

**DEPARTMENT OF RURAL ROADS
MINISTRY OF TRANSPORT
KINGDOM OF THAILAND**

**PREPARATORY SURVEY
FOR
THE CHAO PHRAYA RIVER
CROSSING BRIDGE AT
NONTHABURI 1 ROAD
CONSTRUCTION PROJECT**

**FINAL REPORT
SUMMARY**

JANUARY 2010

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

**NIPPON KOEI CO., LTD.
CHODAI CO., LTD.**

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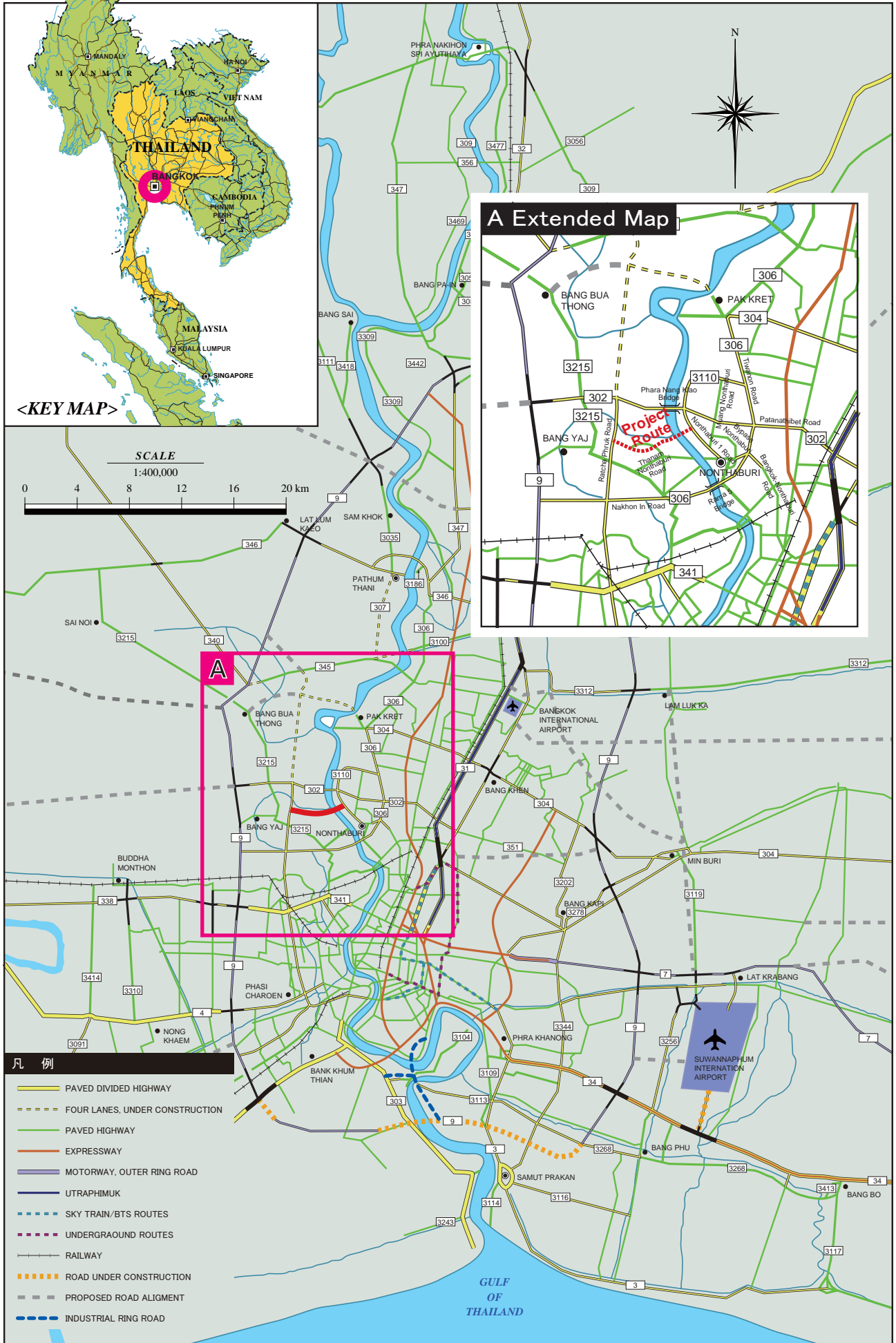
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(1) Thai Baht vs. US Dollar

USD 1= THB 34.5

(2) Thai Baht vs. Japanese Yen

THB 1 = JPY 2.75



Survey Location Map

Preparatory Survey
for
The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project

FINAL REPORT
SUMMARY

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List of Abbreviation

AADT	Average Annual Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
ADB	Asian Development Bank
AIDS	Acquired Immune Deficiency Syndrome
ARD	Office of Accelerated Rural Development
B/C	Benefit Cost Ratio
BMA	Bangkok Metropolitan Administration
BMR	Bangkok Metropolitan Region
BOD	Biochemical Oxygen Demand
BQ	Bill of Quantity
CFRP	Carbon Fiber Reinforced Plastics
CMLT	Commission of Management of Land Traffic
C/S	Construction Supervision
D/D, DD	Detailed Design
DOH	Department of Highways
DRR	Department of Rural Roads
DVD	Digital Versatile Disk
EIA	Environment Impact Assessment
EIRR	Economic Internal Rate of Return
E/N	Exchange of Notes
EXAT	Expressway Authority of Thailand
F/S	Feasibility Study
GDP	Gross Domestic Products
GRDP	Gross Regional Domestic Products
GMS	Greater Mekong Sub-region
H	Height
HDPE	High Density Polyethylene
Hgc	Height at Center
Hgs	Height at Support (Bearing)
HIV	Human Immunodeficiency Virus
HWL	High Water Level
IBRD	International Bank for Reconstruction and Development
IRR	Industrial Ring Road
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
L	Length
L/A	Loan Agreement
L/C	Letter of Credit
LCC	Life Cycle Cost
Lmax	Maximum Length
M/C	Motor Cycle
MEA	Metropolitan Electronic Association

M/M	Man-Month
MOF	Ministry of Finance
MOI	Ministry of Interior
MOT	Ministry of Transport
MRT	Mass Rapid Transit
MRTA	Mass Rapid Transit Authority of Thailand
MSL	Mean Sea Level
NESDB	Office of the National Economic and Social Development Board
NESDP	National Socio– Economic Development Plan
NPV	Net Present Value
OD	Origin and Destination
ODA	Official Development Assistance
O&M	Operation and Maintenance
ONEP	Office of Natural Resources and Environmental Policy and Planning
OTP	Office of Transport and Traffic Policy and Planning
PC	Pre-stressed Concrete
PCC	Property Compensation Community
PCU	Passenger Car Unit
PDMO	Public Debt Management Office
PPP	Public and Private Partnership
P/Q	Pre-Qualification
PWD	Public Works Department
RAP	Resettlement Action Plan
ROW	Right of Way
SAPS	Special Assistance for Project Sustainability (JBIC)
SRT	State Railway of Thailand
TDMC	Transport Data and Model Center
TDML	Transport Data and Model Integrated with Multimodal Transport and Logistics
UTDP	Urban Transport Development Partnership
VAT	Value-added Tax
V/C (VCR)	Volume/ Capacity Ratio
VOC	Vehicle Operating Cost
VOT	Value of Time
WB	World Bank

SYNOPSIS

1. Country	Kingdom of Thailand
2. Name of Study	Preparatory Survey for the Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project
3. Counterpart Agency	Department of Rural Roads (DRR), Ministry of Transportation
4. Objectives of Study	<ol style="list-style-type: none"> 1) To formulate the Project for the JICA appraisal, which includes the confirmation of the background and necessity of the Project, the appropriateness of the scope, implementation program and cost estimate prepared by DRR of the MOT of the government of Thailand. The Project includes the construction of an extradosed girder bridge of which technology has been developed in Japan. The survey includes the review of the detailed design and the identification of a possible technical assistance to the Project for assurance of the quality and safety during construction. 2) To confirm the development effects achieved from the existing 19 highway bridges over the Chao Phraya River, to conduct visual inspection on the existing 13 bridges completed by the ODA loan projects, and to identify the possible technical assistance to the maintenance organizations in-charge for the future effective use of the bridges.
5. Study Area	Bangkok Metropolitan Region (BMR)
6. Scope of Study	<ol style="list-style-type: none"> 1) To confirm the project background and necessity: Present conditions and issues in the road and bridge sector in Bangkok Metropolitan Area, transportation policy of the road and bridge Sector in Bangkok Metropolitan Area, review of traffic demand forecast, review of traffic demand forecast, study of the qualitative and quantitative impact of 19 bridges across Chao Phraya River, and proposed development plan for the Project Area 2) To confirmation the project outlines: Project objectives, project outline, and project cost and funding plan 3) To confirm implementation structure and program 4) To review and confirm the project evaluation: Quantitative effects, qualitative effects, and operational effect indicators 5) To review and confirm the environmental social consideration: Review of EIA, and confirmation of resettlement and land acquisition 6) To conduct visual inspection on the existing bridges over Chao Phraya River 7) To propose technical assistance programs
7. Major Findings	<p>7-1 Effects of the Project on the Urbanization Structures and Road Network in BMR</p> <ol style="list-style-type: none"> 1) The survey team examined the viability of the Project by reviewing the contents of the feasibility study and subsequent detailed design on the Project as well as by linking it to the present traffic conditions as of October 2009, Purple Line Project, Urban Plan in Nonthaburi, etc. As a result, the survey team confirmed that the Project properly met the present 10th NESDP (2007 – 2011) target of sustainable society and comfortable living environment. The possibility of access from the Project road to the Porn Sawan Station of the Purple Line in the future was also confirmed. In this

regard, the Project can be a prospective one to work with not only road networks in BMR but also with other transport systems.

- 2) As there are two sub-center locations in the north of Bangkok, namely, Nonthaburi and Pak Kret according to the comprehensive plan for BMA, the areas in the vicinity of the Project are expected to be developed. The survey team produced an urban structure map by associating the Project to the existing bridges such as Phra Nangklao Bridge and Rama V Bridge, and the road network function of the existing north-south corridor. From the map, it is estimated that urbanization shall go beyond the river from Nonthaburi to the west area. As such, the survey team confirmed the importance of the Project.
- 3) Within BMR, there are 20 bridges already built over the Chao Phraya River. After assessing the urbanization pattern and bridge-building projects in the past, the urbanization has been rapidly progressed in the vicinity of bridges. The enhancement of the bridges' traffic capacity is crucial for strengthening the urban structural function of Nonthaburi as the sub-center.
- 4) According to the results of traffic study, project costs and economic analyses of the Project, EIRR of the base case of the Project is estimated at 22.0%. The survey team also confirmed that at least 17.3% of EIRR be estimated as a result of the sensitivity analysis of 10 to 20% cost increase and 10 to 20% benefit decrease.

7-2 Confirmation of Appropriateness of the Project Components

- 1) The survey team reviewed the outcomes of the detailed design for the Project, viz. pre-qualification documents along with evaluation criteria and tender documents and confirmed that all the documents had been prepared in accordance with the JICA procurement guideline.
- 2) After checking mainly the number of tender drawings, it was found that the construction works contractor should newly produce a number of detailed drawings since the number of drawings prepared by the design consultant is limited to the basic design level. Therefore, the survey team recommended to the design consultant to add the cost for drawing preparation into the cost for construction works. It was likewise recommended for the design consultant to add the explanation about drawing preparation in the tender documents. The design consultant agreed to do so.
- 3) Taking into consideration the quality and safety during construction and future maintenance after completion, the survey team checked the tender drawings. Improvements on the tender drawings related to bridge details, road geometry and details of interchanges were recommended. The design consultant promised to improve the tender drawings before the distribution of tender documents.
- 4) As a result of the review of the the cost estimate prepared by the design consultant, some missing items which are shown in the tender drawings were suggested to be included, and the extremely unit price of prestressing tendons was pointed out. The design consultant has already corrected the estimates based on the comments from the survey team.
- 5) The survey team reviewed and confirmed that the construction and implementation plans were basically prepared using appropriate methods. Assuming that the Project progresses in accordance with the implementation plan, E/N and L/A will be signed in March 2010, procurement of the contractor including P/Q, tender and L/C open will be by April 2011, and the commencement of construction works will be May 2011. The completion of the works is estimated to be by October 2013, 30 months after the commencement.
- 6) The survey team conducted surveys on DRR's institutional structure, annual budget, and maintenance of the existing 11 bridges over the Chao Phraya River. As a result of the surveys, it was confirmed that maintenance systems by DRR were quite appropriate. Accordingly, the survey team thought that the maintenance for the bridge to be built by the Project would be well-done appropriately owing to the capability of maintenance works by DRR.
- 7) The survey team reviewed the EIA related to the activities of environment and social

consideration, and confirmed the present state of environment (water quality, air, noise, vibration). In addition, it was confirmed through the perusal of the latest documents that four households, out of 123 households, are occupying the Project site. According to the DRR's reply on the question by the Survey Team, the remaining four households within the Project site have already agreed to move before the commencement of the construction works of the Project. In case of remaining households exist before the start of construction, compulsory expropriation will be done based on the Land and Property Expropriation Act B.E. 2530.

- 8) As a whole, the survey team confirmed that outcomes of the detailed design by the design consultant and the plan by DRR are appropriate. However, it is desirable to assist DRR with technical assistance by a JICA consultant team that consists of qualified engineers having experiences in design and construction supervision on extradosed girder bridges, of which construction is the first attempt in Thailand.

7-3 Present Conditions of the Existing Bridges over the Chao Phraya River built by Japanese Assistance

- 1) The survey team conducted visual inspection on the existing bridges over the Chao Phraya River, which were built through Japanese assistance, in addition to the preparatory survey on the Project. The existing bridges consist of 11 bridges of DRR, three bridges of DOH and one bridge of EXAT.
- 2) It was confirmed that the 11 bridges of DRR and the bridge of EXAT were quite well-maintained.
- 3) Among the three bridges of DOH, it was found that the Nonthaburi Bridge (steel truss girders) was severely deteriorated and Phra Nangklao Bridge (PC box girder) had a probable trouble of a central hinge. Accordingly, a conceivable technical assistance from Japan is to assist DOH with maintenance advisory services on the DOH bridges over the Chao Phraya River.
- 4) The existing bridges of DRR are quite well-maintained and DRR intends to contentiously use the existing bridges as long as possible. In the future, however, DRR may encounter reinforcing and rehabilitating works unexpectedly, which are still never experienced by DRR. Accordingly, it is considered necessary to assist DRR with the conduct of detailed inspection of each bridge to lead the preparation of a maintenance program through technical assistance from Japan, which includes future rehabilitation and reinforcement works.

8. Conclusions and Recommendations

- 1) The Project is the first attempt in Thailand to construct an extradosed girder bridge. In fact, most of state-of-art technologies for the extradosed girders have been developed through the efforts of a number of Japanese entities. On the other hand, the detailed design of the extradosed girder bridge of the Project was produced entirely by a Thai national consulting firm. The tender drawings are of basic design level thus will require a number of design changes and material alterations during construction. DRR intends to employ Thai national consulting firm(s) for further construction supervision works. So as to maintain good quality and safe construction of the extradosed girder bridge in Thailand, it is very significant and effective to provide technical assistance to DRR with a qualified consultant team during the course of the various construction stages.
- 2) There are 20 bridges over the Chao Phraya River in BMR, with about 75% or 15 existing bridges built through assistance from Japan. These 15 bridges have an important role as transport infrastructure in BMR and are symbolic of the friendship between the Japanese and Thai people. These bridges are still likely used as long as possible in the future, hence appropriate maintenance on these bridges is crucial.

At present, DRR deals with the maintenance for 11 bridges, DOH, for three bridges and EXAT for one bridge. As a result of visual inspections, the maintenance of the bridges of DRR and EXAT are judged in good condition and no urgent rehabilitation work is needed. On the other hand, two bridges of DOH have partially deteriorated.

For the 11 bridges of DRR, these are of various types consisting of steel truss girders, steel plate girders, steel bascule girders, PC box girders and steel cable-stayed girders and require quite different maintenance and rehabilitation works. Even though the 11 bridges are well-maintained, it is important to grasp the necessary works in the future for rehabilitation and reinforcement that DRR has never experienced before. Accordingly, it is desirable to prepare medium- and long-term maintenance programs for each bridge under the technical assistance from Japan.

For the three bridges of DOH, two bridges have partial deterioration problems.

As for one steel cable-stayed girder bridge of EXAT, adequate monitoring and repair works have been conducted since its completion. In addition, the financial situation of EXAT is regarded as healthy. Consequently, no technical assistance to EXAT is desired.

- 3) The survey team conducted interview surveys on DRR and DOH regarding bridge maintenance systems. DRR has developed a BMS (Bridge Maintenance System) for 6,000 bridges in a whole of Thailand. Now, DRR intends to develop the BMPS (Bridge Master Plan System) which deals with bridge prioritization among existing bridges and conceivable new bridges.

On the other hand, DOH tried to develop a database system BMMS (Bridge Maintenance Management System) 20 years ago under grant assistance from Denmark. According to DOH information, BMMS is totally frozen and no longer in use. In addition, DOH intended to develop another BMMS under the assistance of the World Bank for managing 16,000 bridges in a whole of Thailand.

The survey team identified a necessary technical assistance to DOH since the maintenance of bridges by DOH is still backward if compared with the other two organizations of DRR and EXAT.

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND OF THE SURVEY

(1) Road and Bridge Development in Bangkok Metropolitan Area

The Bangkok Metropolitan Region (BMR) consists of the Bangkok Metropolitan Administration (BMA) and the surrounding five provinces of Nonthaburi, Pathum Thani, Samut Prakan, Samut Sakhon and Nakhon Pathom, with a total area of 7,761.5 km² and with 10.07 million population as of year 2008. BMR expands from BMA towards the surrounding five provinces and the recent population growth rate in BMR is 1.5% per annum. In Thailand, BMA is the most densely populated area with about 4,000 persons/km² or more, and the Nonthaburi Prefecture ranks next to BMA with about 700 persons/km², and the Pathum Thani Prefecture ranks the seventh with about 600 persons/km². Based on the recent population growth trend, a significant population increase is expected in these two provinces.

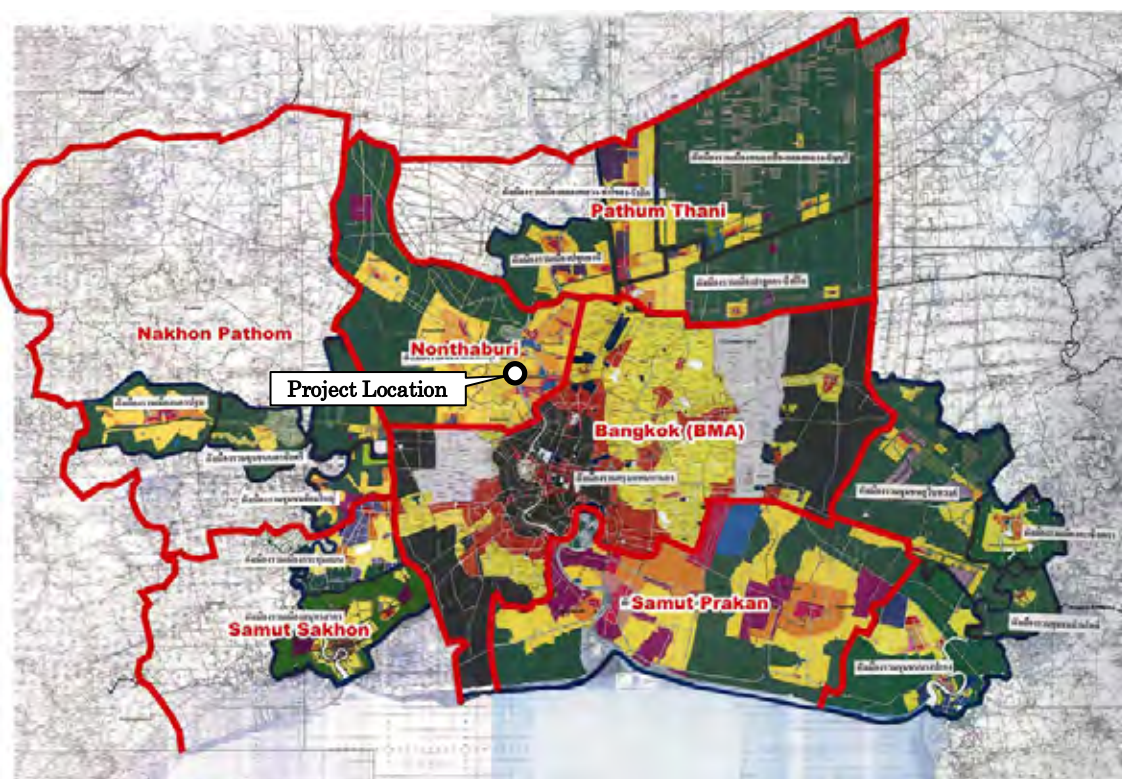


Figure 1.1.1 Bangkok Metropolitan Region (BMR)

Major roads and bridges have been constructed by the Department of Rural Roads (DRR) and the Department of Highways (DOH) of the Ministry of Transportation (MOT), the Expressway Authority of Thailand (EXAT) and the BMA.

DRR is the executing agency of “The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project” (the Project), which belongs to Nonthaburi Province.

(2) Road and Bridge Development in Bangkok Metropolitan Area

There are 20 bridges crossing over the Chao Phraya River in BMR as shown in Figure 1.1.2 (North and South bridges of the Industrial Ring Road are counted at 1).

