KINGDOM OF THAILAND

FEASIBILITY STUDY ON NEW KRUNGTHEP BRIDGE CONSTRUCTION AND THONBURI ROAD EXTENSION

FINAL REPORT

MAIN VOLUME

JUNE 1987

JAPAN INTERNATIONAL COOPERATION AGENCY

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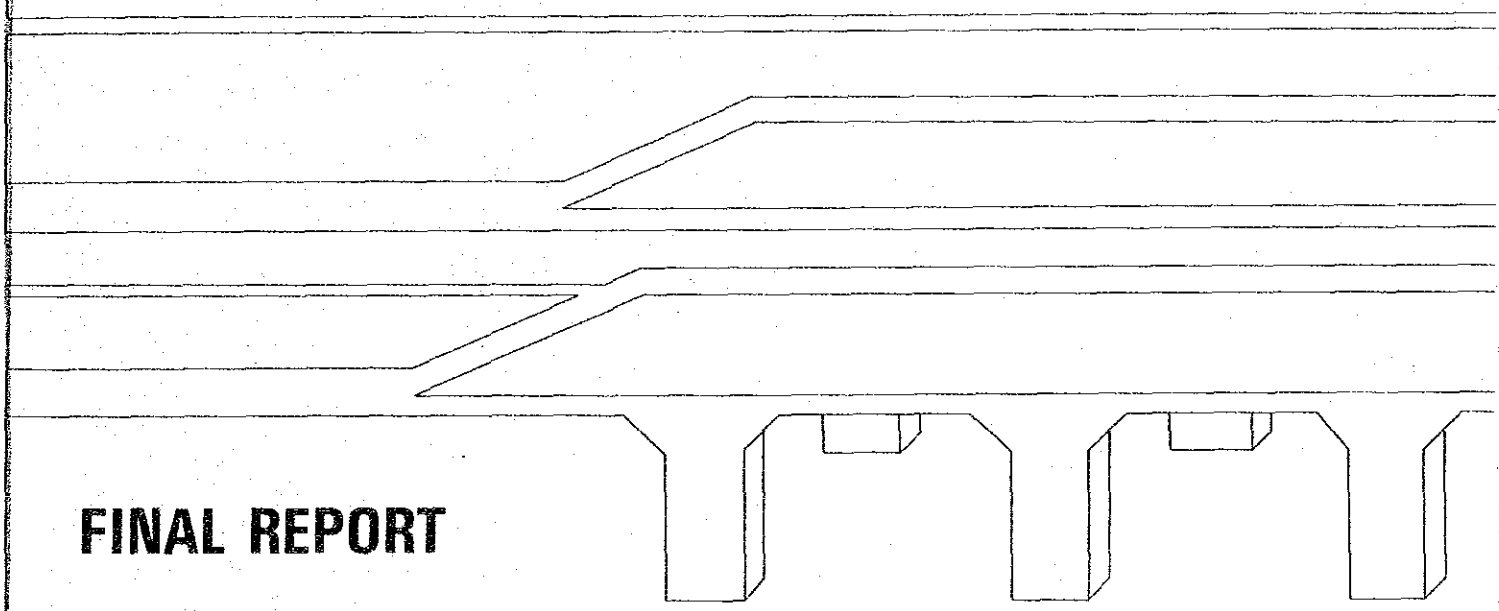

FINAL REPORT

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PREFACE

It is with great pleasure that I present this Feasibility Study Report on New Krungthep Bridge Construction and Thonburi Road Extension to the Government of the Kingdom of Thailand.

This report embodies the result of the study which was carried out from March, 1986 to March, 1987 by a Japanese study team commissioned by the Japan International Cooperation Agency following the request of the Government of the Kingdom of Thailand to the Government of Japan.

The study team, headed by Mr. Hisashi Oshima and organized by the Nippon Koei Co., Ltd. and the Central Consultant Inc., had a series of close discussions on the project with the officials concerned of the Government of Thailand and conducted a wide scope of field survey. After the team returned to Japan, further studies were made and the present report has been prepared.

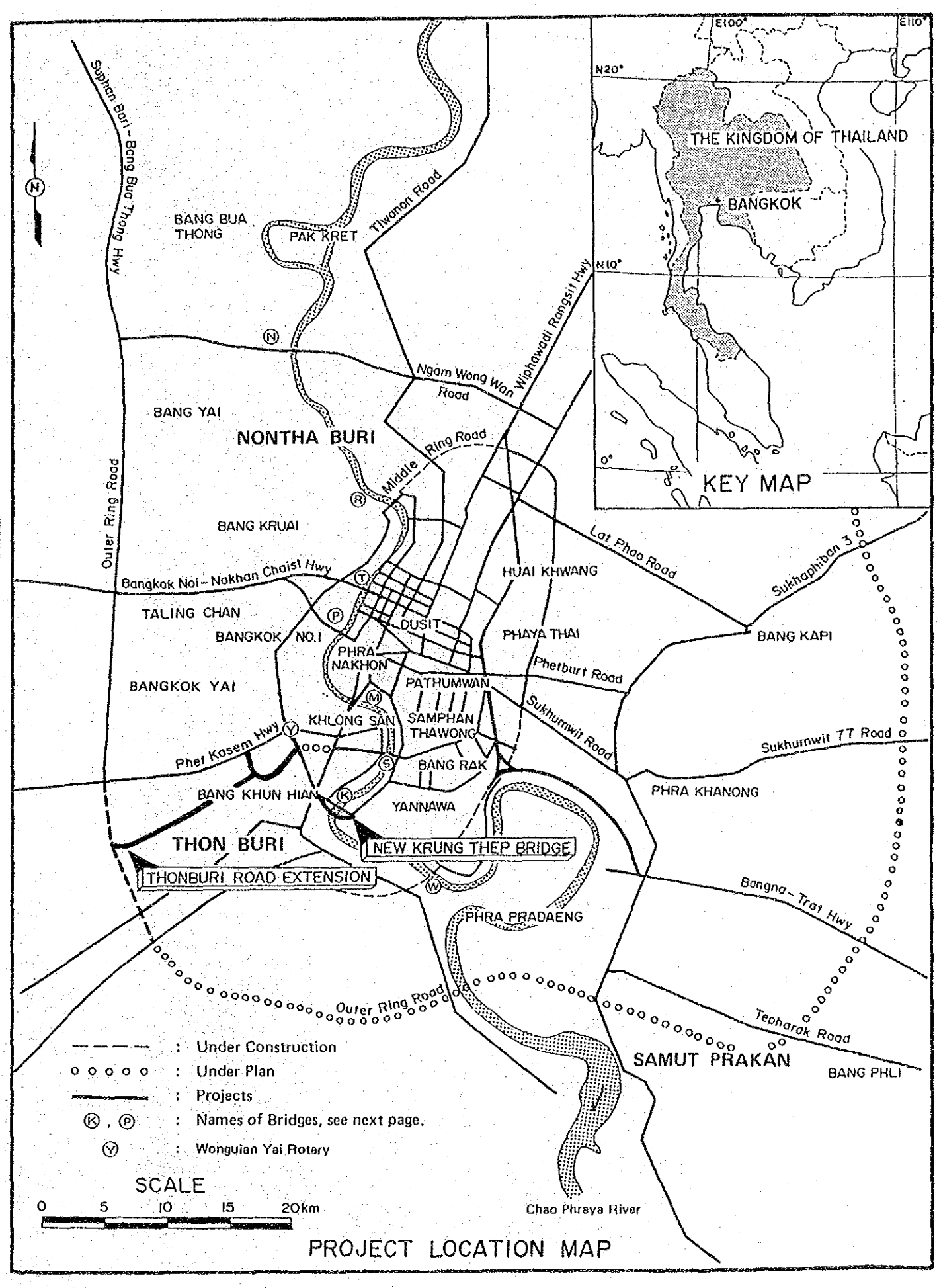
I hope that this report will be useful as a basic reference for development of the Project.

