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THE KINGDOM OF THAILAND

The Feasibility Study on

THE RAMA VI BRIDGE CONSTRUCTION PROJECT

FINAL REPORT IN PHASE I

DECEMBER 1981

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Kingdom of Thailand, the Government of Japan decided to conduct a feasibility study on the RAMA VI Bridge Construction Project and entrusted it to the Japan International Cooperation Agency (JICA). The JICA sent to Thailand a preliminary survey team headed by Dr. Hirohiko Tada in March, 1981 and a further survey team headed by Mr. Terukazu Endo in June, 1981.

The team exchanged views with the officials concerned of the Government of Thailand over the project and conducted field survey in Thailand.

The study consists of two phases: Phase I (Feasibility Study for Rama VI Bridge) and Phase II (Preliminary Design for Rama VI Bridge).

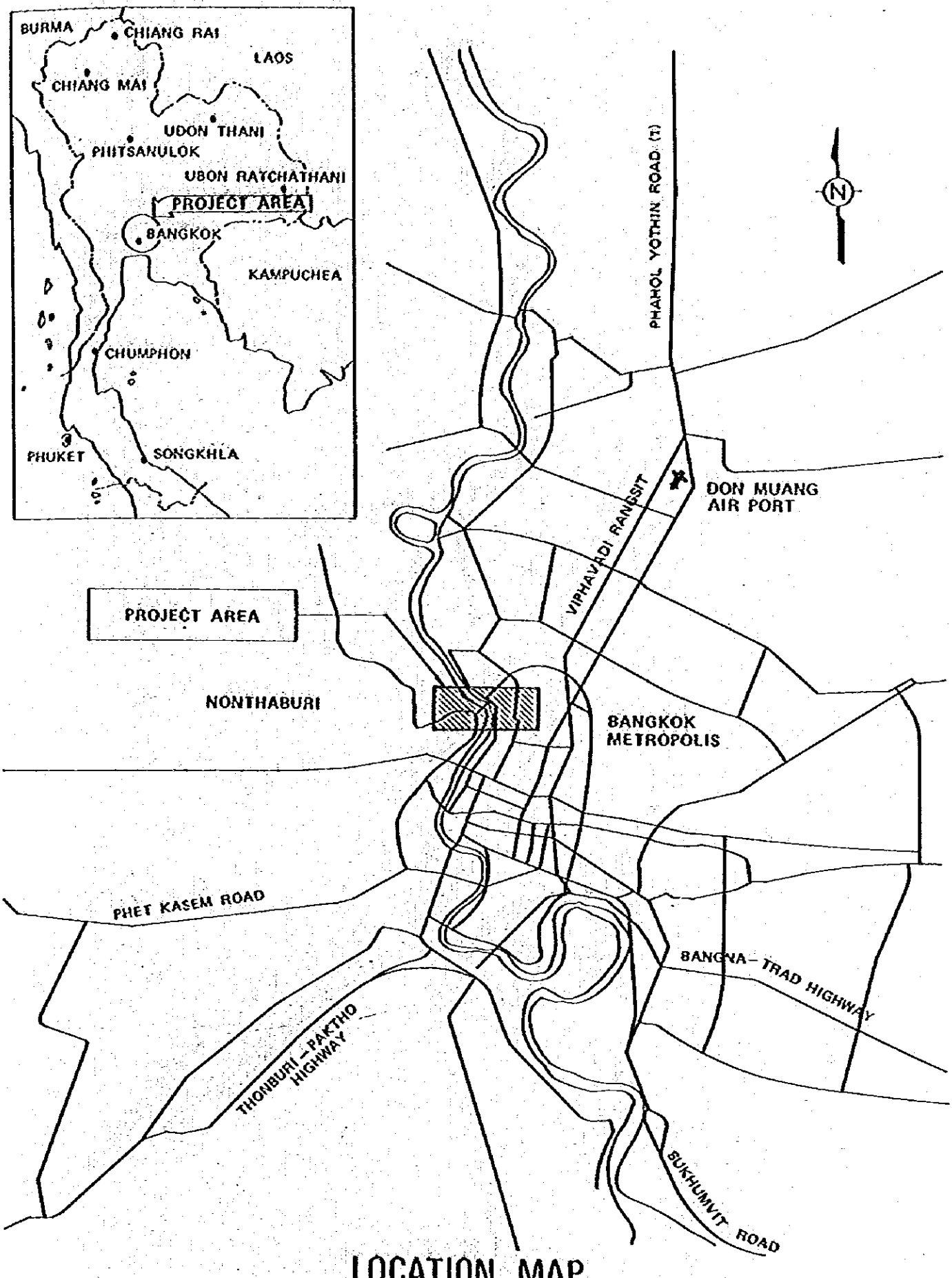
This report has been prepared as the final report for Phase I of the study and the Phase II study is continuing at present on the basis of results of this report.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

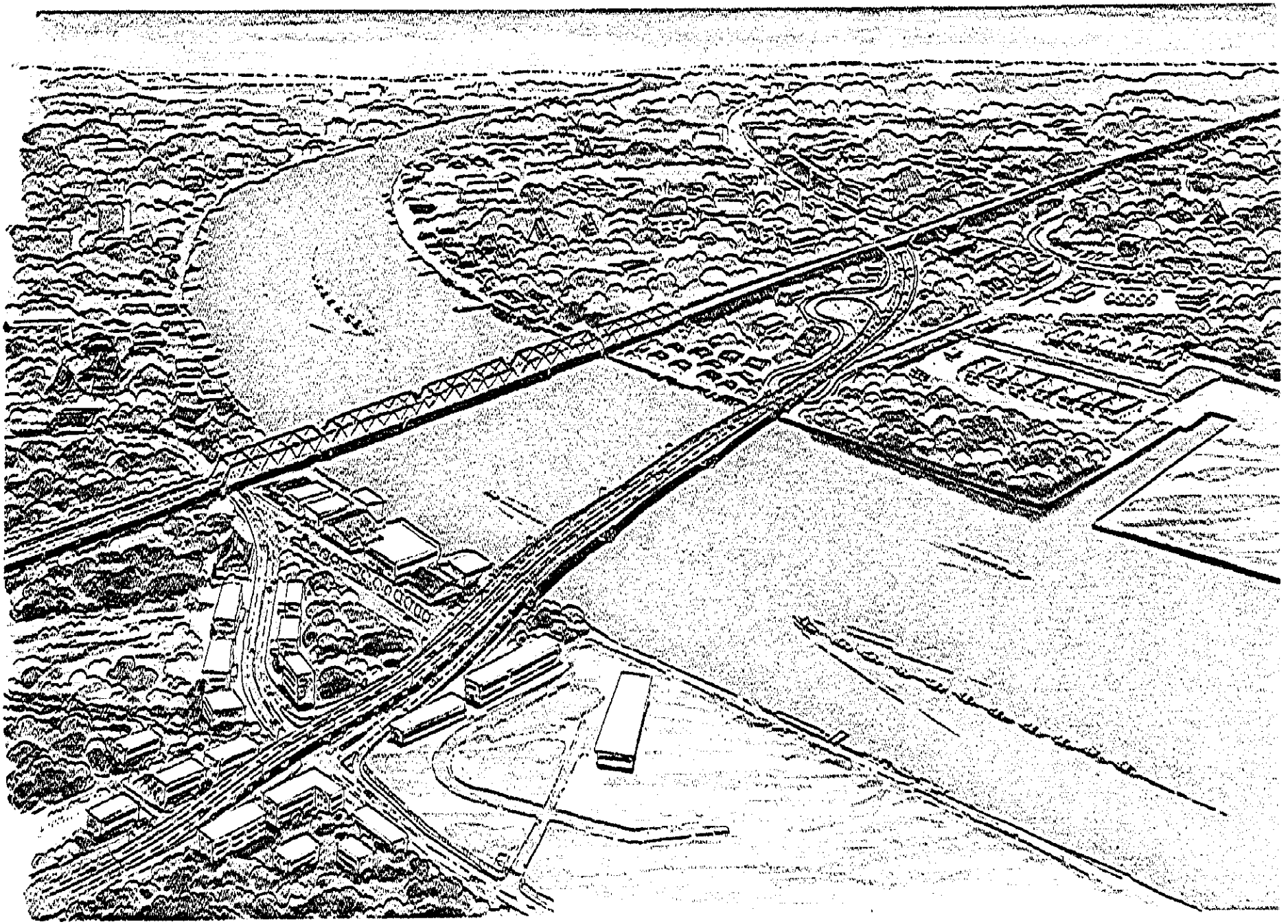
I wish to express my deep appreciation to the officials concerned of the Government of Thailand for their close cooperation extended to the team.

December, 1981

Keisuke Arita
President
Japan International Cooperation Agency



LOCATION MAP



PERSPECTIVE VIEW OF NEW RAMA VI BRIDGE

ABBREVIATION

GOVERNMENT OFFICE :

BMA	Bangkok Metropolitan Administration
DOH	Department of Highway, Ministry of Communications
DTCP	Department of Town and Country Planning, Ministry of Interior
DTEC	Department of Technical and Economic Cooperation, Office of The Prime Minister
EGAT	Electricity Generating Authority of Thailand
HD	Harbour Department, Ministry of Communications
JICA	Japan International Cooperation Agency
NESDB	The National Economic and Social Development Board
OECF	The Overseas Economic Cooperation Fund (Japan)
PAT	The Port Authority of Thailand.
PWD	Department of Public Works, Ministry of Interior
RID	Royal Irrigation Department, Ministry of Agriculture and Cooperatives
RTASD	Royal Thai Armed forces Survey Department, Ministry of Defence
SRT	The State Railway of Thailand
ADB	Asian Development Bank
ESCAP	Economic and Social Commission for Asia and the Pacific, United Nation
IBRD	International Bank for Reconstruction and Development
IDCJ	International Development Center of Japan
JARTS	Japan Railway Technical Service

ECONOMICS

IRR	Internal Rate of Return
NPV	Net Present Value

TRAFFIC

ADT	Average Daily Traffic
GBA	Greater Bangkok Area
MRR	Middle Ring Road
MRT	Mass Rapid Transit
BT STUDY	The Comprehensive Study for Bangkok Suburban Transportation Project
NPB STUDY	Feasibility Study of the Nonthaburi and Pathumthani Bridge Construction Project
ORR STUDY	Feasibility Study for the Outer Bangkok Ring Road

ENGINEERINGS

AASHTO	American Association of State Highway and Transportation Officials
BS	British Standard
DWT	Dead Weight Tonnage
GL	Ground Level
MSL	Mean Sea Level
HWL	High Water Level

SUMMARY

1. Feasibility of the Project

The construction of the New RAMA VI Bridge in the vicinity of the existing RAMA VI Bridge is highly necessary and technically feasible in a total construction time of 3 years including land acquisition. The total construction period of 3 years has been so decided as to attain the maximum IRR value. Furthermore, in this project, this 3 year time nicely conforms with the most economical construction schedule which attains the minimum construction cost.

The total project cost has been estimated to approximately 800 million Baht financial term in mid 1981 price for the proposed six-lane bridge with its approach viaducts and appropriate improvements of intersections.

The total project cost has been divided into 39% of the foreign currency portion and 50% of domestic currency portion. The remaining 11% has been absorbed into local tax portion. Foreign currency portion of the cost excluding land acquisition and compensation amounts to approximately 50%.

The benefits in this analysis are mainly estimated with the loss accruing from the difficulty to maintain the design service level, due to the traffic of A.D.T. 22,600 and daily distribution of its traffic, and the difference in V.O.C. and traveling time, between in case to use present bridge and in case to use other bridges and detour pass, due to over flow of traffic.

The Internal Rate of Return (IRR) of the entire project for a 30 year project life period has been calculated to 20.3% which is substantial in excess of the figure of 12% assumed to be the opportunity cost of public capital in Thailand.

IRR is calculated, based on the clearly quantified items only, therefore, if the benefits accruing from economic impact on the zone of influence by the New Bridge Project and the level up of service level on other bridges, due to the diversion of the traffic to the New RAMA VI Bridge were included,

the index would become much higher.

The Net Present Value (NPV) which is the difference between the discounted benefits and discounted costs has been assessed to approximately 647 million Baht, positive by wide margin and indicates that the project is highly viable.

2. Traffic Forecast

The traffic of the Present RAMA VI Bridge is A.D.T. 22,600 which already exceeds considerably the design service level.

The location of the proposed bridge constitutes one of the most important portions of the Middle Ring Road (MRR), namely, a crossing on the Chao Phraya River. The MRR plays a vital role of a circumferential urban highway in the Greater Bangkok Metropolitan Area and its completion is expected in the middle of 1983 for the total length of 48 Kilometers.

The MRR has been mainly designed as 8-lane arterial highway for its eastern and southern sections and the former section has been already opened for public use on 26 August 1981.

The remaining western section, Charansanitwong Road, has been in use as six-lane highway. Another ring road called the Outer Ring Road (ORR) has been planned and in the designing stage, and on its completion sometime around 1990, it will affect substantially to the traffic of the MRR.

The traffic forecast for the New RAMA VI Bridge, therefore, will vary widely according to the availability of the ORR in a specific forecast year.

Analyzed at chapter 3, the growth of traffic in Thailand would continue 6.3 % until next decade as forecasting 9.3 % nominal economic growth and 0.68 elasticity of traffic growth to nominal economic growth.

Furthermore, the population growth in the zones alongside of MRR as analyzed in Chapter 5, which is the key factor to describe the traffic growth is estimated much higher than the nation's avarage.

Assuming the whole system of the ORR would be completed in sometime between 1985 and 1995, the traffic forecast of the New RAMA VI Bridge can be anticipated as follows:

Year	Traffic excluding motorcycles (veh/day)	
	W/O ORR	W/ORR
1985	52,800	-
1990	69,200	55,600
2000	-	88,700

Since design traffic capacities for a bridge on the Chao Phraya River is calculated as 52,000 veh/day for a 4-lane bridge and 78,000 veh/day for a 6-lane bridge, the above figures indicate that the traffic of the New RAMA VI Bridge will reach at its 4-lane design capacity as earlier as in 1985.

In view of rapid increase of traffic after 1985, it has been considered that a 4-lane bridge is not sufficient enough. Nevertheless, in case of an earlier completion of the ORR, a 4-lane bridge could be utilized until 1990.

In 2000, however, the RAMA VI Bridge traffic will exceed its 6-lane design capacity and almost reach at its critical traffic capacity.

After studying possibility of stage construction of a 4-lane bridge, it has been concluded that a six-lane dual carriageway bridge could be regarded as the most appropriate and economical solution and has been adopted for the design of the New RAMA VI Bridge.

3. Selection of Route and Alignment

The alignment of connecting roads and the location of the bridge site have been investigated using 1/6600 aerial photographs for several alternatives.