Among the existing 20 bridges, 15 bridges were built through the assistance of the Japanese Government. In 1950, the Nonthaburi, Krungthon and Krungthep Bridges, which are built of

steel truss girders and bascule structure at the navigation course, were funded by Japanese Special Funds. Thirteen bridges have been developed through the utilization of the Japanese Official Development Assistance (ODA) loan since its first loan to Thailand in 1971, which is composed of the construction of 12 bridges and the rehabilitation of Krungthep Bridge. As well known that the BMR traffic congestion in the 1980s was really a problem, the new developments brought about by the Japanese ODA have greatly contributed to ease the traffic congestion in the metropolis. However, the rapid growth in industrial and economic activities in BMR is still causing traffic bottlenecks and congestion in many places resulting in the hampered flow of goods and passengers. Accordingly, there are six new bridge building projects that are underway through the various authorities. These projects are: 1) one project in Nonthaburi (this specific project, the Project) by DRR, 2) four projects by BMA and 3) one project by EXAT.

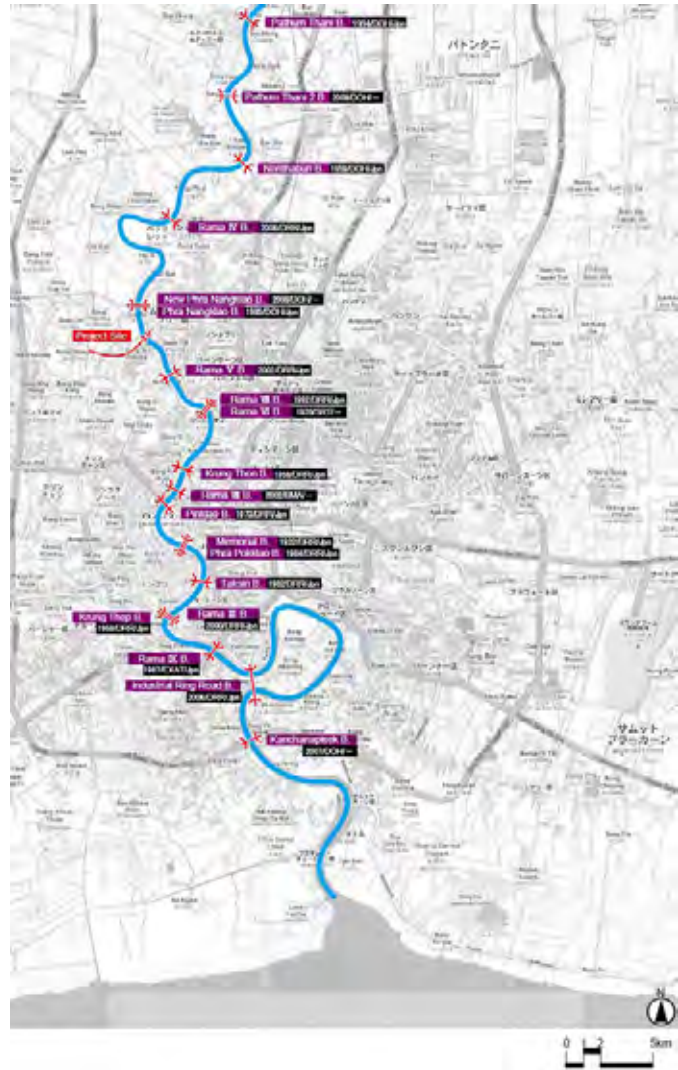


Figure 1.1.2 Location Map of the Project and Existing Bridges

(3) The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project

The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project (the Project) is proposed in Nonthaburi Prefecture, the second densely populated area in Thailand. The prefecture is located in the northern border of the BMA, the national capital and most densely populated area. The Project aims to provide a direct crossing between the east bank of the Chao Phraya, where traffic congestion is chronically severe during morning and evening peak hours, and the west bank, which has potential for economic growth.

The DRR of MOT is the executing organization to implement the project. At present, the feasibility study (F/S) and detailed design (D/D) have been completed by a Thailand national consultant team and draft tender documents for construction works are already prepared.

The Project is to construct a 4.3-km 6-lane road, including a 460-m long extradosed girder bridge, two interchanges (Nonthaburi 1 Road at the beginning point and Ratcha Phruk Road at the end point), and one flyover. The general concept and outline of the Project is shown in Figure 1.1.3.

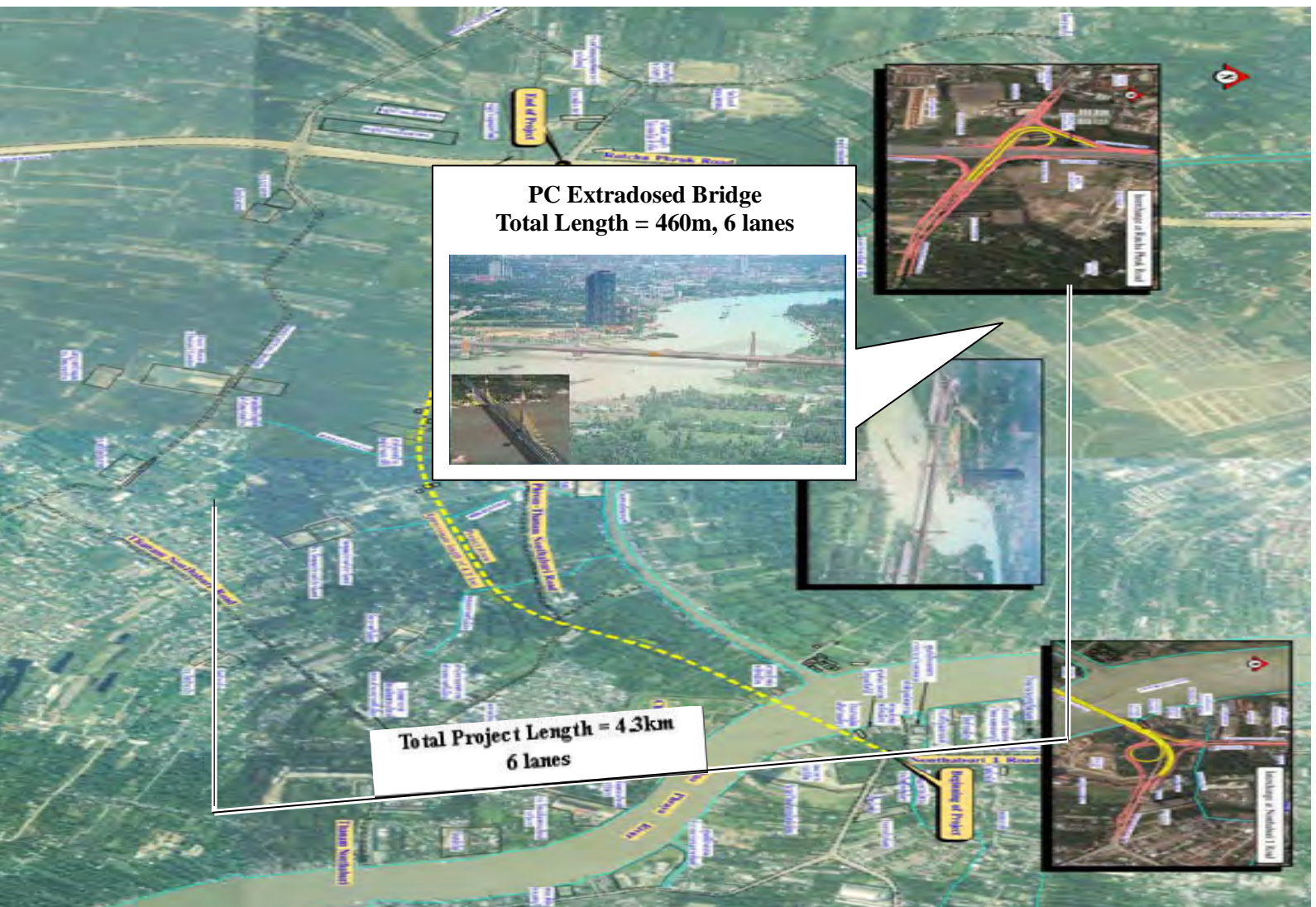


Figure 1.1.3 Outline of the Project “The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project”

1.2 PURPOSES OF THE SURVEY

- 1) To formulate the Project for the JICA appraisal, which includes the confirmation of the background and necessity of the Project, the appropriateness of the scope, implementation program and cost estimate prepared by DRR of the MOT of the government of Thailand. The Project includes the construction of an extradosed girder bridge of which technology has been developed in Japan. The survey includes the review of the detailed design and the identification of a possible technical assistance to the Project for assurance of the quality and safety during construction.
- 2) To confirm the development effects achieved from the existing 19 highway bridges over the Chao Phraya River, to conduct visual inspection on the existing 13 bridges completed by the ODA loan projects, and to identify the possible technical assistance to the maintenance organizations in-charge for the future effective use of the bridges.

1.3 SURVEY AREA

The survey area refers to the BMR. The technical survey is mainly conducted in and around the area of the Project which starts from the end of the planned interchange on Nonthaburi 1 Road to the end of the interchange on Ratcha Phruk Road, with a total length of 4.3 km.



Figure 1.3.1 Survey Area Map

CHAPTER 2 PROJECT BACKGROUND AND NECESSITY

2.1 PRESENT CONDITIONS AND ISSUES IN THE ROAD AND BRIDGE SECTOR IN BANGKOK METROPOLITAN AREA

(1) General

In the Bangkok Metropolitan Area (BMA), urban traffic has become worse as the population and vehicles have significantly increased since the high-growth period in the late 1980's. Traffic congestion, especially on the arterial road between the downtown and residential areas which are expanding year by year, are getting serious.

All road development works in the central area of BMA were not under the long-term plan and some were developed by each road administrator. Therefore, the network is neither rational nor systematic. Although major arterial roads have been developed with high capacity roads through ring road development, grade separation of intersections, and viaducts, these structures cause chronic traffic congestion especially on arterial roads. This is mainly due to the many tertiary roads directly connecting to such arterial roads forming fishbone roads without mutual linkage. Such road network makes many vehicles turn at intersections that cause uneconomical driving routes for vehicles.

West BMA is connected with the central area by 19 highway bridges on the Chao Phraya River as an important area of BMA. However, only two bridges which are about five kilometers apart, Phra Nangklao Bridge and Rama 5 Bridge, exist in the Nonthaburi Prefecture. Traffic congestion is chronic in this area due to the increase of traffic volume from expanded residential areas in the recent years. Therefore, the Project will be one of the important radial roads connecting the BMA and the residential areas to distribute the traffic load of the existing bridges.

Under such situation, the government of Thailand has taken several measures to ease the traffic congestion in the central BMA. The urban development policy aims to transfer from over concentration to multi-polarization. In the road and bridge sector, the development of intra urban highways and the separated four-lane development of major national roads have been undertaken since the Seventh Road Development Plan (1992-1996).

The Ninth Road Development Plan (2002- 2006) planned by the Department of Roads, Ministry of Transport is underway as a rolling plan for arterial road network development. Major development targets in the plan are the i) east coast road network development, ii) west coast road network development and widening to four-lane in southern regions, iii) development of the southern part of the Outer Bangkok Ring Road, iv) development of major inter-city roads in the northern regions, and v) development of major inter-city roads in the northeastern regions. On-going inter-city road development projects are listed in Table 2.1.2. The projects located in BMR are Bang Yai-Nakhon Pathom, Nakhon Pathom-Samut Songkram, and Nakhon Pathom-Kanchanaburi.

Introduction of Public and Private Partnership (PPP) scheme for the implementation of Bang Pa In-Saraburi, Saraburi-Nakhon Rachasima, Pattaya-Map Ta Phut, Saraburi-Nakhon Rachasima, and Nakhon Pathom-Kanchanaburi are under discussion.

Table 2.1.4 Outlines of Bridges on Chao Phraya Rive

	Name	Administrator	Operation Year	Main Span Length (m)	Superstructure	Bridge Distance (km)
1	Patum Tani Bridge	DOH	1984	73	PC Box	5.6
2	Patum Tani 2 Bridge	DOH	2009	160	PC Box	4.7
3	Nonthaburi Bridge	DOH	1959	64	Metal Truss	6.6
4	Rama IV Bridge	DRR	2006	134	PC Box	10.3 (5.6)
5	New Phra Nangklao Bridge	DOH	2008	229	PC Box	0
6	Phra Nangklao Bridge	DOH	1985	84	PC Box	2.1
7	Rama V Bridge	DRR	2002	130	PC Box	2.8
8	Rama VII Bridge	DRR	1992	120	PC Box	3.2
9	Rama VI Bridge	SRT	1926	120	Metal Truss	4.3
10	Krung Thon Bridge	DRR	1958	64	Metal Truss	0
11	Rama VIII Bridge	BMA	2002	300	Cable-Stayed	4.3
12	Pinklao Bridge	DRR	1973	114	PC Box	1.5
13	Memorial Bridge	DRR	1932	78	Metal Truss	1.1
14	Phra Pokklao Bridge	DRR	1984	100	PC Box	3.1
15	Taksin Bridge	DRR	1982	92	PC Box	0
16	Rama III Bridge	DRR	2000	226	PC Box	3.1
17	Krung Thep Bridge	DRR	1959	64	Metal Truss	0
18	Rama IX Bridge	EXAT	1987	450	Cable	4.1
19-1	Industrial Ring Road Bridge (North)	DRR	2006	326	Cable	2.7
19-2	Industrial Ring Road Bridge (South)		2006	398	Cable	16.8 (1.2)
	Kanchanapisek Bridge	DOH	2007	500	Cable	3.3

Note) Bridge distance measured along river center. However, bridge distance shown in () is linear distance due to S-shaped river.

Table 2.1.2 List of Inter-City Road Projects

ID	Sections	Length (km)	Project Cost (mil. THB)	Project Period
81	Bang Yai – Nakhon Pathom	51	12,200	2006-2008
6	Saraburi – Nakhon Rachasima	156	21,800	2007-2009
7	Pattaya – Map Ta Phut	38	4,100	2007-2009
8	Nakhon Pathom – Samut Songkram	62	16,000	2008-2010
6	Bang Pa In – Saraburi	43	3,800	2008-2010
8	Samut Songkram – Cha Am	72	18,000	2009-2011
81	Nakhon Pathom – Kanchanaburi	47	6,410	2009-2011
5	Bang Pa In – Ang Thong	60	12,000	2009-2011
5	Lampang – Lamphun – Chang Mai	99	27,500	2009-2011
91	Saraburi – Bang Pakong	150	36,500	2009-2011
	Total	778	158,310	2009-2011

Source: Department of Highways, MOT

(2) Issues of Road and Bridge Sector

1) Systematic Road Development Harmonizing with Land Use Plan

In the BMA road development, radial roads were prioritized due to rapid expansion of the urban area. However, these radial roads have not been connected and it has caused serious traffic congestion. A new ring road with appropriate length and distance is necessary to

connect the radial roads practically and efficiently to ease the heavy traffic load.

Existing roads were not systematically developed to balance the arterial roads, secondary roads, and tertiary roads because land use policy was not clear and there are many areas where roads are ending at canals. Therefore, it is necessary to review the function of each road in the BMA network considering the land use plan and road development with the appropriate standards for each function.

2) Road Development Supporting the Expansion of the Urban Area

The development of BMA started from the east of Chao Phraya River to the eastern areas, and then expanded to western area over the river. The existing bridges over the river contributed to the development of the western areas especially in Thonburi area where bridge distance is two to three kilometers, and this has been developed where urbanization is expanding to northern areas. On the other hand, in upper Chao Phraya areas, where the bridge distance is five to eight kilometers, the infrastructure for urbanization has not yet been developed enough. Therefore, it is necessary to construct bridges with appropriate spans for such areas with high potential for urbanization.

3) Upgrading of Traffic Management

Traffic management measures on arterial roads in BMR are implemented not only through traffic regulations such as one-way restriction and reversible lanes, but also by installation of traffic signals and information boards. However, the implementation of these measures has not been alleviated to drastically decongest the traffic situation in BMR. Manual traffic regulation at the major intersections by traffic police is also an ad hoc countermeasure to mitigate but only tends to worsen the congested areas.

Therefore, the examination of comprehensive traffic management measure is needed with the consideration of the introduction of advanced and effective countermeasures such as area-controlled traffic signal system and Traffic Display Monitoring (TDM). Moreover, prompt organizational coordination among the traffic police and other road traffic authorities such as BMA, and institutional set up is essential.

2.2 TRANSPORTATION POLICY OF THE ROAD AND BRIDGE SECTOR IN BANGKOK METROPOLITAN AREA

(1) Transportation Policy of the Road and Bridge Sector and Conformity with Road and Bridge Sector Development Plan

The development of the trunk road network in Bangkok Metropolitan Area is proceeding according to the master plan approved by the Commission of Management of Land Traffic (CMLT) on February 23, 2004, known as the CMLT's Resolution No.1/2547. In the master plan, 75 projects are listed as urgent to be developed and this project is designated as one of the urgent project to be implemented by DRR.

Three out of seven projects assigned by CMLT No. 1/2547 have not been completed. This Project is one of the uncompleted ones and DRR is processing it as the highest priority project. This road connects to Nonthaburi 1 Road, then to the Purple Line as a feeder road, and further, connecting to Red Line. In the west, the road connects to Ratcha Phruk Road and further, to the outer ring road. In the north, it is planned to connect to the north-south line, east-west line (Ratcha Phruk~Kanchana Phisek Connecting Road). There is no concrete development plan yet to extend the road in the west and east. However, in the north, DRR is preparing the east and west line as shown in Figure 2.2.1. In the phase 1 stage, the D/D is almost finished and DRR is preparing for funding, while the phase 2 line is now under planning.

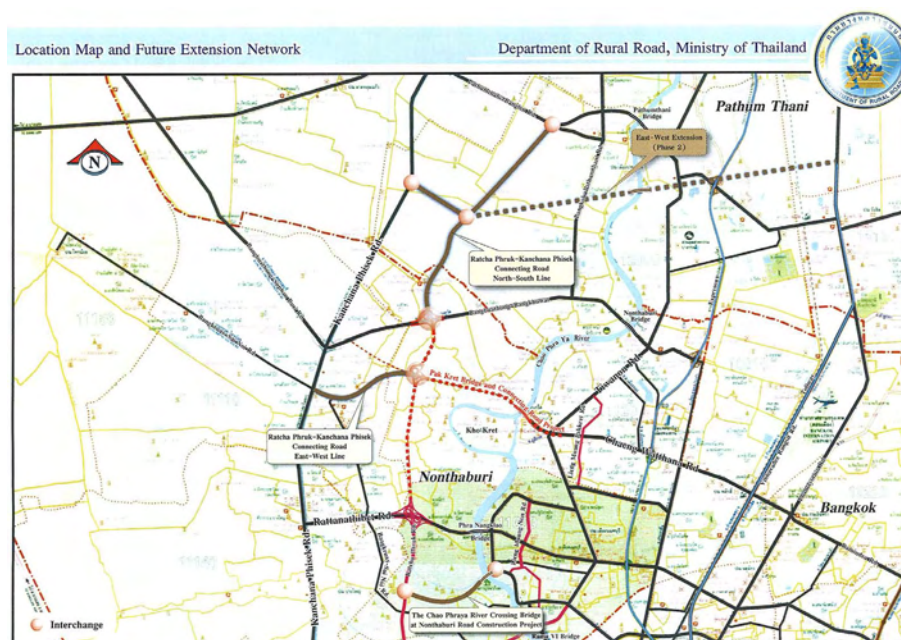


Figure 2.2.1 Road Extension Plan by DRR

Furthermore, the development of the transportation network in the upper area of Bangkok Metropolitan and Nonthaburi Province in accordance with the strategic plan to serve the community expansion in Bangkok Metropolitan and vicinity areas will be better fulfilled through the implementation of this project.

(2) Review of other Donor's Activities in the Transportation Sector

1) WB

The main aid by WB has been related to project preparation, assessment and feasibility studies. In collaboration with ADB, the French Agency and JICA, WB organized the Urban Transport Development Partnership (UTDP) and studied the traffic problems in Bangkok. The evaluation and recommendations are summarized in the report published in 2007. It was presented that the importance of the highway development is recognized and likewise, that of the improvement of the traffic management system is emphasized. Without the improvement of the total network system of modal mix with mass transit, bus network with common ticket, feeder roads and pedestrian roads, expensive mass transportation cannot produce the expected results to solve the traffic congestion.

WB has been helping DOH through its Highway Management Project. The objective of this project is to enhance the efficiency, productive use, and management of the road network. It especially, supports the commercialization of the road sector, including the PPP and BOT systems, strengthens the operations of the DOH, helps to preserve road assets, and improves the competition and transparency in the award of contracts.

WB will evaluate the possibility of financing of future road sector projects if and when the Thai Government will raise the need.

2) ADB

ADB opened a Bangkok office five years ago and has been helping in the field of transportation, capital market, and energy sectors. At present, ADB is now preparing to finance the development of the highway improvement in response to the need of the Thai Government. This project is called as the Greater Mekong Sub-region (GMS) Highway

Expansion Project and aims to improve part of the GMS highway by upgrading the narrow road to a four-lane highway, two sections in the east-west corridor (Phitsanulok – Lom Sak (105 km), Nakrai – Akamcha-e (39 km), and Phanom Sarakham – Sakaew (73km)) and one section in the south corridor, for a total of 217 km. In collaboration with DOH, the preparation was started in 2008 and will be implemented after the approval of the Thai Parliament.

About the future possibility of financing a road sector project, there is no concrete plan yet since there is no request for project financing from the Thai Government.

(3) Compatibility to Regional Planning

1) Regional Planning Policy on the National Level

The Thai Government formulates and updates the National Economic and Social Development Plan (NESDP). The first NESDP (1961 - 66) was formulated in 1961, and was updated every five years until the present plan, which is the 10th Plan.