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

June, 1987

Keisuke Arita
President

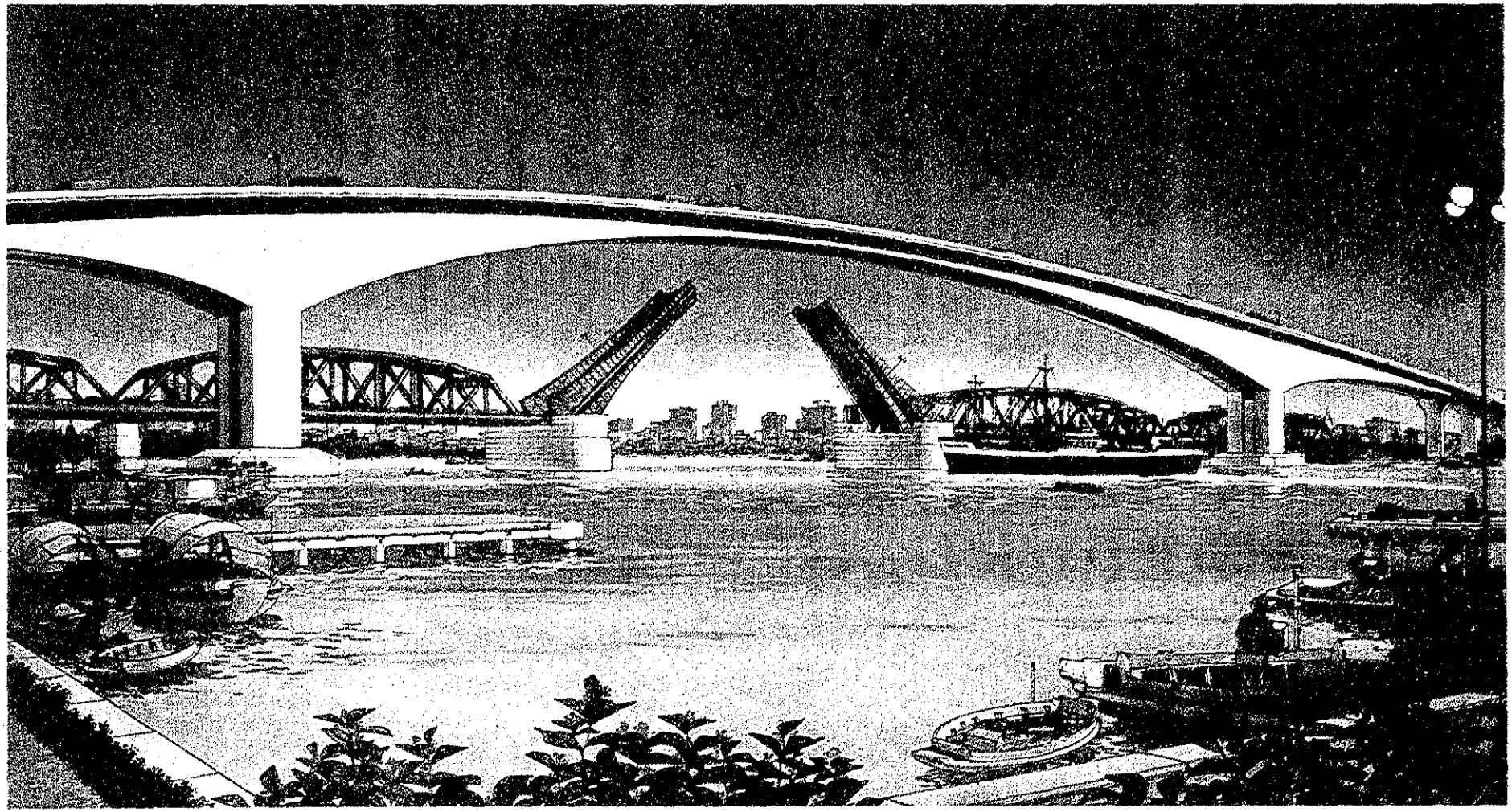
Japan International Cooperation Agency



PROJECT LOCATION MAP

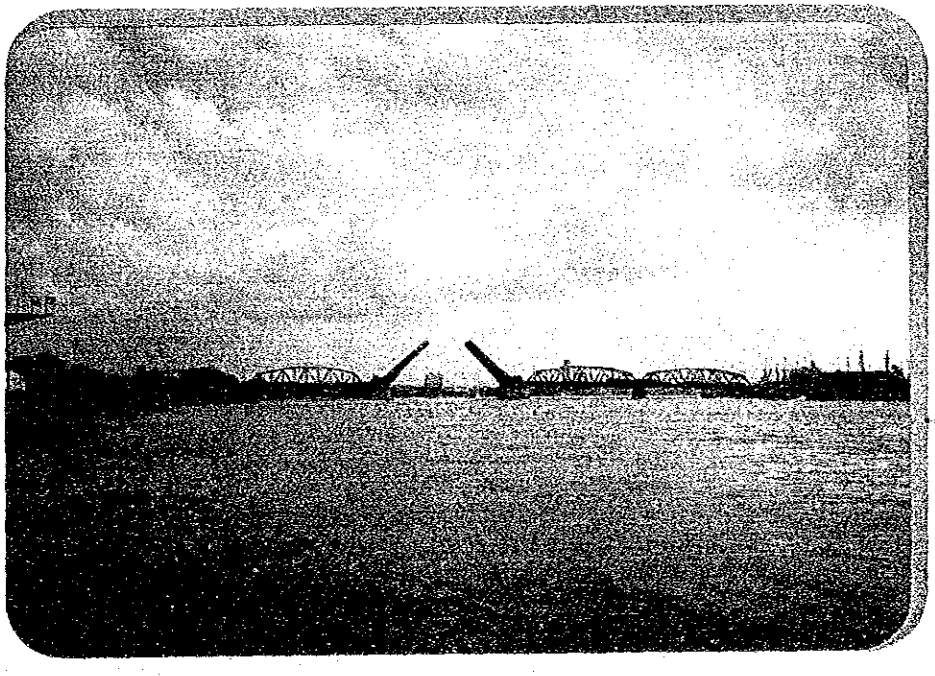
Name of Bridges over Chao Phraya River

(K)	:	Krungthep
(W)	:	Wat Sai (Expressway)
(S)	:	Taksin (Sathorn)
(M)	:	Old & New Memorial
(P)	:	Phra Pin Klao
(T)	:	Krung Thon
(R)	:	Rama VI
(N)	:	New Nonthaburi



Proposed Fixed Type Long Span PC Box Girder Bridge with High Pier,
Down stream View from Thonburi.

RECOMMENDATIONS AND SUMMARY



Feasibility Study on
New Krungthep Bridge Construction and
Thonburi Road Extension

RECOMMENDATIONS AND SUMMARY

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RECOMMENDATIONS AND SUMMARY

A. RECOMMENDATIONS

A.1 New Krungthep Bridge Construction and Thonburi Road Extension Project

It is recommended that the implementation of these projects be commenced as soon as possible, in view of urgent necessity for more traffic capacity in this portion of the Metropolis.

The economic internal rates of return of the New Krungthep Bridge Construction Project and Thonburi Road Extension Project are estimated at 20% and 41% respectively.

A.2 New Krungthep Bridge Construction

It is proposed to construct a new 4-lane bridge next to and downstream of the existing Krungthep Bridge which will be farther used as a 2-lane bridge restricted to passage of light vehicles only. The main features of the project as shown in Fig. S-1 are:

a) Main Bridge
* Type: three span continuous PC box girder
* Length: 442 m (111 m + 220 m + 111 m)
* Navigation clearance: 34 m above MSL in the center

* The Bangkok Dock and other ship repair facilities are assumed not to be moved downstream following the current policy of the Navy.

* Steel cable-stayed girder type may result in a lower cost through competitive bidding and may give better aesthetic view. This type is designated as an alternative because of its inherent higher cost and maintenance requirements.

* The construction of another movable bridge adjacent to the existing one is not recommendable because: a) the danger of pier-destabilizing deep scouring is high judging from the results of bathymetric survey, and b) the length of narrow navigation channel is too long.

b) Approach Structure

	Thonburi Side	Bangkok Side
Approach Bridge (Max. Grade 4%)	787 m	635 m
Approach	126 m	229 m

c) Recommended Opening Year 1991

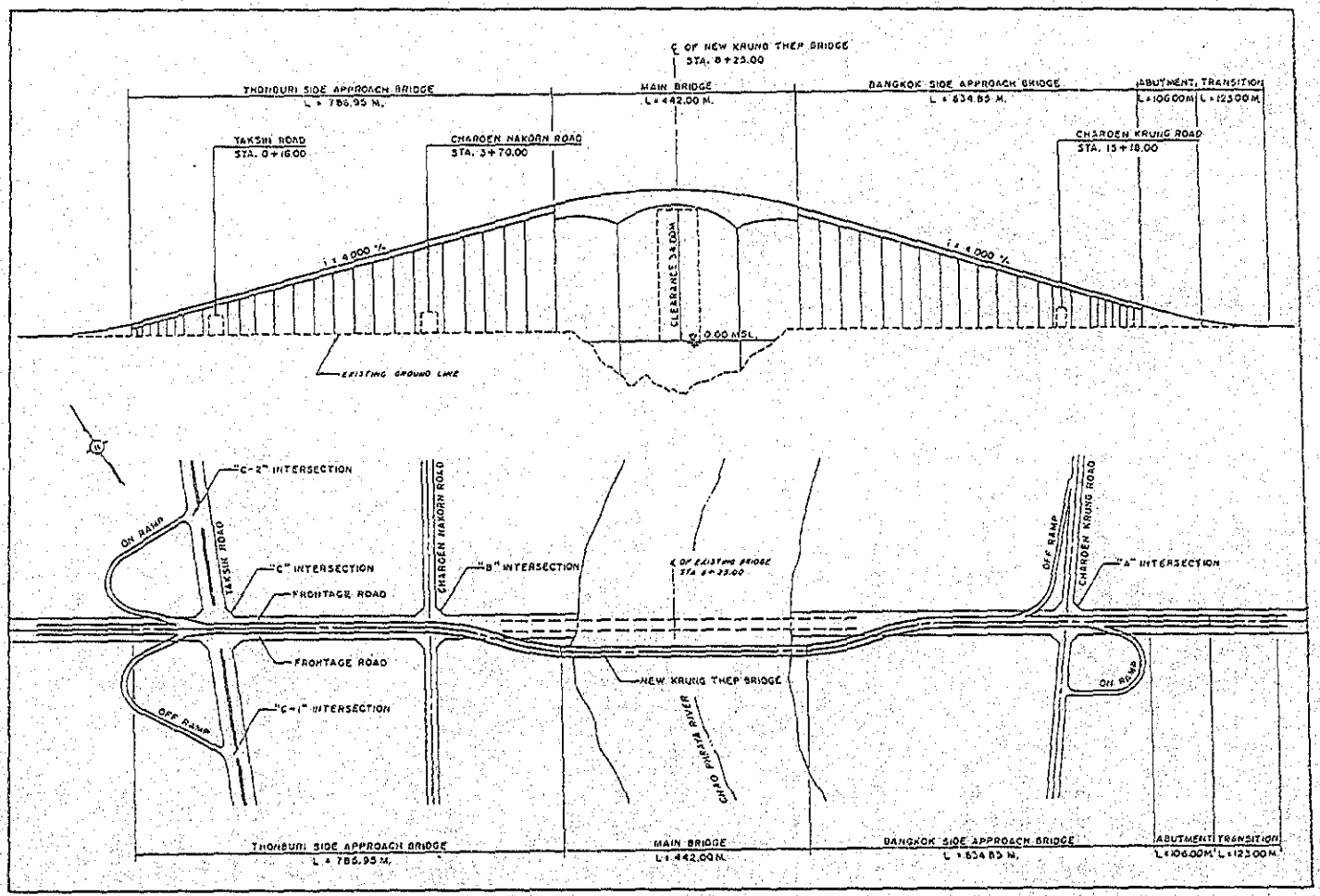

Fig. S-1 Layout of New Krungthep Bridge

A.3 Thonburi Road Extension

It is recommended to implement the Thonburi Road Extension Project in two stages. The layout plan is shown in Fig. S-2.

a) First Stage (Segments A and C)

Construction of a L-shape road linking the Middle Ring Road and the Phet Kasem Highway.

