No.

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

JANUARY 2010

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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

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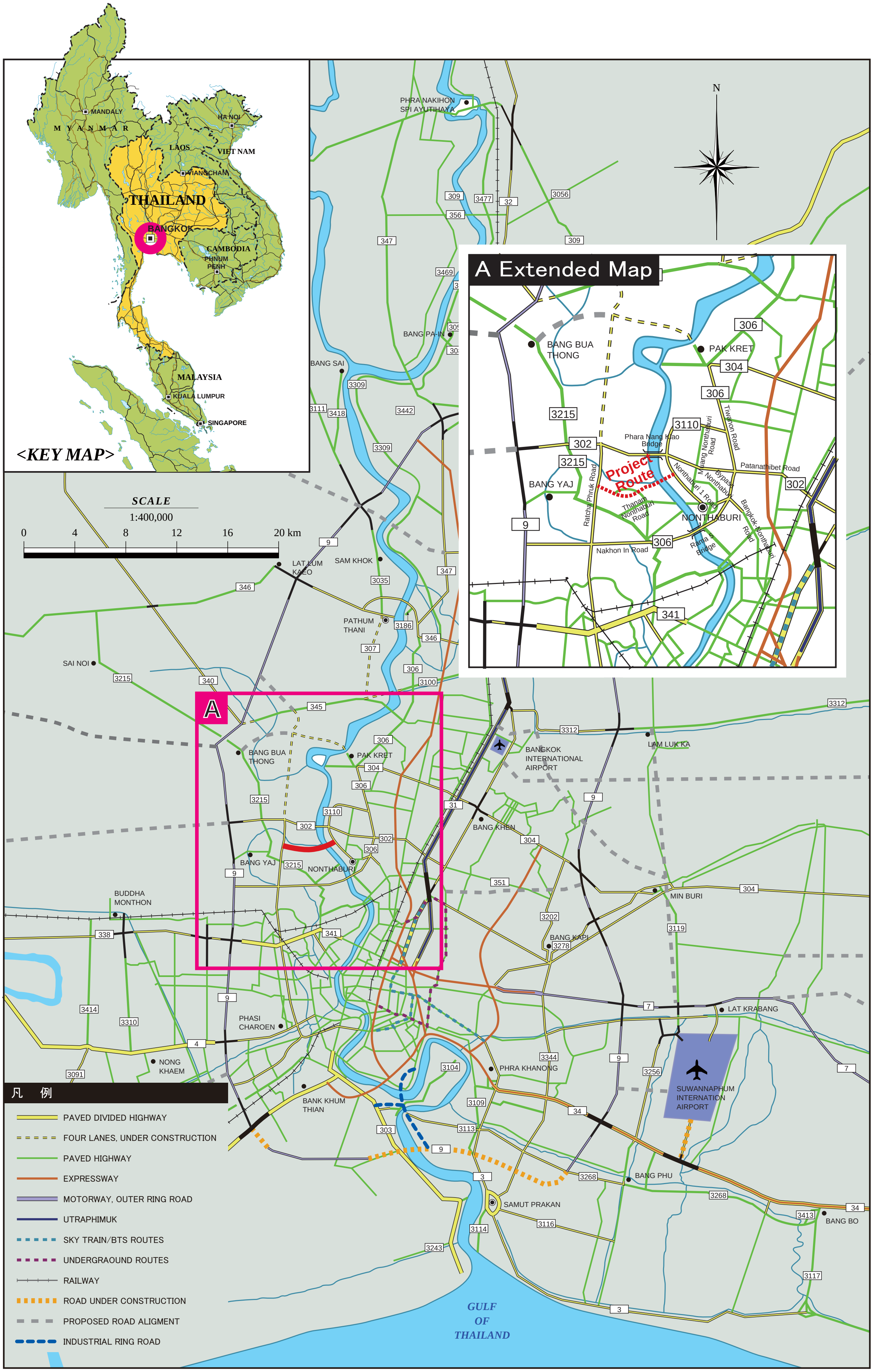
CURRENCY EXCHANGE RATE

Following currency exchange rates were adopted in this report unless otherwise stipulated.

(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

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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	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

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

7-1 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.

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

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND OF THE SURVEY

1.1.1 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 km^2 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/km^2 or more, and the Nonthaburi Prefecture ranks next to BMA with about. 700 persons/km^2), 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.

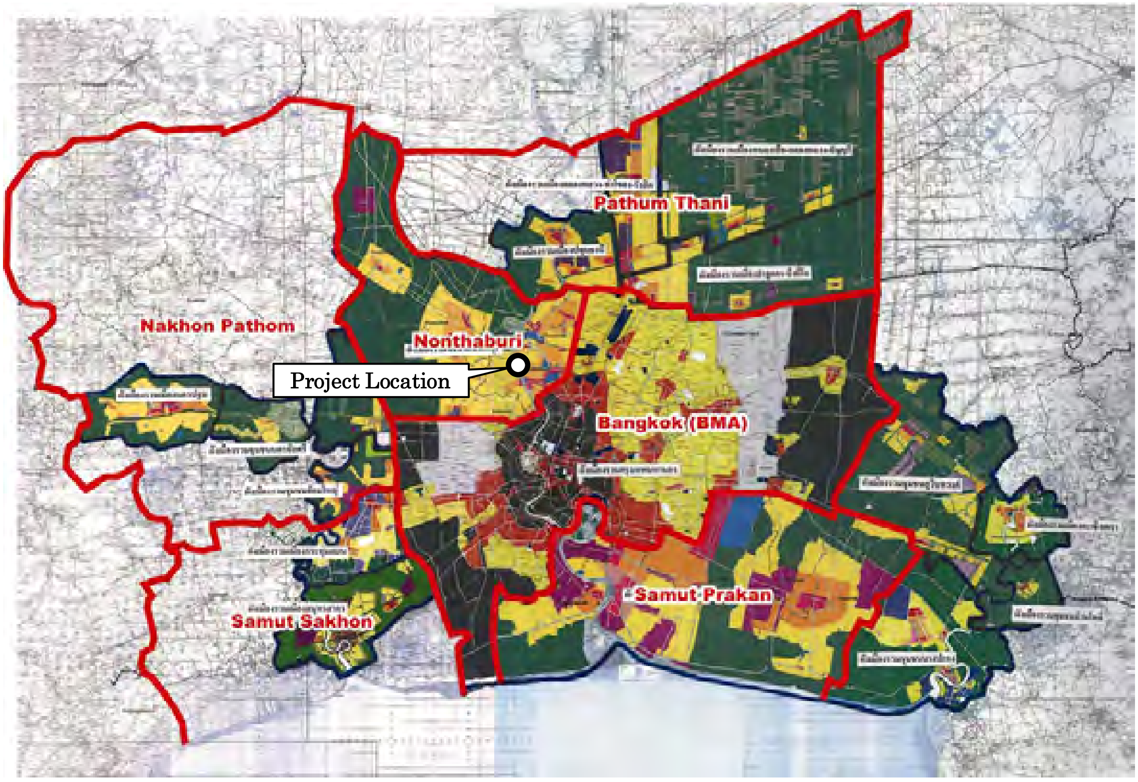


Figure 1.1.1 Bangkok Metropolitan Region (BMR)

In the past, major roads and bridges have been constructed by the Public Works Department (PWD) of the Ministry of Interior (MOI), the Department of Highways (DOH) of the Ministry of Transportation (MOT), the Expressway Authority of Thailand (EXAT) and the BMA. In October 9, 2002, the Department of Rural Roads (DRR) was established on October 9, 2009 under MOT by transferring the staff from PWD and the Office of Accelerated Rural Development of MOI. After its establishment, DRR has the responsibility of developing new road infrastructures in BMR other than the areas of BMA. However, the operation and maintenance of the existing bridges by the previous PWD are still under DRR.

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.

1.1.2 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. The first bridge is Rama VI Bridge built in 1982 as a railway bridge under assistance of the French and British Governments. Afterwards, a number of bridges had been built, and there are 19 roadway bridges (North and South bridges of the Industrial Ring Road are counted at 1) and a railway bridge totaling 20 bridges as October 2009. Recently, one rail bridge carrying the BTS Sky Train was accommodated in the mid-space between the upstream and downstream side girders of the Taksin Bridge and this makes it two rail bridges in BMR. The summary of the existing bridges is presented in Appendix-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.

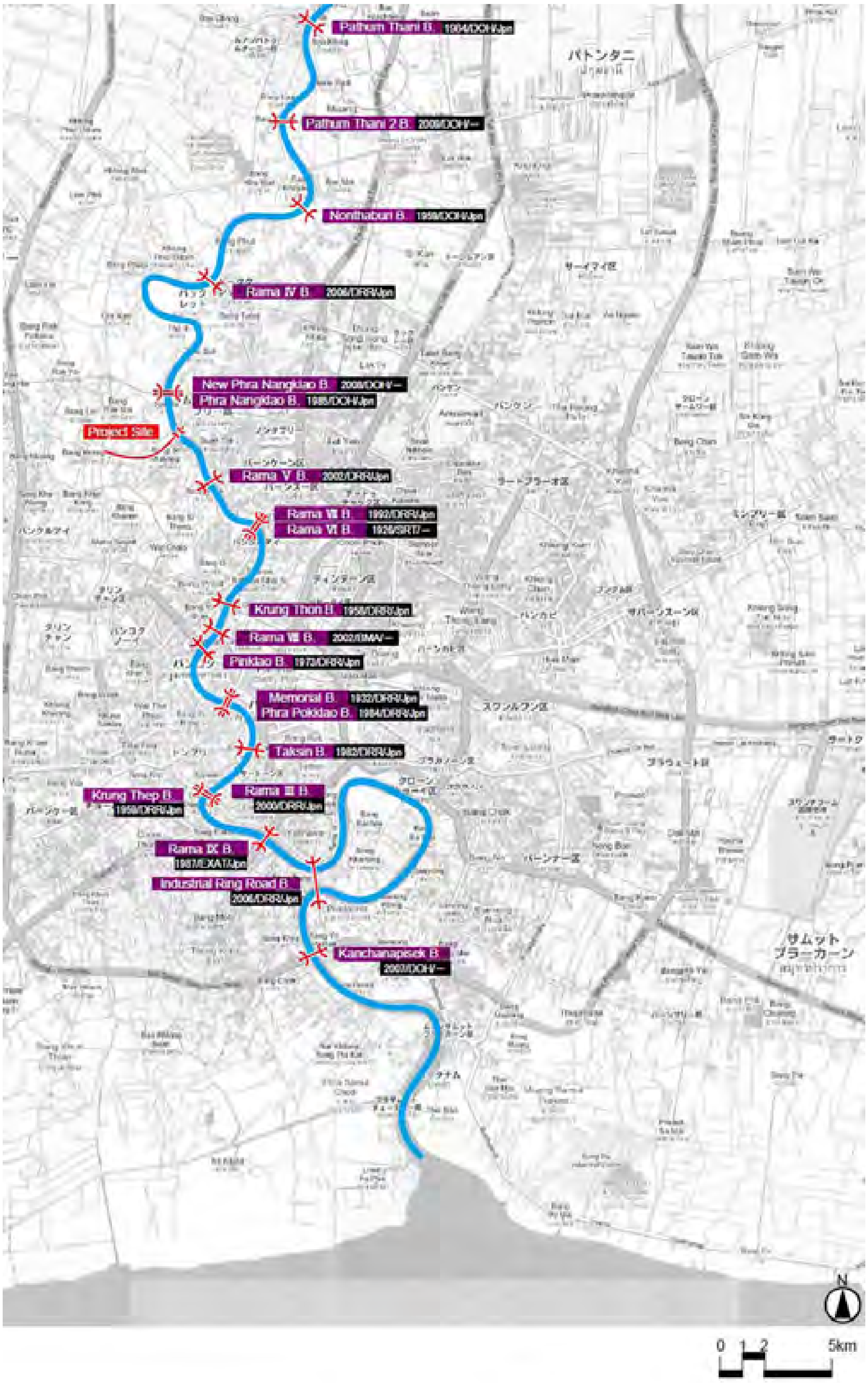


Figure 1.1.2 Location Map of the Project and Existing Bridges

1.1.3 THE CHAO PHRAYA RIVER CROSSING BRIDGE AT NONTHABURI 1 ROAD CONSTRUCTION PROJECT

There are five bridges in Nonthaburi Prefecture as of October 2009. These are the: 1) Nonthaburi Bridge in the border of Patum Thani Prefecture which was built through the Japanese Special Fund in 1959, 2) Rama IV Bridge, the so-called Pak Kret Bridge built in 2006 through the ODA 22nd loan, 3) New Phra Nangklao Bridge which was built in 2008), 4) Phra Nangklao Bridge which was built in 1985 through the ODA 8th loan, and 5) Rama V Bridge, the so-called Wat Nakorn-in in the border of BMA which was built in 2002 through the ODA 20th loan.

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.

As discussed above, the F/S and D/D were conducted by the Thailand national consultant team. Likewise, the Thailand Government intends to avail the services of Thai national consultants for the construction supervision of the Project

As the government of Thailand expects the Japanese ODA loan to extend assistance for the construction of the Project, the Japan International Cooperation Agency (JICA) decided to conduct the Preparatory Survey for The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project. In addition, the survey includes the identification of Japanese technical assistance in order to properly use the facilities completed in past ODA projects.

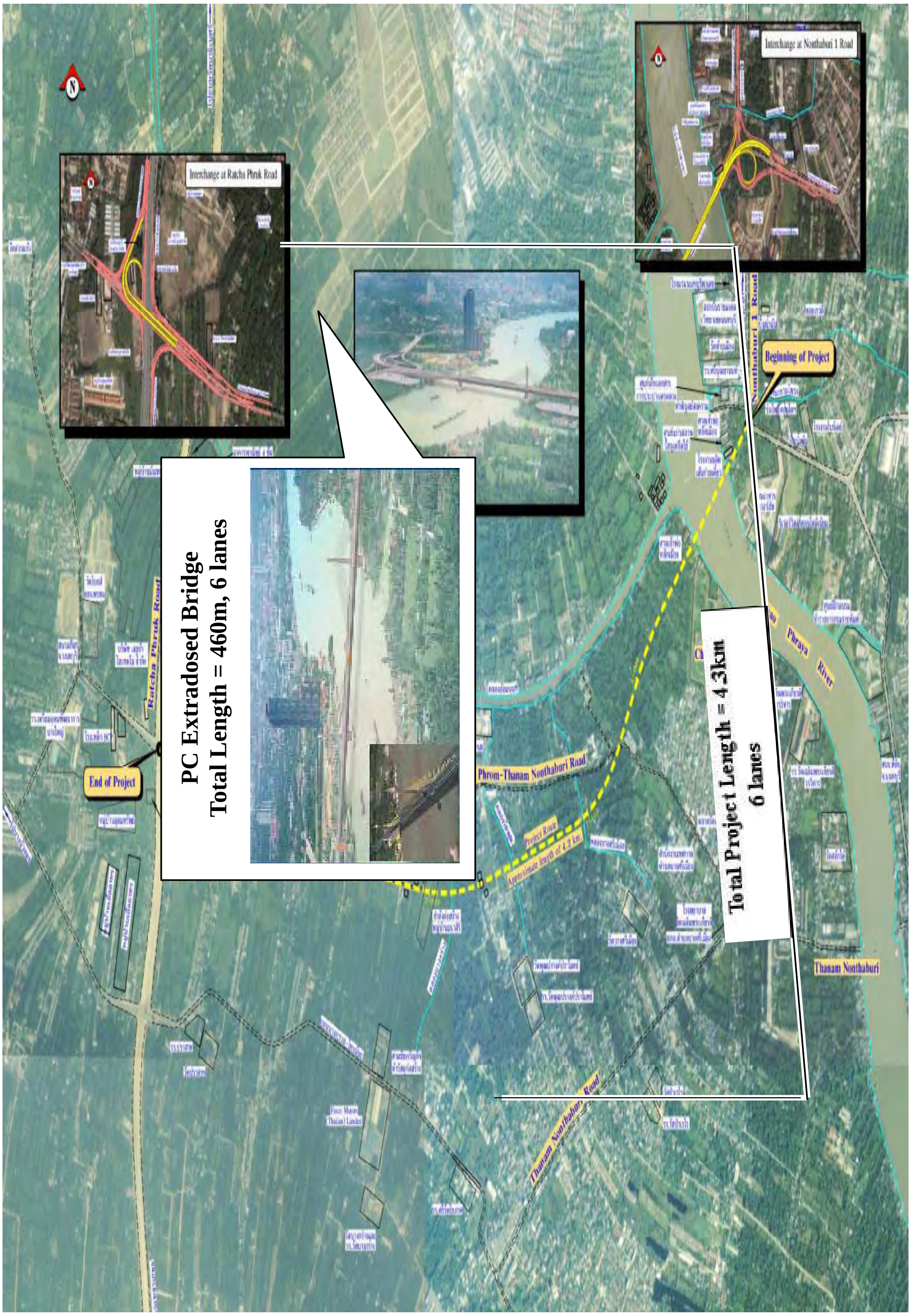


Figure 1.1.3 Outline of the Project "The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project"

1.2 PURPOSES OF THE SURVEY

The purposes of the preparatory survey for the Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project are as follows:

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.

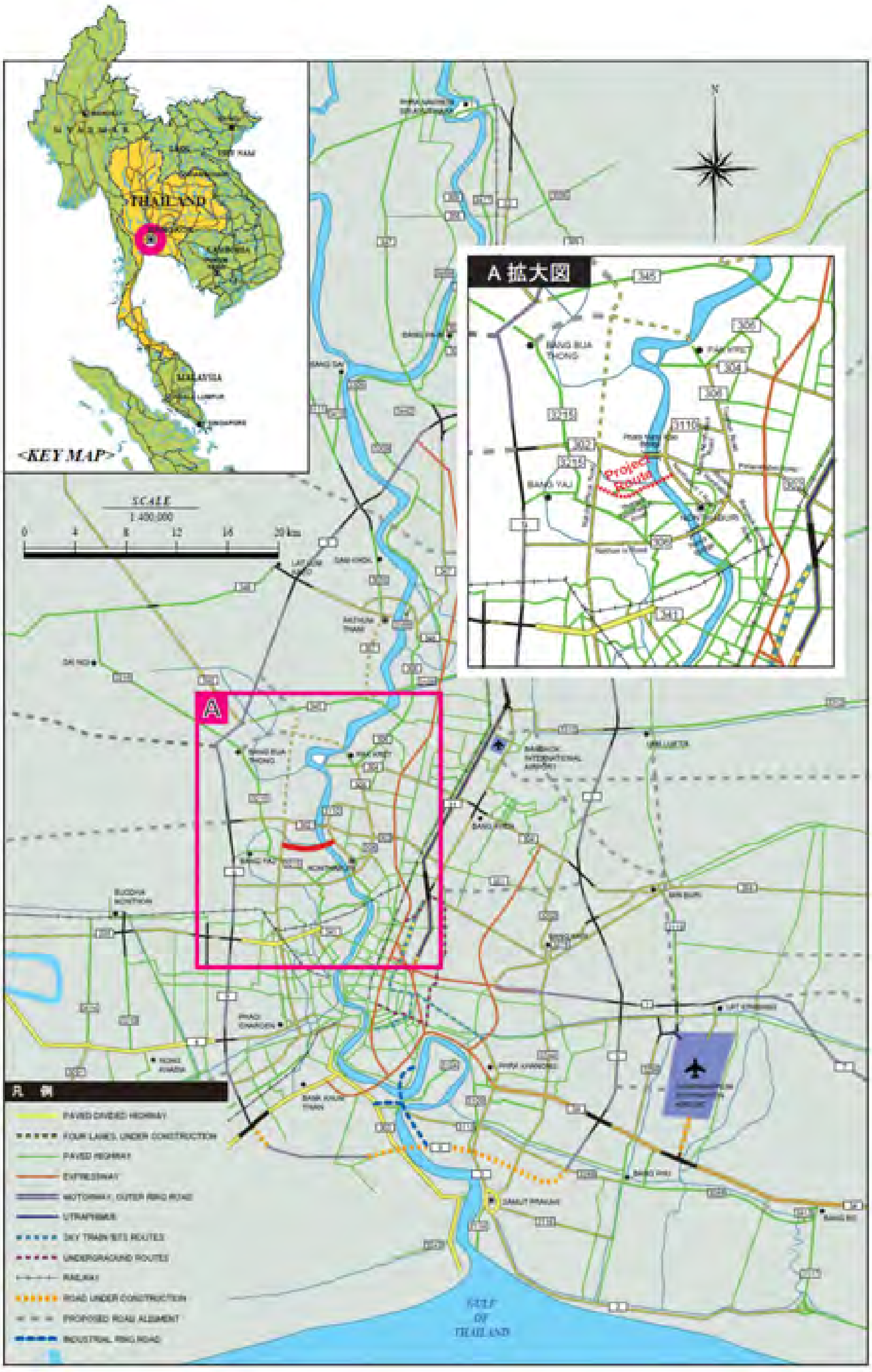


Figure 1.3.1 Survey Area Map

CHAPTER 2

PROJECT BACKGROUND AND NECESSITY

CHAPTER 2 PROJECT BACKGROUND AND NECESSITY

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

2.1.1 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.

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). Likewise, other road management authorities are developing and improving arterial roads to form the ring and radial road networks in and around the BMA.

2.1.2 CURRENT SITUATION OF ROADS AND BRIDGES

(1) Types of Roads and Administrators

As shown in Table 2.1.1, the roads in BMA are classified into six groups according to administrative management category.

Table 2.1.1 Types of Roads and Administrators

Category	Administrators	Outline
National Highways	Department of Highways, Ministry of Transport	Major inter-city roads connecting the major cities nationwide. Two-lane is the standard and classified into the following three grades. First: with one or two digit serial number connecting regions Second: with three digit serial number running within the regions Third: with four digit serial number connecting the regional center
Rural Roads	Department of Rural Roads (DRR), Ministry of Transport, Office of the National Security Council, Royal Irrigation Department, Ministry of Agriculture and Cooperatives, etc.	Roads outside of the local administration constructed by various public authorities DRR constructs rural roads, industrial ring roads in Bangkok City, bridge over the Chao Phraya River, and Outer Bangkok Ring Road.
Municipal Roads	Bangkok Metropolitan Administration, Other Municipalities	Road networks in local administration. Major local governments such as Bangkok City construct and maintain the roads, however, others undertake maintenance only while the DRR constructs the roads.
Motorways	Department of Highways, and Ministry of Transport	High standard toll way. No.7 (Bangkok - Chonburi) and No. 9 (Outer Bangkok Ring Road: 146 km) are operated.
Expressways	Expressway Authority of Thailand	Intra-urban toll roads in Bangkok City 171 km operated, 4.7 km under construction
Concession Roads	Department of Highways, and Ministry of Transport	Private sector constructs under BOT (Build, Operate and Transfer) contract with the Department of Highways Ex. Don Muang Toll Way

Source: Economy Outlook of Thailand (2008/09), Japanese Chamber of Commerce, Bangkok

(2) Road Development

BMA had expanded in the delta estuary of Chao Phraya River and water transportation via the canal is used as the major mode of transportation. Although the road network has been developed in the reclamation of canals since 1960, the capacity is still not enough.

The road network densities of BMA and BMR are 0.88 km/km^2 and 2.60 km/km^2, respectively. These are far less than the preferred density for urban planning of 3.5 km/km^2.

Table 2.1.2 Road Length by Type in BMA, 2006 (km)

Types/ Administrators	Type			
	Intra-urban Roads	Primary Roads	Secondary Roads	Tertiary Roads
Expressway Authority of Thailand	173.2			
Department of Highways, Ministry of Transport		346.2		
Department of Rural Roads, Ministry of Transport				1,447.1
Bangkok Metropolitan Administration		1,215.4	407.0	2,453.7
Other Municipalities		240.0	80.0	480.0
Total	173.2	1,801.6	487.0	4,380.8
Grand Total	6,842.6			

Source: Strategic Urban Transport Policy Directions for Bangkok, June 2007, World Bank

As shown in Table 2.1.3, the road ratio of BMA in 2000 was 7.03% and has increased to 8.1%. It is still low compared with other cities such as Tokyo urban areas (15.4%), London (16.6%), Paris (20.0%) and Washington DC (25.0%). (Source: Roads of Tokyo, 2000)

Table 2.1.3 Road Ratio in BMA

Year	Road Area (km^2)	Road Ratio (%)	Growth rate (%/year)
1986	38.4	2.45	6.13
1995	85.7	5.46	4.45
2000	110.3	7.03	

Source: Comprehensive Plan of Bangkok Metropolis, BMA

(3) Road Network

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 bridges on 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.

(4) Bridges on Chao Phraya River

There are 19 road bridges on Chao Phraya River, including the Memorial Bridge constructed in the 1930's, and 14 of which are from the assistance of the Japanese Government. As shown in Table 2.1.4, the long-span bridges, such as PC box girder bridges and cable-stayed bridges, with main span of more than 200 m, are also included.

Table 2.1.4 Outlines of Bridges on Chao Phraya River

	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 2Bridge	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.

As shown in Figure 2.1.1, some bridges are on the arterial roads from the central BMA and some are on the outer ring roads. The average interval of these bridges is two to three kilometers near the center and five to eight kilometers in the north.

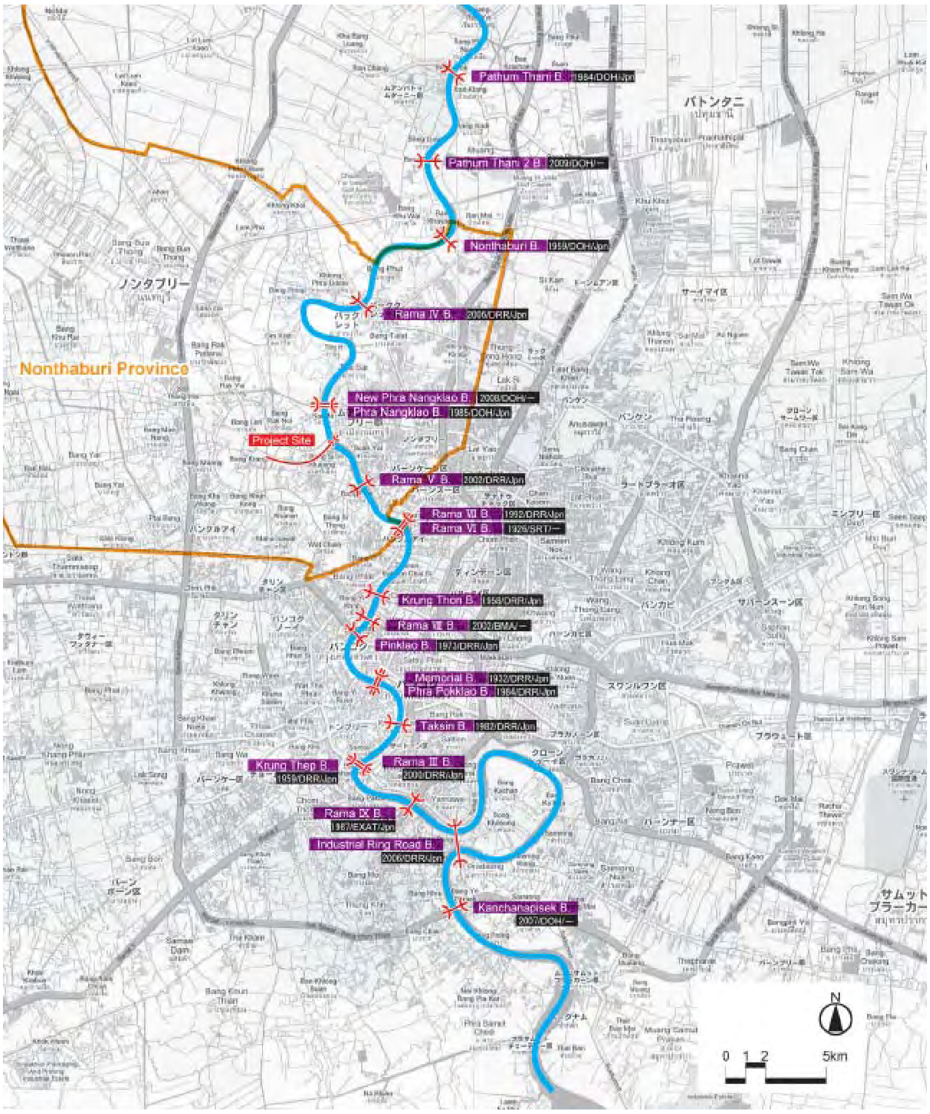


Figure 2.1.1 Location of Bridges on Chao Phraya River

(5) Road Development Plan

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 2.1.5. 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 2.1.5 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 Pakopng	150	36,500	2009-2011
Total		778	158,310	2009-2011

Source: Department of Highways, MOT

As for the road development plan in BMR, several ring road and east-west corridor development projects are underway as major projects in the area as shown in Figure 2.3.2 and Appendix 4. Specific major projects are the Outer Bangkok Ring Road Development, Chaeng Watthana Road Improvement, Ram Intra Road Improvement, Ratana Thibet Road Improvement, Ngam Wongwan Road Improvement, and Prasoet Manunkit Road Improvement.

2.1.3 CURRENT ROAD TRAFFIC SITUATION

(1) Vehicle Registration

Registered cars in BMA have increased by 3.5% per year since 2000 and 5.7 million in 2007, which is almost the same as the population of BMA.

Table 2.1.6 Number of Registered Cars in BMA from 2000 to 2007 (Thousand)

Year	2000	2001	2002	2003	2004	2005	2006	2007
Number	4,495	4,464	5,399	5,481	4,288	6,253	5,557	5,715

Source: Thailand in Figures 2008/2009 Bangkok, Alfa Research

(2) Traffic Volume

As shown in Table 2.1.6, the total traffic volume of BMA is increasing as the number of cars increase. The number of passenger cars increased significantly as shown in Table 2.1.7 which indicates the growing economic activities in the area.

Table 2.1.7 Total Traffic Volume of Cars in BMA from 1996 to 2004 (million･km)

Type	1996	1997	1998	1999	2000	2001	2002	2003	2004
Passenger cars	10,250	10,914	10,356	11,100	14,451	14,043	14,520	17,823	14,045
Trucks	7,582	7,961	6,391	7,002	7,525	7,740	6,514	8,275	8,927
Total	17,832	18,875	16,747	18,102	21,976	21,783	21,034	26,098	22,972

Source: Department of Roads, Ministry of Transport

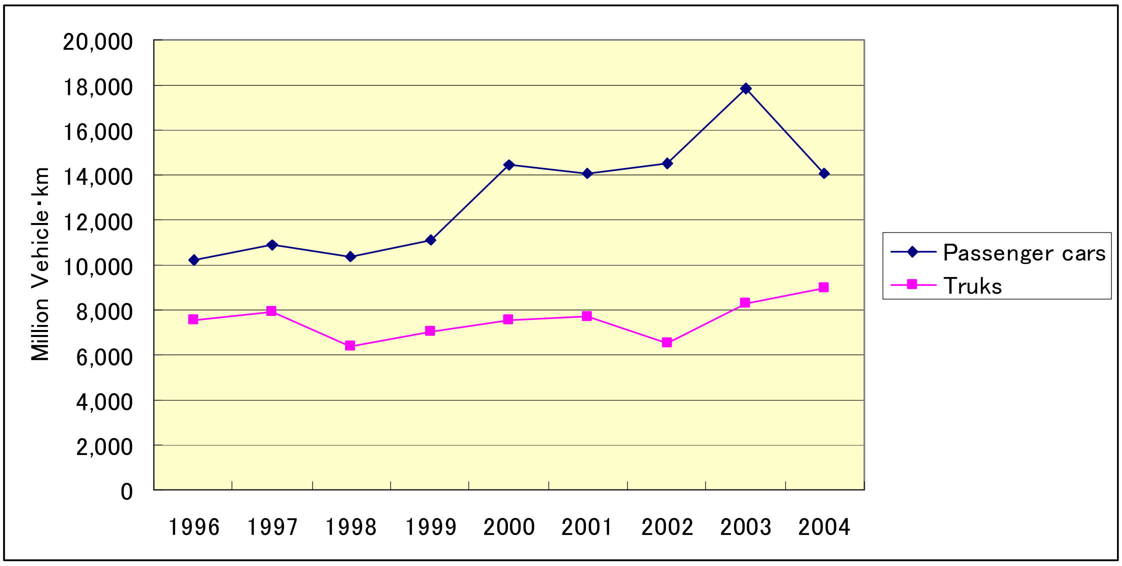


Figure 2.1.2 Total Traffic Volume of Cars in BMA from 1996 to 2004

Table 2.1.8 shows the traffic volume during peak hours in the morning, from 7:00 to 8:00, of each bridge on Chao Phraya River in 2005 and 2008. The volumes did not show significant changes and vary among the bridges. One possible reason why traffic volume did not increase from 2005 to 2008 is the economic crisis in BMA in 2008.

Table 2.1.8 Traffic Volume of Bridges on Chao Phraya River in 2005 and 2008

Name of Bridges	Traffic Volume (Morning Peak Hour: PCU)	
	Tue., 14 June 2005	Tue, 15 July 2008
Patum Tani Bridge	-	4,381
Nonthaburi Bridge	-	2,752
Rama IV Bridge	-	4,713
Phra Nangklao Bridge	5,160	4,170
Rama V Bridge	4,964	7,557
Rama VII Bridge	3,502	2,833
Krung Thon Bridge	2,966	1,733
Rama VIII Bridge	4,198	3,122
Pinklao Bridge	6,345	8,214
Memorial Bridge	3,240	2,611
Phra Pokklao Bridge	6,140	7,562
Taksin Bridge	4,864	4,849
Rama III Bridge	3,691	3,762
Krung Thep Bridge	4,247	1,886

Source: F/S (2005 data), TDML Study, OTP (2008 data)

2.1.4 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

2.2.1 TRANSPORTATION POLICY OF THE ROAD AND BRIDGE SECTOR

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. Concrete planning is prepared by Bangkok City (BMA) and the Office of Transportation Planning (OTP) under the Ministry of Transport (MOT). The implementation of the plan is delegated to related organizations such as Bangkok City (BMA), concerned provinces, DOH and DRR and ETA of MOT.

In the master plan, 75 projects are listed as urgent to be developed and the priority order is decided by the designated agencies. The present status, as of October 2009,, of these projects is shown in Figure 2.3.2. Some of them have been completed, while some were canceled.

The traffic congestion in Bangkok is serious, disturbing the transportation flow in the city. To alleviate this congestion, the first, second, and further, the third, ring roads are planned, outside and development is proceeding. To link to these roads, the development of the east-west and north-south roads, and mass transportation system such as the Purple Line with feeder roads, the improvements of intersections, and others are under implementation to strengthen the total transportation network. The accessibility from the Project road to the Purple Line is shown in Figure 2.2.1.

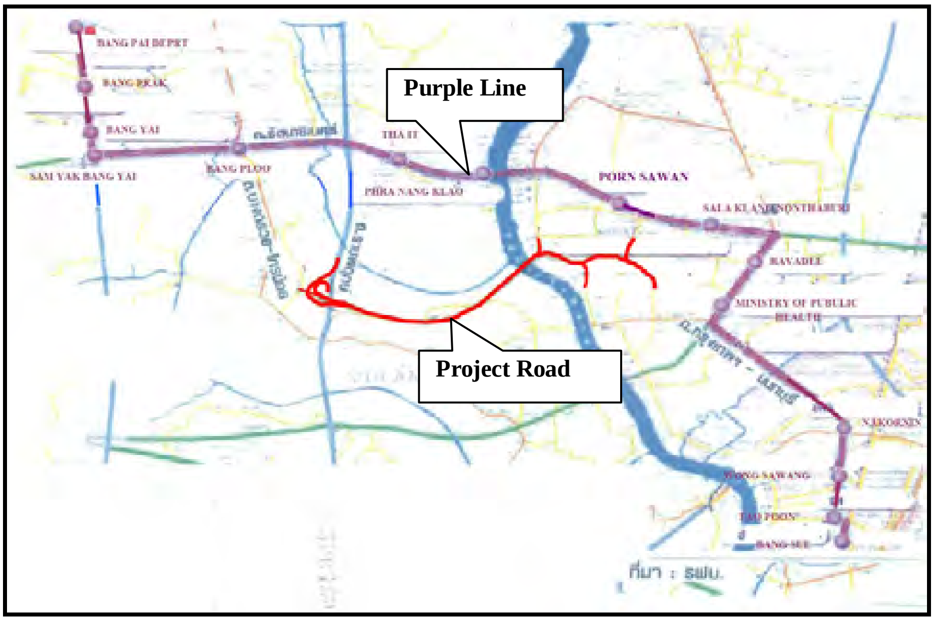


Figure 2.2.1 Location Map of the Porn Sawan Station and the Project Route

DRR considers that this project will be one of the transportation network development projects connecting the areas on both sides of the river. This will not only be an effective transportation route alternative but also a potential enhancement aspect in the economy, quality of life and environment for Nonthaburi people. 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.

2.2.2 CONFORMITY WITH ROAD AND BRIDGE SECTOR DEVELOPMENT PLAN

1) The Commission of Management of Land Traffic's (CMLT) Resolution No.1/2547

The CMLT has approved the total 75 priority projects to alleviate traffic problems in Bangkok and vicinity areas in 2004 as per CMLT's Resolution No.1/2547. This Project is one of the approved top priority projects, which was assigned to DRR for implementation.

2) The Tenth National Economic and Social Development Plan (2007~2011)

The 10th Plan, which came into force on October 19, 2006, has emphasized the development of infrastructure and logistics system, both quantitative and qualitative, as one of the major factors to support the reform of the country's economic structure to increase productivity and competitiveness. The strategies include the development of the logistics network by improving every mode of transport and feeder routes, promotion of energy-efficient transport to reduce production costs, and development of efficient transportation network in Bangkok Metropolitan and vicinity areas.

Moreover, the high-level public private cooperation committee (PPP committee) was set up in June, 2008 to secure the financial resources for the above development chaired by the Prime Minister. Three projects are approved to be implemented with PPP finance by the committee. The road development project between Bang Pa-in and Nakom Ratchasima of 199-km length is one of the three projects.

3) Ministry of Transport's Strategic Plan (2005~2009)

Approved by NESDB on April 17, 2006, the Ministry of Transport's Strategic Plan aims at developing an integrated transport system to support the country's economic growth and serve as a logistic hub for the Indochina regions. For Bangkok and vicinity areas, the improvement of the road network to alleviate traffic problems and to increase mobility, and the development of feeder routes for mass transit network are considered as major strategic issues to be addressed by the relevant departments in the Ministry.

4) Department of Rural Road's Road Network in the Greater Bangkok and Vicinity

This project will add to the existing road network in Bangkok and the five neighboring provinces under the responsibility of DRR, which covers the 11 major bridges crossing the Chao Phraya River and 1,666,926 km of road, as of October 2009. The project will also provide a linking network between two recently completed projects financed by Japanese ODA loans.

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 2.2.2. 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.

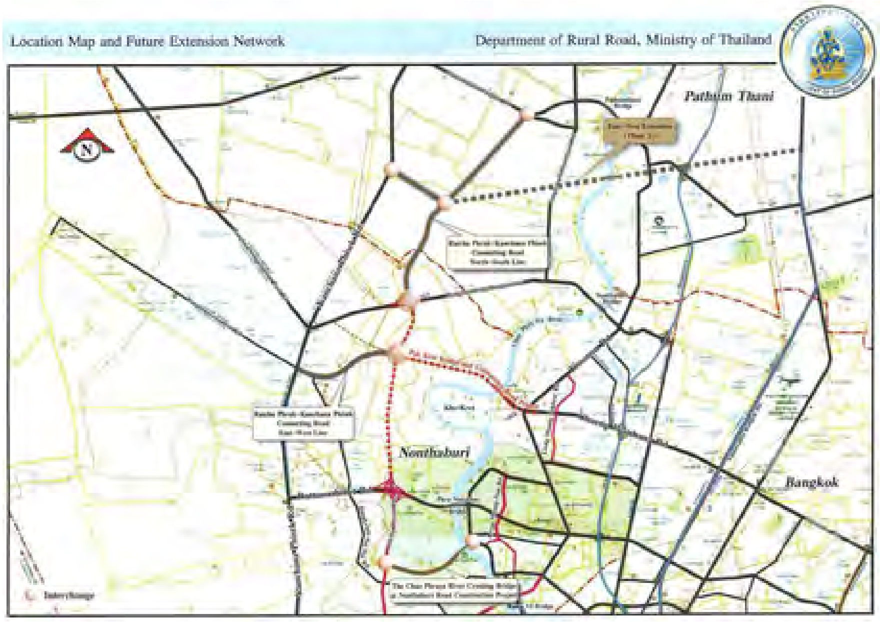
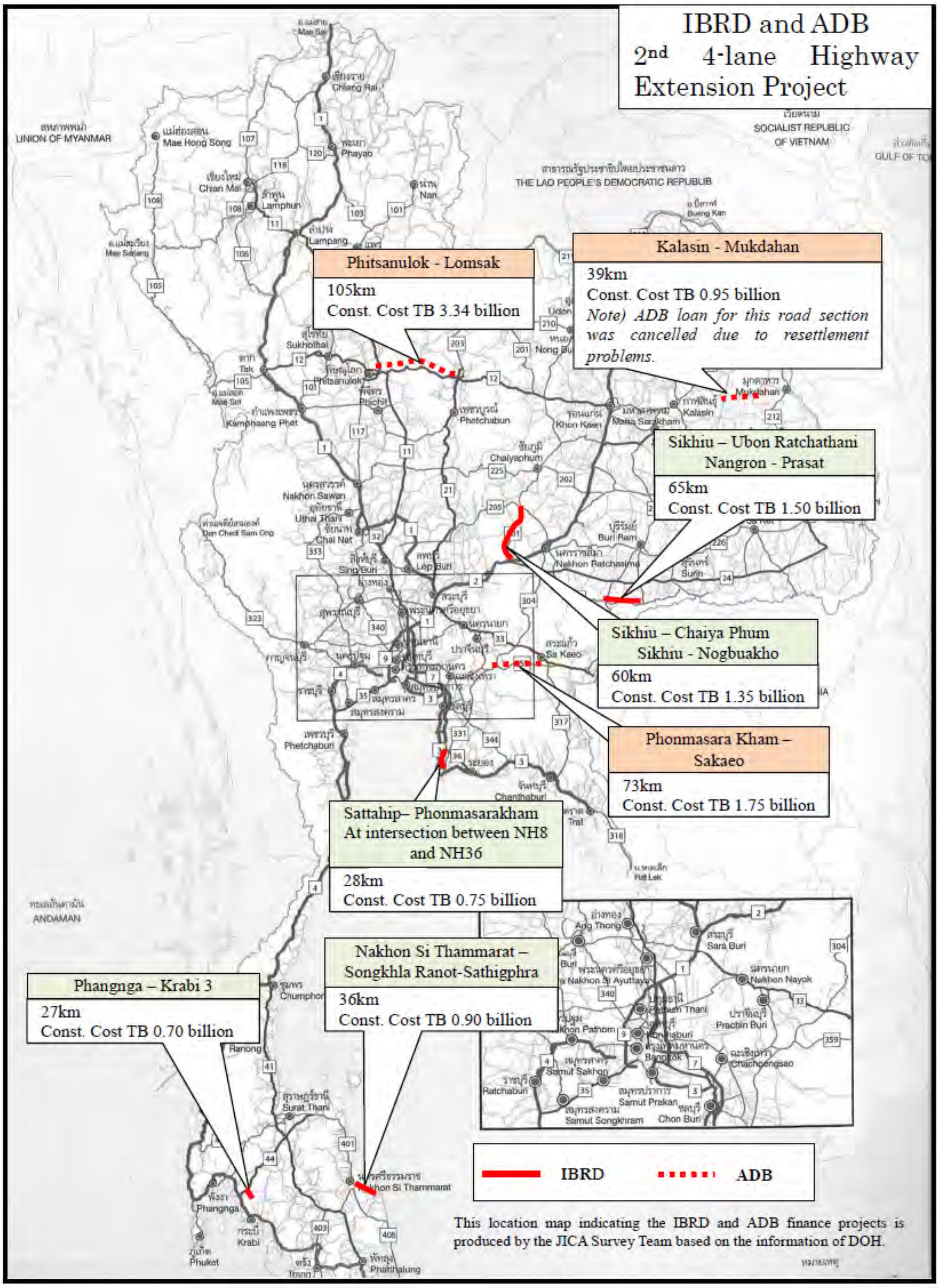


Figure 2.2.2   Road Extension Plan by DRR

2.2.3 REVIEW OF OTHER DONOR'S ACTIVITIES IN THE TRANSPORTATION SECTOR

The main donors in Bangkok are the World Bank (WB) and Asian Development Bank (ADB). Both banks have been cooperating together to support the Thai Government, but for the past ten years, there was no project financing. It was reported that the reason for this is that the Thai Government did not express their need for project loans to the financing institution. For reference purposes, the International Bank for Reconstruction and Development (IBRD) and ADB 2nd Four-lane Highway Extension Project which was approved by the Thailand Parliament on November 10, 2009, is shown in Figure 2.2.3.



This location map indicating the IBRD and ADB finance projects is produced by the JICA Survey Team based on the information of DOH.

Figure 2.2.3 New Highway Projects of DOH to be Financed by IBRD and ADB

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.

Table 2.2.1 shows the summary of WB under IBRD assistance projects to DOH in the past 20 years.

Table 2.2.1 DOH Highway Projects Assisted by WB -IBRD in the Past 20 Years

Loan No.	Loan Type	Project Outline	Amount (US$)	Signing Date	Effective Date	End of Contract
2894-TH	SECTOR	NA	50,000,000	17-Feb-88	15-Jun-88	31-Dec-92
3008-TH	3 TOLLS	**Intercity Tollway** Saraburi-Nakhonratchasima(43.100KM.),Thonburi-Pak tho section2A(8+100KM.),Thonburi-Pak tho section2B(7.4KMS.),Bangpain-Nakhonsawan(17.259KMS.),Bangpain-Nakhonsawan(33.00KMS.)	87,000,000	1-Mar-89	20-Jun-89	31-Mar-94
3220-TH	SECTOR	NA	50,000,000	13-Jul-90	11-Oct-90	31-Dec-94
3446-TH	SECTOR	NA	164,466,000	27-Mar-92	31 JU 1992	30-Jun-98
3968-TH	4 LANES	**National Highway** Lampang-Lamphun(section2),Ubonratchathani-Mukdahan(20KM.)Khonkaen-A.Namphong(23+912.734KM),A.Banna-Nakhonnayok(14+993.929KM.),Pattaya-Rayong(58+625.380KM.)	76,100,000	9-Feb-96	17-May-96	31-Dec-01
4721-TH	4 LANES	**National Highway** A.Sichon-A.Thasala(20.00KMS),A.NikhomKhamSroi-A.LoengNokTha(22+600KMS.),B.NongBuaKhok-ChaiyaPhum(42.573KM.),Overpass at Route22 and UdonThani Bypass,Overpass at Km.8 Ramindra,RailwayOverpass at BanPong	84,299,000	16-Dec-03	15-May-04	30-Jun-10
TOTAL			511,865,000			

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.

Table 2.2.2 shows the summary of ADB-assisted projects to DOH in the past 20 years.

Table 2.2.2 DOH Highway Projects Assisted by ADB in the Past 20 Years

Loan No.	Loan Type	Project Outline	Amount (US$)	Signing Date	Effective Date	End of Contract
943-THA	SECTOR	NA	110,000,000	17-Aug-89	28-Dec-89	31-Dec-94
1027-THA	SECTOR	NA	34,343,843	27-Sep-91	8-Jan-91	28-Feb-97
1098-THA	3 TOLLS	**Intercity Tollway** Kaengkhoi Interchange,Chainat Interchange,Sinburi Interchange,Outer ring road Interchange,Inburi Interchange,Angthong Interchange,A. Nong Bua-A.Tha Tako	54,100,000	27-Sep-91	26-Dec-91	31-Aug-97
1176-THA	SECTOR	NA	70,829,927	16-Sep-92	21-Mar-93	30-Jun-98
1306-THA	4 LANES	**National Highway** A.Mae Chan-A. Mae sai(31.545KM.)A.Nago(10.0KM.),A.Lang suan-A.Chaiya(23.726KM.),A.Lang suan-A.Chaiya(25.00KM.),Lampang-Phayao(22.600KM.),Phayao-Jct.to A.Mae suai Section1(35.800KM.),Phayao-Jct.to A.Mae suai Section2(34.200KM.),Kamphaengphet-B.wang chao(33.327KM),B.wang chao-Tak(33.695KM.),22.00KM.,A.Namphong-Udonthani section1(40.643KM.),A.Namphong-Udonthani section2(42.837KM.)	134,251,779	26-Aug-94	6-Dec-94	31-Dec-03
1391-THA	4 LANES	**National Highway** Changmai-Tak, Nongkai-Udonthani, Pattani-Sungaikolog	131,800,000	29-Sep-95	17-Jan-96	30-Jun-04
TOTAL			535,325,549			

In addition to the assistance to DOH, ADB has assisted DRR in 2000 to 2002, with its Bangkok Urban Transport Project (Loan 1195-THA), which aimed at constructing the Tonburi Road Extension, the so-called part of Rajapreuk Road, amounting to US$ 29.4 million of ADB loan out of the total project cost of US$ 131.7 million.

2.2.4 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 1st NESDP was focused on the formation of the industrial base for the nation, and promoted the national and regional arterial road network, and called for the infrastructure development for the economic development. But one consequence of this was the high influx of population in BMR, together with aggravating urban problems such as environmental pollution and traffic jam. The 5th NESDP introduced a decentralization policy, calling for new growth centers such as the Eastern Seaboard developments.

The economic order after Plaza Accord on the exchange rates brought a rapid economic expansion to Thailand since 1975. Consequently, the accumulation of the economic activities in the metropolitan area further accelerated, and the regional gap in income and production expanded. 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. The comprehensive plan for BMA was modified in 2003, and this modified plan is called the 2nd modification plan and was approved and took effect in 2006, which is the present plan.

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

① Metropolis predominating in art and culture, with a national uniqueness

② Metropolis with quality of life of the people considering environmental conservation and natural resources

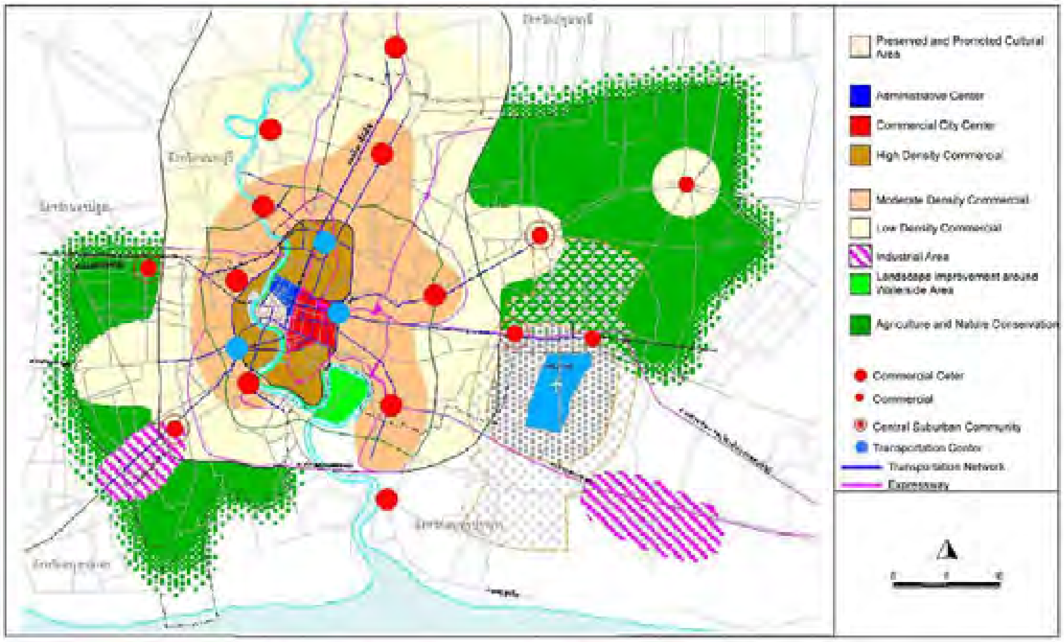
③ Metropolis that is the center of economic activities and technology of the nation and Southeast Asia

④ Metropolis that is the center of administration, institution and international organizations

⑤ Metropolis that is flexible and convenient with a communication and transport network

Further details on the present plan are discussed in Sub-section 2.5.2.

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 2.2.4 Future Image of Bangkok Metropolitan

(3) Urban Planning for Nonthaburi Province

In this sub-section, the present Comprehensive Plan for Nonthaburi Province is summarized and further details are described in sub-section, 2.5.2.

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.

As discussed above, the urban area of the Nonthaburi Province has expanded and shifted from the east bank to the west bank of the river, as a result of the development and the construction of new roads and bridges in the west bank areas in recent years.

(4) Possible Effects of the Project Bridge on Urbanization

As discussed in Item (1) above, historical changes in the urbanization in Bangkok indicates that one new road with a bridge across the Chao Praya is not quite enough to urbanize the area on the opposite side of the river, but rather create a “tongue” like road-side urbanization only. However, after a few bridges at intervals of two to three km are constructed, this would tend to convert the opposite side of the river into continuous urbanization.

The proposed Project bridge is the third bridge in the area, after Phra Nongklao Bridge on the north, and Rama V Bridge on the south. The existing two bridges are about five km apart, and the conditions for the continuous urbanization almost apply. The road network improvement in the Nonthaburi area may lead to significant urbanization considering that the

Nonthaburi area is located at about 10 to 15 km radius from the Bangkok City center. It is projected that the opposite side of Nonthaburi along the Project Bridge will face continuous urbanization in the near future as a result of the bridge construction.

(5) 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 2.2.3 below.

Table 2.2.3 Conformity of the Project Bridge to Regional Planning

Regional Unit	Relevant Plan	Conformity	Remarks
National Level	NESDP (8th, 9th and 10th)	High	• Countermeasure for excessive accumulation to Bangkok • Promoting development of regional cities
Bangkok Metropolitan Region	BMA Comprehensive Plan	High	• 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	• Promotion of road network improvement and new urbanization in the west bank of Chao Praya River

Source: JICA Study Team

2.2.5 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

2.3.1 OVERVIEW OF PREVIOUS FEASIBILITY STUDY

(1) General

The previous feasibility study on the Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project was carried out by the DRR, and MOT as one of components of the detailed design and land acquisition survey and the final report was submitted in October

2005. After submission of the final report, DRR prepared a series of additional documents to revise/update the final report from February 2009.

The traffic demand forecast for the Project in the above revised feasibility study presented the results of the forecast for the target years 2011, 2016, 2021, and 2026. The results of reviewing the demand forecast are summarized below.

(2) Pre-Conditions of Traffic Demand Forecast of the FS

1) Development Plan(s) and Socio-Economic Framework

In the original version of the previous F/S, the future socio-economic data was taken from the BMTA Route Planning and Scheduling Project (BRPS) Traffic Model which was developed by the Office of Transport and Traffic Policy and Planning (OTP) in 2004.

On the other hand, the future socio-economic data for the revised F/S was based on another data source by the Transport Data and Model Center V (TDMC) which presently revised/updated to Transport Data and Model Integrated with Multimodal Transport and Logistics (TDML) developed by OTP in 2007.

There were no detailed explanations in the F/S report and in the technical report of TDML about the future development plans. According to the information from OTP and local consultants who have carried out the demand forecast, the development plans, including the future land use plan adopted for the bases of future socio-economic framework, were as follows:

(a) National Development Plan: The 9th National Economic and Social Development Plan (2002-2006)

(b) Regional/ Urban Development Plan/Socio-economic Data by Traffic Zone: available from the Division of Transport and Traffic Information Center (in OTP)

The following four kinds of future socio-economic data were projected for the traffic demand forecast:

- Population
- Average Income per Household
- Number of Employments
- Number of Students

The JICA survey team reviewed the socio-economic framework based on future socio-economic data by traffic zone obtained from the Division of Transport & Traffic Information Center (in OTP), the socio-economic data as shown in the F/S, and transitional statistical data of the above socio-economic indexes.

On the other hand, land use plans of the BMR as well as Nonthaburi Province were provided by the Ministry of Interior (MOI) as shown below:

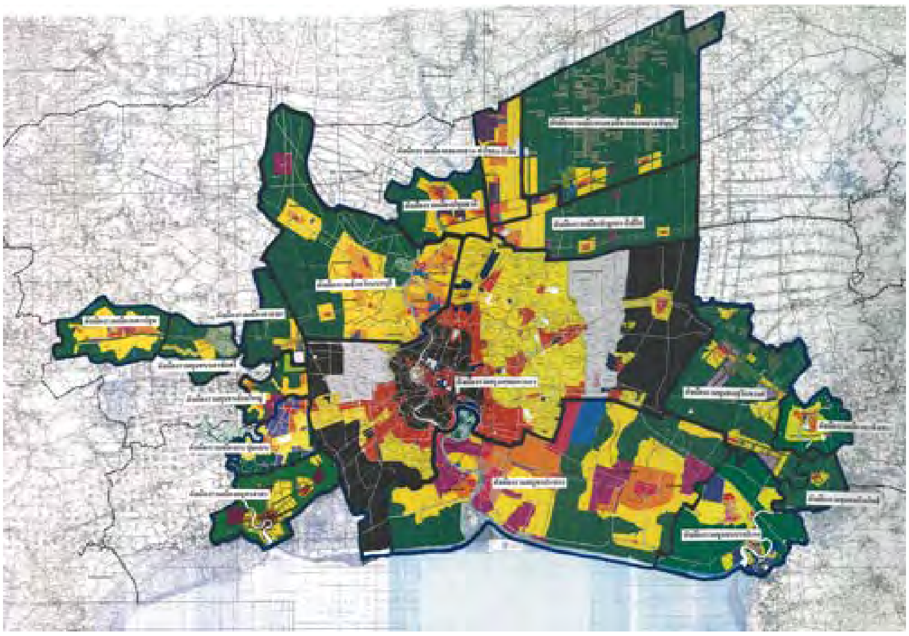


Figure 2.3.1 Future Land Use Map (BMR)

2) Transport Network Plans

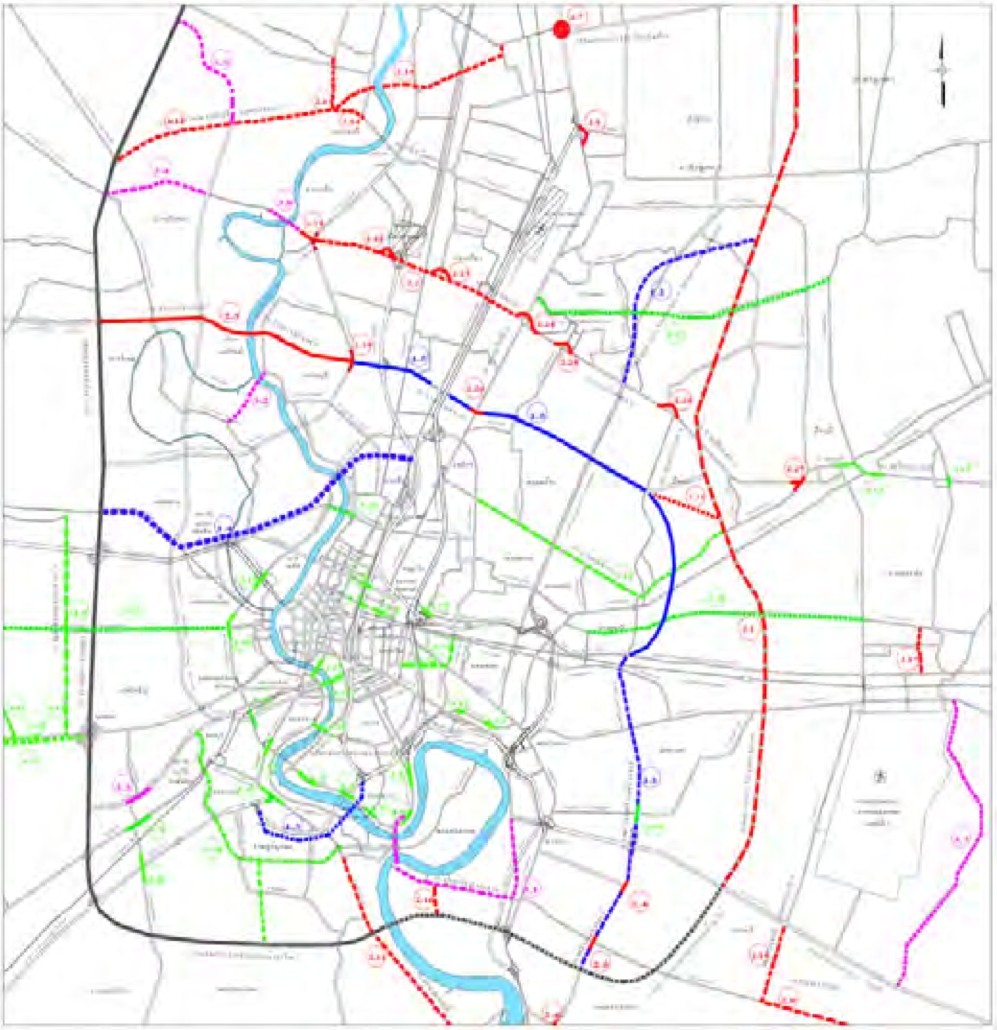
a) Present Road Network (2009) for the bases of traffic demand forecast

The present road network as of October 2009, including the completed and on-going projects, is shown below:

b) Future Road Network

The future road network for traffic demand forecast is composed of the future road development projects from the concerned government organizations listed below:

- Department of Rural Roads
- Bangkok Metropolitan Administration
- Department of Highways
- Expressway Authority of Thailand



Source: OTP

Figure 2.3.2 Present and On-Going Road Projects in BMR (2009)

c) Public Transport Network

Major public transport modes in BMR are buses and the light railway system operated by the Mass Rapid Transit Authority of Thailand (MRTA), and the State Railway of Thailand (SRT). The expansion plan for the Mass Railway Transit (MRT) up to 2029 is shown below with its implementation schedule. Part of this plan was reflected in the traffic demand forecast.

Figure 2.3.3 MRT Plan Map

(3) Methodology for Traffic Demand Forecast

The traffic models applied to the demand forecast for the Project bridge was based on the Transport Data and Model Center V developed by the Office of Transport and Traffic Policy and Planning, which has updated now to the Transport Data and Model Integrated with Multimodal Transport and Logistics. In this latest transport model, the study area, BMA and its surrounding five provinces, is subdivided into 625 traffic zones of which Nonthaburi Province, the direct influence area, is divided into 60 zones.

In the above traffic forecast system, the traffic demand forecast consists of the following four steps:

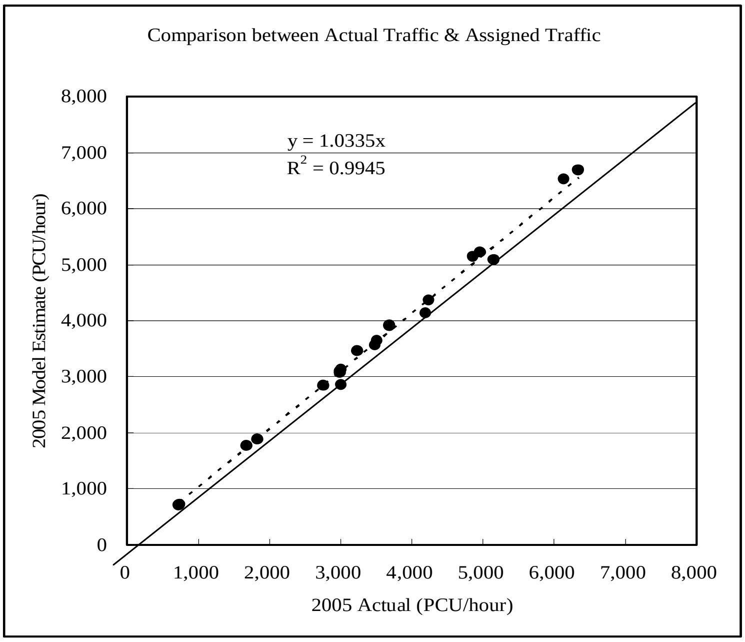
1) Trip Generation Model
2) Trip Distribution Model
3) Modal Split Model
4) Trip Assignment Model

The trip generation model adopts the method of the trip rate per household explained with the household income and household size distribution. The trip distribution model applies the traditional gravity model explained with the trip generation, trip attraction by each traffic zone and inter-zonal impedance function. The modal split model applies the Binary Logit Type model and forecasted two modes trips, public and private trips. At the final step, the equilibrium assignment method was used to assign all trips to the road network and the public transport network.

The forecast methodologies explained above are considered to be reasonable and concluded to be appropriate.

(4) Confirmation of Validity of the Present Origin-Destination (OD) Matrix (2005) and Traffic Assignment

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.

(5) 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

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.

It should be noted, however, that the congestion rates (V/C) for each target year of the project cases described in the document of the“1st Additional Information on General and Technical Issues” are not correct due to the input mistakes by the local consultants and the correct values of congestion rate are shown in the above table.

2.3.2 SUPPLEMENTAL TRAFFIC SURVEY

(1) General

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:

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

(2) Hourly Traffic Count Survey

1) Survey Method

The hourly traffic count survey was conducted during morning peak hours from 6:00AM to 10:00AM and evening peak hours from 4:00PM to 8:00PM on 8th October, 2009. The classification of vehicle type is shown in Table 2.3.2.

Table 2.3.2 Vehicle Classification

1) Bicycle	5)Small Bus	9) Middle Truck (2-axle)
2) Tuk Tuk	6) Large Bus	10) Large Truck (more than 3 axle)/Trailer
3) Motorcycle	7) Pick Up	
4) Sedan/Taxi/Jeep	8) Small Truck	

Five stations are subjected to the hourly traffic count survey as shown in Table 2.3.3 and Figure 2.3.5. The survey stations are selected consistent with the survey location selected in the FS.