The accumulation of the economic activities in the metropolitan area further accelerated, and the regional gap in income and production expanded after Plaza Accord. The 8th NESDP (1997 - 2001) called for a new policy to promote regional cities to lessen the one-polar structure of the national economy. In 1999, the Decentralization Act was passed, which promoted the budgetary basis for regional development.

In 2000, the Thai economy recovered from the Asian currency crisis and adopted the sustainable urban and rural development in the 9th NESDP (2002 – 2006), and called for the affluent urban and rural communities as well as the participatory PPP as the implementation instruments. The present is the 10th NESDP (2007 – 2011), continued to adopt to promote decentralization with the target of sustainable society and comfortable living environment.

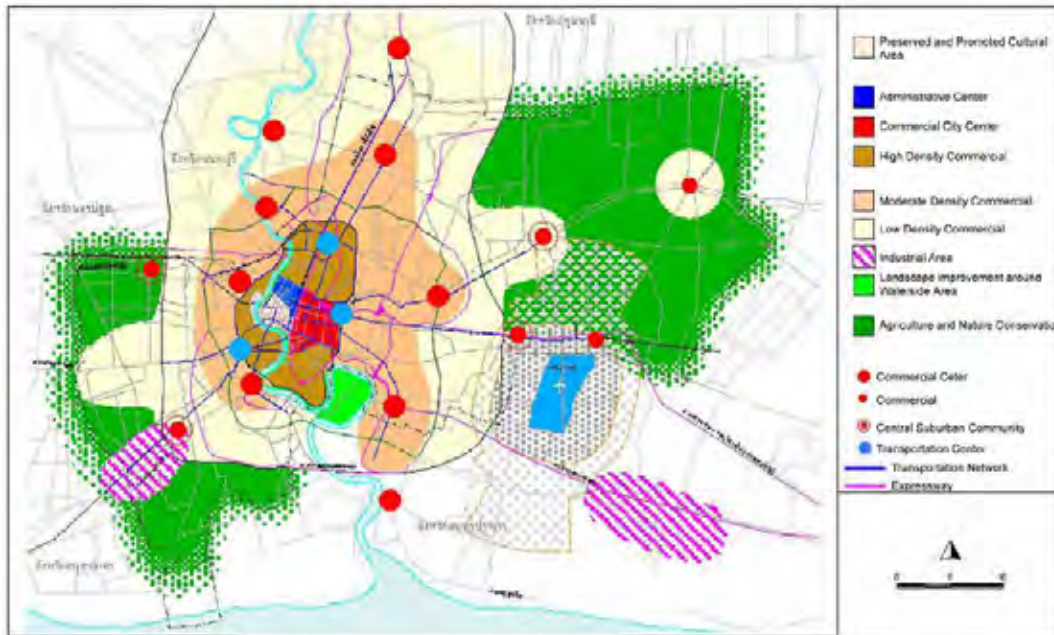
2) Urban Planning for BMA

Urban planning in Thailand is practiced based on the Town Planning Act in 1975, and it includes the comprehensive plan for the entire administrative entity, and a specific plan for a selected area as necessary, although there has not yet been any specific plan formulated in Thailand.

There are five pillars in the vision of the present comprehensive plan, as follows:

- a) Metropolis predominating in art and culture, with a national uniqueness
- b) Metropolis with quality of life of the people considering environmental conservation and natural resources
- c) Metropolis that is the center of economic activities and technology of the nation and Southeast Asia
- d) Metropolis that is the center of administration, institution and international organizations
- e) Metropolis that is flexible and convenient with a communication and transport network

In relation to the third pillar of the vision, BMA promotes the formation of sub-centers around Bangkok as commercial centers supplemental to the Bangkok City Center. As can be seen in the figure below, there are two sub-center locations in the north of Bangkok, namely the Nonthaburi and Pak Kret.



Source; Bangkok Metropolitan Administration

Figure 2.2.2 Future Image of Bangkok Metropolitan

3) Urban Planning for Nonthaburi Province

In Nonthaburi District which is included in the survey area, most of the urban areas are densely populated. In BMR, the Nonthaburi Province is located about 10 to 15 km from the Bangkok urban center, hence the population of Nonthaburi is fast growing and the urbanization is expanding rapidly. However, in the east bank areas of Chao Phraya River, urbanization has been much progressive and there are no more potential areas for future urban developments. This condition on the east bank is accelerating the present movement of urbanization on the west bank, especially the areas near the bridge crossings.

The comprehensive plan was modified in 2005 based on the actual circumstances of the urbanization on the west bank, and correspondingly, the land use zoning plan was also modified.

4) Conformity of the Project Bridge and Regional Planning

As discussed above, the Project bridge is located in the north of Bangkok, and Nonthaburi is considered as a candidate for the sub-center of Bangkok area. The new bridge will give positive impact to the existing agricultural lands on the west side of the Chao Phraya River that will contribute to the continuous urbanization. The conformity of the Project with regards to the urban and regional planning in the national, capital, and provincial levels is considered to be high, as shown in Table 2.2.1 below.

Table 2.2.1 Conformity of the Project Bridge to Regional Planning

Regional Unit	Relevant Plan	Conformity	Remarks
National Level	NESDP (8 th , 9 th and 10 th)	High	<ul style="list-style-type: none"> Countermeasure for excessive accumulation to Bangkok Promoting development of regional cities
Bangkok Metropolitan Region	BMA Comprehensive Plan	High	<ul style="list-style-type: none"> High population growth in Nonthaburi to accommodate the increasing population in the BMR Development of Sub-Centers (Nonthaburi and Pak Kredt Cities)
Nonthaburi Province	Nonthaburi Province Comprehensive Plan	High	<ul style="list-style-type: none"> Promotion of road network improvement and new urbanization in the west bank of Chao Praya River

Source: JICA Study Team

(4) Necessity of the Project

DRR considers this project as necessary for the following reasons:

- 1) The traffic congestion of the related area is serious and this project contributes to solve the problem. The regional traffic network will be improved between the east side and west side of Chao Phraya River. This contributes to the improvement of the transportation network of Bangkok Metropolitan Area and its economic development.
- 2) The Thai Government recognized this project as one of the urgent project in the master plan (No.1/2547) and entitled DRR as the execution agency. DRR placed the first priority on this project among their road projects.
- 3) PWD under MOI conducted the Feasibility Study for Chao Phraya River Bridge Crossing in Greater Bangkok Area (FSBC) on April 1995, and the FS proposed 29 bridge projects. This Project is one of the 29 proposed projects and the DRR conducted FS for this project and the high value of the economic internal rate of return (EIRR) was confirmed.

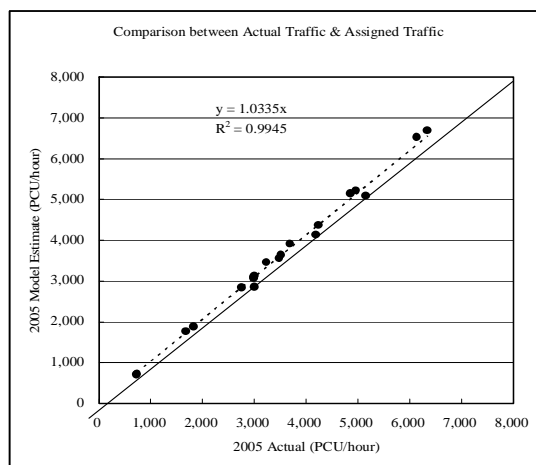
2.3 REVIEW OF TRAFFIC DEMAND FORECAST

(1) Overview of Previous Feasibility Study

The traffic demand forecast was carried out in the previous feasibility study on the Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project carried out by the DRR in 2005. And, the traffic demand forecast for the Project in the revised feasibility study of the above presented the results of the forecast for the target years 2011, 2016, 2021, and 2026.

Pre-conditions and methodology of the traffic demand forecast is reviewed to confirm its validity in this survey.

In order to confirm the validity of the present OD matrix, the passenger car unit (PCU)/hour in the morning time and the assignment procedure, a comparison between actual traffic counts and assigned traffic (model estimates) was made in the F/S and the results are shown below:



Source: JICA Survey Team (Original data: DD Report, 2005)

Figure 2.3.4 Comparison between the Actual Traffic (Counted) and Assigned Traffic (Model Estimates)

The results indicate that the percentage error is only about 3%, which is within the acceptable range. Therefore, it is confirmed that the present OD matrix and the traffic assignment procedure are both appropriate as the bases of the future demand forecast.

(2) Results of Traffic Demand Forecast of the Previous FS

The forecasted results by the previous F/S are summarized below together with the influences to the existing two bridges, the Phra Nang Klao Bridge and Rama V Bridge.

Table 2.3.1 Results of Traffic Demand Forecast by F/S (Morning Peak, to Bangkok, PCU/hour)

Bridge	Year Situation	2016		2021		2026	
		PCU/hr	V/C	PCU/hr	V/C	PCU/hr	V/C
Phra Nang Klao Bridge	Without Project	7,643	1.02	7,248	0.97	6,443	0.86
	With Project	6,796	0.91	6,421	0.86	5,792	0.77
Project Bridge		3,159	0.70	3,200	0.71	3,913	0.87
Rama V Bridge	Without Project	4,708	1.05	4,608	1.02	4,552	1.01
	With Project	3,945	0.88	3,550	0.79	3,342	0.74

Source: F/S Report (1st Additional Information, 2009)

Note: V/C = Traffic Volume/Capacity, C=1,500 PCU/hour

The traffic demand in 2026 in terms of PCU during morning peak hour from Nonthaburi to Bangkok was forecast at around 3,900 PCU per hour and congestion rate (V/C ratio) was estimated at 0.87.

Congestion on the existing two bridges will be mitigated and reduced to the lower level than the congestion rate 1.0 for both Phra Nang Klao Bridge and Rama V Bridge. The percentage of reduction of congestion rate will be 10% for the Phra Nang Klao Bridge, and 20% for the Rama V Bridge. The Phra Nang Klao Bridge was expanded to ten lanes from the four lanes of the old bridge and constructing another six-lane bridge above the old double deck type bridge in November 2008. It was confirmed that this capacity expansion to ten lanes of the Phra

Nang Klao Bridge was already reflected in the above traffic demand forecast as a condition of the future road network.

In conclusion, it is judged that the results of the future demand forecast by the previous FS are appropriate after careful review of its pre-conditions and methodology.

(3) Supplemental Traffic Survey

The supplemental traffic survey is conducted to confirm the traffic volume transition from the F/S, and likewise, the reliability, and accuracy of the traffic demand forecast results in F/S. The survey results are as follows:

- Hourly Traffic Count Survey (Morning and evening peak hours (4 hours each), 5 locations, a day on weekdays)
- Travel Speed Survey (Morning and evening peak hours (4 hours each), 5 routes (3 round survey per route), a day on weekdays)

1) Hourly Traffic Count Survey

Five stations are subjected to the hourly traffic count survey as shown in Figure 2.3.2. The survey stations are selected consistent with the survey location selected in the FS.

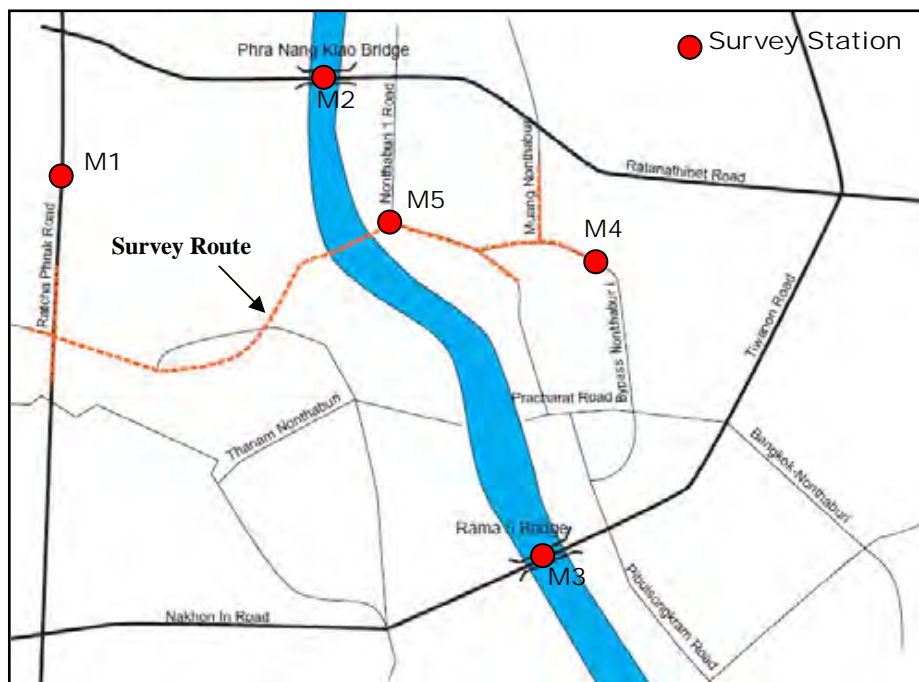


Figure 2.3.2 Location Map of Survey Stations

Table 2.3.2 shows the comparison between traffic result in the F/S (14th June, 2005) and the survey results. Morning peak hour traffic volume from 7:00AM to 8:00AM is subjected to the comparison as peak traffic volume data representative.

As a result of the comparison, significant increment is found at Ratcha Phruk Road, Rattanathibet (Pranang Klao Bridge) Road, and Nakorn-In (Rama 5 Bridge), especially at Ratcha Phruk Road (2.24 times). Major reasons of the increment seem that recent road development in the northbound extension of Ratcha Phruk after 2005 and Rama 4 Bridge in 2006 has developed into a new road network.

On the other hand, there was no increment found at the Nonthaburi 1 Road and Bypass

Nonthaburi. The main reason for this seems that there is less impact by through traffic because the Nonthaburi 1 Road and Bypass Nonthaburi are categorized as secondary roads and these roads are located inside the area of primary road network. Hence, there is less trip generation due to saturated residential development.

As for river crossing traffic volume at Rattanathibet (Pranang Klao Bridge) Road and Nakorn-In (Rama 5 Bridge), traffic volume has increased to 3.4%/year and 4.6%/year, respectively.

Table 2.3.2 Comparison Results with F/S Traffic Volume (Morning Peak, 7:00-8:00)

Survey Stations	Direction	Traffic Volume		2009/2005			
		2005	2009	Directional	Both Direction		
M1:Ratcha Phruk Road	Northbound	995	2,766	2,667	6,207	2.68	2.24
	Southbound	1,771		3,540		2.00	
M2: Rattanathibet (Pranang Klao Bridge)	Eastbound	3,300	5,160	3,851	5,893	1.17	1.14
	Westbound	1,860		2,042		1.10	
M3:Rama V Bridge	Eastbound	2,788	4,964	4,381	5,941	1.57	1.20
	Westbound	2,176		1,560		0.72	
M4:Bypass Nonthaburi	Northbound	1,309	3,012	1,703	3,105	1.30	1.03
	Southbound	1,703		1,402		0.82	
M5:Nonthaburi 1	Northbound	1,107	1,686	581	1,498	0.52	0.89
	Southbound	579		917		1.58	

In terms of congested ratio, all survey stations are about less than 0.5 except the Rattanathibet (Pranang Klao Bridge) Road which shows 0.86 in F/S. Meanwhile, the Ratcha Phruk Road and Nakorn-In (Rama 5 Bridge) Road exceeded 0.6 in the survey. However, Rattanathibet (Pranang Klao Bridge) Road is reduced to 0.39 due to the new development in the six-lane Pranang Klao Bridge.

Table 2.3.3 Comparison Results with FS VCR (Morning Peak, 7:00-8:00)

Survey Stations	Number of Lanes		VCR	
	2005	2009	2005	2009
M1:Ratcha Phruk Road	6	6	0.31	0.69
M2: Rattanathibet (Pranang Klao Bridge)	4	10	0.86	0.39
M3:Rama V Bridge	6	6	0.55	0.66
M4:Bypass Nonthaburi	4	4	0.50	0.52
M5:Nonthaburi 1	4	4	0.28	0.25

Note: C=1,500pcu/lane

2) Travel Speed Survey

The travel speed survey was conducted during morning peak hours from 6:00AM to 10:00AM and in the evening peak hours from 4:00PM to 8:00PM on October 8, 2009. There are five survey and travel routes, as shown in Figure 2.3.3.

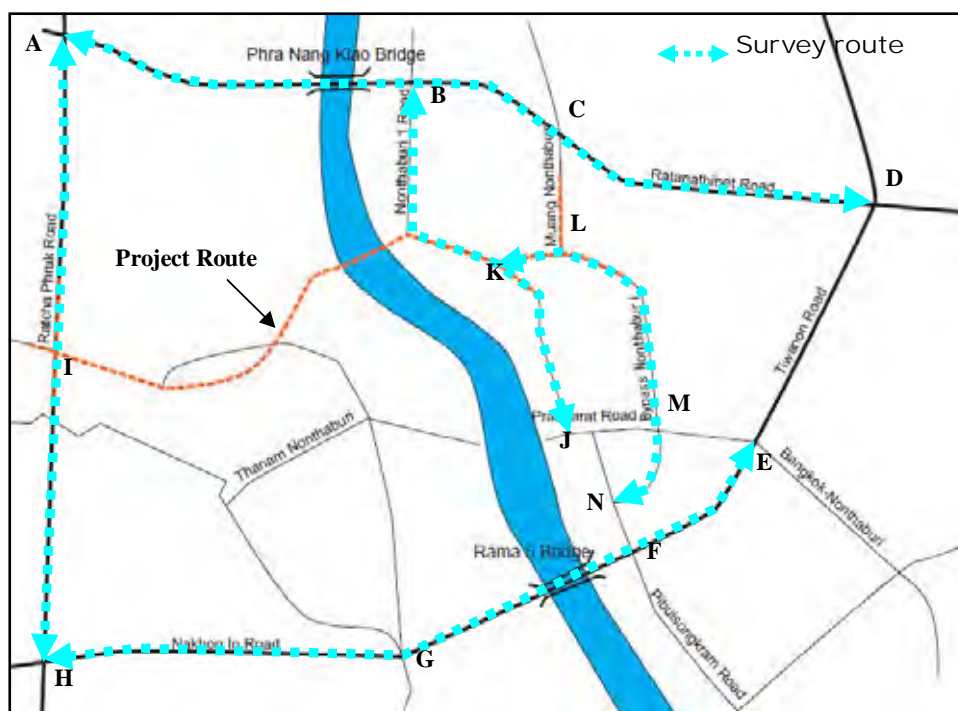


Figure 2.3.3 Location Map of Survey Routes

Travel speeds of outbound traffic from the city center and northbound are generally higher than the opposite directions of each in conformity with the results of the counted traffic volume as shown in Table 2.3.4. Average travel speeds are higher than the one in the city center.

Table 2.3.4 Results of Travel Speed Survey

		(km/h)	
Survey Routes	Route	Mornning Peak	Evenning Peak
Ratcha Phruk Road	A-H	38.57	29.15
	H-A	66.84	59.65
Rattanathibet (Pranang Klao Bridge)	A-D	26.9	26.1
	D-A	67.83	66.38
Nakhon-In Road (Rama V Bridge)	H-E	59.2	61.81
	E-H	71.81	71.23
Bypass Nonthaburi	K-N	37.83	31.89
	N-K	25.19	19.41
Nonthaburi 1	B-J	27.74	42.16
	J-B	61.43	60.52

2.4 STUDY OF THE QUALITATIVE AND QUANTATIVE IMPACT OF 19 BRIDGES ACROSS CHAO PHRAYA RIVER

(1) Construction of Bridges on the Chao Phraya and Expansion of the Urban Area

Historically, the Chao Phraya River has served as a substantial hindrance to the expansion of the Bangkok urban area.

Today, there are 20 bridges constructed over the Chao Phraya. In this sub-section the relationship between the expansion of the urban area and the construction of new bridges in BMR will be analyzed.

Table 2.4.1 Chronology of Bridges in Bangkok Metropolitan Region

	Name	Year	1900's	1910's	1920's	1930's	1940's	1950's	1960's	1970's	1980's	1990's	2000's	2010's
North	Pathum Thani	1984												
	Pathum Thani 2	2009												
	Nonthaburi	1959												
	Rama IV	2006												
	New Phra Nangklao	2008												
	Phra Nangklao	1985												
	New Nonthaburi	-												
	Rama V	2002												
	Rama VII	1992												
	Rama VI (Railway)	1926												
	Krung Thon	1958												
	Rama VIII	2002												
	Pinklao	1973												
	Memorial	1932												
	Phra Pokklao	1984												
	Taksin	1982												
	Rama III	2000												
Krung Thep	1959													
Rama IX	1987													
Industrial Ring Road	2006													
South	Kanchanapisek	2007												

As discussed earlier, the urban area of Bangkok in 1900 was limited to the east bank of the Chao Phraya River. The construction of Memorial Bridge in 1932 has brought new urbanization to the west bank area, which is generally observed in the development of new residential settlements in Thonburi and Bangkok Noi areas, but the overall urbanization on the west bank of the river took place during the years 1958 and 1968. It was during this period in the year 1959, when the Krung Thep Bridge, the third bridge in this district was built. This new bridge marked the commencement of the grid-like road network in the area, which presumably allowed for unrestricted traffic flow. In just about the same period as in Thonburi, new urban projects have been developed in Bangkok Noi area between the Krung Thon Bridge built in 1953 and Memorial Bridge. In 1968, the total population in BMA was about 2.7 million, which is more than 4.5 times that in 1900.

The situation in the north area of Bangkok Noi after the development as depicted in Figures 2.4.2 in 1968 and 1994 has demonstrated the gradual expansion of the urban area which are supported and serviced by the Krung Thon Bridge in 1953, Pinklao Bridge in 1973 and most recently, the Rama VII Bridge in 1992.