* Width: 6 lanes over a distance of 1.9 km and 4 lanes over 1.4 km
* Type: reinforced concrete pavement road over 1.0 km and viaduct and bridge over 2.3 km
* Intersections with Middle Ring Road, Railway and Wutthakat Road are to be designed as grade separated.
* Recommended opening year: 1991

b) Second Stage (Segment F)

Construction of a road paralleling Phet Kasem Highway and connecting the first stage segment and Outer Ring Road.

* Width: 4 lanes over 6.5 km
* Type: reinforced concrete pavement road
* All intersections are to be designed as at-grade
* Recommended opening year: 1995

A.4 Effects on Other On-going Projects

The New Krungthep bridge will affect traffic on the Wat Sai bridge, which is under construction. However, the future vehicular traffic demand in Bangkok will far surpass the supply of road space including those for river crossing. In any case, effects on the Expressway System including the Wat Sai bridge would be positive in the long run.

The New Krungthep bridge will not have much effects on traffic using the planned Siphraya bridge as the latter will be mostly limited to short distance river crossing traffic.

The western portion of the Thonburi Road Extension will induce significant residential and other development in the vicinity. The role of the road should be viewed more as a development road than a through route and should be differentiated from arterial through routes such as the Outer Ring Road. It is possible that the development in the vicinity may increases traffic on the Outer Ring Road.

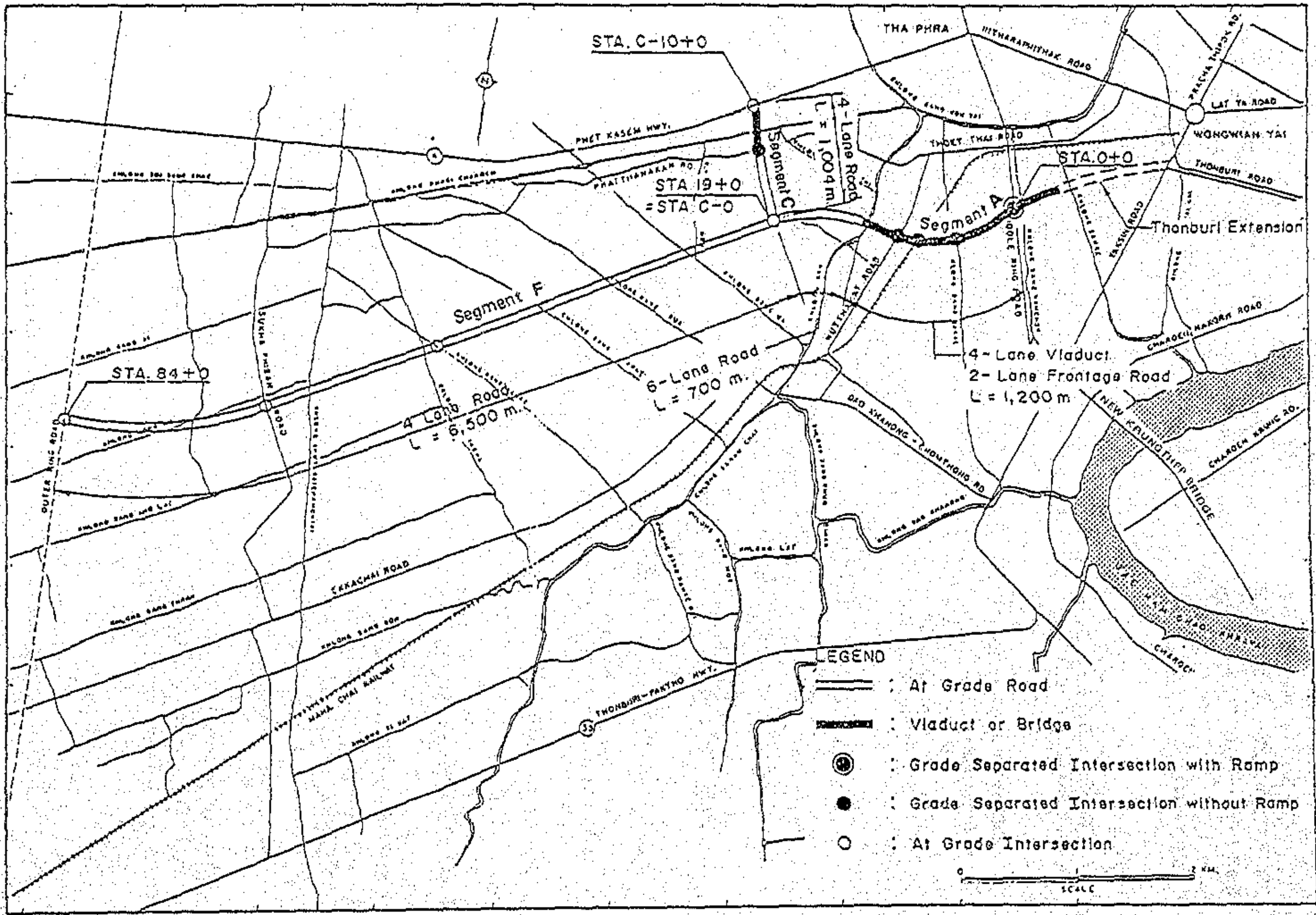

Fig. S-2 Layout of Thonburi Road Extension

B. SUMMARY

B.1 Introduction

B.1.1 Study Background

Recognizing the pressing needs of expanding the capacity of the Krungthep Bridge as it forms an important link of the Middle Ring Road and of improving the road network on the west bank of the Chao Phraya River, the Government of the Kingdom of Thailand requested the Japanese Government to provide an assistance for feasibility study on the enlargement of traffic capacity of the Krungthep Bridge and the extension of the Thonburi Road. In response to the request, the Government of Japan has decided to carry out the feasibility study (hereinafter referred to as "the Study") on the New Krungthep Bridge Construction and Thonburi Road Extension Project.

B.1.2 Objective of the Study

The main objective of the Study which has been carried out by the Japan International Cooperation Agency (JICA) is to determine the optimum schemes of expanding the traffic capacity of the Krungthep Bridge and the alignment and capacity of the Thonburi Road extending westward from the Middle Ring Road.

B.1.3 Study Schedule

Following studies were conducted:

a) March 1986 to August 1986

* Data collection and analysis
* Review of related reports
* Traffic surveys
* Traffic forecasting

b) September 1986 to December 1986

* Field surveys
* Preliminary engineering of bridge and road

c) January 1987 to March 1987

* Construction cost estimates
* Economic evaluation
* Implementation programing

d) April 1987 to June 1987

* Preparation of Final Report

B.1.4 Reports

Following reports were submitted to PWD

* Inception Report, March 1986
* Progress Report (I), May 1986
* Progress Report (II), September 1986
* Interim Report, December 1986
* Draft Final Report, March 1987
* Final Report, June 1987

B.2 Existing Traffic Conditions

The following traffic surveys were carried out

* Traffic volume counts on road sections
* Turning movement counts at intersections
* Roadside interview OD survey
* Home interview survey
* Vehicle speed survey

According to the results of various traffic surveys, the following traffic conditions were observed

a) Traffic Volumes

In the study area, the Taksin Road (80,000), Sathon Nua and Sathorn Tai Road (66,000) and Intharapitak Road (74,000) are three major roads with heavy traffic volumes, followed by the Phet Kasem Road (54,000), Suksawat Road (49,000) and Thonburi-Paktho Highway (48,000). In contrast, the Thoed Thai Road (35,000) and Dao Kanong Road (30,000) should have much less traffic volumes due to their capacity.

As for bridges across the Chao Phraya River, ADT (excluding motorcycle) on the Memorial Bridge and Phra Pokklao Bridge (92,000) is the heaviest, followed by Prapinklao Bridge (89,000), Taksin Bridge (70,000), Krung Thon Bridge (50,000) and Krungthep Bridge (50,000).

b) Hourly Fluctuation

On the Krungthep Bridge, there are two commuting peak hours: 07:00-08:00 and 16:00-18:00. However, there is not so much difference between peak hour and off-peak hour volumes during daytime. In addition, traffic volume towards Yannawa (Bangkok Side) is larger than in the other direction during the whole survey period.

c) Vehicle Composition

The rate of passenger cars and taxis to total traffic flow is about 20%, while motorcycles vary from 25% to 30%, except for the Thoed Thai Road, on which the composition percentages of taxis and motorcycles are as high as 25% and 31%, respectively.

The percentage of heavy vehicles, including 6 wheel and 10-wheel trucks, trailers, minibuses (6 wheels) and heavy buses, is 23% on the Krungthep Bridge while that of light vehicles is 54%.

B.3 Traffic Forecasting

B.3.1 Methodology

The entire Bangkok Metropolitan Region was chosen as the subject of traffic analysis considering the far reaching effects of the proposed projects in congested road networks in Bangkok. The Region was divided into 106 zones with particular attention to the vicinity of the projects. Existing vehicular trip origin and destination tables were established by fully integrating the results of the 1985 vehicle origin and destination surveys carried out by the JICA BMA Traffic Safety Study. The O&D tables were further refined by a computer process which adjusted O&D tables so that volumes obtained as a result of network assignment match actual traffic counts.

Future trip origin and destination tables were estimated on the basis of macro-economic forecasts by NESDB, income elasticities of trip demand by vehicle types and existing trip patterns with due consideration of changes in trip modes including mass transit. Developmental effects of the Thonburi Road Extension were taken into account by means of an analysis of what happened to the vicinity of Bangkok Noi-Nakhorn Chaisri Highway.

An intersection delay model was developed specifically for the Bangkok road network, which is characterized by at or near capacity conditions at many intersections. The traffic assignment model used in this study required as much as 40 incremental assignments for a single run because of near capacity conditions of many intersections. The model suspends further assignment of any O&D pair when no alternative route is available without going through a link already at capacity or the alternative route is unreasonably long. The network traffic assignments were done on the hourly basis for three periods: morning peak, evening peak and off-peak hours.

It was found that by the year 2011 only one half of trip demand to and from the central area of Bangkok can be accommodated by the road network currently planned.

B.3.2 Traffic Forecasts

Traffic forecasts were made for all road links and selected intersections by turning directions for the three target years of 1991, 2001 and 2011. Table S-1 summarizes the forecast volumes of the proposed facilities.