A comprehensive comparison list has been prepared as regards with the selected alternatives which have been remained through first steps of sieving and after discussing with the PWD, the only two Alternatives of II and III, the both of which being a North Route, have been selected for further detail review.

Although Alternative II has some advantages as regards with its shorter traveling distance for traffic users and an advantageous traffic treatment at each intersection, more land acquisition including lumber yards and freight railway extension and also engineering difficulties involved in drainage and the railway viaduct have all been considered fatal enough to discard Alternative II.

Taking all factors into considerations, Alternative III has been basically considered to be the most attractive and practical alignment for the new bridge route.

The alignment of the Alternative III has a straight line for the Main Bridge and, on the Bangkok side, the main roadway has gone over the Phibul Songkhram - Wongsawang Intersection by a flyover viaduct.

The very short distance between the eastern end of the main bridge and the Pibul-Wongsawang Intersection has caused a difficult engineering problem. In order to descend to the intersection at a smooth gradient, widening of the bridge is necessary to provide an auxiliary deceleration lane.

On the other side an acceleration lane has to be provided on the bridge for ascending traffic.

Since the flyover goes through a busy commercial area, various engineering techniques have been applied in order to attain a good appearance as not to give unpleasantness to the inhabitants and users in the area.

On the Thonburi side, the route has been designed originally to have a large radius of curvature of 300 meters and two intersections-at-grade.

In response with the comment made to the effect that a more smooth traffic flow in Thonburi Side would be more favorable for the future traffic users by the Thai Committee on 4 September 1981 an improved plan for the Thonburi Intersection is being prepared in the stage of preliminary design (Phase II) of the present study.

4. Design of Bridge and Roads

Criteria

For the design of the approach roads, current Department of Highways and AASHTO standards have been adopted.

For the bridge, the Standard Specification of Highway Bridges of AASHTO has been used and in compliance with the actual traffic involving those of heavy trucks in the Study Area, the British Standard of BS 5400 has been adopted for live load instead of AASHTO. The number of units of H.B. loading is 45 as specified in BS 5400. A collision impact of 500 ton and a stream current velocity of 3 meters/sec are also taken into calculations.

Span Arrangement

The total length of the main bridge has been decided to be 290 meters and, on the previously selected alignment, there is no other way but the horizontal alignment of the proposed bridge being askew and also not parallel with the existing RAMA VI Bridge.

As the location of the both bridges comes upon a curved section of the River, navigational tails of long convoys of barges dragged by a tugboat would not coincide with the center stream line. Hence, a horizontal clearance of 70 meters, instead of the 60 meter minimum requirement, has been considered necessary. With the total length of 290 meters and a navigational clearance of 70 meters as the design condition, only three alternatives in term of span arrangement have been conceived for design of a prestressed concrete bridge.

Alt. 1	290 m = 44 + 61 + 80 + 61 + 44	5 Spans
Alt. 2	290 m = 60 + 85 + 85 + 60	4 Spans
Alt. 3	290 m = 85 + 120 + 85	3 Spans

Alternative 2 has been simply discarded due to its defect for navigational difficulties for a long convoy of barges.

After Alternative 2 and 3 have been studied in full details comparing overall engineering factors including costs, Alternative 3 has been adopted as a more preferable solution because of its aesthetical and navigational advantages in spite of its slightly higher construction cost, since the present RAMA VI Bridge also has 3 spans in the river.

Structural Type

In the case of prestresed concrete bridge with a span length of up to 150-160 meters, it is generally admitted that a box-girder bridge type by cantilevering method is superior due to lower cost and simpler construction.

In this project, a bridge type having shallower girder depth has been considered as a more attractive design, because, with thinner girder, it is also possible to built shorter rampways and also to lessen vertical gradient of ramps, thus achieving lower cost and improving vertical alignment for rampsways as well.

Also in designing the proposed bridge, restrictions have been caused from the critical clearance for the underpassing railway viaduct and also the necessary clearance for the two klongs on Thonburi side.

The two structural types, namely, a cable-staged concrete girder bridge and a concrete sail bridge have been added for study as possible alternatives.

The results of a detailed comparison study have shown that construction cost for each type of three different types of bridge only slightly differs in the approximate amount of 800 million baht, and advantages and disadvantages for each type also equals in an overall evaluation.

The concrete sail type has first been rejected due to its peculier shape and unpleasant impacts for drivers in spite of its low cost.

On 4 September 1981, at the meeting with the Thai Committee, The JICA Committee and the Study Team recommended the Box-girder Cantilevering Type and the Cable-stayed Type in their order as the two preferable alternatives and has left the decision to the hand of PWD for further review.

The most important reason for recommending the conventional Box Girder Type Bridge has been the asymmetrical cross section

of the Bridge in the Bangkok side span caused by installation of speed changing lanes on the both roadways, because the Cable-stayed Type Bridge has not been regarded as a preferable solution for an asymmetrical width of a bridge.

The final decision was thus made in the letter of intent on 1st October 1981 by the PWD to the effect that the PWD considered the Box-girder Cantilevering Bridge Type as the most favorable type and that the special considerations should be placed concerning the appearance of the bridge.

Substructures

In-situ concrete piles using reverse circulation drilling method has been adopted for foundation structure as has been practiced in similar cases of bridges on the Chao Phraya River.

Approach viaduct and Flyover

On Bangkok side, an approach viaduct has been designed as a flyover at the Pubul Songkhram - Wongsawang Intersection. To attain slender piers at longer spacings, a one-leg mush-room type prestressed concrete structure has been adopted for the flyover section.

For the other section of viaduct, reinforced concrete voided slab having span length of 16-18 meters has been designed.

Railway viaduct

The alignment for the bridge has involved construction of a difficult case of a railway viaduct on Thonburi side. As the difference in elevation between railway and roadway is very small and to attain necessary vertical clearance for roadway, the viaduct has to be a through-type railway bridge which is far more expensive than a simpler deck type bridge.

Although, at the time of study, the plan for double track

improvement of the exsisting railway by the SRT has not been determined definitely, a single track railway viaduct has been designed in the present stage of the Study.

5. Construction Method and Schedule

For this project, a conventional cast-in-situ method for prestressed concrete girder bridges has been adopted in the design, partly due to the asymmetrical cross-section on the Bangkok side span.

The method has been practiced in many cases of bridge construction in Thailand and has been regarded as most reliable and economical on account of availability of materials and equipment.

The necessary construction time for the bridge has been estimated to two and half (2 1/2) years after the notice to proceed.

Assuming land acquisition would take one year and could be overlapped by six-months to construction time of the bridge, the total construction time for the project will be three (3) years.

6. Preliminary Design (Phase II)

The present report comprises only the Phase I of the present study. The Preliminary Design (Phase II) for this study has been carried out since September 1981. Based on revised construction costs obtained in the Phase II Study, the economic evaluation has been reassessed and a Budgetal and Financial Studies combined with an Implementation Program will be prepared in the beginning of December 1981 and be submitted to the PWD.

Revised figures are as follows:

Total Project Financial Cost .... 781.9 M฿,mid 1981 price
Net Present Value .....659.7 M฿,mid 1981 price
Internal Rate of Return ..... 20.6 %

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CHAPTER 1
INTRODUCTION

CHAPTER 1 INTRODUCTION

1-1 BACKGROUND

Population and economic activities in the Kingdom of Thailand have been extremely concentrated in its primary city, Bangkok. The speed of its growth is among the highest in South Asian countries and causes many difficulties in every aspect of city administrations, with traffic congestion in the central districts of the city being one of the most serious problems.

In order to cope with rapidly deteriorating highway traffic conditions in urban area, the Government of Thailand has implemented every possible counter-measure. As early as 1971 the Government had set forth the construction of the Middle Ring Road. Furthermore a system of urban expressway and an elevated rapid transit system are under construction and, for improvement of across-Chao-Phraya-River traffic, constructions of Sathorn Bridge and New Memorial Bridge had also been started.

Meanwhile, all of the existing bridges with only the exception of Phra Pin Klao Bridge, have been becoming obsolete and are dangerously lacking in their traffic capacities.

Around the northern section of the Middle Ring Road, where the existing RAMA VI Bridge is located, rush-hour traffic congestion is most serious because the bridge has only two carriageways accompanied by one single railway track. Under such circumstances, the Public Works Department has contemplated the possibility of a new bridge construction or improvement of the existing RAMA VI Bridge.

In July, 1980, the Government of Thailand made a request to the Government of Japan to conduct a feasibility study on the RAMA VI Bridge construction project including;

1) A feasibility study on higher rehabilitation or new bridge construction in the vicinity of the existing RAMA VI Bridge.

2) A further study on either rehabilitation or new bridge construction for the section of Chao Phraya River between Nonthaburi and Samuthprakan.

In response to the above request, the Government of Japan decided to cooperate with the Government of Thailand in the carrying out of the said study, and the Japan International Cooperation Agency (hereinafter referred to as JICA), the official agency responsible for implementing the technical cooperation programs of the Japanese Government, dispatched a fact-finding mission headed by Dr. H. Tada, to Thailand in March, 1981, to make a preliminary survey and to formulate the scope of work for the study.

An agreement was set forth in accordance with the result of the study and feasibility study, for the construction of New RAMA VI Bridge including its appropriate approaches and connecting roads, was to be conducted in Bangkok during the period of eleven months starting in May, 1981.

The study for the RAMA VI Bridge consists of the two phases; Phase I will be executed as a Feasibility Study during the first three months and Phase II as a Preliminary Design of the new bridge for the consecutive three months.

The Draft Final Report of the Feasibility Study (Phase I) of the RAMA VI Bridge has been submitted to the PWD on 4 September 1981.

The Record of Discussions was exchanged on 7 September 1981 between the JICA Supervisory Committee team and the PWD to the effect that the PWD has agreed to regard the route Alignment III as the most favorable route provided that minor alterations or improvements on the design should be applied in order to eliminate the intersections-at-grade on Thonburi side.

Also on the matter of structural type of the main bridge the PWD had chosen the two bridge types of Box Girder Cantilevering Type and Prestressed Concrete Cable-stayed Type for further review.

Finally on 1st October 1981, the PWD has issued the letter of intention to the effect that the PWD considered the Box Girder Cantilevering Type as the most favorable type for the New RAMA VI Bridge with a comment concerning the bridge appearance that it should be well designed and attractive to the public.

This report comprises the Final Report of the Feasibility Study (Phase I) of the RAMA VI Bridge.

The Preliminary Design (Phase II) of the Study is being conducted since September 1981.

Budgetal and Financial Studies and Implementation Program will be included in Phase II and has not been treated in this report.

1-2 OBJECTIVES OF THE STUDY

The objective of the study is to conduct a feasibility study including a preliminary design of a proposed bridge in the vicinity of the existing RAMA VI Bridge. The RAMA VI Bridge constitutes the most important section of the Middle Ring Road, a crossing across the Chao Phraya River. The study area will, therefore include bridge approaches and connecting roads linking the WONGSAWANG intersection on the Bangkok side and CHARAN-SANITWONG ROAD (National Highway No. 306) on the Thonburi side of the river.

The principal objectives of Phase I (Feasibility Study) are as follows, while Phase II of the study (Preliminary Design) will be carried out successively after Phase I of the study.

1) To comment on the strategic impact of the bridge on overall land use and transport network development in the area.

2) To predict future traffic flow on the bridge, investigate the effects of bridge construction on the adjacent road network and determine the required numbers of traffic lane for the new bridge.

3) To determine the best location for the bridge and the most satisfactory arrangements for the bridge and the connecting roads.

4) To determine the optimum method of construction and construction schedules for the bridge and connecting roads.

5) To develop tentative cost estimates for the project

6) To analyse the economic consequences to constructing the bridge.

7) To develop a design and construction program for the bridge.

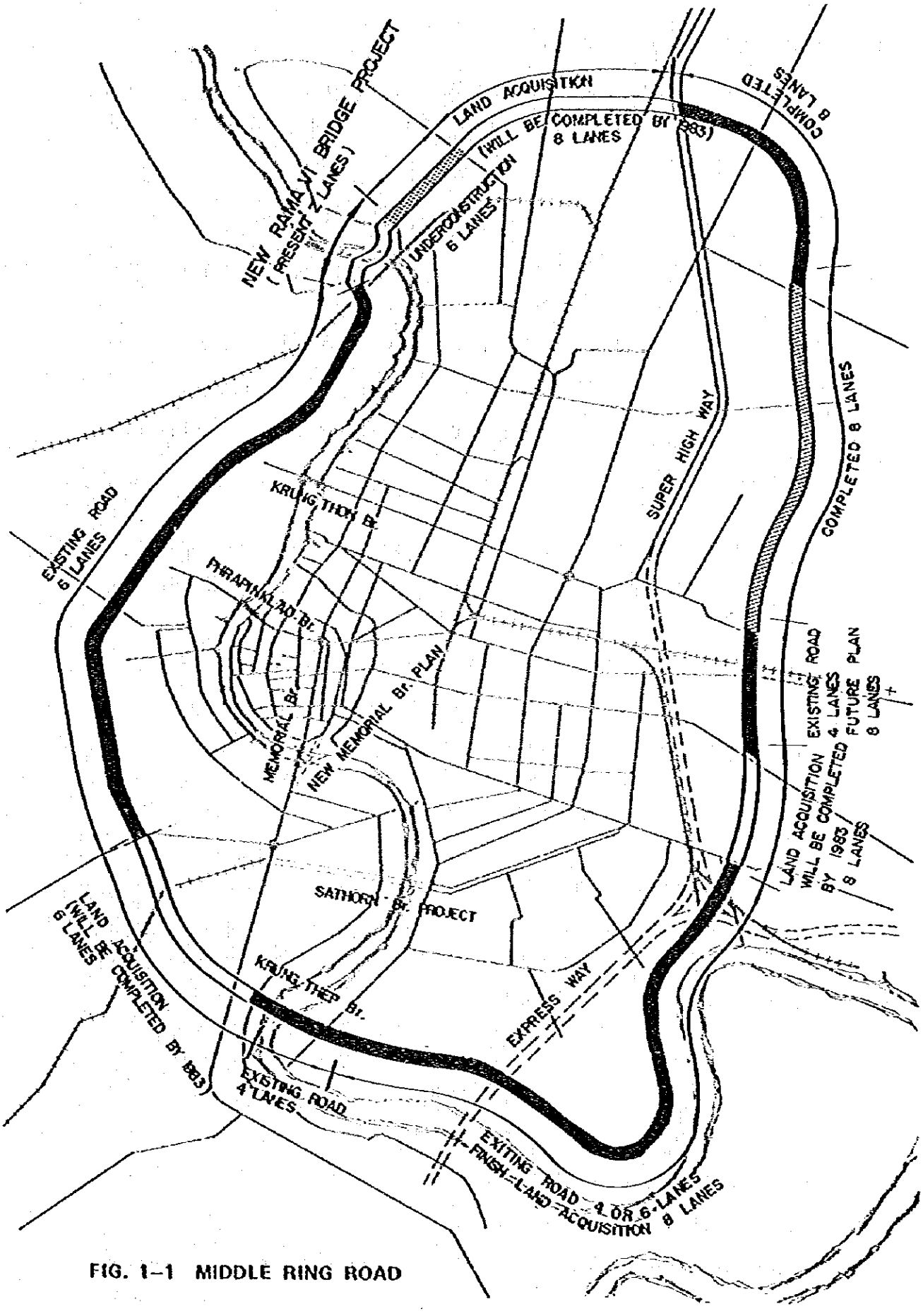


FIG. 1-1 MIDDLE RING ROAD

1-3 THE SCOPE OF THE STUDY

The scope of the study was definitely specified in the agreement concluded on March 16, 1981, between Public Works Department and JICA, as follows:

1.3.1 Traffic and Socio-Economic Studies

The following studies will be carried out in the area related to the RAMA VI Bridge.