Table 2.3.3 Survey Station and Outlines

Survey Stations	Number of Lanes
M1:Ratcha Phruk Road	6 lanes, median
M2: Rattanathibet (Pranang Klao Bridge)	Old bridge; 4 lanes New bridge; 6 lanes
M3: Rama V Bridge	6 lanes
M4: Bypass Nonthaburi	4 lanes, median
M5: Nonthaburi 1	4 lanes, median

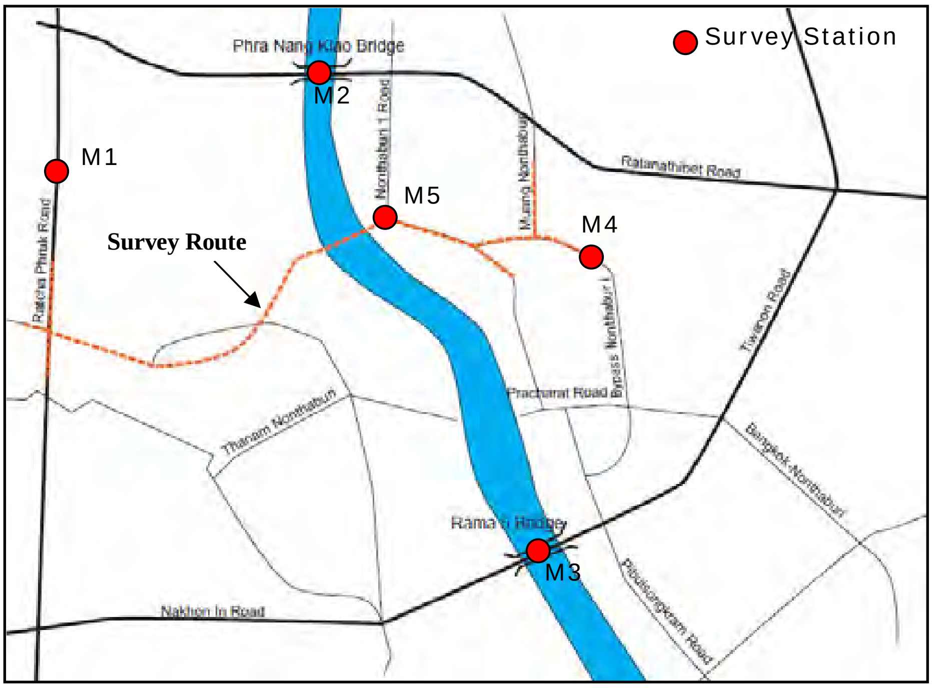
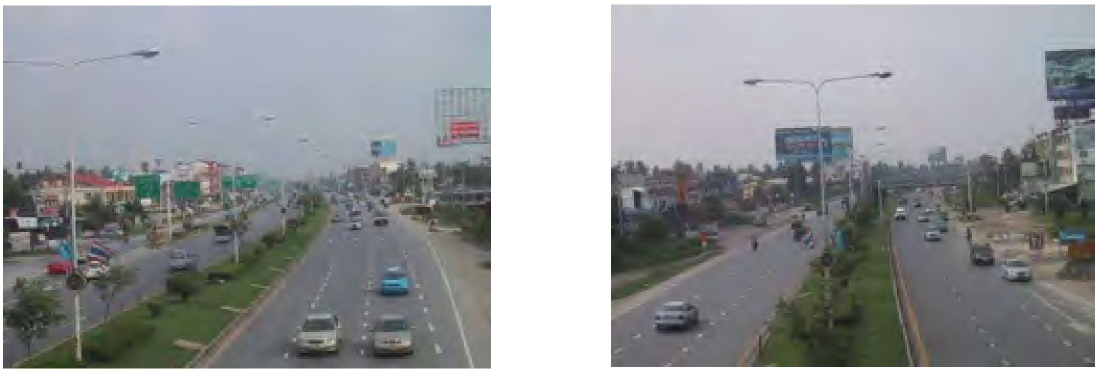
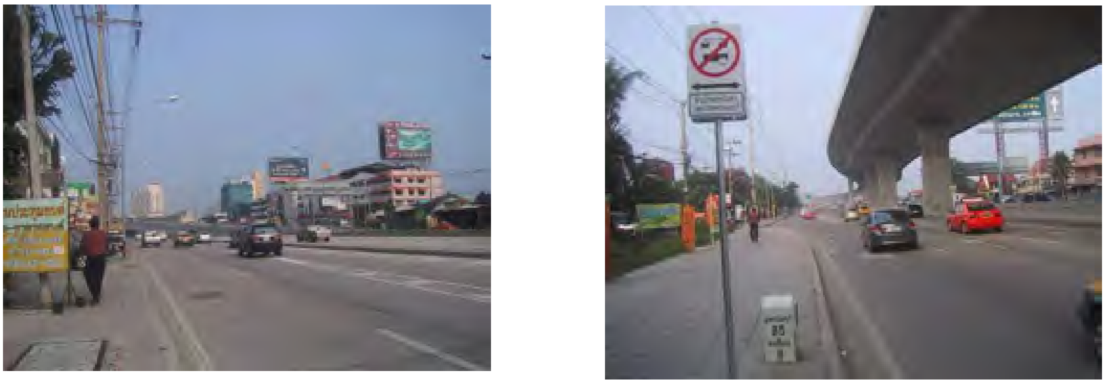


Figure 2.3.5 Location Map of Survey Stations



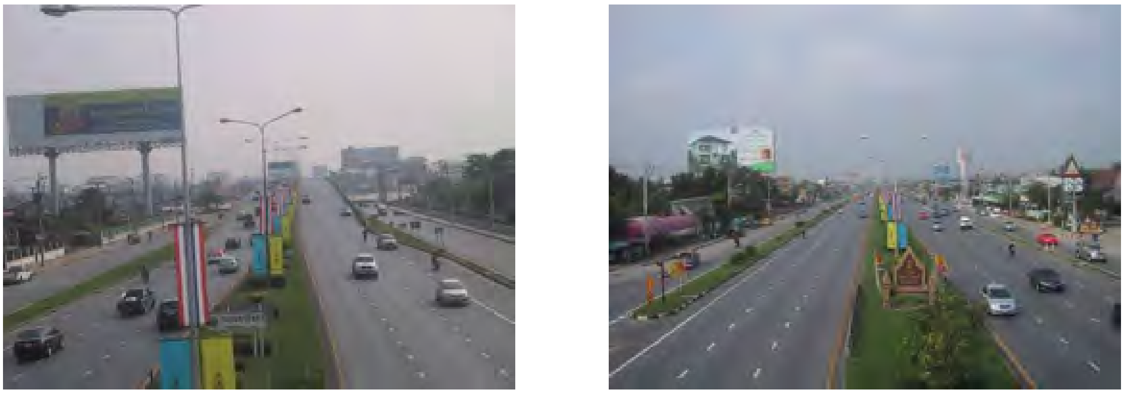
M1: Northbound

M1: Southbound



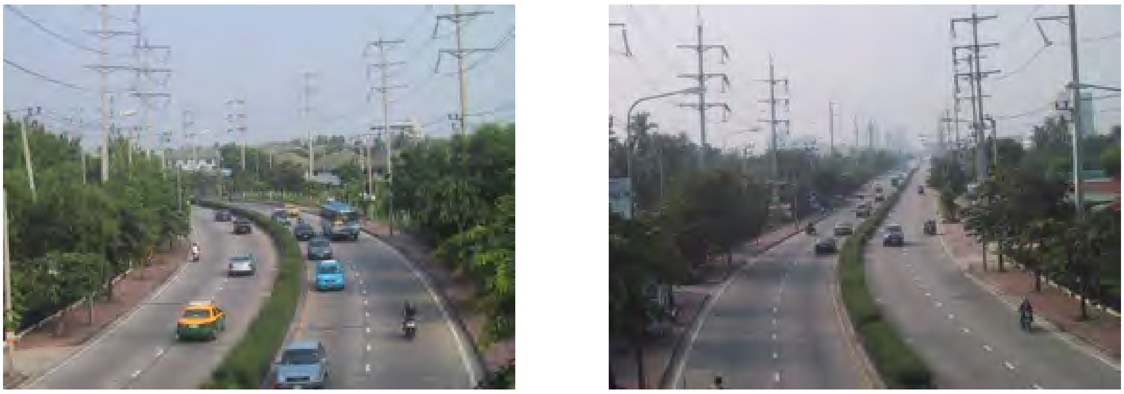
M2: Westbound(1)

M2: Westbound(2)



M3: Eastbound

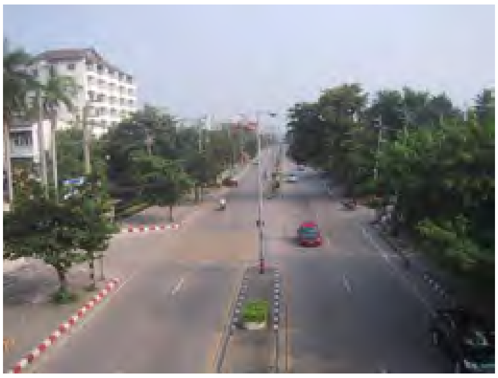
M3: Westbound



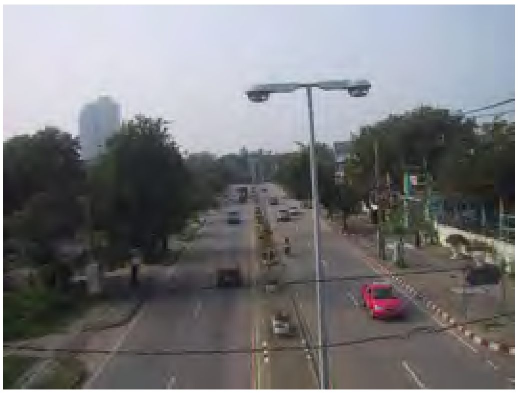
M4: Northbound

M4: Southbound

Figure 2.3.6 Traffic Condition at Survey Stations (1/2)



M5: Northbound



M5: Southbound

Figure 2.3.7 Traffic Condition at Survey Stations (2/2)

2) Survey Result

The weather was clear on the survey date, and there was not any road section restricted to passage due to road construction and/or flooding.

Vehicle numbers are accumulated every 15 minutes, and tabulated for each direction and vehicle type, as shown in Table 2.3.5 to Table 2.3.9. The total hourly traffic volumes are estimated by applying the PCU conversion factor as shown in Table 2.3.4.

Table 2.3.4 PCU Convert Factors

Vehicle Type	PCU Conversion Factors	Vehicle Type	PCU Conversion Factors
Motorcycle	0.25	Medium Bus, Heavy Bus	2.00
Car	1.00	Light Truck	1.00
Pickup	1.00	Medium Truck	2.00
Light Bus	1.00	Heavy Truck	2.50

The composition of the major vehicle type in the counted traffic volume are; Motorcycle (12%-33%), Sedan/Taxi/Jeep (55%-74%), and Pickup (10%-29%). Peak hour mostly occurred in the morning and evening peak time.

Table 2.3.5 Directional Hourly Traffic Volume by Vehicle Type (M1: Ratcha Phruk Road)

Location M1: Ratchapreuk Rd. Direction Northbound

Time	Tuk Tuk	Motocycle	Sedan/Taxi Jeep	Small Bus	Large Bus	Pick Up	Small Truck	Middle Truck (2 axle)	Large Truck (≧ 3 axle)	PCU
06:00 － 07:00	2	350	1,715	73	3	479	2	0	0	2,363
07:00 － 08:00	1	374	1,779	87	6	672	17	2	1	2,667
08:00 － 09:00	3	370	1,736	81	12	929	15	5	10	2,913
09:00 － 10:00	4	285	1,364	80	0	942	29	33	10	2,578
Total	10	1,379	6,594	321	21	3,022	63	40	21	10,522
16:00 － 17:00	3	412	2,273	62	3	900	16	13	3	3,394
17:00 － 18:00	3	580	2,426	75	4	961	13	9	2	3,652
18:00 － 19:00	1	575	2,601	58	8	642	3	2	5	3,481
19:00 － 20:00	1	373	1,756	58	6	487	0	4	19	2,462
Total	8	1,940	9,056	253	21	2,990	32	28	29	12,989

Location M1: Ratchapreuk Rd. Direction Southbound

Time	Tuk Tuk	Motocycle	Sedan/Taxi Jeep	Small Bus	Large Bus	Pick Up	Small Truck	Middle Truck (2 axle)	Large Truck (≧ 3 axle)	PCU
06:00 － 07:00	3	1,012	2,524	9	2	841	21	26	1	3,707
07:00 － 08:00	1	894	2,329	10	6	878	24	24	6	3,540
08:00 － 09:00	4	524	1,776	14	2	1,007	44	26	15	3,067
09:00 － 10:00	10	329	1,435	47	1	811	154	54	38	2,737
Total	18	2,759	8,064	80	11	3,537	243	130	60	13,050
16:00 － 17:00	2	305	1,778	96	2	810	69	21	13	2,908
17:00 － 18:00	3	331	1,629	68	4	771	29	12	8	2,633
18:00 － 19:00	3	295	1,465	56	2	805	26	12	14	2,490
19:00 － 20:00	4	220	1,130	31	0	487	13	32	10	1,806
Total	12	1,151	6,002	251	8	2,873	137	77	45	9,836

Table 2.3.6 Directional Hourly Traffic Volume by Vehicle Type (M2: Rattanathibet (Pranang Klao Bridge))

Location M2-1: New Pranangklao Bridge Direction Eastbound

Time	Tuk Tuk	Motocycle	Sedan/Taxi Jeep	Small Bus	Large Bus	Pick Up	Small Truck	Middle Truck (2 axle)	Large Truck (≧ 3 axle)	PCU
06:00 – 07:00	0	162	824	81	2	89	1	0	1	1,042
07:00 – 08:00	0	756	1,275	71	3	125	3	1	0	1,671
08:00 – 09:00	0	629	1,130	80	2	175	3	0	0	1,549
09:00 – 10:00	0	469	782	76	2	155	15	6	0	1,161
Total	0	2,016	4,011	308	9	544	22	7	1	5,424
16:00 – 17:00	0	283	587	85	5	208	15	4	0	984
17:00 – 18:00	0	290	1,151	122	4	253	14	1	0	1,623
18:00 – 19:00	0	198	1,257	67	12	281	6	1	0	1,687
19:00 – 20:00	0	139	1,016	102	3	220	6	8	0	1,401
Total	0	910	4,011	376	24	962	41	14	0	5,694

Location M2-1: New Pranangklao Bridge Direction Westbound

Time	Tuk Tuk	Motocycle	Sedan/Taxi Jeep	Small Bus	Large Bus	Pick Up	Small Truck	Middle Truck (2 axle)	Large Truck (≧ 3 axle)	PCU
06:00 – 07:00	0	63	559	21	1	80	1	4	0	687
07:00 – 08:00	1	156	649	73	1	188	5	1	0	958
08:00 – 09:00	0	120	629	57	2	279	5	3	0	1,010
09:00 – 10:00	0	96	579	51	3	324	5	18	0	1,025
Total	1	435	2,416	202	7	871	16	26	0	3,680
16:00 – 17:00	0	158	878	40	1	257	4	5	0	1,231
17:00 – 18:00	0	333	1,657	90	7	403	9	3	1	2,265
18:00 – 19:00	1	187	1,499	79	3	301	5	3	0	1,943
19:00 – 20:00	1	166	1,346	86	0	274	6	5	1	1,766
Total	2	844	5,380	295	11	1,235	24	16	2	7,205

Location M2-2: Old Pranangklao Bridge Direction Eastbound

Time	Tuk Tuk	Motocycle	Sedan/Taxi Jeep	Small Bus	Large Bus	Pick Up	Small Truck	Middle Truck (2 axle)	Large Truck (≧ 3 axle)	PCU
06:00 – 07:00	2	702	1,094	216	48	283	16	0	4	1,891
07:00 – 08:00	10	795	1,257	211	63	371	10	2	0	2,180
08:00 – 09:00	7	778	1,395	183	50	451	18	5	5	2,366
09:00 – 10:00	8	354	863	127	50	335	21	16	25	1,631
Total	27	2,629	4,609	737	211	1,440	65	23	34	8,068
16:00 – 17:00	5	399	752	103	48	324	8	4	3	1,400
17:00 – 18:00	4	484	1,016	133	48	382	9	5	18	1,813
18:00 – 19:00	10	538	1,191	135	36	276	3	2	22	1,873
19:00 – 20:00	11	330	874	97	27	202	3	3	14	1,356
Total	30	1,751	3,833	468	159	1,184	23	14	57	6,442

Location M2-2: Old Pranangklao Bridge Direction Westbound

Time	Tuk Tuk	Motocycle	Sedan/Taxi Jeep	Small Bus	Large Bus	Pick Up	Small Truck	Middle Truck (2 axle)	Large Truck (≧ 3 axle)	PCU
06:00 – 07:00	0	327	699	88	49	168	1	0	0	1,136
07:00 – 08:00	1	258	549	133	44	234	5	4	1	1,084
08:00 – 09:00	0	227	496	116	33	146	0	2	3	892
09:00 – 10:00	0	163	427	103	68	209	5	12	8	965
Total	1	975	2,171	440	194	757	11	18	12	4,077
16:00 – 17:00	0	221	703	115	65	255	1	3	0	1,265
17:00 – 18:00	0	348	979	134	60	369	3	16	1	1,727
18:00 – 19:00	1	429	967	100	51	198	0	4	6	1,498
19:00 – 20:00	0	336	613	56	28	128	2	7	7	971
Total	1	1,334	3,262	405	204	950	6	30	14	5,460

Table 2.3.7 Directional Hourly Traffic Volume by Vehicle Type (M3: Rama V Bridge)

Location M3: Rama V Bridge Direction Eastbound

Time	Tuk Tuk	Motocycle	Sedan/Taxi Jeep	Small Bus	Large Bus	Pick Up	Small Truck	Middle Truck (2 axle)	Large Truck (≧ 3 axle)	PCU
06:00 – 07:00	3	186	956	19	3	337	1	0	0	1,366
07:00 – 08:00	9	1,313	3,075	16	9	914	17	5	0	4,381
08:00 – 09:00	19	1,064	2,221	13	5	1,041	30	9	5	3,616
09:00 – 10:00	18	555	1,454	13	8	1,038	141	29	7	2,881
Total	49	3,118	7,706	61	25	3,330	189	43	12	12,244
16:00 – 17:00	5	506	1,524	20	6	847	46	5	1	2,589
17:00 – 18:00	8	804	1,835	21	11	998	28	10	2	3,132
18:00 – 19:00	6	599	1,522	9	9	770	25	2	0	2,499
19:00 – 20:00	6	432	1,097	13	7	548	18	3	4	1,816
Total	25	2,341	5,978	63	33	3,163	117	20	7	10,036

Location M3: Rama V Bridge Direction Westbound

Time	Tuk Tuk	Motocycle	Sedan/Taxi Jeep	Small Bus	Large Bus	Pick Up	Small Truck	Middle Truck (2 axle)	Large Truck (≧ 3 axle)	PCU
06:00 – 07:00	53	175	538	24	2	143	1	0	1	770
07:00 – 08:00	32	517	1,020	62	15	271	15	11	1	1,560
08:00 – 09:00	15	525	987	75	4	330	31	15	0	1,596
09:00 – 10:00	14	343	811	137	0	361	87	33	0	1,551
Total	114	1,560	3,356	298	21	1,105	134	59	2	5,477
16:00 – 17:00	11	610	1,919	86	26	405	56	0	0	2,673
17:00 – 18:00	8	652	2,685	154	55	233	31	0	0	3,378
18:00 – 19:00	8	627	2,605	132	54	160	13	0	0	3,177
19:00 – 20:00	7	553	2,735	95	15	173	14	0	0	3,187
Total	34	2,442	9,944	467	150	971	114	0	0	12,415

Table 2.3.8 Directional Hourly Traffic Volume by Vehicle Type (M4: Bypass Nonthaburi)

Location M4:Nontaburi Rd. Direction Northbound

Time	Tuk Tuk	Motocycle	Sedan/Taxi Jeep	Small Bus	Large Bus	Pick Up	Small Truck	Middle Truck (2 axle)	Large Truck (≧ 3 axle)	PCU
06:00 － 07:00	30	388	637	14	31	141	0	0	0	959
07:00 － 08:00	61	510	1,264	59	30	177	0	0	0	1,703
08:00 － 09:00	53	677	1,272	50	35	244	0	0	0	1,819
09:00 － 10:00	39	388	746	59	26	266	0	0	7	1,247
Total	183	1,963	3,919	182	122	828	0	0	7	5,727
16:00 － 17:00	59	360	828	43	15	168	0	0	0	1,174
17:00 － 18:00	32	572	920	40	12	159	0	0	2	1,299
18:00 － 19:00	27	445	909	38	7	304	0	0	0	1,383
19:00 － 20:00	23	369	770	36	4	237	0	0	7	1,167
Total	141	1,746	3,427	157	38	868	0	0	9	5,022

Location M4:Nontaburi Rd. Direction Southbound

Time	Tuk Tuk	Motocycle	Sedan/Taxi Jeep	Small Bus	Large Bus	Pick Up	Small Truck	Middle Truck (2 axle)	Large Truck (≧ 3 axle)	PCU
06:00 － 07:00	5	70	654	48	50	65	2	14	0	916
07:00 － 08:00	24	200	995	45	50	189	1	8	0	1,402
08:00 － 09:00	20	268	948	51	46	172	3	10	0	1,358
09:00 － 10:00	11	189	424	41	45	257	8	23	0	916
Total	60	727	3,021	185	191	683	14	55	0	4,592
16:00 － 17:00	18	251	831	30	35	213	6	17	0	1,251
17:00 － 18:00	8	390	920	32	32	167	40	6	1	1,337
18:00 － 19:00	9	377	1,055	21	40	199	0	1	0	1,454
19:00 － 20:00	10	344	1,008	24	48	240	0	4	1	1,467
Total	45	1,362	3,814	107	155	819	46	28	2	5,509

Table 2.3.9 Directional Hourly Traffic Volume by Vehicle Type (M5: Nonthaburi 1)

Location M5:Nonthaburu 1Rd. Direction Northbound

Time	Tuk Tuk	Motocycle	Sedan/Taxi Jeep	Small Bus	Large Bus	Pick Up	Small Truck	Middle Truck (2 axle)	Large Truck (≧ 3 axle)	PCU
06:00 － 07:00	51	211	297	119	10	92	1	4	3	610
07:00 － 08:00	40	205	282	130	14	71	2	2	1	581
08:00 － 09:00	45	254	402	82	20	104	5	3	0	714
09:00 － 10:00	58	166	363	76	16	125	4	7	2	675
Total	194	836	1,344	407	60	392	12	16	6	2,580
16:00 － 17:00	54	194	404	104	16	123	2	2	3	739
17:00 － 18:00	29	188	477	85	11	78	3	4	2	732
18:00 － 19:00	48	250	511	95	13	138	3	1	0	850
19:00 － 20:00	36	248	371	61	13	194	0	0	1	726
Total	167	880	1,763	345	53	533	8	7	6	3,046

Location M5:Nonthaburu 1Rd. Direction Southbound

Time	Tuk Tuk	Motocycle	Sedan/Taxi Jeep	Small Bus	Large Bus	Pick Up	Small Truck	Middle Truck (2 axle)	Large Truck (≧ 3 axle)	PCU
06:00 － 07:00	88	260	579	148	18	76	0	2	0	930
07:00 － 08:00	63	297	542	175	17	74	0	1	0	917
08:00 － 09:00	54	283	520	155	17	86	0	2	0	883
09:00 － 10:00	33	153	349	80	8	63	2	12	0	581
Total	238	993	1,990	558	60	299	2	17	0	3,311
16:00 － 17:00	55	159	308	96	9	50	1	0	0	527
17:00 － 18:00	45	235	348	109	9	70	3	1	0	620
18:00 － 19:00	54	258	351	86	5	61	0	1	0	588
19:00 － 20:00	24	169	262	52	4	42	1	1	0	415
Total	178	821	1,269	343	27	223	5	3	0	2,150

3) Traffic Volume Comparison with F/S

Table 2.3.10 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 2.3.10 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
	Southboun	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
	Southboun	1,703		1,402		0.82	
M5:Nonthaburi 1	Northbound	1,107	1,686	581	1,498	0.52	0.89
	Southboun	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 2.3.11 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

(3) Travel Speed Survey

1) Survey Method

Travel speed survey was conducted to measure the average travel speed on roads near the project by “Floating Car Method”. The mechanics of the method is that the survey vehicle shall be driven at the same speed with the surrounding traffic flow and the vehicle shall not overtake the other car.

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 Table 2.3.12 and Figure 2.3.8.

Table 2.3.12 Survey Routes and Travel Routes

Survey Routes	Travel Routes
Ratcha Phruk Road	A-I-H
Rattanathibet (Pranang Klao Bridge)	A-B-C-D
Nakhon-In Road (Rama V Bridge)	E-F-G-H
Bypass Nonthaburi	K-L-M-N
Nonthaburi 1	B-K-J

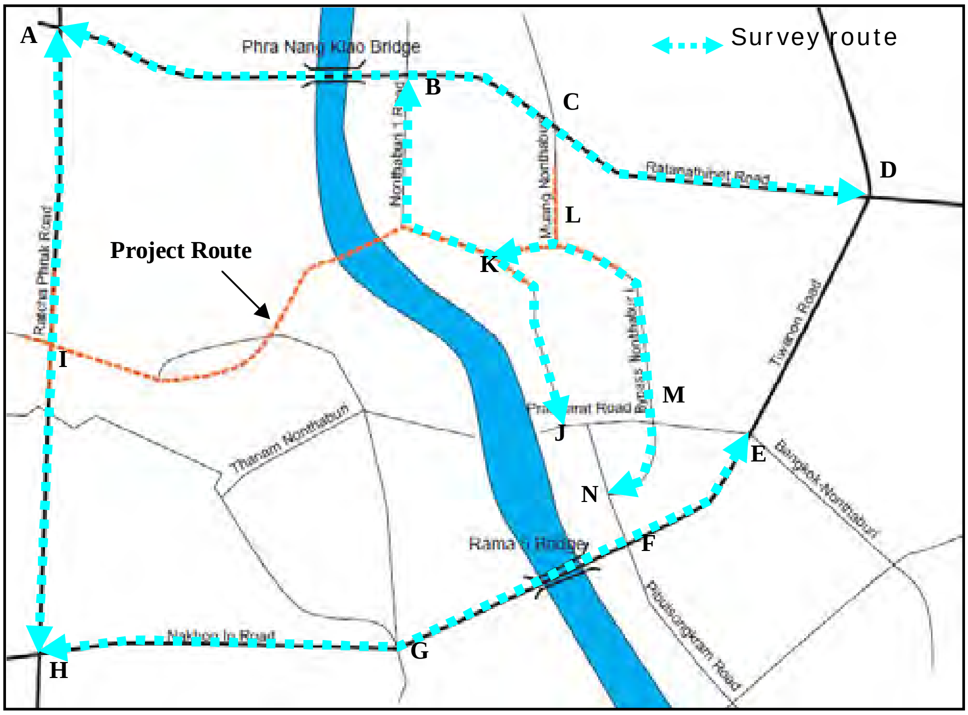


Figure 2.3.8 Location Map of Survey Routes

2) Survey Results

Table 2.3.13 shows the results of the survey.

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 2.3.10. Average travel speeds are higher than the one in the city center.

Table 2.3.13 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

Table 2.3.14 Results of Travel Speed Survey (Ratcha Phruk Road)

Ratcha phruk Road AM Peak Hour

CW

Station	KM.	Hour	Min	Second	km./hr.
A	0	7	10	19	
brigde canal	2.0	7	12	23	58.06
Junction	3.2	7	13	52	48.54
Junction (I)	4.1	7	15	37	30.86
brigde canal	5.2	7	17	45	30.94
stop (Red Signal)	5.3	7	18	19	10.59
start (Green Signal)	5.3	7	18	45	-
H	5.7	7	19	11	55.38
All Range	**5.7**	**0**	**8**	**52**	**38.57**

CCW

Station	KM.	Hour	Min	Second	km./hr.
H	0	7	21	21	
brigde canal	0.5	7	22	23	29.03
Junction (I)	1.8	7	23	26	74.29
Junction	2.6	7	24	3	77.84
brigde canal	3.7	7	25	0	69.47
A	5.7	7	26	28	81.82
All Range	**5.7**	**0**	**5**	**7**	**66.84**

Ratcha phruk Road PM Peak Hour

CW

Station	KM.	Hour	Min	Second	km./hr.
A	0	18	1	27	
brigde canal	2.2	18	2	59	86.09
Junction	3.4	18	4	2	68.57
Junction (I)	4.2	18	4	46	65.45
stop (Red Signal)	4.7	18	5	31	40.00
start (Green Signal)	4.7	18	6	10	-
brigde canal	5.2	18	7	12	29.03
stop (Red Signal)	5.4	18	8	22	10.29
start (Green Signal)	5.4	18	9	9	-
H	5.7	18	13	11	4.46
All Range	**5.7**	**0**	**11**	**44**	**29.15**

CCW

Station	KM.	Hour	Min	Second	km./hr.
					Km/Hr
H	0	18	16	20	
brigde canal	0.5	18	17	31	25.35
Junction (I)	1.8	18	18	24	88.30
Junction	2.6	18	18	54	96.00
brigde canal	3.7	18	19	52	68.28
A	5.7	18	22	4	54.55
All Range	**5.7**	**0**	**5**	**44**	**59.65**

Table 2.3.15 Results of Travel Speed Survey (Rattanathibet (Pranang Klao Bridge)

Rattanathibate Road AM Peak Hour

CW

Station	KM.	Hour	Min	Second	km./hr.
A	0	8	2	10	
Upward brigde	2.2	8	3	46	82.50
B	3.8	8	5	46	48.00
downward Brigde	4.2	8	6	45	24.41
C	4.6	8	7	31	31.30
Front Hotel	6.3	8	10	44	31.71
D	7.8	8	19	34	10.19
All range	**7.8**	**0**	**17**	**24**	**26.90**

CCW

Station	KM.	Hour	Min	Second	km./hr.
D	0	8	33	18	
Front Hotel	1.3	8	34	16	80.69
C	2.9	8	35	18	92.90
Upward brigde	3.9	8	36	27	52.17
B	4.3	8	37	4	38.92
downward Brigde	5.0	8	37	57	47.55
A	7.8	8	40	12	74.67
All range	7.8	0	6	54	**67.83**

Rattanathibate Road PM Peak Hour

CW

Station	KM.	Hour	Min	Second	km./hr.
A	0	18	22	52	
Upward brigde	2.2	18	25	17	54.62
B	3.8	18	26	23	87.27
downward Brigde	4.2	18	26	46	62.61
C	4.6	18	27	34	30.00
Front Hotel	6.3	18	32	32	20.54
D	7.8	18	40	48	10.89
All Range	**7.8**	**0**	**17**	**56**	**26.10**

CCW

Station	KM.	Hour	Min	Second	km./hr.
D	0	18	40	1	
Front Hotel	1.3	18	41	40	47.27
C	2.9	18	43	3	69.40
Upward brigde	3.9	18	43	53	72.00
B	4.3	18	44	12	75.79
downward Brigde	5.0	18	45	15	40.00
A	7.8	18	47	4	92.48
All Range	7.8	0	7	3	**66.38**

Table 2.3.16 Results of Travel Speed Survey (Nakhon-In Road (Rama V Bridge)

Nakhon-In Road AM Peak Hour

CW

Station	KM.	Hour	Min	Second	km./hr.
H	0	9	43	18	
Bangkoknoi Canal	2.1	9	45	33	56.00
G	3.3	9	46	18	96.00
Up	4.9	9	47	27	83.48
Ramp	5.6	9	48	9	60.00
F	6.3	9	48	47	66.32
Down	6.4	9	49	19	11.25
E	7.4	9	50	48	40.45
All Range	7.4	0	7	30	**59.20**

CCW

Station	KM.	Hour	Min	Second	km./hr.
E	0	9	32	36	
Up	0.8	9	33	32	51.43
F	1.5	9	34	51	31.90
Ramp	1.8	9	35	16	43.20
Down	2.4	9	35	46	72.00
G	4	9	36	46	96.00
Bangkoknoi Canal	5.2	9	37	32	93.91
H	7.4	9	38	47	105.60
All Range	**7.4**	**0**	**6**	**11**	**71.81**

Nakhon-In Road PM Peak Hour

CW

Station	KM.	Hour	Min	Second	km./hr.
H	0	19	12	23	
Bangkoknoi Canal	2.1	19	14	33	58.15
G	3.3	19	15	40	64.48
Up	4.9	19	16	51	81.13
Ramp	5.6	19	17	32	61.46
F	6.3	19	18	4	78.75
Down	6.4	19	18	32	12.86
E	7.4	19	19	34	58.06
All Range	7.4	0	7	11	**61.81**

CCW

Station	KM.	Hour	Min	Second	km./hr.
E	0	19	19	49	
Up	1.4	19	20	53	78.75
F	1.5	19	21	10	21.18
Ramp	1.8	19	21	40	36.00
Down	2.4	19	22	19	55.38
G	4	19	23	44	67.76
Bangkoknoi Canal	5.2	19	24	40	77.14
H	7.4	19	26	3	95.42
All Range	**7.4**	**0**	**6**	**14**	**71.23**

Table 2.3.17 Results of Travel Speed Survey (Bypass Nonthaburi Road)

BYPASS NONTHABURI Road AM Peak Hour

CW

Station	KM.	Hour	Min	Second	km./hr.
K	0	6	10	19	
stop (Red Signal)	0.8	6	11	17	49.66
start (Green Signal)	0.8	6	11	34	-
L	1.6	6	12	27	54.34
M	2.6	6	14	29	29.51
N	3.1	6	15	14	40.00
All range	**3.1**	**0**	**5**	**-5**	**37.83**

CCW

Station	KM.	Hour	Min	Second	km./hr.
N	0	6	20	10	
M	0.7	6	21	11	41.31
L	2.5	6	24	32	32.24
K	3.1	6	27	33	11.93
All range	3.1	0	7	23	**25.19**

BYPASS NONTHABURI Road PM Peak Hour

CW

Station	KM.	Hour	Min	Second	km./hr.
					Km/Hr
K	0	17	31	34	
stop (Red Signal)	0.3	17	32	35	17.70
start (Green Signal)	0.3	17	33	45	-
L	1.6	17	34	52	69.85
M	2.6	17	36	41	33.03
N	3.1	17	37	24	41.86
All Range	**3.1**	**0**	**5**	**50**	**31.89**

CCW

Station	KM.	Hour	Min	Second	km./hr.
					Km/Hr
N	0	17	38	57	
M	0.7	17	39	52	45.82
stop (Red Signal)	1.3	17	42	23	14.30
start (Green Signal)	1.3	17	43	1	-
L	2.5	17	46	3	23.74
K	3.1	17	48	32	14.50
All Range	3.1	0	9	35	**19.41**

Table 2.3.18 Results of Travel Speed Survey (Nonthaburi 1 Road)

NONTHABURI Road AM Peak Hour

CW

Station	KM.	Hour	Min	Second	km./hr.
B	0	7	38	11	
Nangklao Hospital	0.6	7	39	40	24.27
M5	1.6	7	40	45	55.38
K	2.3	7	41	34	51.43
J	4.3	7	47	29	20.28
All range	**4.3**	**0**	**9**	**18**	**27.74**

CCW

Station	KM.	Hour	Min	Second	km./hr.
J	0	7	48	11	
K	1.3	7	49	36	55.06
M5	2	7	50	7	81.29
Nangklao Hospital	3.9	7	51	19	95.00
B	4.3	7	52	23	22.50
All range	4.3	0	4	12	**61.43**

NONTHABURI Road PM Peak Hour

CW

Station	KM.	Hour	Min	Second	km./hr.
B	0	17	0	13	
Nangklao Hospital	0.6	17	1	34	26.67
M5	1.6	17	2	41	53.73
K	2.3	17	3	31	50.40
J	5.2	17	7	37	42.44
All Range	**5.2**	**0**	**7**	**24**	**42.16**

CCW

Station	KM.	Hour	Min	Second	km./hr.
J	0	18	40	1	
K	1.3	18	41	38	48.25
M5	2.1	18	42	11	87.27
Nangklao Hospital	3.9	18	43	53	63.53
B	4.3	18	44	12	75.79
All Range	4.3	0	4	11	**60.52**

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

The gross regional domestic product (GRDP) in BMA accounts for about 43% of the country's GRDP and Bangkok Metropolitan Area has played its role in the economic activities in Thailand. Moreover, Thailand has spurred the development in surrounding countries as an economic center in the region, and plays the role to establish the presence of the Southeast Asian economic bloc in the world economy.

Therefore, the continuous economic development in BMA is indispensable, and the bridge development on Chao Phraya River has contributed to the expansion of social and economical activities. This project development will also support the streamlining and upgrading of the economic activities in BMA, which is essential to the economic growth.

Previously, the contribution of the past 20 bridge developments in Chao Phraya River, including those funded by Japanese assistance, is confirmed based on clarification results of quantitative and qualitative effect of the bridge development in the past.

2.4.1 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.

As seen in Figure 2.4.1, Bangkok in 1900 was an urban agglomeration on one side of the Chao Phraya River, with a population of 600,000. When the first bridge over the Chao Phraya, Rama VI Bridge, a railway bridge, was built in 1926, and then Memorial Bridge in 1932, these marked the start of the expansion of the urban area to the western bank of the river.

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											■	■

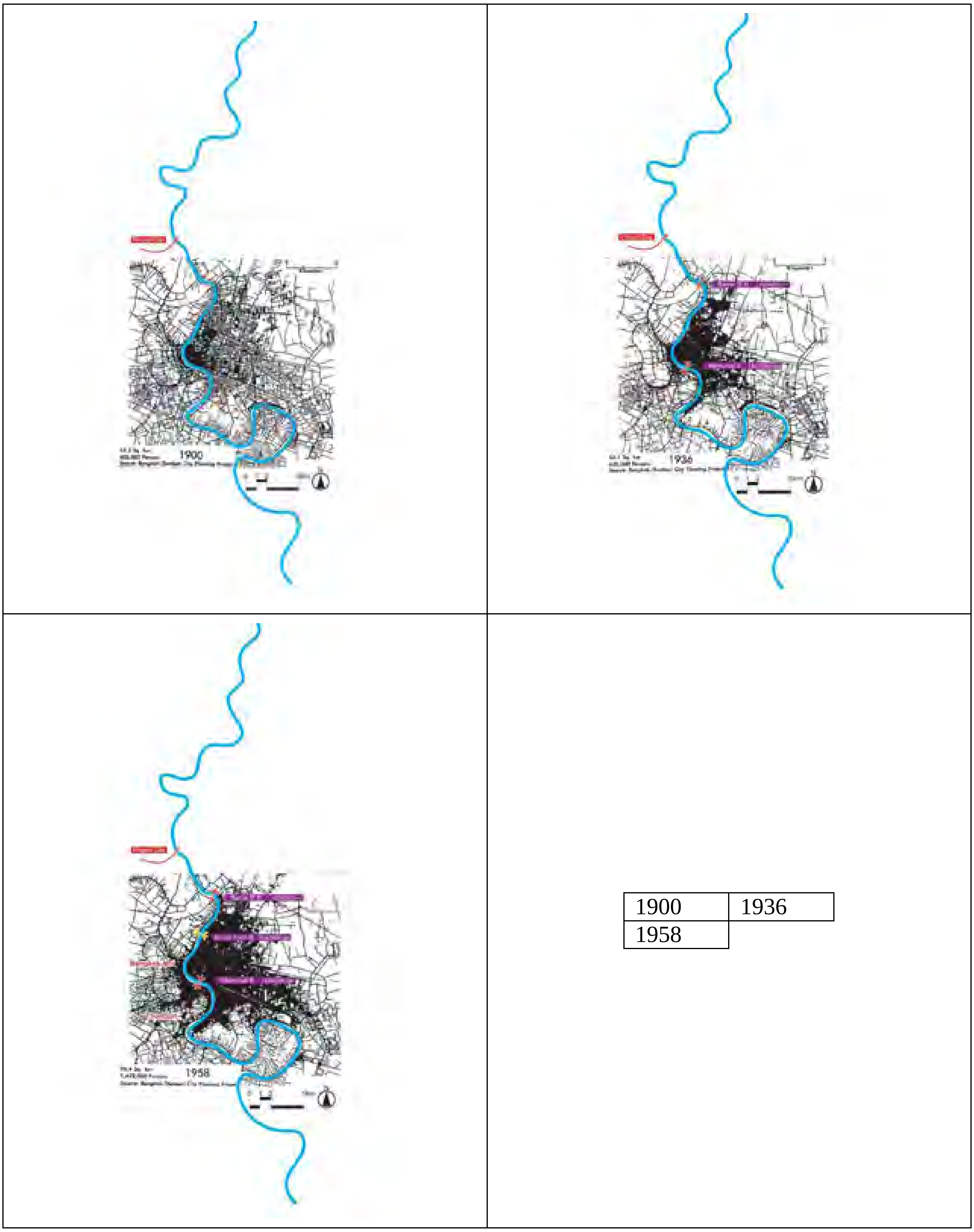
As discussed earlier, the urban area of Bangkok in 1900 was limited to the east bank of the Chao Phraya River. The construction of Memorial Bridge in 1932 has brought new urbanization to the west bank area, which is generally observed in the development of new residential settlements in Thonburi and 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.

Figure 2.4.3 depicts the urbanization condition of Bangkok in 2004. 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.

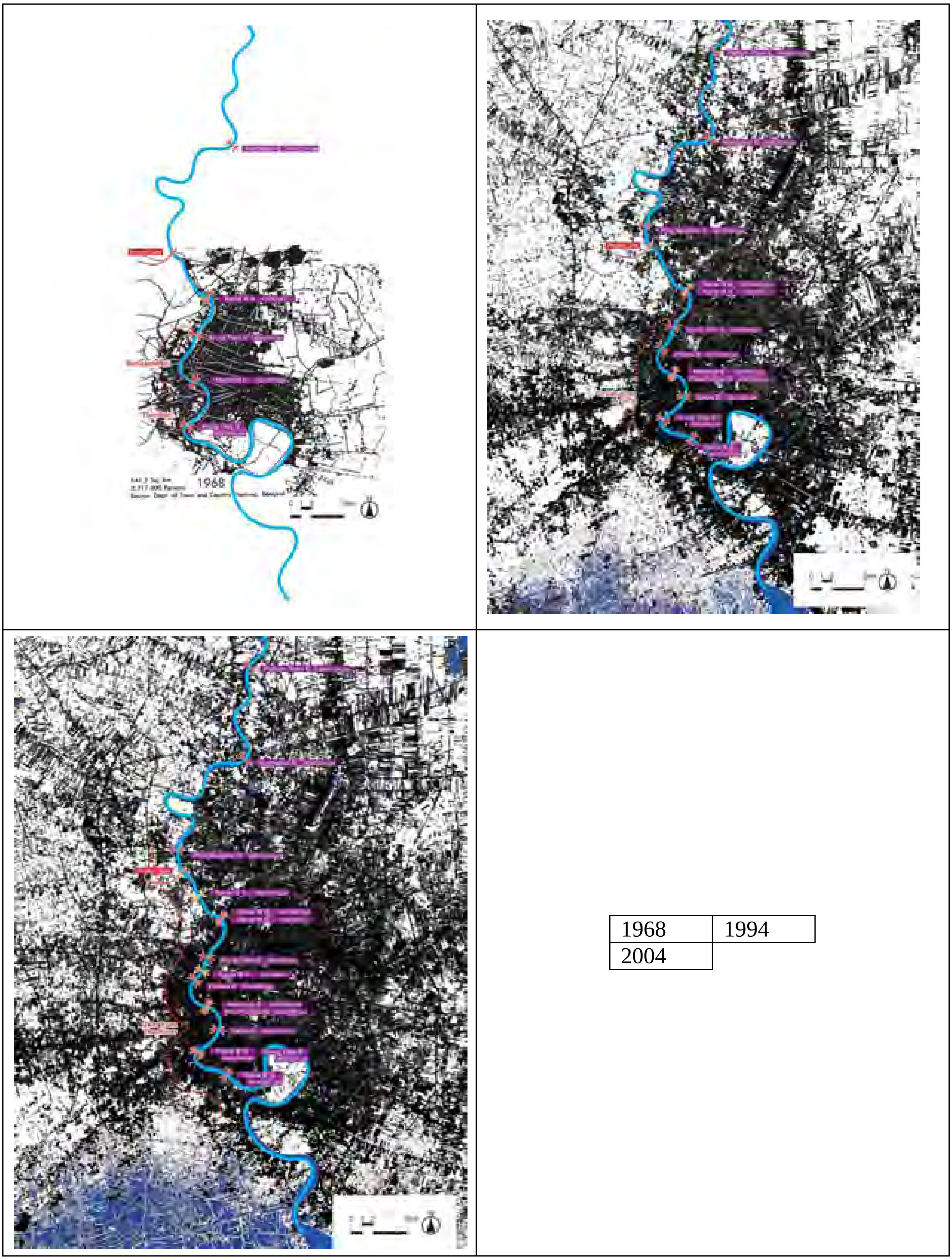
In regards to Nonthaburi Province, the interval between Rama V Bridge and the next bridge upstream, Phra Nangklao Bridge, is about five km. This is one of the reasons why urbanization does not reach beyond the river. If and when the Project is built, the interval between Rama V Bridge, the Project bridge 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.



1900	1936
1958	

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



1968	1994
2004	

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

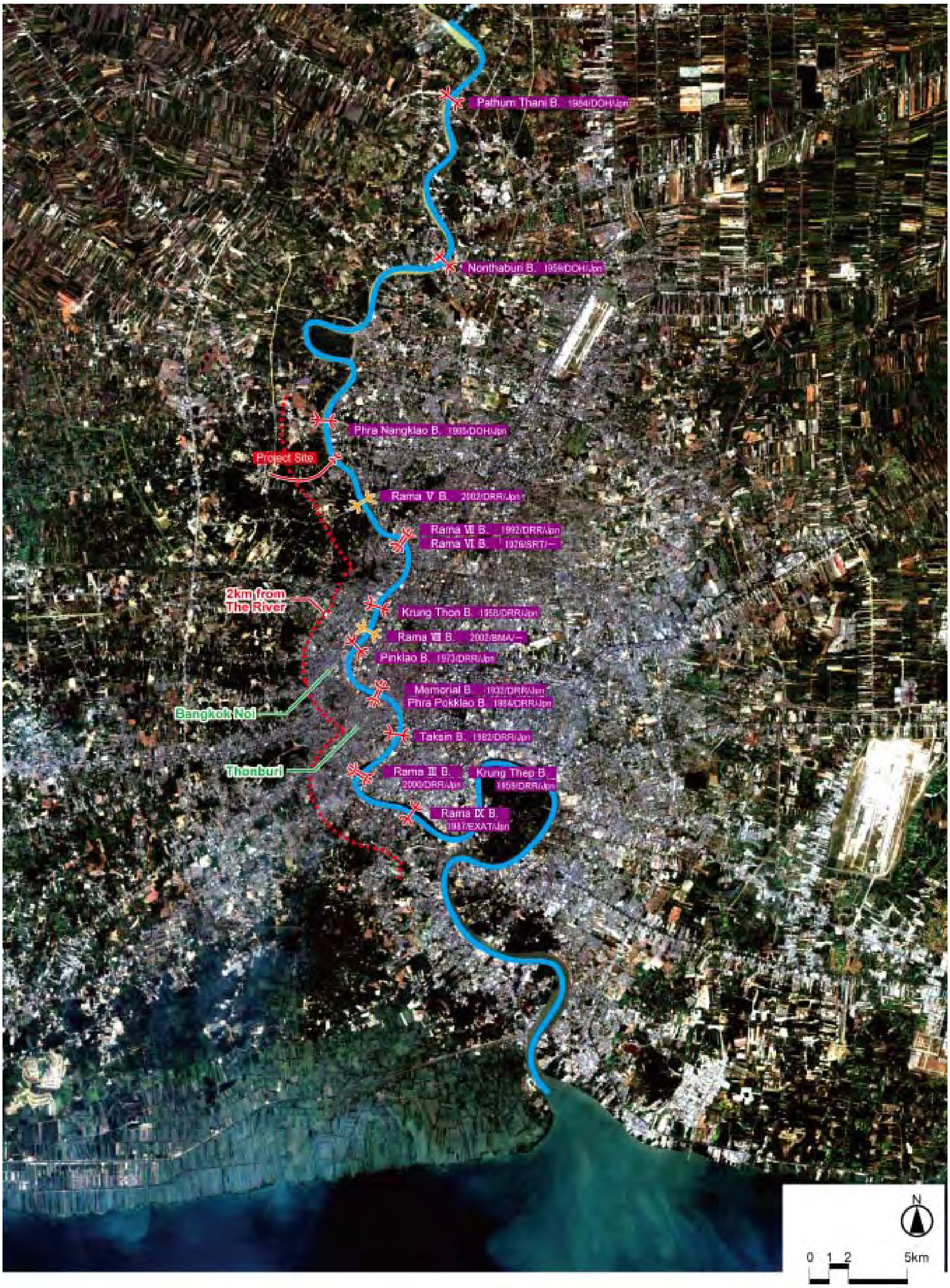


Figure 2.4.3 Urban Area of BMA in 2004 Based on Landsat Data

2.4.2 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.

Transition of traffic volume and 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 Traffic Volume

Since there is no continuous and uniform traffic data of the 20 bridges crossing the Chao Phraya River in the past due to the different bridge administrators as shown in Table 2.4.2 and 2.4.3, collected traffic data in this survey was corrected to compare with each other. The correction for the traffic data was made based on the following assumption to compare the traffic volume uniformly:

- Morning Peak Hour Traffic Ratio: 0.06
- Proportion between PCU traffic volume and actual traffic volume: 1.2/1.0

Corrected traffic volume of each bridge is tabulated in Table 2.4.4 to Table 2.4.6.

Traffic volume after bridge operation on most of the bridges shows upward trend until close to the saturation capacity. However, the traffic volume on each bridge became stable or decreased in these years because new bridge developments have eased traffic flow. While the average growth rate of traffic volume on each bridge is 1.2% per year as shown in Table 2.4.6, the growth rate is still lower than the 3.5% per year of vehicle registration growth rate in BMA for years 2000 to 2007.

Table 2.4.2 Sources of Traffic Data used in the Survey (1/2)

Sl No.	Bridge Name	Data Details		Survey Date	Source, Executing Agency
1	Pathum Thani	AADT, Vehicle/day			Average Annual Daily Traffic on Highway 2007, Bureau of Highway Safety, DOH
		Morning Peak (pcu/h)	7:00-8:00	2008/7/15(Tue)	TDMLSurvey, OTP, 2008
2	2nd Phatum Thani				
3	Nonthaburi-Pathum Thani	pcu/day	AM Peak	1993	The Feasibility Study and IEE of the Pak Kret Bridge and Connecting Road Construction Project, MOI, 1994
		pcu/day		1990/11/	Feasibility Study for Wat Nakorn-In Bridge Construction Project, MOI, 1991
		Vehicle/day	exc. MC	1981/6/30 (Tue)	Feasibility Study for Rama VI Bridge in the Kingdom of Thailand, JICA, 1981
		Morning Peak (pcu/h)	7:00-8:00	2008/7/15(Tue)	TDML Survey, OTP, 2008
4	Pak Kret(Rama IV)	Vehicle/day	7:00-9:00 16:00-19:00 0:00-24:00	2006/11/21～2007/2/28 2007/11/15～2008/2/28	Traffic Statistic 2007, Beaureu of Traffic and Transport, BMA
		Morning Peak (pcu/h)	7:00-8:00	2008/7/15(Tue)	TDMLSurvey, OTP, 2008
5	New Phra Nangklao				
6	Phra Nangklao	pcu/day	AM Peak	1993	The Feasibility Study and IEE of the Pak Kret Bridge and Connecting Road Construction Project, MOI, 1994
		pcu/day		1990/11/	Feasibility Study for Wat Nakorn-In Bridge Construction Project, MOI, 1991
		Morning Peak (pcu/h)	7:00-8:00	2005/6/14(Tue)	The Detailed Design and Land Acquisition Survey for The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project, DRR, 2005
		Morning Peak (pcu/h)	7:00-8:00	2008/7/15(Tue)	TDMLSurvey, OTP, 2008
7	Wat Nakorn-In (Rama V)	Morning Peak (pcu/h)	7:00-8:00	2005/6/14(Tue)	The Detailed Design and Land Acquisition Survey for The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project, DRR, 2005
		Morning Peak (pcu/h)	7:00-8:00	2008/7/15(Tue)	TDMLSurvey, OTP, 2008
8	Rama VII	Vehicle/day	Year 2000: Daily average during 25Jan-2March and 20June-29June, Year 2002: Daily average during 11June-1August		DOR Traffic Volume Evaluation Project on Chao Phraya River Crossing Bridge, 2543, 2545
		pcu/day	AM Peak	1993	The Feasibility Study and IEE of the Pak Kret Bridge and Connecting Road Construction Project, MOI, 1994
		Vehicle/day	7:00-9:00 16:00-19:00 0:00-24:00	2006/11/21～2007/2/28 2007/11/15～2008/2/28	Traffic Statistic 2007, Beaureu of Traffic and Transport, BMA
		Morning Peak (pcu/h)	7:00-8:00	2005/6/14(Tue)	The Detailed Design and Land Acquisition Survey for The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project, DRR, 2005
		Morning Peak (pcu/h)	7:00-8:00	2008/7/15(Tue)	TDMLSurvey, OTP, 2008
9	Rama VI (Rail Bridge)	Vehicle/day			PWD (Post Evaluation for New Rama VII construction project, 1999.3, JBIC)
		AADT, Vehicle/day			Post Evaluation for Bridges crossing Chao Phraya River and Intra-Urban Expressway projects, Jan 1986, JBIC
		Vehicle/day		1990/11/	Feasibility Study for Wat Nakorn-In Bridge Construction Project, MOI, 1991
10	Krungthon	Vehicle/day	Year 2000: Daily average during 25Jan-2March and 20June-29June, Year 2002: Daily average during 11June-1August		DOR Traffic Volume Evaluation Project on Chao Phraya River Crossing Bridge, 2543, 2545
		Vehicle/day			PWD (Post Evaluation for New Rama VII construction project, 1999.3, JBIC)
		AADT, Vehicle/day			Post Evaluation for Bridges crossing Chao Phraya River and Intra-Urban Expressway projects, Jan 1986, JBIC
		Morning Peak (pcu/h)	7:00-8:00		Ratcha Phruk Road Project Benefit Monitoring and Evaluation Report, 2005
		Vehicle/day		1990/11/	Feasibility Study for Wat Nakorn-In Bridge Construction Project, MOI, 1991
		Vehicle/day	7:00-9:00 16:00-19:00 0:00-24:00	2006/11/21～2007/2/28 2007/11/15～2008/2/28	Traffic Statistic 2007, Beaureu of Traffic and Transport, BMA
		Morning Peak (pcu/h)	7:00-8:00	2008/7/15(Tue)	TDMLsurvey, OTP, 2008
11	Rama VIII	Vehicle/day	7:00-9:00 16:00-19:00 0:00-24:00	2006/11/21～2007/2/28 2007/11/15～2008/2/28	Traffic Statistic 2007, Beaureu of Traffic and Transport, BMA
		Morning Peak (pcu/h)	7:00-8:00	2005/6/14(Tue)	The Detailed Design and Land Acquisition Survey for The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project, DRR, 2005
		Morning Peak (pcu/h)	7:00-8:00	2008/7/15(Tue)	TDML Survey, OTP, 2008

Table 2.4.3 Sources of Traffic Data used in the Survey (2/2)

Sl No.	Bridge Name	Data Details		Survey Date	Source, Executing Agency
12	Phra PinkLao	Vehicle/day	Year 2000: Daily average during 25Jan-2March and 20June-29June, Year 2002: Daily average during 11June-1August		DOR Traffic Volume Evaluation Project on Chao Phraya River Crossing Bridge, 2543, 2545
		Vehicle/day			PWD (Post Evaluation for New Rama VII construction project, 1999.3, JBIC)
		AADT, Vehicle/day			Post Evaluation for Bridges crossing Chao Phraya River and Intra-Urban Expressway projects, Jan 1986, JBIC
		Vehicle/day		1990/11/	Feasibility Study for Wat Nakorn-In Bridge Construction Project, MOI, 1991
		Vehicle/day	7:00-9:00 16:00-19:00 0:00-24:00	2006/11/21～2007/2/28 2007/11/15～2008/2/28	Traffic Statistic 2007, Beaureu of Traffic and Transport, BMA
		Morning Peak (pcu/h)	7:00-8:00	2005/6/14(Tue)	The Detailed Design and Land Acquisition Survey for The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project, DRR, 2005
		Morning Peak (pcu/h)	7:00-8:00	2008/7/15(Tue)	TDML Survey, OTP, 2008
13	Memorial (Phra Phutta Yodf)	Vehicle/day	Year 2000: Daily average during 25Jan-2March and 20June-29June, Year 2002: Daily average during 11June-1August		DOR Traffic Volume Evaluation Project on Chao Phraya River Crossing Bridge, 2543, 2545
		Vehicle/day			PWD (Post Evaluation for New Rama VII construction project, 1999.3, JBIC)
		AADT, Vehicle/day			Post Evaluation for Bridges crossing Chao Phraya River and Intra-Urban Expressway projects, Jan 1986, JBIC
		Vehicle/day		1990/11/Date is NA	Feasibility Study for Wat Nakorn-In Bridge Construction Project, MOI, 1991
		Vehicle/day	7:00-9:00 16:00-19:00 0:00-24:00	2006/11/21～2007/2/28 2007/11/15～2008/2/28	Traffic Statistic 2007, Beaureu of Traffic and Transport, BMA
		Morning Peak (pcu/h)	7:00-8:00	2005/6/14(Tue)	The Detailed Design and Land Acquisition Survey for The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project, DRR, 2005
		Morning Peak (pcu/h)	7:00-8:00	2008/7/15(Tue)	TDMLSurvey, OTP, 2008
14	Phra Pok Klao (New Memorial)	Vehicle/day	Year 2000: Daily average during 25Jan-2March and 20June-29June, Year 2002: Daily average during 11June-1August		DOR Traffic Volume Evaluation Project on Chao Phraya River Crossing Bridge, 2543, 2545
		Vehicle/day			PWD (Post Evaluation for New Rama VII construction project, 1999.3, JBIC)
		Vehicle/day		1990/11/Date is NA	Feasibility Study for Wat Nakorn-In Bridge Construction Project, MOI, 1991
		Vehicle/day	7:00-9:00 16:00-19:00 0:00-24:00	2006/11/21～2007/2/28 2007/11/15～2008/2/28	Traffic Statistic 2007, Beaureu of Traffic and Transport, BMA
		Morning Peak (pcu/h)	7:00-8:00	2005/6/14(Tue)	The Detailed Design and Land Acquisition Survey for The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project, DOR, 2005
		Morning Peak (pcu/h)	7:00-8:00	2008/7/15(Tue)	TDMLSurvey, OTP, 2008
15	Taksin (Sathon)	Vehicle/day	Year 2000: Daily average during 25Jan-2March and 20June-29June, Year 2002: Daily average during 11June-1August		DOR Traffic Volume Evaluation Project on Chao Phraya River Crossing Bridge, 2543, 2545
		Vehicle/day			PWD (Post Evaluation for New Rama VII construction project, 1999.3, JBIC)
		AADT, Vehicle/day			Post Evaluation for Bridges crossing Chao Phraya River and Intra-Urban Expressway projects, Jan 1986, JBIC
		Vehicle/day		1990/11/	Feasibility Study for Wat Nakorn-In Bridge Construction Project, MOI, 1991
		Vehicle/day	7:00-9:00 16:00-19:00 0:00-24:00	2006/11/21～2007/2/28 2007/11/15～2008/2/28	Traffic Statistic 2007, Beaureu of Traffic and Transport, BMA
		Morning Peak (pcu/h)	7:00-8:00	2005/6/14(Tue)	The Detailed Design and Land Acquisition Survey for The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project, DRR, 2005
		Morning Peak (pcu/h)	7:00-8:00	2008/7/15(Tue)	TDML Survey, OTP, 2008
		Vehicle/day	24 hr	1996/9/17～1996/10/1	The Feasibility Study on the Southern Outer Bangkok Ring Road in Kingdom of Thailand, JETRO, March 2000
		Morning Peak (pcu/h)	7:00-8:00	1996/9/17～1996/10/1	The Feasibility Study on the Southern Outer Bangkok Ring Road in Kingdom of Thailand, JETRO, March 2000
16	Krung Thep	Vehicle/day	Year 2000: Daily average during 25Jan-2March and 20June-29June, Year 2002: Daily average during 11June-1August		DOR Traffic Volume Evaluation Project on Chao Phraya River Crossing Bridge, 2543, 2545
		Vehicle/day			PWD (Post Evaluation for New Rama VII construction project, 1999.3, JBIC)
		AADT, Vehicle/day			Post Evaluation for Bridges crossing Chao Phraya River and Intra-Urban Expressway projects, Jan 1986, JBIC
		Vehicle/day		1990/11/	Feasibility Study for Wat Nakorn-In Bridge Construction Project, MOI, 1991
		Vehicle/day	7:00-9:00 16:00-19:00 0:00-24:00	2006/11/21～2007/2/28 2007/11/15～2008/2/28	Traffic Statistic 2007, Beaureu of Traffic and Transport, BMA
		Morning Peak (pcu/h)	7:00-8:00	2005/6/14(Tue)	The Detailed Design and Land Acquisition Survey for The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project, DRR, 2005
		Morning Peak (pcu/h)	7:00-8:00	2008/7/15(Tue)	TDML Survey, OTP, 2008
		Vehicle/day	24 hr	1996/9/17～1996/10/1	The Feasibility Study on the Southern Outer Bangkok Ring Road in Kingdom of Thailand, JETRO, March 2000
17	New Krung Thep (Rama III)	Vehicle/day	Year 2000: Daily average during 25Jan-2March and 20June-29June, Year 2002: Daily average during 11June-1August		DOR Traffic Volume Evaluation Project on Chao Phraya River Crossing Bridge, 2543, 2545
		Morning Peak (pcu/h)	7:00-8:00	2005/6/14(Tue)	The Detailed Design and Land Acquisition Survey for The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project, DRR, 2005
		Morning Peak (pcu/h)	7:00-8:00	2008/7/15(Tue)	TDML Survey, OTP, 2008
18	Rama 9	Vehicle/day		1990/11/	Feasibility Study for Wat Nakorn-In Bridge Construction Project, MOI, 1991
		Vehicle/day	24 hr	1996/9/17～1996/10/1	The Feasibility Study on the Southern Outer Bangkok Ring Road in Kingdom of Thailand, JETRO, March 2000
		Morning Peak (pcu/h)	7:00-8:00	1996/9/17～1996/10/1	The Feasibility Study on the Southern Outer Bangkok Ring Road in Kingdom of Thailand, JETRO, March 2000
19	Industrial Ring Road (North)	Vehicle/day	7:00-9:00 16:00-19:00 0:00-24:00	2006/11/21～2007/2/28 2007/11/15～2008/2/28	Traffic Statistic 2007, Beaureu of Traffic and Transport, BMA
20	Kanchanapisek				

Table 2.4.4 Transitional Traffic Volume on Bridges crossing Chao Phraya River (1/3)

(pcu/day)

	Bridge Name	Administrator	Year														
			1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	Pathum Thani	DOH															
2	2nd Phatum Thani	DOH															
3	Nonthaburi-Pathum Thani	DOH															8,736
4	Pak Kret（Rama IV）	DRR															
5	New Phra Nangklao	DOH															
6	Phra Nangklao	DOH															
7	Wat Nakorn-In (Rama V）	DRR															
8	Rama VII	DRR															
9	Rama VI (Rail Bridge）	SRT	7,200						16,800		21,600			24,000			31,200
10	Krungthon	DRR	33,600						48,000		45,600			63,600			58,800
11	Rama VIII	BMA															
12	Phra PinkLao	DRR									68,400			98,400			105,600
13	Memorial (Phra Phutta Yodf)	DRR	127,200						171,600		127,200			118,800			141,600
14	Phra Pok Klao (New Memorial)	DRR															
15	Taksin (Sathon)	DRR															
16	Krung Thep	DRR	25,200						46,800		49,200			64,800			75,600
17	New Krung Thep (Rama III)	DRR															
18	Rama 9	EXAT															
19	Industrial Ring Road	DRR															
20	Kanchanapisek	DOH															

Note: As the Rama VI Bridge was a single track railway cum road bridge until late 1992 when the construction of the Rama VII Bridge was completed, vehicle traffics on the Rama VI Bridge were recorded.

Table 2.4.5 Transitional Traffic Volume on Bridges crossing Chao Phraya River (2/3)

(pcu/day)

	Bridge Name	Year														
		1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	Pathum Thani															
2	2nd Phatum Thani															
3	Nonthaburi-Pathum Thani									25,191			35,956			
4	Pak Kret（Rama IV）															
5	New Phra Nangklao															
6	Phra Nangklao									50,208			43,279			
7	Wat Nakorn-In (Rama V）															
8	Rama VII												85,461		163,273	
9	Rama VI (Rail Bridge）	32,400					49,200			59,683						
10	Krungthon	60,000		75,600			86,640			88,606	138,762				116,533	
11	Rama VIII															
12	Phra PinkLao	106,800		147,600			162,360			159,523	255,977				229,648	
13	Memorial (Phra Phutta Yodf)	140,400		176,400			88,320			78,922	109,754				111,157	
14	Phra Pok Klao (New Memorial)						144,120			153,238	193,529				172,980	
15	Taksin (Sathon)	79,200		157,200			169,560			174,316	256,044				227,023	116,733
16	Krung Thep	57,600					82,200			104,467	119,681				122,316	81,840
17	New Krung Thep (Rama III)															
18	Rama 9									74,902						135,433
19	Industrial Ring Road															
20	Kanchanapisek															

Table 2.4.6 Transitional Traffic Volume on Bridges crossing Chao Phraya River (3/3)

(pcu/day)

	Bridge Name	Year													Growth
		1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Rate
1	Pathum Thani										85,716		79,683		0.96
2	2nd Phatum Thani														-
3	Nonthaburi-Pathum Thani												52,000		1.07
4	Pak Kret（Rama IV）										89,995	89,729	75,150		0.91
5	New Phra Nangklao														-
6	Phra Nangklao									86,333			71,817		1.02
7	Wat Nakorn-In (Rama V）									82,733			130,867		1.17
8	Rama VII				172,303		142,916			58,667	113,072	119,485	46,617		0.96
9	Rama VI (Rail Bridge）														-
10	Krungthon				123,802		107,536			49,933	80,384	91,565	31,750		1.00
11	Rama VIII									69,967	85,916	85,516	61,100		0.96
12	Phra PinkLao				235,487		207,144			105,750	120,864	124,386	148,900		1.02
13	Memorial (Phra Phutta Yodf)				98,178	0	105,114			54,000	62,708	69,319	56,000		0.98
14	Phra Pok Klao (New Memorial)				176,296		196,172			102,333	121,961	133,813	140,633		1.00
15	Taksin (Sathon)			227,225	210,265		203,502			81,067	99,210	131,740	90,933		1.01
16	Krung Thep	90,437	93,950	112,327	93,035		117,043			70,783	67,637	62,074	70,967		1.03
17	New Krung Thep (Rama III)				83,015		79,284			61,517			34,833		0.90
18	Rama 9			144,391											1.08
19	Industrial Ring Road										54,646	61,460			1.12
20	Kanchanapisek														-
													Average		1.012

(2) 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 2.4.7 to Table 2.4.9. 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: 1,500 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 2.4.7 to Table 2.4.9 show the effect for decentralization of traffic demand with the new bridge constructions.