Table S-1 Forecast Traffic Volumes

(PCU/Morning Peak Hour)

		Traffic Volume 1991	2001	2011
Existing Krungthep Bridge		-*	570	690
		-#	700	1600
New Krungthep Bridge		-	3200	3100
		-	2800	3600
Thonburi Road Extension	Segment A	2800	4700	4900
		3500	4100	4100
	Segment C	1700	2100	2100
		2400	2300	2300
	Segment F	-	1900	2700
		-	900	1800

* (upper) to Bangkok
\# (lower) to Thonburi

Note:

The above traffic volumes by PCU/Hour of year 2011 are converted into ADT as follows:

* Existing Bridge as 2-lane Bridge, 37,000 ADT (Both directions)
* New Bridge as 4-lane Bridge, 134,000 ADT (Both directions)
* Thonburi Road Extension Segments A&C, 160,500 ADT (Both directions)
* Thonburi Road Extension Segment F, 28,000 ADT (Both directions)

B.4 Field Surveys

Following field surveys were carried out in July to October 1986 by the Study Team.

* Topographic survey along the proposed route
* Building condition survey
* Subsurface investigation
* Bathymetric survey

Three 70 m-deep boreholes were drilled at the site of the Krungthep Bridge and another three of 25 m each were done along the proposed Thonburi Road Extension for investigation f soil conditions.

The foundation of the New Krungthep Bridge is planned to be supported by the dense sand layer of about -55 m from MSL.

The findings about the local scouring downstream of the existing main piers gave much effect on the selection of a bridge type for the New Krungthep Bridge.

B.5 Bridge Alternative Study

B.5.1 Identification of Bridge Alternatives

Various alternative schemes were formulated and evaluated, and schemes inferior to others were eliminated from further considerations. In the Progress Report (I) issued in May 1986 twenty two alternatives were identified and preliminary evaluation was made. In the Progress Report (II) issued in September 1986 seven alternatives of A through G were identified and examined. They included low fixed bridges, low movable bridges, and high fixed bridge with varying use of the existing bridge including its complete removal. Three alternatives --alternative D, E and G -- were selected for further study and the results were presented in the Interim Report issued in December 1986. The outline of alternatives D, E and G are summarized in Table S-2

Table S-2 Bridge Alternative Plan

Alternative		Type of Br.	Clearance (m + MSL)	Removal of River Facility	Reinforced Existing Br.	Center Span Length (m)	Bridge Material
D	1	Fixed	7.5	Necessary	No need	75	concrete
	2	Fixed	7.5	Necessary	No need	75	concrete
	3	Fixed	7.5	Necessary	Necessary	75	concrete
E	1	Movable	7.5	No need	No need	90	steel
	2	Movable	7.5	No need	No need	80	steel
	3	Movable	7.5	No need	No need	90	steel
G	1	Fixed	34	No need	No need	220	concrete

B.5.2 Evaluation and Conclusion of Alternatives

The evaluation of alternatives was carried out taking into account the following considerations

* Internal rate of return
* Land acquisition problems
* River facilities conditions
* Navigation safety
* Risk due to river hydrology
* Motoring public image
* Appearance

In order to determine the most recommendable plan, overall evaluation was made based on the evaluation criteria and weights shown in Table S-3. The results are shown in Table S-4. Judging from this table, the alternative G-1 is recommended.

B.5.3 Necessity of a New Krungthep Bridge

Construction of the New Krungthep Bridge is necessary for the following reason:

- The existing Krungthep bridge is of bascule type. It has been evaluated, however, that excessive stress of the bascule girders are 48% of the allowable stress under the load of HB-45 unit, and there is no way to strengthen it unless the bascule girders are closed to form a fixed type bridge; and

- The traffic of 50,000 ADT in 1986 of the existing 4-lane bridge with a 12-meter carriageway is already saturated in 1986 and this may impair the aged bridge unless light vehicles only are allowed and the bridge be used as 2-lane bridge. On the other hand, the replacement of the existing bridge by a new one will cause a loss of 740 million Baht per year during the construction period in BMR. The above proves the necessity of a New Krungthep Bridge as soon as possible besides the existing one to secure the traffic capacity of the 6 - 8 lane MRR link.

Table S-3 Evaluation Criteria and Weights

Criteria	Score 1	2	3	4	5	Weight
1. Internal Rate of Return	less than 8%	8 - 12%	12 - 0.18%	18 - 25%	over 25%	0.60
Plans Ranked				All plans		
2. Land Acquisition	Very difficult	Fairly difficult	A little difficult	No difficulty	Not required	0.06
Plans Ranked		D-2, E-3	D-1, D-3 E-1, G-1.	E-2		
3. River Facility, Moving (Bangkok Dock, Private)	Extremely difficult	Fairly difficult	Difficult	No need	No relations	0.10
Plans Ranked	All Plan D			G-1	All Plans E	
4. Navigation Safety	Impossible	Poor	Fair	Good	Excellent	0.08
Plans Ranked	All Plans D	E-2	E-3	E-1	G-1	
5. Risk Due to River Hydrology	Very High	High	Medium	Low	None	0.10
Plans Ranked		E-3	E-1, E-2.	All Plans D	G-1	
6. Motoring Public Image	Very Poor	Poor	Fair	Good	Excellent	0.03
Plans Ranked		All Plans E	G-1	D-1, D-2	D-3	
7. Appearance	Very Poor	Poor	Fair	Good	Excellent	0.03
Plans Ranked			E-3, G-1	D-1, D-2	D-3, E-2	

Table S-4 Overall Evaluation by Weighted Score

Evaluation/Plans	Alternative D D-1	D-2	D-3	Alternative E E-1	E-2	E-3	Stage. Con. E-1	E-3	Alt. G G-1	Score/Weight
1) Internal Rate of Return	4	4	4	4	4	4	4	4	4	1-5 / 60%
2) Land Acquisition	3	2	3	3	4	2	3	2	3	1-5 / 6%
3) River Facilities Moving	1	1	1	5	5	5	5	5	4	1-5 / 10%
4) Navigation Requirement	1	1	1	4	2	3	4	3	5	1-5 / 8%
5) Risk due to River Hydrology	4	4	4	3	3	2	3	2	5	1-5 / 10%
6) Motoring Public Image	4	4	5	2	2	2	2	2	3	1-5 / 3%
7) Appearance	4	4	5	4	5	3	4	3	3	1-5 / 3%
Total Weighted Score	3.40	3.34	3.46	3.88	3.81	3.61	3.88	3.61	4.03	

1	G-1	4.03 points
2	E-1 (Stag-wise)	3.88 points
3	E-2	3.81 points
4	E-3 (Stag-wise)	3.61 points
5	D-3	3.40 points
6	D-1	3.40 points
7	D-2	3.34 points

B.6 Preliminary Design of New Krungthep Bridge

B.6.1 Design Criteria

a) Navigation Clearance

Navigation requirements were investigated in detail. It was found that no ship movements, present and future, would be affected if the vertical clearance (VC) is set at 34 m above MSL. Virtually all ships of significant size entering the area upstream of the Krungthep Bridge are for repair, except for those of the Fisheries Department and Shaw Wanakit Company.

Lateral clearance requirements were also examined. The existing pier opening of 60 m is considered adequate for the largest ship passing through this waterway. The distance of the narrow channel between the New Krungthep Bridge and the existing one, however, should not be more than 60 m.

b) Live Load

The HA and HB-45 unit loadings as specified in "6. Highway bridge live loads" of BSI BS 5400 were adopted.

B.6.2 Preliminary Design

The results of preliminary design are presented in "Drawings" which contain the following.

* A maximum longitudinal gradient of 4% is adopted.
* The bridge is designed to have 4 lanes.
* Main bridge: PC box girder type of 442 m in total (= 111 m + 220 m + 111 m).
* Approach bridge in Thonburi side: PC box girder of average 35 m span and continuous hollowed RC slab of 787 m in total.
* Approach bridge on Bangkok side: PC box girder of average 35 m span and continuous hollowed RC slab of 635 m in total.
* Interchanges and Access Road on Thonburi and Bangkok sides with a total 880 m of rampway and 355 m of access road of abutment structure with its transition slab to prevent sedimentation
* Construction materials of main items are shown in Table S-5 and construction cost is given in Table S-6.
* The outline of design is shown in Fig. S-1.
* The construction schedule is shown in Fig. S-3.

Table S-5 Main Materials for New Krungthep Bridge Construction

Item / Site	Main Bridge	Approach Bridge	Others	Total
Concrete cu.m				
fc = 350 kgf/sq.cm	13,890	18,310	1,710	33,910
fc = 300 kgf/sq.cm	13,370	-	-	13,370
fc = 240 kgf/sq.cm	10,120	23,220	6,040	39,380
Total cu.m	37,380	41,530	7,750	86,660
Cement ton				
0.38 ton/cu.m	14,200	15,780	2,950	32,930
PC Tendon ton	1,270	1,730	160	3,160
Re-bar ton	3,470	5,940	1,260	10,670
Embank cu.m	-	-	13,500	13,500
PC pile 0.6 m dia.	-	35,550	9,350	44,900
RC pile 0.2 x 0.2 m	-	-	9,600	9,600

Table S-6 Construction Cost

(Unit: 1,000 Baht)

Construction cost	1,500,000
Engineering services	150,000
Land acquisition and compensation	235,000
Total	1,885,000