1) Traffic Data Collection, Traffic Survey and Analysis.

2) Socio-Economic Data Collection and Analysis.

3) Review of Population and Socio-Economic Conditions.

4) Forecast of Future Traffic Demand.

1.3.2 Engineering Studies

The following studies will be carried out with alternative bridges and approach roads.

1) Engineering Data Collection and Analysis

   a) Soil and Geological Data

   b) Hydrological and Hydrographic Data

   c) Material Data

2) Surveying

   a) Aerial Photograph

   b) Hydrographic Surveying (Cross-Sectional Surveying, etc.)

3) Design Criteria

   a) Geometric Design Standards

   b) Structural Design Standards

4) Engineering Works

   a) Design Works

   b) Quantity Estimation

5) Construction Program

   a) Construction Method

b) Construction Schedule

6) Cost Estimates

a) Right-of-way Acquisition Cost

b) Construction Cost

c) Maintenance Cost

1.3.3 Economic Evaluation

1) Estimates of Benefit

2) Estimates of NPV, IRR, and B/C

3) Sensitivity Analysis

1.3.4. Budgetal and Financial Studies

1.3.5 Implementation Program

1) An implementation program will be prepared based on the construction program and the study of budgetal and financial aspect.

2) Possibility of stage construction.

Among the above-described works, 1.3.4, Budgetal and Financial Studies and 1.3.5, Implementation Program will be carried out in Phase II, and therefore being omitted in this report.

The study team has understood that the above-stated scope of the study constitutes the minimum requirements of the study. Therefore, the study team will carry out all the necessary works to achieve the objectives of the study even for the works not specified in the above-mentioned Scope of the Study.

The conceptual flow of the study is illustrated in Fig. 1.2 showing crucial events together with analytical activities required.

1.3.6 Work Flow of the Study

Fig. 1-4 shows a more detailed schedule of the works and descriptions of each work as a refinement of the previous conceptual flow of the study.

1-4 ORGANIZATION FOR THE STUDY

The study is being carried out by a team of experts selected from Chiyoda Engineering Consultants Co., Ltd. and Japan Oversea Consultants Co., Ltd. under the supervision of the Supervisory Committee, headed by Dr. Hirohiko Tada consisting of Japanese Government officials organized by JICA.

The study team has maintained close collaboration with the counter-part team of engineers organized by the Thai Government.

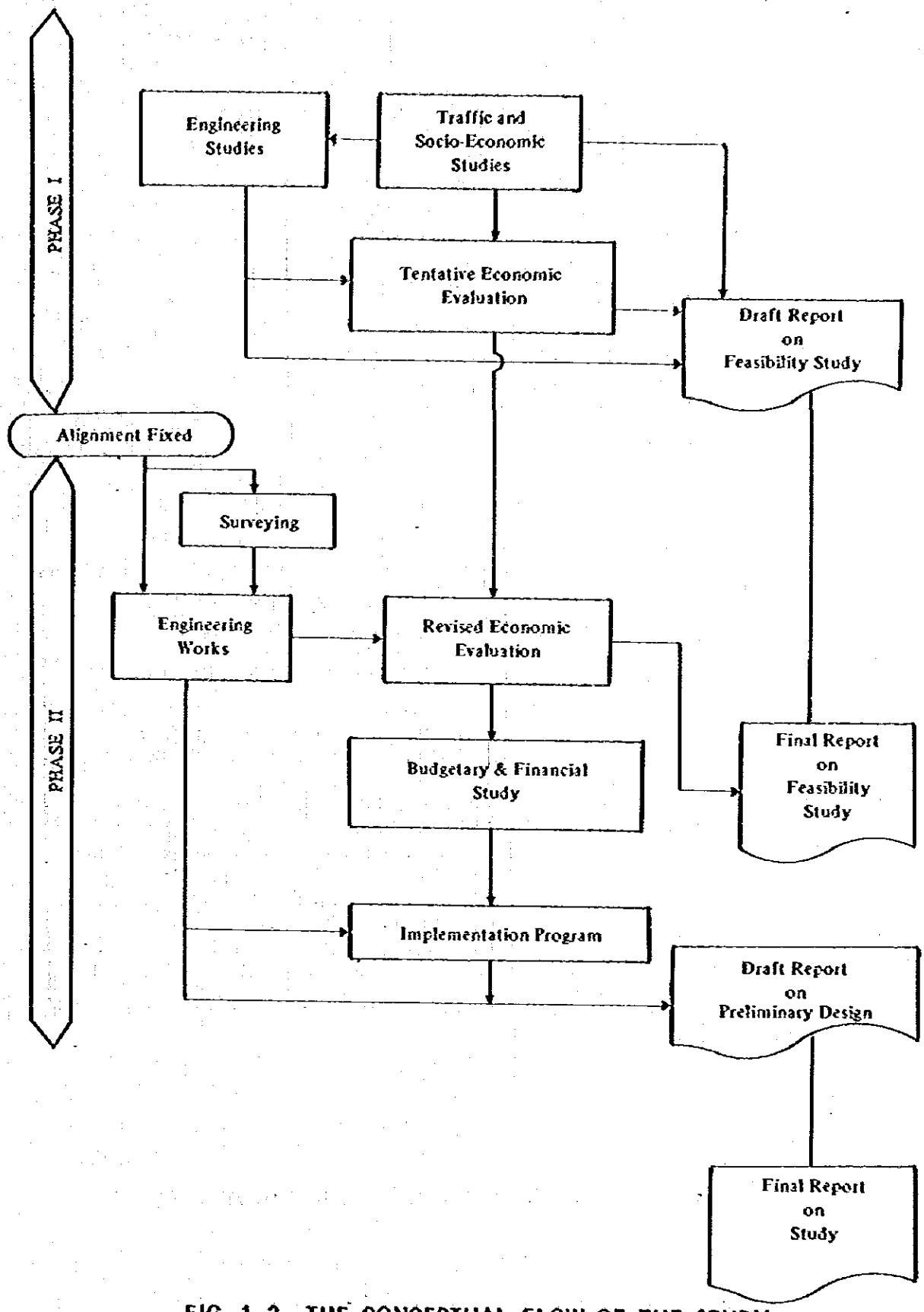


FIG. 1-2 THE CONCEPTUAL FLOW OF THE STUDY

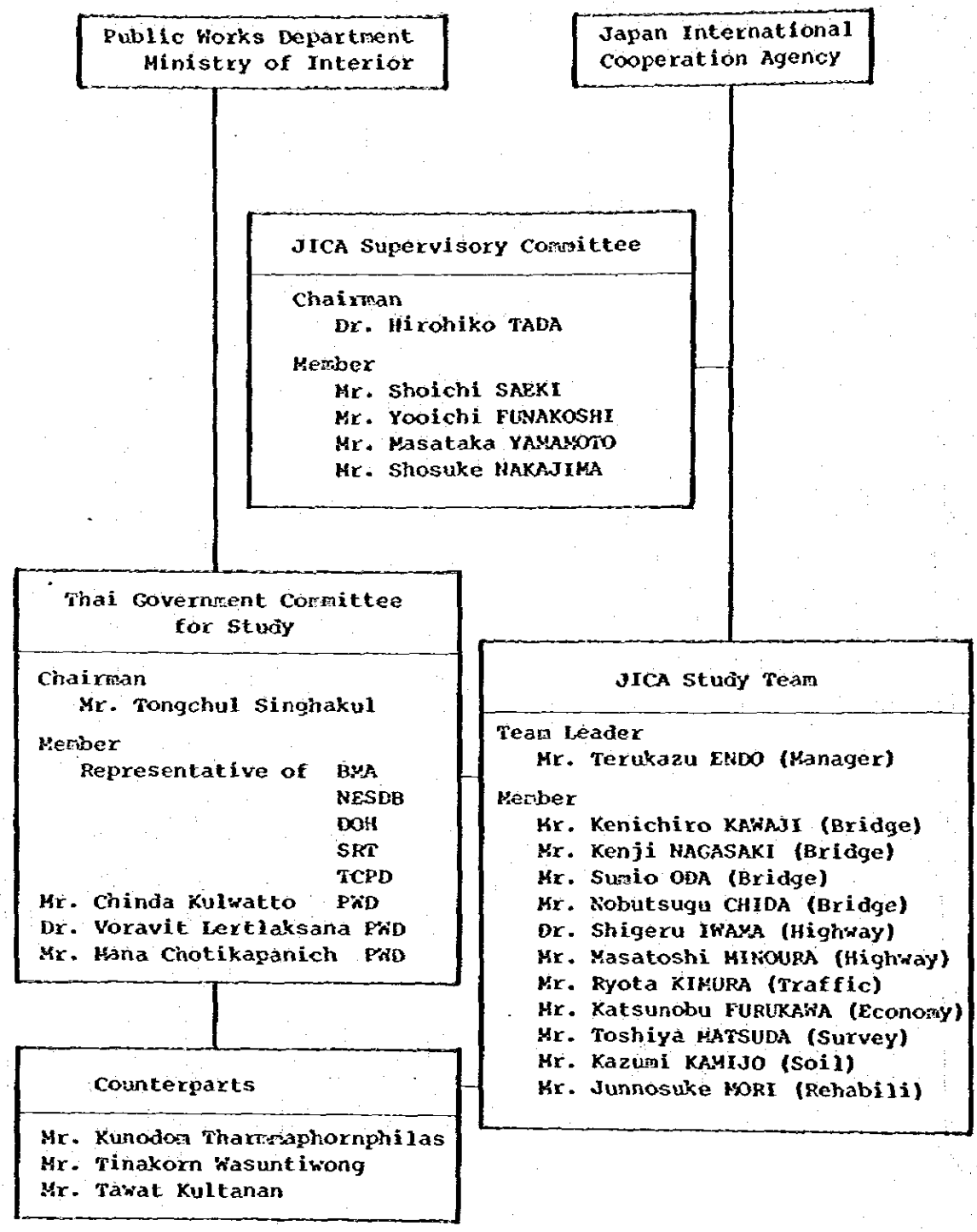


FIG. 1-3 ORGANIZATION OF THE STUDY TEAM

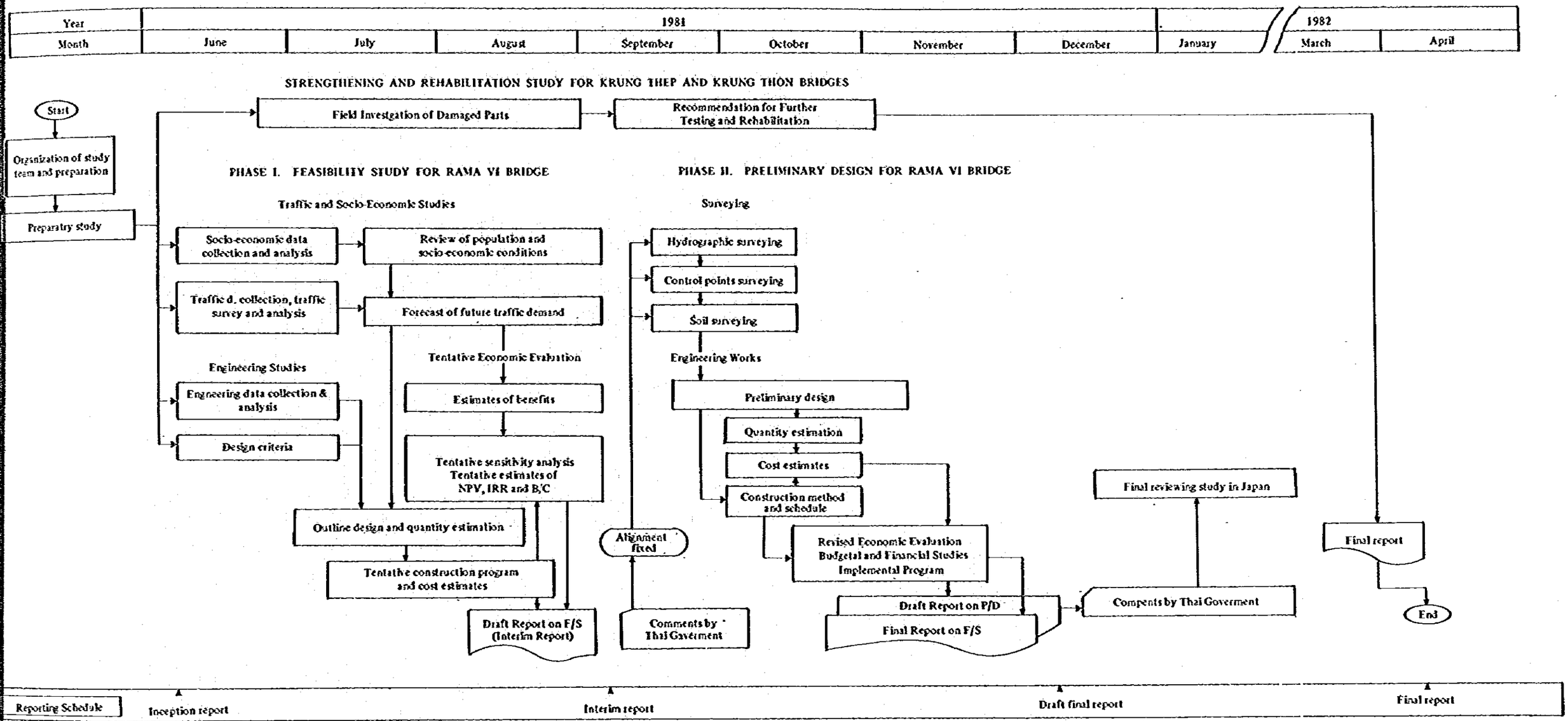


FIG. 1-4 WORK FLOW FOR RAMA VI BRIDGES CONSTRUCTION PROJECT

CHAPTER 2
SOCIO-ECONOMIC STUDY

CHAPTER 2 SOCIO-ECONOMIC STUDY

2-1 GEOGRAPHY

Thailand situated in the central part of Indochinese Peninsula with its border neighbouring with Burma to the North-west and West, with Laos across the Mekong River, with Campuchea to the South-east and finally open into the Bay of Thailand to the South except the part bordering with Malaysia. The area of the land amounts to 513,000 square kilometer equaling 1.4 times of that of Japan.