Table 2.4.7 Transitional Congestion Ratio on Bridges crossing Chao Phraya River (1/3)

	Bridge Name	Number of	Year														
		Lanes	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 2.4.8 Transitional Congestion Ratio on Bridges crossing Chao Phraya River (2/3)

	Bridge Name	Number of	Year														
		Lanes	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 2.4.9 Transitional Congestion Ratio on Bridges crossing Chao Phraya River (3/3)

	Bridge Name	Number of	Year												
		Lanes	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	Pathum Thani	2										1.71		1.59	
2	2nd Phatum Thani	2													
3	Nonthaburi-Pathum Thani	2												1.04	
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		1.36			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													

(3) 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 2.4.10 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 2.4.7 to Table 2.4.9.

Table 2.4.10 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 Phatum 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

2.4.3 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

1) Population

Table 2.4.11 shows the transition of population and growth rate of population increase on Nonthaburi and BMA. 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 as shown in Figure 2.4.4, and it is expected that further urbanization of Nonthaburi will continue as a suburb city in BMA.

Table 2.4.11 Population Growth in Surrounding Area of Chao Phraya River ('000)

	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

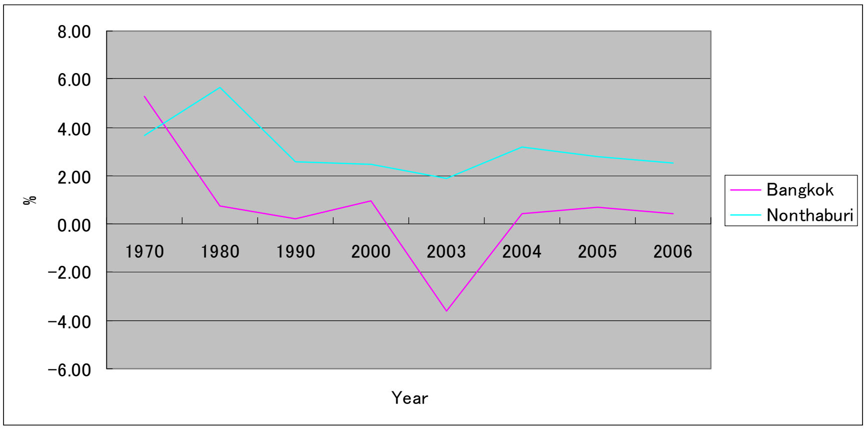


Figure 2.4.4 Population Growth in Surrounding Area of Chao Phraya River

2) Employees

Table 2.4.12 shows the transition of growth rate and number of employees of Nonthaburi and BMA. 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 2.4.12 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

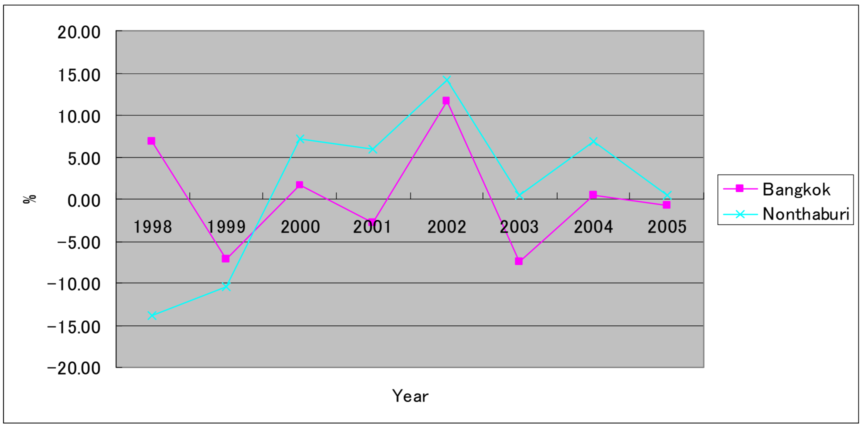


Figure 2.4.5 Transitional Growth Rate of Employees in the Surrounding Area of Chao Phraya River

3) Houses

Table 2.4.13 shows the transition of growth rate and numbers of houses of Nonthaburi and BMA. 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 2.4.13 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

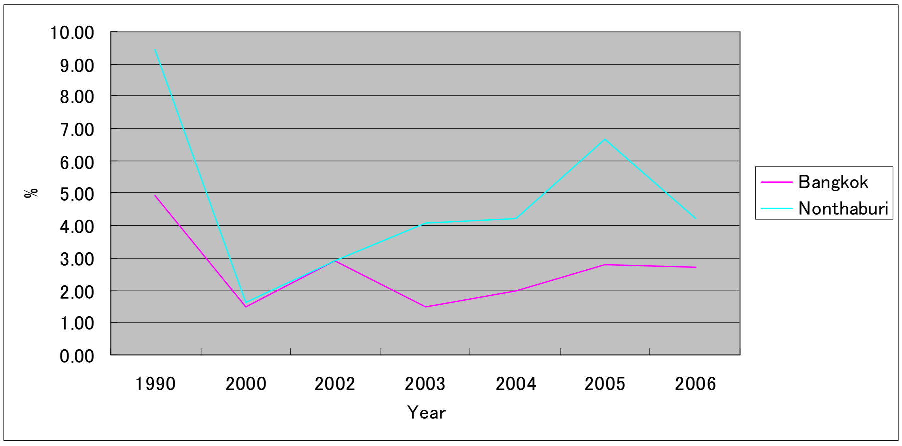


Figure 2.4.6 Transitional Growth Rate of Houses in Surrounding Area of Chao Phraya River ('000)

4) Business Enterprise

Table 2.4.14 shows the transition of growth rate and numbers of business enterprises of Nonthaburi and BMA. 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 2.4.14 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

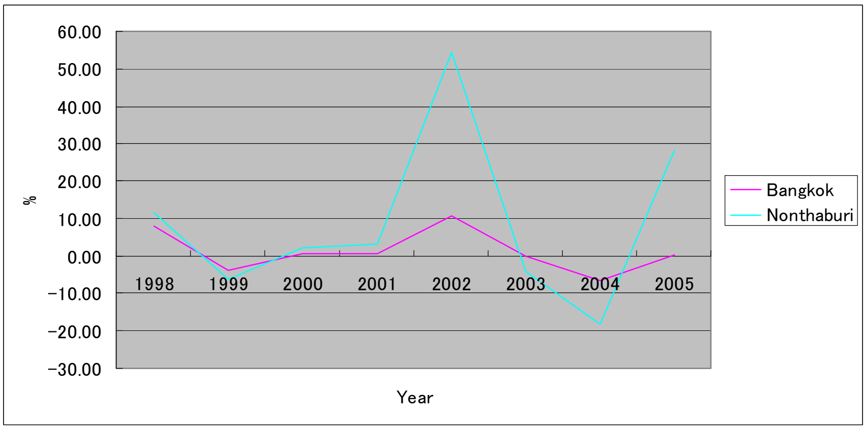


Figure 2.4.7 Transitional Growth Rate of Business Enterprise in the Surrounding Area of Chao Phraya River

5) 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

1) 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.

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

Table 2.4.15 The Survey Areas of Interview

Area		Bridges in Areas	Responses
Area A	Planning area (Nonthaburi province)	New Bridge Phra Nangklao (New Phra Nangklao) Rama 5 (Rama 4)	65 (+12 Japanese companies)
Area B	Bangkok Noi (BMA)	Rama 7 Krung Thon Rama 8 Pinklao	66
Area C	Thongburi (BMA)	Memorial Phra Pokklao Taksin Rama 3 Krung Thep	72
Area D	South of Thongburi (BMA)	Rama 9	10

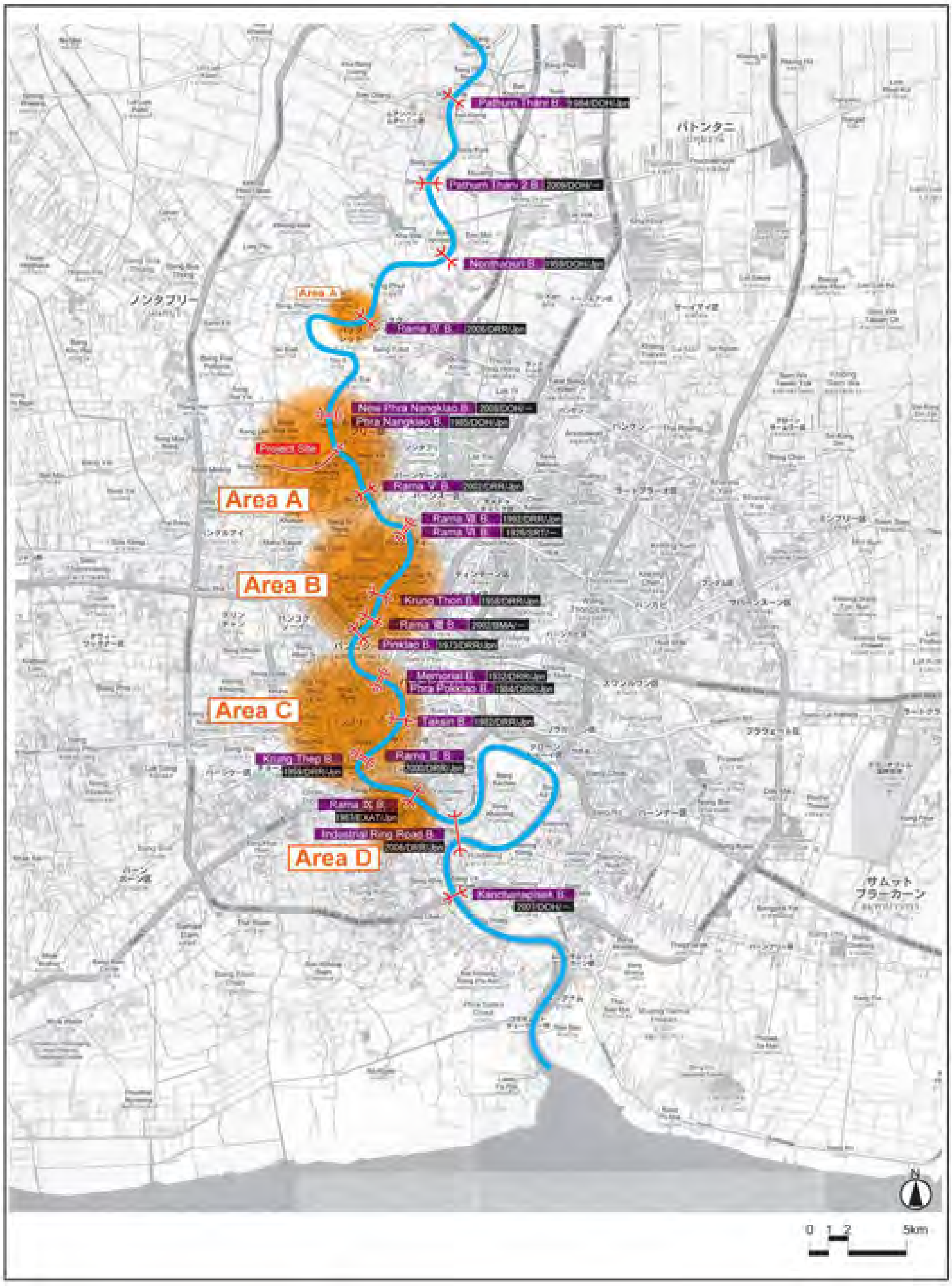


Figure 2.4.8 The Survey Area of Interview

The survey questionnaire consists of nine questions and each question is answered in five levels (much better benefit – much worthy impacts). The interviews were carried out by local surveyors through directly visiting the local companies, while the interviews to Japanese companies were done by the study team.

The details of the questionnaire form and the results are shown in Appendix-6.

Table 2.4.16 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:

a) Result of Expectations for the New Bridge

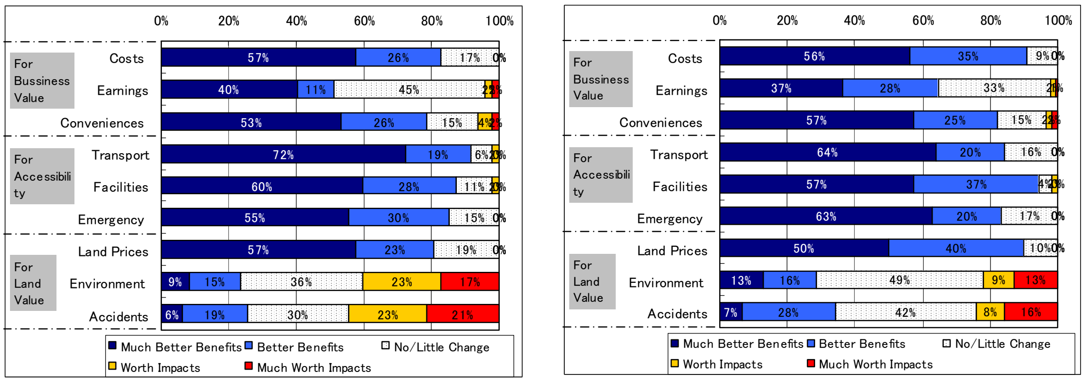


Figure 2.4.9 The Results in Comparison between The New Bridge (L) and the others (R)

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.

b) The Results of Comparison among the Survey Areas

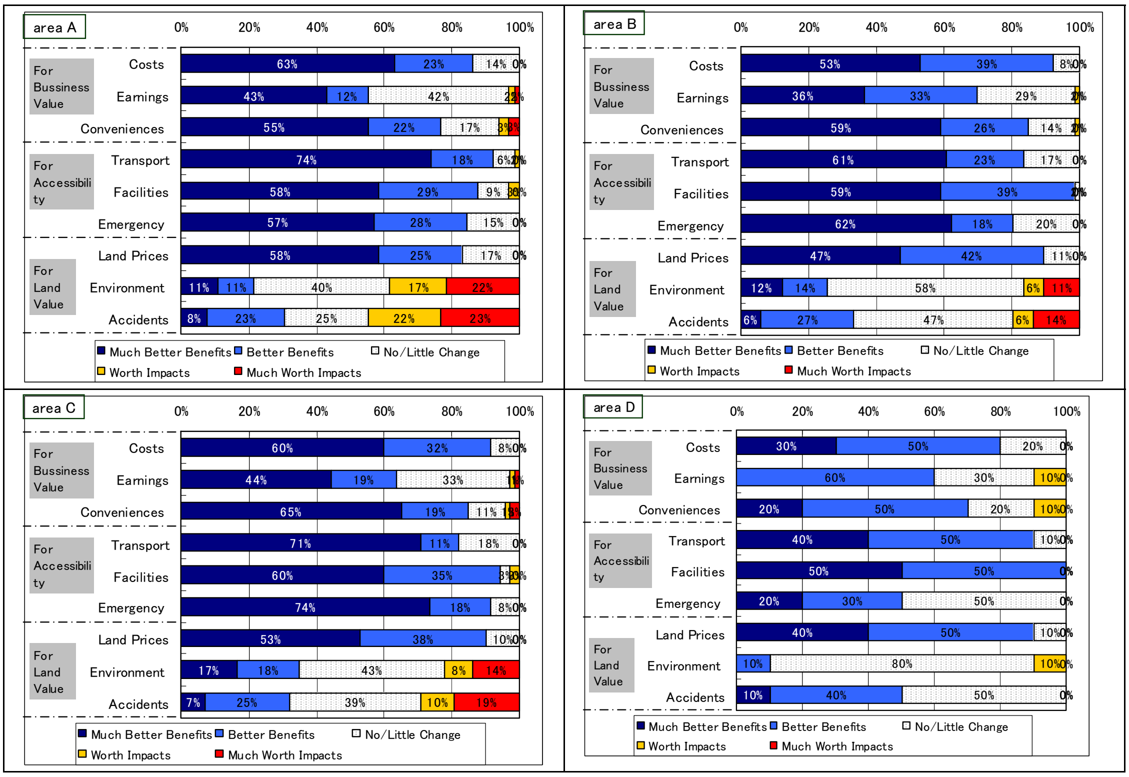


Figure 2.4.10 The Results of comparison Among the Four Areas

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.

2) 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, as shown below.

Table 2.4.17 Target Organizations of Interview Survey

Organizations	Respondents	Date
Nonthaburi Province Department of City Planning	Ms. Unehaleeluk Anonthasorn <City Planner>	7th October 2009
Bangkok Metropolitan Administration Department of City Planning	Mr. Sompong Chirabundarnsook <City Planner>	6th October 2009
Ministry of Interior Department of Town and Country Planning and Public Works	Dr. Thongchai Roachanakanan <Director>	9th October 2009

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.

With respect to the city plan, the new bridge project is not mentioned in the current comprehensive plan of Nonthaburi Province (2005 modified). According to the Department of City Planning in Nonthaburi, in the period between 2005 and 2010, the modification of current comprehensive plan is not estimated. Additionally, they have some opinion such as, “We never have any objection to the new bridge”, and “When the new bridge opens to the public, urbanization in the west bank will be advanced and we should modify the next plan”.

2.5 PROPOSED DEVELOPMENT PLAN FOR THE PROJECT AREA

2.5.1 PURPOSE AND TARGET OF THE PROPOSED AREA DEVELOPMENT PLAN

(1) Purpose

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. It was pointed out in Sub-section 2.1.2 that the 20 bridges over the Chao Phraya River have contributed to the urbanization on the west bank. And in summary, the connections of the urban areas between east and west banks have been strengthened as the result of synergism with the two or three 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.

(2) The Target Area

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 Nothaburi Province was selected as the project area for the proposed development plan in view of the suited conditions. This Nonthaburi District includes Nonthaburi City municipality east bank which is the urban center of the province. On the other hand, the other areas in the west bank are rural with relatively low density new housing areas and their activities are generally centered on agricultural sector.

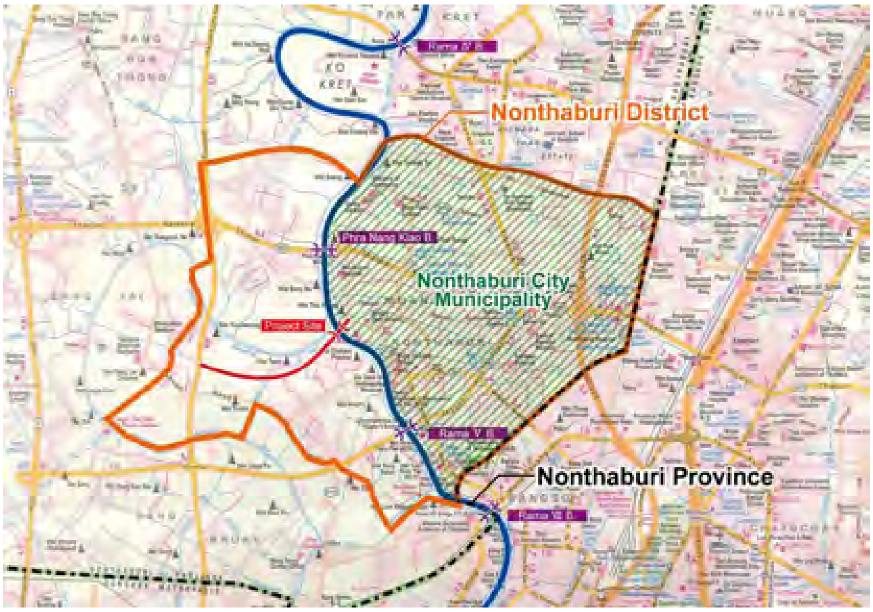


Figure 2.5.1 Project Area for Development Plan "Nonthaburi District"

2.5.2 RELATED PLANS

(1) Socio-Economic Framework for Bangkok Metropolitan Region

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[1]. About half of the BMR population lives in BMA area. The population projection for BMR up to 2026 is tabulated in Table 2.5.1. The projected population in 2026 is 13.78 million and the annual average growth rate for BMR is 1.15%. 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%. On the other hand the annual growth rates for western provinces are in the range of 1.2 and 1.4%. These indicate that the expansion of urban population is leaning towards the north and southeast direction from the center of Bangkok.

Table 2.5.1 Population Projection (Revised) for Bangkok Metropolitan Region

Province	2011	2016	2021	2026	Growth rate 2011-2026
BMA	6,525,170	6,579,331	6,696,170	6,913,536	0.39%
Samut Prakan	1,358,976	1,517,066	1,674,966	1,855,559	2.10%
Nonthaburi	1,378,608	1,615,245	1,845,528	2,100,137	2.85%
Pathumthani	851,093	934,348	1,017,962	1,115,512	1.82%
Nakornpathom	946,901	1,000,735	1,059,125	1,132,615	1.20%
Samut Sakorn	532,882	568,688	606,380	652,641	1.36%
Total	11,593,630	12,215,413	12,900,131	13,770,000	1.15%

Source: "The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project 1st Additional Information on General and Technical Issues, DRR"

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[1] Bangkok has a quite large unregistered population, which is said to be almost about 50% of the registered population. The total population of BMR could thus be estimated around 17 million.

(2) Urban Plan of Nonthaburi Province

As seen in sub-section 2.2.4, 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 2.5.2, one for 1990 and the other for 2005.

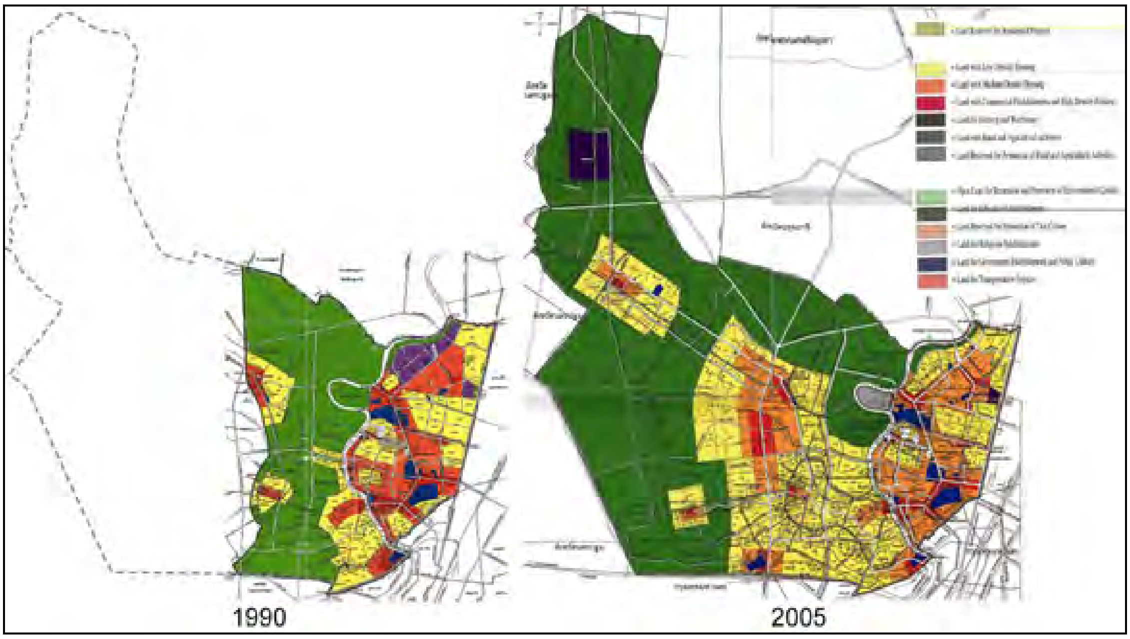

Figure 2.5.2 Comprehensive Plans for Nonthaburi Province (1990 and 2005)

In 1990, there are two expressways running through the Nonthaburi Province on both sides of the Chao Praya River, and there are a few roads connecting the two expressways in the east-west directions, including the Rattana Thibet Road in the central part of the province. Thus the trunk road network is a mere H shaped grid, and the connectivity within the province was weak and insufficient. There were plans for the Twanon and Chaeng Wattana Roads, but they had not been completed. On the north-south direction, there is a plan for Rachapuek Road, but not yet complete. The connection for the western and eastern banks of the Chao Praya River was remote and the land on the west of the river is more on agricultural use.

In the 2005 comprehensive plan, the two north-south road on the west bank of the river are complete in addition to the one existing expressway, and the above mentioned two east-west roads are now complete, making a ladder like network on both sides of the river.

The improvement in the road network also affected the land use in the province. On the west bank of the Chao Pray a belt between the river and Kanchanapaseuk Road was mostly urbanized except for the areas around Koh Kredt, particularly in the areas in the opposite side of Nonthaburi City. Comprehensive Plan of 2005 made a change in this area from the previous agricultural area (green) to residential area (yellow) in this riverside belt. Thus, as the result of the road network improvement, urbanization is proceeding to the west bank of the Chao Phraya in the opposite side of Nonthaburi City.

2.5.3 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/km^2 in 1990 and 1,646/km^2 in 2007.

Table 2.5.2 Population Transition in Nonthaburi Province (1990-2007)

	1990	1995	2000	2005	2007
Population	661,573	754,627	859,607	972,280	1,024,191
Density (622.31km^2)	1,063/km^2	1,213/km^2	1,381/km^2	1,562/km^2	1,646/km^2
Growth of population	+362,618 (1990-2007)				
Growth Rate	2.6% (1990-2007)				

The population from each district was analyzed in this section. The analysis was conducted in the eight districts as illustrated in Figure 2.5.3. However there are normally 6 administrative districts in Nonthaburi Province. ①The Nonthaburi District and ②Pak Kret District cross over the Chao Phraya River, hence these districts were sub-divided into east and west banks in order to analyze exactly the impacts of the bridges.

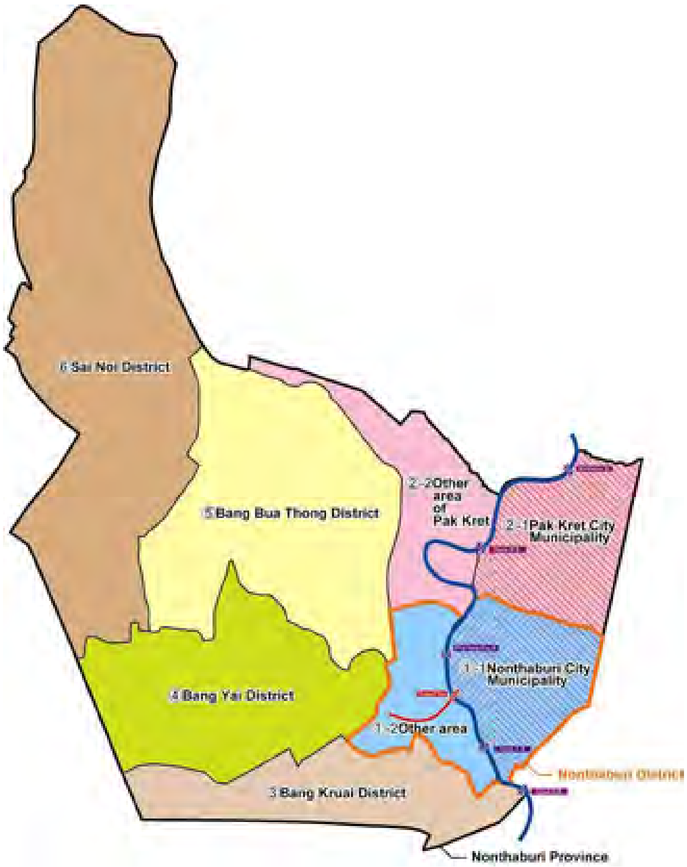

Figure 2.5.3 Eight Districts of Nonthaburi Province

Table 2.5.3 and Figure 2.5.4 summarize 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.

Table 2.5.3 Population Transition in each District (1990-2007)

District Name	Population (Density)					Area (km^2)
	1990	1995	2000	2005	2007	
①-1 Nonthaburi City Municipality	254,678 (6,547)	265,773 (6,832)	269,315 (6,923)	267,097 (6,866)	265,796 (6,833)	38.90
①-2 Other area of Nonthaburi	47,247 (1,239)	61,149 (1,604)	70,330 (1,845)	80,776 (2,119)	87,684 (2,300)	38.12
②-1 Pak Kret City Municipality	116,356 (3,229)	134,756 (3,739)	150,354 (4,172)	165,829 (4,601)	169,782 (4,711)	36.04
②-2 Other area of Pak Kret	33,833 (0,639)	34,288 (0,647)	34,798 (0,657)	37,280 (0,704)	39,121 (0,738)	52.98
③Bang Kruai District	75,873 (1,322)	80,973 (1,410)	82,855 (1,443)	91,419 (1,592)	97,650 (1,701)	57.41
④Bang Yai District	35,283 (0,366)	47,338 (0,491)	61,148 (0,634)	79,602 (0,826)	92,215 (0,957)	96.40
⑤Bang Bua Thong District	64,203 (0,551)	93,945 (0,807)	148,000 (1,271)	198,652 (1,706)	218,030 (1,872)	116.44
⑥Sai Noi District	34,100 (0,183)	36,405 (0,196)	42,807 (0,230)	51,625 (0,278)	53,913 (0,290)	186.02
Total	661,573	754,627	859,607	972,280	1,024,191	622.31

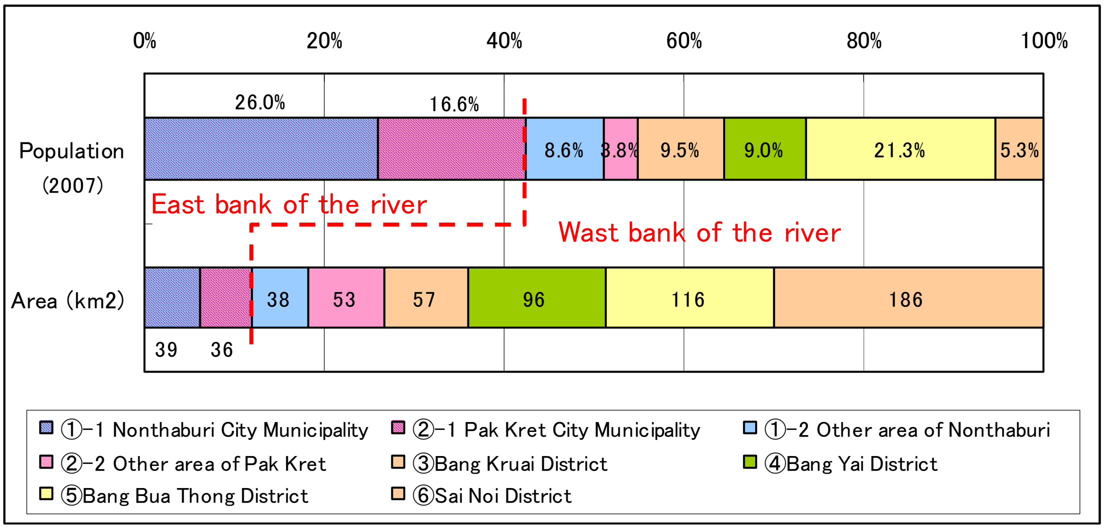

Figure 2.5.4 The Proportion of Population and Area in each District

As seen in Table 2.5.4, 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 form 1990 up to 2007 in the districts on west bank indicate much high level, such as 7.5% in ⑤Bang Bua Thong District and 5.8% in ④Bang 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.

Table 2.5.4 Growth Rate in each District

District Name	Growth Rate （Growth of Population） 1990-2007				
		(1990-1995)	(1995-2000)	(2000-2005)	(2005-2007)
①-1 Nonthaburi City Municipality	0.3% (11,118)	0.9% (11,095)	0.3% (3,542)	-0.2% -(2,218)	-0.2% -(1,301)
①-2 Other area of Nonthaburi	3.7% (40,437)	5.3% (13,902)	2.8% (9,181)	2.8% (10,446)	4.2% (6,908)
②-1 Pak Kret City Municipality	2.2% (53,426)	3.0% (18,400)	2.2% (15,598)	2.0% (15,475)	1.2% (3,953)
②-2 Other area of Pak Kret	0.9% (5,288)	0.3% (0,455)	0.3% (0,510)	1.4% (2,482)	2.4% (1,841)
③Bang Kruai District	1.5% (21,777)	1.3% (5,100)	0.5% (1,882)	2.0% (8,564)	3.4% (6,231)
④Bang Yai District	5.8% (56,932)	6.1% (12,055)	5.3% (13,810)	5.4% (18,454)	7.6% (12,613)
⑤Bang Bua Thong District	7.5% (153,827)	7.9% (29,742)	9.5% (54,055)	6.1% (50,652)	4.8% (19,378)
⑥Sai Noi District	2.7% (19,813)	1.3% (2,305)	3.3% (6,402)	3.8% (8,818)	2.2% (2,288)

(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/km^2, which is still much lesser than the east bank of 5,812/km^2. The estimated reasons are listed below and are shown in Figure 2.5.5.

- 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.

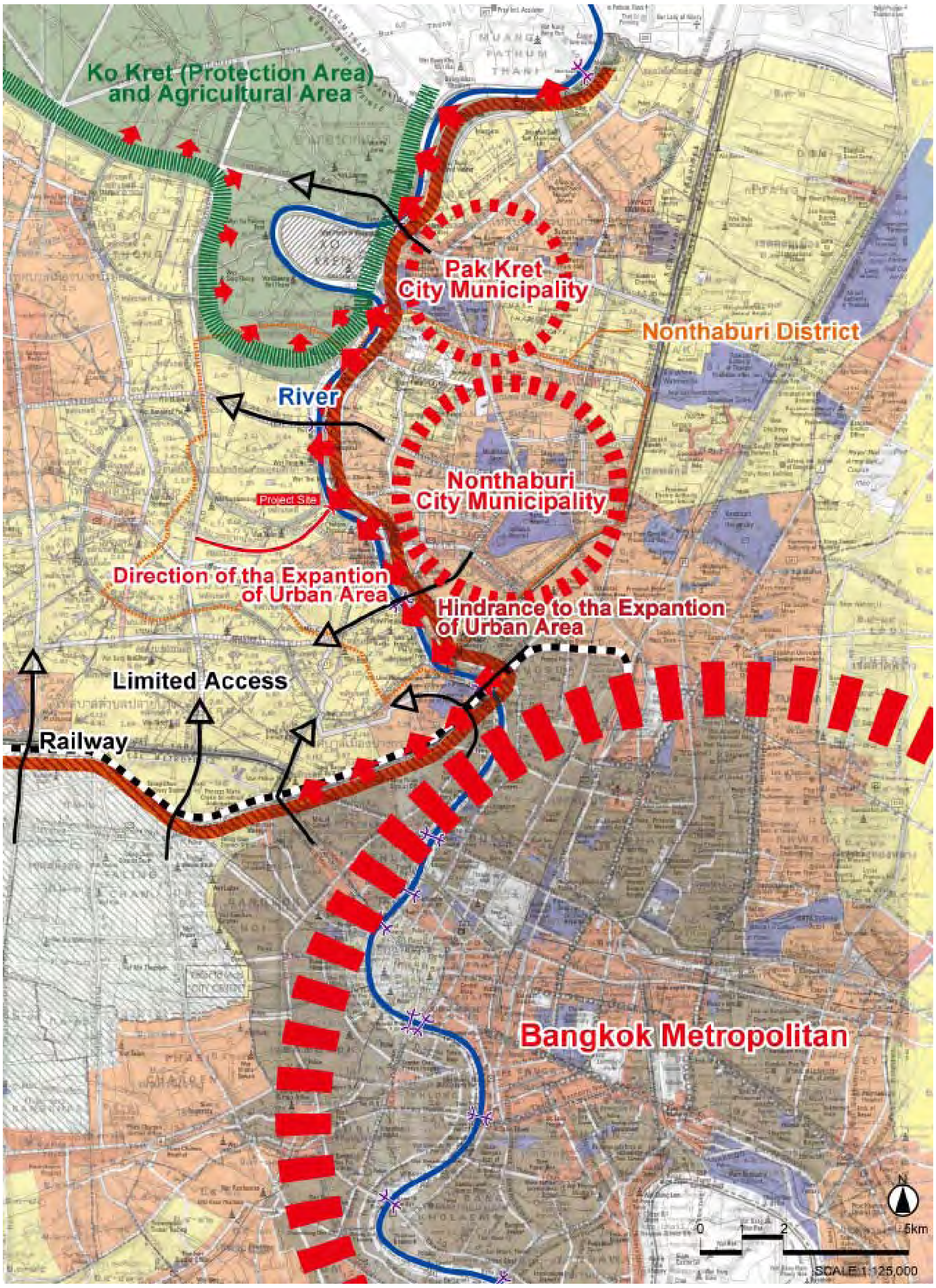

Figure 2.5.5 Structure and Restriction for Urbanization in Nonthaburi Province and BMA

(3) The Population Framework for Nonthaburi Province

The 2007 population of Nonthaburi Province is 1,024,191 and its density is 1,646/km^2. The average growth rate from 1990 to 2007 is about 2.6%. The population projection in Table 2.5.1 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 as seen in Figure 2.5.6. Hence, this rate indicates that the Nonthaburi Province shall be the future potential settlement area in the Metropolitan.

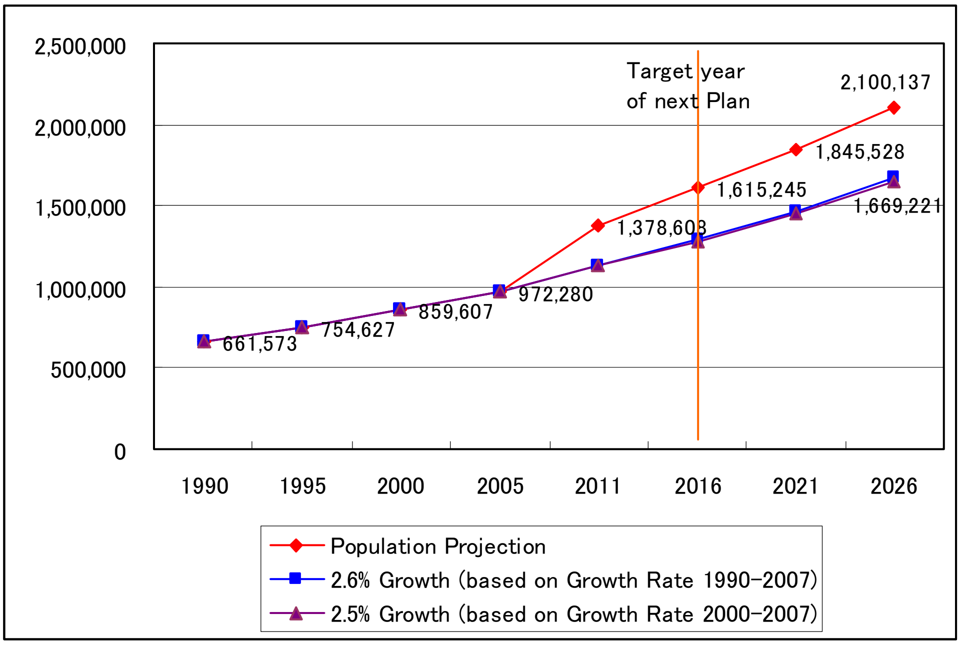

Figure 2.5.6 The Population Projection for Nonthaburi Province

In each district, it might be inferred from the decrease of population in ①-1 Nonthaburi City Municipality that the density in east bank is close to full capacity. It is reasonable to assume that the upper limit of density of east bank is 7,000/km^2, based on the current density of 6,833/km^2. Additionally, the same figure can apply to ②-1 Pak Kret City Municipality in the east bank.

Table 2.5.5 summarized the proposed population framework of each district in the target year 2016. This framework is based mainly on the proper population density in the future and partly on the growth rate in the past. In addition, this framework has been finalized considering the feedback of the results in the following sub-sections (4) and (5).

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/km^2. 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/km^2 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/km^2, 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 Figure 2.5.7. Furthermore, middle or high density urban areas will be formed mainly along the primary roads, such as Kanchanaphisek Road, Ratchaphruek Road, Rattana Thibet (302) Road and Twanon (306) Road. As a consequence , three urban centers in Nonthaburi City Municipality expanding more to west bank, Pak Kret City Municipality, and Bang Bua Thong City, will be developed in the province. Finally, the fringe of urban areas will spread out throughout the whole province, mainly due to the expansion of the low density housing areas.

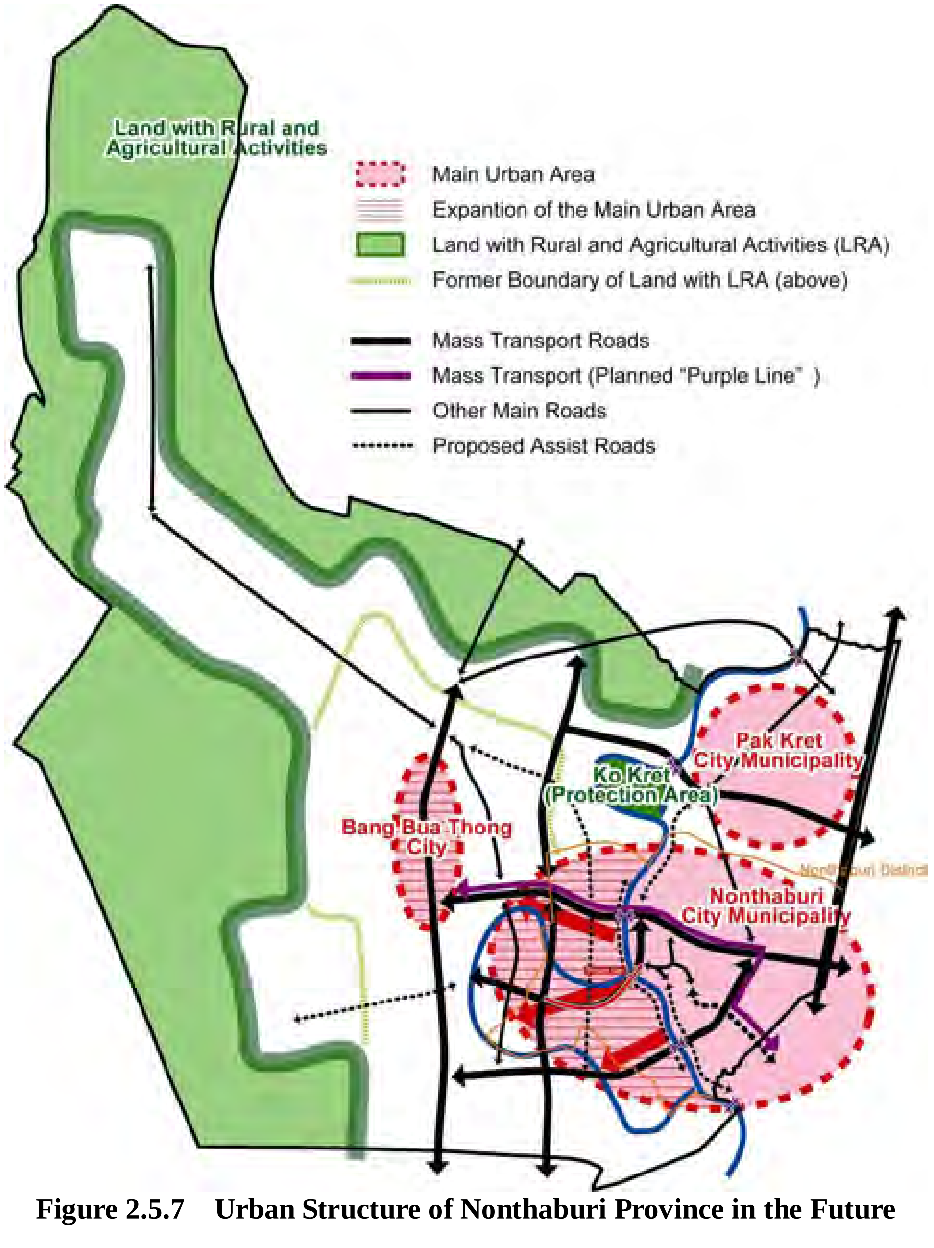

Figure 2.5.7 Urban Structure of Nonthaburi Province in the Future

(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.

Table 2.5.6 shows the proposed land use plan for each district on the basis of population framework as shown in Table 2.5.5. This is not to say that these figures are based on the accurate or official source, but these were roughly estimated only in this study.

Table 2.5.6 Distribution of Land Use in each District (Rough Estimate)

District Name	Plan	Ratio of Land Use (Rough Estimate)			
		Medium-High Density Housing	Low Density Housing	Industry & Public Utilities	Rural & Agricultural Activities
①-1 Nonthaburi City Municipality	2005 Plan	70%	20%	10%	0%
	Next Plan	90%	0%	10%	0%
①-2 Other area of Nonthaburi	2005 Plan	20%	70%	0%	10%
	Next Plan	90%	10%	0%	0%
②-1 Pak Kret City Municipality	2005 Plan	40%	50%	5%	5%
	Next Plan	90%	0%	5%	5%
②-2 Other area of Pak Kret	2005 Plan	0%	0%	0%	100%
	Next Plan	0%	40%	0%	60%
③ Bang Kruai District	2005 Plan	10%	50%	10%	30%
	Next Plan	40%	20%	10%	30%
④ Bang Yai District	2005 Plan	10%	30%	0%	60%
	Next Plan	40%	20%	0%	40%
⑤ Bang Bua Thong District	2005 Plan	20%	20%	0%	60%
	Next Plan	40%	20%	0%	40%
⑥ Sai Noi District	2005 Plan	0%	10%	10%	80%
	Next Plan	0%	20%	10%	70%

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

- Medium-High Density Housing: The proposed population density is 5,000/km^2. It is reasonable to assume that the density in ①-1 Nonthaburi City Municipality that occupied mainly by this land use is equivalent to 5,000/km^2 at present. In addition, this corresponds to the lower limit density defined as the Densely Inhabited District (DID) in Japan. On the other hand, the density of east bank districts is set at 7,000/km, because of the current conditions.
- Low Density Housing: The proposed population density is 2,000/km^2. It is also reasonable to assume that the density in ①-2 Other Area of Nonthaburi District that occupied mainly by this land use is equivalent to 2,000/km^2. In addition, this corresponds to the lower limit defined as the urban area, according to some literatures[2].

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[2] Source: “New Outlane for City Planning (Kyoritsu Syuppan Co., Ltd.)”

- Rural & Agricultural Activities, Industry & Public Utilities: The proposed population density is 500/km^2. It is also reasonable to assume that the density in ②-2 Other area of Pak Kret and ⑥ Sai Noi District that occupied mainly by this land use is equivalent to 500/km^2.

It corresponds to the population framework as shown in Figure 2.5.5 that the estimated population multiplied the distributions of land use as shown in Figure 2.5.6 by the proper population densities

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. Figure 2.5.8 shows the land use plan and Figure 2.5.9 shows the area development plan.

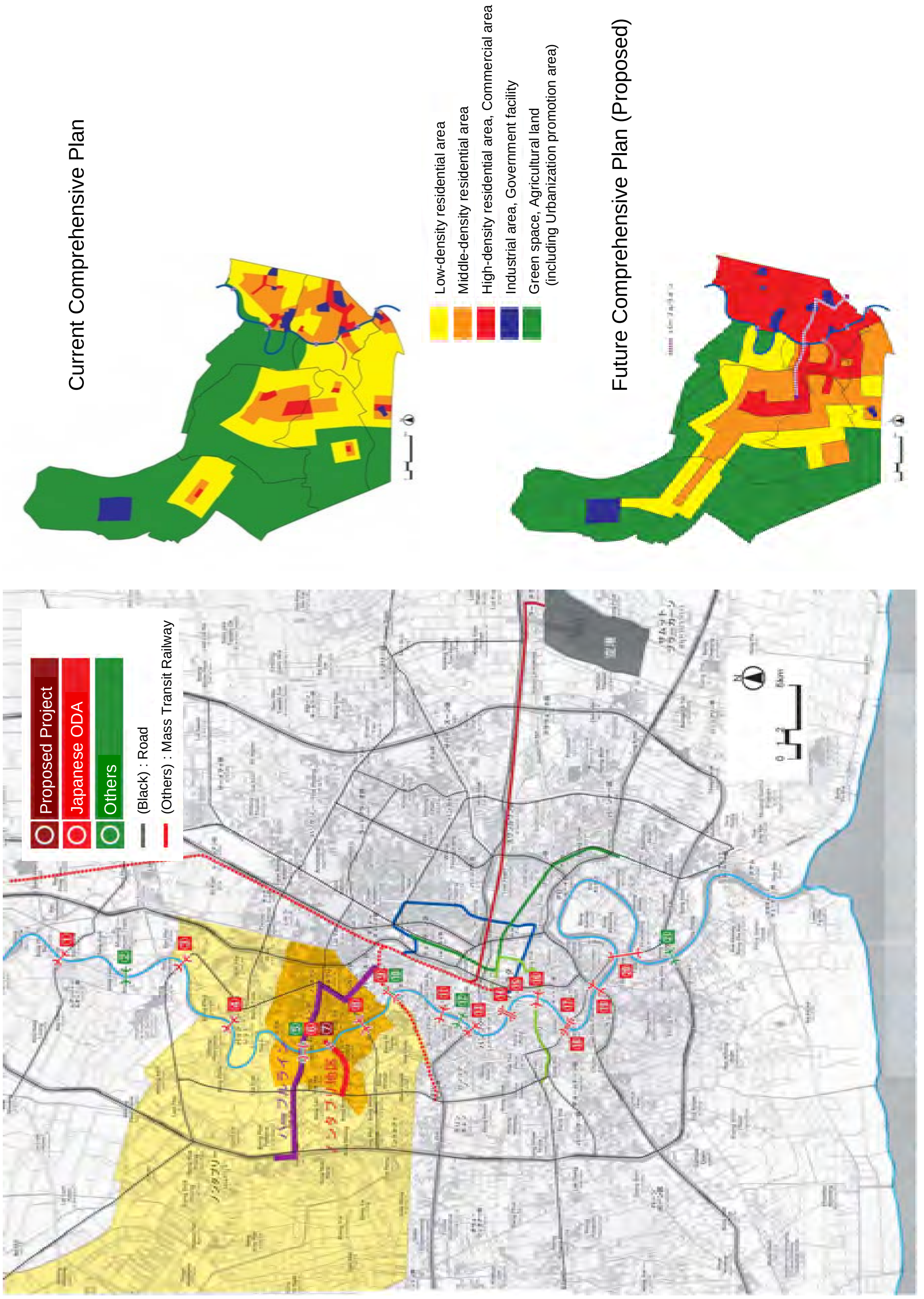


Figure 2.5.8 Proposed Land Use Plan in Nonthaburi Province

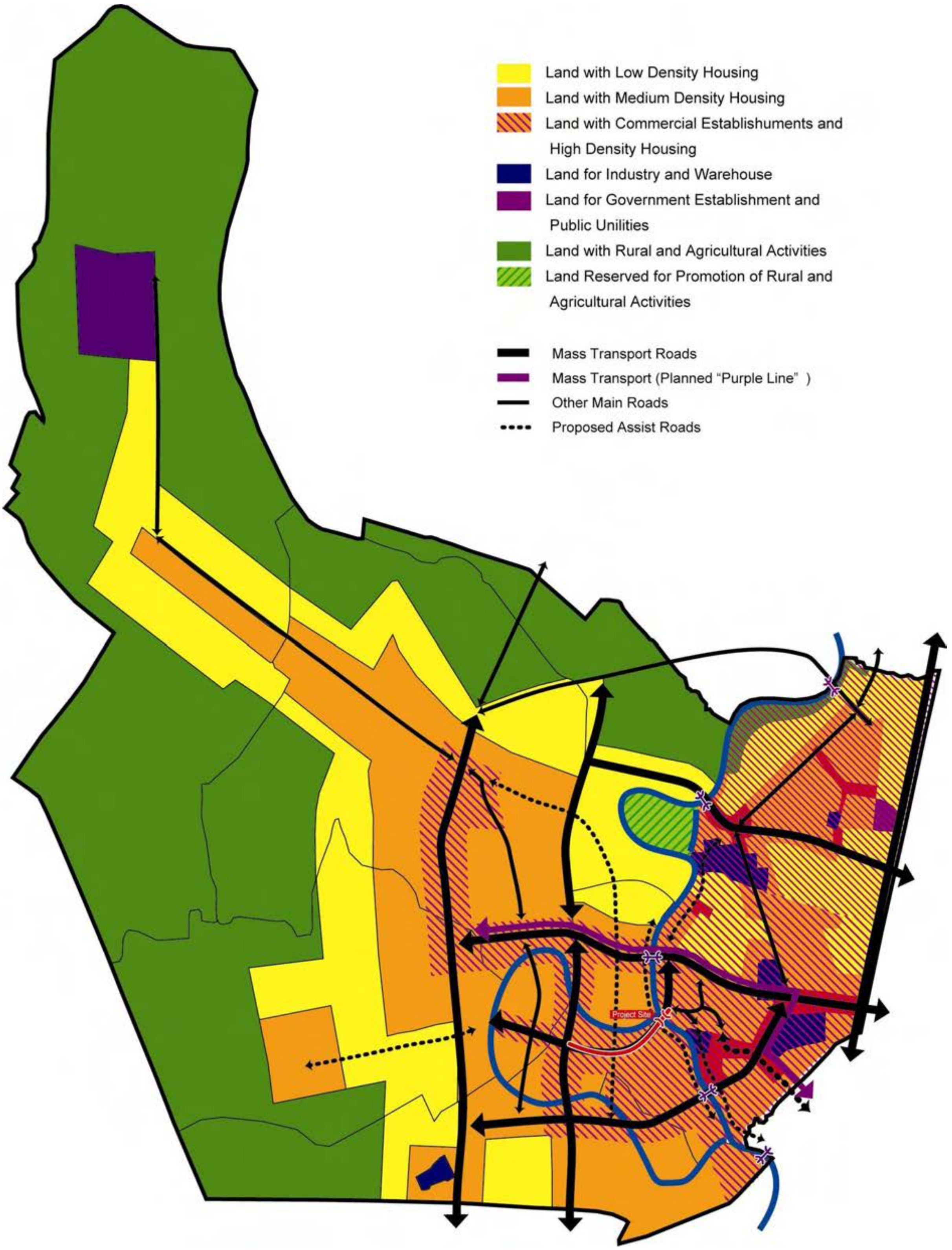


Figure 2.5.9 Proposed Area Development Plan of Nonthaburi Province -the Next Comprehensive Plan (Draft)

Lastly, the area development plan of Nonthaburi District is proposed as follows. Figure 2.5.10 is abstracted only from the project area in Figure 2.5.9, besides the area development plan has been finally summarized.

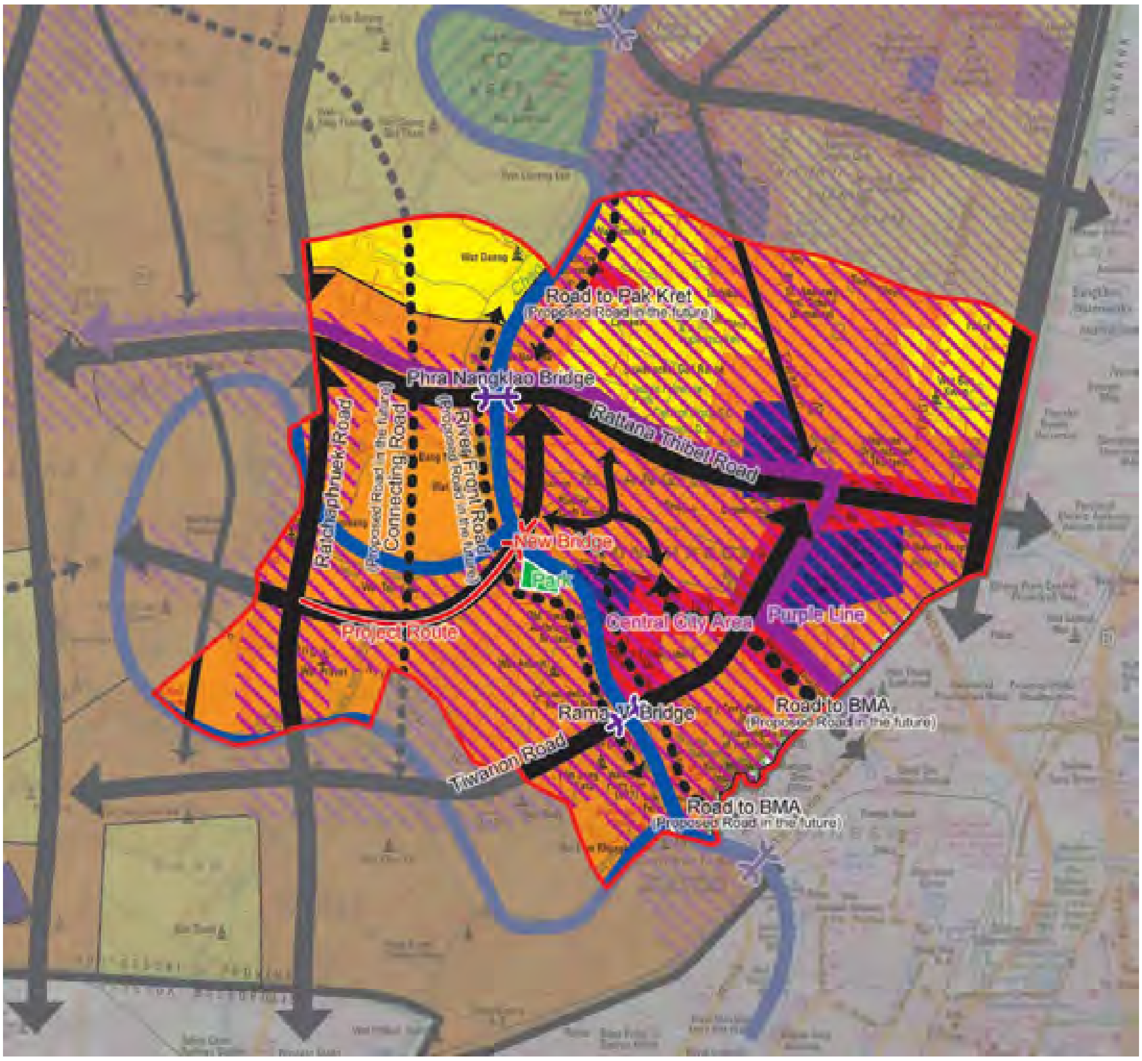


Figure 2.5.10 Proposed Area Development Plan of Nonthaburi District

As discussed in sub-section 2.2.4 (4), the middle and high density urbanization seems to expand widely to the west bank of the river caused by the new bridge, especially in the project area. 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.

Similarly, it is also likely that urbanization will expand continuously along the new road between the new bridge and the Ratchaphruk Road. This will lead to make middle-high density urban area on the west bank as large as the east bank in the future. In view of this movement, it is expected that the commercial and governmental center and the north-south assist roads should be constructed on west bank in the long-term span.

CHAPTER 3

PROJECT OUTLINES

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

3.2.1 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.

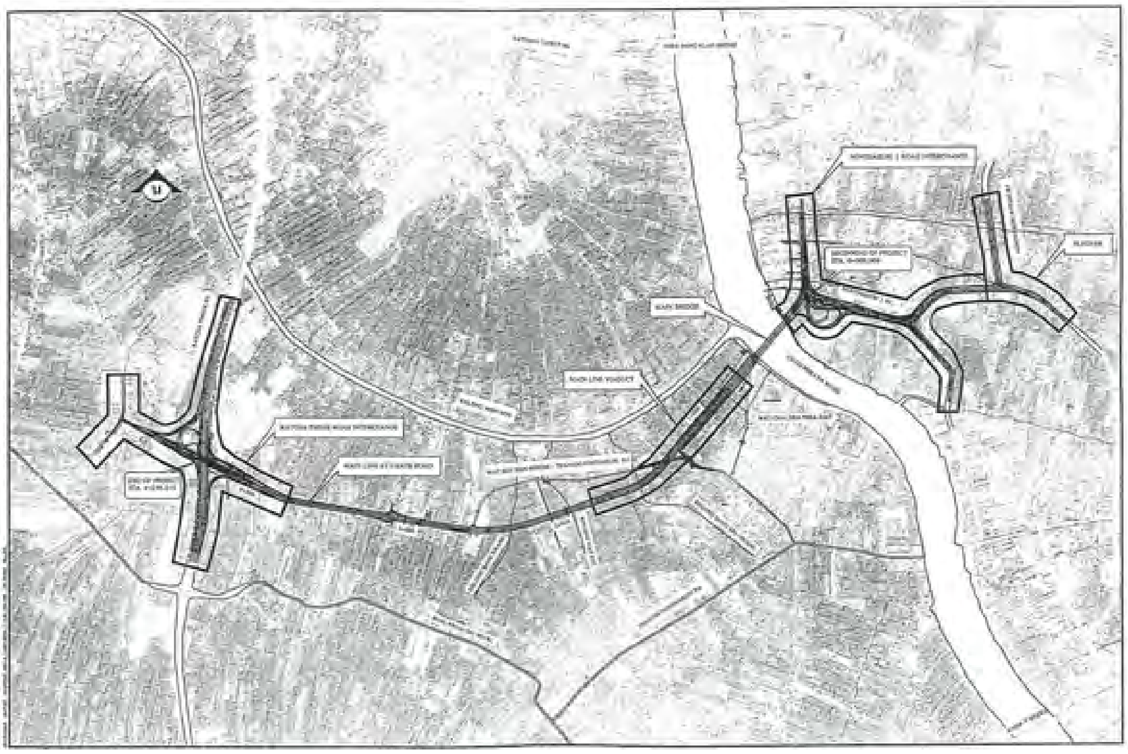


Figure 3.2.1 Planning Map of the Project

The main components of construction works include:

1) The structure crossing the Chao Phraya River is an extradosed bridge with two pylons. The bridge provides six traffic lanes with two sidewalk, having main span of 200 m and 130 m side span each on two major piers. The pylons are of reinforced concrete construction. The main and side spans are made of cast in-place post-tensioned concrete construction.
2) Main lane viaduct on the west side of the Chao Phraya River comprises of four lanes which serve as the main lane and one lane on-off ramps of post-tensioned concrete

construction, with a total length of 930 m and 275 m, respectively.

3) Nonthaburi 1 Road Interchange located on the east side of the Chao Phraya River comprises of one to three-lane lamps and the main lane, with a total length of 2,343 m.
4) A two-lane flyover with a total length of 286 m located at a junction of Nonthaburi Bypass Road.
5) Ratcha Phruk Road Interchange is a two-lane interchange, with a total length of 1,088 m.
6) Local road on ground under main lane viaduct is a four-lane with a total length of 1500 m.
7) Main road at grade road is a six-lane with a total length of 2,275 m.
8) Three minor bridges over canals.
9) Landscaping works for a public park to be located beneath the high-level interchange and main bridge.
10) Other works related to all the above.

This construction work is very famous by the pioneer construction of the extradosed bridge. This bridge is provided with the PC cables placed high above the girder making cables used efficiently and has the characteristics between a cable-stayed bridge and girder bride. The degree of freedom to decide the components (girder, tower, cable, etc.) is high compared to the other bridge types. This leads to a rational and economical design only if the balance of these factors is well-kept. To make this balanced design, it is necessary to have an excellent knowledge coupled with sound experience in design and construction. As the rigidity of the girder is comparatively high and the cable angle is low, it becomes difficult to adjust the camber on site. It is necessary to involve the inputs of an experienced consultant even in the early design stage. This bridge becomes one of the world's biggest of this type of bridge in size and it should be carefully constructed.

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.

3.2.2 PACKAGE OF THE PROJECT

Earlier, this project had been divided into two contracts. The idea behind this was to finish the western and smaller part earlier and make it open for traffic, and then, connecting it to Thanam Nonthaburi Road and Watbotonphron Thanarinow Road. However, these roads are narrow and their beneficial effects to the public are not so big compared to the efforts of building wider roads with slightly higher cost. Because of these considerations, 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.

3.2.3 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

Detailed design and administration cost are excluded because they are disbursed from the general expense of DRR.

3.2.4 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

3.3.1 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.

(1) Review of Main Bridge (Extradosed Bridge)

The main bridge crossing the Chao Phraya River was reviewed through tender drawings, design notes and discussion with DRR's Engineers. Listed below are the topics or points of discussions;

1) Review of Main Span and Bridge Length based on the River Conditions

The center span of the bridge crossing the river is determined with the navigation clearance and the basic conditions of design requested from the Marine/River Authority. For Chao Phraya River crossing the main bridge, the navigation clearance is 5.5 m height x 60 m width, similar to Rama V Bridge. The basic conditions of design relating river are discussed between DRR and the Marine Authority and confirmed below;

(a) Only one bridge footing is allowed in the river

(b) The maximum distance of the footing is 100 m. from the east side of the river bank

Based on the above basic conditions, the minimum main span length is 200 m and the side span should be minimum of 100 m because the river width is approximately 300m. One of the piers can be maintained in the river. The river is slightly winding towards the east-south side so that depth of the river on the east side is deeper than the west side due to scouring. It is reasonable that western pier is constructed on-shore and eastern pier is off-shore with 200 m center span, 120 m side span on both sides and 460m in total length.

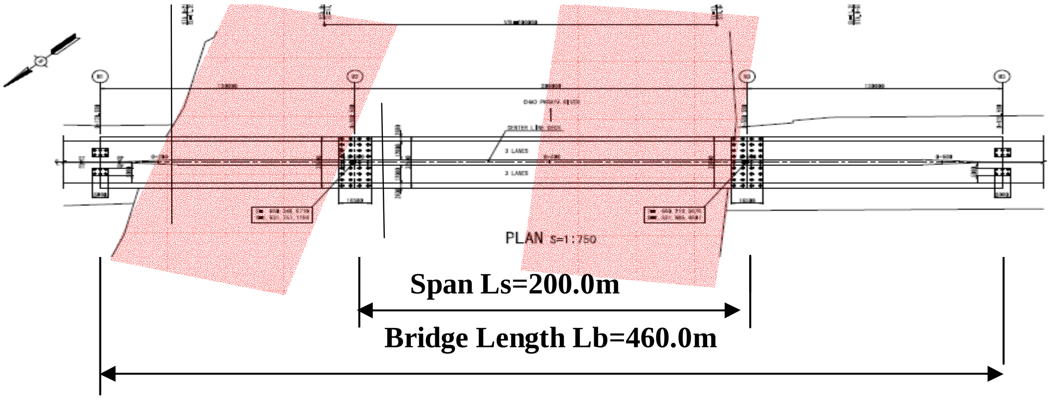


Figure 3.3.1 River Condition and Bridge Length

2) Review of Type of Bridge

In the F/S, the following types of bridges are compared and evaluated: cantilever box girder bridge, extradosed bridge and cable-stayed bridge.The extradosed bridge was finally selected for the main bridge crossing Chao Phraya River due to aesthetic reason while the cantilever box girder bridge ranked very close to extradosed bridge due to economic consideration.