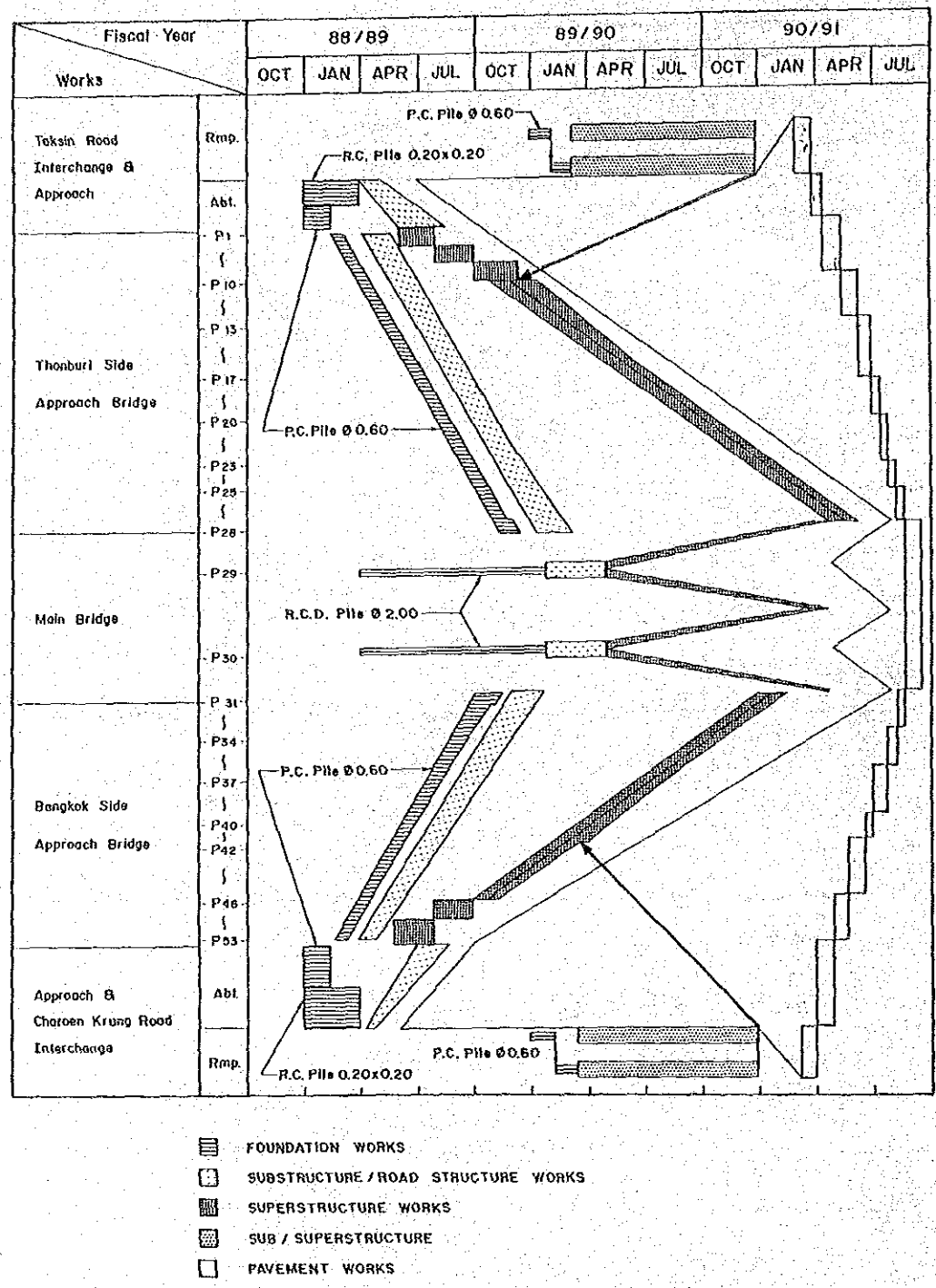

Fig. S-3 **Construction Schedule of New Krungthep Bridge**

B.7 Alternative Route Study

B.7.1 Route Location

The alternative route location was carried out using the aerial photographs with a scale of 1:6000 and by means of careful reconnaissance survey. Various alternative routes are shown in Fig. S-4.

a) Area between MRR and Wuttakat Road

* Segment A
* Segment B

b) Junction with Phet Kasem Highway

* Segment C
* Segment D
* Segment K
* Segment S

c) Junction with Outer Ring Road

* Segment E
* Segment F
* Segment G

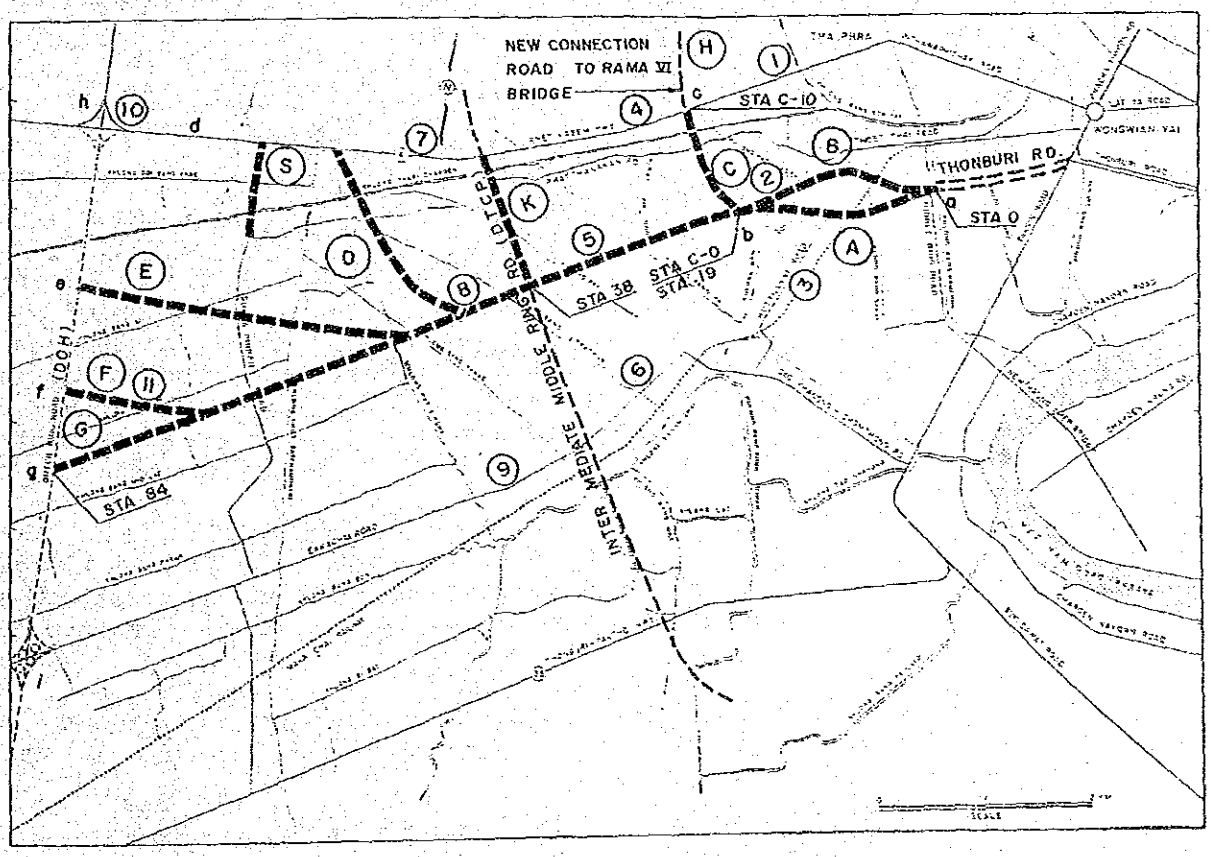

Fig. S-4 Alternative Route Segment

B.7.2 Evaluation of Alternative Routes

The alternative routes were evaluated under various aspects including effects on traffic, economic return, and technical feasibility. Table S-7 shows the results of economic evaluation on the selection of junction with the Phet Kasem Highway. As a result of the various comparison studies, the segments A, C and F were selected as the best combination.

Table S-7 Benefit/Cost Ratio by Different Access Points

	No TRE	TRE Access Plans					
		C	K	D	S	F	C+F
Total Traffic Cost	10.460	10.301	10.306	10.326	10.320	10.312	10.289
Traffic Benefit	-	0.159	0.154	0.134	0.140	0.148	0.171
Construction Cost	-	1.654	2.003	2.323	2.275	2.203	3.857
Ratio (Benefit Cost)	-	0.096	0.077	0.058	0.062	0.067	0.044

Note: Traffic costs are for 1991 morning peak period in million Baht per hour. Benefits are in million Baht per hour. Construction costs are in billion Baht.

B.7.3 Necessity of Extending the Thonburi Road

Extending the Thonburi road is necessary for the following reason:

- The existing Thonburi Road constitutes a direct access to the Taksin bridge with 6-lane carriageway. The construction of a L shape short bypass of 3.3 km between the Phetkasem highway and the existing Thonburi road which will be connected with MRR is necessary to divert the traffic from the Taksin road - Wonguian Yai round about in Thonburi area which has been most seriously congested in BMR;

- Extending the Road of 6.5 km up to ORR in parallel with the Phet Rasem highway will enhance accessibility in the area, and realize a significant amount of new development, along the route due to short distance from the developed center of Bangkok; and

- This extension will play a roll as a bypass for Phet Kasem Highway and Ekkachai road or Thonburi-Paktho Highway in the Thonburi area.

B.8 Preliminary Design for Thonburi Road Extension

The results of preliminary design are presented in "Drawings" which contain the following.

* STA 0 - STA 12:
  4-lane viaduct with noise barrier and 1-lane frontage roads on both sides.

* STA 12 - STA 19:
  6-lane road with sidewalk, average embankment height of about 1.0 - 1.5 m.

* STA 19 - STA 84, STA C-0 - STA C-10:
  4-lane road with sidewalk, average embankment height of about 1.5 - 2.0 m.

* Intersection with MRR grade separated, and others at-grade.

* Construction materials by main items are shown in Table S-8 and construction costs are given in Table S-9.

* The layout plan is shown in Fig. S-2.

Table S-8 Main Materials for Thonburi Road Extension A&C Segment

Item / Site	Main Bridge	Approach Bridge	Others	Total
Concrete cu.m				
fc = 350 kgf/sq.cm	1,200	14,220	1,730	17,150
fc = 240 kgf/sq.cm	3,850	19,860	4,770	28,480
Total cu.m	5,050	34,080	6,500	45,630
Cement ton				
0.38 ton/cu.m	1,920	12,950	2,470	17,340
PC Tendon ton	70	860	110	1,040
Re-bar ton	700	4,290	880	5,870
Embank cu.m	1,000	173,400	45,540	219,940
PC pile 0.6 m dia.	8,300	64,260	10,530	83,090
RC pile 0.2 x 0.2 m	2,300	7,680	6,140	16,120
Steel of Bridge ton	300	-	-	300

* Main materials for Segment F are pavement concrete of 21,100 cu.m and embakment of 575,600 cu.m.

