 2A: Section B Superhighway - Pracharat Road	Case 2A: Section C Pracharat Road - Tachang Ext.	Case 2A: Section D Tachang Ext. - Phetkasem	Case 2A: Total
Land Acquisition	217,775	136,275	125,200	77,920	557,170	271,600	129,200	125,200	77,920	603,920
Demolition	2,400	35,250	22,400	24,000	84,050	25,000	18,000	22,400	24,000	89,400
Viaduct (1) Main Rd.	166,896	300,139	440,689	270,180	1,177,904	158,688	270,864	440,689	270,180	1,140,421
Viaduct (2) Service Rd	17,192	59,173	8,596	29,226	114,187	17,192	59,346	8,596	29,226	114,360
Roadway (1) Main Road	115,110	40,698	100,620	75,150	331,578	128,520	48,420	100,620	75,150	352,710
Roadway (2) Service Rd.	170,300	79,100	146,200	113,400	509,000	182,920	84,480	146,200	113,400	527,000
Interchange	-	30,000	-	-	30,000	-	30,500	-	-	30,500
Sub-total	689,673	680,635	843,705	589,876	2,803,889	783,920	640,810	843,705	589,876	2,858,311
Cost for Railway	268,800	99,360	-	-	368,160	57,600	86,400	-	-	144,000
Total	958,473	779,995	843,705	589,876	3,172,049	841,520	727,210	843,705	589,876	3,002,311

Estimation of Construction Cost

Ring Road Part II, Case 2B L = 26.84 Km | Ring Road Part II, Case 3 L = 26.69 Km | Thousand bahts

	Case 2B: Section A Petchaburi - Superhighway	Case 2B: Section B Superhighway - Pracharat Road	Case 2B: Section C Pracharat Road - Tachang Ext.	Case 2B: Section D Tachang Ext. - Phetkasem	Case 2B: Total	Case 3: Section A Petchaburi -	Case 3: Section B Superhighway - Pracharat Road	Case 3: Section C Pracharat Road - Tachang Ext.	Case 3: Section D Tachang Ext. - Phetkasem	Case 3: Total
Land Acquisition	266,800	119,600	125,200	77,920	589,520	259,200	129,000	125,200	77,920	591,320
Demolition	37,000	25,800	22,400	24,000	109,200	61,400	59,250	22,400	24,000	167,050
Viaduct (1) Main Rd.	240,768	300,960	440,689	270,180	1,252,597	166,896	300,139	440,689	270,180	1,177,904
Viaduct (2) Service Rd	17,192	59,346	8,596	29,226	114,360	17,192	59,346	8,596	29,226	114,360
Roadway (1) Main Road	111,060	37,620	100,620	75,150	324,450	115,110	40,698	100,620	75,150	3 331,578
Roadway (2) Service Rd.	176,600	75,800	146,200	113,400	512,000	170,300	79,100	146,200	113,400	509,000
Interchange	–	31,000	–	–	31,000	–	30,000	–	–	30,000
Sub total	849,420	650,126	843,705	589,876	2,933,127	790,098	697,533	843,705	589,876	2,921,212
Cost for Railway	57,600	86,400	–	–	144,000	57,600	105,600	–	–	163,200
Total	907,020	736,526	843,705	589,876	3,077,127	847,698	803,133	843,705	589,876	3,084,412

Estimation of Construction Cost

Section 5 L = 7.06 Km. (thousand bahts)

	Case 1	Case 2	Case 3	Case 4
Land Acquisition	430,800	107,800	206,100	72,500
Demolition	398,000	70,000	365,000	122,000
Viaduct (1) Main Rd.	292,975	224,575	251,935	292,975
Viaduct (2) Service Rd.	26,525	26,525	26,525	26,525
Roadway (1) Main Road	81,800	161,400	87,200	90,800
Roadway (2) Service Rd.	199,500	154,200	135,500	140,500
Railway Line Diversion	—	—	—	22,500
Sub Total	1,429,600	744,500	1,072,260	767,800
Interchange (Direct Junction)	347,500	345,000	345,000	378,000
Total	1,777,100	1,089,500	1,417,260	1,145,800