The Chao Phraya River Crossing Bridge is directly connected to the river interchange situated on the west side corner so that decrease on the depth of bridge girder will somehow reduce the cost of interchange. It has to be noted that the depth of the girder of the extradosed bridge is 3 ~ 4 m lower than cantilever box girder bridge. Therefore, this type of bridge – the extradosed bridge - may be economical in terms of the total construction cost, if including the interchange. The alignment of the bridge crossing point is located near the public facilities such as temple, park and school/college. The type of bridge that must be constructed is required to harmonize to the surroundings, the structures, and facilities, especially the temple. It is accepted that the extradosed bridge that was designed will harmonize to the surrounding landscape and aesthetically pleasing from the surrounding community when viewed from a distance.

The general plan of the extradosed bridge prepared by the local consultant is shown in Fig. 3.3.2.

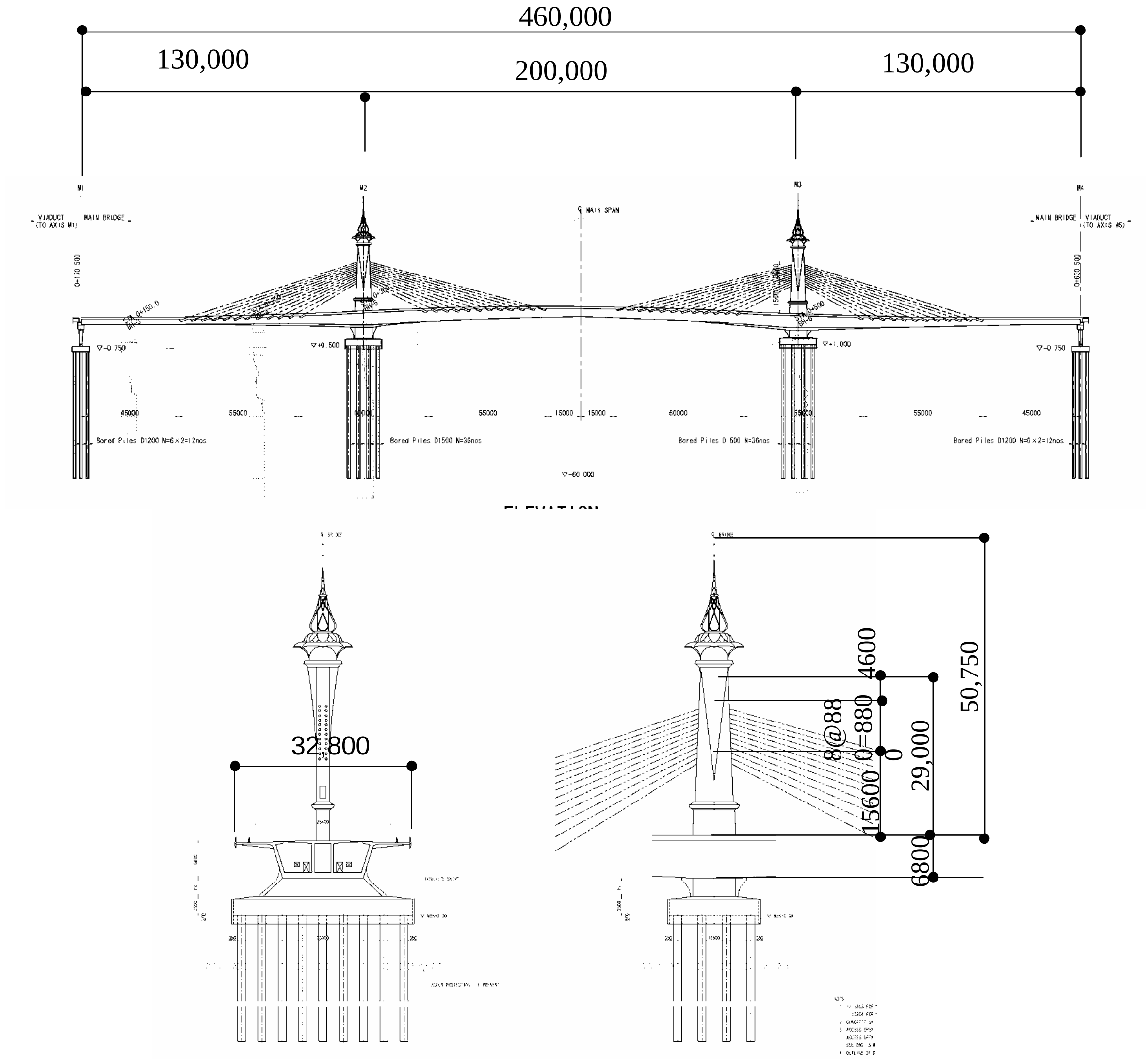


Figure 3.3.2 General Plan of Extradosed Bridge

Moreover, this extradosed bridge has single-plane stay cables, which are situated in the central median. The single-plane arrangement of the cables is advantageous in aesthetic points of view because it allows the piers to be arranged compactly and the intersecting stay cables to be inconspicuous. On the other hand, however, ample torsional stiffness is needed for the girder. Since this design has similar width and cross-sectional shape as the Kisogawa Bridge (span Ls=275 m), it should possess sufficient torsional stiffness. Therefore, it is deemed appropriate to select the aesthetically preferable single-plane cable arrangement for the bridge.

- Review of the main dimensions of the structure

Since the applicable span length of extradosed bridges is around 100~250 m, this bridge is the largest of its kind. The largest span of any extradosed bridge adopting concrete girders is Lmax=220m of the Tokunoyama-Hattoku Bridge. Hence, checking is conducted to make sure that the main dimensions of the structure of this bridge comply with the general requirements of extradosed bridges.

Table 3.3.1 Review of Structural Characteristics

Item		The Chao Phraya River Crossing Bridge	General Range
Max Span Lmax		200 m	100~250 m
Height of Pylon H（Ratio H/Lmax）		25.0 m(L/8)	(L/8~L/15)
Height of Girder	At Intermediate Pier Hgs (Hgs/Lmax)	6.8 m(L/30)	(L/35~L/40)
	At Center of Span Hgc (Hgc/Lmax)	3.3 m(L/60)	(L/50~L/60)

As shown in Table 3.3.1, the main bridge dimensions here fall within the general structural dimensions of extradosed bridges, except for the bridge height at the support. However, the bridge height at the support is higher than the generally adopted bridge height and does not represent a safety risk. Accordingly, this bridge is deemed to possess main structural dimensions capable of utilizing the structural characteristics of an extradosed bridge.

3) Review of the Safety Factor of Stay Cables

- Deciding on the safety factor for the stay cable

Review of the safety factor for the stay cable is verified by following the design stipulations stated in the "Standards for Design and Construction of PC Cable-Stayed Bridges and Extradosed Bridges, Japan Prestressed Concrete Engineering Association". The safety factor of the stay cable changes with the varying stress of the stay cable from live load. According to the standards, the safety factor of the stay cable is specified as specified in Table 3.3.2.

Table 3.3.2 Safety Factor of Stay Cable

Varying Stress ΔδL(N/mm2)	Safety Factor k (fa=k*fpu)	Type of Bridge
ΔδL<=70N/mm2)	K=0.6	Extradosed Bridge
70<ΔδL<100N/mm2	K=(1.067 – 0.00667ΔδL)	Cable- Stayed Bridge
ΔδL>100N/mm2	K=0.4	Cable-Stayed Bridge

(where、fa ;allowable stress of the stay cable, fpu; tensile strength of the stay cable)

- Review of the fluctuating stress of the live load

Table 3.3.3 shows the fluctuating stress based on the live load. The fluctuating stress of all stay cables shows less than or equal to 50 N/mm2 and the maximum stress is about 40 N/mm2. Accordingly, the allowable safety factor of the stay cable can be decided to be k= 0.6, which is equal to the allowable safety factor for a general extradosed bridge.

- Safety factor of stay cable: k=0.6
- Allowable stress : fa=0.6*fpu=1062kN

Table 3.3.3 Fluctuating Stress of the Cable by Live Load

Cable NO.		Hs	LaneLoad 1.3HS20-44	TruckLoad 1.3HS20-44	Bs truck HB45
			Δ σ L1	Δ σ L2	Δ σ L3
		m	N/mm2	N/mm2	N/mm2
Side Span	C12	82.214	29	9	23
	C11	79.219	30	10	25
	C10	74.224	32	10	26
	C9	69.230	33	11	27
	C8	64.237	33	11	28
	C7	59.245	33	11	29
	C6	54.254	33	11	29
	C5	49.265	32	10	28
	C4	44.278	31	10	27
	C3	39.295	30	9	26
	C2	34.316	29	9	24
	C1	29.345	27	8	22
Center Span	C1	29.328	27	8	21
	C2	34.298	29	8	23
	C3	39.276	32	9	25
	C4	44.258	34	10	27
	C5	49.245	35	10	28
	C6	54.234	37	11	29
	C7	59.224	38	11	30
	C8	64.217	39	11	31
	C9	69.210	39	12	31
	C10	74.205	39	12	31
	C11	79.200	39	12	31
	C12	84.196	38	11	31

Note: The value shown in the above table is carried out based on the calculation result offered by the D/D company. The table shows the horizontal distance of the stay cable from the anchored position at the pylon to the girder.

- Review of the safety factor of stay cables

Table 3.3.4 shows the safety factor of the stay cables. Since all stay cables show a safety factor of no more than 0.6, then the minimum limit value is satisfied.

Table 3.3.4 Safety Factor of Each Stay Cable

Cable NO.		Hs	Strand per CABLE	Area of CABLE	Braking Force	Safety Factor	Working Load
				Api=150mm2	Spu	fa=Sp/Spu	σ sp
		m	nos	mm2	kN	-	kN/mm2
Side Span	C12	82.214	50	7500	13,275	0.581	1028
	C11	79.219	50	7500	13,275	0.575	1018
	C10	74.224	50	7500	13,275	0.568	1005
	C9	69.230	40	6000	10,620	0.565	1000
	C8	64.237	40	6000	10,620	0.562	995
	C7	59.245	40	6000	10,620	0.559	989
	C6	54.254	30	4500	7,965	0.559	989
	C5	49.265	30	4500	7,965	0.558	988
	C4	44.278	30	4500	7,965	0.558	988
	C3	39.295	30	4500	7,965	0.557	986
	C2	34.316	30	4500	7,965	0.555	982
	C1	29.345	30	4500	7,965	0.553	979
Center Span	C1	29.328	30	4500	7,965	0.557	986
	C2	34.298	30	4500	7,965	0.557	986
	C3	39.276	30	4500	7,965	0.557	986
	C4	44.258	30	4500	7,965	0.558	988
	C5	49.245	30	4500	7,965	0.560	991
	C6	54.234	30	4500	7,965	0.560	991
	C7	59.224	40	6000	10,620	0.562	995
	C8	64.217	40	6000	10,620	0.565	1000
	C9	69.210	40	6000	10,620	0.568	1005
	C10	74.205	50	7500	13,275	0.572	1012
	C11	79.200	50	7500	13,275	0.578	1023
	C12	84.196	50	7500	13,275	0.582	1030

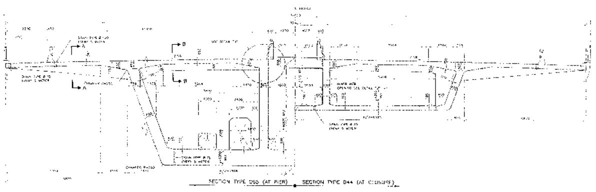
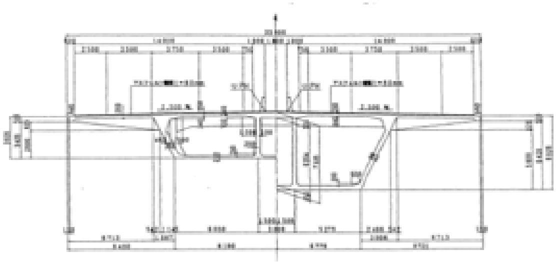
Note: The value shown in the above table is carried out based on the calculation result offered by the D/D company

4) Review of Standard Cross Section

The Chao Phraya River Bridge has a total width of 32.8 m and configured to have slabs with ribs. An example of a ribbed slab bridge of similar width in Japan is the Kisogawa Bridge. The cross-sectional examination is thus carried out by comparing the cross section components of the Chao Phraya River Bridge with Kisogawa Bridge.

As indicated in Table 3.3.5, the Chao Phraya River Bridge has the same cross-sectional composition as Kisogawa Bridge. Since a similar cross-sectional composition was adopted and the performance was so far excellent, it is anticipated that there will be no structural problems that will be encountered in the future. However, whereas the cantilever construction method using precast segments was used in the case of Kisogawa Bridge, the cast-in-place cantilever construction method is planned for the Chao Phraya River Bridge. One of the disadvantages of using this method will be its complication while working with the formworks and may entail much time to prepare than the usual method.

Table 3.3.5 Comparison of the Cross Section Components

Bridge Name	Dimension			Typical Cross Section
The Chao Phraya River Bridge	Bridge Width		32.8m	
	Deck Slab	Span	6.600m	
		Thickness	0.260m	
	Deck Slab Reinforced Rib	Spacing	2.500m	
		Height	0.660m	
		Thickness	0.400m	
	Web Minimum Thickness	Outside Web	0.400m	
		Inside Web	0.400m	
The Kisogawa Bridge	Bridge Width		33.0m	
	Deck Slab	Span	6.780m	
		Thickness	0.260m	
	Deck Slab Reinforced Rib	Spacing	2.500m	
		Height	1.200m	
		Thickness	0.250m	
	Web Minimum Thickness	Outside Web	0.350m	
		Inside Web	0.300m	

5) Review of Saddle

When adopting a saddle structure for affixing the stay cables to the tower, in order to prevent fretting strain on PC steel, it is stipulated that the stress variation caused by live load should not be more than 50 N/mm2 (Refer to Standards for Design and Construction of PC Cable-Stayed Bridges and Extradosed Bridges, Japan Prestressed Concrete Engineering Association). Checking here is mandatory and must be conducted to ensure that this criterion is satisfied.

As indicated above, the maximum stress variation caused by live load is 40 N/mm2, which satisfies the limit value.

The stay cables adopted in the Chao Phraya River Bridge has larger capacity than those for common extradosed bridges. Hence, the possibility for adopting saddle structure is verified upon review of the performance of stay cables in saddle structures (See Table 3.3.6). The maximum capacity of stay cables used in the Chao Phraya River Bridge is as follows:

- Type of steel cables: 50S15.7mm
- Allowable tension: Pa=0.6*265*50=7,950 kN

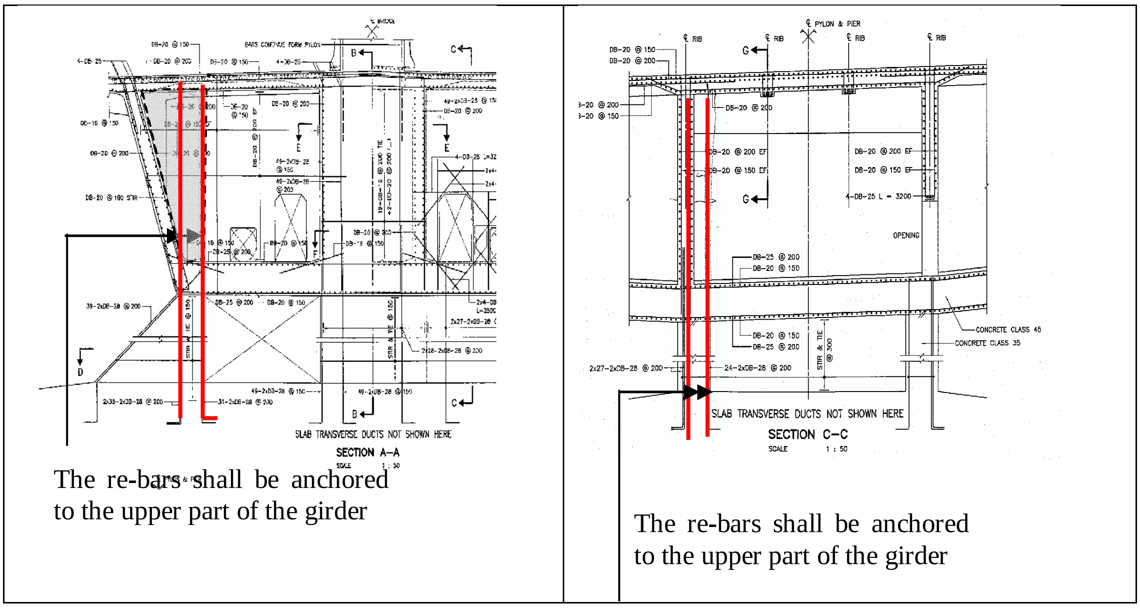
The largest stay cables adopted on extradosed bridges with saddle structure are 48S15.2. In the case of cable-stayed bridges, a saddle structure for large capacity (156S15.2) has been developed. Although the Chao Phraya River Bridge will require stay cables with the greatest capacity for extradosed bridges in the world, the development of saddle structure suited to large capacity stay cables means that it will be possible to adopt the saddle structure. However, it will be necessary to implement tests to measure its performance characteristics, such as bond and friction, etc.

Table 3.3.6 Results of the Saddle System for Stay Cables with Large Capacity

Bridge Name	Type of PC Cable	Allowable Force	Country
Second Mactan Bridge	48S15.2	7,500kN	Philippines
Yanagawadamu No.9 Bridge	37S15.2	5,780kN	Japan
Nakanoike Bridge	37S15.2	6,780kN	Japan
Maumee River Crossing (Cable-Stayed Bridge)	156S15.2	15,600kN	USA

6) Review of Connection between Superstructure and Sub-structure

The Chao Phraya River Bridge adopts a rigid frame structure with fixed connections between superstructure and sub-structure. These connections play an important role in transferring loads from the superstructure to the substructure. These connections are the subject of structural investigation and verification. In the current design, since the use of reinforcing bars leading out of the piers are not sufficiently developed to take any loads from the superstructures, there is a possibility that the bending moment from girders to piers will not be transferred. Therefore, as shown in Figure 3.3.3, the reinforcing bars from the piers should be adequately fixed to the superstructure.



The re-bars shall be anchored to the upper part of the girder

The re-bars shall be anchored to the upper part of the girder

Figure 3.3.3 Connection between Superstructure and Sub-structure

7) Review of Stay Cable Damping

Since the Chao Phraya River Bridge is an extradosed bridge with a span of 200 m, the stay cables are long and arranged in parallel. Because of the concern over rain vibration or wake galloping vibration caused by wind, it is recommended that dampers be installed on the stay cables.

8) Review of PC Stressing of Pile Cap in Water

The bottoms of the M2 pier pile caps installed in the river are reinforced with PC steel tendons. Since these are repeatedly exposed to a constant and changing environment that is “with or without “ moisture/water and air conditions and depending on the river water level due to high or low tide, the environment that is created is a corrosive environment. This condition has detrimental effects to the concrete and reinforcing bars, and therefore must be addressed during the design and construction.

Accordingly, it is recommended that design for pile cap of pier in the river, which is pre-stressed by PC tendons at the bottom, should be changed to reinforced concrete in order to avoid the risk of breakage due to corrosion of PC steel tendons.

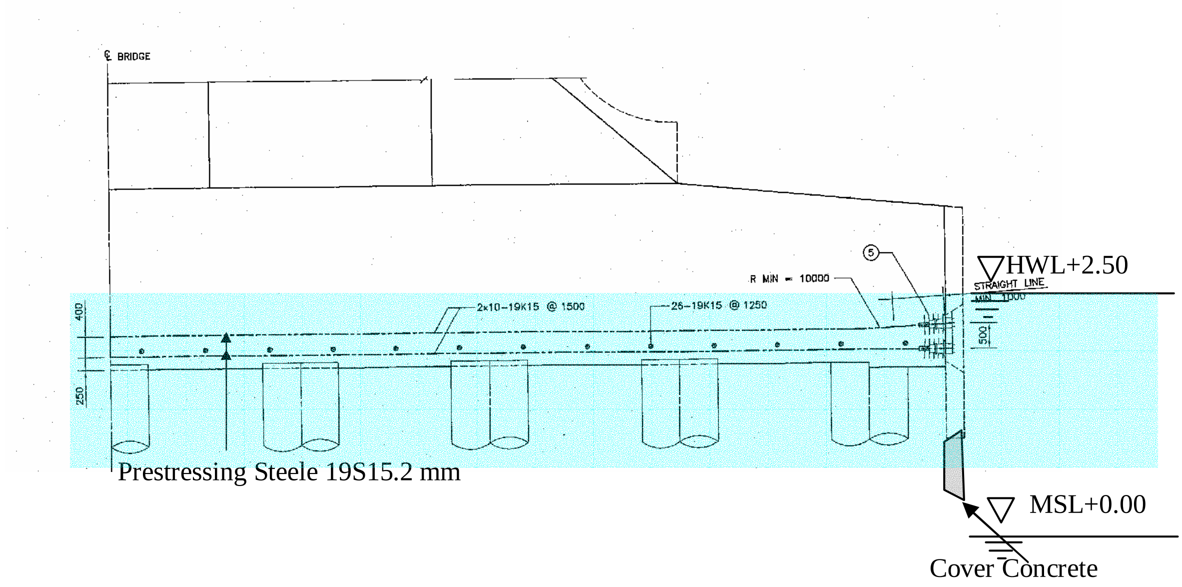


Figure 3.3.4 Prestressing Steel in the Pile Cap

(2) Review of Main Lane Viaduct

The main lane viaduct and on-off ramps are designed as cast-in-place prestressed concrete box girders using post-tensioned construction method and the foundation is also supported by cast-in-place concrete bored piles. The viaduct has been extended up to 930 m from the main bridge because the U-turn facility and overpass of the existing road are planned to maintain smooth driving.

This type of viaduct and on-off ramp is standardized and utilized in Bangkok. Design review was conducted and there is no comment on the completed design.

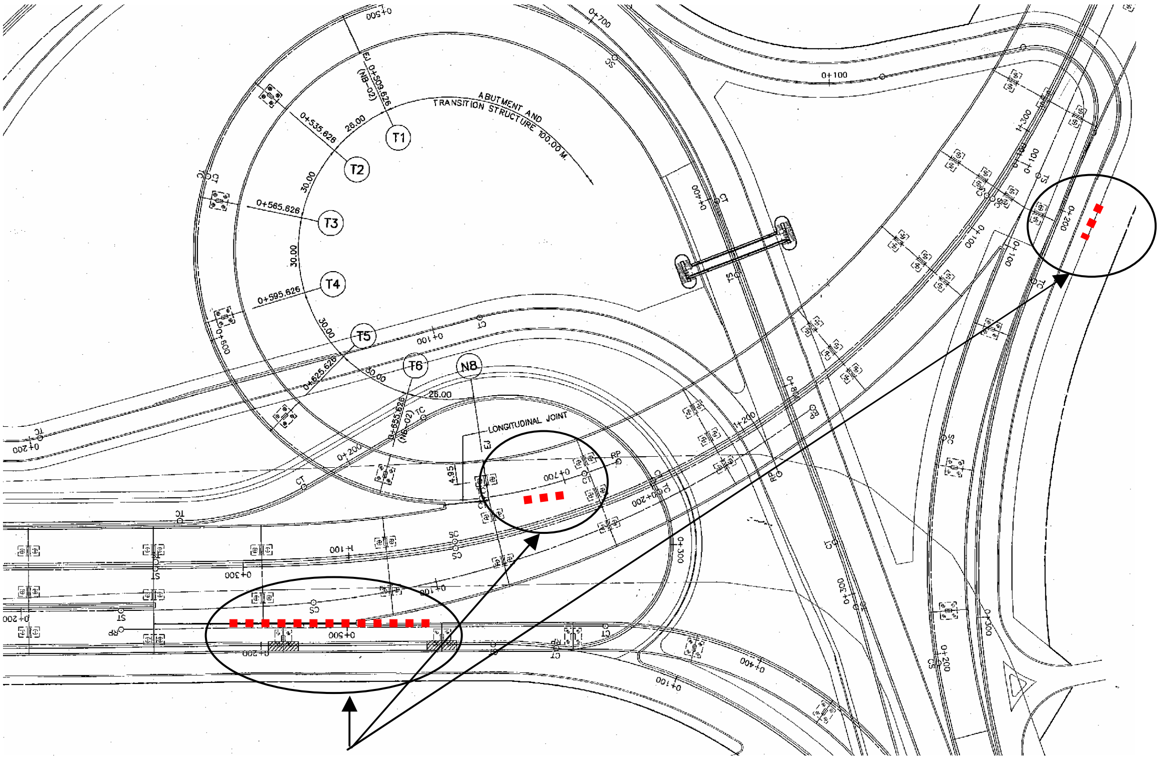
(3) Review of Nonthaburi 1 Road Interchange

1) Review of Longitudinal Expansion Joint

The ramp section includes three longitudinal joints between the main road and the ramp junction (see Figure 3.3.6). However, the longitudinal joints are prone to structural vulnerability and lead to reduced structural durability and grade differentials caused by varying flexure. Accordingly, it is recommended that a structure that does not require longitudinal joints be examined. The following approaches can be considered:

(a) Installing the piers in nose positions (in this case it is necessary to greatly alter the existing D/D span layout).

(b) Branching girders so that the superstructure is in line with the ramp alignment (in this case the superstructure design becomes complicated and it is necessary to give ample consideration to the detailed design).



Longitudinal Joint

Figure 3.3.5 Longitudinal Joints in the Interchange

(4) Review of Ratcha Phruk Road Interchange

1) Review of Flyover

The Ratcha Phruk Road Interchange consists of one flyover with two traffic lanes in parallel with the existing flyover and two ramp bridges (457 m and 486 m), both with two traffic lanes. The total length of the new bridges is 1,188 m. The ramp bridges, which are crossing over the existing road and connect to the main lane at-grade road, are functioning as flyovers. New flyovers and ramp bridges are constructed separately in proper order considering traffic safety especially in the construction of the ramp bridge crossing over the existing flyover. Since the bridge type of post-tensioned PC box girder is standardized and often constructed in Thailand, there is no objection or comment on adopting it. It is however requested that an economical detailed design of the foundation be conducted in consideration of the different pier heights.

(5) Minor Bridge

Two minor bridges crossing canals are designed on the at-grade road. This type of minor bridge is standardized and often constructed in Thailand. As a result of the review, there is no objection or comment adopting it on the design.

(6) Review of the Main Lane At-Grade Road

The main lane at-grade road is designed as a low embankment between the main lane viaduct on the west side of the river and Ratcha Phruk road interchange with six traffic lanes. The height of embankment is less than 2.0 m and the transition section to structures such as flyover and interchange viaduct and ramps are provided with concrete structures supported piles to avoid settlement. Structures of the transition section have two types which are a piled slab and Π shaped ridged structures. The piled slab is applied for heights of less than 3.0 m and Π shaped ridged structures for heights less than 5.0 m. This combination structure is structurally and economically a good design. As a viaduct and flyover are provided at the height of over 5.0 m, bridge maintenance around the abutment is easier especially for replacement of bearings.

This type of at-grade road on soft ground is standardized and utilized in Thailand. As a result of the review, there is no objection or comment on the design of the at-grade road for the main lane road.

3.3.2 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

There are two methods in erecting extradosed bridge, namely the cast-in-place method using large traveler wagons and the pre-cast segmental method. In the pre-cast segmental method, the segment box girders are pre-fabricated at the fabrication yard and transported by barge and lifted up by erection nose in the site. A large fabrication yard is required near the site and also, river traffic may be interrupted during transportation and lifting up of the segment.

On the other hand, the cast-in place method using traveler wagon, which is selected in the detailed design, is the common erection method for extradosed bridges and river traffic is not interrupted during the erection. Large traveler wagon for six lanes is available in Thailand. There is no objection on the use of the cast-in-place method selected in the detailed design. However, the concrete deck slab with rib may disturb the traveler wagon moving forward smoothly and the cycle time for the erection will be longer than ordinary.

(2) Review of Erection of Post-tension PC Box Girder Construction

The methods of erection of PC box girders are also limited to two methods only, the cast-in-place and pre-cast segmental methods. Since the cast-in-place method is selected for the extradosed bridge, the same method should be selected for the PC box girders of viaducts due to economic consideration. Launching scaffolding, which is proposed in the detailed design, is a very common cast-in place method which will not disturb the traffic in Bangkok and the equipment is available in Thailand. However, this launching scaffolding is only applied for straight or large curve sections but PC box girders with small curve sections in the interchange should use cast-in-place method supported by fixed steel staging.

(3) Review of Temporary Bridge or Jetty for Construction of Pier in the River

Transportation of materials and equipment to the pier construction in the river can be done using two methods; one by using barges and provided with temporary jetty. The temporary jetty method proposed in the design is accepted in order to maintain the main navigation width without interrupting the river traffic. The sketch of the jetty is shown Fig. 3.3.6.

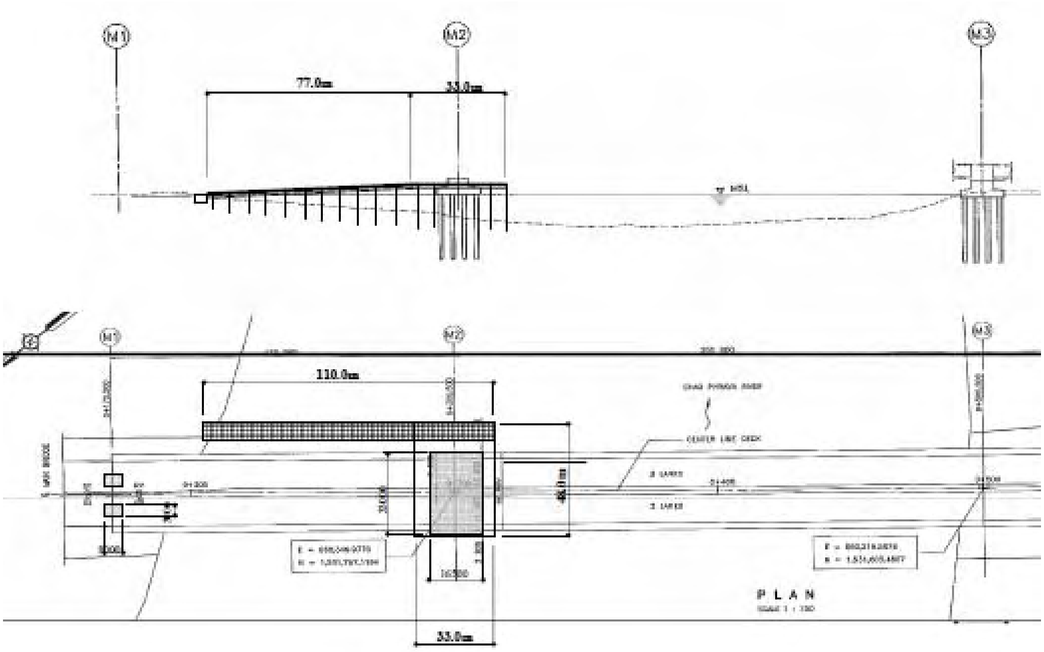


Figure 3.3.6 Construction Plan of Temporary Jetty

(4) Review of Pre-stress in Cantilever Erection

Pre-stress in the center of the upper slab in cantilever erection of stay cables must be reviewed, since cracks are likely to occur at the point not pre-stressed by the stay cable due to the weight of the box girder and traveler wagon. It is recommended that temporary pre-stressing bars be provided for temporary measurement when moving the traveler wagon forward as shown in Fig.3.3.7.

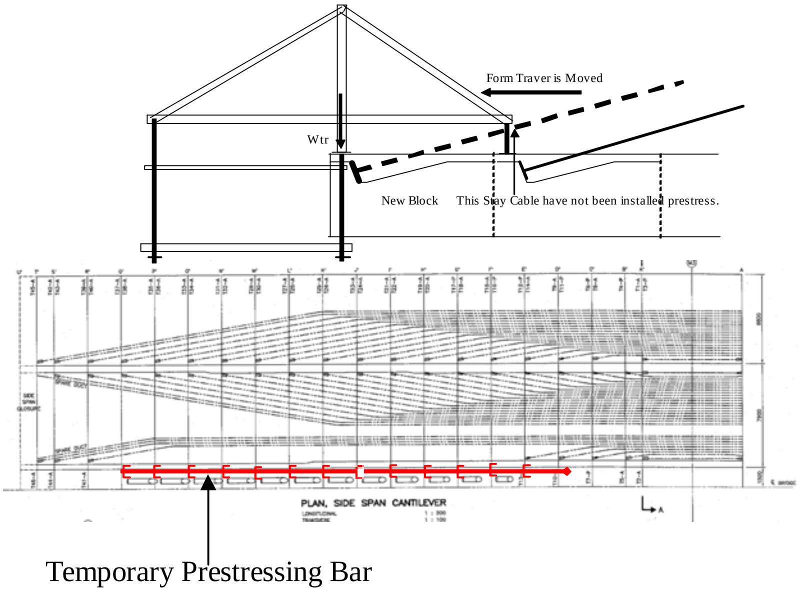


Figure 3.3.7 Temporary Prestressing Bar in Cantilever Erection

3.3.3 REVIEW OF PROCUREMENT PLAN

(1) Major Works

Major works consist of the main bridge, main lane viaduct, Nonthaburi 1 Road Interchange, Ratcha Phruk Road Interchange and main lane at-grade road with 2,275 m. Most of the road structures are bridges, including an extradosed bridge. The details of the bridges such as main bridge, ramp bridge and flyovers are summarized in Table 3.3.7

Table 3.3.7 Summary of Bridges and Structures

NO.	Bridge name	Type of Bridge	Bridge Length	Number of Span	Number of Pier	Max. Span
			m	nos	nos	m
1	Main Bridge	Extra-dosed Bridge	460.000	3	4	200.00
2	Main Line Viaduct	PC Box Girder	930.000	29	29	36.00
3	Ramp (ML-01)	PC Box Girder	151.000	5	5	33.00
4	Ramp (ML-02)	PC Box Girder	124.000	4	4	34.00
5	Ramp (NB-02)	PC Box Girder	172.000	6	6	30.00
6	Viaduct (NB-03)	PC Box Girder	904.000	30	30	40.00
7	Ramp (NB-04)	PC Box Girder	601.000	19	19	44.00
8	Ramp (NB-05)	PC Box Girder	130.000	4	4	35.00
9	Ramp (NB-14)	PC Box Girder	194.000	6	5	36.00
10	Ramp (NB-15)	PC Box Girder	286.000	9	10	36.00
11	Ramp (NB-16)	PC Box Girder	314.000	10	10	38.00
12	Ramp (RP-02)	PC Box Girder	457.000	15	16	44.00
13	Flyover (PR-03)	PC Box Girder	245.000	7	8	41.00
14	Ranp (RP-04)	PC Box Girder	486.000	12	13	40.00
15	Minor−1	PC Box Beam	15.000	1	2	15.00
16	Minor−2	PC Box Beam	20.000	1	2	10.00
Total			5,489.00	163.00	167.00	712.00

(2) 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 3.3.8.

Table 3.3.8 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	

(3) Procurement of Consultant and Contractor

Extradosed bridge is the first bridge of its kind in Thailand. However, six cable-stayed bridges, which are of similar type to the extradosed bridge, have been constructed in Thailand. Consultants and contractors in Thailand have been involved in the construction of the cable stayed bridges as shown in Table 3.3.9.

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.

Table 3.3.9 List of Consultants and Contractors Experienced in Cable-Stayed Bridges

NO	BRIDGE NAME	DE SI G		SUPERVISION CONSULTANT		CONTRACTOR	
1	Rama VIII Bridge		-	1	Epsilon Co.,Ltd. (Thai)	1	PPD Construction (Thai)
				2	Mott MacDonald Co.,Ltd.	2	Chaina State Construction Engineering
				3	P&Cigna Co.,Ltd. (Thai)	3	BBR Systems Ltd.
						4	BBR Holding Ltd.
						5	Sctt Wiilson Kirkpatrick (Thailand)Ltd. (Thai)
						6	Scott Wilson Asia-Pacifiic Ltd.
						7	Buckland & Taylor Ltd.
						8	Asdecon Co.,Ltd. (Thai)
						9	PCD Group Engineering Consultant (Thai)
2	Rama IX Bridge						
		1	Peter Fraenkel & Partners	1	Peter Fraenkel & Partners	1	Hitachi Zosen Corp.
		2	Dr.-ING. Hellmut Homberg	2	Dr.-ING. Hellmut Homberg	2	Tokyo Consturction
		3	Parsons Brinckerhoff International	3	Parsons Brinckerhoff International	3	Kobe Steel
		4	National Engineering (Thai)	4	National Engineering (Thai)		
3	Industrial Ring Road Bridge (North)						
		1	Epsilon Co.,Ltd. (Thai)	1	Asian Engineering Consultants (Thai)	1	Taisei Corporation
		2	Mott MacDonald Ltd.	2	Team Consulting Engineer (Thai)	2	Nishimatsu Construction
		3	Norconsult International A.S.	3	Thai Egnineering Consultant (Thai)	3	JFE Engineering
				4	Index Internatiional Group (Thai)	4	Sino-Thai Engineering and Construction (Thai)
				5	Jean Muller International		
4	Industrial Ring Road Bridge (South)						
		1	Epsilon Co.,Ltd. (Thai)	1	Asian Engineering Consultants (Thai)	1	Taisei Corporation
		2	Mott MacDonald Ltd.	2	Team Consulting Engineer (Thai)	2	Nishimatsu Construction
		3	Norconsult International A.S.	3	Thai Egnineering Consultant (Thai)	3	JFE Engineering
				4	Index Internatiional Group (Thai)	4	Sino-Thai Engineering and Construction (Thai)
				5	Jean Muller International		
5	Kanchanapisek Bridge						
		1	Asian Engineering Consutlants (Thai)	1	Asian Engineering Consultants (Thai)	1	CH. Karnchang (Thai)
		2	Thai Engineering Consultants (Thai)	2	PB Asia (Thai)		
		3	PB Asia Ltd.	3	Thai Engineering Consultants (Thai)		
		4	Oriental Consultants Co.,Ltd.				
		5	Siam General Engineering (Thai)				
		6	Enviormental Research Institute (Thai)				
6	SECOND THAI-LAO FRIENDSHIP BRIDGE						
		1	Oriental Consultants Co.,Ltd.		-	1	Sumitomo
		2	Nippon Koei Co.,Ltd.			2	Wichitpun (Thai)
						3	Siam Syntec Construction (Thai)

3.3.4 REVIEW AND UPDATE OF THE CONSTRUCTION COST

Construction cost was reviewed based on the following materials:

- Third Additional Information on the Cost Estimate, Contract No.1 and Contract No.2
- Design (Mainly Construction Drawings)
- Breakdown of Unit Prices

(1) Review of Construction Cost

Construction materials required for the project are mainly procured in Thailand except for the stay cable and anchorages, PC tendons and anchorages, HDPE sheath, and saddle for the stay cable. Equipment for the erection girder including erection wagon for the extradosed bridge and other construction of the works are available in Thailand.

Unit price for each work item was estimated by the local consultant and accepted by DRR. The unit prices are a little bit lower compared to JICA-assisted projects in other countries. However, it is reasonable that the following construction conditions may reduce the unit prices in Bangkok.

- Almost all materials and equipment are procured in Bangkok
- Most of structures and road, except the extradosed bridge, are common types and local contractors are experienced and possess suitable equipment (including formworks) for

such structure and road works.

- Skilled labors experienced in similar projects have high capacities.

Regarding the extradosed bridge, the unit prices may increase in case a foreign contractor will join the Project. Direct cost such as materials, equipment and labor are of the same condition as estimated by local consultant, but it is recommended that the contractor’s overhead be modified for the foreign contractor.

(2) Update of Construction Cost

Construction cost was updated through the following factors:

1) Factor F

Factor F is the conversion factor from original construction cost which is suggested by DRR in September 2009 and governmental factor for civil construction. It may be for price adjustment of materials, equipment and labor.

2) Additional works

As a result of the review by JICA survey team, the additional works proposed by bridge specialists will be included in the construction cost. The proposed additional works include:

- Highly moist rubber damper which is to absorb vibration of the stay cable due to vortex and rain-wind induced and galloping.
- Waterproofing on concrete deck slab of extradosed bridge.

3) Missing Works in BQ Item

After the review by the JICA survey team, missing works found by bridge specialists will be included in the construction cost. The recovered missing works are:

- Temporary bridge or jetty for construction of the pier in the river
- HDPE sheath to protect deterioration of stay cables

4) Review of Unit Price and Overhead

Based on the design and cost review by JICA Survey Team, bridge specialists found out that some of the unit prices are unreasonably low prices. These unit prices are as follows:

- Unit price of stay cable for extradosed bridge is approximately Baht 210,000 but Baht 110,000 in the cost estimate. The cost difference of Baht 100,000 was added to the unit price and the resulting cost estimate amount increased by Baht 27,000,000.
- As extradosed bridge is constructed by the foreign contractor, site overhead including mobilization is necessary to be increased in comparison with local contractor. An additional ten percent of site overhead is necessary for a foreign contractor (approximately Baht 37,487,000)

5) Cost Estimation of Additional Items

Based on the above reviews by JICA survey team, additional costs are provisionally estimated as shown in Table 3.3.10.

Table 3.3.10 Additional Costs

Unit: Baht

No.	Description	Unit	Quantity	Unit Price	Amount
1.	Rubber Damper of Stay Cable	ea	48	180,000	8,640,000
2	Waterproofing material on Deck Slab	m2	11,000	770	8,470,000
3	Temporary Jetty	m2	2,200	5,040	11,088,000
4	HDPE Sheath	m	2,260	1,770	4,000,200
	Total				32,198,200

6) Review of Tender Documents (Design Drawings and BQ)

Based on the results of the review of tender documents by the JICA survey team, the tender drawings were found to be only on preliminary level of basic design. Design calculations of structures are not done per structure part. Considering the quality, safety and maintenance aspects in bridge design, the following points should be considered in the original design.

a) Design for pile cap of pier in the river is pre-stressed by PC tendons at bottom should be changed to reinforced concrete because of the risk of breakage due to corrosion of PC tendon.

b) Longitudinal gradient of viaduct shall be 0.2% ~ 0.5% instead of 0% to improve the drainage function.

c) Longitudinal expansion joint shall be deleted in point of maintenance and structural defect. Span re-arrangement is necessary for the measure.

d) Main bridge shall be symmetric on both sides at the crown of vertical arrangement of road. The crown of the vertical alignment of the road shall move 15.5 m toward the west side.

Tender documents obtained in DRR may apply for selection of contractor. However, the preparation of new drawings and detailed design stated above should be made by the consultant before the construction, although the contractor may do it and the consultant checks for Engineer’s approval. Costs of detailed design and preparation of new drawings are roughly estimated at Baht 23,833,000.

DRR proposed that local consultants should be selected for supervision of construction. Judging from the design review and experience of the local consultant, foreign consultants to control construction safety and quality should be involved in the Project.

7) Update of Construction Cost

Based on the above review, the construction cost is updated in Table 3.3.11.

Table 3.3.11 Updated Construction Cost in October 2009

Unit: Baht

No.	Description	Construction Cost	Additional Cost	Updated Cost
1	General Requirements	124,501,000	61,320,000	193,154,000
2	Nonthaburi Road Interchange	848,936,000		832,423,000
3	Main Bridge	720,682,000	59,198,000	812,994,000
4	Main Line Viaduct and Land Minor Bridge	601,007,000		576,704,000
5	Ratcha Phruk Road Interchange	267,870,000		243,098,000
6	Bridge Accessories	114,682,000		103,660,000
7	Roads and Landscaping	764,799,000		765,542,000
8	Mechanical and Electrical Services	102,518,000		123,872,000
9	Utility and Miscellaneous Relocation	167,477,000		182,196,000
10	Force Account Work	9,183,000		8,653,000
Total		3,721,655,000	120,518,000	3,842,296,000

The breakdown of the construction cost is shown in Appendix-2.

3.3.5 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 3.3.12 and 3.3.13. 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. The construction cost after adjustment is Baht 3,796,000 which is almost the same amount approved by the DRR cabinet.

Table 3.3.12 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)
	Total				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 3.3.13 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 shown in Table 3.3.14.

Table 3.3.14 Final Construction Costs after Adjustment

Unit: Baht

No.	Description	Original Construction Cost	Revised Construction Cost	Balance
1	General Requirements	124,501,000	131,834,000	7,333,000
2	Nonthaburi Road Interchange	848,936,000	832,423,000	-16,513,000
3	Main Bridge	720,682,000	753,796,000	33,114,000
4	Main Line Viaduct and Land Minor Bridge	601,007,000	576,704,000	-24,303,000
5	Ratcha Phruk Road Interchange	267,870,000	243,098,000	-24,772,000
6	Bridge Accessories	114,682,000	103,660,000	-11,022,000
7	Roads and Landscaping	764,799,000	765,542,000	743,000
8	Mechanical and Electrical Services	102,518,000	123,872,000	21,354,000
9	Utility and Miscellaneous Relocation	167,477,000	182,196,000	14,719,000
10	Force Account Work	9,183,000	8,653,000	-530,000
Total		3,721,655,000	3,721,778,000	123,000

Note: VAT is not included in construction cost

3.3.6 REVIEW OF IMPLEMENTATION SCHEDULE

(1) Present Condition

DRR had finished the F/S, EIA, D/D works and most of the land acquisition, consigning it to a consulting firm as the first phase. Preparation for tender is also consigned as the second phase to a consultant and is now proceeding. As of the end of September 2009 most of the work seems completed, except detailed design in which more technical cooperation seems necessary. The work is now temporarily stopped and will be reopened after the pledging by JICA. The consulting work until the decision of the contractor is cosigned by the joint venture of Epsilon Co., Ltd. and Wishakorn Co., Ltd.

(2) Work Schedule from the present

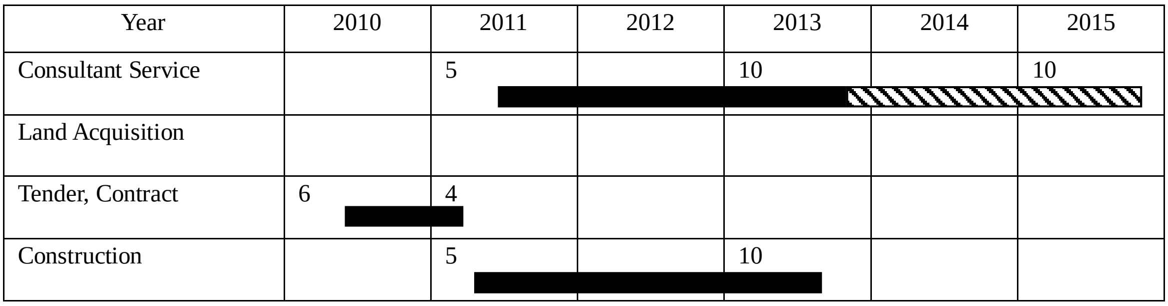
The earliest schedule from the present will be as following;

- Pledge	Jan., 2010
- E/N, L/A sign	March, 2010

- Tender document, PQ, JICA agree	March, April, and May, 2010
- Tender of bid	Jun, July, and Aug., 2010
- Evaluation of bid	Sept. and Oct., 2010
- JICA agree	Nov., 2010
- Contract negotiation	Dec., 2010
- Approval by Budget Beaureu	Feb., 2011
- Contract L/C open	April, 2011
- Construction start	May, 2011
- Construction finish	Oct., 2013

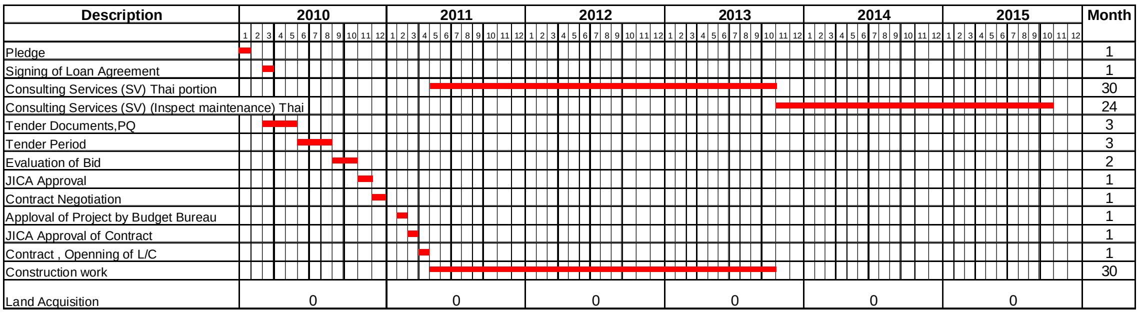
The selection of the consulting firm for construction supervision, which takes six months, can be done while preparing for the tendering for construction. This detailed schedule is shown in Table 3.3.16.

Table 3.3.15 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 3.3.16 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	1 2 3 4 5 6 7 8 9 10 11 12	1 2 3 4 5 6 7 8 9 10 11 12	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
Applova of Project by Budget Bureau							1
JICA Approval of Contract							1
Contract , Openning of L/C							1
Construction work							30
Land Acquisition	0	0	0	0	0	0	

3.3.7 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

CHAPTER 4 IMPLEMENTATION STRUCTURE AND PROGRAM

4.1 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).

4.1.1 ORGANIZATION

The headquarter of DRR consists of 11 Bureaus, and the Regional Bureau which is one of the Bureau in the headquarter consists of 18 District Offices as shown in Figure 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 18 district offices.

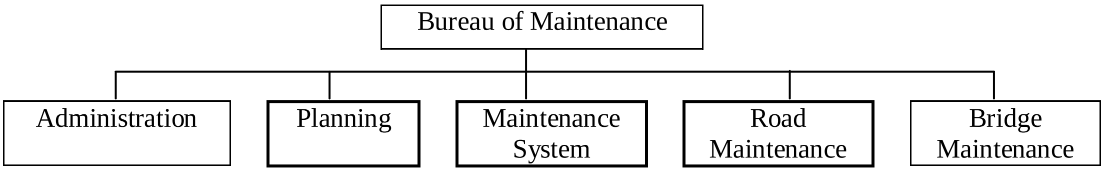
Location of the headquarters and 18 district offices are shown in Table 4.1.1. The city and region of each office are shown in the table.

Table 4.1.1 Location of Office

Office Name	Location		Office Name	Location	
	City	Region		City	Region
Headquarters	Bangkok	Central	District 10	Chiang Mai	Northern
District 1	Pathum Thani	Central	District 11	Surath Thani	Southern
District 2	Sara Buri	Central	District 12	Songkhla	Southern
District 3	Chon Buri	Central	District 13	Chachemgsao	Central
District 4	Pechaburi	Southern	District 14	Suphan Buri	Central
District 5	NakhonRachasima	Northeastern	District 15	Udon Thani	Northeastern
District 6	Khon Kean	Northeastern	District 16	Kalasin	Northeastern
District 7	Ubon Rachathani	Northeastern	District 17	Chang Rai	Northern
District 8	Nakhon Sawan	Northern	District 18	Krabi	Southern
District 9	Utaradit	Northeastern			

Due to the 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.



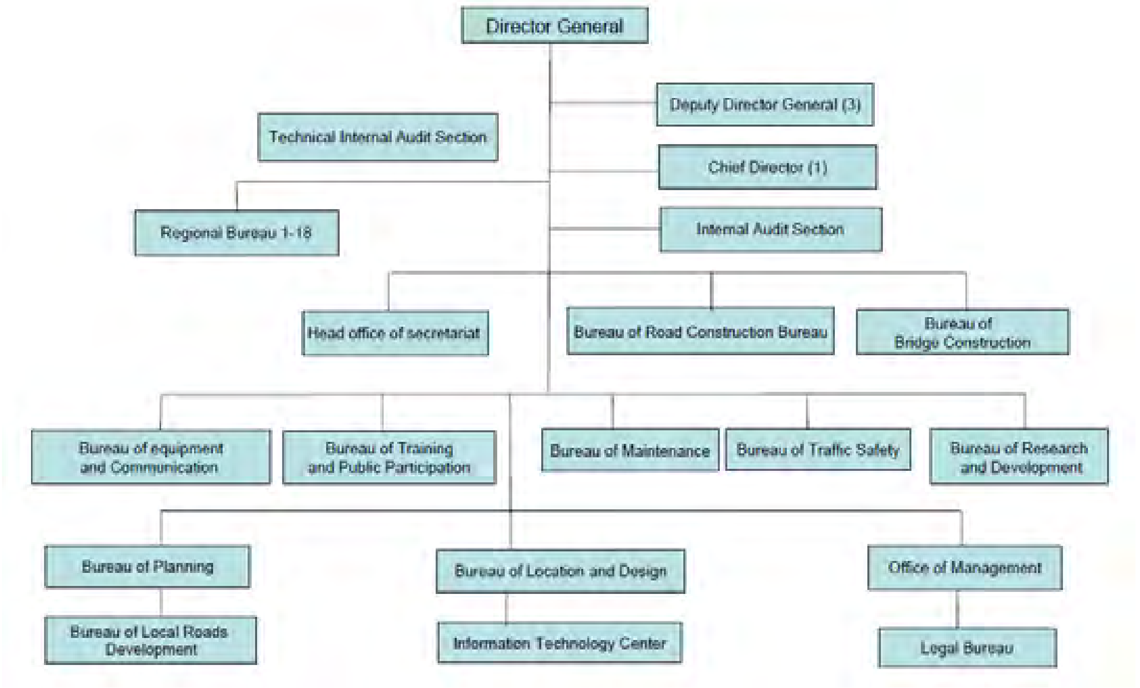


Figure 4.1.1 Organization Chart of DRR

The budget in 2007 and 2008 decreased by about 18% compared with 2006, although it expanded from 2003 to 2006 by 15% on the average, and the budget in 2009 recovered to the 2006 level as shown in Table 4.1.2. As the breakdown of the budget, development road and network, operation and maintenance, and others (capacity development, etc.) are shown in the table. DRR has no other income sources such as toll roads.

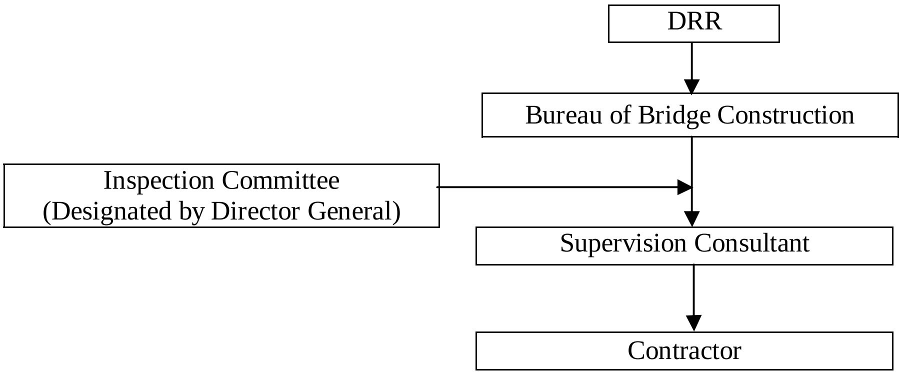
Table 4.1.2 Transition Annual Budgets of DRR, including Personnel Expenses

Unit:million baht

Fiscal year	2005	2006	2007	2008	2009
1.Development Road and Network	13,539.121	13,693.612	9,624.842	8,705.409	13,087.791
2.Operation and Maintenance	4,127.736	5,179.868	5,752.207	6,436.451	6,853.131
3.Others	95.212	2,568.560	2,481.813	2,162.513	2,429.051
Total	17,762.069	21,442.040	17,858.862	17,304.373	22,369.973

4.1.2 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 Figure4.1.2.



* Inspection committee is responsible for approval of procurement documents, such as payment and certificate of completion. The committee's members consist of representatives of each department of DRR.

Figure 4.1.2 Project Organization Chart for Implementation of Construction Phase

Thus, the construction of this project will be executed with the same system as the industrial ring road bridge construction which completed in 2006. Bureau of Bridge Construction of DRR will take charge of construction of Nonthaburi 1Road Bridge Project, and it will take charge of maintenance after construction. And there is no idea of the installation of project management unit (PMU).

There are one expert civil engineer, nine senior engineers, 17 civil engineers and 18 technicians in the Bureau of Bridge Construction

The project is a road construction of 4.3 km in the total length, six lane widths including Extradosed prestressed concrete bridge, 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 200 m in the main span length and 32.8 m width.

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 had 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.

4.2 OPERATION AND MAINTENANCE STRUCTURES

4.2.1 PRESENT CONDITION OF O&M OF DRR

There are ten maintenance offices under the Bureau of Maintenance of DRR. Those offices conducted the maintenance works of the road and bridge in the Bangkok Metropolitan Area as shown in Table 4.2.2.

Exceptionally, the maintenance work of the Industrial Ring Road (IRR) Bridge is conducted by the office under the Bureau of Bridge Construction which constructed Industrial Ring

Road Bridge. Director of IRR Bridge Management Division will double as the director of project division, and new staffs will be assigned from the Bureau of Bridge Construction. 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.

And, Pathum Thani District Office in the District 1 is conducted maintenance work for Liang Muang Pak Kret Road connecting with Tivanon Road, and Liang Muang Nontaburi Road which will be connected with Nonthaburi 1 Road (Project Road).

The budget in 2009 decreased by 5% compared with the previous year although it expanded from 2003 to 2006 by 15% on the average as shown in the Table 4.2.1. The reason for a decrease is that the maintenance cost was decreased to correspond to the increase of the construction cost.

Table 4.2.1 Transition of the Budget of the Bureau of Maintenance, excluding Personnel Expenses

million Baht

Fiscal year	2004	2005	2006	2007	2008	2009
Budget	3,423	3,778	4,800	5,330	6,000	5,717

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

The roads and bridges that are well-managed or attended are shown in the same Table while the location of the office and as welll as the managed roads and bridges are shown in the Figure 4.2.1

Table 4.2.2 Maintenance Office and Outline of Office

Maintenance Office	Managed Road and Bridge		Number of Stuff
	Roads	Bridges	
Office 1 (Rattana Thibet Interchange)	Ratcha Phruek Road (km17+200-31+102) Chaiya Phruck Road	Rama IV Bridge	Senior Technician 1 Technician: Civil 1,Electrical 1 Secretary 1 Labor 70
Office 2 (Nakhon In Interchange)	Nakron In Road (+Park)	Rama V Bridge	Senior Technician 1 Technician: Civil:1,Electricity:1 Secretary:1 Labor:7550
Office 3 (Pinklao Nakonchaisri)	Ratcha Phruck Road (km0+000-17+200)		Senior Technician 1 Technician: Civil 1,Electrical 1 Secretary 1 Labor 54
Office 4 (Kallaprapruk Road)	Kallapra Phurk Road (+Park)		Senior Technician 1 Technician: Civil 1,Electrical 1 Secretary 1 Labor 46
Office 5	--	Rama VII Bridge (+Park)	Senior Technician 1 Technician:Civil 1 Secretary 1 Labour 28
Office 6	--	Pinklao Bridge	Senior Technician 1 Technician:Civil 1 Secretary 1 Labour 6
Office 7	--	Memorial Bridge + Pokkalao Bridge	Senior Technician Technician:Civil 1 Secretary 1 Labour 7
Office 8	--	KrungThon Bridge	Senior Technician 1 Technician:Civil 1 Labour 3
Office 9	--	Taksin Bridge	Senior Technician 1 Technician: Civil 1 Secretary 1 Labour 7
Office 10	--	Krung Thep Bridge + Rama III Bridge	Senior Technician 1 Technician: Civil 1 Labour 3
Office (Bureau of Bridge Construction)	Industrial Ring Road	Industrial Ring Road Bridge	Engineer: Civil:2,Electrical:1, Mechanical:1,Supporting:1 Technical: Civil:2,Electrical:1,Mechanical:1 Labor:60
Office (District 1:Pathum Thani)	Liang Muang Pakkret Road Liang Muang Nontaburi Road		

Figure 4.2.1 Location of the Office and Managed Roads and Bridges of DRR

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.

(1) Maintenance Operation Work

Daily inspection, maintenance work and other maintenance related works are described below.

1) Daily Inspection

Inspections take place during the day and at night on weekdays and during the day on weekends and holidays. Inspections are generally done visually, and sometimes performed from a patrol car, depending on the situation. The following items are obtained.

Table 4.2.3 Routine Maintenance

	Frequency	Item	Inspector	Remark
Daytime, weekday	Once a day	All pads of the bridge (including attachments); M & E; pavement; traffic facilities including buildings; plantings; and cleaning condition	Technician	Inaccessible bearings, etc., are inspected once a week using telescopes or a ladder
Nighttimes, weekdays	Four times a day	Primarily lighting equipment, damage from accidents, and pavements	security and labour	Inspection times are fixed. There are many cases of drivers crashing and leaving the scene, so this inspection is made very frequently.
Daytime, weekdays and holiday	Three times a day	The entire area is covered; primarily damage from accidents, pavements, guard rails, and drainage system	Security and labour	Inspection times are fixed.

* While identification of damage is one of the main purposes of the inspections, information from traffic police and general road users is also obtained as part of the inspection activities.

Technicians and engineers assign a judgment of "normal" or "damaged." in the inspection record as part of the routine maintenance. This judgment is used as the basis for repair work performed according to the following procedure:

(a) Urgent Minor Repair

For urgent minor repairs, such as the patching of potholes in a pavement, technicians make the decision and DRR's force account carries out the repairs.

(b) Major Repair Made at the Discretion of an Engineer

When a decision beyond the authority or ability of a technician is needed, an engineer visits the site, makes the decision and, if deemed necessary, has the repair work done immediately.

(c) Major Repair Beyond the Discretion of an Engineer

When a decision beyond the authority or ability of an engineer is needed, the matter is turned over to the Bridge Engineering Division. If this division is unable to make a decision, a consultant is employed via ordinary competitive bidding or competitive bidding by invited tenderers. The consultant makes a decision, develops a repair plan and submits an estimate of the repair cost.

2) Daily Maintenance Work

Cleaning and minor repairs shown below are conducted on a daily basis.

- Minor repairs such as patching of potholes in a pavement are carried out by the DRR's Force Account.
- Road surfaces are cleaned every weekday except holidays. On weekends and holidays.
- Cleaning is done only when a cleaning request is made in advance for a special reason, such as an event. The maintenance control section has a mad surface cleaning vehicle, which makes a circuit around the patrolled area. This vehicle is used once a week; manual cleaning is done on the other days.
- DRR does not clean lighting equipment. It was revealed, however, that when dirty lighting facility is found during routine work, the Metropolitan Electricity Association (MEA) is asked to do the cleaning. The MEA regularly measures the luminous intensity of the lighting fixtures and reports the results to the DRR, which sometimes asks the MEA to clean the fixtures.
- The DRR does not have its own criteria regarding brightness of the road surface. Their measurements are evaluated according to DOH standards which were originally developed from the MEA standards.

3) Periodic Maintenance Work (Minor repair)

In the DRR, main members that require periodic replacement are systematically repaired under a ten-year-plan developed from the viewpoints of efficient management and budget control. The parts and frequencies are estimated as follows according to past data.

- Change expansion joints every five years
- Overlay pavements every four years
- Re-paint steel girders every four years
- Re-paint piers and signs every three years

- Check water depths every three years
- Re-draw line markings every two years

Repairs are carried out based on the results of routine maintenance inspections since the above repair plan is developed purely from a budgetary standpoint. When there is not enough money in the budget, a priority level is assigned to each item to be checked or repaired. Priority is determined by the inspection results or traffic volume. The PWD says they intend to store and utilize the past data and consider the concept of the life cycle cost.

4) Special Maintenance (Major Maintenance)

The DRR looks for damage on all main structures, such as girders and piers, identifies the degree of deterioration over time, looks for damage caused by collisions from vehicles or vessels, and repairs any damage found.

The DRR has entrusted some repair works of members damaged by deterioration to PTE Engineering Consultant Co., Ltd. and Dessau International Ltd. in 1997. The results of the consultants' repairs indicate that all bridges checked were generally maintained in good condition.

The DRR has a repair plan for a sway bracing damaged by a bus, and for the fenders of the footing, which were damaged by a vessel.

The Maintenance Control Section carries out improvement and environment work as well as maintenance work. For example, the section has landscaped the Rama XII Bridge and improved the fences for a sidewalk and parking lot at the Pinklao Bridge.

(2) Others

1) Repair Standard

The DRR has no Technical Standards or Manuals that officially and systematically document the procedures of the current maintenance system. For pavements, however, the AASHTO Standard is used for designing, mixture selection, and repair method selection. The mixture is determined internally by the Materials and Research Division. Although the DRR has no official standard for road surface brightness, they use the DOA Standard, which was originally developed by the MEA.

2) Data Storage

(a) Completion Documents

Documents that must be readily available once the project is completed are the following: completion documents, design calculations, and specifications (which are mostly in English and partly in Thai), are permanently stored by the office in charge. When the management of a facility changes hands from the building section to the management section, the hand-off is confirmed at the site with the design, construction, and management staff in attendance.

(b) Inspection and Repair Records

When inspection records are kept, they are compiled weekly using a fixed form and then filed, and then compiled into monthly and yearly reports. When repair and reinforcement work is done as a part of periodic maintenance, a report for each service is prepared and these reports are filed per bridge.

(c) Maintenance System

After the 1997 investigation, conducted jointly by PTE Engineering Consultant Co., Ltd. and Dessau International Ltd., a new maintenance system was developed. This system, called BRAHMS incorporated a database system for seven bridges, including the four covered herein the system became very complex, however, the system is not practical to be adopted today.

3) Available Maintenance Equipment and Machine

The maintenance equipment and machine belong to Bureau of Maintenance and is as shown in Table 4.2.4. Whenever other departments would like to avail of such equipment or machine, they are leased from other bureau after siging appropriate documentations.