Table S-9 Construction Cost

(Unit: 1,000 Baht)

	Segment A&C	Segment F	Total
Construction cost	1,140,000	530,000	1,670,000
Engineering services	114,000	37,000	151,000
Land acquisition and compensation	399,000	249,000	648,000
Total	1,653,000	816,000	2,469,000

* The slow banking method was adopted for the construction method considering soft soil foundation, economic and technical aspects. The construction schedule is illustrated in Fig. S-5.

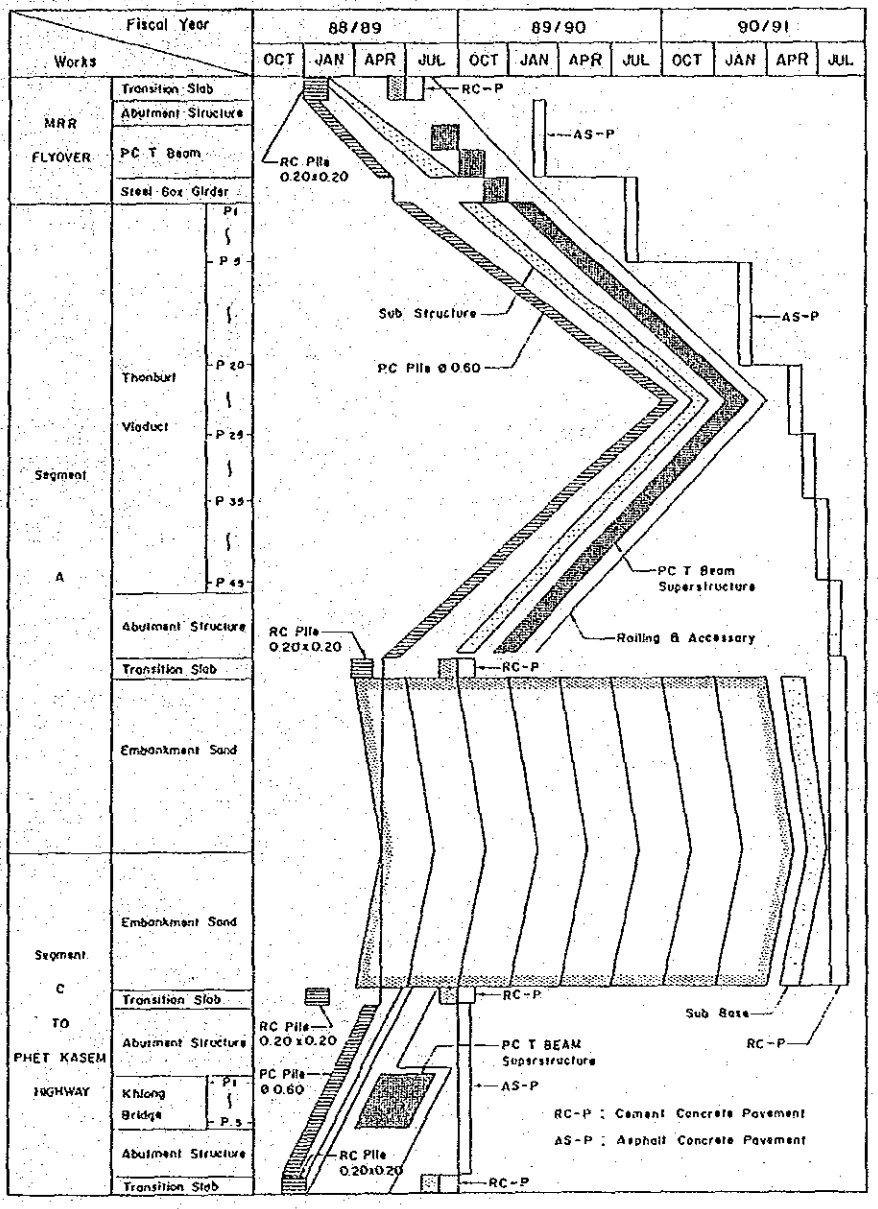

Fig. S-5 Construction Schedule of First Stage Thonburi Road Extension

B.9 Economic Evaluation

B.9.1 New Krungthep Bridge

Economic evaluation of the New Krungthep Bridge proved that the project is feasible showing a IRR value of 20% for the opening year in 1991.

If the total project cost overruns by 15%, the internal rate of return would drop to 18.9% and likewise it would be 18.6% if the benefit stream is uniformly 15% less. In either case the project is still economically justifiable.

Table S-10 Economic Evaluation of New Krungthep Bridge

Case	Net Present Value at 12% (million Baht)	B/C Ratio at 12%	Internal Rate of Return %
Base	1247	2.09	20.71
Cost 15% up	1075	1.82	18.86
Benefit 15% down	888	1.78	18.57

B.9.2 Thonburi Road Extension

The results of economic evaluation of the following three cases are shown in Table S-11. Each case is illustrated in Fig. S-6.

Case 1: Segment A and C will be constructed in 1991.

Case 2: Segment A, C and F will be constructed in 1991.

Case 3: Segment A and C will be constructed in 1991 and Segment F in 2001.

All cases were proved to be feasible.

Table S-11 Economic Evaluation of Thonburi Road Extension

Case	Segment 1991	Segment 2001	Net Present Value (million Baht)	B/C Ratio	IRR %
1	A+C	-	4,073	4.83	41.75
2	A+C+F	-	4,092	3.55	33.40
3	A+C	F	4,092	4.35	41.46

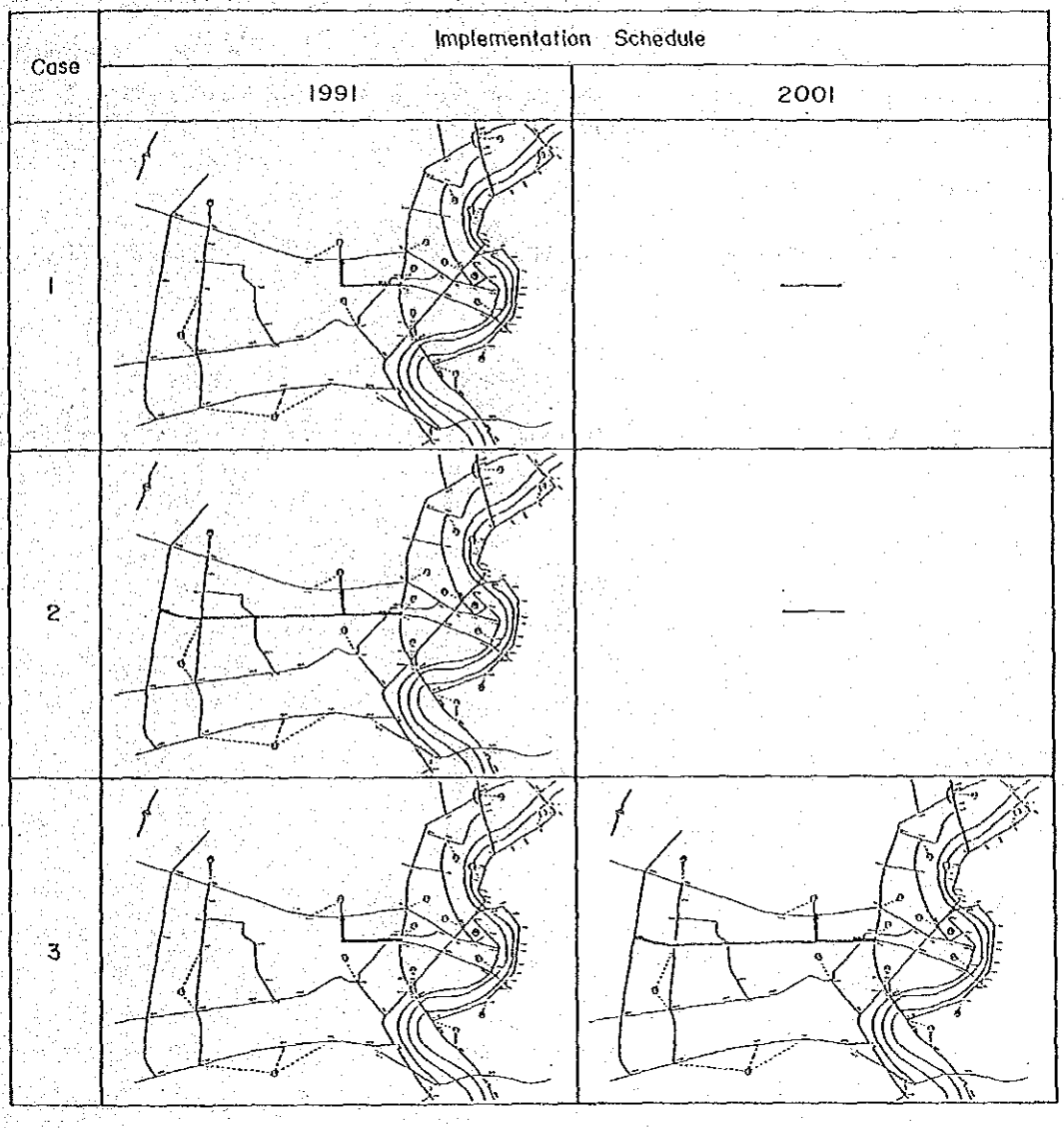

Fig. S-6 Implementation Schedule for Each Case

B.10 Implementation Program

B.10.1 Implementation Schedule

The opening year of both the projects is planned to be 1991/1992 fiscal year. The second stage of the Thonburi Road Extension Project should immediately follow the completion of the first stage.

The implementation schedule by year for the New Krungthep Bridge Project and the Thonburi Road Extension Project is shown in Fig. S-6.

B.10.2 Fund Requirements

The fund requirements by year for the New Krungthep Bridge Project and the Thonburi Road Extension Project are shown in Table S-12.