There are a number of bridges over the Chao Phraya, such as Rama V Bridge on the north to Rama IX Bridge on the south, roughly at the interval of 2 to 3 km from one another, and the urban area on the west bank of the river is almost continuously urbanized due presumably to the combined effect of the bridges in 2004.

In regards to Nonthaburi Province, the interval between Rama V Bridge and the next bridge upstream, Phra Nangklao Bridge, is about five km. This is one of the reasons why urbanization does not reach beyond the river. If and when the Project is built, the interval between Rama V Bridge, the Project bridge and Phra Nangklao Bridge will be in the range of two to three km. It is estimated that urbanization shall go beyond the river from Nonthaburi to the west bank area, forming a new urban area with about two km belt, similar to what happened in Thongburi and Bangkok Noi areas.

As discussed above, in order for the urban area to go beyond the Chao Phraya, the construction of new bridges at an interval of two to three km would be necessary. The expansion of the urbanization in Bangkok may take the northern direction naturally, and the Project bridge now prepared shall accelerate widespread urbanization on the west bank of the river, combined with the construction of Ratchaphruek Road as a north-south arterial road.

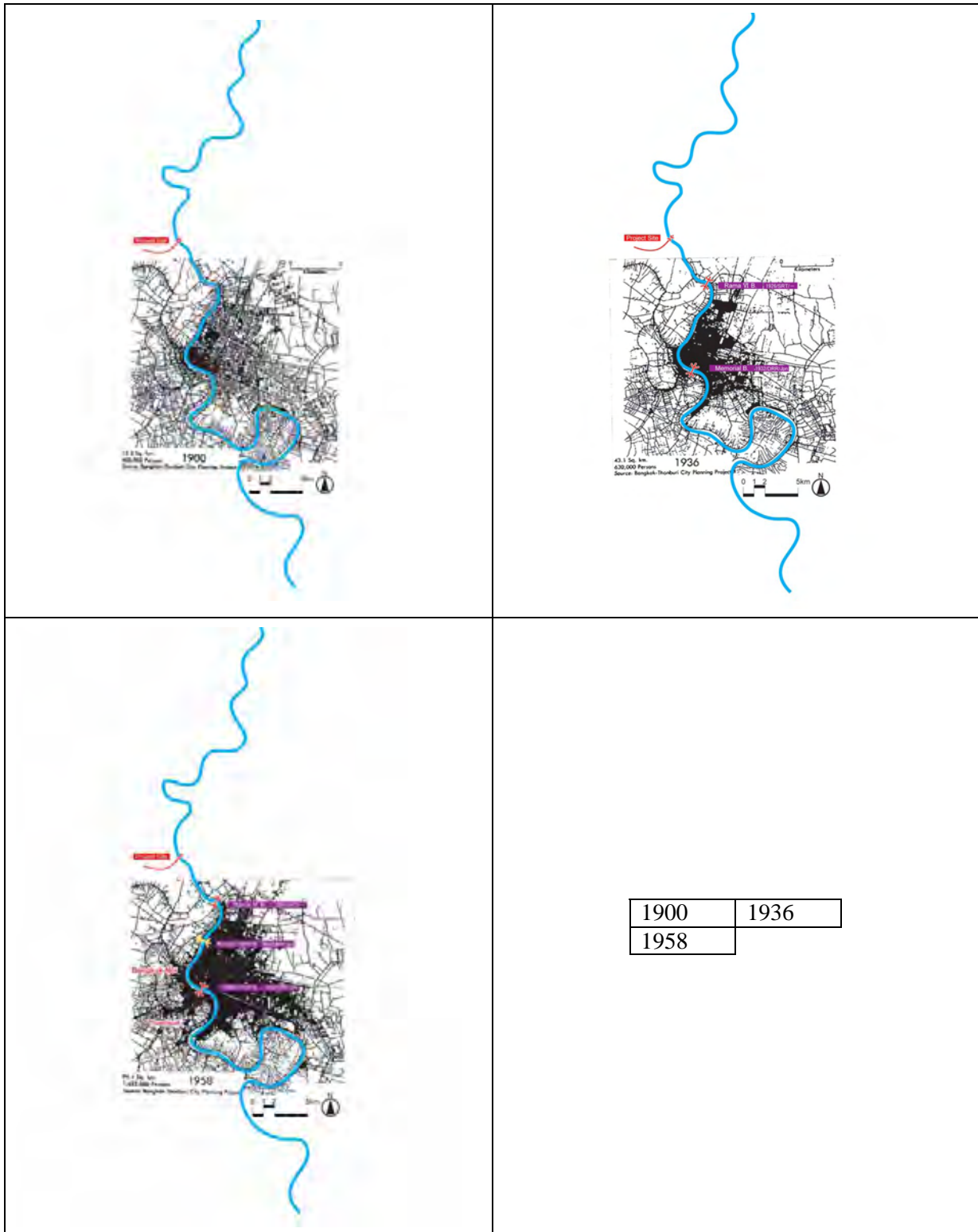


Figure 2.4.1 Transition of Urban Area Expansion in BMA (1/2) (1900 - 1958)

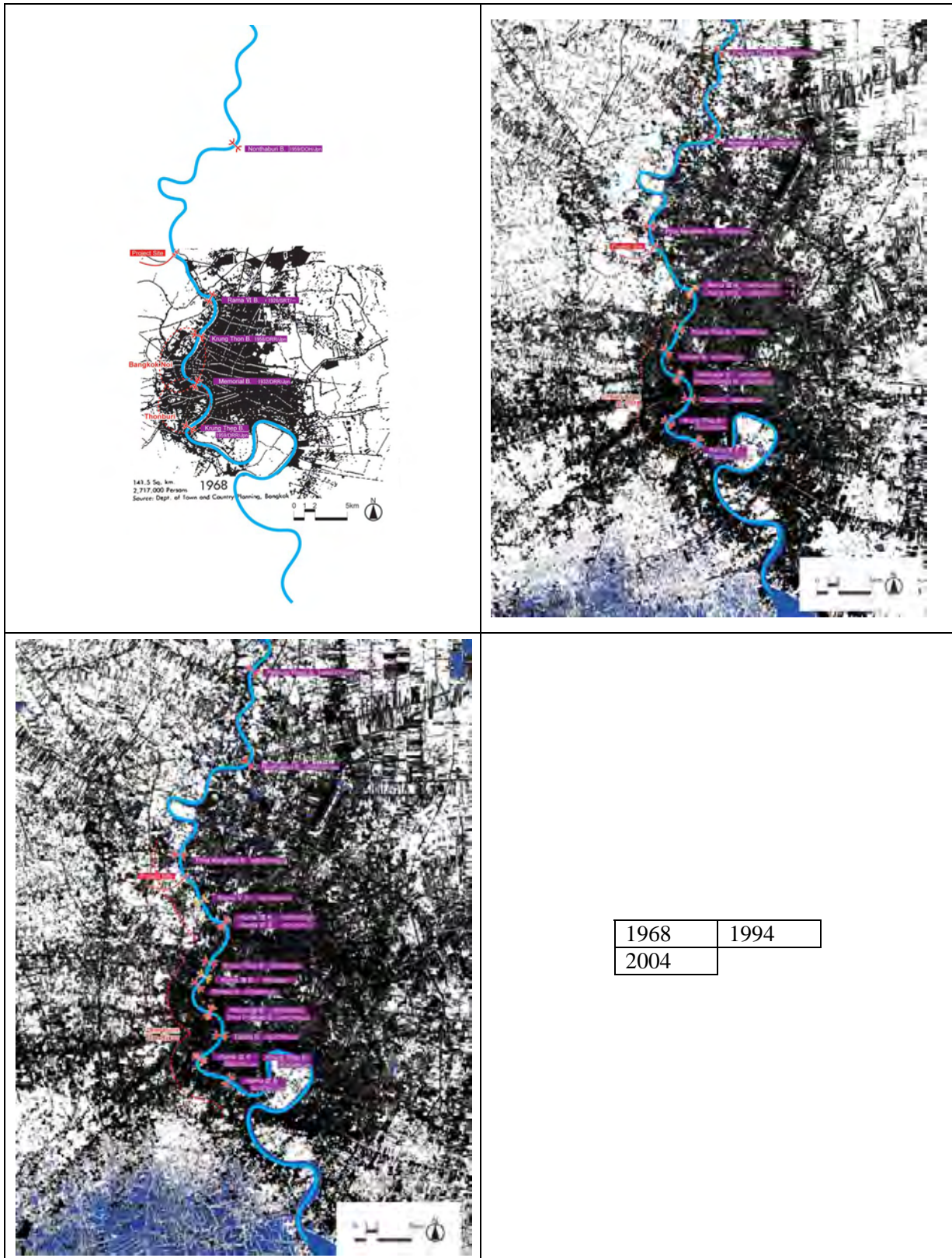


Figure 2.4.2 Transition of Urban Area Expansion in BMA (2/2) (1968 - 2004)

(2) Quantitative Effects

It was clarified in the foregoing paragraph that there are implications between the bridge development at Chao Phraya River and the urbanization of the district on its west bank.

In general, the generated and attracted traffic volume of the city is in proportion to its urban size. Therefore, it is simple to visualize the trend of the urbanization in the west bank of Chao Phraya River in connection with the transition of the bridge traffic volume in the past.

Moreover, appropriateness of scale and schedule of the past bridge developments including the developments funded by Japanese assistance are assessed from the aspect of demand-supply balance to put the assessment results to practical use of verification for the project.

Congestion ratio at sections of bridges crossing the Chao Phraya River is analyzed to clarify the quantitative effect from the above-mentioned viewpoint in this chapter.

1) Transition of Congestion Ratio

The congestion ratio of each bridge in the past was calculated to assess the validity of demand-supply balance between the bridge developments and traffic demand as shown in Table 2.4.2 to Table 2.4.4. In the congestion rate calculation, the following assumption was set to compare the congestion ratio uniformly based on the example of traffic survey result in BMR:

- Lane Capacity: 1,800 pcu

As mentioned earlier, the construction of bridges on Chao Phraya River has been implemented with appropriate scale and schedule considering the infrastructure capacity corresponding to the increase of traffic demand. Table 2.4.2 to Table 2.4.4 show the effect for decentralization of traffic demand with the new bridge constructions.

Table 2.4.2 Transitional Congestion Ratio on Bridges crossing Chao Phraya River (1/3)

Bridge Name	Number of Lanes	Year														
		1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1 Pathum Thani	2															
2 2nd Phatum Thani	2															
3 Nonthaburi-Pathum Thani	2															0.17
4 Pak Kret (Rama IV)	6															
5 New Phra Nangklao	6															
6 Phra Nangklao	4															
7 Wat Nakorn-In (Rama V)	6															
8 Rama VII	6															
9 Rama VI (Rail Bridge)	2	0.14						0.34		0.43			0.48			0.62
10 Krungthon	4	0.34						0.48		0.46			0.64			0.59
11 Rama VIII	4															
12 Phra Pinklao	6									0.46			0.66			0.7
13 Memorial (Phra Phutta Yodf)	6	0.85						1.14		0.85			0.79			0.94
14 Phra Pok Klao (New Memorial)	6															
15 Taksin (Sathon)	6															
16 Krung Thep	4	0.25						0.47		0.49			0.65			0.76
17 New Krung Thep (Rama III)	6															
18 Rama 9	6															
19 Industrial Ring Road	6															
20 Kanchanapisek	6															

Table 2.4.3 Transitional Congestion Ratio on Bridges crossing Chao Phraya River (2/3)

Bridge Name	Number of Lanes	Year														
		1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1 Pathum Thani	2															
2 2nd Phatum Thani	2															
3 Nonthaburi-Pathum Thani	2									0.5			0.72			
4 Pak Kret (Rama IV)	6															
5 New Phra Nangklao	6															
6 Phra Nangklao	4									0.5			0.43			
7 Wat Nakorn-In (Rama V)	6															
8 Rama VII	6												0.57		1.09	
9 Rama VI (Rail Bridge)	2	0.65					0.98			1.19						
10 Krungthon	4	0.6		0.76			0.87			0.89	1.39				1.17	
11 Rama VIII	4															
12 Phra PinkLao	6	0.71		0.98			1.08			1.06	1.71				1.53	
13 Memorial (Phra Phutta Yodf)	6	0.94		1.18			0.59			0.53	0.73				0.74	
14 Phra Pok Klao (New Memorial)	6						0.96			1.02	1.29				1.15	
15 Taksin (Sathon)	6	0.53		1.05			1.13			1.16	1.71				1.51 0.78	
16 Krung Thep	4	0.58					0.82			1.04	1.2				1.22 0.82	
17 New Krung Thep (Rama III)	6															
18 Rama 9	6									0.5					0.9	
19 Industrial Ring Road	6															
20 Kanchanapisek	6															

Table 2.4.4 Transitional Congestion Ratio on Bridges crossing Chao Phraya River (3/3)

Bridge Name	Number of Lanes	Year												
		1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1 Pathum Thani	2													
2 2nd Phatum Thani	2													
3 Nonthaburi-Pathum Thani	2													
4 Pak Kret (Rama IV)	6											0.6	0.6	0.5
5 New Phra Nangklao	6													
6 Phra Nangklao	4									0.86				0.72
7 Wat Nakorn-In (Rama V)	6									0.55				0.87
8 Rama VII	6				1.15		0.95			0.39	0.75	0.8	0.31	
9 Rama VI (Rail Bridge)	2													
10 Krungthon	4				1.24		1.08			0.50	0.8	0.92	0.32	
11 Rama VIII	4									0.70	0.86	0.86	0.61	
12 Phra PinkLao	6				1.57		1.38			0.71	0.81	0.83	0.99	
13 Memorial (Phra Phutta Yodf)	6				0.65		0.7			0.36	0.42	0.46	0.37	
14 Phra Pok Klao (New Memorial)	6				1.18		1.31			0.68	0.81	0.89	0.94	
15 Taksin (Sathon)	6				1.51		1.4			0.54	0.66	0.88	0.61	
16 Krung Thep	4	0.9	0.94	1.12	0.93		1.17			0.71	0.68	0.62	0.71	
17 New Krung Thep (Rama III)	6				0.55		0.53			0.41			0.23	
18 Rama 9	6				0.96									
19 Industrial Ring Road	6										0.36	0.41		
20 Kanchanapisek	6													

2) Economic Internal Rate of Return (EIRR)

The economic evaluation index such as EIRR of the 20 bridges crossing Chao Phraya River was tabulated in Table 2.4.5 excluding the bridges developed without F/S which was constructed during old times or urgent project and bridges conducted F/S as integrated project with access roads.

Since most of the bridge developments were carried out after traffic demand for bridges became obvious, the EIRR for most of the bridge development projects were estimated at 20% or more. While, economic effects of the bridges missing their EIRR are obviously high because the high project benefits can be explained based on the high vehicle congestion ratio as shown in Table 2.4.2 to Table 2.4.4.

Table 2.4.5 Project Evaluation Results of Bridges Crossing Chao Phraya River

	Bridge Name	Administrator	Operation Year	NPV (100 mil. Baht)	EIRR	B/C	Source
1	Pathum Thani	DOH	1984		27.2		Post Evaluation Report of "Construction of Bridges Crossing Chao Phraya River and Expressways", Jan 1986, JBIC
2	2nd Pathum Thani	DOH	2009				
3	Nonthaburi-Pathum Thani	DOH	1959				
4	Pak Kret (Rama IV)	DRR	2006	33.95	33.9	3.39	The Feasibility Study and IEE of the Pak Kret Bridge and Connecting Road Construction Project, MOI, 1994
5	New Phra Nangklao	DOH	2008				
6	Phra Nangklao	DOH	1985		20.9		Post Evaluation Report of "Construction of Bridges Crossing Chao Phraya River and Expressways", Jan 1986, JBIC
7	Wat Nakorn-In (Rama V)	DRR	2002	8.86	17.4		Feasibility Study for Wat Nakorn-In Bridge Construction Project, MOI, 1991
8	Rama VII	DRR	1992	6.59	20.6	1.91	The feasibility study on the Rama VI Bridge construction project, 1981.12, JICA
9	Rama VI (Rail Bridge)	SRT	1926				
10	Krungthon	DRR	1958				
11	Rama VIII	BMA	2002				
12	Phra PinkLao	DRR	1973		12.0		Post Evaluation Report of "Construction of Bridges Crossing Chao Phraya River and Expressways", Jan 1986, JBIC
					45.0		Post Evaluation Report of "Construction of Bridges Crossing Chao Phraya River and Expressways", Jan 1986, JBIC
13	Memorial (Phra Phutta Yodf)	DRR	1932				
14	Phra Pok Klao (New Memorial)	DRR	1984		17.0		Post Evaluation Report of "Construction of Bridges Crossing Chao Phraya River and Expressways", Jan 1986, JBIC
					15.0		Post Evaluation Report of "Construction of Bridges Crossing Chao Phraya River and Expressways", Jan 1986, JBIC
15	Taksin (Sathon)	DRR	1982		32.0		Post Evaluation Report of "Construction of Bridges Crossing Chao Phraya River and Expressways", Jan 1986, JBIC
					44.0		Post Evaluation Report of "Construction of Bridges Crossing Chao Phraya River and Expressways", Jan 1986, JBIC
16	Krung Thep	DRR	1959				
17	New Krung Thep (Rama III)	DRR	2000	12.47	20.7	2.09	Feasibility Study on New Krungthep Bridge Construction and Thonburi Road Extension, 1987, JICA
18	Rama 9	EXAT	1987				
19	Industrial Ring Road	DRR	2006	100.94	18.9	1.82	The Feasibility Study and Initial Environmental Impact Study of Industrial Ring Road Project, 1996, MOI
20	Kanchanapisek	DOH	2007	260.18	23.9	3.30	The Feasibility Study on the Southern Outer Bangkok Ring Road Project in Kingdom of Thailand, March 2000, JETRO

(3) Qualitative Effects

As clarified in the foregoing paragraph, the bridges crossing the Chao Phraya River has contributed to provide the traffic demand between the east and west banks of Chao Phraya River, which kept on increasing correspondingly with the improving economic activities in BMA. On the other hand, it is obvious that the urbanization from the east bank of Chao Phraya River to the west bank has accelerated the socio-economic activities in the west bank, resulting to huge benefits for the area.

In this chapter, the indirect benefit of bridge development is examined through comparisons of social trend index between Nonthaburi prefecture, as the representative area on the west bank of Chao Phraya River, and BMA, as the representative area on the east bank of Chao Phraya River.

Moreover, it is considered that the evaluation and expectation of effectiveness for the developed bridges and the project through interview survey of the municipalities and business establishments that seemed to be direct beneficiaries. Assessment of the impact by the project based on the above examination afterward is carried out.

1) Development and Social Trend on the Surrounding Area of Chao Phraya River

a) Population

The growth rate in BMA and Nonthaburi has stagnated in 1980 and 1990, respectively. The timings are corresponding to the bridge development of Krung Thon Bridge, the

Pinklao Bridge, Memorial Bridge, Krung Thep Bridge in BMA during 1970s, Nonthaburi Bridge, Pathum Thani Bridge, and Phra Nangklao Bridge in Nonthaburi during the 1980s. This correspondence indicates that the bridge development influenced urbanization on vicinal areas. Moreover, the population growth in Nonthaburi has been kept to 2.5% or more in these days, and it is expected that further urbanization of Nonthaburi will continue as a suburb city in BMA.

Table 2.4.6 Population Growth in Surrounding Area of Chao Phraya River

	1970	1980	1990	2000	2003	2004	2005	2006	2007
Bangkok	3,077	5,153	5,546	5,680	5,844	5,634	5,658	5,695	5,716
Growth Rate(%/year)	-	5.29	0.74	0.24	0.95	-3.60	0.40	0.70	0.40
Nonthaburi	269	386	668	859	924	942	972	999	1,024
Growth Rate(%/year)	-	3.68	5.64	2.55	2.46	1.90	3.20	2.80	2.50

Source: Bureau of Registration Administration, Department of Local Administration,
Ministry of Interior

b) Employees

The trend of growth rate both in Nonthaburi and BMA are synchronized by the influence of economic performance. However, the growth rate of Nonthaburi has not been less than 0%, and it has kept above 1% to 5% of the growth rate of BMA.

**Table 2.4.7 Transitional Numbers and Growth Rate of Employees
in the Surrounding Area of Chao Phraya River ('000)**

	1998	1999	2000	2001	2002	2003	2004	2005	2006
Bangkok	3,165	3,379	3,135	3,185	3,094	3,457	3,200	3,213	3,192
Growth Rate(%/year)	-	6.80	-7.20	1.60	-2.90	11.70	-7.40	0.40	-0.70
Nonthaburi	201	173	155	166	176	201	202	216	217
Growth Rate(%/year)	-	-13.90	-10.40	7.10	6.00	14.20	0.50	6.90	0.50

Source: Year Book of Labour Protection and Welfare Statistics 2006, Department of Labour Protection and Welfare,
Ministry of Labour

c) Houses

The growth rate from year 2000 and year 2002 of Nonthaburi and BMA were reduced, and the growth rate of BMA has been maintained to about 2% afterwards. After year 2002 Nonthaburi growth rate has been steadily maintained to about 4% and this indicates the high development potential of Nonthaburi as the bed town in BMR.