Table 4.2.4 Maintenance Equipment and Machine belong to Bureau of Maintenance

	Item	Quantity
1	Pickup	2
2	Truck(6 wheel)	1
3	Sweeping machine (6 wheel)	1
4	Watering machine (6 wheel)	1
5	Grass cutting machine	1

4) Training Engineers

Bureau of Training and Public Participation is in charge of staff training. The trainers are from senior engineers or in-house consultants of each department, in area of design, construction and maintenance. Training for maintenance is mainly executed to the road of the rural area. It is thought that a seminar and on-the-job trainings concerning maintenance are necessary.

5) Traffic Control during Maintenance Work

When traffic control is necessary during maintenance work, negotiations with the police department must take place 15 days before the repair date. This is required by the police. The details of the repair work, such as the repair plan, personnel, and equipment to be used, are provided to the police seven days in advance. The work generally takes place between I1 p.m. and 5 a.m. to avoid traffic congestion.

4.2.2 ISSUE OF O&M

Issues obtained from consultation and site-inspection is summarized below.

(1) 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. Especially, the bridge inspection car which can inspect the bridge girder from the under.
- 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.

(2) Site investigation of Rama V Bridge (October 7, 2009)

- The finger joint is installed at the Rama V 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.

(3) 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 must be a person 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) 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 year.
- Concrete and pavement monitoring will be executed as a special monitoring program.

(4) 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)

4.2.3 PROPOSED O&M PLAN

(1) Maintenance office was set up for each bridge which had been managed by PWD before and the maintenance work was taken over from PWD. The maintenance offices of Rama Ⅳ and Rama Ⅴ Bridges, which were constructed in recent years, were responsible for management and conduct of required maintenance works, including those for the

connecting road. Then, 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.

(2) 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.

(3) 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.

General content of inspection is shown in Table 4.2.5. Items for inspection for each type is shown in Table 4.2.6 and the detailed inspection method is shown in Table 4.2.7.

Table 4.2.5 General Content of Inspection

Type of Inspection		Purpose and Content
Normal Inspection	Daily Inspection	The purpose is earlier detection of abnormality, and main subject of inspection is a related facility of road condition and traffic safety. Inspection by observation from a car or with binoculars.
	Regular Inspection	The purpose is earlier detection of abnormality and damage after inspection of the entire bridge. Inspection by observation on foot or with binoculars. . Watching on foot or with binoculars.
	Detailed Inspection	The purpose is preventiing secondary damage after detailed inspection of bridge with measurement instrument etc, Observation from aerial work platforms and with measurement instrument.
Special Inspection	Inspection at Storm	The purpose is to find damage due to the storm. Inspection is done immediately after occurrence of storm. Watching on foot or with binoculars.
	Other Inspection	Inspection when admitted that detailed inspection is necessary from periodic inspection or when a report is received.

Table 4.2.6 Inspection Item for each Type

Part	Item of Inspection	Type of Inspection				
		Usually Inspection			Temporary Inspection	
		Daily	Regular	Detailed	At storm	Other
Stay cable	Vibration	○	○	○	○	Δ
	Tension	-	-	○	-	Δ
	Protecting tube	○	○	○	○	Δ
	Anchorage of stay cable	-	○	○	-	Δ
	Damping device	○	○	○	○	Δ
Girder	Deflection	-	Δ	○	-	Δ
	Crack	-	○	○	-	Δ
Pylon	Inclination	-	Δ	○	-	Δ
	Crack	-	○	○	-	Δ

○: Anytime Δ: If necessary

Table 4.2.7 Detailed Check Method

Object of Inspection	Method of Inspection
Girder	It is general to measure the deflection of the girder by using the level. It is necessary to complete the measurement before the temperature in the stay cable rises. Moreover, the width of the crack of concrete is measured, if necessary.
Pylon	The measurement of the inclination of the pylon measures the bridge axial direction and the bridge axis right angle direction in the upper part of the pylon with a transit etc. Concrete width of the crack is measured if necessary.
Stay cable	It is general that the tension measurement in the stay cable depends on the forced vibration method. The forced vibration method is a method of simply requesting the tension of stay cable from measured natural frequency.
	When the vibration is admitted, the amount of the vibration is measured with a video etc.
Protecting tube	The presence of the transformation of the main body of the protecting tube and the damage of the crack etc. and the presence of discoloration and the crack of painting are confirmed with watching or binoculars.
Anchorage	Inspection of the anchorage observes the degradation etc. of rust, corrosion, and the painting of the metal component. Likewise, the width of a concrete crack is measured, if necessary.
Damper	Inspects the damper by observing the parts including installation framing, and confirms the presence of rust and the degradation.

(4) 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. (These inspections have already been observed with the monitoring system in the Rama 9 Bridge managed by EXAT)

CHAPTER 5

PROJECT EVALUATION

CHAPTER 5 PROJECT EVALUATION

5.1 GENERAL

The evaluation of the Project is carried out by classifying the effects that can be expressed quantitatively and the effects that are difficult to grasp quantitatively but expected to result in huge positive impacts.

5.2 QUANTITATIVE EFFECTS

(1) Contents of Project Effects

The quantitative effects are generated mainly from the improvement of vehicle flow conditions, such as reduction of congestion, increase in travel speed, savings in travel time, and savings in vehicle operating costs (VOC savings).

(2) 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.

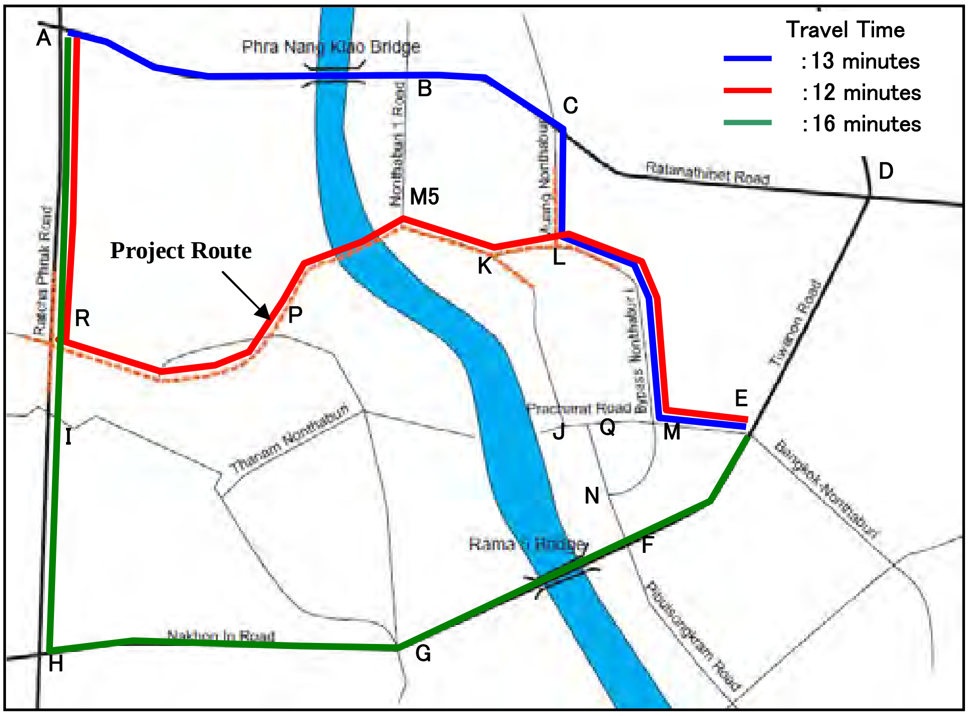


Figure 5.2.1 Case-1: From Point A – To Point E (No significant time savings)

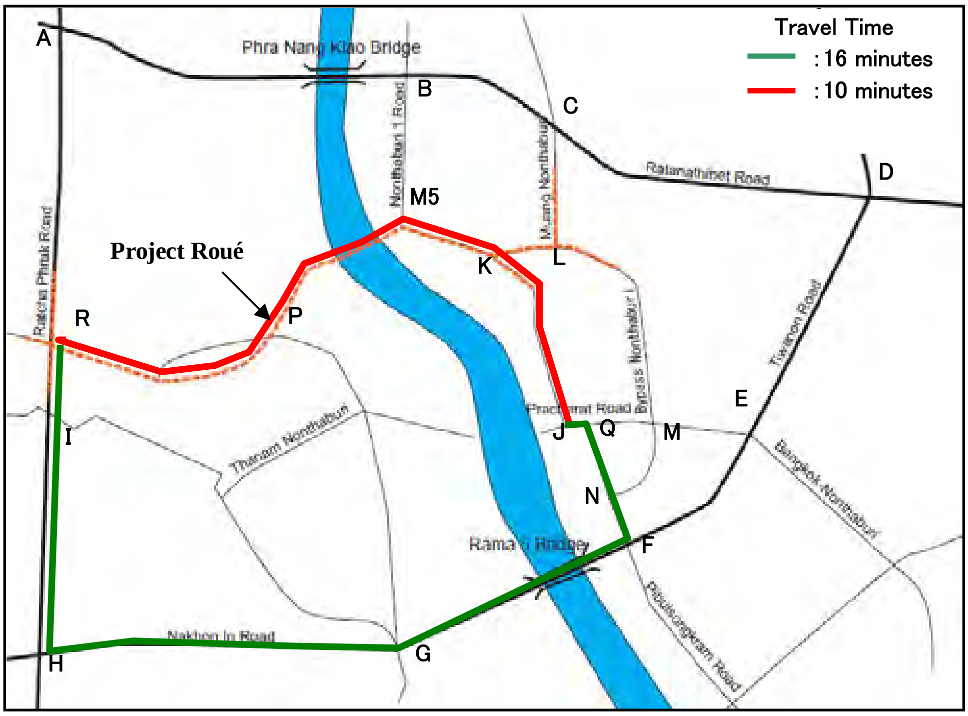


Figure 5.2.2 Case 2: From Point R – To Point J :Central area of Nonthaburi Province (about 6 minutes time savings)

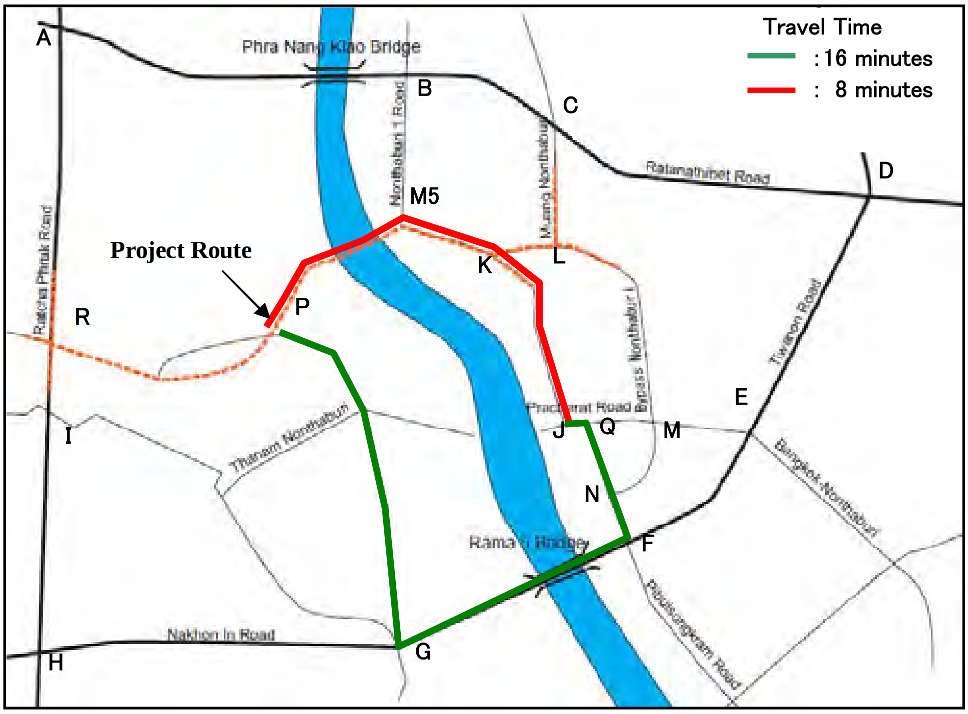


Figure 5.2.3 Case 3: From Point P – To Point J (about 8 minutes of time savings)

(3) Reduction of Congestion

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

Table 5.2.1 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

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.

(4) Economic Internal Rate of Return (EIRR)

The value of EIRR was estimated based on the following conditions:

1) Economic Project Costs:

The construction costs are allocated for each construction year in accordance with the construction schedule and converted into economic costs by applying the same economic conversion factor of 0.88 as adopted in the previous FS. Costs for the design and land acquisition at 2009 prices are the same as estimated in the FS, and operation and maintenance (O&M) costs after opening the project are also the same as estimated in the previous FS.

2) Economic Benefits:

The estimated benefits are generated from the savings in VOC and value of time (VOT). It was judged that the values of benefits estimated in the previous FS for the years 2016, 2021, and 2026 are considered to be appropriate after reviewing the results of the traffic demand forecast and the unit benefits applied in the FS, the same values of benefits in the previous FS are applied. However, as the methodology to estimate benefits of the savings in VOT of intermediate years was different from the method of estimation of VOC benefit (linear interpolation method), the same method of VOC benefit estimation is applied to VOT benefits of intermediate years. The values of unit VOC and VOT were taken from the BMTA (Bangkok Mass Transit Authority) Route Planning and Scheduling Project (BRPS) as shown below:

Table 5.2.2 Vehicle Operating Cost

Unit: Baht/Ton-Kilometer

Type of Vehicle	Vehicle Operating Cost							
	Gasoline	Lube	Tyre	Spare part	Maintenance	Investment Cost	Wages	Total
Motorcycle	0.755	0.017	0.031	0.035	0.148	0.069		1.055
Passenger Car (Small)	1.658	0.084	0.113	1.259	0.210	2.228		5.552
Passenger Car (Medium	1.874	0.088	0.127	1.629	0.210	2.879		6.807
Passenger Car (Large)	2.141	0.092	0.155	3.136	0.210	5.560		11.294
Light Truck	2.569	0.207	0.234	1.014	0.673	0.708	0.225	5.630
Medium Truck	4.010	0.224	0.218	2.634	0.804	1.042	0.933	9.865
Heavy Truck	8.665	0.454	0.624	6.939	1.161	1.316	1.089	20.248
Trailor	11.351	0.486	1.081	10.435	1.205	1.938	1.238	27.734
Light Bus	2.960	0.123	0.134	4.720	0.261	0.964	0.544	9.706
Heavy Bus	5.928	0.353	0.571	2.541	0.914	0.688	1.210	12.205
Air-Conditioned Bus	5.620	0.349	0.413	6.953	1.074	2.309	1.209	17.927

Source: 3rd Additional Information on the Cost Estimation, Drawing and Economic Analysis

Table 5.2.3 Value of Time

Unit: Baht/Person/hour

	2005	2008	2011	2016	2021	2026
Household Vehicle						
No vehicle	35.41	39.78	44.96	54.59	64.33	74.06
One motorcycle	37.05	41.62	46.93	57.11	67.28	77.46
One passenger car	76.40	85.84	96.93	117.82	138.83	159.83
More than one passenger car	104.62	117.45	132.48	158.63	184.78	210.92
Level of Service for Public Transport						
High Standard	84.06	94.32	106.34	129.42	152.50	175.59
Low Standard	37.82	42.51	48.03	58.31	68.70	79.10
Type of Vehicle						
Passenger Car	76.40	85.84	96.93	117.82	138.83	159.83
Motorcycle	37.05	41.62	46.93	57.11	67.28	77.46
Taxi	76.40	85.84	96.93	117.82	138.83	159.83

Source: 3rd Additional Information on the Cost Estimation, Drawing and Economic Analysis

3) Opening Year and the Project Life:

The opening year of the Project was set at the beginning of 2014 and the project life was assumed at 20 years, the same opening years and life span of the project as estimated in the FS.

4) Salvage Value:

The salvage value was estimated by applying the same rate to the construction cost and land acquisition cost adopted in the FS.

5) Opportunity Cost of Capital (Discount Rate) = 12%

The cost benefit stream is shown in the table below:

Table 5.2.4 Cost Benefit Stream

(Million Baht)

No.	Year	Economic Project Cost							Economic Project Benefit			B-C	Present Value (discounted at 12%)	
		Design	Investment Cost	Construction Supervision	Administration	O&M		Total Cost	VOC Savings	VOT Savings	Total Benefit			
						Routine	Periodic						Cost	Benefit
1	2006	16.28	50.00		1.32			67.60			0.00	-67.60	60.36	0.00
2	2007		1,600.00		32.00			1,632.00			0.00	-1,632.00	1,301.02	0.00
3	2008		550.00		11.00			561.00			0.00	-561.00	399.31	0.00
4	2009							0.00			0.00	0.00	0.00	0.00
5	2010		0.00	0.00				0.00			0.00	0.00	0.00	0.00
6	2011		973.88	27.72				1,001.60			0.00	-1,001.60	507.44	0.00
7	2012		1,467.08	55.44				1,522.52			0.00	-1,522.52	688.71	0.00
8	2013		1,227.71	55.44				1,283.15			0.00	-1,283.15	518.24	0.00
9	2014					22.65		22.65	224.18	1,663.74	1,887.92	1,865.27	8.17	680.80
10	2015					22.65		22.65	251.21	1,864.31	2,115.52	2,092.87	7.29	681.14
11	2016					22.65		22.65	278.24	2,064.87	2,343.11	2,320.46	6.51	673.59
12	2017					22.65		22.65	343.84	2,265.43	2,609.27	2,586.62	5.81	669.73
13	2018					22.65		22.65	409.43	2,466.00	2,875.43	2,852.78	5.19	658.97
14	2019					3.32		3.32	475.03	2,666.56	3,141.59	3,138.27	0.68	642.83
15	2020					3.32	63.09	66.41	540.62	2,867.13	3,407.75	3,341.34	12.13	622.58
16	2021					3.32		3.32	606.22	3,067.69	3,673.91	3,670.59	0.54	599.29
17	2022					3.32		3.32	833.84	2,747.92	3,581.76	3,578.44	0.48	521.66
18	2023					3.32		3.32	1,061.46	2,428.15	3,489.60	3,486.28	0.43	453.79
19	2024					3.32		3.32	1,289.07	2,108.37	3,397.45	3,394.13	0.39	394.47
20	2025					3.32		3.32	1,516.69	1,788.60	3,305.29	3,301.97	0.34	342.65
21	2026					3.32		3.32	1,744.31	1,468.83	3,213.14	3,209.82	0.31	297.41
22	2027					3.32	63.09	66.41	1,744.31	1,468.83	3,213.14	3,146.73	5.49	265.54
23	2028					3.32		3.32	1,744.31	1,468.83	3,213.14	3,209.82	0.24	237.09
24	2029					3.32		3.32	1,744.31	1,468.83	3,213.14	3,209.82	0.22	211.69
25	2030					3.32		3.32	1,744.31	1,468.83	3,213.14	3,209.82	0.20	189.01
26	2031					3.32		3.32	1,744.31	1,468.83	3,213.14	3,209.82	0.17	168.76
27	2032					3.32		3.32	1,744.31	1,468.83	3,213.14	3,209.82	0.16	150.68
28	2033		-2,359.32			3.32		-2,356.00	1,744.31	1,468.83	3,213.14	5,569.14	-98.64	134.53
		16.28	3,509.35	138.60	44.32	163.05	126.18	3,997.78	21,784.31	39,749.41	61,533.72	57,535.94	3,431.20	8,596.21

EIRR (%)	22.0%
NPV (Million Baht)*	5,165.02
B/C*	2.51

(*): Discount Rate=12%

6) Results of Evaluation

The results of the evaluation are summarized below together with the sensitivity analysis.

Table 5.2.5 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 5.2.6 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.

5.3 QUALITATIVE EFFECTS

Substantial qualitative and significant effects are expected from the construction of the Project- , as other bridges crossing over the Chao Phraya River were given important roles to generate indirect effects and to promote regional development, and for supporting the daily lives of people residing at both sides of the river. Examples of the qualitative effects of the Project are as follows:

1) The improvement of accessibility to the east side of the river is essential for the people living in the west side in various aspects of daily commuting, going to schools and economic activities. Even inside of Nonthaburi Province, the provincial offices, major public facilities and commercial areas are concentrated to the east river side and the direct access to those facilities and amenities from the west side by the Project bridge will be very convenient than the routes via congested roads going to the existing Phra Nang Klao Bridge and Rama V Bridge.
2) The west side of the river is located comparatively nearer to the Central Area of BMA and has wide undeveloped lands. When the Project bridge is completed, the development potential of these lands in the west side will be accelerated and would attract the new locations of factories and commercial facilities.
3) There are residential blocks in the west side of the direct influence area at present. However, high quality hospitals and medical facilities mainly exist in the east side of the river. The Project bridge will provide the residents in the west side with all-weather access to these facilities and raise the living condition of the people.
4) From the more widespread aspects, the Project bridge will function as an access to the trunk transport network (Red Line and Blue Line of MRT and expressways) and, as a result, will increase accessibility not only inside the Province but also in the whole area of BMR and hence, will generate considerable economic effects of expansion of market.

5.4 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.

The traffic demand of the Project was forecasted in terms of PCU/hour in morning peak (7:00AM-8:00AM). It is converted into AADT applying the reciprocal value of peak hour ratio 8% (=12.5). AADT of two years after opening is shown as below:

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 AND SOCIAL CONSIDERATIONS

CHAPTER 6 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

6.1 REVIEW OF ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

6.1.1 REVIEW OF EIA

(1) Applicable Guidelines

On October 1, 2008, the operations of the Overseas Development Assistance (ODA) of Japan Bank for International Cooperation (JBIC) merged with Japan International Cooperation Agency (JICA). The JBIC Guidelines for Confirmation of Environmental and Social Considerations dated April 2002 is applied to the projects.

(2) EIA Procedure

The EIA report was not required for the Project in accordance with Environmental Act B.E. 2535. The Act said that EIA is required for the project such as road passing through wildlife sanctuaries, national park, mangrove forest, and coastal area in terms of road construction in Thailand. However, EIA report is required to be approved for the Project because it is classified as Category A under the JBIC Guidelines for Confirmation of Environmental and Social Consideration.

DRR had the meeting for project detailed design, environmental impact and land acquisition survey as shown in Table 6.1.1 from July 2005 to March 2006. A focus group meeting was held for all the people and other stakeholders that might be affected by the Project. The EIA report was completed by the end of October 2005, and the report was then opened to the public and therefore, every one could read and be allowed to photocopy it at the DRR Bangkok Office.

Table 6.1.1 Schedule of Seminars and Focus Group Meetings

Fixture	Meeting place	Meeting style	Contents of explanation
8th July 2005	Nonthaburi Province Head Office	Orientation Seminar	Detailed Design and Land Acquisition Survey, Environmental survey result
2nd august 2005	Sai Ma Municipality Office	Focus Group Meeting	Same as above
4th August 2005	Muang Nonthaburi Municipality Office	Focus Group Meeting	Same as above
4th August 2005	Bangrak Noi Temple	Focus Group Meeting	Same as above
6th August 2005	Wat Chalerm Phra Kiat School	Focus Group Meeting	Same as above
6th August 2005	Bang krang Municipality Office	Focus Group Meeting	Same as above
10th October 2005	Wat Chalerm Phra Kiat School	1st Seminar	Same as above
11th March 2006	Wat Chalerm Phra Kiat School	2nd Seminar	Same as above

DRR explained that the final alignment was decided in consideration of minimizing the environmental and social impacts as well as efficiency and effectiveness from technical and economical perspectives. The EIA report was submitted to the Office of Natural Resources and Environmental Policy and Planning (ONEP) on 22 March 2006. Finally, DRR submitted to JICA the revised EIA Report for the project which has been approved by DRR on 31 March 2009.

6.1.2 EXISTING ENVIRONMENT CONDITION ON PROJECT SITE

(1) Literature Searching in EIA Report

1) Water Quality

Water samples were taken at the different sampling stations near the project area and the water quality survey results are shown in Table 6.1.2. The following index of pollution like the DO, BOD, coliform counts were most of the time not observed and followed environmental standards in Thailand. The rivers located near the project site; the Chao Phraya River and Khlong Om Non were used for transportation, reportedly the water quality condition was not suitable for drinking because of too much pollution from human waste effluent.

Table 6.1.2 Water Quality around Project Site

Sampling Station	Parameter			
	pH	DO (mg/l)	BOD (mg/l)	Coliform bacteria (MPN/100 ml.)
1. Chao Phraya River				
- Rama VI	7.0	4.6	7.1	
- Nonthaburi Bridge	7.7	4.4	3.6	
2. Khlong Om Non				
- Wat Ta-node Pier	7.2	2.6	5.9	2.8E + 04
- Wat Pracha Rangsan Pier	7.3	2.4	5.7	3.0 E + 04
Environmental Standard (for class 3)	5 – 9	≧ 4.0	≦ 2.0	≦ 20,000

Source: Water Quality Management Division, Pollution Control Department, 2003

2) Air Quality

Air quality monitoring data measured at two permanent sampling stations in Nonthaburi Province were shown in Table 6.1.3, which was almost within or meeting the standard levels except for periodic excess for ozone and PM10. Air quality conditions in Nonthaburi Province were still in good and acceptable levels.

Table 6.1.3 Air quality monitoring result at permanent stations at Nonthaburi Province（2003）

	Air Pollutants					
(Unit)	SO_2 (ppb)	NO_2 (ppb)	CO (ppm)	CO (ppm)	O_3 (ppb)	PM_{10} ($\mu g/m^3$)
Average of time	1 hr	1 hr	1 hr	8 hrs	1 hr	24 hrs
Department of Alternative Energy Development and Efficiency	4.8	22.7	0.8	0.8	18.4 *(16/8377)	51.0 **(1/364)
Sukhothai Thammatirat University	5.2	19.33	0.7	0.7	18.2 *(26/8280)	57.9 **(23/350)
Environmental Standards	300	170	30	9	100	120

Standard: Air Quality Standard according to the NEB Notification No. 10, BE 2538

*The numerator is exceeding hours to standard, denominator is total measuring hours.

** The numerator is exceeding days to standard, denominator is total measuring days.

3) Noise Level Monitoring

Noise level measured at Sukhothai Thammatirat University in 2003 was in the range of 54.3 to 68.1 dB(A) (average is 58.3 dB(A)), and noise level along trunk road was from 63.8 to 71.3 dB(A) as average of day. Those measured values exceeded periodically the standard for noise level in Thailand (70 dB(A)).

4) Fauna and Flora

Within the 500 m band of alignment of planning road it was not found natural protected area and forest based on the law. According to the survey result for fishes implemented between Prakret to mouth of Chao Phraya River including project site, four species designated as vulnerable and one specie as near threatening of IUCN red list was found. Within the 500 m band of alignment of planning road natural protected area and primary forest based on the law was not found. According to EIA Report on the Animal Survey implemented in August 2005, there were four species of amphibian, five species of reptile and 23 species of birds were found. Within these classifications of animals, four species of reptiles and 15 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

In order to confirm and validate whether there are drastic changes for existing environmental conditions around the project site since the `conduct of the first EIA, a confirmatory primary data survey for water quality, air pollution and noise/vibration was conducted in this study. For easy and exact comparisons, it was decided that the sampling location, frequency and analyzing methodology would be same manners as EIA report.

1) Water Quality

The present status and conditions of the locations of sampling points can be seen in the selected photographs shown in Figure 6.1.1 and the laboratory water quality result was shown in Table 6.1.4. It has to be noted that the water sampling locations are within one kilometer upstream of the construction site, and limited to one kilometer downstream of the construction site.

According to the results of comparison between the selected data in the EIA Report and that of the supplemental survey, most of the suspended solids (SS) values reflected in the supplemental survey are higher than in EIA report. It has been assumed that this occurrence was due to muddy water flow in from the tributary river because of proximate rainfall in the area. At the same time, the DO level increased and BOD level decreased so that these values are within the environmental standards. On the other hand, the Ammonium Nitrogen Index was also within the guideline value quoted in the standard. But the coliform bacteria count almost excceeded the guideline value thoughout the duration of the exercise. It is assumed that human effluent without prior treatment before discharge to the tributary river may have contributed to this coliform bacteria pollution. Throughout the conduct of the whole exercise, it is confirmed that water quality condition in Chao Phraya River had not changed drastically since the conduct of the EIA in 2005.

Table 6.1.4 Comparison of Water Survey Results

Location		Station 1		Station 2		Station 3		Standard for class 3
Survey		EIA	Supplementary	EIA	Supplementary	EIA	Supplementary	
Parameters	unit	*2005	*2009	2005	2009	2005	2009	
Temperature	ºC	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 (NO2)	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	>240000	>160,000	≤20,000
Ammonium Nitrogen (NH_4-N)	mg/l NH_4-N	-	0.19	-	0.19	-	0.19	≤0.5

Station 1: Chao Phraya River (Upstream of the construction site)

Station 2: Chao Phraya River (At the construction site)

Station 3: Chao Phraya River (Downstream of the construction site)

*Sampling date: supplement survey October 7, 2009 and EIA report August 20-21, 2005

	
Upstream of the construction site	Surrounding area at upstream
	
At the construction site	Surrounding area at the construction site
	
Downstream of the construction site	Surrounding area at downstream

Figure 6.1.1 Status of Water Sampling

2) Air Quality

Air quality survey result was shown in Table 6.1.5. Status of air quality and noise/vibration sampling locations were shown in Figure 6.1.2.

Table 6.1.5 Comparison of Air Quality

1. Sri Boonyanon School

Parameter	Unit	Duration	Sat	Sun	Mon	Tue	Wed	Average	Standard
TPS (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/]
Wind Speed	m/sec	Supplement	0.3-1.4	0.3-1.4	0.5-1.9	0.3-1.7	0.3-1.3	0.7	-
Wind Direction	-	Supplement	W	ENE, E	E	E	WSW	-	-

2. Wat Chalerm Phra Kiat

Parameter	Unit	Duration	Sat	Sun	Mon	Tue	Wed	Average	Standard
TPS (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/]
Wind Speed	m/sec	Supplement	0.3-1.6	0..3-1.8	0.3-1.5	0.3-1.3	0.3-1.2	0.7	-
Wind Direction	-	Supplement	N	E	SE	SW	WSW	-	-

3. Wai Sai Kindergarten

Parameter	Unit	Duration	Sat	Sun	Mon	Tue	Wed	Average	Standard
TPS (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/]
Wind Speed	m/sec	Supplement	0.4-2.0	0.3-3.9	0.6-2.3	0.3-2.6	0.4-1.6	1.1	-
Wind Direction	-	Supplement	SE	N	E	SE, E	S	-	-

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

Sri Boonyanon School

View of Planning Road direction

Wat chalerm pra klat

Pole for weather monitoring

Wai Sai Kindergarten

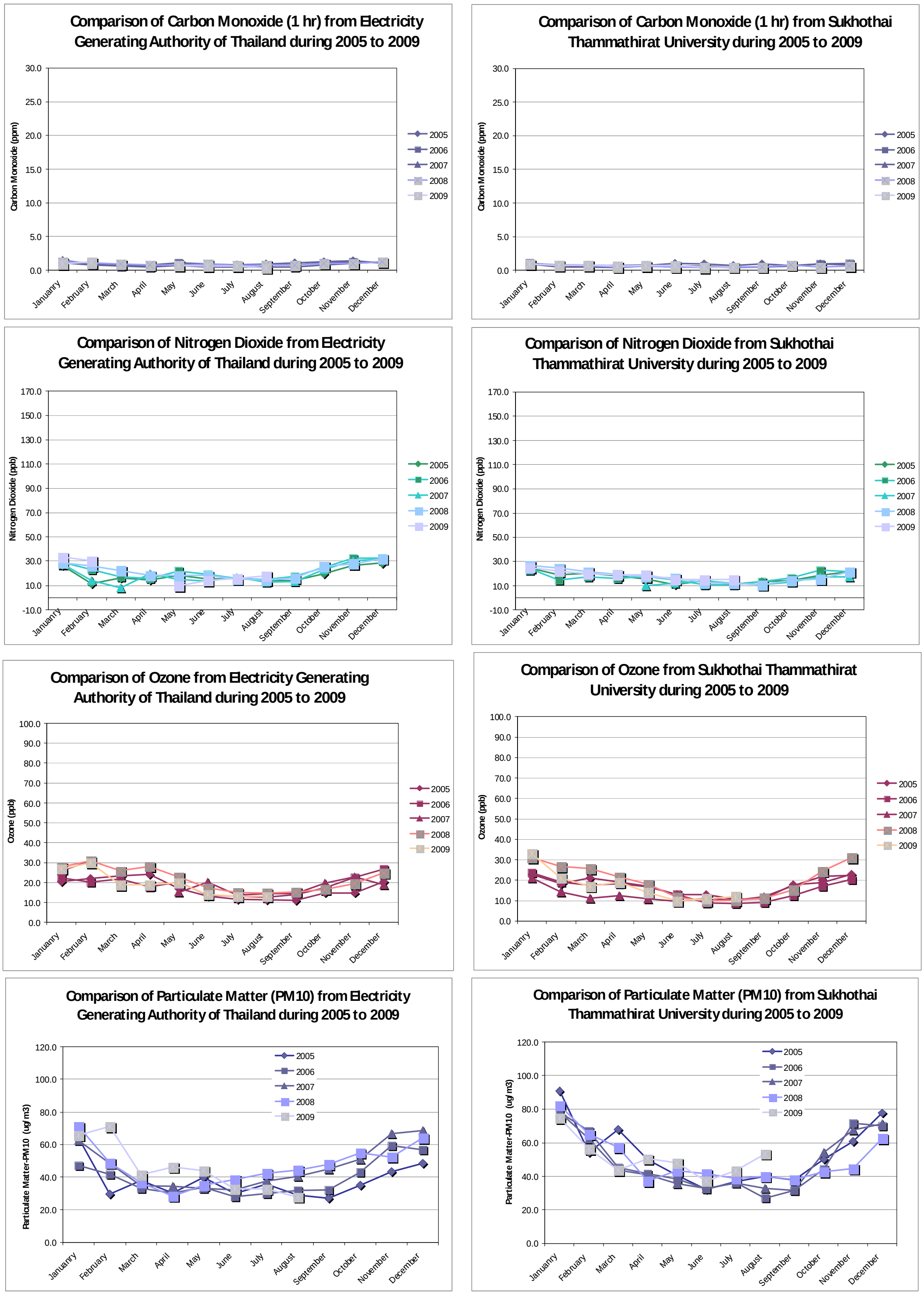
From sampling point to Road

Figure 6.1.2 Status of Sampling Locations for Air and Noise/Vibration

Air quality samplings as reported in the EIA report were conducted during Saturday and Tuesday dated 20-25 August 2005, and the supplemental surveys were also conducted during Saturday and Thursday dated 10-15 October 2009 for almost five consecutive days. CO, and NO_2 level tended to be higher than the levels of pollution mentioned in the EIA. But all in all, the air pollution concentration, including the ozone level, were still below the maximum limit stated in the standard.

To confirm whether there is change in the regional pollution level in the Nonthaburi Province, the latest five years monitoring data from two locations, namely; from the Electricity Generating Authority of Thailand and Sukhothai Trammatirat University were compared. The monthly averages are shown in Figure 6.1.3. Monthly average of pollution tends to be higher in the dry season as compared to during the onset of the rainy season; the lines of monthly average had not changed for latest five years. Most of the monitoring data in Nonthaburi

Province were far below the maximum standard level shown in upper range and therefore, the air quality in the areas were in good and acceptable conditions. Monthly maximum measured result is shown in Figure 6.1.4 to compare with standard. In these Figure, the CO and NO_2 are within the standards, but the levels of ozone and PM10 taken at the Sukhothai Trammatirat University exceeded the maximum limit for a certain period.



Comparison of Carbon Monoxide (1 hr) from Electricity Generating Authority of Thailand during 2005 to 2009

Comparison of Carbon Monoxide (1 hr) from Sukhothai Thammathirat University during 2005 to 2009

Comparison of Nitrogen Dioxide from Electricity Generating Authority of Thailand during 2005 to 2009

Comparison of Nitrogen Dioxide from Sukhothai Thammathirat University during 2005 to 2009

Comparison of Ozone from Electricity Generating Authority of Thailand during 2005 to 2009

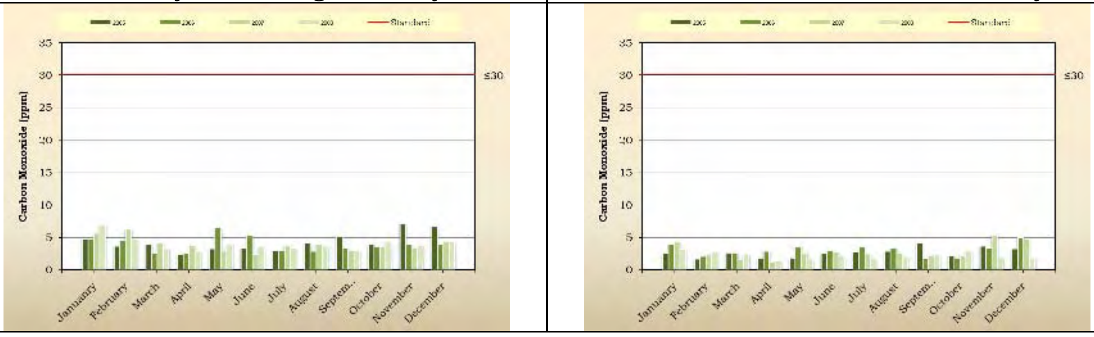
Comparison of Ozone from Sukhothai Thammathirat University during 2005 to 2009

Comparison of Particulate Matter (PM10) from Electricity Generating Authority of Thailand during 2005 to 2009

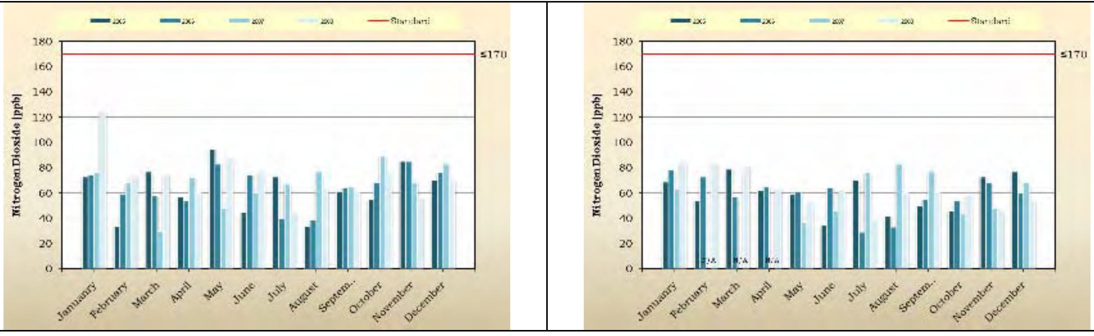
Comparison of Particulate Matter (PM10) from Sukhothai Thammathirat University during 2005 to 2009

Figure 6.1.3 Air Pollution Trend in Nonthaburi Province (Monthly Average of 2005-2009)

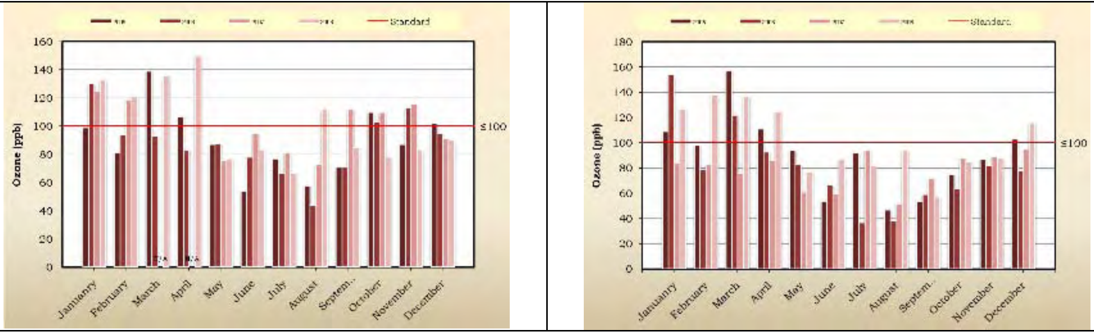
Electricity Generating Authority	Sukhothai Thammathirat University



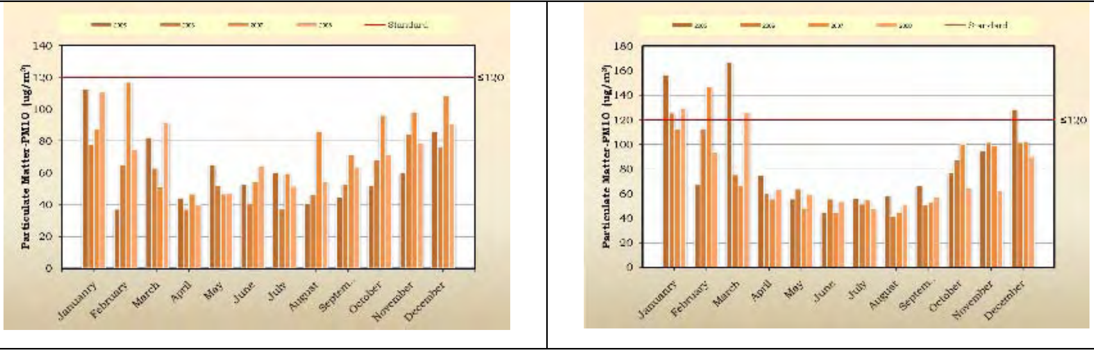
CO Average 1 Hour



NO_2 Average 1 Hour



Ozone Average 1 Hour



PM_{10} Average 24 Hour

Figure 6.1.4 Air Pollution in Nonthaburi Province (Comparison with standard between 2005-2008)

3) Noise

The result of the noise survey is shown in Table 6.1.6. Sampling for noise levels as written in the EIA report were conducted during Saturday and Tuesday dated 20-25 August 2005, and the supplemental surveys for the same parameters were conducted also during Saturday and

Tuesday dated 10-15 October 2009.for five consecutive days. Comparing the noise level taken during the EIA and supplemental survey, one can see that the noise level taken during the supplemental survey was lower than in the EIA at Sri Boonyanon School and Chalerm Pra Klat. On the other hand, the noise level taken during the supplemental survey at Wal Sal Kindergarten was higher than EIA report. There were two days during the conduct of the supplemental survey that the noise level exceeded the maximum limit taken at Wal Sal Kindergarten and the same level as written in the EIA report. The timing or period for the conduct of the supplemental survey coincided with the vacation of the school children in order to reduce the level of impact. On the other hand, the noise level at Wal Sal Kindergarten was mainly affected by road traffic noise because this facility was situated right facing the Ratcha Phruk Road. Increase of traffic volume between 2005 and 2009 is 2.24 at peak time as shown in Table 2.3.10, which explains the the daily difference of average noise level as of five days between 2005 and 2009 +4.5, +5.3, +2.1, -3.3, +3.0 dB (A), since noise level increase @3.5 decibel in case of 2.24 times of traffic volume with same speed and same composition of vehicle type.

Table 6.1.6 Comparison of Noise Levels

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))

4) Vibration

Comparison of vibration is shown in Table 6.1.7 Sampling in EIA report were conducted during Saturday and Tuesday on 20-25 August 2005, and the supplemental survey were conducted also during Saturday and Thursday on 10-15 October 2009. Vibration levels both in the EIA and supplemental survey were under Reiher & Meister standard 2.5 mm/s so that impact of vibration was small and consistent.

Table 6.1.7 Comparison of Vibration (PVS)

Vibration (PVS)		Result (mm/s)						
		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Average
1.Sri Boonyanon school	EIA	1.20	1.45	2.05	2.13	2.30	2.30	1.9
	Supplement	0.48	1.14	2.19	0.87	0.83	0.47	1.0
2.Chalerm Pra Klat	EIA	0.33	0.20	1.30	1.17	1.14	0.78	0.8
	Supplement	0.89	0.89	1.44	1.27	0.63	0.24	0.9
3.Wai Sai Kindergarten	EIA	0.40	1.60	1.10	1.60	0.65	1.37	1.1
	Supplement	1.06	2.04	1.17	1.05	1.16	0.97	1.2

[@] 10 Log10(2.24) = 3.5 dB(A)

5) Summary of Comparison

As a consequence, there is no drastic change of environmental condition in Project site between data on EIA and supplemental survey. Almost all the measured data and parameters were within the environmental standard in Thailand, except for data on water quality index such as coliform and noise level at Wal Sal Kindergarten situated facing the trunk road.

6.1.3 REVIEW OF ENVIRONMENTAL MITIGATION MEASURES

(1) Water Quality

Selection of best and appropriate work methodology must be done such as the possibility of applying the closed boring method and to take counter measures as required necessary to mitigate the influence on the water quality during construction stage. Based on the conditions of the contract, the ontractor shall comply with all the environmental mitigation measures such as prevention of sediment discharge during construction.

Especially for the boring work in Chao Phraya River, closed boring with steel casing method will be applied, water drained from the excavation works will be treated in a sedimentation basin installed on a prepared siltation area. After the treatment, the water will be discharged to public drainage water system. In case the water stored on the sedimentation basin still exceed the standard on suspended solids, then chemicals like coagulant will be added to the water before finally discharing out the water.

On the east side of Project Area, the planned road section has a road crossing with three small canals as shown in Figure 6.1.5.

Figure 6.1.5 Location of Small Canal Crossing

Planning road of intersection with three small canals is planned by viaduct and bridges, thus the impact of flood and sediment discharge is minimally considered. As mentioned in the EIA report, the construction period is limited only during the dry season. The best earth work methodology must be employed such as closed or bypass is available to keep the functionality of the canal. It is anticipated that the impact of contamination such as flood and sediment discharge will be nil or very little.

(2) Air Quality

By strict enforcement of adequate measures such as sheet cover on transportation of construction material, periodically cleaning and/or water spraying during construction, air quality condition will be stabilized and ultimately will attain the desired air quality standard.

Predicted NO_2 concentration during operation stage at 20 m from road in EIA report was 0.348 mg/m^3, which was exceeded the standard value of 0.320 mg/m^3. Though this assumption for simulation such as wind speed 0.5 m/s, stability of atmosphere class extremely stable (F) and traffic volume at peak hour are available, so that it is anticipated that substantial security and safety provisions are employed in the implementation of the project.

On the other hand, actual wind speed based on metrological observation in Bangkok for over 30 years is 2.6 m/s (see EIA report p3-28, Table 3.3-7) and usually atmosphere stability neutral (D) is most frequent.

Line Source Model Formula of CALINE4 used in EIA report is described as below:

$C=Q/ (MW)$

Here, C: contamination concentration (mg/m^3)

Q: contamination gas volume (mg/m)

M: mixing height (m)

W: wind speed (m/s)

If the volume of gas emission and the diffusion condition are the same, other than the wind speed change 0.5 m/s to 2.6 m/s concentration will be about one fifth (1/5). Thus based on normal weather condition and traffic volume, it is estimated concentration will never exceed standard value of NO_2.

TSP and PM_{10} concentration during operation stage is not shown in the EIA report because of no available information for emission factor in Thailand. Trial simulation based on emission factor used for prediction during construction in EIA Report (EIA report p4-8, Table4.2-2) is shown in Table 6.1.8. TSP emission from traffic stream is estimated at 3.5 – 20 % in gravity. Meanwhile, based on the interview of the writer of the EIA, the ratio of NO_2/NO_x is 0.22, so NO_x concentration is estimated as 0.348/0.22=1.582 mg/m^3. By using the gravity ratio of emission TSP/NO_x, TSP concentration is estimated as 0.055 - 0.316 mg/m^3, which is under the standard value of TSP (0.33 mg/m^3).

Same procedure as TSP with assumption of 10% for large vehicle rate, PM_{10} is 4.6% in gravity based on emission factor used in Japan and PM_{10} is estimated as 0.0728 mg/m^3, which will not exceed the standard value (0.12 mg/m^3).

Table 6.1.8 Trial Estimation of TSP

	Rate of Pollutant Construction Emission (kg/h)		Ratio of emission rate (%)	Estimated concentration quoted from NO2 0.348mg/m3 (**NOx 1.582mg/m^3) in 2026
Equipment and Machine and Vehicle	*NO_2 (NOx)	TSP	TSP/ NOx	TSP(mg/m^3)
1. Backhoe	1.09	0.08	7.3	0.115
2. Grader	2.3	0.08	3.5	0.055
3. Truck	0.25	0.05	20	0.316
6. Excavator	2.83	0.19	6.7	0.106
7. Diesel Engine	3.46	0.12	3.5	0.055

*Emission rate of NOx is usually expressed with NO_2.

**From interview of EIA writer, ratio of NO_2／NO x used for prediction is 22%.

Table 6.1.9 Trial Estimation of PM10

	Rate of Pollutant Construction Emission (kg/h)		Ratio of emission rate (%)	Estimated concentration quoted from NO2 0.348mg/m3 (**NOx 1.582mg/m3) in 2026
Emission Rate in Japanese at speed 8okm/s	*NO2 (NOx)	PM10	PM10/ NOx	PM10(mg/m3)
Small car (90%)	0.068	0.004	-	-
Large car (10%)	1.39	0.056	-	-
Average from composition	0.2002	0.0092	4.6	0.0728

(3) Noise

The level of road traffic noise predicted in the EIA was exceeding noise standard of 70dB (A). Mitigating measures such as the installation and provision of noise barriers were proposed, however the effect was not simulated. According to the interview of EIA writer, the reduction effect of noise barrier in field test is about 2 to 33 db (A). Based on trial calculation by ASJ RTN-Model 2003 shown in Table 6.1.10, banking road with three meter height noise barrier installation will reduce 3 -3-4 db (A) noise level near the road side. Therefore by installing noise barriers, the noise level will be minimized and will attain the noise level standard, and noise level near the viaduct with concrete railing will be under noise standard. In necessary case, noise barrier shall be installed to observe noise standard at sensitive areas.

Table 6.1.10 Road Traffic Noise prediction during operation period

Road structure	Receptor height (m)	Noise level db (A)				
Banking	4m	79.7	77.0	74.5	71.5	68.5
	1.5m	72.0	71.3	70.3	68.8	66.7
Banking with noise barrier H=3m	4m	75.3	73.5	71.5	68.7	65.8
	1.5m	67.7	67.7	67.0	65.8	63.9
Via duct with concrete railing	4m	67.9	68.4	67.8	66.6	64.9
	1.5m	63.3	64.9	65.2	64.8	63.7
		0m	10m	20m	40m	80m
		Distance from road				

Calculation method based on ASJ RTN-Model 2003

(4) Fauna and Flora

Project road is located almost on the existing road alignment and there is very little possibility to diminish forest and swamp land where protected animals may live between new construction sections. In the EIA report, impact of movement of earth and sand is little, and 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. According to EIA writer’s interview hunting of birds by construction worker will be strictly prohibited based on protection guideline of ONEP. It is said that the impact to protected fauna and flora during construction and operation period is little in project site.

(5) Environmental Check List and Monitoring Form

DRR submitted the Summary of Environmental and Social Considerations as Check List. DRR present conducting organization chart of environmental monitoring and 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 the operation stage for two years. The requisite monitoring form is attached in Appendix-3.

6.2 CONFIRMATION OF RESETTLEMENT AND LAND ACQUISITION

(1) Scale of Resettlement and Land Acquisition

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

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

DRR has completely paid compensation to all land and property owners. However, there are some households which have/tried to file a petition in court in order to voice out their objection to the compensation price set by the committee in accordance with the Thailand Expropriation Act and Land-use Act.

There are 125 households which have already settled but eight households are still residing within Project site. As of this study, DRR explained that four households agreed to be resettled before the start of construction. In case there are still residents or households who decide to stay and remain in the Project site before the commencement of the construction, then compulsory expropriation will be done based on the Land and Property Expropriation Act B.E. 2530.

CHAPTER 7

PRELIMINARY SURVEY FOR CHAO PHRAYA RIVER CROSSING BRIDGES

CHAPTER 7 PRELIMINARY SURVEY FOR CHAO PHRAYA RIVER CROSSING BRIDGES

7.1 BACKGROUND OF SURVEY

Reference is made to paragraph 2) of Subchapter 1.2 - Purposes of the Survey.

For the bridges constructed over the Chao Phraya River with Japanese government finances, JICA decided to conduct a preliminary survey by visual inspection on the conditions of these bridges to study what technical cooperation JICA can provide for their continued use. The visual inspection survey activity in Bangkok is discussed in detail in Appendix-7.

All the bridges currently spanning the Chao Phraya River at the Bangkok Metropolitan Area are listed in Table 7.1.1 below, in which the bridges marked under the column of Japanese government finance are scheduled for the preliminary survey.

Table 7.1.1 Bridges over Chao Phraya River

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	Patum 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	IRR North	Cable-stayed	2006	DRR	✔ Loan
20	IRR South	Cable-stayed	2006	DRR	✔ Loan
21	Kanchanapisek	Cable-stayed	2007	DOH	

7.2 REPORT OF SURVEY RESULTS

7.2.1 RESULTS OF BRIDGE CONDITION SURVEY

Upon completion of the preliminary survey, the team concluded that the bridges over the Chao Phraya River had been generally maintained in good condition, although many minor damages and deteriorations were noticeable on the aged bridges, except for the Nonthaburi Bridge which was severely corroded.

The visual inspection sheets for the surveyed bridges are attached in Appendix-8.

From the preliminary survey results, the team attempts to evaluate the bridges over the Chao Phraya River by grouping under construction age, as follows.

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

By 1960, four road bridges in total, 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. Of these, two bridges, Memorial and KrungThep Bridges, have draw-bridge spans. Memorial Bridge was repaired in 1984 to fix the draw-bridge truss chords but not to connect floor beams and deck slabs. Meanwhile, Krung Thep Bridge still preserves its draw-bridge function. Both bridges are being used, although suffering the mechanical impact of vehicles passing on the draw-bridge gap. During the survey, a new bridge was under construction next to the existing Rama IV Rail Bridge.

These old steel truss bridges have been repeatedly repaired in the past and are still being used despite the many observed damages on them. There are also many vehicle and vessel collision scars seen on the bridges. The lower chords deformed by vessel collision are left unrepaired since such deformations are rather minor. Inhibiting the progression of steel corrosion, it does not pose an immediate danger. However, to confirm safety, it is advised to investigate cracks accompanied or not by deformation at the earliest opportunity.

The painting of these bridges looks still clean overall but deterioration was seen partially at the floor beams on which rain water drops from the draw-bridge gap.

As to the Nonthaburi Bridge in question, steel corrosion of truss members and deterioration of concrete deck slab (spalling of cover concrete due to swelling of rusted reinforcing bars) were noticeable. It is predicted that the bridge will likely become dangerous in five years if the bridge is left unrepaired.

Bridges of Second Generation (Blue display in Table 7.1.1)

Following the steel truss bridges mentioned above, the bridges grouped in the second generation were mostly of PC box girder bridges built in the 1970s and 80s. In the 1970s, as PC box girder bridges became popular worldwide, the bridge type was also used for the bridge construction over the Chao Phraya River, except for the Rama IX Bridge which is a steel cable-stayed bridge. These PC box girder bridges, which have aged for almost 30 years, still look sound in general. Obviously, there are many deteriorations and damages seen in some parts of the girder concrete, but these have not yet led to structural damage of whole bridge. The bridge surface pavements and expansion joints are observed as having been repaired and generally maintained in good condition. Many vessel collision scars are seen but are not serious enough to affect the bridge structures.

While many PC box girder bridges built in this period were constructed by cantilever method, the Phra Nangklao and Phra Pinklao Bridges were also constructed by this method, although the cantilever girders on either side were not connected to each other and provided with an expansion joint. At the Phra Nangklao Bridge, these unconnected cantilever girders are shaking independently on either side, suggesting that it has not been equipped with any hinge connection device from the beginning or it is crippled if equipped. It is, however, considered not serious for the safety of the bridge structure because this behavior of cantilever beam was taken into account in design, but it causes mechanical impact at vehicle running. At the same time, the Phra Nangklao Bridge holds a water main pipe each inside the twin box girder and water is observed continuously running from the bottom hole of the girders. It is suspected that the water leakage might be caused by this shaking of the cantilever girder.

As for the Taksin Bridge (a PC box girder bridge built in 1982), the bearing width looks as if it is diminishing at the end support of the box girders. In addition to the originally narrow bearing width, the contraction of the girder due to long-run pre-stress creep and shrinkage of concrete is thought to have caused this phenomenon. Considering the 27 years after construction until the present condition, it is not in immediate danger but periodical inspection is necessary to check the bearing width because there is concern of cracking on the girder end or the bearing pedestal due to stress concentration if the bearing width will further diminish. In the future, widening of the bearing pedestal may be required.

In addition, while the appearance of free lime is a common sign of deterioration in concrete structures, the same deterioration was also noticeable on the Taksin Bridge, particularly at the girder construction joints. Rain water infiltration through the surface pavement is thought to be a cause of deterioration of the girder concrete. The pavement surface usually looks clean by overlaying or replacement in three to five years, but deterioration of the girder concrete has often progressed underneath the pavement. To prevent this type of deterioration and consequently, to prolong the bridge life, it was advised to place a waterproof membrane on the deck surface before placing overlain pavement on it.

Rama IX Bridge (a cable-stayed bridge built in 1982), unlike the PC box girder bridges at the upper reaches of the Chao Phraya River, is a big bridge with a 450-m long span and a 41-m high clearance built at the Bangkok port area in the lower reach of the river. Since the bridge is too big to see throughout, the survey was conducted on the bridge deck with the EXAT staff as a guide. On the bridge, the repair works based on the 20th year inspection was underway: (1) the main tower and staying cables have just been re-painted, (2) the outer surface of the steel girder was being repainted, (3) the expansion joint (rolling leaf type) was going to be renewed for the first time in 20 years, and (4) the steel rib plates on the top and floor decks were being reinforced with CFRP (carbon fiber reinforced plastic). Not only repairs but also improvement was made as seen in the damping devices installed inside the steel girder to suppress traffic vibration. Although the explanation for the reinforcement of rib plates was questioned, the aggressive effort of EXAT for the bridge maintenance was more than the team had expected.

Bridges of Third Generation (Gray display in Table 7.1.1)

Looking at the bridges built in 2000 and later, distinct technology advancement and scale expansion are observed if compared to the PC box girder bridges of the second generation. Major changes seen on the bridges of third generation are summarized below:

- Increase of under-bridge clearance and span length to improve vessel/vehicle collision risks.
- Construction of curved PC box girder bridges, necessitated by sterical use of approach road space as seen in the New Phra Nangklao and Rama III Bridges.
- Following Rama IX Bridge (1987), three cable-stayed bridges namely IRR North, IRR South and Kanchana Pisek Bridges were newly constructed at the further lower reaches of the Chao Phraya River.

The PC box girder bridges of this generation are still new so that no significant deterioration or damage was observed on any bridge, except minor poor finishings of construction. At the Rama V Bridge (built in 2002), some vessel collision scars on the underside girder close to the piers and a loss of footpath railing on the deck were found but both are man-made failures.

IRR North and South Bridges (cable-stayed bridges built in 2006) is a pair of big bridges having a 326-m long span at the north bridge and a 398-m at the south, with a 41-m high clearance at each bridge. The bridges are constructed at the Bangkok port area in the lower reaches of the Chao Phraya River. At first, the survey was conducted on the bridge deck with the DRR staff as a guide. The DRR staff showed the team some problems on the deck such as broken expansion joints, sags of the main span surface profile, and a vertical crack on the inner face of the main tower. Besides the vertical crack, the team found other evidences of several diagonal lines, suggesting cracks at the corner of the main tower and cross beam. Considering the possibility of structural cracks, the team had discussions at a later date with the DRR staff in charge of the bridge maintenance about causes of the said cracks.

Also, for the water pond on the deck in contact with the staying cable anchoring device, the team advised to create a gap between the deck and the anchoring device as a corrosion-prevention measure.

According to DRR, constant monitoring activities on the bridge include CCTV traffic watching, wind velocity measurement, and staying cable strain measurement. In addition, the staying cables are annually inspected in detail by the cable supplier.

Conditions of Bridge Foundation

The bridge foundations hidden under ground and water cannot be visually inspected, but stability of the foundation can be evaluated through observation of the bridge structure above ground. If the foundation becomes unstable, deformation (settlement and leaning) will appear on the piers and further on the bridge girders. From this point of view, bridge piers and girders were inspected, but no such deformation was found in all the bridges surveyed from historical bridges to brand-new bridges.

7.2.2 RESULTS OF INTERVIEWS WITH BRIDGE MAINTENANCE DEPARTMENTS

The survey team visited DRR, DOH and EXAT to learn about the current maintenance status and future rehabilitation plan for the bridges over the Chao Phraya River. The results of interviews and discussions held with the team are summarized by department, as follows.

(1) DRR

Out of 16 bridges surveyed, 11 bridges are under the control of the DRR Maintenance Department. Only the IRR North and South Bridges are maintained under the DRR Construction Department continuously following construction, due to the huge bridge size.

1) DRR Maintenance Department

- The DRR Maintenance Department keeps site offices and staff exclusive for maintenance of the bridges over the Chao Phraya River at respective bridge site utilizing under-bridge spaces, for daily check, cleaning, small repair, and event preparation and clearing.
- The department has been carrying out full-scale inspections for the bridges over the Chao Phraya River periodically in two- to five-year intervals on contract bases. The latest example of the contract-based inspection was of the Krung Thon Bridge (steel truss bridge built in 1958). The detailed bridge inspection has been completed this year, including concrete sample coring and vehicle loading test, and the department will carry out a full-scale repair work next year, with a budget of 20 million bahts. The repair work will include pavement overlay, strengthening of steel truss members, repainting and stone-placing on the scoured riverbed.
- For the Phra Pinklao, Memorial, Phra Pokklao and Taksin Bridges, the department is recently monitoring the bridges' behaviors remotely from the head office by installing strain gages and accelerometers inside the box girders.
- As to the steel truss bridges, the team reported the observed corrosions at edges and corners of steel truss members and provided advice for rain-proofing measures for the deck slab in contact with steel truss members. The team also reported the deterioration

sign seen on the underside of deck slabs where concrete covers have decreased to expose rusted reinforcing bars in some spots.

- Concerning the Taksin Bridge, the team called attention to de-centering of the bearing shoes on the end support of the continuous PC box girders and advised to inspect it periodically.
- In answer to the team, the DRR staff indicated that the department would maintain the present maintenance system for the bridges over the Chao Phraya River for some time in the future and accordingly, the department seemed to have no intention at present to request JICA bridge inspection.

2) DRR Construction Department

- For maintenance of the IRR North and South Bridges, the department has a main site office with three technical staff, under which two maintenance bases for the north and south bridges each, with three technical staff and ten workers for daily inspection, minor repairs, cleaning and monitoring.
- The survey team reported about the cracks of the main tower which the team inspected on the IRR Bridge, and advised the department to keep watching the crack width to check if it is progressing or dormant. As the damageable finger joints, the team advised to replace with another type suitable for long span bridges such as a modular joint (used in Rama VIII Bridge) or a rolling leaf joint (used in Rama IX Bridge).
- The department explained such cracks had been known by DRR, saying that before construction, the bridge designer predicted such cracks had to occur within a year of traffic opening because of the dogleg shape of the main tower.
- Through discussions about the cracks, the department made an inquiry to the team about the possibility for DRR to request JICA for a technical assistance for detailed inspection and analysis of such cracks.

(2) DOH Bridge Construction Bureau

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

The personnel of DOH Bridge Construction Bureau explained the measures currently being taken by DOH for maintenance of the bridges over the Chao Phraya River as follows: DOH had once set up a bridge inspection team comprised of DOH technical staff when introduced with BMMS (Bridge Maintenance Management System) through the assistance of the Danish government nearly two decades ago. However, the bridge inspection team could not be maintained up to the present and has no activity today. Consequently, DOH now needs to contract out bridge inspection jobs for large bridges like the bridges over the Chao Phraya River. However, DOH maintains four regional logistic bases across the country and there holds equipment and work forces to carry out small-scale and emergency bridge repairs. In this way, DOH has kept bridge maintenance capabilities to a certain level.

- Among the three bridges inspected, the team informed DOH of the problems of Nonthaburi and Phra Nangklao Bridges. DOH had already recognized the damages of these two bridges but the department deemed that these damages are not yet serious.
- On the Nonthaburi Bridge, the team explained that the deterioration of the bridge, such as corrosion of steel truss members and deterioration of reinforced concrete deck slabs, has reached the alarming stage. Considering the severity of deterioration of the bridge

and taking into account its geographical location such that no other bridge would be available in the vicinity when it becomes unusable, the team advised it was time for DOH to take action for planning the new Nonthaburi Bridge and for rehabilitation of the existing Nonthaburi Bridge.

- In reply to the team, DOH personnel stated their intention to request JICA for technical assistance for the detailed inspection and rehabilitation design for the Nonthaburi Bridge after reporting the team's advice to the Director General. Furthermore, as to the concern for the Phra Nangklao Bridge i.e. shaking of the cantilever girder and leakage of the water main pipe inside the girder, the DOH personnel also indicated willingness to request for JICA technical assistance for detailed inspection of this latter bridge.
- On the question about the probability of re-construction rather than repairing for old bridges like Nonthaburi Bridge, the DOH personnel revealed the idea that it is usual practice in Thailand to use old bridges as long as possible through repair, even if vehicle loading weight is limited.

(3) EXAT

Among the bridges inspected, Rama IX Bridge (cable-stayed steel bridge built in 1987) is the only bridge controlled under EXAT. As the inspection of the bridge is already reported above, the results of consultation and discussions with EXAT are as follows:

- EXAT outlined the history of the maintenance of Rama IX Bridge. The maintenance program for the bridge actually started with the issuance of the maintenance manual in 1994 through a JICA technical assistance. After that, the bridge underwent the 10th year inspection in 2001.
- The bridge is currently under repair works based on the 20th year inspection just completed which was entrusted to the Chulalongkorn University. Major repair works based on this latest inspection include replacement of pavement with an asphalt mix using slug aggregate, replacement of expansion joints (rolling leaf type), repainting of tower, cables and girders, and reinforcement of girder rib plates with CFRP (Carbon Fiber Reinforced Plastic).
- EXAT informed the team that it is now in the midst of doing repair works following the 20th year inspection so that it is in no position to request the bridge inspection to JICA. Instead, EXAT requested assistance for their staff training in Japan, not as lecture and study tour but as on-the-job training at an actual bridge maintenance site in Japan.