Table S-12 Fund Requirements

(Unit: 1,000 Baht, 1986 price)

Items / Fiscal Year	1988	1989	1990	1991	1992	1993	1994	1995
1. New Krungthep Br.								
a. D/D & Tender	45,000	-	-	-				
b. Land Acquisition	235,000	-	-	-				
c. Supervision	-	31,500	42,000	31,500				
d. Construction	-	507,064	492,737	500,199				
Subtotal	280,000	538,564	534,737	531,699				
2. Thonburi (Stage1)								
a. D/D & Tender	34,200	-	-	-				
b. Land Acquisition	399,000	-	-	-				
c. Supervision	-	23,940	31,920	23,940				
d. Construction	-	293,619	618,364	251,957				
Subtotal	433,200	317,559	650,284	251,957				
3. Thonburi (Stage 2)								
a. D/D & Tender					13,250	-	-	-
b. Land Acquisition					249,000	-	-	-
c. Supervision					-	4,770	11,925	7,155
d. Construction					-	157,185	230,582	142,233
Subtotal					262,250	161,955	242,507	149,388
Total	713,200	856,123	1,185,021	783,656	262,250	161,955	242,507	149,388

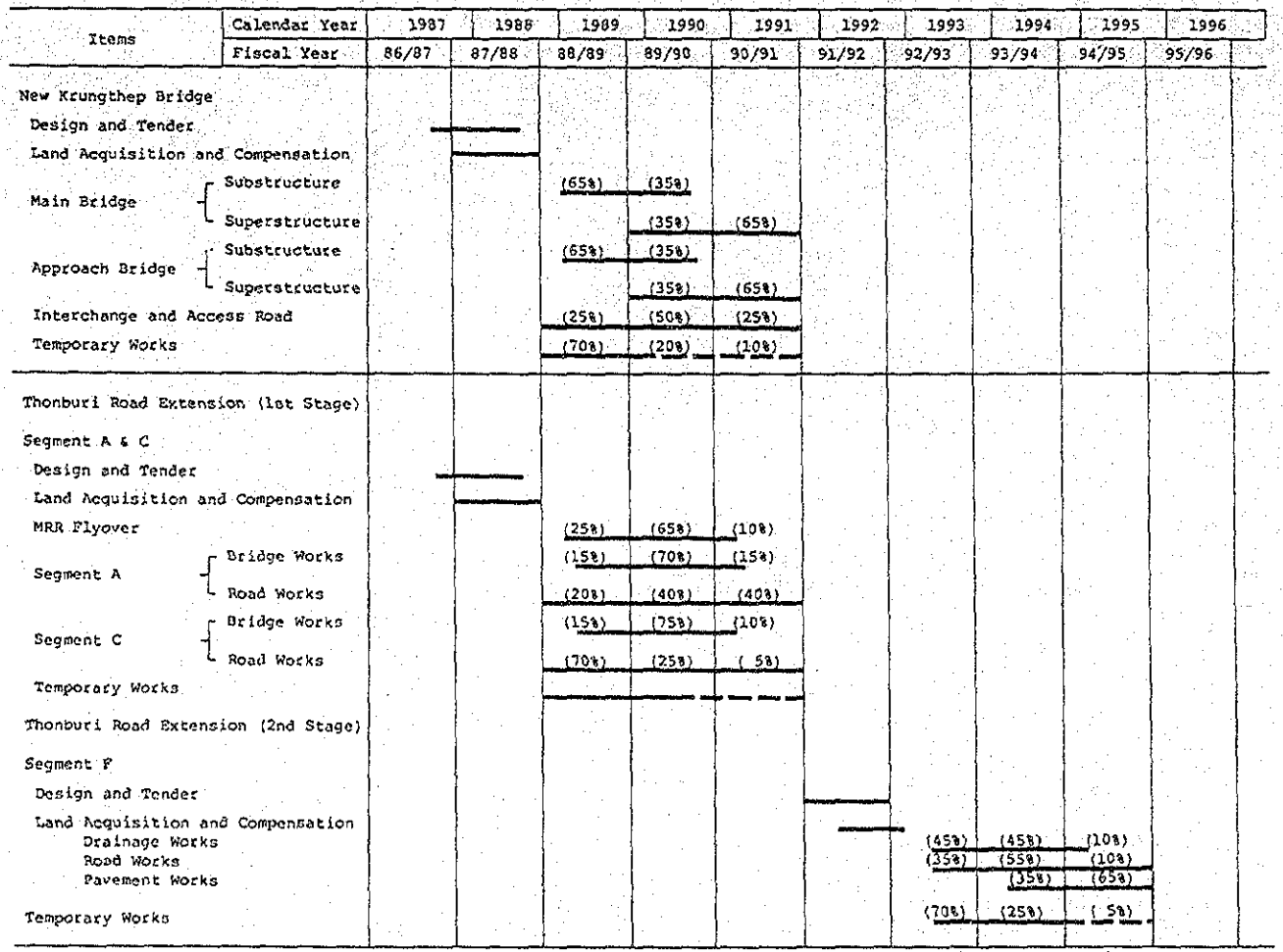

Fig. S-7 Implementation Schedule

Feasibility Study on
New Krungthep Bridge Construction and
Thonburi Road Extension

Final Report

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PART IV THONBURI ROAD EXTENSION

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ABBREVIATIONS

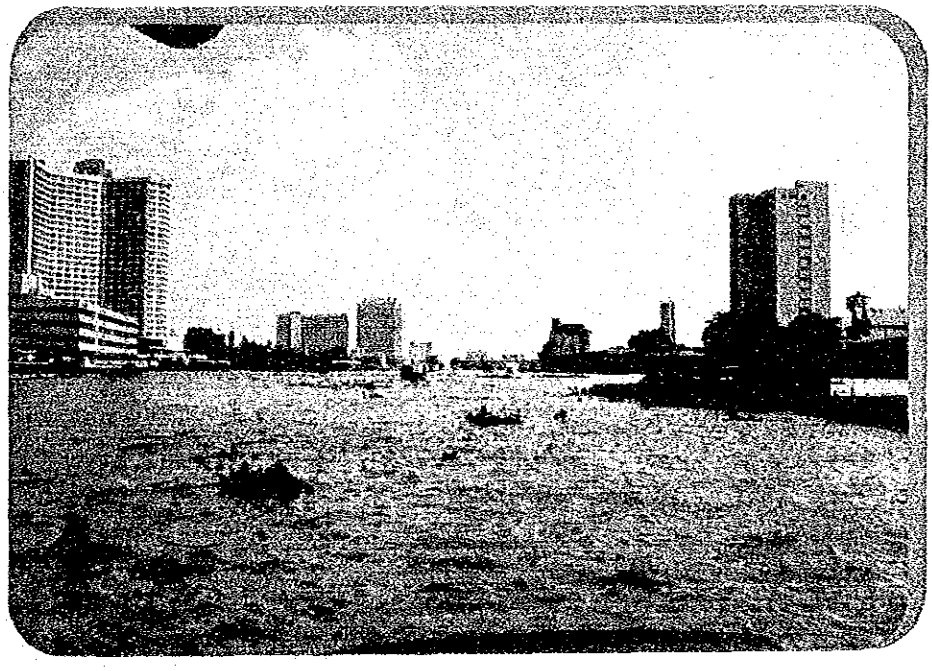
A	parameter of clothoid curve
AASHTO	The American Association of State Highway and Transport Officials
ADT	average daily traffic
B/C	benefit cost ratio
BMA	Bangkok Metropolitan Administration
฿	Baht (Thai currency)
BMR	Bangkok Metropolitan Region
BSI	British Standards Institute
BTS	Bangkok Metropolitan Study
C.C	construction cost
C.degree	degree celsius
CBD	central business district
cm	centimeter(s)
cum	cubic meter(s)
D/D	detailed design
DDS	Department of Drainage and Sewerage
dia.	diameter
DIN	Deutsche Industrie Normen
dB(A)	decibel
DOH	Department of Highway
DTCP	Department of Town and Country Planning
EIS	Environmental Impact Statement
EP	evening peak
E.S	Engineer Services
ETA	Expressway and Rapid Transit Authority of Thailand

Exist.	existing
fc	extreme fiber compressive stress in concrete
Fig.	figure
FMO	Fish Marketing Organization
F/S	feasibility study
GDP	gross domestic products
GT	gross tonage
h	hour(s)
HD	Harbour Department
HWL	high water level
IEE	Initial Environmental Examination
I.MRR	Intermediate Middle Ring Road
IRR	Internal Rate of Return
JICA	Japan International Cooperation Agency
JIS	Japan Industrial Standards
JRA	Japan Road Association
kgf	kilogram(s) weight
km	kilometer(s)
kgf/sq.cm	kilogram(s) weight per square centimeter
kgf/sq.m	kilogram(s) weight per square meter
km/h	kilometer(s) per hour
L.A	land acquisition
LDPD	Licences Division of Police Department
m	meter(s)
MOD	Ministry of Defence
MOI	Ministry of Industry
M & O.C	maintenance and operation cost
MP	morning peak

mph	mile(s) per hour
MRR	Middle Ring Road
MSL	mean sea level
N.A	not available
NC	navigational clearance
NEB	National Environmental Board
NESDB	Office of the National Economic and Social Development Board
nos	numbers
OCMRT	office of the Committee for the Management of Road Traffic
OD	origin and destination
OP	off peak hour
ORR	Outer Ring Road
Pa	pascal(s)
PC	prestressed concrete
PCU	passenger car unit
PCU/H	passenger car unit per hour
PWD	Public Works Department
R	radius
RC	reinforced concrete
RCD	reverse circulation drilling method
s	second(s)
SES	Second Stage Expressway System in Bangkok Study
SPT	standard penetration test
sq.cm	square centimeter(s)
sq.wa	square wa, equivalent to 4 square meters
STA	station
STTR	Short Term Urban Transport Review
tf	ton(s) weight

tf/sq.m	ton(s) weight per square meter
TIS	Thailand Industrial Standards
TRE	Thonburi Road Extension
VC	vertical clearance
V/D	vehicle(s) per day
V/H	vehicle(s) per hour

PART I
INTRODUCTION



CHAPTER 1

INTRODUCTION

1.1 Study Background

Recognizing the pressing needs of expanding capacity of the Krungthep Bridge as it forms an important link of the Middle Ring Road and of improving of the road network on the west bank of the Chao Phraya River, the Government of the Kingdom of Thailand requested the Japanese Government to provide an assistance for a feasibility study on enlargement of traffic capacity of the Krungthep Bridge and extension of the Thonburi Road. In response to the request, the Government of Japan has decided to carry out the feasibility study (hereinafter referred to as "the Study") on the New Krungthep Bridge Construction and Thonburi Road Extension.