**Table 2.4.8 Transitional Numbers and Growth Rate of Houses
in Surrounding Area of Chao Phraya River ('000)**

	1990	2000	2002	2003	2004	2005	2006	2007
Bangkok	1,176	1,905	1,963	2,020	2,050	2,091	2,150	2,207
Growth Rate(%/year)	-	4.94	1.51	2.90	1.50	2.00	2.80	2.70
Nonthaburi	148	365	377	388	404	421	449	468
Growth Rate(%/year)	-	9.45	1.63	2.90	4.10	4.20	6.70	4.20

Source: Bureau of Registration Administration, Department of Local Administration,
Ministry of Interior

d) Business Enterprise

The transition of growth rate in BMA and Nonthaburi are synchronized. However, the data in 2003 and 2006 of Nonthaburi does not seem reliable because of its high fluctuation. The growth rate between 1998 and 2006 in Nonthaburi is 75% out of 8.5% in BMA, which indicates firm location in Nonthaburi has steadily proceeded compared to BMA.

Table 2.4.9 Transitional Numbers and Growth Rate of Business Enterprise in Surrounding Area of Chao Phraya River

	1998	1999	2000	2001	2002	2003	2004	2005	2006
Bangkok	153,317	165,366	158,864	159,818	160,762	178,036	177,635	166,195	166,299
Growth Rate(%/year)	-	7.90	-3.90	0.60	0.60	10.70	-0.20	-6.40	0.10
Nonthaburi	4,138	4,627	4,343	4,434	4,571	7,052	6,762	5,536	7,092
Growth Rate(%/year)	-	11.80	-6.10	2.10	3.10	54.30	-4.10	-18.10	28.10

Source: Year Book of Labour Protection and Welfare Statistics 2006, Department of Labour Protection and Welfare, Ministry of Labour

e) Land Prices

Detailed data on land prices in Nonthaburi and BMA were not acquired. However, according to the post-evaluation survey for Rama V Bridge project conducted by JBIC, it was observed by pre-post comparison that the land price increment was from 1 to 3 times in Ratcha Phruk Road and from 2 to 3.5 times in Nakorn In Road.

The bridge development commonly provides more significant accessibility than the roads, and a remarkable land price hike, especially near the bridge site on the westbank of Chao Phraya River, is obvious.

2) Interview Survey

a) Interview of Local Companies

Interview survey was conducted in order to gather qualitative effects caused by crossing bridge from companies located in some areas near the existing and new bridges. The survey areas were focused on the four areas where urbanization may have been brought from the east bank of the Chao Phraya River to the west bank by the effects of two or three bridges (Planning area (Nonthaburi province), Bangkok Noi (BMA), Thongburi (BMA), South of Thongburi (BMA)).

As a result, a total of 225 responses have been collected in this survey.

The survey questionnaire consists of nine questions and each question is answered in five levels (much better benefit – much worthy impacts) as shown in Table 2.4.10.

Table 2.4.10 Questions of Interviews

Items	Questions
For Business Value	Reduce Costs (fuel, time, etc), Increase Earnings, Sales and/or A Number of Customers, Improve Conveniences for Employees and/or Business Customers
For Accessibility	Reduce Times for Transport, Improve Access to Useful Facilities, Improve Access in Emergency (hospital)
For Lands Value	Increase Land Prices, Improve Life Environment (Noise, Atmosphere, etc), Reduce Traffic Accidents

The results of this survey are summarized as follows:

- Result of Expectations for the New Bridge

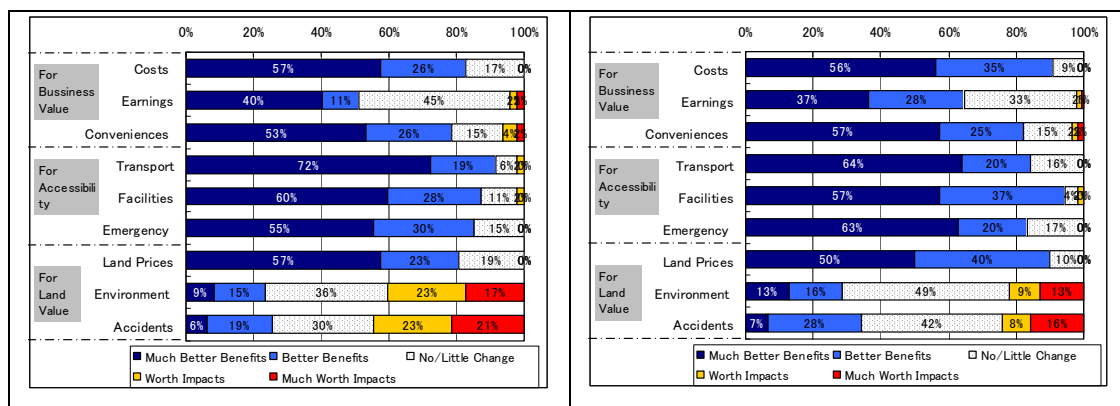


Figure 2.4.3 The Results in Comparison between the New Bridge (L) and the others (R)

Based on the comparison made between the new bridge and the other bridges, the result indicated that the new bridge has been highly expected in 5 out of 9 questions than the other bridges built in the past.

As the figure indicates, in regard to “Reduce Costs (fuel, time, etc)” for business value, 58% responded as “expect much better benefits” from the new bridge. It is likely that some reduction of costs and time in transport are expected. In the question of “Increase Earnings, Sales and/or a Number of Customers”, positive expectations for the new bridge are 51% which is less than the others with 65%. One reason is to assume that the benefits for business values have not yet been sufficiently recognized by the local companies so far because it is not existing yet.

In regards to “Reduce Times for Transport” for accessibility, 91% responded positive in with the new bridge. This figure was 7% higher than that of the others, and this result clearly shows that there are many local companies that have high expectations.

In regards to “Improve Life Environment (Noise, Atmosphere, etc)” and “Reduce Traffic Accidents” for lands value, much worth impacts by the new bridge are their consideration. Generally speaking, this consideration and apprehensions are normal for the proposed projects. Thus, it is very important and necessary to consider appropriate measures.

As analyzed above, the construction of the new bridge is expected to be approved by the local companies as well as the residents, that will give emphasis on the aspects of reduce costs, improvement accessibility.

- The Results of Comparison among the Survey Areas

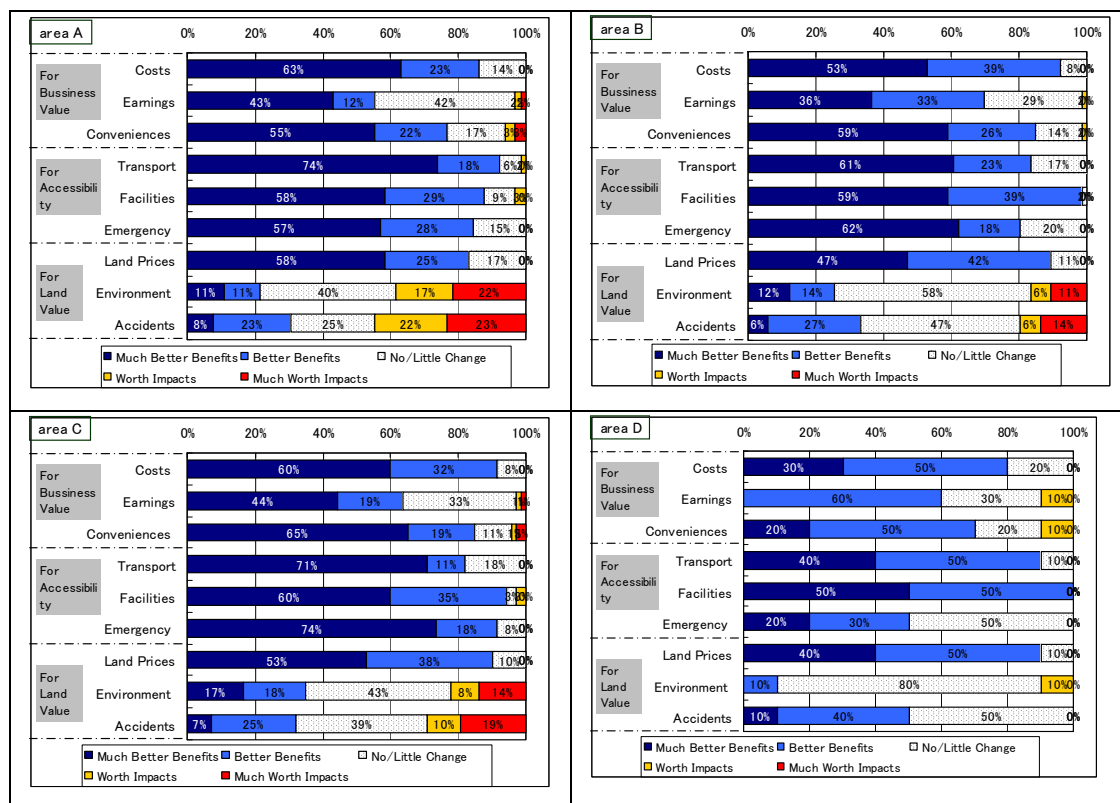


Figure 2.4.4 The Results of Comparison among the Four Areas

In this sub-section, the results were divided into four survey areas and analyzed.

The result indicated that there are no significant differences among area A, B and C in most of the questions. One important point is that the effects of crossing bridges have gotten high positive responses in all areas. In regards to business values and accessibility, more than 80% responded as “Expect (Got) Much Better Benefits” or “Expect (Got) Better Benefits”, with the exception of one question about earnings. On the other hand, the answers of “life environment” and “traffic accident” have high negative responses especially in area A. As described earlier, this reason seems that area A includes the new bridge that will be constructed in the future. In addition, the result in area D was much less answers of “Got Much Better Benefits”, compared with other areas. It is for this reason that the Rama 9 Bridge located in this area is now used in the expressway (EXAT), so there is less benefit for the local companies.

b) Interview of Local Government and Other Organizations

In addition to the local companies, the interview survey of local government and the other organizations have been conducted, such as Nonthaburi Province, Bangkok Metropolitan Administration, and the Ministry of Interior.

The following were obtained that the local government and the other two organizations also have positive outlook to the new bridge in general. The opinions from the person in charge of the city planning are; 1) The land price will increase and the urbanization in the Nonthaburi Province will be advance, and 2) The new bridge will bring expansion of urban area to west bank of the river in BMA. In addition, BMA has positive opinions as follows; 1) There is no idea on the negative impacts brought about by the new bridge, and 2) It is reasonable to consider for the mass labors that will inflow from Nonthaburi to Bangkok, because of the expansion and better accessibility of BMA areas.

On the other hand it is important that planning of transport network including the new bridge should be formulated regionwide for some considerations as stated in following opinions; 1) The improvements of traffic condition are much expected with the development of the new bridge, but there is a big problem that traffic bottleneck still remains at some intersections on the east bank of the Nonthaburi River.

2.5 PROPOSED DEVELOPMENT PLAN FOR THE PROJECT AREA

(1) Purpose and Target of the Proposed Area Development Plan

Historically, the Chao Phraya River has served as a substantial hindrance to the expansion of Bangkok urban area. Therefore, the urbanization has spread out firstly in the east bank of the river under the condition without enough bridges. This section describes the area development plan which is proposed by the study team. And the project area that seems to receive impacts drastically by the new bridge is selected as discussed below.

As seen in the past movement, the significant expansions of urban areas have occurred in the range of 2 and 3 km belt along the river. Therefore, Nonthaburi District of Nonthaburi Province was selected as the project area for the proposed development plan in view of the suited conditions.

(2) Related Plans

Bangkok Metropolitan Region is composed of BMA and the five surrounding provinces. BMR is the mega-city in the region with a present registered population of 11 million. About half of the BMR population lives in BMA area. The population projection on the provincial level, the growth rate for BMA is as low as 0.39%, while those of Nonthaburi and Pathumthani on the north of BMA are comparably higher, 2.85% and 1.82%, respectively, and that of Samut Prakan is also high at 2.1%. These indicate that the expansion of urban population is leaning towards the north and southeast direction from the center of Bangkok.

As seen above, one of the focal problems in BMR is the accumulation of economic activities in the metropolitan area. In order to solve this problem, the policy to promote regional cities called sub-centers to lessen the one-polar structure of the national economy is moved forward, and one of the sub-centers around Bangkok is Nonthaburi District.

Two comprehensive plans for the Nonthaburi Province are shown in Figure, one for 1990 and the other for 2005.

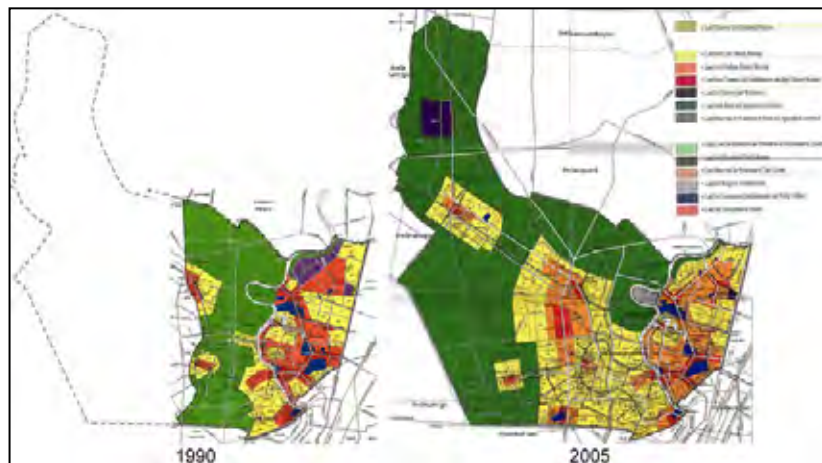


Figure 2.5.1 Comprehensive Plans for Nonthaburi Province (1990 and 2005)

(3) Proposed Area Development Plan for the Project Area

In this sub-section, the impacts brought by the new bridge are estimated by means of qualitative analysis mainly on the relationship between crossing the bridges in the past and expansion of urbanizations. Finally, the drafts of the area development plans targeted in both Nonthaburi Province and Nonthaburi District are proposed based on the detailed analysis.

1) Population Transition in Nonthaburi Province

In Nonthaburi Province, the population in 2007 was 1,024,191, which is more than 1.5 times the 1990 population. The average growth rate in 17 years period is about 2.6%. The population densities were 1,063/km² in 1990 and 1,646/km² in 2007.

The population from each district was analyzed next. The analysis was conducted in the eight districts as illustrated in Figure.

Figure summarizes the 2007 population of the eight districts. As seen in them, the population of ①-1 Nonthaburi City Municipality is 265,796 which is 26% of the province population and that of ②-1 Pak Kret City Municipality is 169,782 which is 17% of the province population. These figures are much larger than the others. This shows that the total population of these two districts in the east bank is equivalent to 43% of the province population and about, 12% of the province area.

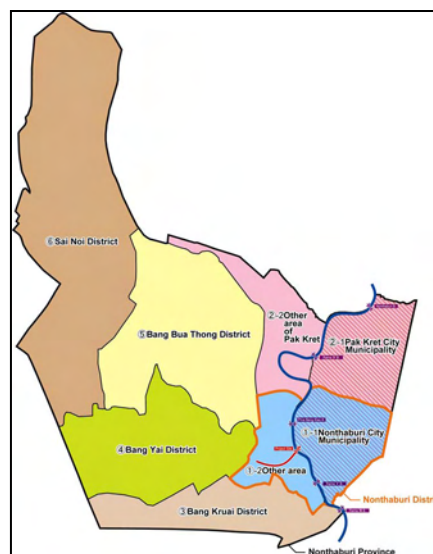


Figure 2.5.2 Eight Districts of Nonthaburi Province

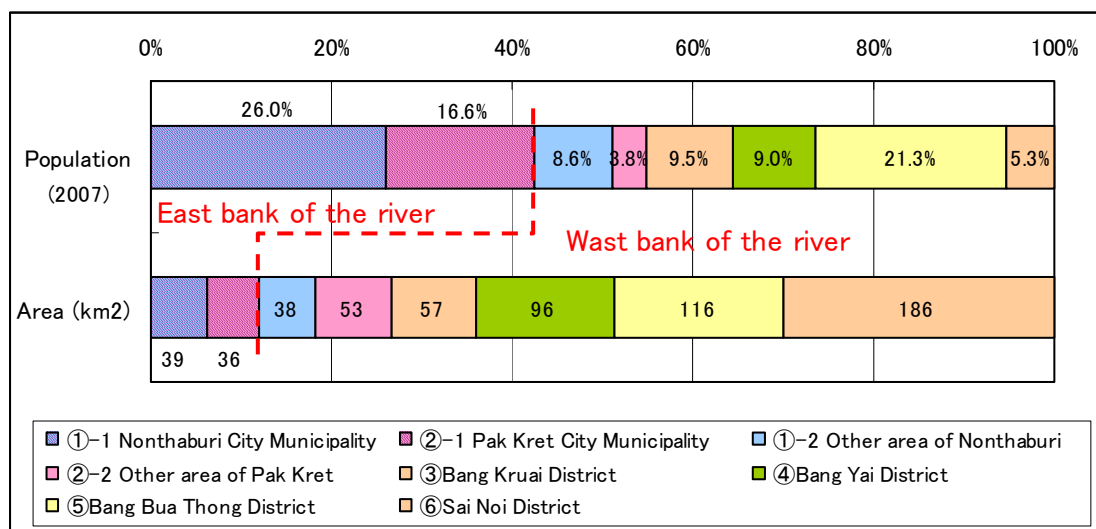


Figure 2.5.3 The Proportion of Population and Area in each District

The population growth rate during the period from 1990 to 2007 in ①-1 Nonthaburi City Municipality and ②-1 Pak Kret City Municipality, are 0.3% and 2.2% respectively, which are lower than 2.6% the average growth rate in province. Furthermore, in the last five years the population in east bank seems to be much enough for its capacity, because the population has slightly decreased.

On the other hand, the growth rates from 1990 up to 2007 in the districts on west bank indicate much high level, such as 7.5% in ⑤ Bang Bua Thong District and 5.8% in ④ Bang Yai District. Additionally, the growth rate in ①-2 Other Area of Nonthaburi District is 3.7% as the high level. Thus, from this viewpoint, one might say that the population increase in the future should be expected mainly in the west bank districts.

2) The Structure and Restriction for Urbanization in Nonthaburi Province and BMA

As mentioned above, the recent growth rates of west bank are much higher than that of east bank, however, the population density of the west bank is 1,075/km², which is still much lesser than the east bank of 5,812/km². The estimated reasons are listed below.

- The Chao Phraya River flows from north to south through the province area
- The railroad of SRT runs east - west on the boundary of Nonthaburi and BMA
- Agricultural lands and Kokret, which is famous for historical heritage, spread out in northern areas of province

The construction of the new bridge is one of most important factors for the expansion of urban areas to west bank, because the population in the east bank seems close to upper limit capacity. In addition, the movement of urbanization in BMR is extending gradually northwards.



Figure 2.5.4 Structure and Restriction for Urbanization in Nonthaburi Province and BMA

3) The Population Framework for Nonthaburi Province

The 2007 population of Nonthaburi Province is 1,024,191 and its density is 1,646/km². The average growth rate from 1990 to 2007 is about 2.6%. The population projection indicates 1,378,608 in 2011 and 1,615,245 in 2016. Based on this projection, 5.2% growth rate in 2007 to 2016 is much higher than that in past.

Proposed population framework of each district in the target year 2016 is summarized below.

Table 2.5.5 Proposed Population Framework in Each District

District Name	2007		Growth Rate		Increase of Population	2016	
	Population	Density	1990-2007	2007-2016		Population	Density
①-1 Nonthaburi City Municipality	265,796	6,833	0.3%	0.3%	7,204	273,000	7,000
①-2 Other area of Nonthaburi	87,684	2,300	3.7%	8.3%	92,316	180,000	4,700
②-1 Pak Kret City Municipality	169,782	4,711	2.2%	4.5%	83,218	253,000	7,000
②-2 Other area of Pak Kret	39,121	738	0.9%	4.5%	19,879	59,000	1,100
③Bang Kruai District	97,650	1,701	1.5%	4.8%	51,350	149,000	2,600
④Bang Yai District	92,215	957	5.8%	11.8%	158,785	251,000	2,600
⑤Bang Bua Thong District	218,030	1,872	7.5%	3.7%	82,970	301,000	2,600
⑥Sai Noi District	53,913	290	2.7%	11.9%	95,087	149,000	800
Total	1,024,191	1,646	2.6%	5.2%	590,809	1,615,000	2,595

The three consideration points related to this framework are the following. Firstly, it is supposed that the upper limit of density of east bank is 7,000/km². Secondly, the construction of the new bridge will bring the expansion of urban area to the west bank, especially in ①-2 Other Area of Nonthaburi District. It is quite likely that the urbanization in this district will be advanced, most remarkably among the west bank districts, and the density will reach around 5,000/km² in ①-2. Thirdly, it is estimated in ③ - ⑤ districts that the population densities in the future will be getting closer to each other to about 2,600/km², which is the average density of province, since three districts have similar conditions of accessibility to BMA and current land uses.

4) Urban Structure of Nonthaburi Province in the Future

The new bridge would lead to the expansion of urban area to west bank, combined with the existing bridges such as Phra Nang Klao Bridge and Rama 5 Bridge, as seen in below.