CHAPTER 8

TECHNICAL ASSISTANCE PROGRAMS

CHAPTER 8 TECHNICAL ASSISTANCE PROGRAMS

As a result of the Survey, the following three programs are identified for the smooth implementation of the Project “The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project” and the proper use of the bridges over the Chao Phraya River, which were built through Japanese assistance in the past.

1) Technical Assistance to the Project during Construction Supervision

   To assist DRR through the JICA technical assistance considering 2 things: viz. The consultant services for the F/S and D/D have been conducted by consultant firms having Thailand nationals and the coming C/S will also be conducted by consultant firms led by Thailand nationals; with the construction technology on extradosed girder bridge developed in Japan.

2) Technical Assistance to Maintenance Organizations of Existing Bridges built through Japanese Assistance

   To assist the concerned maintenance organizations for the existing bridges built by Japanese ODA loans since 1971, so as to enhance appropriate and effective use of these bridges. This assistance may include a reinforcement and rehabilitation program for some specific bridges and a probable asset management program for all the existing bridges.

3) Technical Assistance to DOH for the Development of a Bridge Maintenance Management System

   DRR has developed a computer system on Bridge Maintenance System (BMS) and intends to develop it into a Bridge Master Plan. On the other hand, DOH is trying to develop the computer system for its Bridge Maintenance Management System (BMMS), which is still under preparation stage.

   Since DOH has received a number of Japanese ODA load projects in the past, the development of BMMS is urgently required for the proper use of the existing bridges under DOH control.

8.1 TECHNICAL ASSISTANCE FOR THE PROJECT IMPLEMENTATION

8.1.1 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.

8.1.2 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: It is important that the JICA consultant team, comprising of qualified engineers, would check and review the pre-qualification and tender documents for the construction works.
2) Review shop drawings and drawings of design changes/alterations: The construction works cannot be executed just by following the D/D drawings. Shop drawings for the site works as well as for fabrication will be prevailing whether or not the completed bridge and roadway facilities are sound enough. In addition, the contractor for the construction works would have to newly produce a number of drawings in addition to the shop drawings based on the tender drawings. In this regard, it is desirable that the JICA consultant team, particularly experienced in the design and construction supervision of extradosed girder bridges, would check and review the shop drawings and the drawings related to design changes/alterations.
3) Review construction methodology: Temporary facilities, erection equipment and machine, construction methods and sequence are crucial factors for construction safety. Methods related to the substructure, including foundations and towers, and erection methods related to the superstructure, including camber adjustment and prestressing control, would be incorporated into the statement of construction methodology to be submitted by the contractor to the construction supervision consultant. These documents would be submitted by the contractor from time to time. The statement of construction methodology includes state-of-art technologies in various aspects, thus, it is advantageous that the JICA consultant team, comprising of qualified engineers having experiences in the design and construction supervision of extradosed girder bridges would check and review the statement of construction methodology.
4) Review quality assurance plan: The quality assurance plan, which includes high quality materials such as PC tendons, anchors, sheath, cable saddles, and high-strength concrete, should be checked by the JICA consultant team, especially concerns regarding design and construction of extradosed girder bridges.
5) Periodic site inspection to confirm progress, safety and quality: Periodic inspection by the JICA consultant team is required to confirm whether the project progress, construction safety and quality control are in strict compliance with the contract documents, including items 2) to 4) above.

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

8.2.1 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, as shown in Table 8.2.1.

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

Table 8.2.1 O&M Organization for Bridges Built by Japanese Assistance

Type of Japanese Assistance	Bridges maintained by DRR	Bridges maintained by DOH	Bridge maintained by EXAT
Special Funds from the Government of Japan	2 bridges : Krung Thon, Krung Thep	1 bridge : Nonthaburi Bridge	
Japanese ODA Loans	10 bridges : Rama IV (Pak Kret), Rama V (Wat Nakorn-in）, Rama VII, Phra PinkLao, Memorial (rehabilitated under ODA loan), Phra Pok Klao, Taksin, Krung Thep (rehabilitated under ODA), Rama III (New Krung Thep), IRR North / South	2 bridges : Pathum Thani, Phra Nangklao (New Nonthaburi Bridge)	1 bridge : Rama IX

From the visual inspection by the survey team, the following were found:

1) Eleven bridges under DRR are well-maintained and any rehabilitation works are not urgently required.
2) Among the three bridges of DOH, the Nonthaburi Bridge (steel truss) has deteriorated and the central hinge of the Phra Nangkla Bridge (PC box girder) seems already damaged. These two bridges might require rehabilitation works. The survey team was informed by DOH that the Phra Nangkla Bridge would be transferred to DRR. Rehabilitation works for DOH bridges are discussed in the subsequent Section 8.3.
3) One bridge (Rama IX) is well-maintained by EXAT and no rehabilitation from Japanese technical assistance is not required.

From the above, 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 thmedium 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 8.3.

8.2.2 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.

1) Proposal of introduction of Bridge Asset Management

Bridge asset management is focused on doing the preventive maintenance before the onset of real maintenance works.

It is judged that there is necessity for the introduction of bridge asset management in order to avoid spending huge budget when an office has contraints on budget and number of staff.

Therefore, it is proposed to introduce road asset management in order to decide the priority level of the repair of the 11 bridges crossing the Chao Phraya River under the Bureau of Maintenance of DRR.

Concretely, at first the electronic database made on the inspection and the repair result of each bridge managed by DRR is shown in Table 8.2.2. It is then judged whether the bridge is to be repaired or renewed based on LCC after making the electronic database, and selecting the deterioration prediction and repair/reinforcement method. The capital and annual investment for all bridges are decided based on these results, and the maintenance plan is prepared.

Moreover, training for road asset management is proposed due to its high demand as conveyed during interview of DRR.

Training is for the 11 bridges under DRR. On the first year, the Japanese engineer plans the maintenance program based on the database made in Thailand and then instructs the DRR engineer about the optimum management plan based on the repair cost.

On the following year, the review and improvement of the optimum plan will be executed based on the results of the plan of the first year.

It is assumed that the period of stay at Bangkok of the Japanese engineer for training including site inspection is two months for each year.

The information that the development of maintenance system is pioneered at Chulalongkorn University and Thammasat University was also obtained. Thus, it would be possible to develop the Asset Management System in cooperation with these universities.

Table 8.2.2 Bridges Managed by DRR

	Name	Type of Bridge	Length of Bridge (m)	Number of Lane	Opening Year	Remarks
1	Rama IV Bridge	PC Box	278	6	2006	
2	Rama V Bridge	PC Box	320	6	2002	
3	Rama VII Bridge	PC Box	290	6	1992	
4	Krung Thon Bridge	Steel Truss	366	4	1958	
5	Pinklao Bridge	PC Box	280	6	1973	
6	Memorial Bridge	Steel Truss	234	6	1932	
7	Phra Pokklao Bridge	PC Box	212	6	1984	
8	Taksin Bridge	PC Box	224	6	1982	
9	Krung Thep Bridge	Steel Truss	350	4	1959	
10	Rama III Bridge	PC Box	476	6	2000	
11	Industrial Ring Road Bridge(North+South)	Cable Stayed	1279	7	2006	

Moreover, the necessity of asset management for roads and bridges in rural areas were confirmed during interview of Dr. Koonnamas Punthtaecha of the Bureau of Maintenance. It would be expected that asset management of rural roads and bridges can be executed after implementation of the asset management of the 11 bridges crossing the Chao Phraya River.

2) Technical assistance for the newly developing IT system by DRR “Bridge Master Plan”

DRR is implementing the master plan for the construction and repair of all the bridges of Thailand since 2008.

The potential area is based on the 20 m mesh of the whole country of Thailand, which put the weight by seven items, namely, river net, highway net, traffic volume, traffic demand, an existing bridge, environmental zone, and neighborhood demand.

Moreover, in this potential area, the priority levels of the new bridge construction and existing bridge improvement are evaluated based on the GIS data of the maintenance situation of an existing bridge for feasibility design.

The preparation of the master plan is almost completed. In September 2009, DRR already submitted the proposal for the review of the master plan, feasibility study, and the advice by a Japanese expert and training in Japan on the application of Geographic Information System (GIS), Management Information System (MIS), Mobile Mapping System (MMS) and Clean Development Mechanism (CDM).

The evaluation of the existing bridge improvement relates to asset management of the roads and bridges mentioned above. It is envisioned to have cooperation with asset management considering the presence of available data of an existing bridge.

8.2.3 SCOPE OF TECHNICAL ASSISTANCE

The technical assistance to prepare the rehabilitation and reinforcement program for each bridge is conducted through the following activities:

1) Analyze the visual inspection results of the JICA Preparatory Survey to prepare a detailed survey schedule;

2) Conduct the detailed survey on 11 bridges by using a bridge inspection vehicle if

necessary;

3) Analyze the outcomes from the detailed survey to examine the necessary rehabilitation and reinforcement for main girders, substructures including towers, expansion joints, railings, and bearings, including hinges;
4) Prepare detailed drawings for rehabilitation and reinforcement works; and
5) Prepare implementation programs consisting of time schedule, inputs, etc.

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

8.3.1 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.

8.3.2 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.

8.3.3 DOH ROAD NETWORK

Figure 8.3.1 DOH National Road Network

CHAPTER 9

CONCLUSION AND RECOMMENDATION

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 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.

APPENDIX

Appendix-1

List of Chao Phraya River Crossing Bridges as of October 2009 (Completed Only)

APPENDIX-1: Existing Bridges over the Chao Phraya River, as of October 2009

	Bride Name	Prefecture	Executing Organization	Construction		Gist of Bridge			ODA Loan			Construction Firms	
				Commence	Open	Length (m)	Nos of Lane	Bridge Type	Loan Name	L/AYear. Month	Amount		
1	Pathum Thani	Pathum Thani	DOH	1981	1984	239	2 one side pedestrian	PCBox Girder	8th	1981.4	56	Sumitomo Construction	
2	2nd Phatum Thani	Pathum Thani	DOH	2007	2009		6 Pedestrian	PC Box Girder	Thailand Fund			Italian-Thai	
3	Nonthaburi-Pathum Thani（Nonthaburi Bridge）	Border between Nonthaburi & Pathum Thani	DOH		1959	260	2	Steel Truss	Japanese Special Fund				
4	Pak Kret（Rama IV Bridge）	Nonthaburi	DRR	2003	2006	278 (total length including viaduct = 6.1km)	6 Pedestrian	PCBox Girder	22th	1997	55	Sec.1(Bridge,EW Road: Taise, Shino-Thai JV) Sec2 (Rachaburuk Road)	
5	New Phra Nangklao	Nonthaburi	DOH	2005	2008	489	6 Pedestrian	PC Box Girder	Thailand Fund			Unique Engineering	
6	Phra Nangklao（New Nonthaburi Bridge）	Nonthaburi	DOH	1983	1985	329	4 Pedestrian	PC Box Girder	8th	1981.4	58		
7	Wat Nakorn-in (Rama V Bridge)	Border between BMA and Nonthaburi	DRR	1999	2002	320	6 Pedestrian	PC Box Girder	20th"Wat Nakorn-in & Ancilary Road"	1995.9	72	Sumitomo Mitsui Const, Ital-Thai JV	Others 21th, include. Nakorn-in Road, Rachaburuk Road
8	Rama VII Bridge	BMA	DRR	1990	1992	290	6 Pedestrian	PC Box Girder	13th "New Rama VI	1987.9	56	Obayashi, Sumitomo Const, Thai-Obayshi JV	
9	Rama VI Bridge (Railway Bridge)	BMA	SRT		1926	445	2	PC Box Girder	French & British Fund				
10	Krungthon	BMA	DRR	1954	1958	366	4	PC Box Girder	Japanese Special Fund			Fujimotorcar, Safawi Sawa, Kan Yota	
11	Rama VIII Bridge	BMA	BMA	1997	2002	475	4 Pedestrian	PC Box Girder	Thailand Fund			BBRシステムズ・China State Construction & Engineering・PPD Construction	
12	Phra PinkLao	BMA	DRR	1971	1973	280	6 Pedestrian	PC Box Girder	1st	1971	13	Obayshi-Sumitomo JV	
13	Memorial (Phra Phutta Yodf)	BMA	DRR	1929	1932	234	6 Pedestrian	Steel Truss + Bascule	7th (Rehabilitation)	1980	42	Dorman Long & Co., Ltd-Sumitomo Construction JV	
14	Phra Pok Klao	BMA	DRR	1981	1984	212	6 Pedestrian	PC Box Girder	7th	1980	42	Sumitomo Construction	

	Bride Name	Prefecture	Executing Organization	Construction		Gist of Bridge			ODA Loan			Construction Firms	
				Commence	Open	Length (m)	Nos of Lane	Bridge Type	Loan Name	L/AYear. Month	Amount		
15	Taksin Trucks of Sky Train was accomodated in the median space of this bridge.	BMA	DRR	1979	1982	224	6 Pedestrian	PCBox Girder with V-shaped Pier	2nd (DD) 3rd (Const)	1974 1977	3 57	Ital-Thai, Dragages of Travauz Publica,Impress Generation Dj Construction	
16	Krung Thep	BMA	DRR	1954	1959	350	4 Pedestrian	Steel Truss + Bascule	Japanese Special Fund （17th Rehab）	1993	75	Const: Fujimotorcar Rehab: ED.Zublin AG,Wayss Freytag, Stecon	
17	New Krung Thep (Rama III Bridge)	BMA	DRR	1996	2000	476	6	PC Box Girder	17th "New Krungthep Bridge"			ED.Zublin AG, Wayss Freytag, Stecom	
18	Rama IX Bridge	BMA	EXAT	1984	1987	761	2	Steel Cable Stayed	9th	1982	259	Hitach Shipbuild-Tokyu Const-CH Karnchang-Koberco-	
19	Industrial Ring Road, North Bridge	Samut Sakhon	DRR	2001	2006	582	6	Steel Cable Stayed	22nd	1997	148	Taisei, Nishimatsu, NKK, Shono-Thai	EW Viaduct: Kajima, Tokyu Const, Unique Engineering
	Industrial Ring Road, South Bridge			2001	2006	702	6	Steel Cable Stayed					
20	Kanchanapisek	Samut Sakhon	DOH, EXAT		2007	941		Steel Cable Stayed	PPP			CH Karnchang	

Appendix-2

Detail of Construction Cost

No.	Description	Base Cost	Factor F	Construction Cost
1	General Requirements	131,834,000	1	131,834,000
2	Nonthaburi Road Interchange	777,021,000	1.0713	832,423,000
3	Main Bridge	703,627,000	1.0713	753,796,000
4	Main Line Viaduct and Land Minor Bridge	538,322,000	1.0713	576,704,000
5	Ratcha Phruk Road Interchange	226,919,000	1.0713	243,098,000
6	Bridge Accessories	96,761,000	1.0713	103,660,000
7	Roads and Landscaping	717,001,000	1.0677	765,542,000
8	Mechanical and Electrical Services	116,018,000	1.0677	123,872,000
9	Utility and Miscellaneous Relocation	182,196,000	1	182,196,000
10	Force Account Work	8,653,000	1	8,653,000
Total		3,498,352,000		3,721,778,000

Project Location : The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project
1. GENERAL REQUIREMENT

Item No.	Description	Unit	Estimated Quantity	Material Cost		Labour Cost		Material & Labour Cost	
				Unit Rate	Amount	Unit Rate	Amount	Unit Rate	Amount
1.	General Requirement								
1.01	Central and Site Office for the Representative of the Engineer and the Employer	LS	1			39,500,000	39,500,000	39,500,000	39,500,000
1.02	Provide and Maintenance and Running Cost for Central Office	month	30			100,000	3,000,000	100,000	3,000,000
1.03	Site office for representative of the Engineer and The Enployer	LS	1			17,100,000	17,100,000	17,100,000	17,100,000
1.04	Provide for Maintenance and Running Cost for Site Office	month	30			71,500	2,145,000	71,500	2,145,000
1.05	Laboratory Building and Facilities	Ls	1			1,703,000	1,703,000	1,703,000	1,703,000
1.06	Provide for Maintenance and Running Cost for Laboratory Building and Facilities	month	30			33,000	990,000	33,000	990,000
1.07	Special Test and other tests (Provisional)	PS	1			-		7,000,000	7,000,000
1.08	Maintenance and Protection of Traffic	PS	1			-		9,600,000	9,600,000
1.09	Monthly progress photographs and video Compact Disc.	month	30			13,200	396,000	13,200	396,000
1.1	Completed photograohs and Video Compact Disc.	set	6			60,000	360,000	60,000	360,000
1.11	Environmental mitigation of Construction	PS	1			-		5,000,000	5,000,000
1.12	Sport Utility Vehicle	ea	2			1,220,000	2,440,000	1,220,000	2,440,000
1.13	Sedan Car	ea	6			980,000	5,880,000	980,000	5,880,000
1.14	Double Cab Pick-up	ea	4			930,000	3,720,000	930,000	3,720,000
1.15	Microbus	ea	10			60,000	600,000	60,000	600,000
1.16	11-Seat Van	ea	1			3,100,000	3,100,000	3,100,000	3,100,000
1.17	Boat	month	30			30,000	900,000	30,000	900,000
1.18	Provide for maintenance and running costs for all transport	month	30			180,000	5,400,000	180,000	5,400,000
1.19	Provision of safety measures, Accident Prevension and Insurance	PS	1			-		11,400,000	11,400,000
1.20	Provision of Public Relation and Public Participation of Project	PS	1			-		7,600,000	7,600,000
1.21	HIV programe	PS						4,000,000	4,000,000
1	Total of General Requirements								131,834,000

Project Location : The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project
2. NONTHBURI ROAD INTERCHANGE

Item No.	Description	Unit	Estimated Quantity	Material Cost		Labour Cost		Material & Labour Cost	
				Unit Rate	Amount	Unit Rate	Amount	Unit Rate	Amount
2.	Nonthaburi Road Intechange								
2.1	Abutments and Transition Structures								
	<u>Earth Works</u>								
2.1.1	Structural Excavation	m3	7,130			220.00	1,568,600	220.00	1,568,600
2.1.2	Embankment Fill in Transition Structure	m3	7,810	461.10	3,601,191	35.09	274,053	496.19	3,875,244
	<u>Pavement Works</u>								
2.1.3	Subbase for Transition Structure	m3	3,040	512.00	1,556,480	42.11	128,014	554.11	1,684,494
	<u>Foundation Works</u>								
2.1.4	Bored Piles d=0.5m	m	8,010	1,125.00	9,011,250	570.00	4,565,700	1,695.00	13,576,950
2.1.5	Bored Piles d=0.6m	m	11,870	1,406.00	16,689,220	1,002.00	11,893,740	2,408.00	28,582,960
	<u>Structures</u>								
2.1.6	Lean Concrete	m3	4,320	226.50	978,480	25.00	108,000	251.50	1,086,480
2.1.7	Concrete Grade 30A in wall for abutment and transition structure	m3	1,930	4,240.00	8,183,200	1,150.00	2,219,500	5,390.00	10,402,700
2.1.8	Concrete Grade 30A in deck slabl for abutment and cap beam	m3	1,650	3,950.00	6,517,500	1,020.00	1,683,000	4,970.00	8,200,500
2.1.9	Concrete Grade 30A in apron slab and bottom slab for transition structure	m3	1,840	3,200.00	5,888,000	830.00	1,527,200	4,030.00	7,415,200
2.1.10	Concrete Grade 30A in pile cap	m3	1,190	2,950.00	3,510,500	770.00	916,300	3,720.00	4,426,800
2.1.11	Reinforcement Grade SD40	t	810	22,530.00	18,249,300	3,000.00	2,430,000	25,530.00	20,679,300
2	CF								101,499,228

Project Location : The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project
2. NONTHBURI ROAD INTERCHANGE

Item No.	Description	Unit	Estimated Quantity	Material Cost		Labour Cost		Material & Labour Cost	
				Unit Rate	Amount	Unit Rate	Amount	Unit Rate	Amount
2.	B/F								
2.2	Land Pier								
	Earth Works								
2.2.1	Structural Excavation including backfill	m3	3,280			530.00	1,738,400	530.00	1,738,400
	Foundation Works								
2.2.2	Bored Piles d=0.80 m	m	9,310	2,652.00	24,690,120	1,357.00	12,633,670	4,009.00	37,323,790
2.2.3	Bored Piles d=1.20 m	m	9,070	5,047.00	45,776,290	1,978.00	17,940,460	7,025.00	63,716,750
2.2.4	Bored Test d=0.80 m	ea	2			190,000.00	380,000	190,000.00	380,000
2.2.5	Bored Test d=1.20 m	ea	2			270,000.00	540,000	270,000.00	540,000
2.2.6	Pilot Piles d=0.80 m	ea	2			821,845.00	1,643,690	821,845.00	1,643,690
2.2.7	Pilot Piles d=1.20 m	ea	2			1,826,500.00	3,653,000	1,826,500.00	3,653,000
	Structures								
2.2.8	Lean Concrete	m2	1,750	226.50	396,375	25.00	43,750	251.50	440,125
2.2.9	Concrete Grade 30A in column	m3	2,530	5,140.00	13,004,200	1,970.00	4,984,100	7,110.00	17,988,300
2.2.10	Concrete Grade 30A in pile cap	m3	3,130	2,950.00	9,233,500	870.00	2,723,100	3,820.00	11,956,600
2.2.11	Reinforcement Grade SD40 in pile cap	t	357	22,530.00	8,043,210	3,000.00	1,071,000	25,530.00	9,114,210
2.2.12	Reinforcement Grade SD40 in column	t	825	22,530.00	18,587,250	3,000.00	2,475,000	25,530.00	21,062,250
2.3	SUPERSTRUCTURE								
	Structure								
2.3.1	Concrete Grade 40A1	m3	25,340	9,350.00	236,929,000	2,700.00	68,418,000	12,050.00	305,347,000
2.3.2	Concrete Grade 40A2	m3	2,970	8,150.00	24,205,500	2,100.00	6,237,000	10,250.00	30,442,500
2.3.3	Reinforcement Grade SD40	t	4,980	22,530.00	112,199,400	3,000.00	14,940,000	25,530.00	127,139,400
2.3.4	Prestressing Tebdons	t	457	69,170.00	31,610,690	25,000.00	11,425,000	94,170.00	43,035,690
2	Total of Nonthaburi 1 Road Interchange								777,020,933

Project Location : The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project
3. MAIN BRIDGE

Item No.	Description	Unit	Estimated Quantity	Material Cost		Labour Cost		Material & Labour Cost	
				Unit Rate	Amount	Unit Rate	Amount	Unit Rate	Amount
3.	Main Bridge								
3.1	Pylons and Land Piers								
	<u>Earth Works</u>								
3.1.1	Structural Excavation including backfii	m3	2,300			530.00	1,219,000	530.00	1,219,000
	<u>Foundation Works</u>								
3.1.2	Bored Piles d=1.50m	m	4,540	6,030.00	27,376,200	11,330.00	51,438,200	17,360.00	78,814,400
3.1.3	Bored Piles d=1.20m	m	1,520	5,047.00	7,671,440	1,978.00	3,006,560	7,025.00	10,678,000
3.1.4	Permanent steel casing for bored piles d=1.50m	m	550	14,300.00	7,865,000		0	14,300.00	7,865,000
3.1.5	Pile test d=1.50m	ea	2			400,000.00	800,000	400,000.00	800,000
3.1.6	Pile test d=1.20m	ea	2			270,000.00	540,000	270,000.00	540,000
3.1.7	Pilot pile d=1.50m	ea	2			3,667,070.00	7,334,140	3,667,070.00	7,334,140
3.1.8	Pilot pile d=1.20m	ea	2			1,826,500.00	3,653,000	1,826,500.00	3,653,000
	<u>Structures</u>								
3.1.9	Lean Concrete	m3	710	226.50	160,815	25.00	17,750	251.50	178,565
3.1.10	Concrete Grade 30A in footing	m3	4,100	5,205.00	21,340,500	1,040.00	4,264,000	6,245.00	25,604,500
3.1.11	Concrete Grade 30A in column	m3	860	5,745.00	4,940,700	2,170.00	1,866,200	7,915.00	6,806,900
3.1.12	Concrete Grade 30A in pylon	m3	870	13,470.00	11,718,900	3,900.00	3,393,000	17,370.00	15,111,900
3.1.13	Reinforcement Grade SD40 in footing	t	415	22,530.00	9,349,950	3,000.00	1,245,000	25,530.00	10,594,950
3.1.14	Reinforcement Grade SD40 in column	t	106	22,530.00	2,388,180	3,000.00	318,000	25,530.00	2,706,180
3.1.15	Reinforcement Grade SD40 in pylon	t	245	22,530.00	5,519,850	3,000.00	735,000	25,530.00	6,254,850
3.1.16	Reinforcement Grade SD50 in pylon	t		24,180.00	0	3,000.00	0	27,180.00	0
3.1.17	Prestressed tendons in footing	t	50	69,170.00	3,458,500	25,000.00	1,250,000	94,170.00	4,708,500
3	CF								182,869,885

Project Location : The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project
3. MAIN BRIDGE

Item No.	Description	Unit	Estimated Quantity	Material Cost		Labour Cost		Material & Labour Cost	
				Unit Rate	Amount	Unit Rate	Amount	Unit Rate	Amount
3.	B/F								182,869,885
3.2	Superstructure								
	<u>Concrete Post-tensitoned Deck</u>								
3.2.1	Concrete Grade 45A	m3	16,070	10,470.00	168,252,900	2,100.00	33,747,000	12,570.00	201,999,900
3.2.2	Reinforcement Grade SD 40	t	3,820	22,530.00	86,064,600	3,000.00	11,460,000	25,530.00	97,524,600
3.2.3	Prestressing Tendons	t	815	74,170.00	60,448,550	30,000.00	24,450,000	104,170.00	84,898,550
3.2.6	Prestressed bars, in inner webs	t	22	74,170.00	1,631,740	30,000.00	660,000	104,170.00	2,291,740
3.3	Stay Cable								
3.3.1	Prototype stay cable	ea	2	1,650,000.00	3,300,000	2,200,000.00	4,400,000	3,850,000.00	7,700,000
3.3.2	Prototype saddle	ea	2	1,650,000.00	3,300,000	2,200,000.00	4,400,000	3,850,000.00	7,700,000
3.3.3	Cables with anchorage in deck and saddle in pylon	t	270	250,000.00	67,500,000	112,500.00	30,375,000	362,500.00	97,875,000
3.3.4	Outer HDPE sheath for cable stay	m	5,850	1,500.00	8,775,000	450.00	2,632,500	1,950.00	11,407,500
3.3.5	Damper HDPE sheath for stay cable	ea	48	150,000.00	7,200,000	45,000.00	2,160,000	195,000.00	9,360,000
3	Total of Main Bridge								703,627,175

Project Location : The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project

4. MAIN LINE VIADUCT AND MINOR BRIDGE

Item No.	Description	Unit	Estimated Quantity	Material Cost		Labour Cost		Material & Labour Cost	
				Unit Rate	Amount	Unit Rate	Amount	Unit Rate	Amount
4.	Main Line Viaduct and Minor Bridge								
	<u>Main Line Viaduct</u>								
4.1	Abutment and Transition Structure								
	<u>Earth Works</u>								
4.1.1	Structural Excavation including backfii	m3	4,110			220.00	904,200	220.00	904,200
4.1.2	Embankment fill in transition	m3	2,820	461.10	1,300,302	35.09	98,954	496.19	1,399,256
	<u>Pavement Works</u>								
4.1.3	Subbase for transition structure	m3	230	512.00	117,760	42.11	9,685	554.11	127,445
	<u>Foundation Works</u>								
4.1.4	Bored piles d=0.50m	m	3,780	1,125.00	4,252,500	570.00	2,154,600	1,695.00	6,407,100
4.1.5	Bored piles d=0.60m	m	5,510	1,406.00	7,747,060	1,002.00	5,521,020	2,408.00	13,268,080
	<u>Structures</u>								
4.1.6	Lean Concrete	m2	1,870	226.50	423,555	25.00	46,750	251.50	470,305
4.1.7	Concrete Grade 30A in wall of abutment and transition structure	m3	914	4,240.00	3,875,360	1,150.00	1,051,100	5,390.00	4,926,460
4.1.8	Concrete Grade 30A in deck slab and abutment and cap beam	m3	893	3,950.00	3,527,350	1,020.00	910,860	4,970.00	4,438,210
4.1.9	Concrete Grade 30A in apron slab and bottom slab for transition structure	m3	893	3,200.00	2,857,600	830.00	741,190	4,030.00	3,598,790
4.1.10	Concrete Grade 30A in pile cap	m3	599	2,950.00	1,767,050	770.00	461,230	3,720.00	2,228,280
4.1.11	Reinforcement Grade SD40	t	380	22,530.00	8,561,400	3,000.00	1,140,000	25,530.00	9,701,400
4	CF								47,469,526

Project Location : The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project
4. MAIN LINE VIADUCT AND MINOR BRIDGE

Item No.	Description	Unit	Estimated Quantity	Material Cost		Labour Cost		Material & Labour Cost	
				Unit Rate	Amount	Unit Rate	Amount	Unit Rate	Amount
4.	B/F								47,469,526
4.2	Land Pier								
	Earth Works								
4.2.1	Structural excavation including backfill	m3	1,900			530.00	1,007,000	530.00	1,007,000
	Foundation Works								
4.2.2	Bored Piles d=0.80 m	m	1,320	2,652.00	3,500,640	1,357.00	1,791,240	4,009.00	5,291,880
4.2.3	Bored Piles d=1.20 m	m	7,940	5,047.00	40,073,180	1,978.00	15,705,320	7,025.00	55,778,500
4.2.4	Bored Test d=0.80 m	ea	1			190,000.00	190,000	190,000.00	190,000
4.2.5	Bored Test d=1.20 m	ea	1			270,000.00	270,000	270,000.00	270,000
4.2.6	Pilot Piles d=0.80 m	ea	1			821,800.00	821,800	821,800.00	821,800
4.2.7	Pilot Piles d=1.20 m	ea	1			1,826,500.00	1,826,500	1,826,500.00	1,826,500
	Structures								
4.2.8	lean concrete	m2	930	226.50	210,645	25.00	23,250	251.50	233,895
4.2.9	Concrete Grade 30A in column	m3	1,440	5,140.00	7,401,600	1,970.00	2,836,800	7,110.00	10,238,400
4.2.10	Concrete Grade 30A in pile cap	m3	1,810	2,950.00	5,339,500	870.00	1,574,700	3,820.00	6,914,200
4.2.11	Reinforcement Grade SD40 in pile cap	t	200	22,530.00	4,506,000	3,000.00	600,000	25,530.00	5,106,000
4.2.12	Reinforcement Grade SD40 in column	t	394	22,530.00	8,876,820	3,000.00	1,182,000	25,530.00	10,058,820
4.3	Superstructure								
4.3.1	Concrete Grade 40A2	m3	16,160	9,350.00	151,096,000	2,700.00	43,632,000	12,050.00	194,728,000
4.3.2	Concrete Grade 40A3	m3	2,640	8,150.00	21,516,000	2,100.00	5,544,000	10,250.00	27,060,000
4.3.3	Reinforcement Grade SD40	t	3,220	22,530.00	72,546,600	3,000.00	9,660,000	25,530.00	82,206,600
4.3.4	Prestressing tendons	t	291	69,170.00	20,128,470	25,000.00	7,275,000	94,170.00	27,403,470
4	C/F								476,604,591

Project Location : The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project
4. MAIN LINE VIADUCT AND MINOR BRIDGE

Item No.	Description	Unit	Estimated Quantity	Material Cost		Labour Cost		Material & Labour Cost	
				Unit Rate	Amount	Unit Rate	Amount	Unit Rate	Amount
4.	B/F								476,604,591
4.4	Minor Bridge								
	Earth Works								
4.4.1	Structural excavation including backfill	m3	12,600			220.00	2,772,000	220.00	2,772,000
4.4.2	Embankment fill in transition structure	m3	20,500	461.10	9,452,550	35.09	719,345	496.19	10,171,895
	Pavement Works								
4.4.3	Subbase for transition structure	m3	0	512.00	0	0.00	0	512.00	0
	Foundation Works								
4.4.4	Prestressed concrete piles 0.26x0.26 m	m	29,600	440.00	13,024,000	110.00	3,256,000	550.00	16,280,000
4.4.5	Prestressed concrete piles 0.40x0.40 m	m	2,160	915.00	1,976,400	210.00	453,600	1,125.00	2,430,000
	Structures								
4.4.6	Lean concrete	m2	7,620	226.50	1,725,930	25.00	190,500	251.50	1,916,430
4.4.7	Concrete Grade 30A in column and concrete topping for precast slab	m3	120	3,950.00	474,000	1,020.00	122,400	4,970.00	596,400
4.4.8	Concrete Grade 30A in wall for abutment and transition structure	m3	560	4,240.00	2,374,400	1,150.00	644,000	5,390.00	3,018,400
4.4.9	Concrete Grade 30A in deck slab for abutment and cap beam	m3	30	3,950.00	118,500	1,020.00	30,600	4,970.00	149,100
4.4.10	Concrete Grade 30A in apron slab and bottom slab for transition structure	m3	2,680	3,200.00	8,576,000	830.00	2,224,400	4,030.00	10,800,400
4.4.11	Concrete Grade 30A in pile cap	m3	0	2,950.00	0	770.00	0	3,720.00	0
4.4.12	Reinforcement Grade SD40	t	340	22,530.00	7,660,200	3,000.00	1,020,000	25,530.00	8,680,200
4.4.13	Plank girder 0.35 x 1.00 x 5.00 m	ea	48	7,708.58	370,012	6,424.00	308,352	14,132.58	678,364
4.4.14	Plank girder 0.35 x 1.00 x 10.00 m	ea	24	16,133.17	387,196	11,566.00	277,584	27,699.17	664,780
4.4.15	Plank girder 0.35 x 1.00 x 12.00 m	ea	20	21,868.00	437,360	15,334.00	306,680	37,202.00	744,040
4.4.16	Plank girder 0.35 x 1.00 x 15.00 m	ea	24	43,960.00	1,055,040	23,162.00	555,888	67,122.00	1,610,928
4.4.17	Strip bearing and side walk 1.5 m	ea	262	1,600.00	419,200	320.00	83,840	1,920.00	503,040
4.4.18	Concrete railing and side walk 1.5m	m	94	4,110.00	386,340	680.00	63,920	4,790.00	450,260
4.4.19	Concrete barrier	m	94	2,241.40	210,692	430.00	40,420	2,671.40	251,112
4	Total of Main Line Viaduct								538,321,940

Project Location : The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project
5. RATCHA PHRUK ROAD INTERCHANGE

Item No.	Description	Unit	Estimated Quantity	Material Cost		Labour Cost		Material & Labour Cost	
				Unit Rate	Amount	Unit Rate	Amount	Unit Rate	Amount
5.	Ratcha Phruk Road Intechange								
5.1	Abutments and Transition Structures								
	Earth Works								
5.1.1	Structural Excavation	m3	2,595			220.00	570,900	220.00	570,900
5.1.2	Embankment Fill in Transition Structure	m3	1,550	461.10	714,705	35.09	54,390	496.19	769,095
	Pavement Works								
5.1.3	Subbase for Transition Structure	m3	200	512.00	102,400	42.11	8,422	554.11	110,822
	Foundation Works								
5.1.4	Bored Piles d=0.5m	m	6,160	1,125.00	6,930,000	570.00	3,511,200	1,695.00	10,441,200
5.1.5	Bored Piles d=0.6m	m	8,820	1,406.00	12,400,920	1,002.00	8,837,640	2,408.00	21,238,560
	Structures								
5.1.6	Lean Concrete	m3	1,730	226.50	391,845	25.00	43,250	251.50	435,095
5.1.7	Concrete Grade 30A in wall for abutment and transition structure	m3	908	4,240.00	3,849,920	1,150.00	1,044,200	5,390.00	4,894,120
5.1.8	Concrete Grade 30A in deck slabl for abutment and cap beam	m3	1,160	3,950.00	4,582,000	1,020.00	1,183,200	4,970.00	5,765,200
5.1.9	Concrete Grade 30A in apron slab and bottom slab for transition structure	m3	677	3,200.00	2,166,400	830.00	561,910	4,030.00	2,728,310
5.1.10	Concrete Grade 30A in pile cap	m3	588	2,950.00	1,734,600	770.00	452,760	3,720.00	2,187,360
5.1.11	Reinforcement Grade SD40	t	443	22,530.00	9,980,790	3,000.00	1,329,000	25,530.00	11,309,790
2	CF								60,450,452

Project Location : The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project
5. RATCHA PHRUK ROAD INTERCHANGE

Item No.	Description	Unit	Estimated Quantity	Material Cost		Labour Cost		Material & Labour Cost	
				Unit Rate	Amount	Unit Rate	Amount	Unit Rate	Amount
5.	B/F								60,450,452
5.2	Land Pier								
	Earth Works								
5.2.1	Structural Excavation including backfill	m3	1,000			530.00	530,000	530.00	530,000
	Foundation Works								
5.2.2	Bored Piles d=0.80 m	m	5,950	2,652.00	15,779,400	1,357.00	8,074,150	4,009.00	23,853,550
5.2.4	Bored Test d=0.80 m	ea	1			190,000.00	190,000	190,000.00	190,000
5.2.6	Pilot Piles d=0.80 m	ea	1			821,800.00	821,800	821,800.00	821,800
	Structures								
5.2.8	Lean Concrete	m2	620	226.50	140,430	25.00	15,500	251.50	155,930
5.2.9	Concrete Grade 30A in column	m3	500	5,140.00	2,570,000	1,970.00	985,000	7,110.00	3,555,000
5.2.10	Concrete Grade 30A in pile cap	m3	820	2,950.00	2,419,000	870.00	713,400	3,820.00	3,132,400
5.2.11	Reinforcement Grade SD40 in pile cap	t	74	22,530.00	1,667,220	3,000.00	222,000	25,530.00	1,889,220
5.2.12	Reinforcement Grade SD40 in column	t	170	22,530.00	3,830,100	3,000.00	510,000	25,530.00	4,340,100
2.3	SUPERSTRUCTURE								
	Structure								
5.3.1	Concrete Grade 40A1	m3	7,170	9,350.00	67,039,500	2,700.00	19,359,000	12,050.00	86,398,500
5.3.3	Reinforcement Grade SD40	t	1,150	22,530.00	25,909,500	3,000.00	3,450,000	25,530.00	29,359,500
5.3.4	Prestressing Tebdons	t	130	69,170.00	8,992,100	25,000.00	3,250,000	94,170.00	12,242,100
5	Total of Ratcha Phruk Road Interchange								226,918,552

Project Location : The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project
6. BRIDGE ACCESSORIES

Item No.	Description	Unit	Estimated Quantity	Material Cost		Labour Cost		Material & Labour Cost	
				Unit Rate	Amount	Unit Rate	Amount	Unit Rate	Amount
6.	BRIDGE ACCESSORIES								
6.1	<u>JOINTS</u>								
	<u>Expansion joint scal in bridge decks</u>								
6.1.1	Expansion joint EJ 1 (Movement +/- 55 mm.)	m	835	23,000.00	19,205,000	2,500.00	2,087,500	25,500.00	21,292,500
6.1.2	Epansion joint EJ 2 (Movement +/- 80 mm.)	m	200	30,000.00	6,000,000	3,000.00	600,000	33,000.00	6,600,000
6.1.3	Epansion joint EJ 4 (Movement +/- 115 mm.)	m	45	86,000.00	3,870,000	9,000.00	405,000	95,000.00	4,275,000
6.1.4	Sealed joint between abutment and transition structure	m	200	300.00	60,000	80.00	16,000	380.00	76,000
6.1.5	Sealed joint in barriers	m	2,200	300.00	660,000	80.00	176,000	380.00	836,000
6.1.6	Sealed joint in walls,between abutment and transition	m	265	300.00	79,500	80.00	21,200	380.00	100,700
6.2	<u>BRIDGE BEARINGS</u>								
6.2.1	Pot bearing type 1A (200 ton , 55 mm.)	ea	62	47,000.00	2,914,000	7,400.00	458,800	54,400.00	3,372,800
6.2.2	Pot bearing type 1B (200 ton , 55 mm.)	ea	74	30,000.00	2,220,000	4,300.00	318,200	34,300.00	2,538,200
6.2.3	Pot bearing type 2A (200 ton , 90 mm.)	ea	28	47,000.00	1,316,000	7,400.00	207,200	54,400.00	1,523,200
6.2.4	Pot bearing type 2B (200 ton , 90 mm.)	ea	30	30,000.00	900,000	4,300.00	129,000	34,300.00	1,029,000
6.2.5	Pot bearing type 3A (300 ton , 55 mm.)	ea	4	66,000.00	264,000	10,800.00	43,200	76,800.00	307,200
6.2.6	Pot bearing type 3B (300 ton , 55 mm.)	ea	4	40,000.00	160,000	6,000.00	24,000	46,000.00	184,000
6.2.7	Pot bearing type 5A (500 ton , 90 mm.)	ea		89,000.00		15,100.00	0	104,100.00	0
6.2.8	Pot bearing type 5B (500 ton , 90 mm.)	ea		63,000.00		10,000.00	0	73,000.00	0
6.2.9	Pot bearing type 6A (800 ton , 160 mm.)	ea	4	162,000.00	648,000	29,700.00	118,800	191,700.00	766,800
6.2.10	Pot bearing type 6B (800 ton , 160 mm.)	ea	4	115,000.00	460,000	20,400.00	81,600	135,400.00	541,600
6.3	<u>LADDERS, HANDRAIL, LOUVER, DOOR, ETC</u>								
6.3.1	Steel ladders in pylon	m	105	1,500.00	157,500	1,000.00	105,000	2,500.00	262,500
6.3.2	Steel handrail in pylon	m	16	1,500.00	24,000	1,000.00	16,000	2,500.00	40,000
6.3.3	Louver ventilator w/aluminium insect	ea	8	2,000.00	16,000	1,000.00	8,000	3,000.00	24,000
6.3.4	Steel doors with ventilation in pylons	ea	2	8,000.00	16,000	2,000.00	4,000	10,000.00	20,000
6.3.5	Preast concrete skirt	m	99	10,120.00	1,001,880	2,460.00	243,540	12,580.00	1,245,420
6.4	PYLON PINNACLE	ea	2	2,500,000.00	5,000,000	2,000,000.00	4,000,000	4,500,000.00	9,000,000
6.	C/F								54,034,920

Project Location : The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project

6. BRIDGE ACCESSORIES

Item No.	Description	Unit	Estimated Quantity	Material Cost		Labour Cost		Material & Labour Cost	
				Unit Rate	Amount	Unit Rate	Amount	Unit Rate	Amount
6.	B/F								54,034,920
6.5	<u>BRIDGE DRAINS</u>								
6.5.1	Inlet Gully	ea	1,675	2,600.00	4,355,000	800.00	1,340,000	3,400.00	5,695,000
6.5.2	GMS. Pipe d=150 mm. with fitting	m	6,985	1,148.33	8,021,085	150.00	1,047,750	1,298.33	9,068,835
6.5.3	PVC. Pipe d=150 mm. with fitting	m	3,330	400.00	1,332,000	120.00	399,600	520.00	1,731,600
6.5.4	PVC. Pipe d=250 mm. with fitting	m	390	1,120.00	436,800	450.00	175,500	1,570.00	612,300
6.6	<u>BRIDGE PAVEMENTS</u>								
	<u>Polymer modified Bitumen (PmB) Asphait Pavement</u>								
6.6.1	PmB tack coat	lit	21,000	28.13	590,625	16.69	350,490	44.82	941,115
6.6.2	PmB asphaltic concrete on bridges, thickness 50 mm.	m2	90,050	219.71	19,784,795	54.33	4,892,480	274.04	24,677,275
6.	SUBTOTAL BRIDGE ACCESSORIES (Transfer to Summary)								96,761,045

Project Location : The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project
7. ROAD AND LANDSCAPING

Item No.	Description	Unit	Estimated Quantity	Material Cost		Labour Cost		Material & Labour Cost	
				Unit Rate	Amount	Unit Rate	Amount	Unit Rate	Amount
7.	ROADS AND LANDSCAPING								
7.1	EARTHWORKS								
7.1.1	Clearing and grubbing	LS	1	–	-	1,080,000.00	1,080,000	1,080,000.00	1,080,000
7.1.2	Roadway excavation : classified suitable material	m3	4,400	-	-	51.49	226,556	51.49	226,556
7.1.3	Roadway excavation : classified unsuitable material	m3	2,000	-	-	66.18	132,360	66.18	132,360
7.1.4	Channel execavation	m3	500	-	-	66.18	33,090	66.18	33,090
7.1.5	Embankment fill in roadway	m3	90,260	461.10	41,618,886	35.09	3,167,223	496.19	44,786,109
7.1.6	Geotextile fabrie sheet	m2	5,300	53.00	280,900	12.00	63,600	65.00	344,500
7.2	PAVEMENT WORKS								
7.2.1	Crushed rock subbase (0.15 m.,thickness)	m3	8,900	620.00	5,518,000	42.11	374,779	662.11	5,892,779
7.2.2	Soil aggregate subbase (0.30 m.,thickness)	m3	42,000	512.00	21,504,000	42.11	1,768,620	554.11	23,272,620
7.2.3	Crushed rock base (0.25 m.,thickness)	m3	31,000	581.25	18,018,750	66.57	2,063,670	647.82	20,082,420
7.2.4	Crushed rock for walkway (0.10 m.,thickness)	m3	8,000	542.50	4,340,000	42.11	336,880	584.61	4,676,880
	Reinforeed concrete Pavement								
7.2.5	Removal of existing Reinforeed concrete Pavement	m2	1,200	-		150.28	180,336	150.28	180,336
7.2.6	Reinforced concrete pavement of 0.27 m. thickness	m2	39,050	768.01	29,990,791	34.99	1,366,262	803.00	31,357,052
7.2.7	Reinforeed concrete pavement of varies thickness	m2	50	2,844.47	142,224	129.60	6,480	2,974.07	148,704
7.2.8	Plastic sheet	m2	5,930	13.00	77,090	3.00	17,790	16.00	94,880
	Asphalt Pavement								
7.2.9	Removal of existing Asphalt Pavement	m2	1,000	-		54.36	54,360	54.36	54,360
7.2.10	Prime coat	lit	98,300	25.50	2,506,650	5.56	546,548	31.06	3,053,198
7.2.11	Tack coat	lit	29,500	25.50	752,250	16.69	492,355	42.19	1,244,605
7.2.12	Asphaltic concrele binder course on roads, thickness 50 mm.	m2	98,300	168.02	16,516,366	57.10	5,612,930	225.12	22,129,296
7.2.13	Asphaltic concrele wraring course on roads, thickness 50 mm.	m2	98,300	168.02	16,516,445	54.33	5,340,344	222.35	21,856,789
7.2.14	Asphaltic concrete varies thickness	m3	135	3,360.36	453,649	1,142.00	154,170	4,502.36	607,819
7.	C/F								181,254,353

7. ROAD AND LANDSCAPING

Item No.	Description	Unit	Estimated Quantity	Material Cost		Labour Cost		Material & Labour Cost	
				Unit Rate	Amount	Unit Rate	Amount	Unit Rate	Amount
7.	B/F								181,254,353
7.3	<u>INCIDENTALS</u>								
	<u>Reinforced concrete pipes</u>								
7.3.1	RC pipe d= 400 mm.	m		456.60		195.00			
7.3.2	RC pipe d= 600 mm.	m	2,387	771.00	1,840,377	498.00	1,188,726	1,269.00	3,029,103
7.3.3	RC pipe d= 800 mm.	m	340	1,422.40	483,616	600.00	204,000	2,022.40	687,616
7.3.4	RC pipe d= 1,200 mm.	m	14,847	2,486.00	36,909,642	896.00	13,302,912	3,382.00	50,212,554
	<u>Manholes</u>								
7.3.5	Manhole type A for RC pipe d= 600 mm.	ea	146	11,481.47	1,676,295	2,878.47	420,257	14,359.94	2,096,551
7.3.6	Manhole type A for RC pipe d= 1,200 mm.	ea	1,034	19,951.64	20,629,996	6,332.20	6,547,495	26,283.84	27,177,491
7.3.7	Manhole type B for RC pipe d= 1,200 mm.	ea	10	20,401.24	204,012	6,575.20	65,752	26,976.44	269,764
7.3.8	Manhole type V for RC pipe d= 600 mm.	ea	104	12,348.67	1,284,262	3,097.47	322,137	15,446.14	1,606,399
7.3.9	Manhole type D	ea	22	18,361.12	403,945	5,917.68	130,189	24,278.80	534,134
7.3.10	Modified existing manhole	ea	7	7,612.00	53,284	3,350.00	23,450	10,962.00	76,734
	<u>Box culverts</u>								
7.3.11	Relocate of exising water gate at Khlong Makham Plong	PS	1	-		-		5,000,000.00	5,000,000
7.3.12	Box culvert 1-2.1 × 2.1 m.	m	46	10,251.94	471,589	3,730.83	171,618	13,982.77	643,207
7.3.13	Box culvert 1-3.0 × 3.0 m.	m	20	17,974.69	359,494	6,601.54	132,031	24,576.23	491,525
7.3.14	Box culvert 1-3.6 × 3.6 m.	m	70	23,537.81	1,647,647	7,454.28	521,800	30,992.09	2,169,446
7.3.15	Head wall for box culvert	ea	6	31,076.27	186,458	8,321.86	49,931	39,398.13	236,389
	<u>Catch basin and Outlets</u>								
7.3.16	Catch basin w / rc. Cover	ea	253	9,975.82	2,523,882	3,166.10	801,023	13,141.92	3,324,906
7.3.17	Curb inlet	ea	1,590	867.60	1,379,484	256.00	407,040	1,123.60	1,786,524
7.3.18	RC. Lining ditch	m	125	1,687.41	210,926	393.04	49,130	2,080.45	260,056
7.3.19	RC. U-ditch	m	3,625	2,141.45	7,762,756	424.58	1,539,103	2,566.03	9,301,859
7.3.20	RC. U-ditch w=0.20 m at Transition Structure	m	560	2,660.00	1,489,600	1,140.00	638,400	3,800.00	2,128,000
7.3.21	Transition Catch basin	a	19	10,850.00	206,150	4,650.00	88,350	15,500.00	294,500
	<u>Concrete paving blocks</u>								
7.3.22	Concrete paving blocks for sidewalks and traffic islands	m2	104,200	330.00	34,386,000	60.00	6,252,000	390.00	40,638,000
7.	C/F								333,219,110

Project Location : The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project

7. ROAD AND LANDSCAPING

Item No.	Description	Unit	Estimated Quantity	Material Cost		Labour Cost		Material & Labour Cost	
				Unit Rate	Amount	Unit Rate	Amount	Unit Rate	Amount
7.	B/F								333,219,110
	<u>Concrete curb</u>								
7.3.23	Conerete curb and gutter	m	32,850	451.67	14,837,360	92.80	3,048,480	544.47	17,885,840
7.3.24	Retaining wall type 1	m	4,425	493.60	2,184,180	148.50	657,113	642.10	2,841,293
7.3.25	Retaining wall type 2	m	4,105	1,079.64	4,431,922	256.00	1,050,880	1,335.64	5,482,802
7.3.26	Retaining wall type 3	m	4,650	7,829.07	36,405,176	1,701.70	7,912,905	9,530.77	44,318,081
7.3.27	Retaining wall type 4	m	2,685	10,625.42	28,529,253	2,268.50	6,090,928	12,893.92	34,620,181
7.3.28	Retaining wall type 5	m	500	14,786.46	7,393,230	2,773.00	1,386,500	17,559.46	8,779,730
	<u>Guardrail</u>								
7.3.29	W-stell beam guardrail	m	1,420	1,127.78	1,601,448	197.78	280,848	1,325.56	1,882,295
	<u>Barricrs</u>								
7.3.30	Main bridge traffic railing	m	920	7,270.00	6,688,400	2,283.00	2,100,360	9,553.00	8,788,760
7.3.31	Handrail on main bridge	m	920	5,500.00	5,060,000	1,000.00	920,000	6,500.00	5,980,000
7.3.32	Edge barriers on viaduct	m	12,204	4,407.75	53,792,230	874.72	10,675,132	5,282.48	64,467,362
7.3.33	Median barriers (Barrier type II)	m	8,125	2,398.79	19,490,169	445.80	3,622,125	2,844.59	23,112,294
7.3.34	Concrete barriers (Barrer type I)	m	9,085	2,241.40	20,363,119	430.00	3,906,550	2,671.40	24,269,669
7.3.35	Termination concrete barriers	m	755	1,448.00	1,093,240	268.00	202,340	1,716.00	1,295,580
	<u>Miscellancous works</u>								
7.3.36	East River front stair structure and finishing	LS	1	7,850,163.98	7,850,164	1,123,173.60	1,123,174	8,973,337.58	8,973,338
7.3.37	West River front stair structure and finishing	LS	1	7,240,919.32	7,240,919	1,068,982.50	1,068,983	8,309,901.82	8,309,902
7.3.38	East River front area structure and finishing	LS	1	2,886,000.00	2,886,000	1,110,000.00	1,110,000	3,996,000.00	3,996,000
7.3.39	West River front stair structure and finishing	LS	1	10,198,000.00	10,198,000	3,830,000.00	3,830,000	14,028,000.00	14,028,000
7.3.40	Stair tower structure and finishing	ea	4	1,640,412.40	6,561,650	640,245.00	2,560,980	2,280,657.40	9,122,630
7.3.41	Bridge Sign Board (Provisional Sum)	LS	1	-		-		5,000,000.00	5,000,000
7.3.42	Information Board at Rccreation area	ea	2	40,000.00	80,000	20,000.00	40,000	60,000.00	120,000
7.3.43	Pedestrain Bridge at Ramp NB-01 sta 0+270	LS	1	2,171,490.00	2,171,490	850,820.00	850,820	3,022,310.00	3,022,310
7.3.44	Pedestrain Bridge at Nonthaburi interchange	LS	1	2,171,490.00	2,171,490	850,820.00	850,820	3,022,310.00	3,022,310
7.3.45	Pedestrain Bridge at Main line sta. 2+900	LS	1	2,171,490.00	2,171,490	850,820.00	850,820	3,022,310.00	3,022,310
7.3.46	Pedestrain Bridge at Ratcha Phruk Road Interchange	LS	1	4,009,090.00	4,009,090	1,814,160.00	1,814,160	5,823,250.00	5,823,250
7.3.47	Reiocated Existing Pedestrain Bridge	ea	4	800,000.00	3,200,000	150,000.00	600,000	950,000.00	3,800,000
7.3.48	Differential settlement reduction structure	ea	17	120,047.20	2,040,802	23,320.00	396,440	143,367.20	2,437,242
7.	C/F								647,620,286

Project Location : The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project

7. ROAD AND LANDSCAPING

Item No.	Description	Unit	Estimated Quantity	Material Cost		Labour Cost		Material & Labour Cost	
				Unit Rate	Amount	Unit Rate	Amount	Unit Rate	Amount
7.	B/F								647,620,286
7.4	<u>ROAD MARKING, TRAFFIC SIGNS AND SIGNALS</u>								
	<u>Road marking</u>								
7.4.1	Removal of existing road markings	m2	200	-		65.00	13,000	65.00	13,000
7.4.2	Thermoplastic road marking	m2	5,850	240.00	1,404,000	50.00	292,500	290.00	1,696,500
7.4.3	Paint markings on cubs	m2	3,090	180.00	556,200	40.00	123,600	220.00	679,800
7.4.4	Color pavement	m2	1,200	1,300.00	1,560,000	400.00	480,000	1,700.00	2,040,000
7.4.5	Crush cusion	ea	2	320,000.00	640,000	30,000.00	60,000	350,000.00	700,000
7.4.6	Stud	ea	625	300.00	187,500	90.00	56,250	390.00	243,750
7.4.7	Flexible guide post	ea	172	1,500.00	258,000	200.00	34,400	1,700.00	292,400
	<u>Traffic signs.</u>								
7.4.8	Dismounting and removal of existing signs	ea	4			1,100.00	4,400	1,100.00	4,400
7.4.9	Sign post M1	ea	299	1,350.00	403,650	400.00	119,600	1,750.00	523,250
7.4.10	Sign post M2	ea	35	1,000.00	35,000	350.00	12,250	1,350.00	47,250
7.4.11	Sign post M3	ea	160	1,150.00	184,000	400.00	64,000	1,550.00	248,000
7.4.12	Regulatory signs	m2	27	3,850.00	103,950	500.00	13,500	4,350.00	117,450
7.4.13	Sign post M5	ea	24	200,000.00	4,800,000	74,000.00	1,776,000	274,000.00	6,576,000
7.4.14	Sign post M8	ea	2	25,000.00	50,000	9,000.00	18,000	34,000.00	68,000
7.4.15	Sign post M9	ea	19	48,000.00	912,000	12,000.00	228,000	60,000.00	1,140,000
7.4.16	Warning signs	m2	363	3,600.00	1,306,800	750.00	272,250	4,350.00	1,579,050
7.4.17	Guide signs	m2	28	3,600.00	100,800	750.00	21,000	4,350.00	121,800
7.4.18	Overhead signs	m2	1,541	5,000.00	7,705,000	1,000.00	1,541,000	6,000.00	9,246,000
	<u>Traffic signals</u>								
7.4.19	Traffic signal , type S5	ea	2	39,200.00	78,400	1,500.00	3,000	40,700.00	81,400
7.4.20	Traffic signal , type S6	ea	6	29,400.00	176,400	1,500.00	9,000	30,900.00	185,400
7.4.21	Traffic signal , type S7	ea	10	39,200.00	392,000	1,500.00	15,000	40,700.00	407,000
7.4.22	Traffic signal , type S8	ea	45	19,600.00	882,000	1,000.00	45,000	20,600.00	927,000
7.4.23	Traffic signal , type S9	ea	6	29,400.00	176,400	1,500.00	9,000	30,900.00	185,400
7.4.24	Counter Timer	ea	21	58,500.00	1,228,500	2,500.00	52,500	61,000.00	1,281,000
7.4.25	Standard pole , type P1	ea	48	4,388.00	210,624	1,130.00	54,240	5,518.00	264,864
7.4.26	Pole with arm mast , type P2	ea	21	25,588.00	537,348	2,630.00	55,230	28,218.00	592,578
7.4.27	Controller foundations ,cablc pits.cable ducts and all related road works necessary for a traffic signal system for one one intersection.	LS	1	3,745,700.00	3,745,700	1,260,200.00	1,260,200	5,005,900.00	5,005,900
7.	C/F								681,887,478

Project Location : The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project
7. ROAD AND LANDSCAPING

Item No.	Description	Unit	Estimated Quantity	Material Cost		Labour Cost		Material & Labour Cost	
				Unit Rate	Amount	Unit Rate	Amount	Unit Rate	Amount
7.	B/F								681,887,478
7.5	LANDSCAPING								
	Earthworks								
7.5.1	Earthfill in landscape area : new material	m3	18,260	320.00	5,843,200	42.11	768,929	362.11	6,612,129
7.5.2	Earthfill in median area : new material	m3	10,680	320.00	3,417,600	42.11	449,735	362.11	3,867,335
	Top soil and Grassing								
7.5.3	Top soil	m2	19,900	22.00	437,800	7.00	139,300	29.00	577,100
7.5.4	Grass turf	m2	19,900	16.00	318,400	9.00	179,100	25.00	497,500
	Planting Trees , Shrub and Group covering plants								
7.5.5	Planting Trees	PS	1					800,000.00	800,000
7.5.6	Shrub and Ground Covering Plants	PS	1					900,000.00	900,000
	Miscellancous works								
7.5.7	Relocate of existing Bus stop	ea	3	60,000.00	180,000	30,000.00	90,000	90,000.00	270,000
7.5.8	Pavilion type A	ea	4	468,010.00	1,872,040	141,270.00	565,080	609,280.00	2,437,120
7.5.9	Pavilion type B	ea	2	297,250.00	594,500	89,920.00	179,840	387,170.00	774,340
7.5.10	Guard House	ea	4	98,470.00	393,880	37,550.00	150,200	136,020.00	544,080
7.5.11	Toilet Building	ea	2	720,000.00	1,440,000	252,000.00	504,000	972,000.00	1,944,000
7.5.12	Landscpape for Nonthaburi Interchange	LS	1	5,278,000.00	5,278,000	2,262,000.00	2,262,000	7,540,000.00	7,540,000
7.5.13	Landscpape for Ratcha Ohruk Interchange	LS	1	5,845,000.00	5,845,000	2,505,000.00	2,505,000	8,350,000.00	8,350,000
7.	SUBTOTAL ROADS AND LANDSCAPING (Transfer to Summary)								717,001,081

Project Location : The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project
8. MECHANICAL AND ELECTRICAL SERVICES

Item No.	Description	Unit	Estimated Quantity	Material Cost		Labour Cost		Material & Labour Cost	
				Unit Rate	Amount	Unit Rate	Amount	Unit Rate	Amount
8.	MECHANICAL AND ELECTRICAL SERVICES								
8.1	ELECTRICAL SUPPLY AND ARCHITECTURAL LIGHTING F MAIN BRIDGE, IN PYLON, RIVER FRONT & RECREATION AREA, STAIR TOWER AND PAVILION BUILDING	PS	1	-		-		32,000,000.00	32,000,000
8.2	LIGHTNING PROTECTION SYSTEM	PS	1	-		-		500,000.00	500,000
8.3	STREET LIGHTING AND LANDSCAPE								
8.3.1	Lighting fixture complete with lamp, ballast, ignitor capacitor, dimmimg system (street lighting) and accessaries								
	- 250 HPS Street lighting	ea	589	9,800.00	5,772,200	500.00	294,500	10,300.00	6,066,700
	- 400 HPS Street lighting	ea	114	11,000.00	1,254,000	500.00	57,000	11,500.00	1,311,000
	- 250 HPS Street lighting (Architcctural lighting)	ea	36	31,000.00	1,116,000	1,000.00	36,000	32,000.00	1,152,000
	- 400 HPS Street lighting (Architcctural lighting)	ea	128	33,000.00	4,224,000	1,000.00	128,000	34,000.00	4,352,000
	- 150 HPS Soffit lighting	ea	73	9,000.00	657,000	800.00	58,400	9,800.00	715,400
	- 75 HDS Landscape lighting on 3 m. Architecture Pole	ea	73	12,000.00	876,000	500.00	36,500	12,500.00	912,500
8.3.2	Lighting poles complete with, mounting bracket and anchor bolt Cables, grounding and accessaries								
	- 10 m Mouting height, single arm	ea	541	12,500.00	6,762,500	2,680.00	1,449,880	15,180.00	8,212,380
	- 10 m Mouting height, double arm	ea	24	14,000.00	336,000	2,680.00	64,320	16,680.00	400,320
	- 11 m Mouting height, single arm (Architectural pole)	ea	36	140,000.00	5,040,000	4,000.00	144,000	144,000.00	5,184,000
	- 11 m Mouting height, double arm (Architectural pole)	ea	64	150,000.00	9,600,000	4,000.00	256,000	154,000.00	9,856,000
	- 12 m Mouting height, double arm	ea	57	16,000.00	912,000	3,000.00	171,000	19,000.00	1,083,000
	- 3 m Mouting height (Architectural pole)	ea	73	8,000.00	584,000	500.00	36,500	8,500.00	620,500
8.3.3	Foundation of lighting poles								
	- 10 m Mouting height, single arm and double arm	ea	411	2,600.00	1,068,600	600.00	246,600	3,200.00	1,315,200
	- 12 m Mouting height, single arm and double arm	ea	60	3,000.00	180,000	600.00	36,000	3,600.00	216,000
	- 3 m Mouting height (Architectural pole)	ea	73	1,500.00	109,500	600.00	43,800	2,100.00	153,300
8.	C/F								74,050,300

Project Location : The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project
8. MECHANICAL AND ELECTRICAL SERVICES

Item No.	Description	Unit	Estimated Quantity	Material Cost		Labour Cost		Material & Labour Cost	
				Unit Rate	Amount	Unit Rate	Amount	Unit Rate	Amount
8.	B/F								74,050,300
8.3.4	Power supply and control								
	- Fused sefety switch at MEA's pole								
	-3P,60A.600V	ea	11	13,000.00	143,000	600.00	6,600	13,600.00	149,600
	-3P,100A.600V	ea	6	19,800.00	118,800	600.00	3,600	20,400.00	122,400
	- Supply pilar, complete ,including photo switch and pillar foundation, ground and accessaries	ea	17	69,200.00	1,176,400	5,630.00	95,710	74,830.00	1,272,110
	- MEA power supply and mctering	PS	1	-				700,000.00	700,000
8.3.5	Cables								
	- 2/C.PVC Insulated , 10 sq.mm. (NYY)	m	860	147.00	126,420	20.00	17,200	167.00	143,620
	- 2/C.PVC Insulated , 16 sq.mm. (NYY)	m	440	170.00	74,800	28.00	12,320	198.00	87,120
	- 4/C.PVC Insulated , 10 sq.mm. (NYY)	m	23,500	195.00	4,582,500	32.00	752,000	227.00	5,334,500
	- 4/C.PVC Insulated , 16 sq.mm. (NYY)	m	8,200	294.00	2,410,800	36.00	295,200	330.00	2,706,000
	- 1/C.PVC Insulated , 25 sq.mm. (THW)	m	12,840	108.00	1,386,720	26.00	333,840	134.00	1,720,560
	- 1/C.PVC Insulated , 35 sq.mm. (THW)	m	2,300	147.00	338,100	30.00	69,000	177.00	407,100
	- 1/C.PVC Insulated , 50 sq.mm. (THW)	m	2,000	195.00	390,000	45.00	90,000	240.00	480,000
	- 1/C.PVC Insulated , 16 sq.mm. (THW)	m	13,400	57.00	763,800	16.00	214,400	73.00	978,200
8.3.6	Conduits								
	- HDPE conduit 50 mm. Dia. (PN-6)	m	22,320	42.00	937,440	19.00	424,080	61.00	1,361,520
	- HDPE conduit 63 mm. Dia. (PN-6)	m	5,300	66.00	349,800	22.00	116,600	88.00	466,400
	- HDPE conduit 75 mm. Dia. (PN-6)	m	2,300	92.00	211,600	24.00	55,200	116.00	266,800
	- IMC conduit 40 mm Dia.	m	1,700	140.00	238,000	35.00	59,500	175.00	297,500
	- IMC conduit 50 mm Dia.	m	200	180.00	36,000	40.00	8,000	220.00	44,000
	- IMC conduit 65 mm Dia.	m	40	330.00	13,200	46.00	1,840	376.00	15,040
	- Galvanized rigid steel conduit 65mm dia.	m	1,200	380.00	456,000	57.00	68,400	437.00	524,400
	- Galvanized rigid steel conduit 100mm dia.	m	1,300	710.00	923,000	120.00	156,000	830.00	1,079,000
8.	C/F								92,206,170

Project Location : The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project
8. MECHANICAL AND ELECTRICAL SERVICES

Item No.	Description	Unit	Estimated Quantity	Material Cost		Labour Cost		Material & Labour Cost	
				Unit Rate	Amount	Unit Rate	Amount	Unit Rate	Amount
8.	B/F								92,206,170
8.3.7	Drawpit and handhote	ea	58	7,000.00	406,000	3,200.00	185,600	10,200.00	591,600
8.3.8	Miscellaneous								
	- Pull boxes, junction boxes, expansion fitting and ect.	LS	1	1,500,000.00	1,500,000	300,000.00	300,000	1,800,000.00	1,800,000
8.3.9	Spare part for Road lighting fixture with accessories								
	- 250 HPS Street lighting	ea	59	9,800.00	578,200			9,800.00	578,200
	- 400 HPS Street lighting	ea	11	11,000.00	121,000			11,000.00	121,000
	- 250 HPS Flood lighting (Architectural lighting)	ea	4	31,000.00	124,000			31,000.00	124,000
	- 400 W. HPS Soffit lighting (Architectural lighting)	ea	13	33,000.00	429,000			33,000.00	429,000
	- 150 HPS Soffit lighting	ea	7	9,000.00	63,000			9,000.00	63,000
	- 70 HPS Landscape lighting on 3 m. Pole	ea	7	15,000.00	105,000			15,000.00	105,000
8.4	EM sensor system package	PS	1					10,000,000.00	10,000,000
8.5	CCTV & Health monitoring system	PS	1					10,000,000.00	10,000,000
8	SUBTOTAL MECHANICAL AND ELECTRICAL SERVICES (Transfer to Summary)								116,017,970

Project Location : The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project

9. UTILITY AND MISCELLANEOUS RELOCATION

Item No.	Description	Unit	Estimated Quantity	Material Cost		Labour Cost		Material & Labour Cost	
				Unit Rate	Amount	Unit Rate	Amount	Unit Rate	Amount
9.	UTILITY AND MISCELLANEOUS RELOCATION								
9.1.1	Net cost of removal and relocation of existing utility works (Provisional Sum)	PS		-		-		167,000,000.00	167,000,000
9.1.2	Add 5% to the net cost of work under item 8.1.1 in respect of all contractor's charges and profit (Provisional Sum)	PS		-		-		8,200,000.00	8,200,000
9.1.3	Net cost of Relocation and Improvement of Exiting Public Facilities and Other Structures (Provisional Sum)	PS		-		-		6,996,261.00	6,996,261
9	SUBTOTAL UTILITY (Transfer to Summary)								182,196,261

Project Location : The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project
10. FORCE ACCOUNT WORK

Item No.	Description	Unit	Estimated Quantity	Material Cost		Labour Cost		Material & Labour Cost	
				Unit Rate	Amount	Unit Rate	Amount	Unit Rate	Amount
10.	FORCE ACCOUNT WORK								
10.1	LABOUR								
10.1.1	Driver	h	1,800	-		50.00	90,000	50.00	90,000
10.1.2	Unskilled labourer	h	18,000	-		35.00	630,000	35.00	630,000
10.1.3	Skilled labourer	h	1,800	-		65.00	117,000	65.00	117,000
10.2	EQUIPMENT								
10.2.1	Dump truck, 5 to 7 m^3	h	150	-		360.00	54,000	360.00	54,000
10.2.2	Flat bed truck, 3 to 5 t	h	150	-		280.00	42,000	280.00	42,000
10.2.3	Tank truck, 5,000 1	h	150	-		350.00	52,500	350.00	52,500
10.2.4	Bulldozer, type D8 or equal	h	150	-		1,250.00	187,500	1,250.00	187,500
	Type D7 ….% of D8 rate								
	Type D6 ….% of D8 rate								
109.2.5	Front-end loader, 1.5 m^3 to 2.5 m^3	h	150	-		950.00	142,500	950.00	142,500
10.2.6	Front-end loader, 3/4 m^3 to 1.5 m^3	h	150	-		750.00	112,500	750.00	112,500
10.2.7	Prower shovel or drag-line 1.5 m^3 to 2.5 m^3	h	150	-		950.00	142,500	950.00	142,500
10.2.8	Prower shovel or drag-line 3/4 m^3 to 12.5 m^3	h	150	-		750.00	112,500	750.00	112,500
10.2.9	Backhoe,0.5 m^3 to 1 m^3	h	150	-		700.00	105,000	700.00	105,000
10.2.10	Motor grader w/12 ft blade, min. rating 100 Hp	h	150	-		750.00	112,500	750.00	112,500
10.2.11	Vibratory roller,self-propelled, min. weight 5 t	h	150	-		470.00	70,500	470.00	70,500
10.2.12	Vibratory compactor,hand operated	h	150	-		110.00	16,500	110.00	16,500
10.2.13	Pnenmatic-tyred roller, self-propelied, min. wight 12 t	h	150	-		980.00	147,000	980.00	147,000
10.2.14	Three-wheel steel wheel roller, min. weight 12 t	h	150	-		900.00	135,000	900.00	135,000
10.2.15	Compressor,600 cfm	h	700	-		650.00	455,000	650.00	455,000
	300 cfm, ….% hereof 600 cfm rate								
	150 cfm, ….% hereof 600 cfm rate								
	60 cfm, ….% hereof 600 cfm rate								
10.2.16	Water pump, 6" dia.	h	900	-		320.00	288,000	320.00	288,000
	5" ,….% hereof 6" dia rate								
	4" ,….% hereof 6" dia rate								
	3" ,….% hereof 6" dia rate								
10.	C/F								3,012,500

Project Location : The Chao Phraya River Crossing Bridge at Nonthaburi 1 Road Construction Project
10. FORCE ACCOUNT WORK

Item No.	Description	Unit	Estimated Quantity	Material Cost		Labour Cost		Material & Labour Cost	
				Unit Rate	Amount	Unit Rate	Amount	Unit Rate	Amount
10	B/F								3,012,500
10.2.17	Mobile crane 25 t capacity 10 t……% of 25 t crane	h	400			1,400.00	560,000	1,400.00	560,000
10.2.18	Crane crawler 50 t capacity 25 t ……% of 50 t capacity	h	200			1,700.00	340,000	1,700.00	340,000
10.2.19	Bar bending machine, power driven	h	1,500			55.00	82,500	55.00	82,500
10.2.20	Bar shearing machine, power driven	h	1,500			55.00	82,500	55.00	82,500
10.2.21	Pile driven hammer	h	300			1,250.00	375,000	1,250.00	375,000
10.2.22	Pile boring equipment for bored piles d=1.2 - 1.5 m	h	100			2,000.00	200,000	2,000.00	200,000
10.3	Material								
10.3.1	Various construction materials (Provisional sum)	PS	1					2,000,000.00	2,000,000
10.4	MAINTENANCE FACILITY								
10.4.1	Various construction and outfiting of office and storage space for maintenance personnel and equipment (Provisonal sum)	PS	1					2,000,000.00	2,000,000
10	SUBTOTAL FORCE ACCOUNT WORKS (Transfer to Summary)								8,652,500

Appendix-3

Draft Environmental Monitoring Form and Environmental Check List

Environmental Checklist: 15. Roads and Railways （1）

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
1 Permits and Explanation	(1) EIA and Environmental Permits	① Have EIA reports been officially completed? ② Have EIA reports been approved by authorities of the Thai government? ③ Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? ④ In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of Thai government?	①EIA Report have completed. However, some modifications are required due to changing the project design. ②EIA was authrised by DRR because the Project is not required EIA based on the law. ③EIA report have unconditionally approved. ④Not necessary.
	(2) Explanation to the Public	① Did implementing agency explain contents of the project and the potential impacts adequately to the public based on appropriate procedures concerning information disclosure? Did participants understand what to be explained? ② Are proper responses made to comments from the public and regulatory authorities?	①5 Forcus Groupe Meetings, Seminars(2times), and 1 project orientation were held. Focus Group Meeting is for People, especially affected people, in the Project area. Seminar is for all stakeholders.The purpose of meeting and seminer were to inform stakeholders the project implementation, route alternatives, receive comments, route selection process , design results and land expropriation procedurt. Suggestions that have been received from attendees were on the traffic problem, land acquisition issue and environmental mitigation measures. Information disclosure has been followed by the Cabinet resolution. ②DRR has responded to all the inquiry.
2 Mitigation Measures	(1) Air Quality	① Is there any possibility that air pollutants emitted from various sources, such as vehicle traffic, may affect ambient air quality? Does ambient air quality comply with the country's ambient air quality standards? ② Where industrial areas already exist near the route, is there a possibility that the project make air pollution worse?	① Emission of air pollutants from vehicles or machinery during construction and operation period may effect ambient, but they will be within Thailand ambient air quality standards. ②No industrial area exists along the Project alignment
	(2) Water Quality	① Is there any possibility that soil runoff from the bare lands resulting from landslide, such as cutting and filling works, may cause water quality degradation in downstream water areas? ② Is there a possibility that surface runoff from roads may contaminate water sources such as groundwater? ③ Do effluents from various facilities, such as stations and parking areas/service areas, comply with the country's effluent standards and ambient water quality standards? Is there a possibility that the effluents may cause areas that do not satisfy with the country's ambient water quality standards?	①There are 3 canals to be crossed by the connecting road namely Klong Bang krang, Klong Wat phut and Khlong Bang Sri Muang .In case of cutting and filling work, existing canal will be closed or bypassed, so influence of earth work to the canal such as food and runoff is little. ②Surface runoff water from roads during operation period will be designed to drain public water, and periodical cleaning on road is on menu. Influence of surface runoff water is little. Contamination of groundwater is negligible as the upper soil is clay. Contamination of Chao Phraya river is also neglible due to significant different between volume of runoff from bridge surface and that of the river. ③There is no facilities along the road.