Population is estimated at 46,113,000 in 1979 with the density of 90/sq.km.

Its climate is typically tropical. The year is divided into the rainy season (May-Nov.) and the dry season (Dec.-April) mainly caused by the change of monsoon direction. The average annual precipitation ranges from 1,300 mm. to 2,200 mm. increasing from the lowest in the North towards the highest in the South. The average annual temperature varies in the high range of 25-30 degrees.

Topographically, in the western region of Thailand, there exists the Indochiness Mountain Range which is an extension of the Great Himalayas and runs into the southern peninsula region. In the central region of the country, flows the Menam (mother of water, hence "River") Chao Phraya running the distance of 1,200 km. from north to south, shaping the great alluvial plain which also serves as the most important crop producing regions of the land. In the north-eastern part of Thailand, there develops the Korat highland.

Provided with its fertile soil and abundant rainfall the whole area of the country is covered with variety of floras, and its alluvial plain has been developed and utilized mostly as farmland. Rice consists of not only the staple food for the natives but also is abundant enough to be ranked as the top export commodity followed by rubber, sugar and tapioca

thus placing agriculture as the most important sector in economy. Although the share of agriculture in GNP is only 25.9% (1979), the percentage of employment in agriculture exceeds 78% of the whole nation. Improvement in productivity for both agriculture and industry, therefore, has become the major economical policy target. The fact that agriculture comprises a traditional sector of economy to absorb nation's underemployment and also that the annual growth rate of population is as high as 2.9% (1969-1979) has resulted in the rather lower per capita national income average of US$ 660 as estimated in 1981.

Geographically the country can be divided into four regions which are Central, North-west, North and South. As administrative zones exist 72 of Changwats, 620 of Amphoes and 5,775 of Tambons.

The city of Bangkok is situated on the alluvial plain built on the mouth of the Chao Phraya River. The city has a population of 5 million (1979) and constitutes the Great Bangkok Metropolitan Area together with Thonburi Area in the opposite side of the River thus becoming the political, economical and cultural center of the Royal Kingdom of Thailand.

2-2 POPULATION

The annual increase rate of population of Thailand has been as high as 2.9% during the recent ten years (1969-1979). However, as shown in table 2-1 the economic growth rate has begun to slow down to as low as 1.9% in 1979. This indicates that the initial stage of economic developments in which the economic momentum could be cancelled out by high population growth, thus resulting in staggering per-capita income, has already been taken off into another new stage. If this lower population growth can be kept down, more favorable stage of higher income could be attained in parallel with increasing economic growth rate.

The reason of decrease in population growth rate can be attributed to the fact that governmental promotion in family

planning has succeeded in gaining rapid increase in the number of families accepting the birth control program. Taking population distribution by age group into account, however, average annual increase rate of 2% level can be expected for the coming ten years. The forecast of future population made by the Thai Government is estimated at maximum of 2.8% and minimum of 1.7% and as the most probable rate 2.3% will be expected.

In view of social relocation of population, the urban concentration of population has been taken place as shown in Table 2-2, the flow-in rate into Bangkok has been especially high, with the population exceeding 10% of the total national population being concentrated into the capital. The population in the study area (i.e. The Greater Bangkok Metropolitan Area) was estimated by the Registration Division of Ministry of Interior, as to be 6.2 million and that of whole Kingdom as to be 46.1 million.

Forecast of population in terms of Changwat has also been made by the National Economic and Social Development Board (NESDB) and the Department of Town and Country Planning, Ministry of Interior in the Greater Bangkok Plan 2000. According to the data obtained from the above forecast, future population of the Greater Bangkok Area has been estimated at 7.3 million in 1985, 8.3 million in 1990 and 10.6 million in 2000 respectively.

Using above figures as control total, and also using the following index figures shown in the land use plan described in the Greater Bangkok Plan 2000, the zonal population has been predicted for each zone.

High density mixed land use	:	375 persons/ha
Low density mixed land use	:	75 "
Agricultural Land	:	6 "

This report will use these zonal population data for its analysis.

Table 2-1 Population of Thailand

person:

Items / Year	Whole Kingdom (N)	Bangkok Metropolis (B)	$\frac{N_t - N_{t-1}}{N_t}$ %	(B)/(N), %
1971	36,820,097	3,659,474	3.5	9.9
1972	38,359,008	3,793,763	4.0	9.9
1973	39,950,306	3,967,081	4.0	9.9
1974	41,334,152	4,129,609	3.3	10.0
1975	42,391,454	4,349,494	2.5	10.3
1976	43,213,711	4,545,608	1.9	10.5
1977	44,272,693	4,742,774	2.4	10.7
1978	45,221,625	4,870,509	2.1	10.8
1979	46,113,756	4,949,515	1.9	10.8

Source : Ministry of Interior

Table 2-2 Population Forecast for The Study Area

thousand

Year / Changwat	1978	1980	1985	1990	2000
Bangkok Metropolis	4,742.8	5,126.0	5,928.2	6,729.9	8,573.0
Nonthaburi	355.7	375.9	429.5	482.6	603.4
Pathumthani	301.8	322.7	363.0	403.1	514.0
Samutprakan	465.9	497.2	586.8	675.9	881.5
Total Study Area	5,866.2	6,321.8	7,307.5	8,291.5	10,571.9

Source: National Economic & Social Development Board (NESDB)

2-3 GROSS DOMESTIC PRODUCT

Gross domestic product in Thailand amounts to 673,732 million baht (1980 estimate, market price) and G.N.P. per capita is 13,977 Baht which is equivalent to 616 US dollar. G.D.P. consists of 26.2% of agriculture, 18.7% of manufacturing, and 18.6% of whole sales and retail trade, with a remarkably higher ratio in agriculture.

Growth rates by industrial origin estimated in 1980 are 14.9% for construction, 12.3% for public utilities and 10.1% for service. Both of 3.5% for agriculture and 6.1% for manufacturing are below the average 6.3% for whole industries. Although efforts have been made for accumulating social capital, yearly changes in improvement of industrial sturucture have not been sufficient.

Since reliable data for employment are not avilable, the composition of G.D.P. and ratios of employment are shown in Table 2-3. Productivities in mining and quarrying, public utilities and transport and communication are higher while that of agriculture is extremely low. To enhance productivity in agriculture or to shift industrial structure to more productive sectors is major target in policy making.

It should be noted, however, that since prices of agricultural products have been marked at lower level compared with higher prices of urban or manufacturing products, and also manufacturing itself is mainly agro-based, the share of agriculture among essential value added, could be much higher than its nominal figure of 26.2%.

Although reliable data lacks regarding unemployment rate, an I.B.R.D. estimate based on labor force survey in 1976 shows rather lower rate of 0.9% for whole nation and 1.9% for urban regions. This seems to indicate that most of the underemployment which has no opportunity to be employed by modern sector has been absorbed in traditional sector (agriculture) and that both, dual structure of income and that of economy have been existing together in this country.

The growth rate in real terms are given in Appendix 2-1. The peak of 9.1% in 1978 is followed by 5.0% in 1979 and 5.5% of 1980 estimate indicating a slowing down of economy. The increase rate of G.N.P. per capita is estimated at a level of 2.5% (1979, 1980 estimate) subtracting population growth from real-term growth.

Increase rate of prices in view of G.D.P. deflater shows rather higher figure of 7.9% (1978), 11.6% (1979) and 13.9% (1990 estimate) and this trend seems to continue throughout year of 1981 due to devaluation of baht, price increase of public goods and also wage increase.

Surveying price changes for construction materials and petroleum products which are closely related with this project it can be said that although the speed of inflation has calmed down since the peak in 1979, increase rate of both categories exceeds the average rate of inflation, with noted increase in the latter.

Table 2-3 Ratio of G.D.P. by Origin/of Employee, 1977

	RATIO OF G.D.P. BY ORIGIN (A)	RATIO OF EMPLOYEE BY ORIGIN (B)	A / B
AGRICULTURE	28.5	68.4	0.45
MINING & QUARRYING	2.1	0.4	5.25
MANUFACTURY	19.0	11.0	1.73
CONSTRUCTION	5.0	2.6	1.92
ELECTRICITY & WATER SUPPLY	1.1	0.4	2.74
WHOLESALE & RETAIL	19.1	10.0	1.91
TRANSPORTATION & COMMUNICATION	6.3	2.6	2.42
* -1 SERVICE	19.1	10.6	1.80

Note: * 1 ... Includes Banking, real estate, ownership of dwelling public administration and defence.

Source: National Accounts Bulletin.

2-4 GOVERNMENT REVENUE

The total government expenditure of Thai Government has reached at 112,526 million baht in 1980, an increase of 31% from the previous year.

In terms of revenue, it should be noted that import duties and business tax have increased at about the same rate as in 1979 while corporate tax collection has improved greatly. After the efforts made by the Government, the total revenue came up to 95,775 million Baht, 22% higher than the previous year. (See Appendix 2-2).

The primary objective of Thai tax system has been to raise revenue. Secondary objective has been to promote industry and subsequent export.

The overall incidence of taxation has not increased since the end of 1950's and the level of revenue raised has stagnated at about 12-14% of G.D.P. during 1960's and 1970's. For historical reasons as well as ease of collection, 70-80% of revenue are raised through indirect taxes but business taxes has declined while the share of sales taxes has increased.

The largest single expenditure item in the Government's current budget since 1970 has been for defense, which has accounted for about 20% of total central governmental expenditure, nearly as much as the capital budget and 30% of current expenditure. (See Table 2-4)

Together with other administrative expenditures, these overhead expenditures have absorbed more than one third of the total budget, reflecting the large size of the Thai bureacuracy and the security problems in the future.

The revenue for the fiscal year 1982 has been estimated by National Budget Bureau as to be increased 15% from the previous year.

The ratio of revenue against expenditure has been 80-85% during 1975-1980 period and continued steadily into the present budget, with its deficit being covered by loans both from National Bank of Thailand and overseas loan agencies.

Table 2-4 Government Expenditures by Category

Items	1975	1976	1977	1978	1979	1980
Total Expenditure	100	100	100	100	100	100
Economic Classification						
Current	77.6	73.3	74.3	75.5	78.4	77.8
Capital	22.4	26.7	25.7	24.5	21.6	22.2
Major Functional Classification						
Economic Services	25.2	26.7	22.8	21.9	19.1	19.3
Social Services	29.1	31.0	31.5	30.7	31.0	28.4
Defense	17.9	18.2	19.7	19.7	19.4	17.7
General Admin. & Services	14.7	12.9	11.7	12.3	13.9	15.8
Unallocable	13.0	11.4	14.2	15.3	16.7	18.8

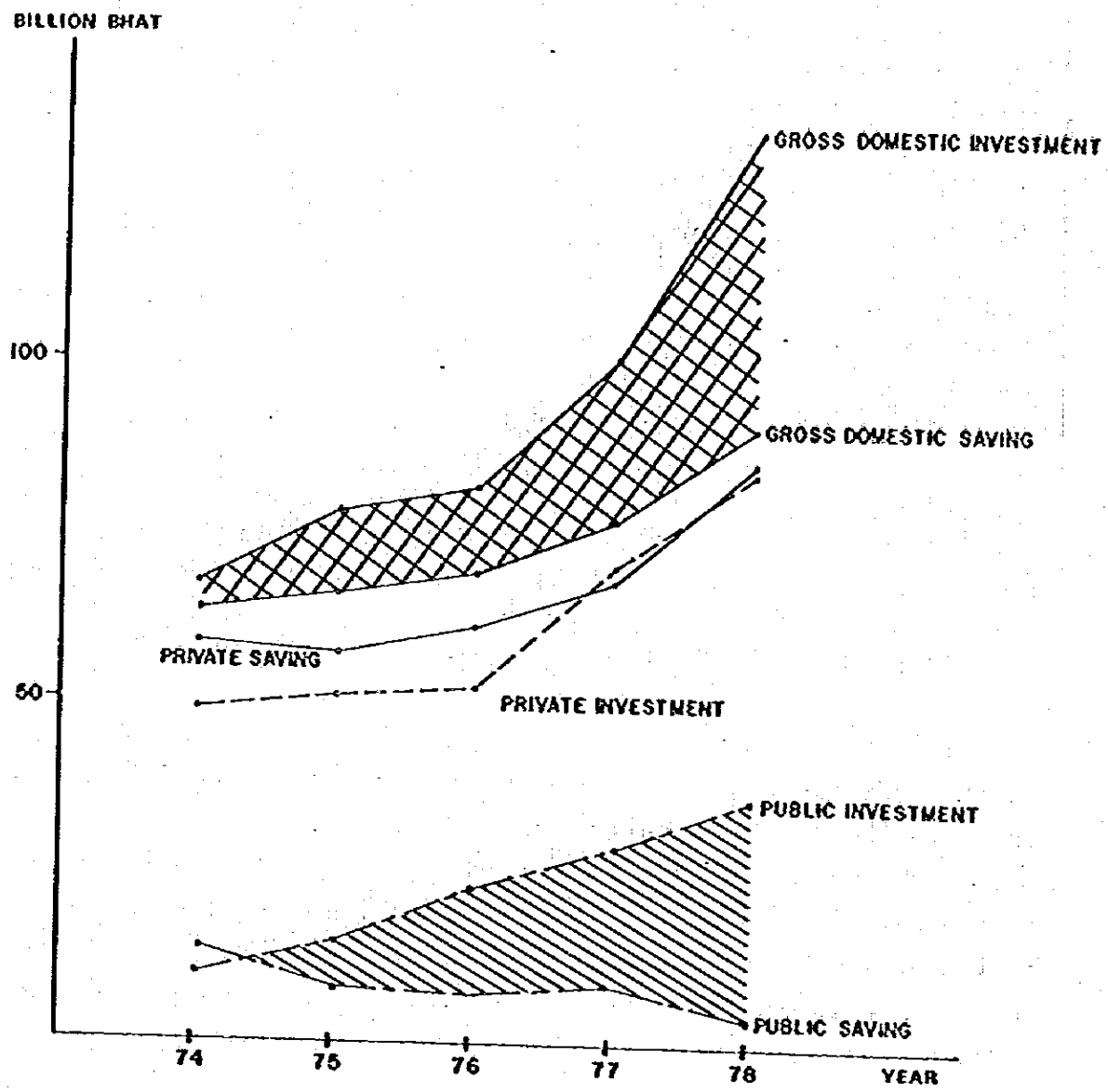
Source: Monthly Report of Commerce

In order to clarify the relation of revenue and expenditure during the period, an economy's infrastructure survey report has been issued by International Development Center of Japan. According to the report, the public sector has been always in a state of excess investment since 1975 while the private sector has been in excess saving until 1975 followed by excess investment in 1977 and balanced state in 1978. (See Fig. 2-1, 2-2).