Figure 2.5.5 Urban Structure of Nonthaburi Province in the Future

5) Proposed Area Development Plan for Project Area

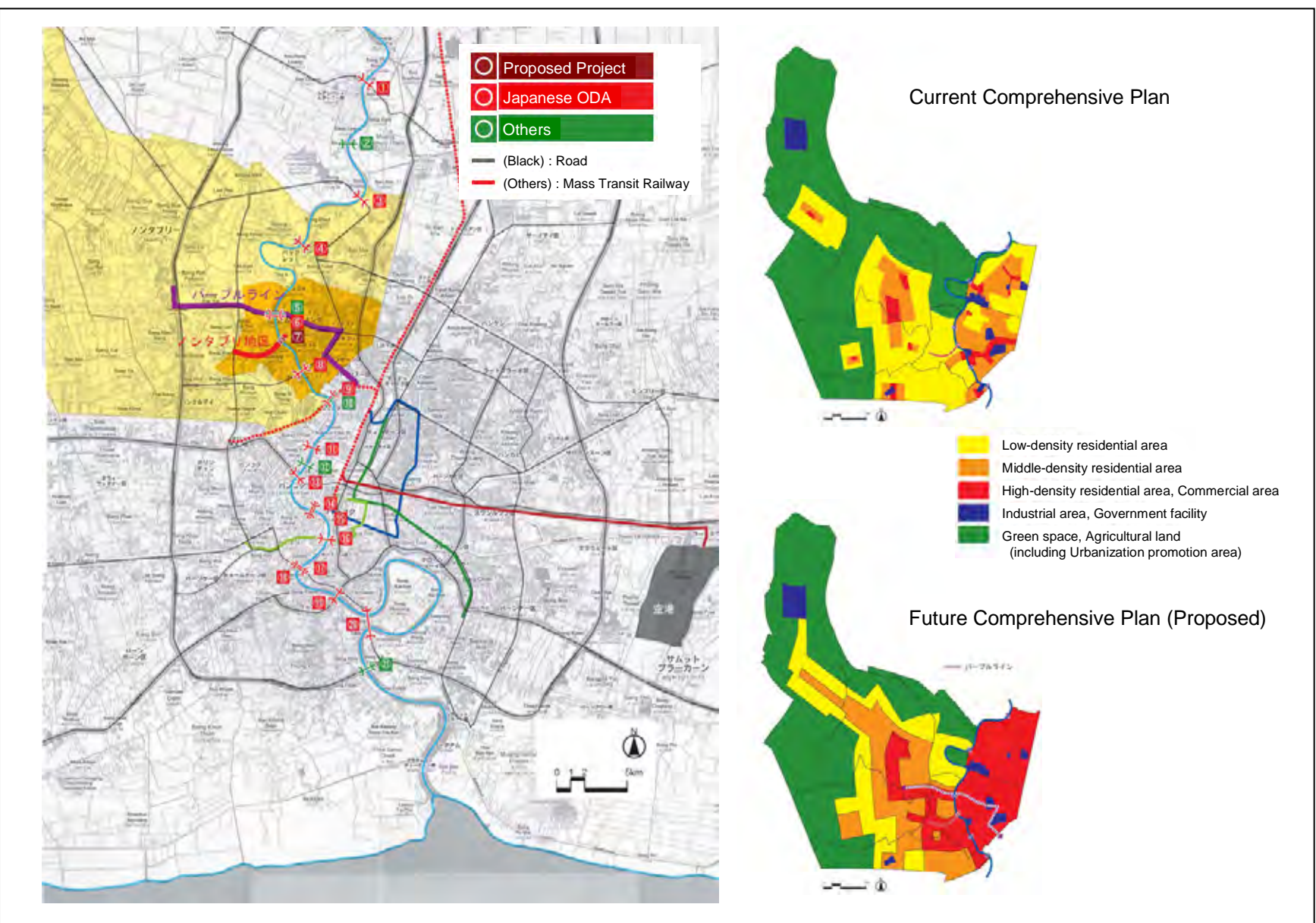
The current comprehensive plan for Nonthaburi Province has effect basically in the five-year period from 2005 to 2010, however, this period will be extended to another one or two years according to the interview survey of Nonthaburi Province. As a result, it is estimated that the next comprehensive plan will be modified in 2011 – 2013 and targeted at 2016 – 2018. The time of next modification might correspond to the time of opening of the new bridge to the public, therefore the next comprehensive plan including impacts by the new bridge will be proposed in this section.

The ideal population densities for each kind of land use are proposed. The proposed figures are given below.

- Medium-High Density Housing: The proposed population density is 5,000/km².
- Low Density Housing: The proposed population density is 2,000/km².
- Rural & Agricultural Activities, Industry & Public Utilities: The proposed population density is 500/km².

Based on the above discussion, the area development plan of Nonthaburi Province which will be as the next comprehensive plan is proposed as follows. It is presumed that the target period of this plan is from 2011–2013 to 2016–2018.

It is quite likely that this urbanization will expand rapidly as soon as the new bridge opens to the public. Therefore, it is recommended that the new bridge in the new road should be lowered to the ground level as much as possible, and then the connection between the new roads and existing local roads, housing, parks should be strengthened. This will lead to make and penetrate the benefits of the new bridge for the project area. In addition, some measures should be taken in order to maintain and improve the local resources and values for the future. One of these measures, for example, is the local area management considered in forming attractive landscape by appropriate use of the river front spaces or existing well-managed park. In the long-term span, it is expected that the river front roads which run from the north to south on west bank should be constructed.



CHAPTER 3 PROJECT OUTLINES

3.1 PROJECT OBJECTIVES

Objectives of this Project are as follows;

- 1) To alleviate and solve traffic congestion problems in the area north of Bangkok and its adjacent area of Nonthaburi Province.
- 2) To improve the linkage of road network in the east and the west area of the Chao Phraya River.
- 3) To be employed as a feeder route to the MRT Purple Line and the SRT Red Line.

3.2 PROJECT OUTLINE

(1) Project Outline

The Project starts from Nonthaburi 1 Road on the east side of the Chao Phraya River, pass over the river by an extradosed bridge and ends at Ratcha Phruk Road on the west side of the river as shown in Figure 3.2.1.



Figure 3.2.1 Planning Map of the Project

There are 121 cases of land purchases, which are already completed. Some of the building relocations still remain but DRR says it will be finished before construction is started.

(2) Package of the Project

Earlier, this project had been divided into two contracts. However, the modality of the contract was revised to make it as one contract as of September 2009. This decision does not seem to pose any problem considering the size of the Project.

(3) Approved Project Cost

The project cost approved by the DRR Cabinet is Baht 6,136 Million. Breakdown of the project cost is as follows;

- Construction cost: Baht 3,796 M, including VAT and other taxes
- Consulting services (Construction supervision): Baht 140 M
- Land acquisition and compensation: Baht 2,200 M

Costs for the detailed design and administration cost are excluded in the approved cost by the Cabinet.

(4) Construction Work for Japanese ODA Portion

1) Consulting Services

Design, tender documents, and construction supervision are all funded by the Thai Government as per agreement between JICA and DRR. However, it is necessary to assist DRR to keep the quality and safety of the construction, and also from the viewpoint of technical knowledge transfer, as the bridge becomes big for this type and DRR has no experience for its construction.

2) Construction

The sharing of funding between the stakeholders will be based on the manner and ratio of total construction cost as agreed by JICA with DRR. So, it is not necessary to demarcate the construction works.

3.3 PROJECT COST AND FUNDING PLAN

(1) Review of Existing Design for the Project

The main bridge crosses the river in the southwest direction to the west bank of the river at the area on the south side of Klong Om Nont and ends in the area between the City Shrine and Chalerm Kanchana Phisek Park. The main components of construction works consist of the following structures and roads;

- Main bridge of extradosed type having 200 m in the center span and 460 m in length provides six traffic lanes and two side walks.
- Main lane viaduct on the west side of the river consists of four traffic lanes and on-off ramps with 930 m, 151 and 124 m, respectively.
- Nonthaburi 1 Road Interchange located on the east side of the river comprises the main lane viaduct, on and off ramp with total length of 2,343 m.
- Ratcha Phruk Road Interchange consists of one flyover and two ramp bridges and its total length is 1,188m.
- Main lane at-grade road with 2,275 m length and two minor roads.

The existing design was reviewed in the following points:

- 1) Review of Main Bridge (Extradosed Bridge)
 - a) Review of Main Span and Bridge Length based on the River Conditions

- b) Review of Type of Bridge
- c) Review of the Safety Factor of Stay Cables
- d) Review of Standard Cross Section
- e) Review of Saddle
- f) Review of Connection between Superstructure and Sub-structure
- g) Review of Stay Cable Damping
- h) Review of PC Stressing of Pile Cap in Water
- 2) Review of Main Lane Viaduct
- 3) Review of Nonthaburi 1 Road Interchange
- 4) Review of Ratcha Phruk Road Interchange
- 5) Review of Flyover

(2) Review of Construction Plan

Construction plans of the Project are mainly reviewed on the erection of girder of both extradosed bridge and PC box girder bridge. Transportation method of materials and equipment for construction of pier in the river is also reviewed considering river traffic.

- 1) Review of Erection of Extradosed
- 2) Review of Erection of Post-tension PC Box Girder Construction
- 3) Review of Temporary Bridge or Jetty for Construction of Pier in the River
- 4) Review of Pre-stress in Cantilever Erection

(3) Review of Procurement Plan

1) Procurement of Materials and Equipment

Construction equipment required for construction of the Project can be procured in Thailand. However, some materials are required to be imported from abroad, as shown in Table 3.3.1.

Table 3.3.1 Materials to be Procured from Foreign Countries

No.	Description	Approximate Quantity
1	Stay Cable	270 Ton
2	Anchorage of Stay Cable	96 Nos.
3	HDPE Sheath	2,260 M
4	Rubber Damper of Stay Cable	48 Nos.
5	Pot Bearing	210 Nos.
6	Expansion Joint	1,100M
7	Waterproofing material on Deck Slab	

2) Procurement of Consultant and Contractor

Six consultants have experience as design consultant and six consultants as construction supervisor, while seven contractors have experience in construction under foreign contractors. No contractor has been involved in any cable-stayed bridge project as the main contractor.

(4) Review and Update of the Construction Cost

Construction cost was reviewed in following points based on the third additional information on cost estimate, design (mainly construction drawings) and breakdown of unit prices.

- 1) Review of Construction Cost
- 2) Update of Construction Cost

Construction cost was updated through the following factors:

- a) Factor F
- b) Additional works
- c) Missing Works in BQ Item
- d) Review of Unit Price and Overhead
- e) Cost Estimation of Additional Items
- f) Review of Tender Documents (Design Drawings and BQ)

(5) Confirmed and Accepted Construction Cost with DRR

Based on the review of designs and costs described in the previous sub-sections, DRR, JICA and the survey team have discussed on the management of the results of design changes and cost increases, and agreed on the revisions as shown in Table 3.3.2 and 3.3.3. Cost increases due to dampers for cost for stay cable, Outer HDPE sheath and revised unit price of the stay cable is Baht 63,992,500, which is only 1.7% of the total construction cost. Such costs are possible to adjust in quantity the allowance for bored pile, reinforcing bar and PC tendon.

Table 3.3.2 Accepted Additional Costs for Main Bridge

No.	Additional Work/ Costs Items	Unit	Q'ty	Unit Price (Baht)	Amount (Baht)	Confirmation
A	Additional Works					
1	Temporary Jetty	m2	2,200	-	-	Included in unit price of bored piles
2	Damper for Stay Cable	No.	48	195,000	8,640,000	Accepted by DRR.
3	HDPE Sheath	m	2,260	1950	11,407,500	Separated Item (Note 1)
4	Waterproofing	m2	11,000		-	(Note 2)
B	Additional Cost					
1	Revised Unit Cost for Stay Cable	ton	270	162,500	43,875,000	Confirmed by new quotation by Supplier
2	Increase of site overhead for foreign contractor	ls			-	Not accepted in DRR's cost estimate system (Note 3)
3	Design review and preparation drawings	ls			-	Not accepted in DRR's cost estimate system (Note 3)
	合計				63,922,500	

Note 1: Item of HDPE sheath is separated from stay cable and the new pay item is provided in B/Q.

Note 2: Waterproofing on deck slab is out of DRR standard but necessary works for long term maintenance. JICA recommends providing the waterproofing if positive balance after tender is accrued.

Note 3: Cost estimate in DRR is institutionalized so that site overhead for foreign contractor is not specially estimated.

Table 3.3.3 Design Changes in Consideration with Quality, Safety and Maintenance

No.	Items of Design Change	Confirmation
1	Design for pile cap of pier in the river is pre-stressed by PC tendons at bottom shall be changed to reinforced concrete or provision of corrosion protection for PC tendons and anchors because of the risk of breakage due to corrosion of PC tendon.	Secure safety by corrosion protection of PC tendons and coverage and also specified in technical specification.
2	Longitudinal gradient of viaduct shall be 0.2%~0.5% instead of 0% to improve function of drainage.	Design change was accepted.
3	Longitudinal expansion joint shall be deleted in point of maintenance and structural defect. Span re-arrangement is necessary for the measure.	Longitudinal expansion is deleted or minimized due to their new design method.
4	Main bridge shall be symmetric on both sides at the crown of vertical arrangement of the road. The crown of vertical alignment of road shall move 15.5 m toward the west side.	Modification was accepted.

Construction costs after adjustment is Baht 3,721,778,000.

(6) Review of Implementation Schedule

1) Work Schedule from the present

The selection of the consulting firm for construction supervision, which takes six months, can be done while preparing for the tendering for construction as shown in Table 3.3.4. This detailed schedule is shown in Table 3.3.5.

Table 3.3.4 Earliest Implementation Schedule

Year	2010	2011	2012	2013	2014	2015
Consultant Service		5		10		10
Land Acquisition						
Tender, Contract	6	4				
Construction		5		10		

Table 3.3.5 Implementation Schedule

Description	2010			2011			2012			2013			2014			2015			Month								
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6		7	8	9	10	11	12		
Pledge	■																									1	
Signing of Loan Agreement		■																								1	
Consulting Services (SV) Thai portion																										30	
Consulting Services (SV) (Inspect maintenance) Thai																										24	
Tender Documents, PQ		■	■																							3	
Tender Period			■	■																						3	
Evaluation of Bid				■																						2	
JICA Approval					■																					1	
Contract Negotiation						■																				1	
Approval of Project by Budget Bureau							■																			1	
JICA Approval of Contract								■																		1	
Contract, Opening of L/C									■																	1	
Construction work																										30	
Land Acquisition					0																						

(7) Review of Funding Plan

This project is funded only by Japanese ODA and the Thai Government. Neither other aid fund nor private fund is expected. Approximately 70% of the construction cost is funded by JICA. Land acquisition and other works are paid by Thai Government, as well as the cost for consulting works. Meanwhile, some Japanese aid will be necessary because the construction of an extradosed bridge is the first experience for the Thai Government.

CHAPTER 4 IMPLEMENTATION STRUCTURE AND PROGRAM

(1) Executing Agency

The Department of Rural Road (DRR), Ministry of Transport is designated as the executing agency of the Nonthaburi 1 Bridge Construction.

DRR was established in October 9, 2002 in order to develop the construction of roads and bridges in the Bangkok Metropolitan Area and Rural Area, after the merging of the concerned division of road and bridge of Public Works Department (PWD) and the Office of Accelerated Rural Development (ARD).

1) Organization

The headquarter of DRR consists of 12 Bureaus as shown in Fig 4.1.1 DRR Organization Chart.

The road and bridge construction and maintenance of Bangkok Metropolitan Area is controlled by the headquarter of DRR. On the other hand, the road and bridge construction and maintenance of rural area is controlled by district offices under Regional Bureau.

Due to increase of the amount of works, the Bureau of Maintenance and Traffic Safety was divided into the Bureau of Maintenance and Bureau of Traffic Safety in March, 2009.

And, there are five groups of Administration, Planning, Maintenance System, Road Maintenance and Bridge Maintenance as shown in the table below.

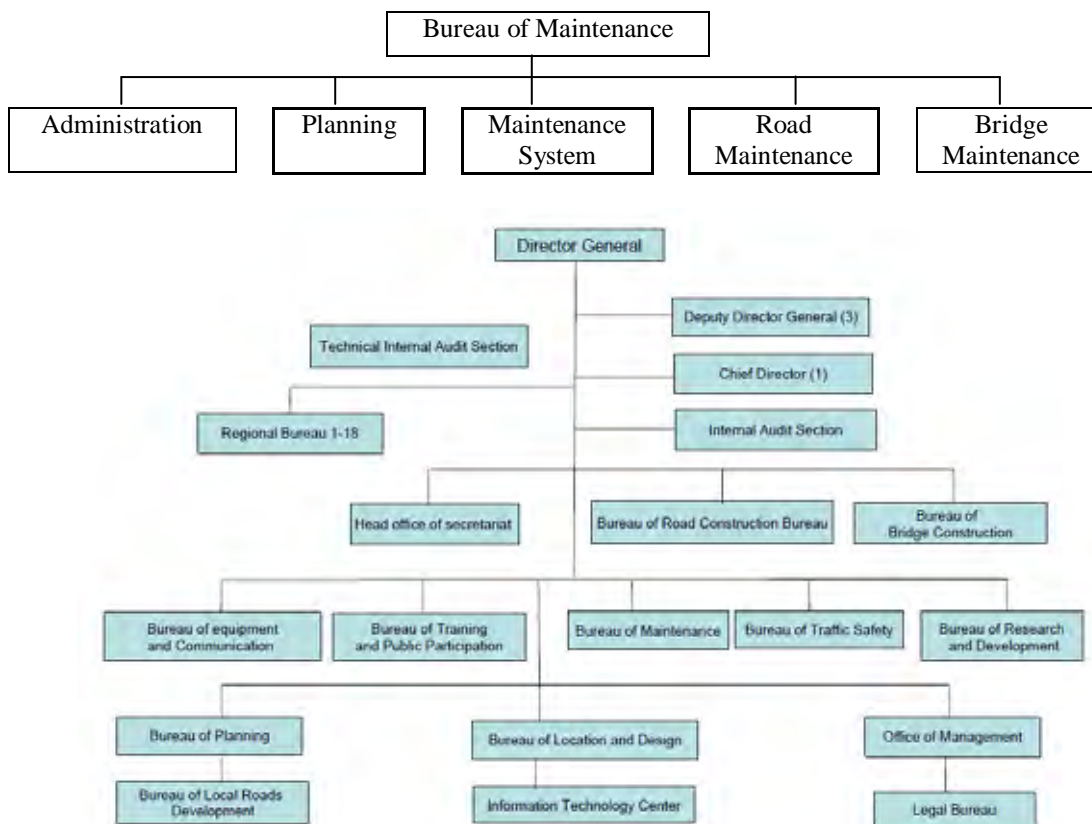


Figure 4.1.1 Organization Chart of DRR

The budget in 2007 and 2008 decreased by about 18% compared with 2006, although it expanded from 2005 to 2006 by 20% on the average, and the budget in 2009 recovered to the 2006 level. DRR has no other income sources such as toll roads.

2) Capacity of the Executing Agency

The Inspection Committee will be established under the Bureau of Bridge Construction and this committee inspects the consultant who takes charge of the supervision of construction work as shown in Figure 4.1.2.

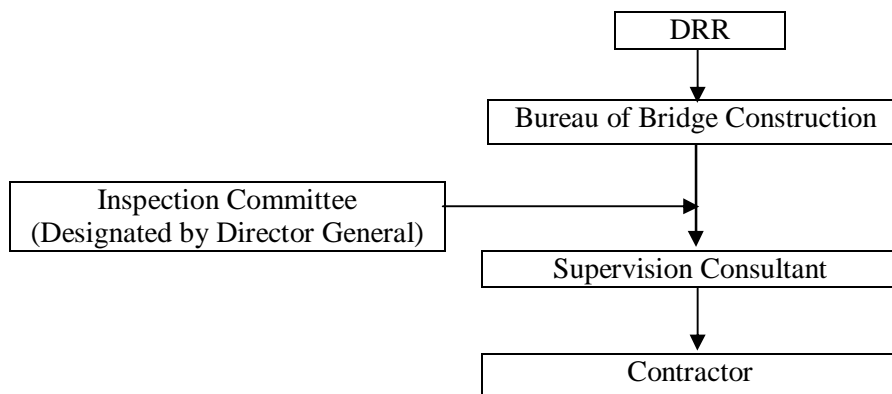


Figure 4.1.2 Project Organization Chart for Implementation of Construction Phase

The construction of this project will be executed by Bureau of Bridge Construction of DRR, and it will take charge of maintenance after construction.

The project is a road construction of 4.3 km in the total length, six lane widths including extradosed prestressed concrete bridge of 460m in length, two interchanges and one flyover.

It is the first time to construct extradosed prestressed concrete bridge in Thailand. Thus, there are apprehensions that problems may arise on the safety management when constructing the bridge considering the main span length 200m and the width 32.8 m.

However, DRR has the experience in the construction of prestressed concrete box girder (main span 134 m) of the Rama IV Bridge in 2006. And PWD antecedent DRR had the experience in the construction of box girder bridge at the six bridges such as Rama V Bridge, Rama VII Bridge, Pinklao Bridge, Phra Pokkalo Bridge, Taksin Bridge, and Rama III Bridge.

Moreover, DRR have the experience on the cable-stayed bridge which is similar to extradosed prestressed concrete bridge as the industrial ring road bridge (main span 326 m-398 m) in 2006.

Therefore, it is anticipated that there might be minimal problem on the construction ability for Nonthaburi 1 Bridge.

(2) Operation and Maintenance Structures

1) Present Condition of O&M of DRR

The budget of maintenance will be allocated from Bureau of Maintenance to Bureau of Bridge Construction. In case of the Project which includes the construction of an extradosed girder, same O&M structure and budgetary allocation as IRR Bridges will be applied to the Project.

The budget in 2009 decreased by 5% compared with the previous year although it expanded from 2003 to 2006 by 15% on the average. The reason for a decrease is that the maintenance cost was decreased to correspond to the increase of the construction cost.

There are 40 engineers in total in the Bureau of Bridge Construction (excluding the maintenance office). The breakdowns are one civil engineer, four senior civil engineers, 16 civil engineers and 19 technicians.

The 10 maintenance offices under Bureau of Maintenance are managed the maintenance works for Bangkok district and Nonthaburi district. And others in Bangkok Metropolitan Area (excluding Bangkok district and Nonthaburi district) are managed by District 1 Office.