Environmental Checklist: 15. Roads and Railways （2）

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	(3) Noise and Vibration	① Do noise and vibrations from vehicle traffic satisfy with the country's standards?	①During construction period, especially land preparation and structural works (with the full use of heavy equipments), noise level at a distance of 100 m from road alignment, will exceed national standards. During operation period, noise level in the area immediate to the road will be the same as present condition i.e exceed the standards. According to need with installation of Noise Barrier, noise level might be within standards. The project may cause insignificant impact of vibration to community or structures compares to Richter and Meister scale and DIN4150.
3 Natural Environment	(1) Protected Areas	① Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project may affect the protected areas?	①No. The Project site is not in protected area.
3 Natural Environment	(2) Ecosystem	① Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? ② Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? ③ If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? ④ Are adequate protection measures taken to prevent impacts, such as disruption of migration routes, habitat fragmentation, and traffic accident of wildlife and livestock? ⑤ Is there a possibility that installation of roads will cause impacts such as destruction of forest, poaching, desertification, reduction in wetland areas, and disturbance of ecosystems due to introduction of exotic (non-native invasive) species and pests? Are adequate measures taken in order to prevent such impacts considered? ⑥ In cases where the project site is located at undeveloped areas, is there a possibility that the new development will result in extensive loss of natural environments?	①There is no primeval, tropical forest, nor ecological valuable habitat in the project area or nearby. ②In around project site 19 protected species based on Law in Thai Land and 5 species of Red List fishes based on IUCN 2008 were found in literature research. DRR committed to take protection measures such as strict prohibition of hunting by construction workers during construction stage, so that protected species will be keeping. ③No significant ecological impacts are anticipated. ④Disruption of migration routes, habitat fragmentation and so on are not anticipated. The project area is mostly agricultural area. ⑤They are not anticipated. ⑥New development is likely to be along the road alignment, but extensive loss to natural environment is not anticipated
	(3) Hydrology	① Is there a possibility that change of topographic features and installation of structures such as tunnels may adversely affect surface water and groundwater flows?	①There might be no impact to suface hydrology and underground hydrology due to the road design considered drainage structures.

Environmental Checklist: 15. Roads and Railways （3）

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	(4) Topography and Geology	① Is there a soft ground on the route that may cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides if needed? ② Is there any possibility that civil works such as cutting and filling will cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides? ③ Is there any possibility that soil runoff will result from cuting and filling areas, waste soil disposal sites, and borrow sites? Are adequate measures taken to prevent soil runoff?	①Topographic and geological conditions may very slightly be affected because the project site is a river terrain. The land might be leveled slightly therefore the topographic conditions might not be affected. ②Cast in place pile will be employed in the bridge foundation work. Such activities may not significantly affect topographic conditions and geological structure. ③Adequate measures will be taken to prevent soil runoff during construction.The earthwork will be carried out in dry season in principal.
	(1) Resettlement	① Is involuntary resettlement caused by project implementation? If yes, are adequate efforts made to minimize the impacts? ② Is adequate explanation on relocation and compensation given to affected persons prior to resettlement by responsible agency? ③ Is the resettlement plan, including proper compensation, restoration of livelihoods and living standards developed based on socioeconomic studies? ④ Does the resettlement plan pay particular attention to vulnerable groups or persons, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? ⑤ Are agreements with the affected persons obtained prior to resettlement? ⑥ Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? ⑦ Is a plan developed to monitor the impacts of resettlement?	①Yes, but adequate efforts have been taken by DRR. ②Yes. Adequate explanation was given to affected persons by DRR by holding the consultation meeting with project affected people. ③Proper compensation has been paid which was calculated based on the market price of land. ④No specific consideration to vulnerable persons have been taken because it is not necessary. ⑤Yes. DRR has gotten agreement with all the households to be affected by the Project for resettlement and land acquisiton, although still 57 cases file objection or law suit regarding the level and detailed measure of compensation. ⑥Yes. JICA received Resettlement Action Plan (RAP) prepared by executing agency. ⑦No. However, regarding the progress of (a)resettlement of remaining 8 households/structures, and (b)solution of objections and/or law suit cases, executing agency will monitor the progress and report to JICA.

Environmental Checklist: 15. Roads and Railways （4）

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
4 Social Environment	(2) Living and Livelihood	① In a place where roads are newly installed, is there any possibility that the project may affect the existing means of transportation and the associated workers? Is there any possibility that the project may cause significant impacts, such as extensive alteration of existing land uses, changes in sources of livelihood, or unemployment? Are adequate measures considered for preventing these impacts? ② Is there any possibility that the project may adversely affect the living conditions of inhabitants other than the affected inhabitants? Are adequate measures considered to reduce the impacts if necessary? ③ Is there any possibility that diseases, including communicable diseases, such as HIV may be introduced due to immigration of workers associated with the project? Are adequate considerations given to public health if necessary? ④ Is there any possibility that the project may adversely affect road traffic in the surrounding areas (e.g., by causing increases in traffic congestion and traffic accidents)? ⑤ Is there any possibility that roads and may cause impede the movement of inhabitants? ⑥ Is there any possibility that structures associated with bridge may cause a sun shading and radio interference?	①The Project may affect agricultural activities. However, the Project cosider these impact adequately. ②The Project may bring some adverse environmental impacts such as noise, air quality, to residents near the Project site. So these impacts may affect adversely to residents, but these are not significant. Soundproof wall will be set up when noise level will exceed the standard and/or DRR will receive complaints from the neighboring people during construction and operation stage. ③Yes. There is a possibility to be brought communicable diseases. ④No. The Project will bring about positive impacts to traffic around Project site, however, there might have certain negative impact to traffic during the construction period. ⑤Same as above. ⑥Not significant impact by the bridge construction.
	(3) Heritage	① Is there a possibility that the project may damage the local archeological, historical, cultural, and religious heritage sites? Are adequate measures considered to protect these sites in accordance with the country's laws and JICA Guidelines for Environmental and Social Considerations?	①No. There is a temple with park nearby the project site, however, adequate mitigation measures will be taken.
	(4) Landscape	① Is there a possibility that the project may adversely affect the local landscape? Are necessary measures taken?	①There might be minimum impact, but adequate measures have been taken in the project design.
4 Social Environment	(5) Ethnic Minorities and Indigenous Peoples	① Where ethnic minorities and indigenous peoples are living in the rights-of-way, are considerations given to reduce the impacts on culture and lifestyle of ethnic minorities and indigenous peoples? ② Does the project comply with the country's laws for rights of ethnic minorities and indigenous peoples?	①There is no minorities and indigenous people in the area.

Environmental Checklist: 15. Roads and Railways （5）

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
5 Others	(1) Impacts during Construction	① Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? ② If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? ③ If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts? ④ If necessary, is health and safety education (e.g., traffic safety, public health) provided for project personnel, including workers?	①Yes.Adequate measures such as casting boring with steel casing will be employed, and excavation water will be drained to public water after treatment to public water, are considered. ②No significant impact might be anticipated. Aquatic ecosystem : Once surface water sources may be affected and then affecting aquatic ecosystem in Chao Phraya River. It may not affect aquatic ecosystem in Khlong Bang Sri Muang, Khlong Wat Phut and Khlong Bang Krang. Terrestrial ecosystem : 8,926trees could be cutdown. Wildlife : There might be no impact to wildlife because most wildlife found in the project area are birds which are small size and can move fast and live in any kind of habitats or have good adaptation to the project area and even migrate to new places. Therefore it is expected that impacts to wildlife may be insignificant. ③Adequate measures have been contsidered to reduce impact on social environment. ④The construction contractor will establish sanitary system in the construction site, construction office and construction camp.
	(2) Monitoring	① Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? ② Are the items, methods and frequencies included in the monitoring program, judged to be appropriate? ③ Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? ④ Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	①Yes.Environmental monitoring programs consist of air quality, noise level vibration, water quality, traffic and Socio-economic condition. ②Yes. JICA and executing agency agreed the monitoring format, including the appropriate assignment/recruitment of the necessary staff/personnel. ③Yes. Adequate framework will be established. ④Yes. Concrete measures are described in monitoring format.
6 Note	Reference to Checklist of Other Sectors	① Where necessary, pertinent items described in the Forestry Projects checklist should also be checked (e.g., projects including large areas of deforestation). ② Where necessary, pertinent items described in the Power Transmission and Distribution Lines checklist should also be checked (e.g., projects including installation of power transmission lines and/or electric distribution facilities).	No Relation with Forestry, Power transmission project.
	Note on Using Environmental Checklist	① If necessary, the impacts to transboundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	No concern.

1) Regarding the term “Country’s Standards” mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are made, if necessary.
In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan' experience).

2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which it is located.

MONITORING FORM

１． Responses/Actions to Comments and Guidance from Government Authorities and the Public

Monitoring Item	Monitoring Results during Report Period

２． Mitigation Measures

- Air Quality（Emission Gas / Ambient Air Quality）

Item	Unit	Measured Value（Max.）	Measured Value（Max.）	National Standards	WHO Standards	Standards for monitoring	Remarks			
							Detail of location	No. of monitoring points	Frequency	duration
Construction										
TSP (24 hr)	μ g/m^3			330	-	330	Sri Boonyanont School, Wat Chalerm Pha Kiat Community, Wai Sai Kindergarden	3	Every three month	Each monitoring will be conducted for 5 consecutive days During construction (30 months)
PM_{10} (24 hr)	μ g/m^3			120	50	120				
CO (1 hr)	ppm			30	-	30				
NO_2 (1 hr)	μ g/m^3			320	200	320				
Operation										
TSP (24 hr)	μ g/m^3			330	-	330	Sri Boonyanont School, Wat Chalerm Pha Kiat Community, Wai Sai Kindergarten	3	Two times a year, once during the dry season and once during the rainy season	For two years. Each monitoring will be conducted for 5 consecutive days.
PM_{10} (24 hr)	μ g/m^3			120	50	120				
CO (1 hr)	ppm			30	-	30				
NO_2 (1 hr)	μ g/m^3			320	200	320				

- **Water Quality（Effluent/Wastewater/Ambient Water Quality）**

Item	**Unit**	**Measured Value（Mean）**	**Measured Value（Max.）**	**National Standards For class 3**	**Standards for monitoring**	**Remarks**			
						Detail of location	**No. of monitoring points**	**Frequency**	**duration**
Construction/Design									
Temperature	℃			-	-	At 1 km upstream of the construction site At the construction site At 1 km downstream of the construction site	3	Every three months.	During construction (30 months)
pH	-			5.0-9.0	5.0-9.0				
Conductivity	S/cm			-	-*				
Suspended solids (SS)	mg/l			-	-*				
Grease and oil	mg/l			-	-*				
Dissolved oxygen(DO)	mg/l			≧4.0	≧4.0				
BOD	mg/l			≦2.0	≦2.0				
Total coliform bacteria	MPN/ 100ml			≦20,000	≦20,000				
Fecal coliform bacteria	MPN/ 100ml			≦4,000	≦4,000				
During boring construction in Chao Phyara River									
Suspended solids (SS)	mg/l			-	-*	Near excavation point About 100m upstream and downstream of excavation point	Two locations near excavation point	Every month	During excavation work in the river
Grease and oil	mg/l			-	-*				
During Construction for effluent water from excavation									
Suspended solids (SS)	mg/l			≦50**	≦5.0**	Effluent water from a sedimentation basin	one location of sedimentation basin	Constantly (at least once a day)	During excavation work in the river
Grease and oil	mg/l			≦5.0**	≦5.0**				

***In case downstream water quality is extremely poor compared with upstream, necessary mitigation measures would be examined and taken, based on the main factor of such contamination.**

****Industrial effluent standard will be applied because of there is no standard for construction effluent.**

- **Noise / Vibration**

Item	Unit	Measured Value （Mean）	Measured Value （Max.）	National Standards	WHO Standards	Standards for monitoring	Remarks			
							Detail of location	No. of monitoring points	Frequency	duration
Construction										
Noise Levels (L_{eq}, L_{max}, L_{90})	dB(A) (24 hr)			70	70(commercial area) 55(residence)	70	Sri Boonyanont School, Wat Chalerm Pha Kiat Community, Wai Sai Kindergarden	3	Every three months.	Each monitoring will be conducted for 5 consecutive days During construction (30 months)
Vibration （PPV） For each Traverse Vertical Longitudinal Directions				-	-	*Frequency <10 Hz 5mm/s 10-50Hz 5-10mm/s 50-100Hz 15-20mm/s	Sri Boonyanont School, and Nearest building of the construction work such as piling and foundations.	At least 3	As needed when the construction is carried out near the particular Location especially during pilling and foundation work.	During construction (30 months)
Operation										
Noise Levels	dB(A) (24hr)			70	70(commercial area) 55(residence)	70	Sri Boonyanont School, Wat Chalerm Pha Kiat Community, Wai Sai Kindergarden	3	Twice a year	For two years, For 5 consecutive days (covering work days and holidays)

Source: DIN4150

3. Social Environment

Transportation

Construction					
	parameter	location			
Transportation condition	Traffic volume (24 hr) Number of traffic accidents	1) Nonthaburi 1 Road at the interchange at the beginning of the project layout 2) Ratchaphruk Road at the interchange at the end of the project layout	2	Every three months	For 30 months, For 1 day (covering work days)

- Socio-Economic

Monitoring parameter	Monitoring Results during Report Period
Construction Period Major parameters : consisting of - Acknowledgement of project procedure - Impacts such as unemployment ratio, living standard during the construction period	Every 6 months for 30 months The number of sampling is preferable over 100.

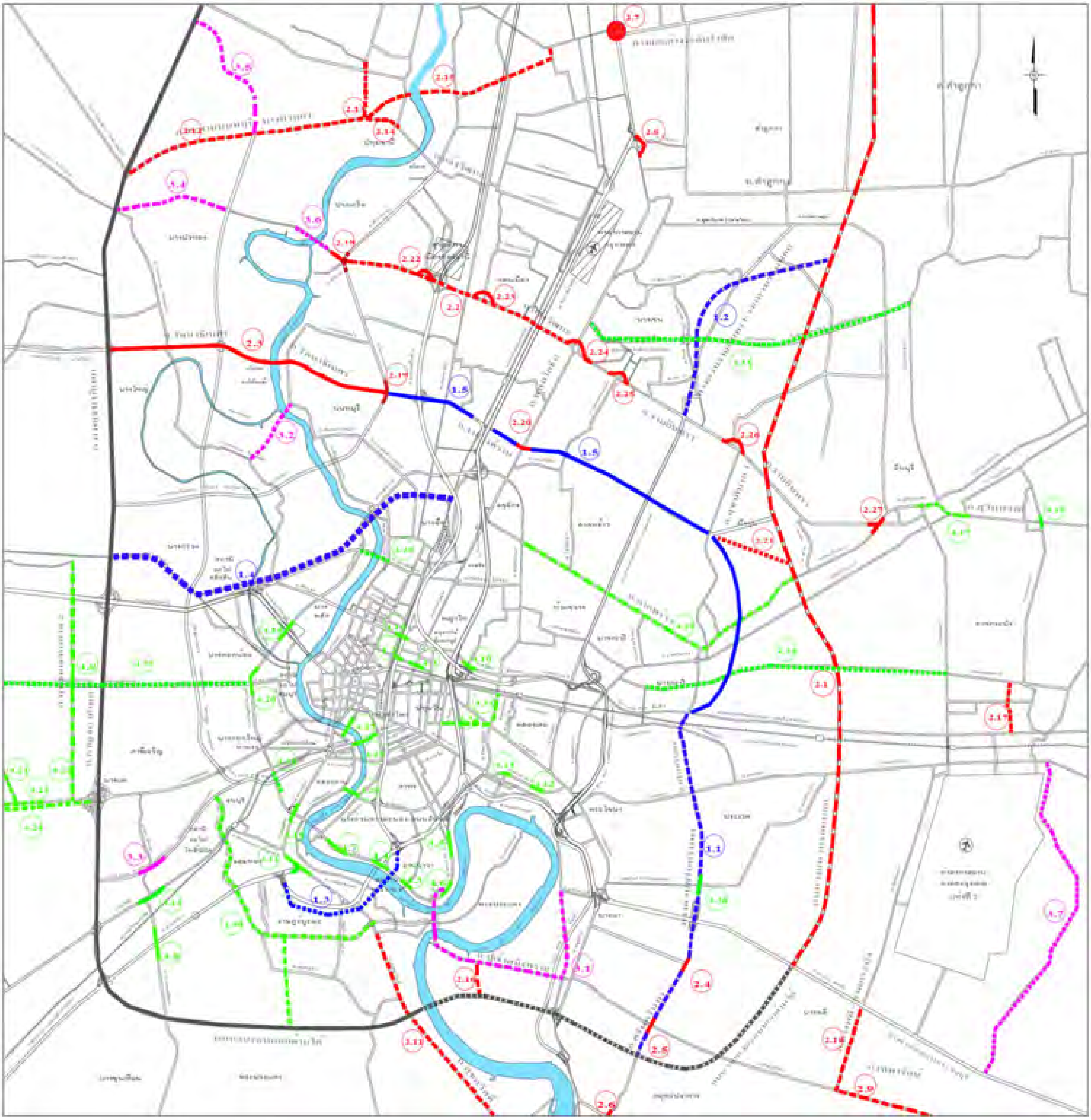
4. Reporting period to JICA

(1) During construction, Contractor will implement Environmental Monitoring and will submit the result to DRR, and DRR will submit it with project status report to JICA every three months.

(2) During operation period, DRR will implement Environmental Monitoring and will submit Monitoring Form to JICA biannually for two years.

Appendix-4

Updated List of Projects under the Commission of Management of Land Traffic’s Resolution No. 1/2547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Expressway Authority of Thailand (EXAT)
1.1 Sri Nakarin – Bangna – Samut Prakarn Tollway (preparation for construction)
1.2 Ramindra – Outer Ring Road Expressway (under construction)
1.3 Srirach Expressway (Chan Road) – Dao Kanong (preparation for construction)
1.4 Ratchadapisek – Outer Ring Road Expressway (preparation for construction)
1.5 The Third Stage Expressway, Northern Route (F/S)

Department of Highways (DOH)
2.1 Eastern Outer Ring Road, Bang Phli – Thanyaburi Section (completed)
2.2 Rehabilitation and Expansion of Changwattana – Ramindra Road (completed)
2.3 Rehabilitation and Expansion of Rattanathibeth – Ngam Wong Wan – Nawamin Road (Bangyai – Kasetsart – Outer Ring Road Section) (under construction)
2.4 Flyover at Sri Nakarin Road (Lasal Junction) (completed)
2.5 Flyover at Sri Nakarin Road (Theparak Junction) (completed)
2.6 Flyover at Sri Nakarin Road (Sukhumvit Junction) (completed)
2.7 Rangsit Interchange, 2nd Phase (completed)
2.8 Flyover at Intersection of Highway No. 1 (Phaholyothin) and Highway No. 3312 (Lamlukka) (completed)
2.9 Theparak Road, Bang Phli – Bang Bo Section (under construction)
2.10 Connecting Road for Highway No. 34 (Bang Na – Trad) and Highway No. 3268 (Theparak) (under construction)
2.11 Phra Pradaeng – Bang Plakod District Road (under construction)
2.12 Connecting Road for Bang Bua Thong Road and Highway No. 307 (Bang Khu Wat) (under construction)
2.13 Highway No. 345 (Bang Khu Wat) – Pathumthani Connecting Road (under construction)
2.14 Highway No. 345 (Bang Khu Wat) – Highway No. 3100 (Rangsit Canal Parallel Road) Connecting Road (completed)
2.15 Highway No. 346 (Rangsit – Lad Lum Kaew) – Rangsit Canal Parallel Road (ending at Chao Phraya River) Connecting Road (completed)
2.16 Connecting Road for Industrial Ring Road and Southern Kanchanapisek Outer Ring Road (completed, transferred to EXAT)
2.17 Rehabilitation of ICD Road (Lad Krabang) (completed)
2.18 Pakkret Intersection Underground Pass (completed)
2.19 Kae Lai Intersection Underground Pass (postponed)
2.20 Kaset Intersection Underground Pass (completed)
2.21 Connecting Road for Sukhapiban 1 Road and Eastern Ring Road (under construction)
2.22 Flyover at Muang Thong Thani 3 (completed)
2.23 Flyover at Muang Thong Thani 1 (construction relocated to Changwattana/Klong Prapa Intersection – completed)
2.24 Flyover at Laksi Intersection (preparation for construction)
2.25 Flyover at Lad Pla Kao Intersection (completed)
2.26 Flyover at Ramindra Road, KM8 Intersection (completed)
2.27 Flyover at Seri Thai Road Junction (under construction)

Department of Rural Roads (DRR)
3.1 Rehabilitation of Old Railway Road (part of Industrial Ring Road) (completed)
3.2 Chao Phraya River Crossing Bridge at Nonthaburi 1 Road (preparation for construction)
3.3 Flyover at Taksin – Petch Kasem Road (completed)
3.4 Pakkret – Kanchanapisek Ring Road Connecting Road (East – West Route) (land acquisition, under construction)
3.5 Highway No. 345 – Kanchanapisek Ring Road Connecting Road (North – South Route) (land acquisition, under construction)
3.6 Chao Phraya River Crossing Bridge at Pakkret Intersection (Completed/Japan ODA Loan)
3.7 Rehabilitation of Highway No. 34 – Highway No. 7 Connecting Road (completed)

Bangkok Metropolitan Administration (BMA)
4.1 Flyover crossing Sri Ayuthaya – Phayathai Road Intersection (completed)
4.2 Flyover crossing Sri Ayuthaya – Rama 6 Road (construction relocated to Chao Khun Taharn Road / Ladkrabang ICD Road – completed)
4.3 Flyover crossing Rama 3 – Sathupradit Road Intersection (completed)
4.4 Flyover crossing Rama 3 – Ratchadapisek Road Intersection (completed)
4.5 Flyover crossing Rama 3 – Narathiwat Ratchanakarin Road Intersection (completed)
4.6 Flyover crossing Rama 3 – Industrial Ring Road Intersection (completed)
4.7 Flyover crossing Rama 3 – Charoen Rath Road Intersection (completed)
4.8 Flyover crossing Bang Khun Tien – Rama 2 Road Intersection (completed)

4.9 Flyover crossing Boromratchonnanee Road – Buddhamontol 2 Road Intersection (completed)
4.10 Flyover crossing Din Daeng – Prachasongkhroh Intersection (completed)
4.11 Flyover crossing Suksawat – Rama 2 Road Intersection (completed)
4.12 Flyover crossing Rama 4 – Sukhumvit 42 Intersection (canceled – construction relocated to Suthisan Inbound Intersection)
4.13 Flyover crossing Rama 4 – Sukhumvit 26 Intersection (canceled – construction relocated to Suthisan Outbound Intersection – completed)
4.14 Flyover crossing Ekachai/Bang Ban Road/Bang Khun Tien Road Intersection (canceled – construction relocated to Buddhamontol 2 Intersection – completed)
4.15 Flyover crossing Chalongkrung – Suwinthawong Intersection (completed)
4.16 Flyover crossing Ratchawithi Road – Rama 6 Intersection (completed)
4.17 Suwinthawong Elevated Road (completed)
4.18 Mahaisawan Intersection Underground Pass (preparation for construction)
4.19 Charansanitwong – Boromratchonnanee Intersection Underground Pass (preparation for construction)
4.20 Fai Chai Junction (Charansanitwong Road) Underground Pass (preparation for construction)
4.21 Petchkasem Road, Lieb Klong Thawee Wattana – Buddhamontol 4 Section (under construction)
4.22 Buddhamontol 2 Road, Petchkasem – Lieb Tang Rotfai Sai Tai Section (under construction)
4.23 Thawee Wattana Road, Uttayan Raod – Petchkasem Road Section (under construction)
4.24 Elevated Road on Petchkasem Road, Outer Ring Road – Bang Bon 5 Section (cancelled)
4.25 Elevated Road on Ladprao Road (cancelled)
4.26 Chao Phraya River Crossing Bridge at Kiek Kai (D/D)
4.27 Chao Phraya River Crossing Bridge at Ratchawong Road – Tha Din Daeng Road (F/S)
4.28 Chao Phraya River Crossing Bridge at Lad Ya Road – Mahaprutharam Road (F/S)
4.29 Chao Phraya River Crossing Bridge at Chan Road – Charoen Nakorn Road (F/S)
4.30 Connecting Road for Suksawat – Rama 2 – Taksin Junction – Petchkasem – Southern Ring Road (F/S, D/D)
4.31 Ratchadapisek Road Expansion (Petchburi Road – Sukhumwit Road Section) (preparation for construction)
4.32 Connecting Road for Sarasin Road – Ratchadapisek Road (preparation for construction)
4.33 Phaholyothin Road – Ratanakosin Sompoch Road (under construction)
4.34 Krungthep Kreetha Road Construction (under construction)
4.35 Prannok – Buddhamontol 4 Road (under construction)
4.36 Underground Pass (Srinakarin Road – Sukhumwit 103 Road) (D/D)

Note: Updated projects are underlined

Appendix-5

Annual Fund Requirement

Annual Fund Requirement

Base Year for Cost Estimation:	Oct, 2009				FC & Total: million JPY
Exchange Rates	Baht = Yen		2.75		LC : million Baht
Price Escalation:	FC:	3.1%	LC:	8.6%	
Physical Contingency	5%				
Physical Contingency for Consultant	5%				

Item		Total			2010			2011			2012			2013			2014			2015		
		FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
A. ELIGIBLE PORTION																						
Ⅰ)	Procurement / Construction	776	3,309	9,875	0	0	0	200	806	2,418	310	1,314	3,922	266	1,189	3,535	0	0	0	0	0	0
	Base cost	673	2,442	7,388	0	0	0	179	651	1,970	269	977	2,955	224	814	2,463	0	0	0	0	0	0
	Base cost for JICA financing	673	2,442	7,388	0	0	0	179	651	1,970	269	977	2,955	224	814	2,463	0	0	0	0	0	0
	Price escalation	66	709	2,017	0	0	0	11	117	333	26	274	780	29	318	904	0	0	0	0	0	0
	Physical contingency	37	158	470	0	0	0	10	38	115	15	63	187	13	57	168	0	0	0	0	0	0
Ⅱ)	Consulting services	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Base cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Price escalation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Physical contingency	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total (Ⅰ + Ⅱ)		776	3,309	9,875	0	0	0	200	806	2,418	310	1,314	3,922	266	1,189	3,535	0	0	0	0	0	0
B. NON ELIGIBLE PORTION																						
a	Procurement / Construction	0	1,594	4,385	0	0	0	0	389	1,069	0	633	1,741	0	573	1,575	0	0	0	0	0	0
	Base cost	0	1,046	2,878	0	0	0	0	279	767	0	419	1,151	0	349	959	0	0	0	0	0	0
	Consulting Service	0	130	358	0	0	0	0	35	95	0	52	143	0	43	119	0	0	0	0	0	0
	Base cost for JICA financing	0	1,177	3,236	0	0	0	0	314	863	0	471	1,294	0	392	1,079	0	0	0	0	0	0
	Price escalation	0	342	940	0	0	0	0	56	155	0	132	363	0	153	422	0	0	0	0	0	0
	Physical contingency	0	76	209	0	0	0	0	19	51	0	30	83	0	27	75	0	0	0	0	0	0
b	Land Acquisition	0	2,200	6,050	0	2,200	6,050	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Base cost	0	2,200	6,050	0	2,200	6,050	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Price escalation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Physical contingency	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
c	Administration cost	0	148	406	0	44	121	0	25	70	0	41	113	0	37	102	0	0	0	0	0	0
d	VAT	0	266	730	0	154	424	0	27	75	0	44	122	0	40	110	0	0	0	0	0	0
e	Import Tax	0	12	34	0	0	0	0	12	34	0	0	0	0	0	0	0	0	0	0	0	0
Total (a+b+c+d+e)		0	4,220	11,605	0	2,398	6,595	0	453	1,247	0	718	1,976	0	650	1,788	0	0	0	0	0	0
TOTAL (A+B)		776	7,529	21,480	0	2,398	6,595	200	1,260	3,665	310	2,032	5,898	266	1,839	5,323	0	0	0	0	0	0
C. Interest during Construction		370	0	370	0	0	0	23	0	23	60	0	60	95	0	95	96	0	96	96	0	96
	Interest during Construction(Const.)	370	0	370	0	0	0	23	0	23	60	0	60	95	0	95	96	0	96	96	0	96
	Interest during Construction (Consul.)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D. Commitment Charge		61	0	61	10	0	10	10	0	10	10	0	10	10	0	10	10	0	10	10	0	10
GRAND TOTAL (A+B+C+D)		1,208	7,529	21,911	10	2,398	6,605	234	1,260	3,698	380	2,032	5,968	371	1,839	5,428	106	0	106	107	0	107
E. JICA finance portion incl. IDC (A + C + D)		1,208	3,309	10,306	10	0	10	234	806	2,451	380	1,314	3,993	371	1,189	3,640	106	0	106	107	0	107

Administration Cost =	2%	
VAT=	7%	of the expenditure in local currency of the eligible portion
Import Tax=	5%	

Appendix-6

Interview Survey Results for Local Company

Interview Survey to Local Companies

■The Purpose of the Survey

Interview survey was conducted in order to gather qualitative effects caused by crossing bridge from companies located in some areas nearby existing and new bridges.

■The Term of the Survey

13th October 2009 – 23rd October 2009

■The Survey Areas

The survey areas were focused on 4 areas, where the urbanizations might have been brought from east bank of the Chao Phraya river to west bank by effects of two or three bridges.

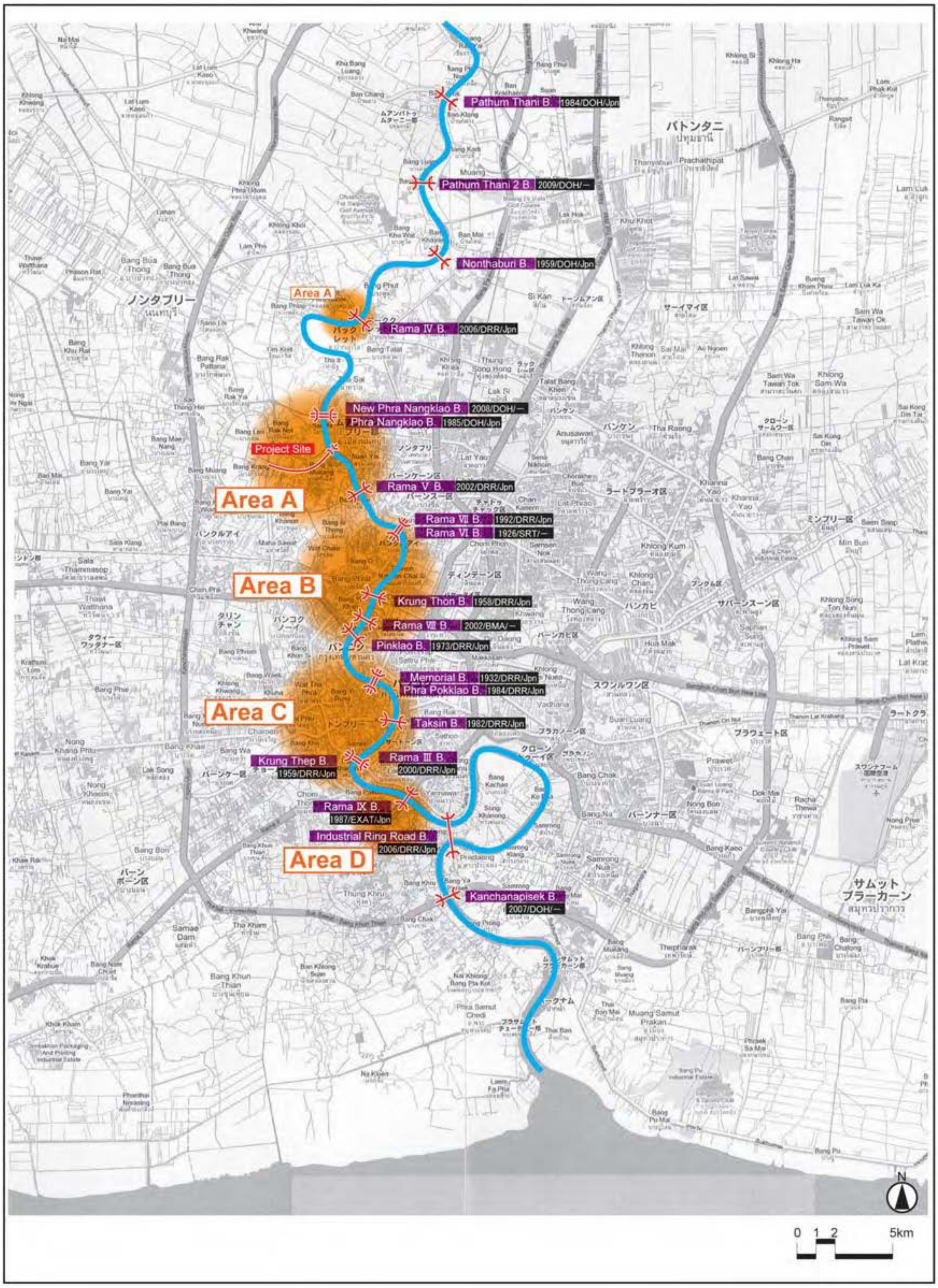
Table　　The Survey Areas of Interview

Area		Bridges in areas	responses
Area A	Planning area (Nonthaburi province)	New Bridge Phra Nangklao (New Phra Nangklao) Rama 5 (Rama 4)	65 （＋12 Japanese companies）
Area B	Bangkok Noi (BMA)	Rama 7 Krung Thon Rama 8 Pinklao	66
Area C	Thongburi (BMA)	Memorial Phra Pokklao Taksin Rama3 Krung Thep	72
Area D	South of Thongburi (BMA)	Rama 9	10

The questionnaire consists of 9 questions and each question shall be answered in 5 levels (much better benefit – much worth impacts). The interviews were carried out by means of visit local companies directly by local surveyors, while the interviews to Japanese companies were done by the Study Team.

Company Name	Respondent	Date
Thai Toshiba Electric Industries Co., Ltd.	Mr. Okamoto	13th October 2009
Kyoritsu Electric (Thailand) Co., Ltd.	Mr. Yoshida	13th October 2009
Shoei Kankyo (Thailand) Co., Ltd.	Mr. Nakamura	19th October 2009

《The Survey Areas》

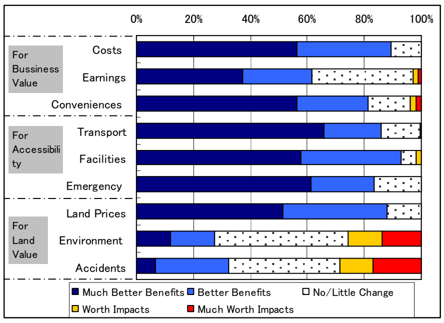


《The Questionnaire Form》

		Expect Much Better Benefits	Expect Better Benefits	No/Little Change	Worry Worth Impacts	Worry Much Worth Impacts
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 the Survey

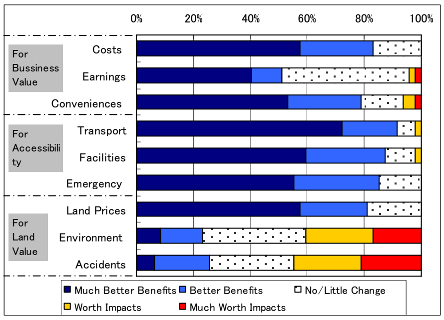
1) The Results for all bridges



《for all bridges》

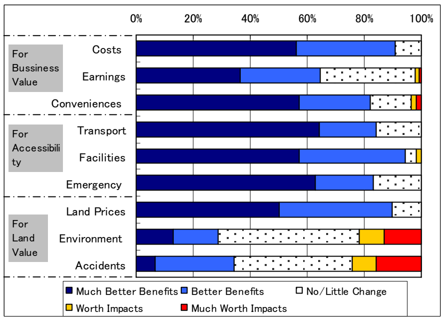
All Answers	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Convenience	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	56%	37%	56%	66%	58%	61%	52%	12%	7%
Better Benefits	33%	24%	25%	20%	35%	22%	36%	16%	26%
No/Little Change	11%	36%	15%	14%	5%	16%	12%	47%	39%
Worth Impacts	0%	2%	2%	0%	2%	0%	0%	12%	12%
Much Worth Impacts	0%	1%	2%	0%	0%	0%	0%	14%	17%
S.A. (total 225)	100%	100%	100%	100%	100%	100%	100%	100%	100%

2) The Results in Comparison between the New Bridge and the others



《for the new bridge》

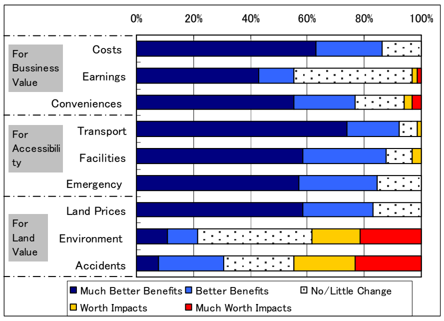
New Bridge	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	57%	40%	53%	72%	60%	55%	57%	9%	6%
Better Benefits	26%	11%	26%	19%	28%	30%	23%	15%	19%
No/Little Change	17%	45%	15%	6%	11%	15%	19%	36%	30%
Worth Impacts	0%	2%	4%	2%	2%	0%	0%	23%	23%
Much Worth Impacts	0%	2%	2%	0%	0%	0%	0%	17%	21%
S.A. (total 47)	100%	100%	100%	100%	100%	100%	100%	100%	100%



《for the other bridges》

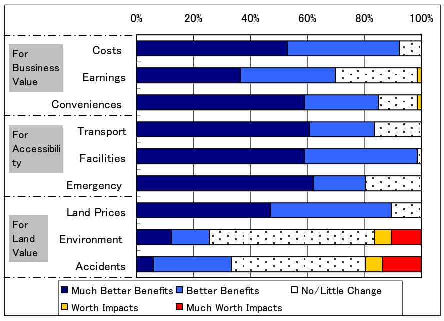
The Other Bridges	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	56%	37%	57%	64%	57%	63%	50%	13%	7%
Better Benefits	35%	28%	25%	20%	37%	20%	40%	16%	28%
No/Little Change	9%	33%	15%	16%	4%	17%	10%	49%	42%
Worth Impacts	0%	2%	2%	0%	2%	0%	0%	9%	8%
Much Worth Impacts	0%	1%	2%	0%	0%	0%	0%	13%	16%
S.A. (total 178)	100%	100%	100%	100%	100%	100%	100%	100%	100%

3) The Results in Comparison among 4 Survey Areas



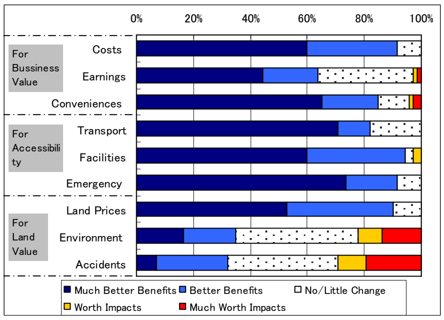
《in area A》

Area A	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	63%	43%	55%	74%	58%	57%	58%	11%	8%
Better Benefits	23%	12%	22%	18%	29%	28%	25%	11%	23%
No/Little Change	14%	42%	17%	6%	9%	15%	17%	40%	25%
Worth Impacts	0%	2%	3%	2%	3%	0%	0%	17%	22%
Much Worth Impacts	0%	2%	3%	0%	0%	0%	0%	22%	23%
S.A. (total 65)	100%	100%	100%	100%	100%	100%	100%	100%	100%



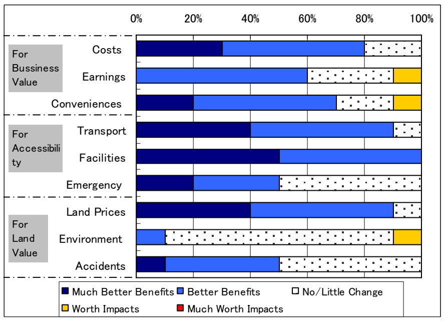
《in area B》

Area B	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	53%	36%	59%	61%	59%	62%	47%	12%	6%
Better Benefits	39%	33%	26%	23%	39%	18%	42%	14%	27%
No/Little Change	8%	29%	14%	17%	2%	20%	11%	58%	47%
Worth Impacts	0%	2%	2%	0%	0%	0%	0%	6%	6%
Much Worth Impacts	0%	0%	0%	0%	0%	0%	0%	11%	14%
S.A. (total 66)	100%	100%	100%	100%	100%	100%	100%	100%	100%



《in area C》

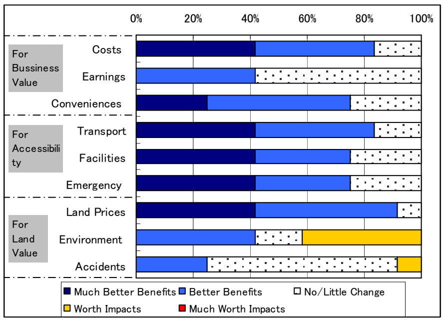
Area C	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	60%	44%	65%	71%	60%	74%	53%	17%	7%
Better Benefits	32%	19%	19%	11%	35%	18%	38%	18%	25%
No/Little Change	8%	33%	11%	18%	3%	8%	10%	43%	39%
Worth Impacts	0%	1%	1%	0%	3%	0%	0%	8%	10%
Much Worth Impacts	0%	1%	3%	0%	0%	0%	0%	14%	19%
S.A. (total 72)	100%	100%	100%	100%	100%	100%	100%	100%	100%



《in area D》

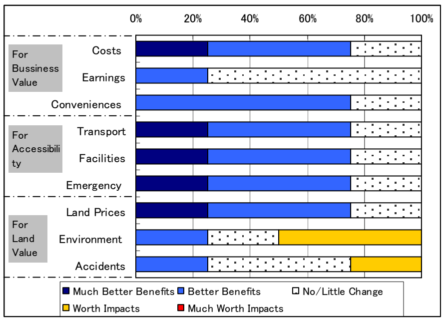
Area D	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	30%	0%	20%	40%	50%	20%	40%	0%	10%
Better Benefits	50%	60%	50%	50%	50%	30%	50%	10%	40%
No/Little Change	20%	30%	20%	10%	0%	50%	10%	80%	50%
Worth Impacts	0%	10%	10%	0%	0%	0%	0%	10%	0%
Much Worth Impacts	0%	0%	0%	0%	0%	0%	0%	0%	0%
S.A. (total 10)	100%	100%	100%	100%	100%	100%	100%	100%	100%

4) The Results of Japanese Companies



《from Japanese Companies about all bridge》

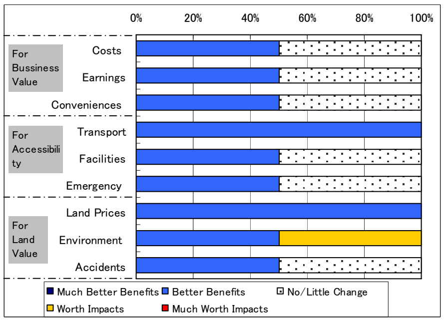
Japanese Companies	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	42%	0%	25%	42%	42%	42%	42%	0%	0%
Better Benefits	42%	42%	50%	42%	33%	33%	50%	42%	25%
No/Little Change	17%	58%	25%	17%	25%	25%	8%	17%	67%
Worth Impacts	0%	0%	0%	0%	0%	0%	0%	42%	8%
Much Worth Impacts	0%	0%	0%	0%	0%	0%	0%	0%	0%
S.A. (total 12)	100%	100%	100%	100%	100%	100%	100%	100%	100%



《from Japanese Companies only about New Bridge》

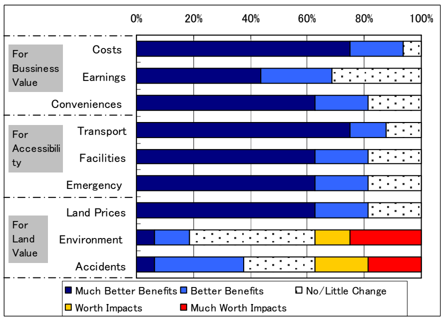
Japanese Companies	For Bussiness Value			For Accessibility			For Land Value		
(New Bridge)	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	25%	0%	0%	25%	25%	25%	25%	0%	0%
Better Benefits	50%	25%	75%	50%	50%	50%	50%	25%	25%
No/Little Change	25%	75%	25%	25%	25%	25%	25%	25%	50%
Worth Impacts	0%	0%	0%	0%	0%	0%	0%	50%	25%
Much Worth Impacts	0%	0%	0%	0%	0%	0%	0%	0%	0%
S.A. (total 4)	100%	100%	100%	100%	100%	100%	100%	100%	100%

5) The Results of each bridge



《about Rama 4 Bridge》

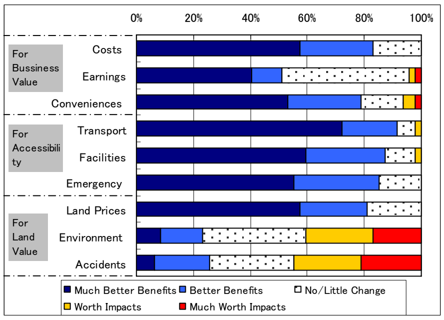
Rama 4	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	0%	0%	0%	0%	0%	0%	0%	0%	0%
Better Benefits	50%	50%	50%	100%	50%	50%	100%	50%	50%
No/Little Change	50%	50%	50%	0%	50%	50%	0%	0%	50%
Worth Impacts	0%	0%	0%	0%	0%	0%	0%	50%	0%
Much Worth Impacts	0%	0%	0%	0%	0%	0%	0%	0%	0%
S.A. (total 2)	100%	100%	100%	100%	100%	100%	100%	100%	100%



《about Phra Nakgklao Bridge》

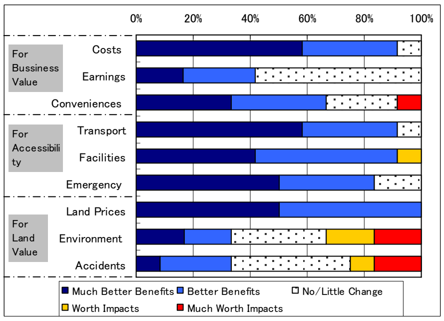
Phra Nangklao	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	75%	44%	63%	75%	63%	63%	63%	6%	6%
Better Benefits	19%	25%	19%	13%	19%	19%	19%	13%	31%
No/Little Change	6%	31%	19%	13%	19%	19%	19%	44%	25%
Worth Impacts	0%	0%	0%	0%	0%	0%	0%	13%	19%
Much Worth Impacts	0%	0%	0%	0%	0%	0%	0%	25%	19%
S.A. (total 16)	100%	100%	100%	100%	100%	100%	100%	100%	100%

《about New Bridge》



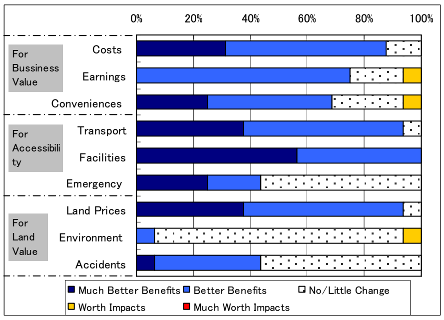
New Bridge	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	57%	40%	53%	72%	60%	55%	57%	9%	6%
Better Benefits	26%	11%	26%	19%	28%	30%	23%	15%	19%
No/Little Change	17%	45%	15%	6%	11%	15%	19%	36%	30%
Worth Impacts	0%	2%	4%	2%	2%	0%	0%	23%	23%
Much Worth Impacts	0%	2%	2%	0%	0%	0%	0%	17%	21%
S.A. (total 47)	100%	100%	100%	100%	100%	100%	100%	100%	100%

《about Rama 5 Bridge》



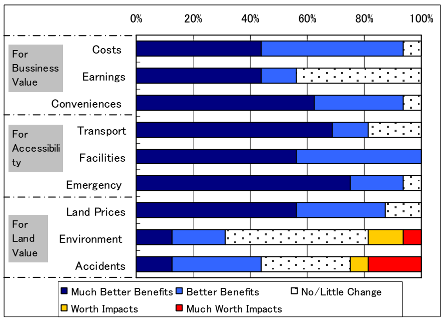
Rama 5	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	58%	17%	33%	58%	42%	50%	50%	17%	8%
Better Benefits	33%	25%	33%	33%	50%	33%	50%	17%	25%
No/Little Change	8%	58%	25%	8%	0%	17%	0%	33%	42%
Worth Impacts	0%	0%	0%	0%	8%	0%	0%	17%	8%
Much Worth Impacts	0%	0%	8%	0%	0%	0%	0%	17%	17%
S.A. (total 12)	100%	100%	100%	100%	100%	100%	100%	100%	100%

《about Rama 7 Bridge》



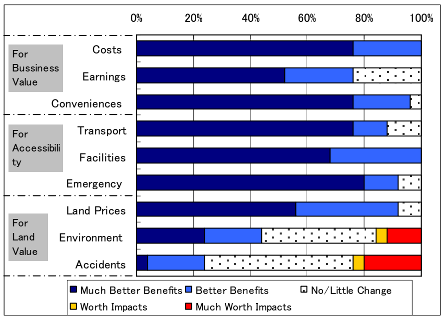
Rama 7	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	31%	0%	25%	38%	56%	25%	38%	0%	6%
Better Benefits	56%	75%	44%	56%	44%	19%	56%	6%	38%
No/Little Change	13%	19%	25%	6%	0%	56%	6%	88%	56%
Worth Impacts	0%	6%	6%	0%	0%	0%	0%	6%	0%
Much Worth Impacts	0%	0%	0%	0%	0%	0%	0%	0%	0%
S.A. (total 16)	100%	100%	100%	100%	100%	100%	100%	100%	100%

《about Krung Thon Bridge》



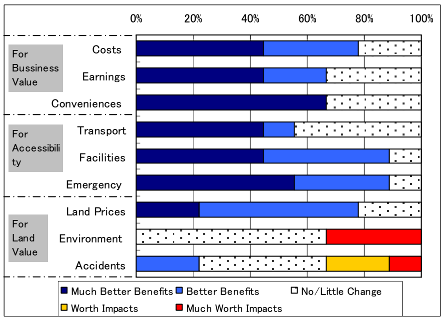
Krung Thon	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	44%	44%	63%	69%	56%	75%	56%	13%	13%
Better Benefits	50%	13%	31%	13%	44%	19%	31%	19%	31%
No/Little Change	6%	44%	6%	19%	0%	6%	13%	50%	31%
Worth Impacts	0%	0%	0%	0%	0%	0%	0%	13%	6%
Much Worth Impacts	0%	0%	0%	0%	0%	0%	0%	6%	19%
S.A. (total 16)	100%	100%	100%	100%	100%	100%	100%	100%	100%

《about Rama 8 Bridge》



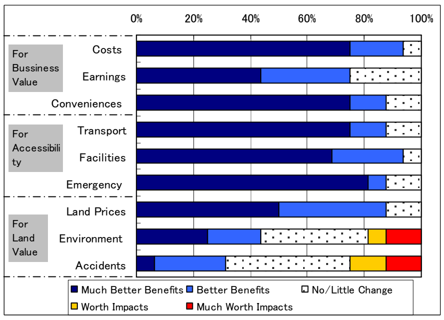
Rama 8	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	76%	52%	76%	76%	68%	80%	56%	24%	4%
Better Benefits	24%	24%	20%	12%	32%	12%	36%	20%	20%
No/Little Change	0%	24%	4%	12%	0%	8%	8%	40%	52%
Worth Impacts	0%	0%	0%	0%	0%	0%	0%	4%	4%
Much Worth Impacts	0%	0%	0%	0%	0%	0%	0%	12%	20%
S.A. (total 25)	100%	100%	100%	100%	100%	100%	100%	100%	100%

《about Pinklao Bridge》



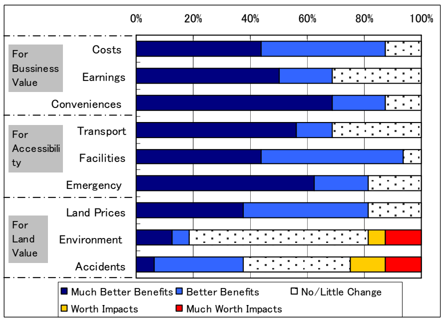
Pinklao	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	44%	44%	67%	44%	44%	56%	22%	0%	0%
Better Benefits	33%	22%	0%	11%	44%	33%	56%	0%	22%
No/Little Change	22%	33%	33%	44%	11%	11%	22%	67%	44%
Worth Impacts	0%	0%	0%	0%	0%	0%	0%	0%	22%
Much Worth Impacts	0%	0%	0%	0%	0%	0%	0%	33%	11%
S.A. (total 9)	100%	100%	100%	100%	100%	100%	100%	100%	100%

《about Memorial Bridge》



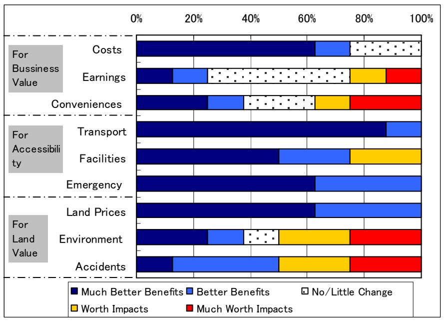
Memorial	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	75%	44%	75%	75%	69%	81%	50%	25%	6%
Better Benefits	19%	31%	13%	13%	25%	6%	38%	19%	25%
No/Little Change	6%	25%	13%	13%	6%	13%	13%	38%	44%
Worth Impacts	0%	0%	0%	0%	0%	0%	0%	6%	13%
Much Worth Impacts	0%	0%	0%	0%	0%	0%	0%	13%	13%
S.A. (total 16)	100%	100%	100%	100%	100%	100%	100%	100%	100%

《about Phra Pokklao Bridge》



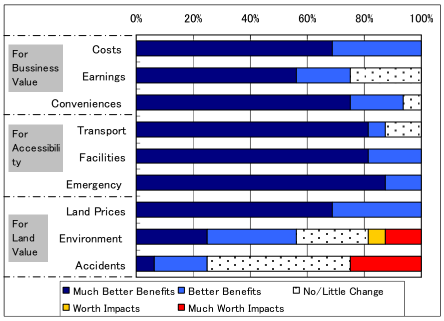
Phra Pokklao	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	44%	50%	69%	56%	44%	63%	38%	13%	6%
Better Benefits	44%	19%	19%	13%	50%	19%	44%	6%	31%
No/Little Change	13%	31%	13%	31%	6%	19%	19%	63%	38%
Worth Impacts	0%	0%	0%	0%	0%	0%	0%	6%	13%
Much Worth Impacts	0%	0%	0%	0%	0%	0%	0%	13%	13%
S.A. (total 16)	100%	100%	100%	100%	100%	100%	100%	100%	100%

《about Taksin Bridge》



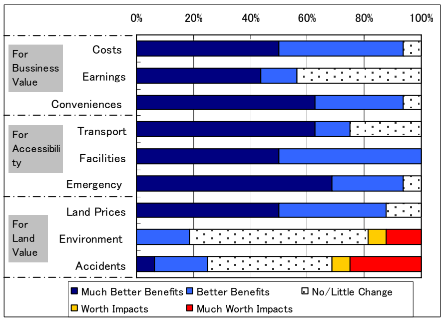
Taksin	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	63%	13%	25%	88%	50%	63%	63%	25%	13%
Better Benefits	13%	13%	13%	13%	25%	38%	38%	13%	38%
No/Little Change	25%	50%	25%	0%	0%	0%	0%	13%	0%
Worth Impacts	0%	13%	13%	0%	25%	0%	0%	25%	25%
Much Worth Impacts	0%	13%	25%	0%	0%	0%	0%	25%	25%
S.A. (total 8)	100%	100%	100%	100%	100%	100%	100%	100%	100%

《about Rama 3 Bridge》



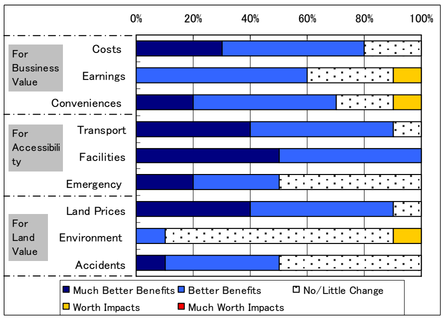
Rama 3	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	69%	56%	75%	81%	81%	88%	69%	25%	6%
Better Benefits	31%	19%	19%	6%	19%	13%	31%	31%	19%
No/Little Change	0%	25%	6%	13%	0%	0%	0%	25%	50%
Worth Impacts	0%	0%	0%	0%	0%	0%	0%	6%	0%
Much Worth Impacts	0%	0%	0%	0%	0%	0%	0%	13%	25%
S.A. (total 16)	100%	100%	100%	100%	100%	100%	100%	100%	100%