While public investment has been continuously increased in recent years, public saving has been dwindling and it becomes urgent to acquire foreign capital.

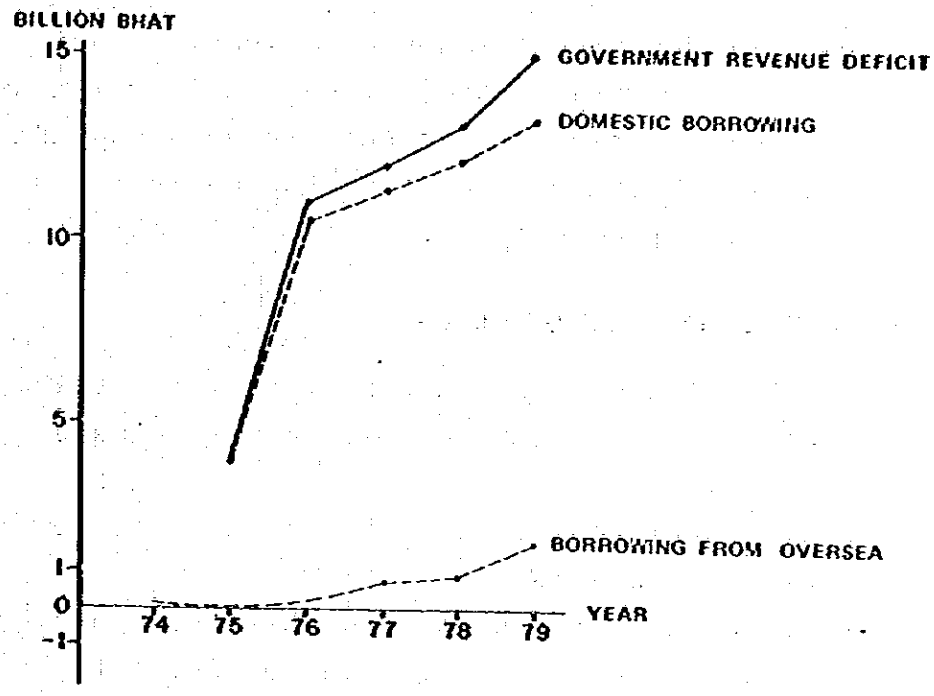
The government policy aiming higher economic growth with its emphasis being placed on infrastructural investment and agricultural development programs and increased defense expenditure has been considered to acceralate this trend.

Viewing the above situations, even in the midst of deficit



Source : I.D.C.J. REPORT

FIG. 2–1 GAP BETWEEN SAVING AND INVESTMENT



SOURCE: I.D.C.J. REPORT

FIG. 2–2 GOVERNMENT DEFICIT AND ITS FINANCE

budget, the Government's intention for highway construction has been very intense and the share of highway budget is expanding year by year and becoming the largest item in social capital formation with its figure of 6.7% in 1979.

If the present accumulation of external debt would continue repayment for the debt would bring forth a financial deadlock affecting the whole economic policy of the country in the future.

A forecast for government revenue collection during the first nine months of fiscal year 1981 was made by Ministry of finance to the effect that revenue had exceeded expenditure by 17,400 million baht, although it is too early to conclude that this favorable trend has already settled down.

2-5 INTERNATIONAL BALANCE OF PAYMENT

The remarkable feature in balance of payment of Thailand is an imbalance in overseas trade, with export always being only about 70% of import.
In service sector, balance is slightly in the black owing to income from foreign tourists.
Although unrequited transfer such as grants from foreign countries have contributed for lessening of deficits, basic balance on goods, services and unrequited transfer has been in deficit.
Although efforts have been made to counterbalance the deficit through both private long term investment and governmental borrowing from overseas in the items of capital, still due to structural defect of borrowing in private sector and also stagnation in unreguited transfer, the importance of governmental borrowing has been gaining its weight gradually. All of these governmental loans have been made by development investment loan offered by international loan agencies or tied loans by foreign governments. (See Fig. 2-2)

In terms of compositions and growth rates of main export commodities, agricultural products such as rice, tapioca and rubber are the three major products followed by tin in the

fourth. Growth of tin has been very high and tin is considered to attain the 2nd place in export in near future. (See Appendix 2-4)

The share of miscellanious items in the total export has been expanding and this indicates diversification of export items and also growth of new commodities in export.

In terms of trading partners, Japan has been ranked first followed by the United States. Japan has a solid share of 20% in both export and import although a sign of gradual decline has shown in recent years.

Viewing composition of imported items, the percentage of mineral, fuel and lubricants had been in 20% level until 1979 when worldly oil price increase had enforced it to jump up into 30% order in 1980.

Terms of trade indicates a downwards trend in recent years, showing the index of 78.36 in Feb. 1981 against the base of 100 of 1975.

This is due to inferior prices of export items compared with increasing prices of import items such as petroleum and machinery.

Foreign reserve excluding those in commercial banks also has been decreasing since June 1980, with 2,968 million US dollar in March 1981.

Deficit trend in trade balance together with accumulation of foreign debt will bring forth deteriolation of debt service ratio. An analysis made by I.B.R.D. shows as debt service ratio 3.1% of public debt, including garranties and with an addition of non-garranteed private debt, totalling at a comparatively low figure of 11.2%. It has been pointed out that no concerns will be expected in the terms of debt service ratio because of increase in export in the future.

In recent trend of foreign exchange, Baht as Thai currency has stayed in a very strong position, since it has been closely linked with US dollar.

Strong US dollar has brought strong Baht against other foreign currencies including Japanese Yen.
Sudden devaluation of Baht of 9% strong announced by the Bank of Thailand in July 1981, however, will affect in favor of export and against import of petroleum products and machinery. (See Table 2-5)

It is strongly recommended that in evaluation of a construction project like the present study, changes in foreign exchanges and also that of interest rates should be taken into consideration since the project requires a long term borrowing of money from overseas loan agencies.

Table 2-5 Rate of Exchange

(Simple average free market rates of exchange) Baht

	1975	1976	1977	1978	1979	1980	1981-7
US $.	20.40	20.45	20.45	20.38	20.48	20.67	22.70
Japanese Yen	-	0.0696	0.0770	0.0984	0.0940	0.0958	0.0991

Source : Bank of Thailand

CHAPTER 3
ANALYSIS OF TRANSPORTATION

CHAPTER 3 ANALYSIS OF TRANSPORTATION

3-1 POLICY

The government's major contribution to economic growth over the past two decades has been through its provision of infrastructure, most notably in the area of the road network which has had a considerable impact on agricultural development in the country.

In airport and harbors, Thailand now possesses basic infrastructures that can be compared favorably with other developing countries and is fairly well maintained.

The followings have been complied through the various governmental section's data regarding transportation policy.

1) To promote the use of high occupancy vehicles such as bus while restraining the use of low occupancy vehicles like passenger car. In order to achieve this target, the policies have been implemented to:

   a) restrict the passenger car traffic at conjested areas

   b) increase bus lanes

   c) raise the service level of mass transit in comparison with that of passenger cars

   d) adopt a toll system in capital using projects.

2) To transfer to governmental management in rural developing area as well as urban area.

3) To abolish low price policy of gasoline and transfer to "pay-as-you-go" system increasing user's burden.

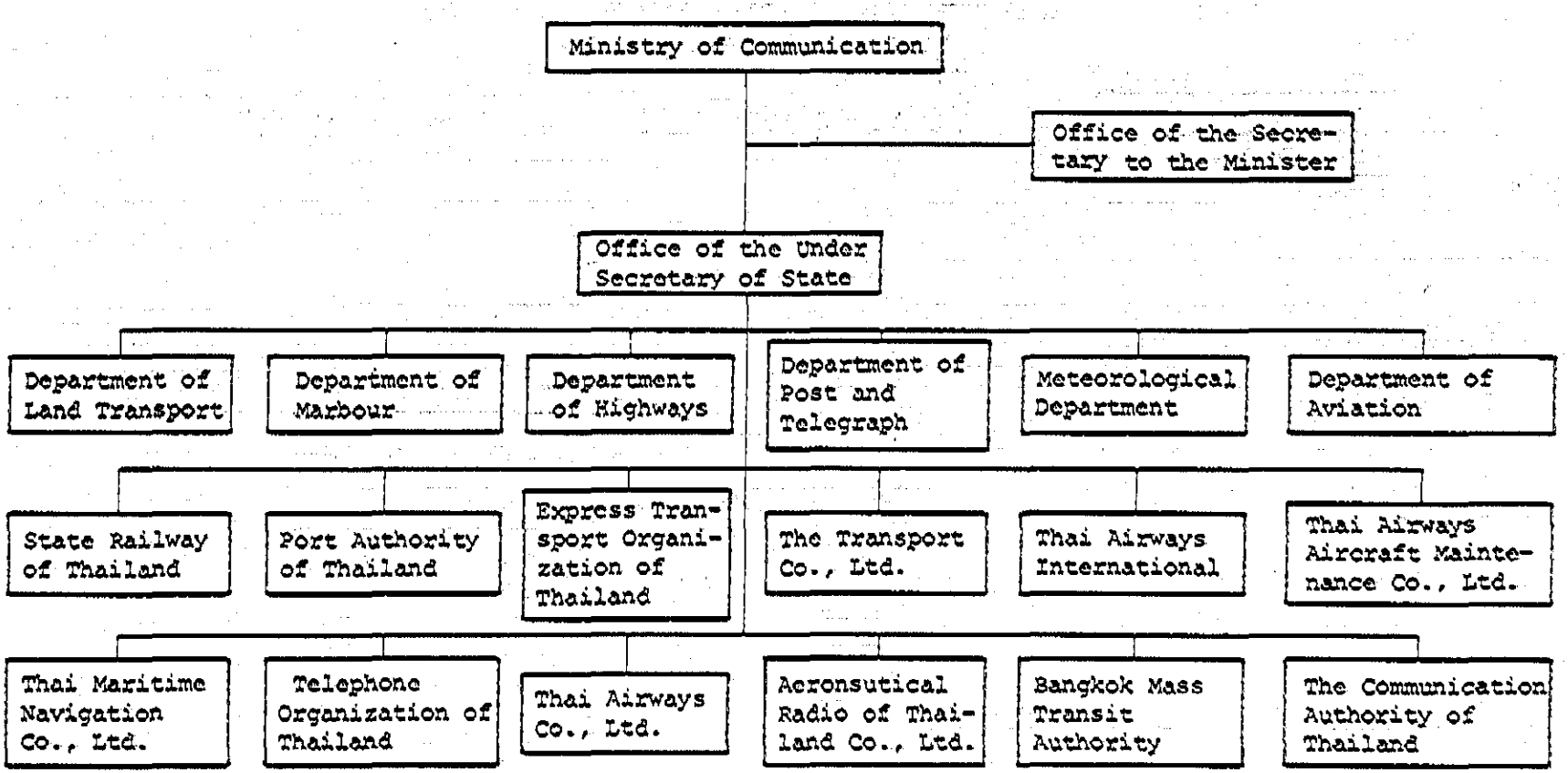
The total investiment for transportation in the Fourth Five Year Plan (1977-1981) has been 31 million Baht with an increase of 50% from the previous five year plan, while the share in the whole public capital formation has fallen down to 12% from 20%.

In the next Five Year Plan (1982-1986) which is being Planned at the present, transport investment is expected to increase at 38 million Baht. In view of the average 7% of nominal economic growth during that period considered in the plan, the figure for transportation investment can be said to be quite appropriate.

Planning and management of transportation sector are implemented by Ministry of Communication through DOH, SRT and PAT (the Port Authority of Thailand). (See Fig. 3-1)

The ministry has established Transport Planning Unit in 1974 and the unit has been a main organization in implementing investment plans, traffic plans and traffic policies for transportation sector as well as investigations for future developments, evaluation of projects and data collection.

The present study has been initially planned and directly controled by Public Works Department (PWD) of the Ministry of Interior and in relevant with the present RAMA VI Bridge as a portion of the Middle Ring Road, DOH of Ministry of Communication, BMA (Bangkok Metropolitan Administration) and SRT (State Railway of Thailand) have shared responsibilities in implementing of this study. (See Fig. 3-2)



Source : Ministry of Communication, Annual Report 1979

FIG.3-1 ORGANIZATION CHART, MINISTRY OF COMMUNICATION

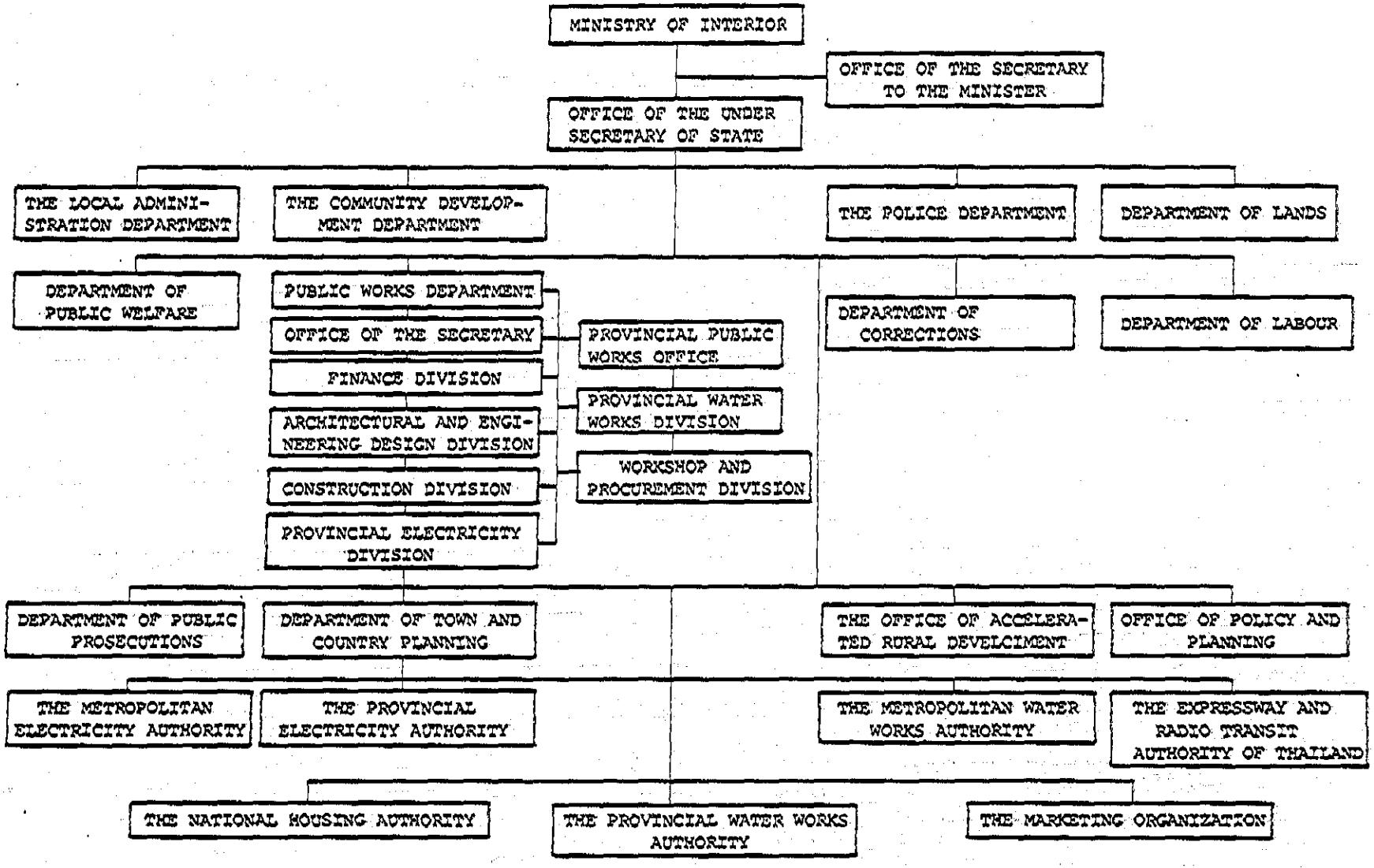


FIG. 3-2 ORGANIZATION CHART, MINISTRY OF INTERIOR

3-2 DEMAND OF TRANSPORTATION

Viewing the pattern of goods transport, primary products move into Bangkok for export, manufacturing and consuming, while imported goods and manufactured products flow out to up countries. The traffic system, therefore, constitutes a transport system radiating from Bangkok as the center.