The works of the maintenance office were succeeded from PWD, which is the antecedent of DRR, since the content of maintenance work is the same as shown in the JBIC Special Assistance for Project Sustainability (SAPS) for Study on Highway and Bridge Maintenance System for JBIC ODA Loan Projects.

2) Issue of O&M

Issues and noticed point which are obtained from consultation to Bridge Maintenance Bureau and from site-inspection of the bridges of Chao Praya River are summarized below.

- a) Discussion with Mr. Narong Khoobaramee, Director of Bridge Maintenance (October 7, 2009)
 - It is difficult to continue the maintenance work because of the limited budget and staff member.
 - It is assumed that the increase of number of engineers who take charge of maintenance, the increase of the number of machines for maintenance, and the maintenance system are necessary.
 - It is necessary to prevent the erosion of the pier foundation of the steel truss bridge.
 - It is recognized that maintenance is important because of the early precautionary measures to the existing bridge. Furthermore, it is expected that the result of research and development of maintenance system of Chulalongkorn University and Thammasat University will be as a reference of maintenance work.
 - Equipment and machines for the maintenance belong to Bureau of Maintenance are Pickup, truck, Sweeper, water supply car and grass cutting machine only. Therefore the bridge inspection car which can inspect the bridge girder from the under is necessary.
- b) Site investigation of Rama V Bridge (October 7, 2009)
 - The finger joint is installed at the RamaV Bridge due to the large joint gap. The joint is renewed almost every four years.
 - The separator holes remain in the prestressed concrete box girder after removing the concrete form works. There are some worries that the steel bar in the concrete might rust due to the infiltration of rain water.
 - The handrails of the bridge are removed. It is dangerous that a child might fall down to the river from the opening of the handrail.
 - The water pipe is installed under the prestressed concrete box girder. The generation of rust was seen in the supporting steel bar. It is necessary to confirm the maintenance work to Metropolitan Waterworks Authority, because it is not included in the maintenance work of DRR.

- c) Site investigation of Industrial Ring Road Bridge (October 12, 2009)
 - Construction work of industrial ring road had been completed in August, 2006. Maintenance office under the Bureau of Bridge Construction takes charge of maintenance after completion of the industrial ring road construction. Moreover, Engineers that must be assigned at the maintenance office who has excellent experience on supervision of construction work.
 - No obstacle of main structure of the bridge is found although three years passed after completion.
 - Replacement of surface of pavement (2 cm in thickness) on the approach ramp way was done on July 7, 2009, because surface of pavement was damaged.
 - The lighting lamps (60 pieces) were changed in August, 2009.
 - Cable monitoring of extradosed bridge will be executed every five years.
 - Concrete and pavement monitoring will be executed as a special monitoring program.
- d) Site investigation of Pinklao Bridge (October 15, 2009)
 - The bridge joints are renewed every two or three years.
 - The upper part of the foundation of the pier in the river repaints the marking (red and white) every two or three years for warning in order to avoid the collision of the vessel.
 - The sensor is installed in the box girder, and behavior (strain, deflection, vibration etc.) of the bridge member are observed in the DRR headquarter with a monitoring system. The monitoring system is adopted for the Memorial Bridge, Pokklao Bridge, and Taksin Bridge except Pinklao Bridge.

3) Proposed O&M Plan

- a) The maintenance work of this Project should include bridge, road (4.3 km), two interchanges, one flyover and the connecting Nonthaburi road. It is effective to manage maintenance work continuously considering the maintenance of pavement and traffic safety facility, etc. Moreover, it is preferable to assign an engineer who had excellent experience and exposures in the supervision of construction work to the maintenance office as well as the industrial ring road bridge.
- b) It is necessary to execute overall inspection including, not only the main girder, but also the tower and diagonals, since prestressed concrete extradosed bridge is a structure that consists of a main girder, a tower, and various materials in the diagonal etc.
- c) It is desirable also in this extradosed prestressed concrete bridge to execute the inspection with the monitoring system. Inspection for the wind force and rainfall at the top of the tower, the deformation at the girder mid-range, and the tension of the cable are necessary.
- d) It is necessary to extend the life of the existing bridge, because the decrease in the maintenance budget is feared to cause an increase in the number of maintenance items in the same bridges in the future. It is likewise necessary to increase the staff members in the Bureau of Bridge Maintenance, because bridge maintenance work will expand and multiply in the future considering the life span of the bridge. However, if there is a fiscal difficulty, it is preferable to improve labor effectiveness for inspection by bridge inspection car etc.

CHAPTER 5 PROJECT EVALUATION

5.1 QUANTITATIVE EFFECTS

(1) Increase of Vehicle Speed and Savings in Travel Time

Comparisons of travel time between a specific origin point and destination point through the route via the Project bridge and via other routes were made by applying the results of the travel survey. Due to the capacity expansion up to ten lanes of the Phra Nang Klao Bridge, no significant time savings are expected under the present condition.

(2) Reduction of Congestion

The expected reduction of congestion on particular bridges two years after opening the Project bridge is shown below:

Table 5.1.1 VCR from Nonthaburi Province to Bangkok Direction, Morning Peak Hour

Name of Bridge	Year Situation	2016	
		PCU/hr	V/C
Phra Nang Klao Bridge	Without Project	7,643	1.02
	With Project	6,796	0.91
Project Bridge		3,159	0.70
Rama V Bridge	Without Project	4,708	1.05
	With Project	3,945	0.88

Note: C=1,500 PCU/hour

The congestion on the Phra Nang Klao Bridge in 2016 will be reduced from 1.02 to 0.91. The congestion rate on the Rama V Bridge will be reduced from 1.05 to 0.88.

(3) Economic Internal Rate of Return (EIRR)

The value of EIRR together with the sensitivity analysis was estimated as followed:

Table 5.1.3 Base Case

Evaluation Indicator	Values
Economic Internal Rate of Return (EIRR)	22.0 %
Net Present Value (NPV), Million Baht	5,165.02
Benefit/Cost Ratio (B/C)	2.51

Table 5.1.4 Sensitivity Analysis

Evaluation Indicator	EIRR
Base Case	22.0%
Cost up by 10% and Benefit down by 10%	19.6%
Cost up by 20% and Benefit down by 20%	17.3%
No Salvage Values of Construction	22.0%

As the values of EIRR in any case as shown above are higher than 12%, the Project bridge is found to be economically feasible.

5.2 QUALITATIVE EFFECTS

- 1) To improve accessibility to the east side of the river (daily commuting, going to schools and economic activities)
- 2) To develop potential of these lands in the west side (accelerated and attract the new locations of factories and commercial facilities)
- 3) To raise the living condition with all-weather access to the east side of the river (high quality hospitals and medical facilities mainly exist in the east side of the river)
- 4) To increase accessibility not only inside the Province but also in the whole area of BMR (generate considerable economic effects of expansion of market)

5.3 OPERATIONAL EFFECT INDICATORS

The Annual Average Daily Traffic (AADT) is selected as an operation indicator of the Project bridge. It is recommended to monitor the future trend of traffic volume on the Project periodically after opening in order to check whether traffic volume is realized as forecasted or not.

Table 5.4.1 Operation Indicator

Indicator	Target Value (2016) Two years after completion	Note
Average Annual Daily Traffic (AADT) (PCU/day)	(*) 46,800 PCU/day	Both Directions

Note: (*) PCU in peak hour for both directions in 2016 (=3,159+585=3,744 PCU/hr) x 12.5 = 46,800

In addition to the above, the Average Annual Daily Traffic and the savings in VOC and VOT are shown as Effect Indicators as summarized below:

Table 5.4.2 Effect Indicator

Indicator	Target Value (2016) Two years after completion	Note
Average Annual Daily Traffic (AADT, PCU/day)	(*) 46,800 PCU/day	Both Directions

Note: (*) PCU in peak hour for both directions in 2016 (=3,159+585=3,744 PCU/hr) x 12.5 = 46,800

Table 5.4.3 Effect Indicator

Indicator	Target Value (2016) Two years after completion	2021 Seven years after completion
Savings in VOC (Million Baht)	278.2	606.2
Savings in VOT (Million Baht)	2,064.9	3,067.7

CHAPTER 6 ENVIRONMENTAL SOCIAL CONSIDERATIONS

6.1 REVIEW OF EIA

(1) EIA Procedure

JBIC Guidelines for Confirmation of Environmental and Social Considerations dated April 2002 is applied to the projects.

EIA report was not required for the Project in accordance with Environmental Act B.E. 2535. However, EIA report is required to be approved for the Project because the Project is classified as A category under JBIC Guidelines for Confirmation of Environmental and Social consideration.

EIA report was submitted to the Office of Natural Resources and Environmental Policy and Planning (ONEP) as of 22nd march 2006. Finally DRR submitted to JICA revised EIA report for the project which has been approved by DRR on the end of March 2009.

(2) Existing Environmental Condition on Project Site

1) Literature Searching in EIA Report

In water quality survey result index of DO, BOD, coliform was not observed environmental standard in Thailand. Though Chao Phraya River and Khlong Om Non around project site were used for transportation, water quality condition was not suitable for drinking because of human waste effluent.

Air quality monitoring data measured at two permanent stations in Nonthaburi Province were almost within the standard except for periodical exceeding for ozone and PM10. Air quality condition in Nonthaburi Province was almost good.

Noise level measured at **Sukhothai Thammatirat University in 2003 was in the range of 54.3 to 68.1 dB(A)** and noise level along trunk road was from 63.8 to 71.3 dB(A) as average of day. These values exceeded periodically standard for noise level in Thai land (70 dB (A)).

According to EIA animal survey four species of reptile and fifteen species of birds are designated as protected species in Thailand. According to the survey result for fishes implemented between Prakret to mouth of Chao Phraya River including project site, four species as vulnerable and one specie as near threatening on IUCN red list were found.

2) Supplemental Survey

To confirm that there in no drastic change for existing environmental condition around project site since the existing EIA was conducted, survey for water quality, air pollution and noise/vibration was conducted in this study.

a) Water Quality

According to comparison between EIA and supplement survey shown in Table 6.1.1. All in all it is confirmed that water quality condition in Chao Phraya River had not changed drastically from the point of EIA which conducted in 2005.

Table 6.1.1 Compare of Water Survey Result

location	survey	Upstream of the construction site		At the construction site		Downstream of the construction site		Standard for class 3
		EIA	Supplementary	EIA	Supplementary	EIA	Supplementary	
parameters	unit	*2005	*2009	2005	2009	2005	2009	
Temperature	°C	30.4	30.0	31.2	30.0	31.4	30.0	-
pH		7.6	7.3	7.5	7.4	7.8	7.3	5 - 9
Conductivity	S/cm	170	286	190	242	210	237	-
Suspended Solids(SS)	mg/l	72.1	112	70.4	98.0	68.8	91.4	-
Grease and Oil	mg/l	<2	<1.0	<2	<1.0	<2	<1.0	-
Total Solids (TS)	mg/l	210	352	250	266	280	228	-
Dissolved Oxygen (DO)	mg/l	4.2	4.6	4.1	4.6	3.9	4.6	≥4
Biochemical Oxygen Demand (BOD)	mg/l	5.2	2.6	5.4	2.4	7.6	2.8	≤2
Nitrate (NO ₃)	mg/l NO ₃ ⁻	0.45	0.70	0.52	0.86	0.78	0.82	≤5
Phosphate(PO ₄)	mg/l PO ₄ ³⁻	0.1	0.21	0.15	0.19	0.14	0.22	-
Total Coliform bacteria	MPN/100ml	24,000	>160,000	46,000	160,000	>240,000	>160,000	≤20,000
Ammonium Nitrogen (NH ₄ -N)	mg/l NH ₄ -N	-	0.19	-	0.19	-	0.19	≤0.5

b) Air Quality

CO, NO₂ level tend to a little bit higher than the point of EIA as shown in Table 6.1.2. But all in all air pollution concentration including ozone were below the standard.

Table 6.1.2 Comparison of Air Quality Survey

1. Sri Boonyanon School

Parameter	Unit	Duration	Sat	Sun	Mon	Tue	Wed	Average	Standard
TSP (24 hrs)	mg/m ³	EIA	0.074	0.056	0.103	0.101	0.022	0.071	0.33 ^{1/}
		Supplement	0.064	0.050	0.041	0.062	0.066	0.057	
PM ₁₀ (24 hrs)	mg/m ³	EIA	0.052	0.056	0.075	0.083	0.069	0.067	0.12 ^{1/}
		Supplement	0.043	0.030	0.023	0.028	0.046	0.034	
CO (1 hr)	ppm	EIA	0.376	0.210	0.529	0.910	0.742	0.553	30 ^{2/}
		Supplement	0.930	0.950	1.010	1.040	0.800	0.560	
NO ₂ (1 hr)	ppm	EIA	0.015	0.013	0.020	0.026	0.026	0.020	0.17 ^{2/}
		Supplement	0.027	0.018	0.019	0.016	0.025	0.012	0.17 ^{3/}
O ₃ (1 hr)	ppm	Supplement	0.023	0.026	0.009	0.010	0.005	0.004	0.10 ^{4/}

2. Wat Chalerm Phra Kiat

Parameter	Unit	Duration	Sat	Sun	Mon	Tue	Wed	Average	Standard
TSP (24 hrs)	mg/m ³	EIA	0.040	0.038	0.053	0.069	0.047	0.049	0.33 ^{1/}
		Supplement	0.047	0.037	0.027	0.041	0.059	0.042	
PM ₁₀ (24 hrs)	mg/m ³	EIA	0.041	0.035	0.068	0.052	0.046	0.048	0.12 ^{1/}
		Supplement	0.034	0.019	0.017	0.029	0.042	0.028	
CO (1 hr)	ppm	EIA	0.050	0.073	0.064	0.170	0.093	0.090	30 ^{2/}
		Supplement	0.930	1.200	0.940	0.990	1.000	0.64	
NO ₂ (1 hr)	ppm	EIA	0.010	0.010	0.013	0.016	0.017	0.013	0.17 ^{2/}
		Supplement	0.016	0.019	0.013	0.017	0.014	0.008	0.17 ^{3/}
O ₃ (1 hr)	ppm	Supplement	0.031	0.027	0.010	0.009	0.005	0.005	0.10 ^{4/}

3. Wai Sai Kindergarten

Parameter	Unit	Duration	Sat	Sun	Mon	Tue	Wed	Average	Standard
TSP (24 hrs)	mg/m ³	EIA	0.061	0.066	0.081	0.074	0.071	0.071	0.33 ^{1/}
		Supplement	0.071	0.070	0.061	0.065	0.087	0.071	
PM ₁₀ (24 hrs)	mg/m ³	EIA	0.055	0.045	0.058	0.058	0.057	0.055	0.12 ^{1/}
		Supplement	0.049	0.043	0.026	0.050	0.043	0.042	
CO (1 hr)	ppm	EIA	0.053	0.024	0.068	0.175	0.192	0.102	30 ^{2/}
		Supplement	1.100	1.080	1.110	1.080	1.150	0.72	
NO ₂ (1 hr)	ppm	EIA	0.011	0.012	0.014	0.021	0.018	0.015	0.17 ^{2/}
		Supplement	0.043	0.028	0.032	0.027	0.040	0.019	0.17 ^{3/}
O ₃ (1 hr)	ppm	Supplement	0.014	0.015	0.007	0.003	0.002	0.002	0.10 ^{4/}

Remark: ^{1/} Ambient Air Quality Standard, Notification of the National Environment Board No. 24, Dated September 22, 2004

^{2/} Ambient Air Quality Standard, Notification of the National Environment Board No. 10, Dated April 17, 1995

^{3/} Nitrogen Dioxide in Ambient Air Standard, Notification of the National Environment Board No. 33, Dated June 17, 2009

^{4/} Ambient Air Quality Standard, Notification of the National Environment Board No. 28, Dated April 10, 2009

c) Noise

Comparing between EIA and supplemental survey shown in Table 6.1.3, noise level was lower than EIA at Sri Boonyanon School and Chalerm Pra Klat. Noise level at Wal Sal Kindergarten was higher than EIA report. Number of date unobserved noise standard in supplement survey is 2 day at Wal Sal Kindergarten same as EIA report. Noise pollution level is not so changed in this area.

Table 6.1.3 Comparison of Noise Level

Location	Sampling item		Sat	Sun	Mon	Tue	Wed	Standard
1.Sri Boonyanon school	Leq.24hrs	EIA	65.5	72.2*	68.0	65.0	65.0	70
		Supplement	54.3	57.7	54.6	57.5	52.4	
	Ldn	EIA	70.2	72.9	68.3	68.0	69.6	-
		Supplement	61.7	62.5	61.0	62.3	57.3	
2.Chalerm Pra Klat	Leq.24hrs	EIA	61.6	60.8	60.4	60.3	63.3	70
		Supplement	55.8	57.5	56.5	57.1	55.3	
	Ldn	EIA	65.7	66.6	65.4	64.8	67.5	-
		Supplement	56.8	58.4	58.0	58.3	57.2	
3.Wal Sal Kindergarten	Leq.24hrs	EIA	65.2	62.2	68.2	71.4*	70.9*	70
		Supplement	69.7	67.5	70.3*	68.1	73.9*	
	Ldn	EIA	70.1	66.1	68.8	72.6	72.3	-
		Supplement	73.2	71.1	73.8	72.0	75.3	

*exceeding noise level standard (day average less than 70 dB(A))

d) Vibration

Vibration level both in EIA and supplement were under Reiher & Meister standard 2.5 mm/s so that impact of vibration was small and not changed.

e) Summary of Comparison

In consequence there is no drastic change of environmental condition in Project site between EIA and supplement survey.

(3) Review of Environmental Mitigation Measures

1) Water Quality

Especially for boring work in Chao Phraya River closed boring with steel casing method will be applied, water effluent of excavation will be treated in sedimentation basin installed on

land after that excavation water will be discharged to public water system. In case of discharged water quality exceed standard coagulant will be add and after treated discharged.

Planning road of intersection with three small canals is planned by via duct and bridges. So that impact of flood and sediment discharge is thought as little. As said in EIA report construction period is limited only in dry season. Earth work methodology such as closed or bypass is available to keep function of canal. It is though that impact of contamination such as flood and sediment discharge is little.

2) Air Quality

By rigid enforcement of adequate measures such as sheet cover on transportation of construction material, periodically cleaning and/or water spray during construction air quality condition will be measured with in air quality standard.

Predicted NO₂ concentration during operation stage at 20m from road in EIA report was 0.348mg/m³, which was over than the standard value 0.320mg/m³. Though this assumption for simulation such as wind speed 0.5m/s, stability of atmosphere class extremely stable (F) and traffic volume at peak hour are available, so it is thought too much safety side.

Thus based on normal weather condition and traffic volume, it is estimated concentration will never exceed standard value of NO₂. At the same time based on trial calculation TSP and PM₁₀ concentration during operation stage will not exceed the standard value.

3) Noise

Road traffic noise predicted in EIA was exceeding noise standard 70dB (A). Based on trial calculation by ASJ RTN-Model 2003, banking road with three meter height noise barrier installation will reduce 3 - 4 db (A) noise level near road side. Therefore by installing noise barrier noise level will observe noise standard, and noise level near via duct with concrete railing will be under noise standard.

4) Fauna and Flora

Project road is located almost on existing road alignment and there is seldom possibility to diminish forest and swamp land where protected animals may live between new construction sections. In EIA report wild animal founded in project site are almost birds, so it is said they will move quickly to other habitat and will accommodate to new habitat. It is said impact to protected fauna and flora during construction and operation period is little in project site.

5) Environmental Monitoring

DRR committed the responsibility on construction stage belong to contractor and to DRR during operation stage. Monitoring result shall be submitted every three months during construction and reported biannually during operation stage for two years.

6.2 Confirmation of Resettlement and Land Aquisition

(1) Scale of Resettlement and Land acquisition

Numbers of households to be resettled by the Project are 133 households and approximate 21 small shops, and 447 households to be affected on their land and asset in total. The area of land acquisition will be 23.4ha.

(2) Current status of Resettlement and Land Acquisition, and their Schedule

DRR completely paid the compensation to all land and property owners. However, there are some households which have/tryed to make a petition to Court in order to take objection to the compensation price set by the Committee in accordance with the Thai Land Expropriation Act and Land-used Act.

As of this study 125 households have already settled, but 8 buildings remain including 4 households in project site. But 4 households agreed to settle in early period in 2010 or before the start of construction. In case of remaining households exist before the start of construction compulsory expropriation will be done based on the Land and Property Expropriation Act B.E. 2530.

DRR explained that compromise of a petition to Court is not condition of starting construction.

CHAPTER 7 BRIDGE PRELIMINARY SURVEY

7.1 BACKGROUND OF SURVEY

For the bridges constructed over the Chao Phraya River with the Japanese government finances, JICA conducted a preliminary survey by visual inspection on conditions of these bridges to study what technical cooperation JICA can provide for their continued use.

Among the bridges currently spanning the Chao Phraya River at the Bangkok Metropolitan Area listed below, the bridges marked on the column of Japanese government finance are scheduled for the preliminary survey.