The Government of Japan entrusted the Study to the Japan International Cooperation Agency (hereinafter referred to as "JICA") the official agency responsible for the implementation of the technical cooperation programs of the Government of Japan, and JICA has organized an advisory committee (hereinafter referred to as "the Advisory Committee" and a study team (hereinafter referred to as "the Study Team") for the said purpose.

Upon arrival of three members of the Study Team and three members of the Advisory Committee at the site, the Study was commenced on March 5, 1986. By the middle of March 1987 the Study has been completed. This Final Report describes the work executed in the course of the Study and presents the conclusions, elaborated based on the kind comments by the Government of Thailand.

1.2 Objectives and Scope of the Study

The objectives and scope of the Study are stated in the Scope of Work signed between the Public Works Department (hereinafter referred to as PWD) and JICA on November 6, 1985. The document is attached in Appendix 1.2.1.

In essence the Study aims to determine the optimum schemes of implementing the Krungthep Bridge and Thonburi Road Extension by means of comparing various alternatives including the do-nothing case. Clarifications concerning the details of the scope of the Study were made during the first week through discussions with PWD officials as recorded in the minutes of discussion dated March 10, 1986, also attached in Appendix 1.2.2. At that time, PWD requested that the Study Team examines, the feasibility of a new road connecting the proposed approach road to the new Rama VI Bridge and Thonburi Road Extension at a prefeasibility study level. The Study Team carried out this additional work and the results are presented in Appendix 1.2.3 as well.

1.3 Work Schedule

The Study was divided into three phases as follows:

- Phase I Study : Fundamental Information and Data Collection
- Phase IIA Study : Thonburi Road Extension Study
- Phase IIB Study : Krungthep Bridge Study

Phase I study lasted six and a half months and was followed by Phase IIA and IIB studies which were carried out concurrently for 6 months. General work flow and schedule are shown in Fig. 1.3.1.

1.4 Study Organization

The Study has been carried out by the Study Team under the supervision of the Advisory Committee organized by JICA, which comprised Japanese government officials and was directed by Mr. Tajiri and later by Mr. Enami. The Study Team, headed by Mr. Oshima and consisting of 9 experts from Nippon Koei Co., Ltd. and Central Consultants Co., Ltd., has kept close collaboration with the counterpart team organized by PWD.

The organization of the Study is illustrated in Fig. 1.4.1.

1.5 Acknowledgements

The Study Team's special thanks are hereby expressed to the PWD's team of counterparts under the guidance of the Director General Khun Pojana Kantamala. Without their constant support and timely guidance the Study could not have proceeded. The Study Team would like to reiterate its sincere appreciation to:

Khun Chinda Kulwato,
Dr. Voravit Lertluksana,
Khun Utra Amatayakul,
Khun Vitoon Janviriyakul,
Khun Dhongchai Tejasen

The Team also would like to thank the members of the Project Steering Committee comprising representatives of various government agencies concerned, who have provided valuable guidance to the Study Team at crucial points during the course of the Study.

The Study Team has obtained information from a large number of people during the course of the Study, officials of other government agencies, contractors, consultants, and other people in related fields of private sector. The Study Team has received full cooperation in almost all occasions. It is impossible to name all those involved in this space, but the Study Team would like to express its sincere thanks to them all, to the end but not at least.

Order of Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Year Month	1986 MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	1987 JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE

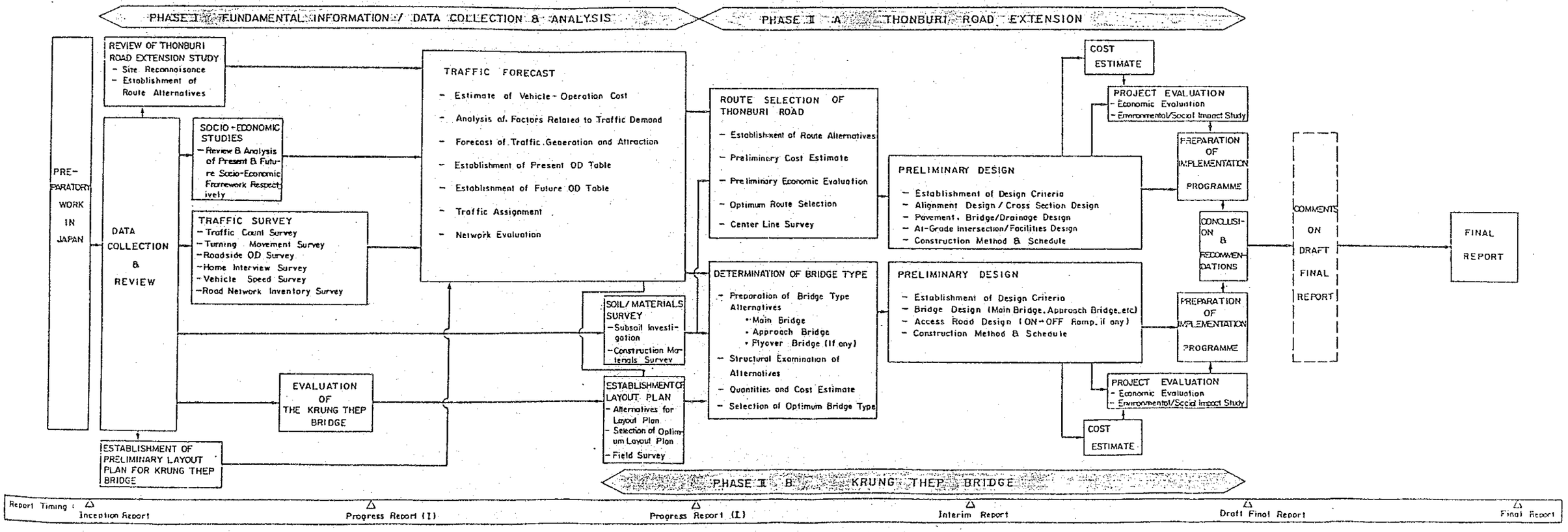


Fig. 1.3.1 Work Flow for the Study

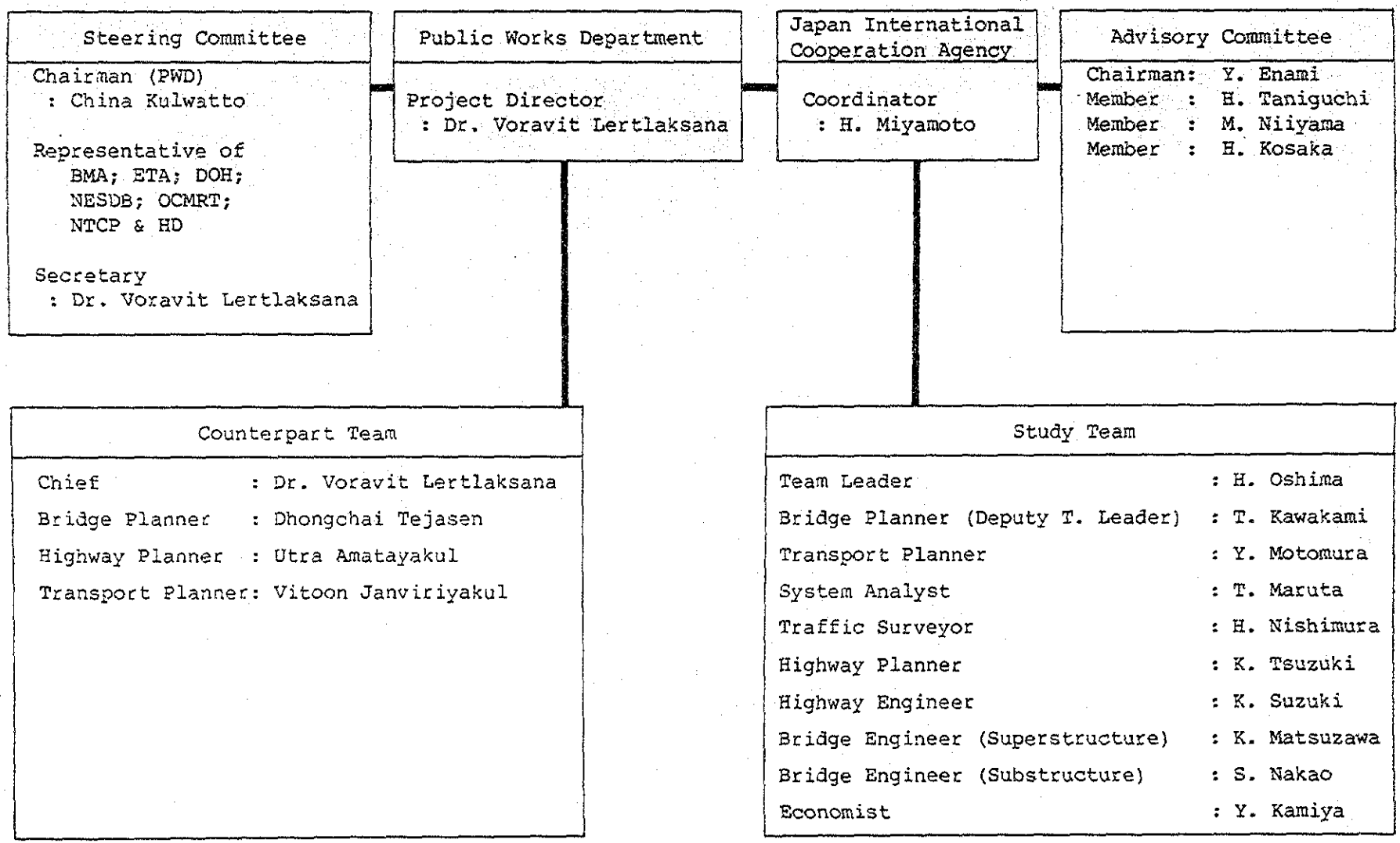


Fig. 1.4.1 Organization Chart