In 1976, almost a third of total commodity export was occupied by agricultural products, 50% of which was considered to be exported via Bangkok.

As statistics regarding commodity flow are not accurate except those of railway transport, modal split can be described in terms of Kilo.Ton as that road transport has shares of 86% in passenger transport and 70% of goods transport ranking as the first mode followed by railway, waterway and airway which plays only a minor role in the transport system.

It is considered that road transportation has a favorable conditions because its improvement program has been relatively well implemented.

It is predicted that the share of road transport will still make a increase for total goods transport from present 75% to future 85%.

The total commodity transport in statistics for road, railway and inland waterway has shown a growth of 9% per a.n. in the past decade while that of G.D.P. of Thailand being as 7%.

As the economic development in Thailand is in a stage of so-called take-off period from developing into developed state, commodity flow is playing a very important role in the composition of industry.

As the stage in economy is considered to be in a growth period of secondary industry, growth of G.D.P. and commodity flow has been in high correlation thus resulting in further growth of commodity flow following the growth of economy.

Predicting future commodity flow using the elasticity of 0.68 in Table 3-1, (modal split, running mileage and other factors to be as constant) the growth rate in commodity flow (i.e.. traffic demand) can be estimated as 6.3% per a.n.

In this calculation the nominal average G.D.P. growth rate in the next decade is assumed to be as 9.3% (break down as 3.0% for per capital G.D.P. growth in real terms and 2.3% for population growth and 4.0% for increase rate of G.D.P. deflator).

At this 6.3% growth rate, a doubling will take place in only 11.5 years and it can be pointed out that transportation investment in the next decade has to be sufficient enough as not to curb economic growth through transportation sector.

TABLE 3-1

ELASTICITY G.D.P. NOMINAL GROWTH RATE TO REGISTERED VEHICLE %

ITEMS / YEAR	Δ T/T	Δ Y/Y	Δ T/T /Δ Y/Y
1971	6.6	5.9	1.12
1972	5.2	12.2	0.43
1973	6.1	24.0	0.25
1974	15.2	19.7	0.77
1975	1.4	9.0	0.16
1976	7.3	10.8	0.68
1977	17.6	12.8	1.38
1978	8.5	13.7	0.62
Σ/ε	8.5	13.5	0.68

3-3 RAILWAY, WATERWAY AND AVIATION

3-3-1 Railway

The operating length of the State Railway of Thailand (SRT) is 3,765 km. with 592 stations.
The railway network consists mainly of four main trunk lines as the Southern Line leading for Malaysia and Singapore, the Northern Line for Chieng Mai located near Burmese border, Northern-Eastern Line for Nong-Khai at the border of Laos and Ubon Ratchathani located at the border of CAMPUCHEA and the Eastern Line for Aranyaprathat located at the border with CAMPUCHEA. All of these lines has rediated from Bangkok.

Dual track section is only 90 km. long between Bangkok and Bang Phaen and all of the remaining is single track and the lines are all meter gauge.

It is considered that the present capacity of railway is sufficient enough to meet the present level of traffic demand. Facility capacities at major terminals except that of Bangkok are spacious enough to absorb 50% increase in traffic demand.

The RAMA VI Bridge of the present project is located on the Southern Trunk Line and dual track improvement has been planned and studied for the Fifth Five Year Plan.

Even if this double tracking program is planned as a separate new line, the existing single track of RAMA VI Bridge would have to be expanded into dual tracks for commuters use from suburban area, in foreseeable future.

The SRT has been an independent governmental organization since 1951 when it separated from Ministry of Communication and Railway and directed by Board of Commissioners, appointed by the Councils of Ministers.

The financial status of the SRT had been in deficit since 1974 to 1976. Improved balance has been attained since 1975 revision of both passenger and freight fares. The annual account has turned into profit for each of fiscal year 1977 and 1978.

Since 1979, the trend reversed and again a revision of fares was implemented. It is expected that SRT's 1982 finance can be in surplus if no more price increases in energy cost would not occurred.

Transport composition by item shows 31.5% of Cement,24.0 of petroleum products, 12.3% for rice products and 16.9% for clinker-marl (each in 1972).

The growth of passengers has been rated as 7-10% per annum until 1977, stagnated ever since to be underlaid at lower than that of passenger trips in whole traffic modes.

Growth of freight has been recorded an average of 4.9% in the years between 1975 and 1976. This has also been below that of whole freight traffic and an attention should be paid for this yearly slowing down in shares.

3-3-2 Waterway

The total of 35 ports and harbors exist in Thailand. Major ports such as Bangkok, Sri Racha and Sattahip all lies within 200 km. distance from Bangkok, functioning as entrances and exists for major foreign trade in Thailand.

The port of Bangkok has handled 80% to foreign trade and 90% of domestic ship transportation with the total trading tonnage of 1.4 million in 1975. Handling of freights is managed by barge loading at in-the-river anchorages and wharfs on both river sides located mostly between the Memorial Bridge and the river month of the Chao Phraya River.

As the depth of the river being 8.5 m M.S.L., ships with more than 14,000 DWT class are not allowed into the ports.

The share of Freight using inland waterway has dropped to below 10% of the total improting freight to the metropolitan area.

3-3-3 Aviation

Thai Airways is a state owned enterprise and monopolizes

domestic airway transportation in Thailand, while Thai International is operated as the national flag carrier with its stocks primarily held by Thai government.

The center of aviation is the Don Muang Airport in the suburb of Bangkok with the supplement of 26 other local airports connecting with Bangkok. Most busy trunk route is Bangkok - Chieng Mai line followed by Bangkok - Songkla (Hat Yai) as the second.

Don Muang is one of most important international airport in Southeast Asia and almost all of major international air lines makes use of it.

Growth rates of passengers, including both domestic and international are estimated as 23.1% in 1976 and 6% in 1977 while that of freight as 17.4% in 1976 and 14.3% in 1977, all of each showing a substantial growth in airway transport.

3-4 PRESENT STATUS OF ROAD TRANSPORT

The vehicle fleet in Thailand grew at an average rate of about 10% per a.n. during the past decade.
Traffic distribution on the road networks reflects Bangkok's dominant position in the whole Kingdom.
Traffic becomes highest on the appreach roads to Bangkok, where it ranges from A.D.T. 15,000 to 30,000 and it decreases sharply as the distance increases from the capital. (See Fig. 3-3)

The number of registered vehicles has increased 12.1% per a.n. (1975-1979) and responding with industrial and commercial demand, the growth rates of vans, Trucks and Motorcycles have been extremely high while those of passenger cars and buses have remained at relatively low level. (See Appendix 3-1)

Since accurate data for changing demand on automobile fuel, are unavailable, consumption of petroleum products had been studied as a substitute. The petroleum demand has increased slowly since 1976 and, come to a peak in 1979 then, turned into a down trend in 1980.

This is caused by the effects of save-energy policy as well as reduced effective operation of vehicles in view of the worldly oil price increase.

Table 3-2 Consumption of Petroleum Products

(1000 Litre)

	1976	1977	1978	1979	1980
Petroleum Products (A)	8,417,564	8,734,384	8,918,329	9,354,551	8,379,263
Number of registrated vehicles (B)	1,144,984	1,389,717	1,519,113	1,678,014	1,829,000
A/B (litre)	7,352	6,314	5,871	5,575	4,603

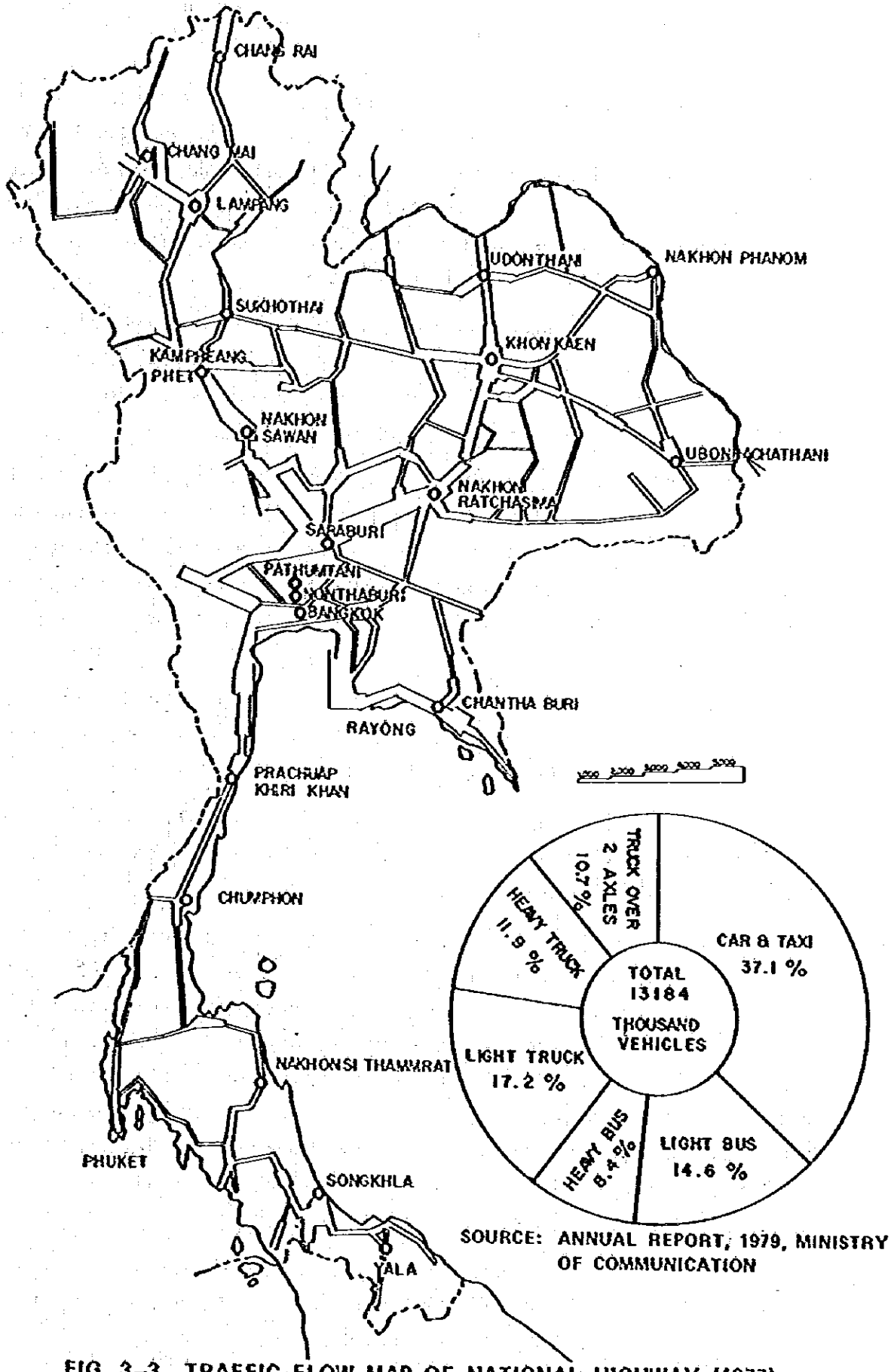


FIG. 3-3 TRAFFIC FLOW MAP OF NATIONAL HIGHWAY (1977)

Viewing the results, the rate of energy consumption against vehicle registration has been continuously decreasing. It is considered running mileage also shrinked down during the same period reflecting the corresponding increase rate of traffic volume of 10% and increase rate of registered vehicles of 12.1% (1975-1979).

However, in view of the fact that only a part of petroleum consumption is spent by automobiles, and also the registered number includes used-up depreciated vehicles, such data might have to be deleted from the above considerations.

The whole highway conditions has been improved in recent years. Among 13,820 km. long, national highways network (1979) almost 95% has been paved and primary arterial highways have reached to the borders with Malaysia to the south, Laos to the east and Burma to the north extending its network system radiating from Bangkok.

Regarding rural highway network, 60% of the total 13,678 km has been paved and the remaining 40% has crushed rocked or soil cemented surface. (See Appendix 3-2)

In terms of sosio-economic data, the whole road network improvement has been considerably delayed and ranked as middle among developing countries.

As Thailand has been already shifted towards being one of the top ranking developing countries in Southeast Asia at the present, relative lack of social infrastructures has to be pointed out seriously. The expenditure for highway investment amounted to 6,177 million Baht in 1979 and 6.7% of total national budget. Although the share has been decreasing recently, still "highway" occupies a very substantial part of the budget and also of infrastructure investment. (See Appendix 3-3)

With the elasticity being 0.66 in terms of nominal economic growth and the number of vehicle fleet, as analysed in section 3-2, the growth of future traffic volume has been estimated as around 6.6%. (See Appendix 3-4)

More efforts must be implemented by Thai Government in view of the present traffic conjestion already occurred in Bangkok. Otherwise the growth of economy could be restrained by the weakness of the transportation sector.