Table 7.1.1 Bridges over Chao Phraya River at Bangkok Metropolitan Area

Serial No. from upstream	Bridge Name	Bridge Type	Traffic Opening Year	Department Responsible for Maintenance	Japanese Government Finance
1	Patum Tani	PC-Box	1984	DOH	✓ Loan
2	Patom Tani-2	PC-Box	2009	DOH	
3	Nonthaburi	Steel Truss	1959	DOH	✓ Special Fund
4	Rama IV	PC-Box	2006	DRR	✓ Loan
5	New Phra Nangklao	PC-Box	2008	DOH	
6	Phra Nangklao	PC-Box	1985	DOH	✓ Loan
7	Rama V	PC-Box	2002	DRR	✓ Loan
8	Rama VII	PC-Box	1992	DRR	✓ Loan
9	Rama VI (Railway)	Steel Truss	1926	SRT	
10	Krung Thon	Steel Truss	1958	DRR	✓ Special Fund
11	Rama VIII	Cable-stayed	2002	BMA	
12	Phra Pinklao	PC-Box	1973	DRR	✓ Loan
13	Memorial	Steel Truss	1932	DRR	✓ Loan for Repair in 1984
14	Phra Pokklao	PC-Box	1984	DRR	✓ Loan
15	Taksin	PC-Box	1982	DRR	✓ Loan
16	Rama III	PC-Box	2000	DRR	✓ Loan
17	Krung Thep	Steel Truss	1959	DRR	✓ Special Fund Loan for Repair in 2002
18	Rama IX	Cable-stayed	1987	EXAT	✓ Loan
19-1	IRR North	Cable-stayed	2006	DRR	✓ Loan
19-2	IRR South	Cable-stayed	2006	DRR	✓ Loan
20	Kanchanapisek	Cable-stayed	2007	DOH	

7.2 REPORT OF SURVEY RESULTS

(1) Results of Bridge Condition Survey

The survey team concluded that the bridges over the Chao Phraya River had been maintained generally in good condition although many small damages and deteriorations were observed on the aged bridges. However, about the Nonthaburi Bridge (steel truss bridge built in 1959), the team called attention for its serious condition needing rehabilitation without delay.

Historical Bridges of First Generation (Yellow display in Table 7.1.1)

By 1960, in total four road bridges namely Nonthaburi, Krung Thon, Memorial and Krung Thep Bridges, and a rail bridge of Rama IV Bridge had been built over the Chao Phraya River, all of which were steel truss bridges. These aged steel truss bridges have been repeatedly repaired in the past and still being used although there are many damages seen on them.

Concerning the Nonthaburi Bridge in question, steel corrosion of truss members and deterioration of concrete deck slab were noticeable. The bridge will become dangerous likely in five years if the bridge is left unrepaired.

Bridges of Second Generation (Blue display in Table 7.1.1)

The bridges grouped in the second generation built in the 1970s and 80s are mostly of PC box girder bridges except Rama IX Bridge of a steel cable-stayed bridge. These PC box girder bridges, which have aged for almost 30 years, look still sound in general although many small damages are seen in part.

However, concerning the Phra Nangklao Bridge constructed in 1985 by cantilever method, its cantilever girders on either side were observed shaking discretely. While the bridge holds water main pipes inside the twin box girder, water is continuously running from the bottom hole of the girders. It is suspected that the water leakage might be caused by this cantilever girder shaking.

As for the Taksin Bridge built in 1982, the bearing width looks as if it is diminishing at the end support of box girders. It is considered not an immediate danger but periodical inspection is necessary to check whether the width will further diminish or not.

At the Rama IX Bridge, a cable-stayed steel girder bridge built in 1987 with a 450 m long span and a 41 m high clearance, the repair works based on the 20th year inspection was underway.

Bridges of Third Generation (Gray display in Table 7.1.1)

On the bridges built in 2000 or later, there are seen distinct technology advancement and scale expansion compared to the PC box girder bridges of the second generation on the following points:

- Increase of under-bridge clearance and span length to improve vessel/vehicle collision risks.
- Construction of curved PC box girder bridges as seen in New Phra Nangklao and Rama III Bridges.
- Another three cable-stayed bridges namely IRR North, IRR South and Kanchana Pisek Bridges were constructed at further lower reach of the Chao Phraya River.

These PC box girder bridges of this generation are still new with no significant damage observed.

On the IRR North and South Bridges, a pair of cable-stayed bridges built in 2006 having 326 and 398 m long spans respectively with a 41 m high clearance, there were some problems such as sags on main span profile, broken expansion joints and cracks on main tower.

Condition of Bridge Foundation

Although the bridge foundation under ground and water could not be visually inspected, there was no sign found on the super-structures to suggest instability of the foundation.

(2) Results of Hearing to Bridge Maintenance Departments

The following are the results of hearing by the Survey Team.

DRR

Out of 16 bridges surveyed, 11 bridges are under control of the DRR Maintenance Department. Only the IRR North and South Bridges are maintained under the DRR Construction Department.

DRR Maintenance Department

- The department keeps maintenance site office and staff at each bridge site for daily check and small repairs. The department has carried out full-scale inspection of the bridges in two to five years interval on contract base. The department is recently monitoring four PC box girder bridges remotely with strain gages and accelerometers inside of box girders.
- The DRR staff indicated that the department seemed to have no intention at present to request JICA bridge inspection.

DRR Construction Department

- For maintenance of IRR North and South Bridges, the department has a main site office and two maintenance bases for daily inspection and small repairs.
- The Survey Team reported about the cracks of main tower and advised to keep watching the crack width. The department explained that such cracks had been predicted by DRR before construction because a dogleg shape was designed for the main tower. Through discussions about the cracks, the department made an inquiry to request JICA a technical assistance for detailed inspection and analysis of such cracks.

DOH Bridge Construction Bureau

Out of 16 bridges surveyed, three bridges such as Patum Tani (PC box girder bridge built in 1984), Nonthaburi (steel truss bridge built in 1959) and Phra Nangklao (PC box girder bridge built in 1985) Bridges are under control of the DOH Bridge Construction Bureau.

- The department staff explained that DOH presently needs to contract out bridge inspection jobs for the bridges on the Chao Phraya River.
- The team explained that the deterioration of the Nonthaburi Bridge had become in alarming stage and advised it was time for DOH to take action for rehabilitation of the bridge. The department staff was keen to request JICA a technical assistance for detailed inspection and rehabilitation design for the bridge.
- For the problem of Phra Nangklao Bridge i.e. shaking cantilever girder and water pipe leakage, the department staff also indicated a willingness to request a JICA technical assistance for detailed inspection.

EXAT

Rama IX Bridge (cable-stayed steel bridge built in 1987) is only the bridge controlled under EXAT.

- EXAT explained that the bridge is currently under repair works based on the 20th year inspection.
- EXAT answered the team that EXAT is now in the midst of doing repair works and therefore in no situation to request the bridge inspection to JICA.

CHAPTER 8 PROPOSED TECHNICAL ASSISTANCE PROGRAMS

The following 3 programs are proposed as the technical assistance from Japan.

- i) Technical Assistance to the Project during Construction Supervision
- ii) Technical Assistance to Maintenance Organizations of Existing Bridges built through Japanese Assistance
- iii) Technical Assistance to DOH for the Development of a Bridge Maintenance Management System

8.1 TECHNICAL ASSISTANCE FOR THE PROJECT IMPLEMENTATION

(1) Necessity of Technical Assistance

The consultant firms of Thailand nationals have conducted the F/S and D/D of the Project, and the coming C/S will also be conducted by consultant firms led by Thailand nationals.

The Project includes the construction of a 200-m mid-span extradosed girder bridge, of which the main span is one of the world's largest span lengths. Therefore, due consideration for construction safety and proper quality control are essential. As the drawings prepared in the D/D are in basic level, the construction firm would have to newly produce a number of detailed drawings during the preparation time for shop drawings. Since the involvement of the foreign consultant staff, who may be able to check the shop drawings, is limited, some difficulties could be encountered in the construction supervision services. Moreover, in case the construction follows the basic design level drawings, a number of design changes and alterations would be required.

It is well known that the extradosed girder bridge was firstly introduced by a French engineer, and then, many applied technologies have later been developed in Japan. Technical assistance related to the extradosed girder bridge construction is thus deemed significant to complete the Project successfully.

(2) Technical Assistance during Construction Supervision Services

It is desirable to assist DRR with technical assistance by a JICA consultant team that consists of qualified engineers having experiences in design and construction supervision on extradosed girder bridges. The JICA team is expected to conduct the following:

- 1) Review P/Q documents and tender documents
- 2) Review shop drawings and drawings of design changes/alterations
- 3) Review construction methodology
- 4) Review quality assurance plan
- 5) Periodic site inspection to confirm progress, safety and quality

8.2 PROPOSAL ON TECHNICAL ASSISTANCE TO THE CONCERNED O&M ORGANIZATIONS FOR CHAO PHRAYA RIVER BRIDGES COMPLETED THROUGH JAPANESE ODA ASSISTANCE

(1) Necessity of Technical Assistance

In the early 1950s, the Nonthabuli, Krung Thon and Krung Thep Bridges were built under the

special funds of the Japanese Government. Afterwards, 12 bridges over the Chao Phraya River have been built by using Japanese ODA loans since the 1st ODA loan to Thailand in 1971. There are 20 bridges (in this case, the North Bridge and South Bridge of the Industrial Ring Road is counted as 1 bridge) in BMR. Seventy-five percent, or 15 out of 20 bridges, were built under Japanese assistance and regarded as tokens between the Thai and Japanese people.

Such 15 bridges have been carrying large traffic volumes that resulted in the wearing out of pavement and deterioration of expansion joints. Three old bridges under the Japanese Special Funds are of steel truss girders. Some rivets in the steel truss girders have been lost due to repeated loads of heavy traffic. Rusts on steel surfaces take place in the area where dusts have likely piled up. Moreover, in case of Krung Thep Bridge, which is a combined structure of steel truss girders and steel bascule girders for the purpose of navigation, the connection pins (so-called removable hinges) are likely worn out. In addition, actual traffic characteristics are different from the design live loads considered in 1950s. In this regard, rehabilitation and reinforcement works for the existing 15 bridges would be required in the future.

Among these 15 bridges, DRR deals with O&M for 11 bridges (in this case, North Bridge and South Bridge of IRR is counted as 1 bridge), DOH, 3 bridges and EXAT, 1 bridge.

It is very significant to conduct a survey on the O&M organization and technical investigation on these bridges.

From the visual inspection by the survey team, the following are recommended:

- As the bridges of DRR and EXAT are well-maintained, there are no problems found in the short term. However, the bridges of DRR include old ones, and rehabilitation and reinforcement works would be indispensable in the medium and long terms. Technical assistance is significant to DRR in preparing an O&M program for each DRR bridge over the Chao Phraya River.
- For DOH bridges, the rehabilitation and reinforcement works are detailed in the subsequent Section 9.3.

(2) Proposal on Technical Assistance to DRR for the Preparation of Rehabilitation and Reinforcement Program for Each Bridge over the Chao Phraya River

The technical assistance is to prepare a rehabilitation and maintenance program for each bridge among the 11 DRR bridges over the Chao Phraya River; viz. Krung Thon, Krung Thep, Rama IV (Pak Kret), Rama V (Wat Nakorn-in), Rama VII, Phra PinkLao, Memorial (rehabilitated under ODA loan), Phra Pok Klao, Taksin, Rama III (New Krung Thep), IRR North / South.

It is desirable to consider the following points:

- Proposal of introduction of Bridge Asset Management
- Technical assistance for the newly developing IT system by DRR “Bridge Master Plan”

8.3 TECHNICAL ASSISTANCE TO DOH FOR DEVELOPMENT OF BRIDGE MAINTENANCE MANAGEMENT SYSTEM (BMMS)

(1) Necessity of JICA Technical Assistance to DOH

In 1985, DOH began to develop a computer system for the Bridge Maintenance Management System (BMMS) under a Danish grant assistance. However, this BMMS was frozen after the Danish grant assistance. In 2007, the World Bank was interested in assisting DOH by

developing another BMMS. The WB BMMS was not implemented until now.

DOH deals with the maintenance works of approximately 16,000 bridges in Thailand and has been keeping the inventory sheets of almost all these bridges. The database for computer use, however, is not functioning.

It is about time for DOH to employ an asset management system for effective maintenance works of the 16,000 bridges. In this regard, the development of BMMS, including database system, is urgently required.

Since Japan has been assisting DOH to develop the national highways network in Thailand, a technical assistance to DOH for the development of the BMMS is very significant for the proper use of existing bridges built under the Japanese ODA projects.

(2) Issues for Development of BMMS

The following are the key issues to newly develop the BMMS:

- 1) DOH of MOT deals with bridge maintenance works for approximately 16,000 bridges in the whole of Thailand. The previous BMMS, which had been tried to be developed in 1985, was frozen.
- 2) On the other hand, DRR maintained the database system, which is so-called BMS (Bridge Management System). The DRR's BMS handles the maintenance information on approximately 6,000 bridges, which are located on small road networks in limited areas.
- 3) So far, DRR's activities are much ahead than those of DOH for developing the computerized bridge maintenance system. It is recommended to unify the forms of inputs and outputs between the systems of DOH and DRR.
- 4) If both database systems of DOH and DRR are unified, efficient maintenance bridge works will be achieved in Thailand.
- 5) Institutional, budgetary allocation and implementation methods ranging from programming to completion of maintenance works established in the technical assistance will be transferred to the appropriate entity within DOH, taking into consideration the previous BMMS experience in 1985.
- 6) Since progress of information technologies is remarkable at present, the developed BMMS under the technical assistance should be improved every year. In this regard, personnel from DOH and Thai national consultants should be involved from the onset of the BMMS development by the technical assistance on full-time assignment basis so as to avoid future system troubles.

(3) DOH Road Network



Figure 8.3.1 DOH National Road Network

CHAPTER 9 CONCLUSION AND RECOMMENDATION

9.1 EFFECTS OF THE PROJECT ON THE URBANIZATION STRUCTURES AND ROAD NETWORK IN BMR

- 1) The survey team examined the viability of the Project by reviewing the contents of the feasibility study and subsequent detailed design on the Project as well as by linking it to the present traffic conditions as of October 2009, Purple Line Project, Urban Plan in Nonthaburi, etc. As a result, the survey team confirmed that the Project properly met the present 10th NESDP (2007 – 2011) target of sustainable society and comfortable living environment. The possibility of access from the Project road to the Porn Sawan Station of the Purple Line in the future was also confirmed. In this regard, the Project can be a prospective one to work with not only road networks in BMR but also with other transport systems.
- 2) As there are two sub-center locations in the north of Bangkok, namely, Nonthaburi and Pak Kret according to the comprehensive plan for BMA, the areas in the vicinity of the Project are expected to be developed. The survey team produced an urban structure map by associating the Project to the existing bridges such as Phra Nangklao Bridge and Rama V Bridge, and the road network function of the existing north-south corridor. From the map, it is estimated that urbanization shall go beyond the river from Nonthaburi to the west area. As such, the survey team confirmed the importance of the Project.
- 3) Within BMR, there are 20 bridges already built over the Chao Phraya River. After assessing the urbanization pattern and bridge-building projects in the past, the urbanization has been rapidly progressed in the vicinity of bridges. The enhancement of the bridges' traffic capacity is crucial for strengthening the urban structural function of Nonthaburi as the sub-center.
- 4) According to the results of traffic study, project costs and economic analyses of the Project, EIRR of the base case of the Project is estimated at 22.0%. The survey team also confirmed that at least 17.3% of EIRR be estimated as a result of the sensitivity analysis of 10 to 20% cost increase and 10 to 20% benefit decrease.

9.2 CONFIRMATION OF APPROPRIATENESS OF THE PROJECT COMPONENTS

- 1) The survey team reviewed the outcomes of the detailed design for the Project, viz. pre-qualification documents along with evaluation criteria and tender documents and confirmed that all the documents had been prepared in accordance with the JICA procurement guideline.
- 2) After checking mainly the number of tender drawings, it was found that the construction works contractor should newly produce a number of detailed drawings since the number of drawings prepared by the design consultant is limited to the basic design level. Therefore, the survey team recommended to the design consultant to add the cost for drawing preparation into the cost for construction works. It was likewise recommended for the design consultant to add the explanation about drawing preparation in the tender documents. The design consultant agreed to do so.
- 3) Taking into consideration the quality and safety during construction and future maintenance after completion, the survey team checked the tender drawings. Improvements on the tender drawings related to bridge details, road geometry and details of interchanges were recommended. The design consultant promised to improve the tender drawings before the distribution of tender documents.
- 4) As a result of the review of the the cost estimate prepared by the design consultant, some

- missing items which are shown in the tender drawings were suggested to be included, and the extremely unit price of prestressing tendons was pointed out. The design consultant has already corrected the estimates based on the comments from the survey team.
- 5) The survey team reviewed and confirmed that the construction and implementation plans were basically prepared using appropriate methods. Assuming that the Project progresses in accordance with the implementation plan, E/N and L/A will be signed in March 2010, procurement of the contractor including P/Q, tender and L/C open will be by April 2011, and the commencement of construction works will be May 2011. The completion of the works is estimated to be by October 2013, 30 months after the commencement.
 - 6) The survey team conducted surveys on DRR's institutional structure, annual budget, and maintenance of the existing 11 bridges over the Chao Phraya River. As a result of the surveys, it was confirmed that maintenance systems by DRR were quite appropriate. Accordingly, the survey team thought that the maintenance for the bridge to be built by the Project would be well-done appropriately owing to the capability of maintenance works by DRR.
 - 7) The survey team reviewed the EIA related to the activities of environment and social consideration, and confirmed the present state of environment (water quality, air, noise, vibration). In addition, it was confirmed through the perusal of the latest documents that four households, out of 123 households, are occupying the Project site. According to the DRR's reply on the question by the Survey Team, the remaining four households within the Project site have already agreed to move before the commencement of the construction works of the Project. In case of remaining households exist before the start of construction, compulsory expropriation will be done based on the Land and Property Expropriation Act B.E. 2530.
 - 8) As a whole, the survey team confirmed that outcomes of the detailed design by the design consultant and the plan by DRR are appropriate. However, it is desirable to assist DRR with technical assistance by a JICA consultant team that consists of qualified engineers having experiences in design and construction supervision on extradosed girder bridges, of which construction is the first attempt in Thailand.

9.3 PRESENT CONDITIONS OF THE EXISTING BRIDGES OVER THE CHAO PHRAYA RIVER BUILT BY JAPANESE ASSISTANCE

- 1) The survey team conducted visual inspection on the existing bridges over the Chao Phraya River, which were built through Japanese assistance, in addition to the preparatory survey on the Project. The existing bridges consist of 11 bridges of DRR, three bridges of DOH and one bridge of EXAT.
- 2) It was confirmed that the 11 bridges of DRR and the bridge of EXAT were quite well-maintained.
- 3) Among the three bridges of DOH, it was found that the Nonthaburi Bridge (steel truss girders) was severely deteriorated and Phra Nangklao Bridge (PC box girder) had a probable trouble of a central hinge. Accordingly, a conceivable technical assistance from Japan is to assist DOH with maintenance advisory services on the DOH bridges over the Chao Phraya River.
- 4) The existing bridges of DRR are quite well-maintained and DRR intends to contentiously use the existing bridges as long as possible. In the future, however, DRR may encounter reinforcing and rehabilitating works unexpectedly, which are still never experienced by DRR. Accordingly, it is considered necessary to assist DRR with the conduct of detailed inspection of each bridge to lead the preparation of a maintenance program through technical assistance from Japan, which includes future rehabilitation

and reinforcement works.

9.4 RECOMMENDATIONS ON TECHNICAL ASSISTANCE FROM JAPAN

- 1) The Project is the first attempt in Thailand to construct an extradosed girder bridge. In fact, most of state-of-art technologies for the extradosed girders have been developed through the efforts of a number of Japanese entities. On the other hand, the detailed design of the extradosed girder bridge of the Project was produced entirely by a Thai national consulting firm. The tender drawings are of basic design level thus will require a number of design changes and material alterations during construction. DRR intends to employ Thai national consulting firm(s) for further construction supervision works. So as to maintain good quality and safe construction of the extradosed girder bridge in Thailand, it is very significant and effective to provide technical assistance to DRR with a qualified consultant team during the course of the various construction stages.
- 2) There are 20 bridges over the Chao Phraya River in BMR, with about 75% or 15 existing bridges built through assistance from Japan. These 15 bridges have an important role as transport infrastructure in BMR and are symbolic of the friendship between the Japanese and Thai people. These bridges are still likely used as long as possible in the future, hence appropriate maintenance on these bridges is crucial.

At present, DRR deals with the maintenance for 11 bridges, DOH, for three bridges and EXAT for one bridge. As a result of visual inspections, the maintenance of the bridges of DRR and EXAT are judged in good condition and no urgent rehabilitation work is needed. On the other hand, two bridges of DOH have partially deteriorated.

For the 11 bridges of DRR, these are of various types consisting of steel truss girders, steel plate girders, steel bascule girders, PC box girders and steel cable-stayed girders and require quite different maintenance and rehabilitation works. Even though the 11 bridges are well-maintained, it is important to grasp the necessary works in the future for rehabilitation and reinforcement that DRR has never experienced before. Accordingly, it is desirable to prepare medium- and long-term maintenance programs for each bridge under the technical assistance from Japan.

For the three bridges of DOH, two bridges have partial deterioration problems which might be solved through the program discussed in the subsequent Item 3.

As for one steel cable-stayed girder bridge of EXAT, adequate monitoring and repair works have been conducted since its completion. In addition, the financial situation of EXAT is regarded as healthy. Consequently, no technical assistance to EXAT is desired.

- 3) The survey team conducted interview surveys on DRR and DOH regarding bridge maintenance systems. DRR has developed a BMS (Bridge Maintenance System) for 6,000 bridges in a whole of Thailand. Now, DRR intends to develop the BMPS (Bridge Master Plan System) which deals with bridge prioritization among existing bridges and conceivable new bridges.

On the other hand, DOH tried to develop a database system BMMS (Bridge Maintenance Management System) 20 years ago under grant assistance from Denmark. According to DOH information, BMMS is totally frozen and no longer in use. In addition, DOH intended to develop another BMMS under the assistance of the World Bank for managing 16,000 bridges in a whole of Thailand.

The survey team identified a necessary technical assistance to DOH since the maintenance of bridges by DOH is still backward if compared with the other two organizations of DRR and EXAT.