3-5 TRAFFIC IN THE GREATER BANGKOK AREA

The transportation system in Bangkok in its earlier days started as a dense network of natural and man-made waterways together with the Menam Chao Phraya.

Waterways still are highly important for both passengers and goods transport, although the vast majority of the transportation goes by roads at the present. The vehicle fleet in the GBA exceed 500 thousand mark in 1978 and has increased at an average annual rate of 8%. Flow-in traffic from external zone has been also increasing. Breakdown of the vehicle fleet in the GBA in 1978 is:

Passenger Car	263,000	Motorcycle	130,000
Taxi	14,000	Samlor	7,000
Truck	72,000	Bus	14,000

The trunk road network in urban areas of Bangkok has a nearly arranged grid-like configuration. Still, in the wake of motorization, a severe state of traffic congestion is taking place in the central urban area just like any other cities in the world.

Main points of traffic problems in relevant with the RAMA VI Bridge can be summerized as follows:

1) Most of trunk road in the GBA consists of radial arterials lacking in circumferential roads. As the result, traffic passing through the GBA has to first flow into the central parts of the city.

2) As urban business and residential area have been developed along arterial highways, most of trunk roads have to play a role of access road thus reducing traffic volume in themselves.

3) The GBA is devided into Bangkok and Thonburi sides of the Chao Phraya River on which only insufficient number of bridges exist, and it causes long detouring and also traffic congestion.

Running speed of vehicles has been surveyed in the Nonthaburi in 1980 by interviewing well informed local inhabitants.

The results has been described in the report as follows:

1) The most congested area within the City has been marked with slash in Fig. 3-4, including Sukhumvit, Rama IV and Petchburi Roads and Ratchadamri Road in Central business districts and Tripet and Yaowarat Roads on Bangkok side of the Memorial Bridge. On those area the speed is reduced as low as 10 km/hr in not only at the peak hours but also in normal daytime hours.

2) Even in external areas of the GBA, traffic congestion has been observed widely. However running speed of vehicles rises up sharply as traffic goes into suburban areas.

The government has implemented various measures in order to improve urban traffic in Bangkok.
Public transport priority policy has already shown favorable effects. Effects of other specific measures have to been seen in the future.

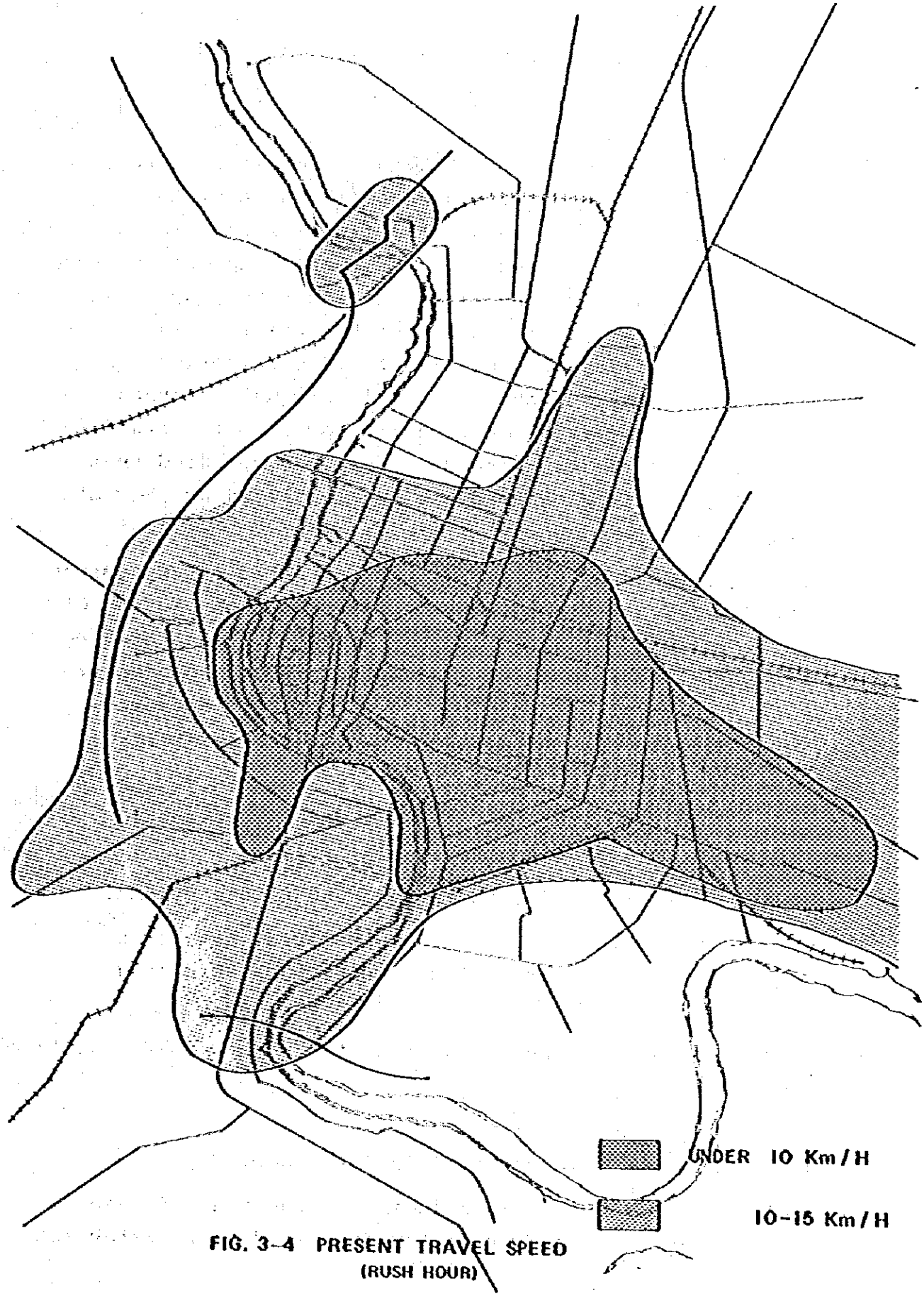


FIG. 3-4 PRESENT TRAVEL SPEED
(RUSH HOUR)

Among those counter-measures are:

1) Priority for bus transport
Bus plays the most important role as mass transit in the GBA. Operated by the Bangkok Mass Transit Authority (BMTA), the total bus transport system has been fairly well maintained although its financial deficit is becoming a more and more difficult problem. The system has well planned routes, frequencies,and is being effectively operated in high occupancy. Installation of bus priority lane or bus preferential lane, especially opposite directional bus lane in one-way streets have been very well planned and effectively operated,contributing for reducing traffic congestion in central areas. It should be noted that even the Middle Ring Road has been utilized as many of bus routes.

2) A toll expressway system being constructed by Expressway and Rapid Transit Authority (ERTA). Upon completion of this project, three of main radial trunk roads entering from east, south and north directions could be connected by three proposed expressway routes of this network. Congestion in central Bangkok can be greatly mitigated owing to by-passing of traffic.

3) The Middle Ring Road by the BMA. Under construction. Expected completion in the middle of 1983.

4) Extension project of Sathorn Road and Bridge by BMA.

5) Construction Projects of the New Memorial Bridge and Nonthaburi and Pathumthani Bridge by PWD. Expected to start in 1981.

6) Elevated train and bus mass transit system by ERTA. detailed designing.

7) Outer Ring Road Project
Planned by DOH. In detailed design stage.

8) Overall traffic control including improvement of main intersections and bus transport described in 1) Establish-

ment of Bangkok Traffic Management Project aiming at improving administrative organization.

The present RAMA VI Bridge construction project has vital significance in relevant with 10,3), 5), 8) of above stated measures.

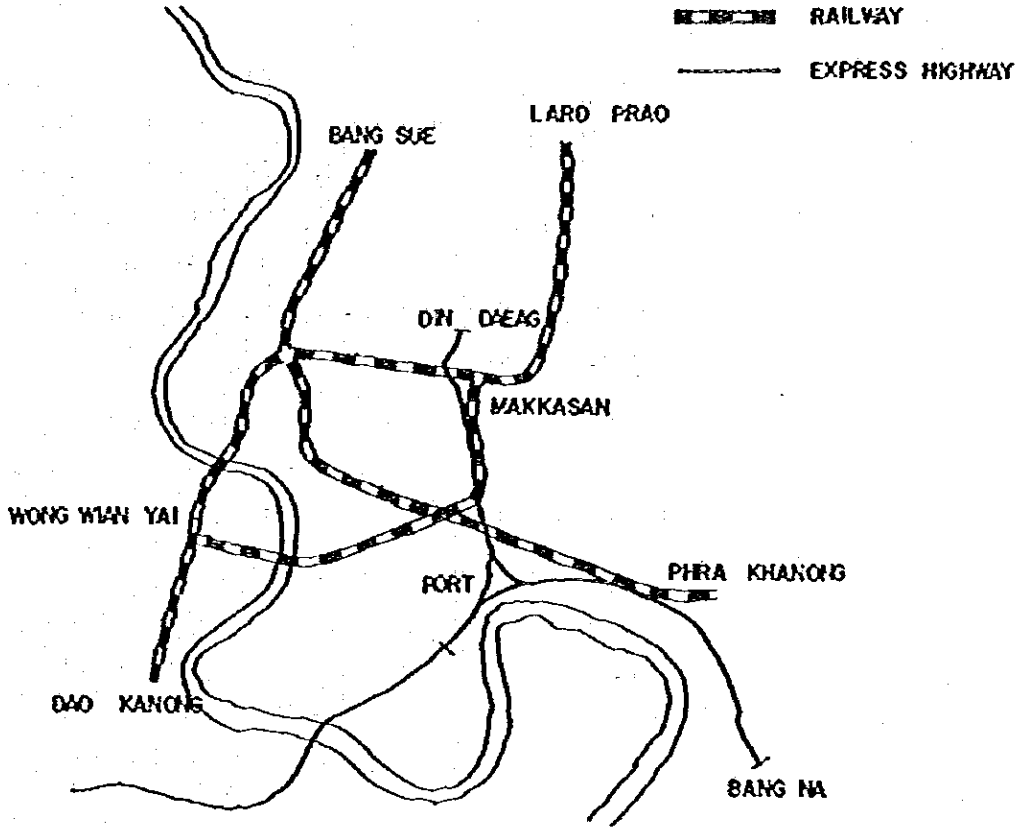


FIG. 3-5 EXPRESS HIGHWAY & MRT, FIRST PLAN IN G.B.A.

3-6 BRIDGES ACROSS THE CHAO PHRAYA RIVER

The Chao Phraya River, dividing the GBA into Bangkok and Thonburi, has played an improtant role of being a natural boundary and also improtant waterway, while, on the other hand, it has become one of major obstacles in view of urban traffic improvement.

Total of six bridges, five in the city area and one in the GBA, share the role of cross-river traffic.

The Memorial Bridge is the oldest bridge spanning both old commercial and residential districts of Bangkok and Thonburi. At two kilometers upstream, Phra Pin Klao Bridge, and at another four kilometers Krung Thon Bridge, up further north the present RAMA VI Bridge exists respectively. Four kilometers downstream from the Memorial Bridge located Krung Thep Bridge connecting Taksin Road in Thonburi and Charoen Krung Road in Bangkok side.

The total cross river traffic has increased each year and each bridge has difficulties in maintaining its specified service level thus hindering overall traffic flows in the GBA.

Several new bridges construction have been undertaken in recent years. Sathorn and New Memorial Bridge has been under construction and further upstream both New Nonthaburi and Pathumthani Bridges are shortly expected to commence work. On downstream Wat Sai Bridge is under designing (See Fig. 3-6).

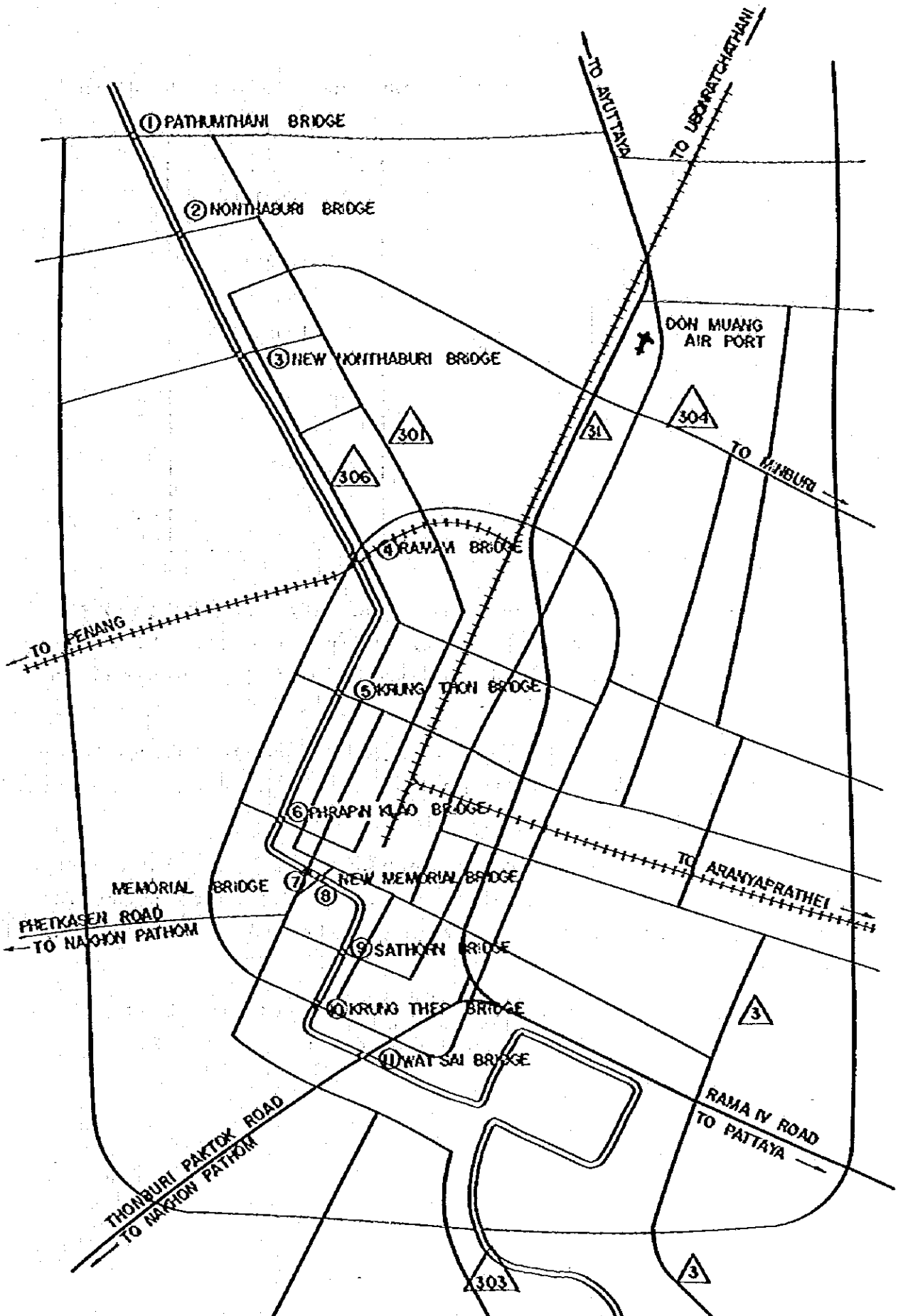


FIG. 3-6 LOCATION MAP OF BRIDGES OVER CHAO PHRAYA RIVER

Table 3-3 List of Bridges across the Chao Phraya River

Bridge Name	No. of lanes	Completion year
1. Pathumthani	2	(1984)
2. Nonthaburi	2	1955
3. New Nonthaburi	4	(1984)
4. Rama VI	2	1951
5. Krung Thon	4	1955
6. Phra Pin Klao	6	1972
7. Memorial	4	1932
8. New Memorial	6	(1982)
9. Sathorn	4	1955
10. Krung Thep	4	1955
11. Wat Sai	6	Not available

Total number of lanes across the river is 22 lanes at the present. The present traffic volume exceeds the minimum design service level of 350,000 veh/day (15,000 veh/day for one lane).

By 1984, if all of proposed projects could be completed and offered its service, the total of 40 lanes carrying 600,000 veh/day at the design service level.

The present RAMA VI Bridge project has been planned as a section of Middle Ring Road in views of these prospects in order to respond to the increasing traffic demand of the Middle Ring Road.

The share of each bridge and its service level in relation with its number of lanes, should refer to Table 4-2.

3-7 PRESENT SITUATIONS OF THE RAMA VI BRIDGE

The existing RAMA VI Bridge was damaged by bombings during the World War II and its piers were rehabilitated in 1951 and the superstructure was newly built on the repaired old piers. The bridge consists of 5 spans, of which both end spans are 78.56 meter simple truss and three middle spans of Gelber type truss (spans lengths of 84+120+84 m). (See Fig. 3-7) It has a two lane roadway with a width of 6 meter and one single railway track and two pedestrian sidewalks of 1.5m wide outside of both trusses. The bridge was designed and manufactured and erected by a British firm, Cleveland Bridge and Engineering Co., Ltd.

For railway and roadway liveload, 15 ton axle load of metergauge railway track and 12 ton truck of 18 ton roller load in accordance with BSS no.153-1937 have been adopted respectively. Concrete slab for roadway has been designed as composite girder with stringer and 15 cm. thick. As steel materials, BS 548 steel with yielding point of 3622 kg/cm has been mostly used supplemented with plain mild steel and high tension rivets.

The bridge started its construction in October 1943 and was planned to be used for 60-70 years for its depreciation.

Being a combined road and railway bridge, the PWD has been responsible for maintaining of the road section and SRT for the railway section of the bridge. The SRT has an intention of improving the southern truck line as dual tracks connecting Bangkok - Had Yai - Padang Besar - Saugei Golok to Malaysian State Railway in the current Five year plan for which the SRT has already made a request for a feasibility study to JARTS through ESCAP.

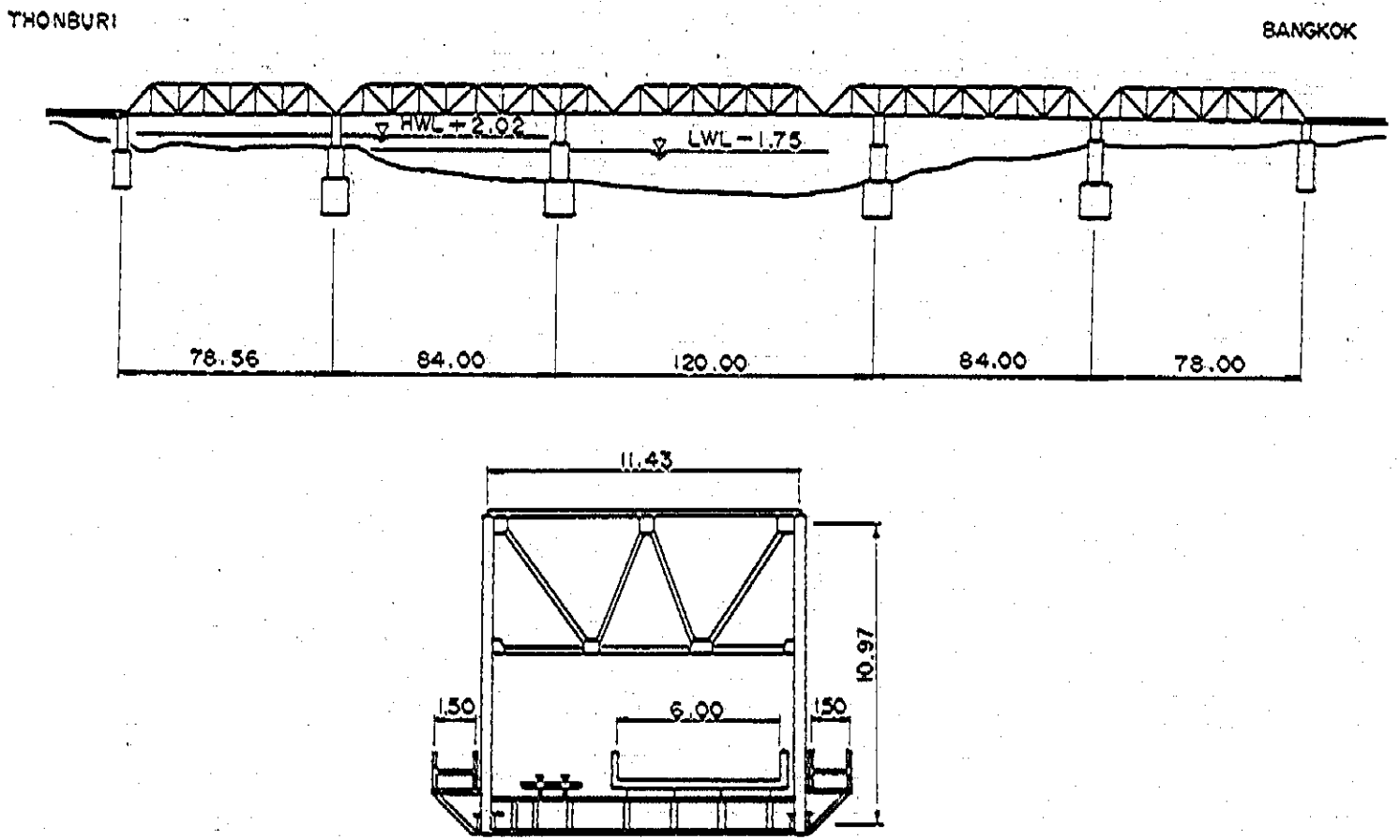


FIG. 3–7 PRESENT RAMA VI BRIDGE

Frequency of the present SRT railway line is 36 train/day and in the next five year a demand of 54 train/day is expected while the present capacity is only 44 train/day. Exceeding capacity is inevitable and in the near future roadway of the bridge must be relocated to other place in this sense.

The RAMA VI Bridge, on the other hand, plays an important role as a section of the Middle Ring Road, 1.75 km. section of which will be expanded into 6-lane highway in future. Thonburi side of the bridge has completed as 6-lane highway except an incompleted 0.8 km. section.

As completion of the whole MRR is expected in 1983, the MRR will have 6-lane roadway with an exception of short southern section of 4-lane roadway, and traffic congestion will subsequently take place in the vicinity of the bridge due to its narrow two pane roadway.

Maintenance of the bridge has been implemented half by half by both of SRT and PWD expeding 324,000 Baht in 1980 for painting of bridge members only. The present conditions of the bridge are deteriolated ones, specially the damages in slab and expansion joints are severe, causing one reason for traffic congestion.

The present traffic volume is A.D.T. 22,400 for both direction reducing the level of allowable service level of the bridge. During morning and evening peak hours, about two hour long traffic congestion takes place bringing a loss of about five minutes for passing traffic.

Arrangements of access roads and intersections also have problems and it is considered necessary to make prompt improvement in this respect.

The vicinity of the present bridge is mainly occupied by medium density residential area and especially on Bangkok side houses are concentrated. On Thonburi side there still exsists undeveloped area.

Both sides have various buildings and facilities such as wats, schools, a power generating plant and transmission lines and cement factories, and it is considered that special considerations have to be taken for in construction of the new bridge.

The present general roads conditions in the vicinity of the RAMA VI Bridge can be briefly described as follows. The RAMA VI Bridge and its approaches constitutes a portion of the Middle Ring Road connecting Wongsawang Road and Charan Sanitwong Road. The alignment for this section of Middle Ring Road is a complicated one. The Wongsawang Road makes a right angled turn to the south and then runs toward west using the viaduct with a curvature of approx, 150 metre radius, and after passing through the existing bridge turns towards north-west and goes west through a short straight course and finally makes a sourth turn in a 50 metre radius curvature to connect with Charan Sanitwong Road. (See Fig. 3-8)

For the whole above-mentioned section, it has only two carriageways. On the embankment section, a comparatively wide soft shoulder is provided while in the viaduct section and in a under-pass crossing for the railway line, shoulders are omitted for the most part of its 6 metre wide roadway. At the Wongsawang & Pibul Songkhram intersection, the east leg constitutes a portion of Wongsawang Road having two carriageway at present and planned to be improved into 6 carriageways in future.

The north leg is 4-lane Pibul Songkhram Road. Its south leg connects with the present RAMA VI Bridge and the west leg connecting with Pracha Rat I Road going further into the central part of Bangkok. As a result, the traffic connecting RAMA VI Bridge and Pracha Rat I has to use an unnatural travelling course using its 270 degree turning loop. Luckily its traffic, however, is very small at the present. The intersection seems to have a very poor capacity in view of its number of lanes.

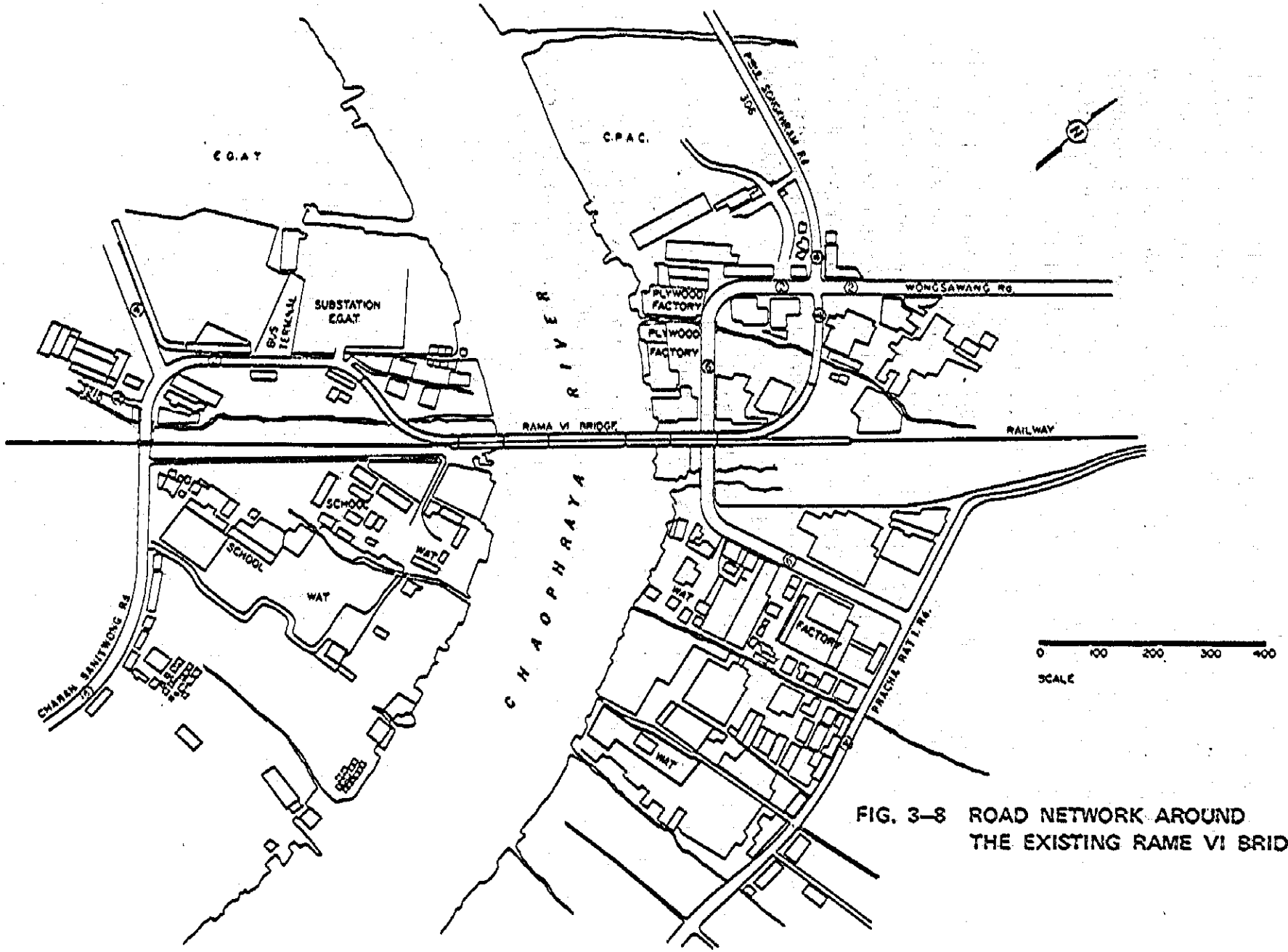


FIG. 3–8 ROAD NETWORK AROUND THE EXISTING RAME VI BRIDGE

In the vicinity of the intersection, a rather wide soft shoulder together with three phase traffic signal having comparatively short cycle times, is providing good operational performances in the present traffic conditions. The RAMA VI Bridge and its approach viaducts have a very narrow roadway with its steep longitudinal grade of 5%. Expansion joints on the above sections have been mostly destroyed and asphaltic pavement upon the slabs also deterorated severely.

On the Thonburi side, the narrow under-pass crossing with the railway is making an another bottleneck. The short distance between EGAT and R 3215 intersections provides another difficulties in traffic treatment because this section is located right on the portion of through traffic roadway using a right angled turn. At the present, the capacity of this intersection can be maintained without problems, thanks to a rather wide soft shoulders on both sides of roadways.

The close spacing of 4 intersections and 2 access openings in a very short distance of 600 metres might present a much more difficult engineering problem. Finally it should be noted that the sudden shift-down from 6-lanes of Charan Sanitwong Road into the narrow 2-lanes is causing an almost chronicle traffic congestion at the underpass crossing with the railway line.