《about Krung Thep Bridge》



Krung Thep	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	50%	44%	63%	63%	50%	69%	50%	0%	6%
Better Benefits	44%	13%	31%	13%	50%	25%	38%	19%	19%
No/Little Change	6%	44%	6%	25%	0%	6%	13%	63%	44%
Worth Impacts	0%	0%	0%	0%	0%	0%	0%	6%	6%
Much Worth Impacts	0%	0%	0%	0%	0%	0%	0%	13%	25%
S.A. (total 16)	100%	100%	100%	100%	100%	100%	100%	100%	100%

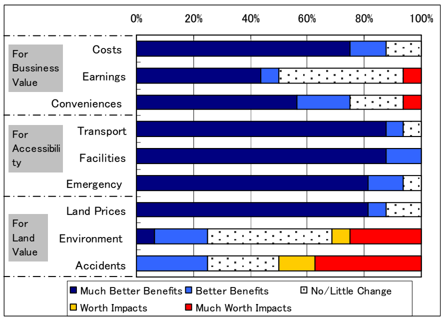
《about Rama 9 Bridge》



Rama 9	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	30%	0%	20%	40%	50%	20%	40%	0%	10%
Better Benefits	50%	60%	50%	50%	50%	30%	50%	10%	40%
No/Little Change	20%	30%	20%	10%	0%	50%	10%	80%	50%
Worth Impacts	0%	10%	10%	0%	0%	0%	0%	10%	0%
Much Worth Impacts	0%	0%	0%	0%	0%	0%	0%	0%	0%
S.A. (total 10)	100%	100%	100%	100%	100%	100%	100%	100%	100%

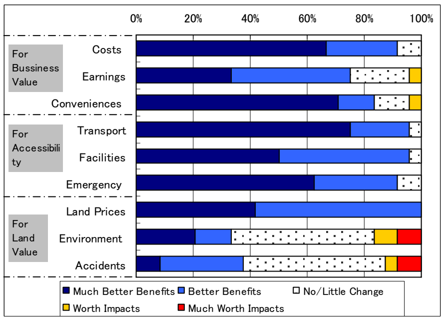
6) The Results of each type of job

《from Apartments》



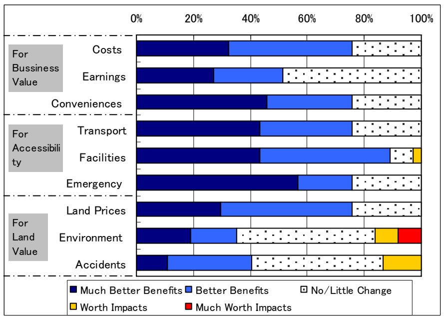
Apartment	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	75%	44%	56%	88%	88%	81%	81%	6%	0%
Better Benefits	13%	6%	19%	6%	13%	13%	6%	19%	25%
No/Little Change	13%	44%	19%	6%	0%	6%	13%	44%	25%
Worth Impacts	0%	0%	0%	0%	0%	0%	0%	6%	13%
Much Worth Impacts	0%	6%	6%	0%	0%	0%	0%	25%	38%
S.A. (total 16)	100%	100%	100%	100%	100%	100%	100%	100%	100%

《from Automobile Companies》



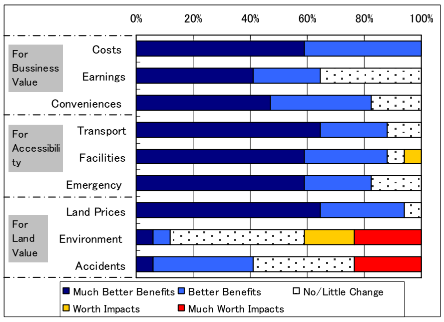
Automobile	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	67%	33%	71%	75%	50%	63%	42%	21%	8%
Better Benefits	25%	42%	13%	21%	46%	29%	58%	13%	29%
No/Little Change	8%	21%	13%	4%	4%	8%	0%	50%	50%
Worth Impacts	0%	4%	4%	0%	0%	0%	0%	8%	4%
Much Worth Impacts	0%	0%	0%	0%	0%	0%	0%	8%	8%
S.A. (total 24)	100%	100%	100%	100%	100%	100%	100%	100%	100%

《from normal Companies》



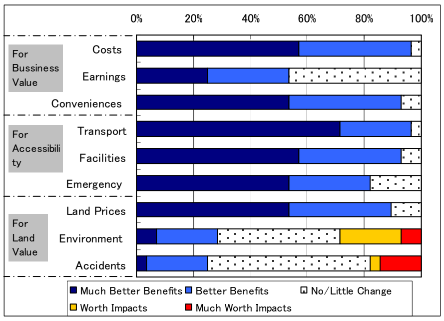
Company	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	32%	27%	46%	43%	43%	57%	30%	19%	11%
Better Benefits	43%	24%	30%	32%	46%	19%	46%	16%	30%
No/Little Change	24%	49%	24%	24%	8%	24%	24%	49%	46%
Worth Impacts	0%	0%	0%	0%	3%	0%	0%	8%	14%
Much Worth Impacts	0%	0%	0%	0%	0%	0%	0%	8%	0%
S.A. (total 37)	100%	100%	100%	100%	100%	100%	100%	100%	100%

《from Condominiums》



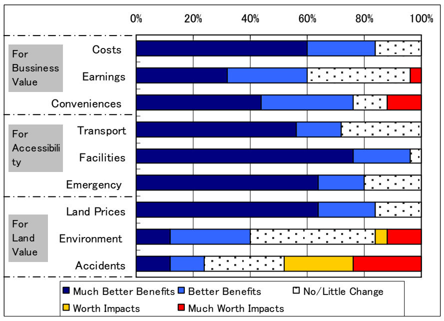
Condominium	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	59%	41%	47%	65%	59%	59%	65%	6%	6%
Better Benefits	41%	24%	35%	24%	29%	24%	29%	6%	35%
No/Little Change	0%	35%	18%	12%	6%	18%	6%	47%	35%
Worth Impacts	0%	0%	0%	0%	6%	0%	0%	18%	0%
Much Worth Impacts	0%	0%	0%	0%	0%	0%	0%	24%	24%
S.A. (total 17)	100%	100%	100%	100%	100%	100%	100%	100%	100%

《from Factories》



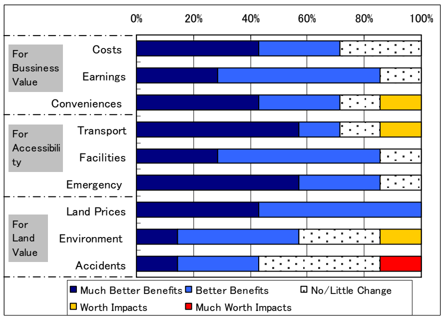
Factory	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	57%	25%	54%	71%	57%	54%	54%	7%	4%
Better Benefits	39%	29%	39%	25%	36%	29%	36%	21%	21%
No/Little Change	4%	46%	7%	4%	7%	18%	11%	43%	57%
Worth Impacts	0%	0%	0%	0%	0%	0%	0%	21%	4%
Much Worth Impacts	0%	0%	0%	0%	0%	0%	0%	7%	14%
S.A. (total 28)	100%	100%	100%	100%	100%	100%	100%	100%	100%

《from Gas Stations》



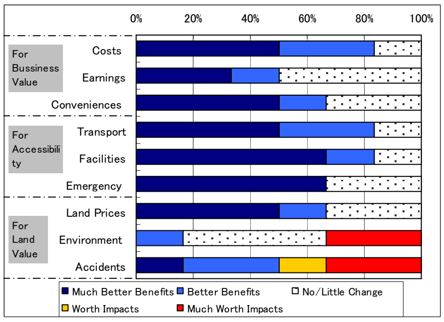
Gas Station	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	60%	32%	44%	56%	76%	64%	64%	12%	12%
Better Benefits	24%	28%	32%	16%	20%	16%	20%	28%	12%
No/Little Change	16%	36%	12%	28%	4%	20%	16%	44%	28%
Worth Impacts	0%	0%	0%	0%	0%	0%	0%	4%	24%
Much Worth Impacts	0%	4%	12%	0%	0%	0%	0%	12%	24%
S.A. (total 25)	100%	100%	100%	100%	100%	100%	100%	100%	100%

《from Hotels》



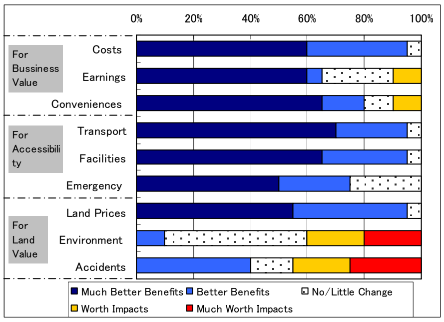
Hotel	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	43%	29%	43%	57%	29%	57%	43%	14%	14%
Better Benefits	29%	57%	29%	14%	57%	29%	57%	43%	29%
No/Little Change	29%	14%	14%	14%	14%	14%	0%	29%	43%
Worth Impacts	0%	0%	14%	14%	0%	0%	0%	14%	0%
Much Worth Impacts	0%	0%	0%	0%	0%	0%	0%	0%	14%
S.A. (total 7)	100%	100%	100%	100%	100%	100%	100%	100%	100%

《from Museums》



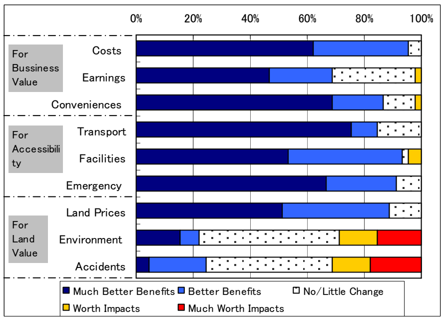
Museum	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	50%	33%	50%	50%	67%	67%	50%	0%	17%
Better Benefits	33%	17%	17%	33%	17%	0%	17%	17%	33%
No/Little Change	17%	50%	33%	17%	17%	33%	33%	50%	0%
Worth Impacts	0%	0%	0%	0%	0%	0%	0%	0%	17%
Much Worth Impacts	0%	0%	0%	0%	0%	0%	0%	33%	33%
S.A. (total 6)	100%	100%	100%	100%	100%	100%	100%	100%	100%

《from Restaurants》



Restaurant	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	60%	60%	65%	70%	65%	50%	55%	0%	0%
Better Benefits	35%	5%	15%	25%	30%	25%	40%	10%	40%
No/Little Change	5%	25%	10%	5%	5%	25%	5%	50%	15%
Worth Impacts	0%	10%	10%	0%	0%	0%	0%	20%	20%
Much Worth Impacts	0%	0%	0%	0%	0%	0%	0%	20%	25%
S.A. (total 20)	100%	100%	100%	100%	100%	100%	100%	100%	100%

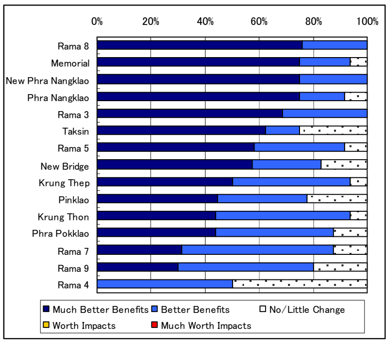
《from Shops》



Shop	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	62%	47%	69%	76%	53%	67%	51%	16%	4%
Better Benefits	33%	22%	18%	9%	40%	24%	38%	7%	20%
No/Little Change	4%	29%	11%	16%	2%	9%	11%	49%	44%
Worth Impacts	0%	2%	2%	0%	4%	0%	0%	13%	13%
Much Worth Impacts	0%	0%	0%	0%	0%	0%	0%	16%	18%
S.A. (total 45)	100%	100%	100%	100%	100%	100%	100%	100%	100%

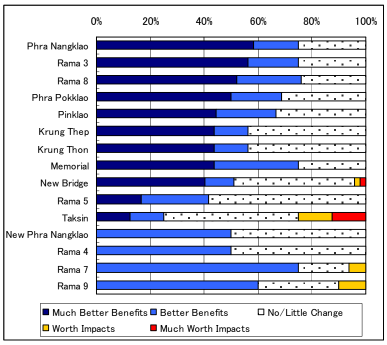
7) The Results of each question (separated in each bridge)

《about Reduce Costs (fuel, time, etc)》



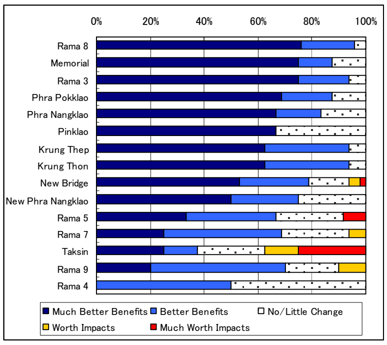
Costs	Much Better	Better Benefits	No/Little Change	Worth Impacts	Much Worth Impacts	Total
Rama 8	76%	24%	0%	0%	0%	100%
Memorial	75%	19%	6%	0%	0%	100%
New Phra Nangklao	75%	25%	0%	0%	0%	100%
Phra Nangklao	75%	17%	8%	0%	0%	100%
Rama 3	69%	31%	0%	0%	0%	100%
Taksin	63%	13%	25%	0%	0%	100%
Rama 5	58%	33%	8%	0%	0%	100%
New Bridge	57%	26%	17%	0%	0%	100%
Krung Thep	50%	44%	6%	0%	0%	100%
Pinklao	44%	33%	22%	0%	0%	100%
Krung Thon	44%	50%	6%	0%	0%	100%
Phra Pokklao	44%	44%	13%	0%	0%	100%
Rama 7	31%	56%	13%	0%	0%	100%
Rama 9	30%	50%	20%	0%	0%	100%
Rama 4	0%	50%	50%	0%	0%	100%

《about Increase Earnings, Sales and/or A Number of Customers》



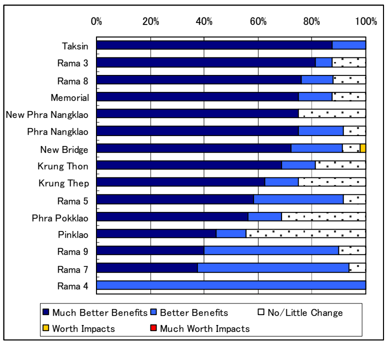
Earnings	Much Better	Better Benefits	No/Little Change	Worth Impacts	Much Worth Impacts	Total
Phra Nangklao	58%	17%	25%	0%	0%	100%
Rama 3	56%	19%	25%	0%	0%	100%
Rama 8	52%	24%	24%	0%	0%	100%
Phra Pokklao	50%	19%	31%	0%	0%	100%
Pinklao	44%	22%	33%	0%	0%	100%
Krung Thep	44%	13%	44%	0%	0%	100%
Krung Thon	44%	13%	44%	0%	0%	100%
Memorial	44%	31%	25%	0%	0%	100%
New Bridge	40%	11%	45%	2%	2%	100%
Rama 5	17%	25%	58%	0%	0%	100%
Taksin	13%	13%	50%	13%	13%	100%
New Phra Nangklao	0%	50%	50%	0%	0%	100%
Rama 4	0%	50%	50%	0%	0%	100%
Rama 7	0%	75%	19%	6%	0%	100%
Rama 9	0%	60%	30%	10%	0%	100%

《about Improve Conveniences for Employees and/or Business Customers》



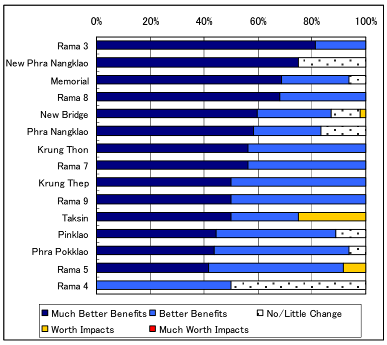
Conveniences	Much Better	Better Benefits	No/Little Change	Worth Impacts	Much Worth Impacts	Total
Rama 8	76%	20%	4%	0%	0%	100%
Memorial	75%	13%	13%	0%	0%	100%
Rama 3	75%	19%	6%	0%	0%	100%
Phra Pokklao	69%	19%	13%	0%	0%	100%
Phra Nangklao	67%	17%	17%	0%	0%	100%
Pinklao	67%	0%	33%	0%	0%	100%
Krung Thep	63%	31%	6%	0%	0%	100%
Krung Thon	63%	31%	6%	0%	0%	100%
New Bridge	53%	26%	15%	4%	2%	100%
New Phra Nangklao	50%	25%	25%	0%	0%	100%
Rama 5	33%	33%	25%	0%	8%	100%
Rama 7	25%	44%	25%	6%	0%	100%
Taksin	25%	13%	25%	13%	25%	100%
Rama 9	20%	50%	20%	10%	0%	100%
Rama 4	0%	50%	50%	0%	0%	100%

《about Reduce Times for Transport》



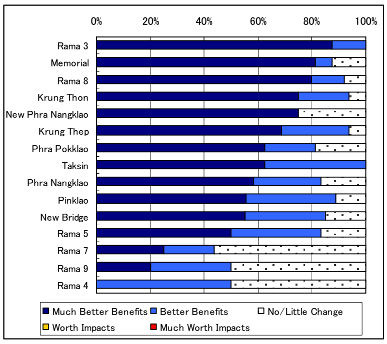
Transport	Much Better	Better Benefits	No/Little Change	Worth Impacts	Much Worth Impacts	Total
Taksin	88%	13%	0%	0%	0%	100%
Rama 3	81%	6%	13%	0%	0%	100%
Rama 8	76%	12%	12%	0%	0%	100%
Memorial	75%	13%	13%	0%	0%	100%
New Phra Nangklao	75%	0%	25%	0%	0%	100%
Phra Nangklao	75%	17%	8%	0%	0%	100%
New Bridge	72%	19%	6%	2%	0%	100%
Krung Thon	69%	13%	19%	0%	0%	100%
Krung Thep	63%	13%	25%	0%	0%	100%
Rama 5	58%	33%	8%	0%	0%	100%
Phra Pokklao	56%	13%	31%	0%	0%	100%
Pinklao	44%	11%	44%	0%	0%	100%
Rama 9	40%	50%	10%	0%	0%	100%
Rama 7	38%	56%	6%	0%	0%	100%
Rama 4	0%	100%	0%	0%	0%	100%

《about Improve Access to Useful Facilities》



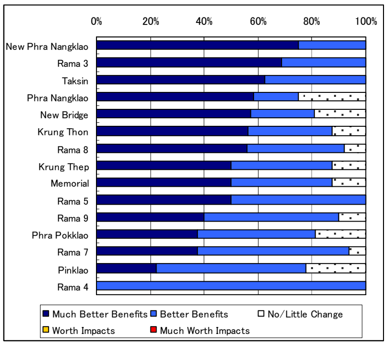
Facilities	Much Better	Better Benefits	No/Little Change	Worth Impacts	Much Worth Impacts	Total
Rama 3	81%	19%	0%	0%	0%	100%
New Phra Nangklao	75%	0%	25%	0%	0%	100%
Memorial	69%	25%	6%	0%	0%	100%
Rama 8	68%	32%	0%	0%	0%	100%
New Bridge	60%	28%	11%	2%	0%	100%
Phra Nangklao	58%	25%	17%	0%	0%	100%
Krung Thon	56%	44%	0%	0%	0%	100%
Rama 7	56%	44%	0%	0%	0%	100%
Krung Thep	50%	50%	0%	0%	0%	100%
Rama 9	50%	50%	0%	0%	0%	100%
Taksin	50%	25%	0%	25%	0%	100%
Pinklao	44%	44%	11%	0%	0%	100%
Phra Pokklao	44%	50%	6%	0%	0%	100%
Rama 5	42%	50%	0%	8%	0%	100%
Rama 4	0%	50%	50%	0%	0%	100%

《about Improve Access in Emergency (hospital)》



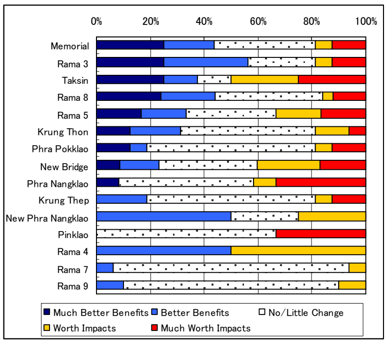
Emergency	Much Better	Better Benefits	No/Little Change	Worth Impacts	Much Worth Impacts	Total
Rama 3	88%	13%	0%	0%	0%	100%
Memorial	81%	6%	13%	0%	0%	100%
Rama 8	80%	12%	8%	0%	0%	100%
Krung Thon	75%	19%	6%	0%	0%	100%
New Phra Nangklao	75%	0%	25%	0%	0%	100%
Krung Thep	69%	25%	6%	0%	0%	100%
Phra Pokklao	63%	19%	19%	0%	0%	100%
Taksin	63%	38%	0%	0%	0%	100%
Phra Nangklao	58%	25%	17%	0%	0%	100%
Pinklao	56%	33%	11%	0%	0%	100%
New Bridge	55%	30%	15%	0%	0%	100%
Rama 5	50%	33%	17%	0%	0%	100%
Rama 7	25%	19%	56%	0%	0%	100%
Rama 9	20%	30%	50%	0%	0%	100%
Rama 4	0%	50%	50%	0%	0%	100%

《about Increase Land Prices》



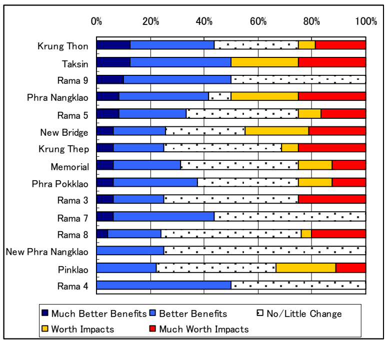
Land Prices	Much Better	Better Benefits	No/Little Change	Worth Impacts	Much Worth Impacts	Total
New Phra Nangklao	75%	25%	0%	0%	0%	100%
Rama 3	69%	31%	0%	0%	0%	100%
Taksin	63%	38%	0%	0%	0%	100%
Phra Nangklao	58%	17%	25%	0%	0%	100%
New Bridge	57%	23%	19%	0%	0%	100%
Krung Thon	56%	31%	13%	0%	0%	100%
Rama 8	56%	36%	8%	0%	0%	100%
Krung Thep	50%	38%	13%	0%	0%	100%
Memorial	50%	38%	13%	0%	0%	100%
Rama 5	50%	50%	0%	0%	0%	100%
Rama 9	40%	50%	10%	0%	0%	100%
Phra Pokklao	38%	44%	19%	0%	0%	100%
Rama 7	38%	56%	6%	0%	0%	100%
Pinklao	22%	56%	22%	0%	0%	100%
Rama 4	0%	100%	0%	0%	0%	100%

《about Improve Life Environment (Noise, Atmosphere, etc)》



Environment	Much Better	Better Benefits	No/Little Change	Worth Impacts	Much Worth Impacts	Total
Memorial	25%	19%	38%	6%	13%	100%
Rama 3	25%	31%	25%	6%	13%	100%
Taksin	25%	13%	13%	25%	25%	100%
Rama 8	24%	20%	40%	4%	12%	100%
Rama 5	17%	17%	33%	17%	17%	100%
Krung Thon	13%	19%	50%	13%	6%	100%
Phra Pokklao	13%	6%	63%	6%	13%	100%
New Bridge	9%	15%	36%	23%	17%	100%
Phra Nangklao	8%	0%	50%	8%	33%	100%
Krung Thep	0%	19%	63%	6%	13%	100%
New Phra Nangklao	0%	50%	25%	25%	0%	100%
Pinklao	0%	0%	67%	0%	33%	100%
Rama 4	0%	50%	0%	50%	0%	100%
Rama 7	0%	6%	88%	6%	0%	100%
Rama 9	0%	10%	80%	10%	0%	100%

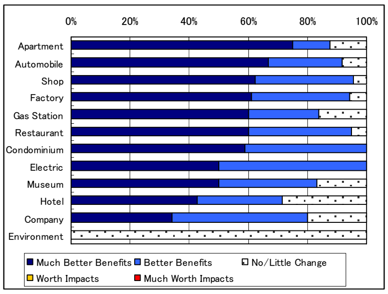
《about Reduce Traffic Accidents》



Accidents	Much Better	Better Benefits	No/Little Change	Worth Impacts	Much Worth Impacts	Total
Krung Thon	13%	31%	31%	6%	19%	100%
Taksin	13%	38%	0%	25%	25%	100%
Rama 9	10%	40%	50%	0%	0%	100%
Phra Nangklao	8%	33%	8%	25%	25%	100%
Rama 5	8%	25%	42%	8%	17%	100%
New Bridge	6%	19%	30%	23%	21%	100%
Krung Thep	6%	19%	44%	6%	25%	100%
Memorial	6%	25%	44%	13%	13%	100%
Phra Pokklao	6%	31%	38%	13%	13%	100%
Rama 3	6%	19%	50%	0%	25%	100%
Rama 7	6%	38%	56%	0%	0%	100%
Rama 8	4%	20%	52%	4%	20%	100%
New Phra Nangklao	0%	25%	75%	0%	0%	100%
Pinklao	0%	22%	44%	22%	11%	100%
Rama 4	0%	50%	50%	0%	0%	100%

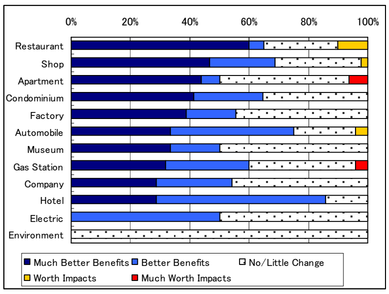
8) The Results of each question (separated in each type of job)

《about Reduce Costs (fuel, time, etc)》



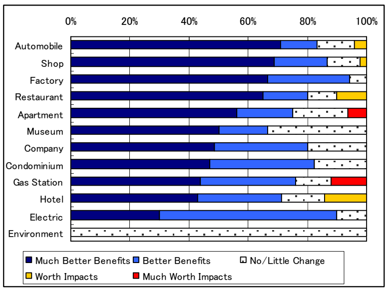
Costs	Much Better	Better Benefits	No/Little Change	Worth Impacts	Much Worth Impacts	Total
Apartment	75%	13%	13%	0%	0%	100%
Automobile	67%	25%	8%	0%	0%	100%
Shop	62%	33%	4%	0%	0%	100%
Factory	61%	33%	6%	0%	0%	100%
Gas Station	60%	24%	16%	0%	0%	100%
Restaurant	60%	35%	5%	0%	0%	100%
Condominium	59%	41%	0%	0%	0%	100%
Electric	50%	50%	0%	0%	0%	100%
Museum	50%	33%	17%	0%	0%	100%
Hotel	43%	29%	29%	0%	0%	100%
Company	34%	46%	20%	0%	0%	100%
Environment	0%	0%	100%	0%	0%	100%

《about Increase Earnings, Sales and/or A Number of Customers》



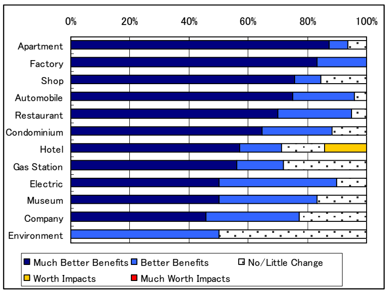
Earnings	Much Better	Better Benefits	No/Little Change	Worth Impacts	Much Worth Impacts	Total
Restaurant	60%	5%	25%	10%	0%	100%
Shop	47%	22%	29%	2%	0%	100%
Apartment	44%	6%	44%	0%	6%	100%
Condominium	41%	24%	35%	0%	0%	100%
Factory	39%	17%	44%	0%	0%	100%
Automobile	33%	42%	21%	4%	0%	100%
Museum	33%	17%	50%	0%	0%	100%
Gas Station	32%	28%	36%	0%	4%	100%
Company	29%	26%	46%	0%	0%	100%
Hotel	29%	57%	14%	0%	0%	100%
Electric	0%	50%	50%	0%	0%	100%
Environment	0%	0%	100%	0%	0%	100%

《about Improve Conveniences for Employees and/or Business Customers》



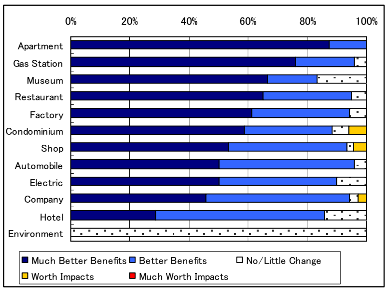
Conveniences	Much Better	Better Benefits	No/Little Change	Worth Impacts	Much Worth Impacts	Total
Automobile	71%	13%	13%	4%	0%	100%
Shop	69%	18%	11%	2%	0%	100%
Factory	67%	28%	6%	0%	0%	100%
Restaurant	65%	15%	10%	10%	0%	100%
Apartment	56%	19%	19%	0%	6%	100%
Museum	50%	17%	33%	0%	0%	100%
Company	49%	31%	20%	0%	0%	100%
Condominium	47%	35%	18%	0%	0%	100%
Gas Station	44%	32%	12%	0%	12%	100%
Hotel	43%	29%	14%	14%	0%	100%
Electric	30%	60%	10%	0%	0%	100%
Environment	0%	0%	100%	0%	0%	100%

《about Reduce Times for Transport》



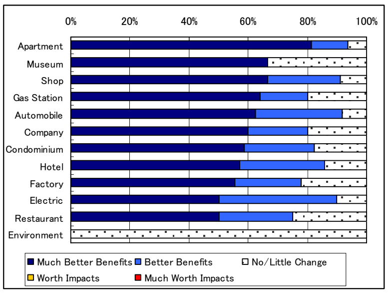
Transport	Much Better	Better Benefits	No/Little Change	Worth Impacts	Much Worth Impacts	Total
Apartment	88%	6%	6%	0%	0%	100%
Factory	83%	17%	0%	0%	0%	100%
Shop	76%	9%	16%	0%	0%	100%
Automobile	75%	21%	4%	0%	0%	100%
Restaurant	70%	25%	5%	0%	0%	100%
Condominium	65%	24%	12%	0%	0%	100%
Hotel	57%	14%	14%	14%	0%	100%
Gas Station	56%	16%	28%	0%	0%	100%
Electric	50%	40%	10%	0%	0%	100%
Museum	50%	33%	17%	0%	0%	100%
Company	46%	31%	23%	0%	0%	100%
Environment	0%	50%	50%	0%	0%	100%

《about Improve Access to Useful Facilities》



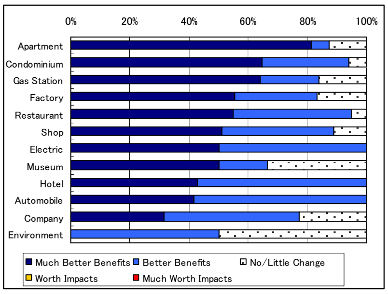
Facilities	Much Better	Better Benefits	No/Little Change	Worth Impacts	Much Worth Impacts	Total
Apartment	88%	13%	0%	0%	0%	100%
Gas Station	76%	20%	4%	0%	0%	100%
Museum	67%	17%	17%	0%	0%	100%
Restaurant	65%	30%	5%	0%	0%	100%
Factory	61%	33%	6%	0%	0%	100%
Condominium	59%	29%	6%	6%	0%	100%
Shop	53%	40%	2%	4%	0%	100%
Automobile	50%	46%	4%	0%	0%	100%
Electric	50%	40%	10%	0%	0%	100%
Company	46%	49%	3%	3%	0%	100%
Hotel	29%	57%	14%	0%	0%	100%
Environment	0%	0%	100%	0%	0%	100%

《about Improve Access in Emergency (hospital)》



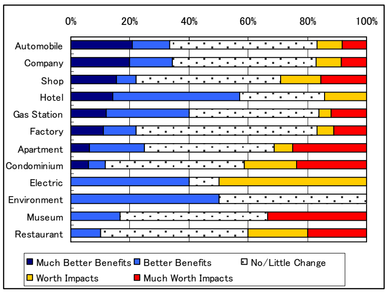
Emergency	Much Better	Better Benefits	No/Little Change	Worth Impacts	Much Worth Impacts	Total
Apartment	81%	13%	6%	0%	0%	100%
Museum	67%	0%	33%	0%	0%	100%
Shop	67%	24%	9%	0%	0%	100%
Gas Station	64%	16%	20%	0%	0%	100%
Automobile	63%	29%	8%	0%	0%	100%
Company	60%	20%	20%	0%	0%	100%
Condominium	59%	24%	18%	0%	0%	100%
Hotel	57%	29%	14%	0%	0%	100%
Factory	56%	22%	22%	0%	0%	100%
Electric	50%	40%	10%	0%	0%	100%
Restaurant	50%	25%	25%	0%	0%	100%
Environment	0%	0%	100%	0%	0%	100%

《about Increase Land Prices》



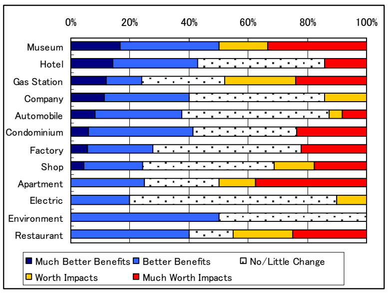
Land Prices	Much Better	Better Benefits	No/Little Change	Worth Impacts	Much Worth Impacts	Total
Apartment	81%	6%	13%	0%	0%	100%
Condominium	65%	29%	6%	0%	0%	100%
Gas Station	64%	20%	16%	0%	0%	100%
Factory	56%	28%	17%	0%	0%	100%
Restaurant	55%	40%	5%	0%	0%	100%
Shop	51%	38%	11%	0%	0%	100%
Electric	50%	50%	0%	0%	0%	100%
Museum	50%	17%	33%	0%	0%	100%
Hotel	43%	57%	0%	0%	0%	100%
Automobile	42%	58%	0%	0%	0%	100%
Company	31%	46%	23%	0%	0%	100%
Environment	0%	50%	50%	0%	0%	100%

《about Improve Life Environment (Noise, Atmosphere, etc)》



Environment	Much Better	Better Benefits	No/Little Change	Worth Impacts	Much Worth Impacts	Total
Automobile	21%	13%	50%	8%	8%	100%
Company	20%	14%	49%	9%	9%	100%
Shop	16%	7%	49%	13%	16%	100%
Hotel	14%	43%	29%	14%	0%	100%
Gas Station	12%	28%	44%	4%	12%	100%
Factory	11%	11%	61%	6%	11%	100%
Apartment	6%	19%	44%	6%	25%	100%
Condominium	6%	6%	47%	18%	24%	100%
Electric	0%	40%	10%	50%	0%	100%
Environment	0%	50%	50%	0%	0%	100%
Museum	0%	17%	50%	0%	33%	100%
Restaurant	0%	10%	50%	20%	20%	100%

《about Reduce Traffic Accidents》



Accidents	Much Better	Better Benefits	No/Little Change	Worth Impacts	Much Worth Impacts	Total
Museum	17%	33%	0%	17%	33%	100%
Hotel	14%	29%	43%	0%	14%	100%
Gas Station	12%	12%	28%	24%	24%	100%
Company	11%	29%	46%	14%	0%	100%
Automobile	8%	29%	50%	4%	8%	100%
Condominium	6%	35%	35%	0%	24%	100%
Factory	6%	22%	50%	0%	22%	100%
Shop	4%	20%	44%	13%	18%	100%
Apartment	0%	25%	25%	13%	38%	100%
Electric	0%	20%	70%	10%	0%	100%
Environment	0%	50%	50%	0%	0%	100%
Restaurant	0%	40%	15%	20%	25%	100%

Appendix-7

Bridge Inspection Survey Activity Report

Data-1: Bridge Preliminary Survey Activity Report

October 20 (Tue), 2009

At 10:00, visit DRR.

Person present: DRR Construction Dept. Dr. Kiti M.
Survey Team Magario, Chujo, Kudo, Poramin

Purpose: Request of cooperation for JICA survey on bridges over Chao Phraya River

Discussions:

- Survey Team requested cooperation for the JICA's bridge condition survey on the bridges constructed over the Chao Phraya River with the Japanese government finances in the past.
- The DRR personnel explained that only the Industrial Ring Road (IRR) Bridge was under control of the construction dept. but other bridges were under the maintenance dept. He said he could arrange for the team to visit the IRR Bridge maintenance office after approval of his director.

Afternoon, two department engineers guided the team to the Rama IV, Rama V and Rama VII bridge sites.

Rama IV Bridge:

- A PC box girder bridge built in 2006 with Japan government finance and currently maintained under DRR control.
- The bridge is new to find no noticeable damage.

Rama V Bridge:

- A PC box girder bridge built in 2002 with Japan government finance and currently maintained under DRR control.
- The bridge looks still clean to find no noticeable damage except theft loss of guardrails.

Rama VII Bridge:

- A PC box girder bridge built in 1992 with Japan government finance and currently maintained under DRR control.
- The bridge looks still clean to find no noticeable damage suggesting structural defect.
- A big water pipe about 100 cm in diameter installed inside the box girder was at maintenance work.

October 21 (Wed), 2009

At 10:00, visit DRR.

Person present: DRR Maintenance Dept. Chawalit T.
Survey Team Magario, Chujo, Kudo, Poramin

Purpose: Request of cooperation for JICA survey on bridges over Chao Phraya River

Discussions:

- Survey Team requested cooperation for the bridge condition survey on the bridges constructed across the Chao Phraya River with the Japanese government finance in the past.
- The DRR personnel said that he understood the aim of the team but needed a request letter from JICA to report to his director.

Afternoon, JICA team submitted a letter by the name of the team leader to the DRR construction and maintenance departments respectively.

October 22 (Thu), 2009

At 10:00, visit IRR Bridge Site Maintenance Office.

Person present:	Site Maintenance Office	Nawapon (Chief Inspector)
	Survey Team	Chujo, Kudo, Poramin

Purpose: Bridge survey and hearing of maintenance on IRR Bridges.

Explanation by Chief Inspector:

- Two major cable-stayed bridges and PC box girder viaducts built in 2006 with Japanese government finance and having being maintained under DRR control.
- Under a main site office with 3 technical staff, two maintenance bases for the north and south bridges each with 3 technical staff and 10 workers for daily inspection, small repairs, cleaning and monitoring.
- Traffic watching on the bridge with CCTV.
- A staying cable tension monitoring system is equipped with but currently under repairing.
- Annual inspection of staying cables by the cable supplier.
- The expansion joint (steel finger type) of the south bridge has been repeatedly damaged so far four times replaced part by part since the traffic opening in 2006.
- Also, damage of electric wire branch boxes by rain water.

After explanation, a maintenance office staff guided the team to the traffic monitoring room and then onto the bridge deck. The team found the following evidences on the bridge deck:

- Cracks on the main tower concrete, a vertical crack on inner face and diagonal crack-like lines on outer face.
- Impact sound and movement from broken expansion joint when vehicle running on.
- Sags of the bridge surface profile at main span.
- A crack on the concrete deck initiated from a staying cable anchoring device and water collecting on the deck surface in contact with the anchoring device.

October 23 (Fri), 2009

All day, bridge survey by Survey Team alone: Magario, Chujo, Kudo, and Poramin.

Rama VIII Bridge:

- A cable-stay bridge built in 2002 by BMA. The team visited this bridge additionally for better understanding of the bridges over the Chao Phraya River although it was not scheduled for survey.
- The bridge looks maintained clean. The street planting under the approach viaduct was impressive.

Phra Pinklao Bridge:

- A PC box girder bridge built in 1973 with Japanese government finance and currently maintained under DRR control.
- No significant problem was found. The bridge generally looks well maintained for its years.

Memorial Bridge:

- A steel truss bridge with a bascule girder span first built in 1932 and repaired in 1984 by Japanese government finance, currently maintained under DRR control.
- The bridge generally looks well maintained for its years after the 1984 repair. However, several evidences of concern were noted such as:
  a. Underside of the bridge, many small vessel collision damages are seen and from where painting deterioration began.
  b. Also, corroded reinforcement bars exposed underside of footpath concrete deck slab in several location.
  c. Probably at repairing of 1984, the bascule span girders were connected each other by adding steel plates but deck slabs were not connected leaving a joint gap, which becomes a cause of traffic impact on the joint.

  These evidences do not mean immediate danger of the bridge structure but will require a repair again in the not so long future. Concerning the problem b above, DRR explained later in meeting, the upstream side footpath was already replaced a few years back and the downstream side reported being damaged is scheduled for replacement in the near future.

Phra Pokklao Bridge:

- Three PC box girder bridges built on a common pier foundation in 1984 with Japanese government finance and currently maintained under DRR control. Out of three box girders, the center girder is left incomplete.
- No significant problem was found. The bridge generally looks well maintained for its years.
- Small damages by vessel collision are noted on the box girder at near the piers in water where clearance is low.

Krungthep Bridge:

- A steel truss bridge with a bascule girder span first built in 1959 by Japanese war reparation and a large repair carried out in 2002 by Japanese government finance, and currently maintained under DRR control.
- The bridge generally looks well maintained and sound after the 2002 repair. No significant damage to need immediate repair was found.
- The bascule girder is still movable according to hearing from DRR later. No wonder the traffic impact on the bascule span joint is significant.
- However, on the underside of the bridge, some steel corrosion is already seen on the lower flange at the bascule girder tip where steels are usually wet with leaking rain water.

Rama III Bridge:

- A PC box girder bridge built in 2000 with Japanese government finance to alleviate traffic congestion on the adjacent Krungthep Bridge, and currently maintained under DRR control.
- The bridge looks still new and no visible damage was found in appearance.

October 24 (Sat), 2009

All day, bridge survey by Survey Team alone: Chujo, Kudo, and Poramin.

Phra Nangklao Bridge:

- Twin PC box girder on a common pier foundation was built in 1985 with Japanese government finance and currently maintained under DOH control.
- The bridge generally looks still sound for its years except the following cantilever joint problem.
- That is, the cantilever girders were shaking independently on either side by vehicle running. It is suspected that hinge connection is not provided with or damaged if provided, although the problem does not directly affect the bridge loading capability.
- While a water main pipe is installed each inside of the box girder, water is continuously running from the bottom hole of the box girder. The water leakage of main pipe might be caused by this cantilever joint shaking.
- Besides, small vessel collision damages on the box girders and loss damage of a pile-cap fender are noted.

New Phra Nangklao Bridge:

- A PC box girder bridge was just built in 2008 to alleviate traffic congestion on the adjacent Phra Nangklao Bridge, and currently maintained under DOH control. This bridge is not scheduled for survey.
- The bridge slightly curves in the river to share the approach road space with the old Phra Nangklao Bridge by grade separation.

Krungthon Bridge:

- A six span steel truss bridge was first built in 1958 by Japanese war reparation and has been repeatedly repaired, and currently maintained under DRR control.
- The bridge generally looks well maintained and no significant damage was found to need immediate repair.
- Many evidences of past repairs and re-paintings on truss members are seen and pavement looks clean on the bridge surface.
- However, on underside of the bridge, many small vessel collision damages are seen on lower truss chords and lateral bracings without repairs. Besides, deterioration of slab concrete is widely seen with traces of free limes in particular on the underside of footpath.
- According to hearing from DRR later, DRR has finished an inspection of the bridge this year and will start the repair work next year.

October 25 (Sun), 2009

Off work.

October 26 (Mon), 2009

At 10:00, visit DOH Bridge Construction Bureau.

Person present:	DOH Bridge Construction Bureau	Jitpong K. (Director), Thongchai W.
	Survey Team	Matsuzawa, Chujo, Kudo, Poramin

Purpose: Request of cooperation for JICA survey on the bridges Chao Phraya River

Discussions:

- Survey Team requested cooperation for the JICA's bridge condition survey on the bridges constructed across the Chao Phraya River with the Japanese government finances in the past.
- The DOH personnel responded they could cooperate with the JICA survey after approval of the Director General of DOH.

At 14:30, visit EXTA.

Person present:	EXTA Maintenance Dept.	Pittaya T. and other staff
	Survey Team	Matsuzawa, Chujo, Kudo, Poramin

Purpose: Request of cooperation for JICA bridge survey for Rama IX Bridge on Chao Phraya River

Site Inspection:

- The EXTA staff immediately took the team to the Rama IX Bridge site. At the site, he and his site staff showed the team around the bridge deck and then inside of the steel girder to explain their maintenance activities.
- On the bridge, the team learned the following maintenance activities engaged by EXTA:
  a. The bridge tower and staying cables had been just newly re-painted.
  b. The expansion joint (rolling leaf type) will have been renewed this month for the first time in 20 years.
  c. In two years after traffic opening, a vibration control technology (German technology) was introduced to install damping devices on underside of the steel deck both on in-bound and out-bound lanes with eight numbers along each lane to suppress traffic vibration.
  d. Some of the steel rib plates on top and floor decks were being reinforced with CFRP (carbon fiber reinforced plastic) because where deformation was found allegedly due to buckling.

Discussions:

Same day after the bridge inspection, the team had a discussion with EXTA.

- EXTA outlined the history of the maintenance of Rama IX Bridge. The maintenance program for the bridge actually started with a maintenance manual given in 1994 by JICA technical assistance. After that, the bridge was given the 10th year inspection in 2001. The bridge is currently under repair works based on the 20th year inspection entrusting to the Chulalongkorn University. Major repair works by this time inspection include replacement of pavement with an asphalt mix using slug aggregate, replacement of expansion joints (rolling leaf type), repainting of tower, cables and girders, and reinforcement of girder rib plates with CFRP (Carbon Fiber Reinforced Plastic).
- EXAT answered the team, saying EXAT is now in the midst of doing repair works following the 20th year inspection so that it is in no situation to request the bridge inspection to JICA. Instead, EXAT requested assistance for their staff training in Japan, not of lecture and study tour but of on-the-job training at actual bridge maintenance site in Japan.

<u>October 27 (Tue), 2009</u>

In the morning, arrangement of a motorboat for bridge inspection from water scheduled on Saturday.

Afternoon, bridge survey by Survey Team alone: Chujo, Kudo, and Poramin.

Taksin Bridge:

- Three PC box girder bridges lying close in parallel with individual foundations connected each other at their tops, was built in 1982 with Japanese government finance and currently maintained under DRR control. Out of three box girders, the center girder is used for LRT (Light Rail Transit).
- The bridge generally looks still durable for its years although there found some signs of aging such as deterioration of girder concrete with free lime visible at expansion and construction joints, a crack-like line on girder side face, and diminishing bearing width at the end support of box girder. On the bridge deck, the expansion joint (steel finger type) is maintained smooth but small damages on concrete barriers are noticeable.

October 28 (Wed), 2009

All day, bridge survey by Survey Team alone: Chujo, Kudo, and Poramin.

Pathum Thani Bridge:

- The bridge was first built in 1984 as a two lane PC box girder bridge with Japanese government finance and later widened to six lanes by constructing another four lane PC box girder bridge abutting on the existing, and currently maintained under DOH control.
- The bridge generally looks still sound for its years. There is a small level difference (max. 10 mm) along the longitudinal joint gap between the old and new bridge decks, that might be disturbing traveling performance but does not become a structural problem. In addition, some pre-cast concrete fenders are observed seriously damaged possibly by vessel collision but no significant damage on the foundation body.

Pathum Thani-2 Bridge

- The twin PC box girder bridge, having three lanes each direction, is brand new just constructed in 2009.

Nonthaburi Bridge:

- A four span steel truss bridge was first built in 1959 by Japanese war reparation and currently maintained under DOH control. The bridge was aged showing lots of corrosions and damages. The bridge seems to have been left not repaired for a long period.
- Many corrosions and deformations are found on truss members at eye level on the bridge deck. Regarding the vertical member, web plates are corroded severer than flanges reducing steel thickness enough to become thin down into a hole. Corrosion is also visible on the lower flanges and gusset plates at bearing shoes and on the cross beams below expansion joints.
- Furthermore, by inspection of the bridge underside from water conducted another day, corrosion was found also on lower flanges and gusset plates where dust and rainwater were easily collected. Some gusset plates were severely rusted with not a little deficiency of steel section.
- Also, on the bridge underside, many vessel collision scars were seen such as lower chords were slightly bended, edges of gusset plates turned, and a lateral brace was removed.
- Moreover, the underside of the reinforced concrete deck slab was seen tanned by aging, locally

delaminated and soiled with free lime leakage. In particular, the underside of the footpath was seen severely damaged; delamination of concrete occurred widely and rusted reinforcement bars were visible locally by spalling of cover concrete.

- One side of a pier foundation at water level was severely worn down to expose reinforcement bars. It is suspected abrasion was caused because of mooring boats over the years.

October 29 (Thu), 2009

At 09:00, visit DOH.

Person present: DOH Bridge Construction Bureau Thongchai W.
Survey Team Matsuzawa, Chujo, Kudo, Poramin

Purpose: Hearing of bridge maintenance activity for the bridges on Chao Phraya River.

Discussions:

- The personnel of DOH Bridge Construction Bureau explained the measures currently taken by DOH for maintenance of the bridges over the Chao Phraya River as follows. DOH had once set up a bridge inspection team of the DOH technical staff when introducing BMMS (Bridge Maintenance Management System) with assistance of the Danish government nearly two decades ago. However, the bridge inspection team could not be well maintained through to the present and no activity today. Consequently, DOH now needs to contract out the bridge inspection jobs for large bridges like the bridges over the Chao Phraya River. However, DOH maintains four regional logistic bases across the country and there holds equipment and work forces to carry out small scale and emergency bridge repairs. In this way, DOH keeps bridge maintenance capabilities to a certain level.
- DOH also explained that DOH does not have any rehabilitation or reconstruction plan at present for the bridges over the Chao Phraya River. DOH wants to maintain these bridges as they stand now for as long as possible.
- The Survey Team reported the conditions of Patum Tani (PC box girder in 1984), Nonthaburi (steel truss in 1959) and Phra Nangklao (PC box girder in 1985) Bridges. Among the three bridges, the team informed DOH of the problems of Nonthaburi and Phra Nangklao Bridges. DOH had already recognized the damages of these two bridges but the department seemed to be considering they had not become serious yet.

Afternoon, gathering of survey data.

October 30 (Fri), 2009

At 10:00, visit DRR.

Person present: DRR Maintenance Dept. Chawalit T.
Survey Team Magario, Chujo, Kudo, Poramin

Purpose: Hearing of bridge maintenance activity for the bridges over Chao Phraya River and reporting of bridge inspection results.

Discussions:

- The DRR personnel explained the current maintenance system for the bridges over the Chao Phraya River as follows. DRR Maintenance Department keeps site offices and staff exclusive for maintenance of the bridges over the Chao Phraya River at respective bridge site utilizing under-bridge spaces, for daily check, cleaning, small repair and event preparing and clearing.
- The department has been carrying out a decent inspection for the bridges over the Chao Phraya River periodically in two to five years interval on contract base. The latest example of the contract-base inspection was of the Krung Thon Bridge (steel truss bridge built in 1958). The bridge inspection has been completed this year in detail including concrete sample coring and vehicle loading test, and the department will carry out a full-scale repair work next year with a budget of 2.0 million bahts. The repair work will include pavement overlay, strengthening of steel truss members, repainting and stone placing on scoured riverbed.
- According to the department, for Phra Pinklao, Memorial, Phra Pokklao and Taksin Bridges, the department is recently monitoring the bridge behavior remotely from the head office by installing strain gages and accelerometers inside of box girders.
- Concerning the steel truss bridges, the team reported the corrosions observed at edges and corners of steel truss members and made advices for rain-proofing measures on the deck slab in contact with steel truss members. The team also reported the sign of deterioration seen on the underside of deck slab where concrete cover dropped off to expose rusted reinforcing bars in spots.
- Concerning the Taksin Bridge, the team called attention to de-centering of the bearing shoes on the end support of continuous PC box girders and advised to inspect it periodically.
- In answer to the team, the DRR staff indicated that the department would maintain the present maintenance system for the bridges over the Chao Phraya River for some time in the future and accordingly the department seemed have no intention at present to request JICA bridge inspection.

Afternoon, preparation for boat inspection next day.
Evening, attend meeting with JICA.

<u>October 31 (Sat), 2009</u>

All day, bridge inspection by boat by Survey Team alone: Chujo, Kudo, and Poramin.

The bridge survey was conducted by boat to inspect all the bridges from upstream to downstream along the Chao Phraya River taking photos of bridge undersides. Major damages found from water include:

- Corrosions and vessel collision deformations of truss members as well as deterioration of concrete deck slabs on the old steel truss bridges. The underside of Nonthaburi Bridge was the most severely damaged.
- Lots of vessel collision scars on PC box girder bridges.
- Damages of the fenders attached to pier foundation top, caused by vessel collision.

<u>November 01 (Sun), 2009</u>

Off work.

November 02 (Mon), 2009

All day, gathering of survey data and preparation for meeting with DOH next day.

November 03 (Tue), 2009

At 09:00, visit DOH.

Person present: DOH Bridge Construction Bureau Jitpong K., Thongchai W., Dr. Tanasap
JICA Kawano
Survey Team Matsuzawa, Magario, Chujo, Kudo, Poramin

Purpose: Reporting of bridge inspection results and hearing of BMMS for rural bridges.

Discussions:

- Appointment for the meeting next day for the Survey Team to report the bridge survey results especially of Nonthaburi Bridge.
- In reference to the Nonthaburi Bridge, Mr. Kawano JICA indicated that the technical assistance to the bridge would be less likely for the bridge was built by war reparation that was a grant while the scheme of this time bridge inspection by JICA is intended for the bridges built with Japanese government loan.
- Instead, Mr. Kawano expressed interest in the inventory survey and maintenance management for rural bridges.
- DOH personnel explained the current initiatives taken by DOH for the inventory and maintenance of rural bridges. Some 16,000 bridges nationwide are currently under DOH control. In 1985, DOH once developed a bridge inventory system called BMMS (Bridge Maintenance Management System) with assistance from the Danish government. Since then, the system had become obsolete through years, and two years before the Word Bank made a study for updating the system to estimate a cost of 16 million baths. However, the cost has not been approved yet by the government.

Afternoon, preparation for reporting to DOH next day.

November 04 (Wed), 2009

At 10:00, visit DRR.

Person present: DRR Construction Dept. Dr. Kiti M., IRR Bridge Project Officer
Survey Team Chujo, Kudo, Poramin

Purpose: Reporting of IRR Bridge inspection results.

Discussions:

- The Survey Team reported about the cracks of main tower and the damage of expansion joints which the team inspected on the IRR Bridge. The team suggested cracks occurred not only on the inner face but also on the outer face of main tower. Crack-like lines were observed diagonally at the corner of main tower and cross beam, but the team could not confirm whether they were real cracks or not for distant inspection.

- DRR explained such cracks had been known by DRR, saying that the bridge designer, before construction, had predicted such cracks had to occur within a year of traffic opening because of the dogleg shape of main tower. DRR suggested another cause that is the cracks might have occurred when pre-stressing the cross beam.
- The team advised DRR to keep watching the crack width to check it is progressing or dormant. Through discussions about the cracks, the department made an inquiry to the team about the possibility for DRR to request JICA a technical assistance for detailed inspection and analysis of such cracks.
- For the water ponding on the deck in contact with the staying cable anchoring device, the team advised to create a gap between the deck and the anchoring device as a corrosion prevention measure.
- The team also advised DRR to replace the damageable finger joints with another type suitable for long span bridges such as a modular joint (used in Rama VIII Bridge) or a rolling leaf joint (used in Rama IX Bridge).
- The team handed the survey data to DRR.

At 13:30, visit DOH.

Person present:	DOH Bridge Construction Bureau	Dr. Tanasap, Sunan
	DOH Design Bureau	Rajwanlop
	Survey Team	Chujo, Kudo, Poramin

Purpose: Final report of bridge inspection results and advice of rehabilitation.

Discussions:

- Following inspection of the bridge undersides by boat last Saturday, Survey Team reported about Nonthaburi (steel truss in 1959) and Phra Nangklao (PC box girder in 1985) Bridges in detail.
- Taking up the Nonthaburi Bridge, the team explained that the deterioration of the bridge, such as steel corrosion of truss members and deterioration of reinforced concrete deck slabs, has become in alarming stage showing the damage photos taken on the deck and on the underside of the bridge. The team warned the bridge might have entered a dangerous situation and become unusable possibly in five years if leaving it unrepaired. Considering the severity of deterioration of the bridge and taking into account such a geographical location of the bridge as no other bridge available in vicinity when the bridge becomes unusable, the team advised it was time for DOH to take action for planning the new Nonthaburi Bridge and for rehabilitation of the existing Nonthaburi Bridge.
- Answering the team, the DOH personnel stated his intension to request JICA a technical assistance for detailed inspection and rehabilitation design for the Nonthaburi Bridge after reporting the team’s advice to the director general. Furthermore, concerning the problem of Phra Nangklao Bridge i.e. shaking of the cantilever girder and leakage of the water main pipe inside girder, the team suggested the water leakage might be caused by this cantilever shaking. The DOH personnel indicated a willingness to request a JICA technical assistance for detailed inspection of this bridge.
- The team handed the survey data to DOH.

November 05 (Thu), 2009

All day, gathering of survey data.

November 06 (Fri), 2009

Morning, preparation for reporting to DRR afternoon.

At 14:30, visit DRR.

Person present:	DRR Maintenance Dept.	Chawalit T.
	Survey Team	Magario, Chujo, Kudo, Poramin

Purpose: Final report of bridge inspection results.

Discussions:

- The Survey Team made the final report and handed the survey data to DRR. The team again called attention to corrosion of the steel truss members, deterioration on the underside of deck slab of truss bridges and de-centering of the bearing shoes of Taksin Bridge.

November 07 (Sat), 2009

All day, gathering of survey data.

Appendix-8

Bridge Inspection Sheets of Visual Survey

Bridge name	Opening	Authority	Type	定期点検、日常的な補修の継続で対応可能（損傷少ない）	定期点検、日常的な補修の継続で対応可能（損傷有り）	定期点検までに落橋の危険性はないが詳細な点検が望ましい	全面改修が必要	補修履歴	補修計画
01_Patum Tani	1984	DOH	PC-Box	概ね健全である					
02_Patom Tani2	2009	DOH	PC-Box	概ね健全である					
03_Nonthaburi	1959	DOH	Truss				全面的に腐食、ひび割れがある	高欄追加	なし
04_Rama 4	2006	DRR	PC-Box	概ね健全である					
05_New Phra Nangklao	2008	DOH	PC-Box	概ね健全である					
06_Phra Nangklao	1985	DOH	PC-Box		ヒンジの抜け、支承の移動、漏水				
07_Rama 5	2002	DRR	PC-Box	概ね健全である					
08_Rama 7	1992	DRR	PC-Box	概ね健全である					
10_Krung Thon	1958	DRR	Truss			断面減少、ひび割れが多い			来年度全面補修
11_Rama 8	2002	BMA	Cable-stayed	概ね健全である					
12_Pinklao	1973	DRR	PC-Box		伸縮排水の劣化、取付橋ひび割れ				
13_Memorial	1932	DRR	Truss			歩道床版の橋軸ひび割れ、車両衝突、船舶衝突による部材変形		大規模補修	歩道床版打ち替え
14_Phra Pokklao	1984	DRR	PC-Box	概ね健全である					
15_Taksin	1982	DRR	PC-Box		斜めひびわれの可能性				
16_Rama 3	2000	DRR	PC-Box	概ね健全である					
17_Krung Thep	1959	DRR	Truss		中央支間の一部断面減少			塗装が新しい	
18_Rama 9	1987	EXAT	Cable-stayed	大規模点検が行われ補修中				20年点検済	
19_IRR North	2006	DRR	Cable-stayed			塔柱のひび割れの可能性			
20_IRR_South	2006	DRR	Cable-stayed			塔柱のひび割れの可能性			
21_Kanchanapisek	2007	DOH	Cable-stayed						

Bridge name	Completion	Authority	Type	Superstructure				Slab		Pavement	Pier,pylon	Bearing	Expansion joint		Drainage		Barrier	Handrail	Others
				Main girder, chord	Other member	Ship collision	Vehicle collision	Main road	Walkway				Spacing, Structure	Drain	Blocked	Others			
01_Patum Tani	1984	DOH	PC-Box	🟨 lime, crack under medium								🟨 set error of side block, rust		🟨 partly	🟧		🟨 chipped		🟨 difference of grade of longitudinal joint
02_Patom Tani2	2009	DOH	PC-Box	🟨 lime												🟨 lack of catch basin			
03_Nonthaburi	1959	DOH	Truss	🟨 rust	🟧 reduce thickness	🟧	🟧	🟧 breaking exfoliation	🟧 breaking	🟧 breaking	🟨		🟧 fixed	🟧 leakage	🟧	🟨 rust			🟨 Lighting
04_Rama 4	2006	DRR	PC-Box	🟨 lime leakage of rust											🟨 partly				
05_New Phra Nangklao	2008	DOH	PC-Box												🟨 partly				
06_Phra Nangklao	1985	DOH	PC-Box	🟨 lime								🟨 rust, movement		🟧 leakage	🟨 partly		🟨 chipped		🟧 Hinge breaking, leakage of water supply
07_Rama 5	2002	DRR	PC-Box	🟨 lime		🟨 scratch							🟨 extension spacing		🟧 upstream	🟨 lack of catch basin		🟧 stolen	
08_Rama 7	1992	DRR	PC-Box	🟨 lime on approach										🟨 leakage	🟨 partly			🟨 lost bolt	🟨 leakage of water supply, lighting cover
10_Krung Thon	1958	DRR	Truss	🟨 rust	🟧 reduce thickness	🟧	🟨 surface, under girder		🟧 crack exfoliation			🟨 rust soil dump		🟨 leakage		🟧 pipe falling	🟨 chipped		
11_Rama 8	2002	BMA	Cable-stayed							🟨 pot-hole									🟨 leakage from cable
12_Pinklao	1973	DRR	PC-Box	🟨 lime									🟨 corrosion	🟧 leakage	🟧				🟧 leakage from manhole, crack of approach pier
13_Memorial	1932	DRR	Truss	🟨 rust remaining water	🟨 rust remaining water	🟧 1 member lost	🟧	🟨 lime, crack	🟧 lime, crack		🟨 crack under bearing	🟨 rust soil dump	🟨 rust		🟧				🟨 rivet lost
14_Phra Pokklao	1984	DRR	PC-Box	🟨 lime on center bridge		🟨 scratch											🟨 chipped		
15_Taksin	1982	DRR	PC-Box	▨ lime, cold joint or crack				-		🟨 unevenness (small)		🟨 rust, movement		🟨 partly	🟧		🟨 cover disappear		
16_Rama 3	2000	DRR	PC-Box									-	-	-	-	-	-	-	
17_Krung Thep	1959	DRR	Truss	🟨 rust	🟨 reduced thickness at center span			🟨 lime, crack	🟧 crack exfoliation		🟧 crack under bearing (approach)	🟨 rust		🟨 partly		🟨 lack of catch basin			
18_Rama 9	1987	EXAT	Cable-stayed																
20_IRR North	2006	DRR	Cable-stayed	🟨 remaining water					🟨 crack		▨ crack		🟧 noise						🟨 unevenness of vertical alignment
21_IRR_South	2006	DRR	Cable-stayed	-					🟨 crack		▨ crack								
22_Kanchanapisek	2007	DOH	Cable-stayed																

🟨 Slight defect
🟧 Remarkable defect
▨ Difficult to approach and measure the defect. Possibility of remarkable defect

Inspection sheet of visual survey

Bridge No. 1

Photo No. (～)

Bridge name	**Patum Thani Bridge**	Route name	3110, 346	Authority	DOH	Code of authority	-
						No.	-
Place	from Amphue Lat Lun Kaeo	Distance	from km+ 0			Survey date	2009/10/28
	to Amphoe Mueang Pathum Thani		to km+ 0				

Bridge properties	
Bridge type(1)	[✓ main road] · side road · ramp
Bridge type(2)	[✓ bridge] · viaduct · plank pass
Bridge type(3)	4-span continuous PC box girder
Total length	240.00 (m)
Span	47 + 73 + 73 + 47 (m)
Nos. of span	4 span
Width	32.21 (m) ／ 10.6-original (m)
Completion	1984 original, 2006 additional

Road information	
Horizontal	[✓ Straight] · incli(θ = 1.5 °) · Curve (R m)
Gradient	One way (↗ · ↘) [✓ parabol] ([✓ 凸] · 凹)
Nearby tunnel	yes · [✓ no] (m)
Nearby crossing	yes · [✓ no] (m)
Traffic	Much · [✓ Medium] · Little
Commercial traffic	Much · [✓ Medium] · Little

Environment			
1.Urban	[✓ 2.Suburbs]	3.Mountain	4.Seaside
5.Industrial	6.Harbor	7.Residential	8.Bussiness
9.Salty	10.Cold and snow	11.Heavy snow	12.Others

Under bridge			
1.Shinkansen	2.Railway	3.Highway	4.Road
[✓ 5.River]	6.Lake	7.Ravine	8.Valley
9.Waterway	10.Parking	11.Bike parking	12.Park
13.Vacant	14.Harbor	Name (Chao Phraya)	

Access method	
Superstructure	[✓ 1.Inspection car] 2.Falsework 3.On ground 4.Ladder 5.Lift car 6.On boat 7.Special camera 8.Others( )
Substructure	[✓ 1.Inspection car] 2.Falsework 3.On ground 4.Ladder 5.Lift car [✓ 6.On boat] 7.Special camera 8.Others( )
Reason	• All bridge section is on the water • If inspection car is not available, false work will be required

Survey result		
Camber deform		yes · [✓ no]
Difference in glade		yes · [✓ no]
Continuous of barrier		[✓ yes] · no
Continuous of curve		[✓ yes] · no
Noise		yes · [✓ no]
Joint	Space change	yes · [✓ no]
Joint	difference grade	yes · [✓ no]
Joint	draining damage	yes · [✓ no]
Blocked drainage		[✓ yes] · no
Crack of pavement		yes · [✓ no]
Damage of lighting		yes · [✓ no]
Damage of sign		—
Damage of handrail		yes · [✓ no]
Possibility of scour		[✓ yes] · no

Inspection way

Walkway yes · [✓ no]

Vehicle yes · [✓ no]

Height of girder about 10m

Diagnosis

◆ Deterioration of bridge ◆

deficient · fair · [✓ good]

◆ Noticeable point ◆

- Fracture of slab under gap
- Difference of grade of Longitudinal joint

Outline of damage		
Item	Type	State
Main girder	PC-Box	Leakage from gap between girder
Cross beam	-	-
Stringer	-	-
Cross frame	-	-
Lateral brace	-	-
Slab		free lime, leakage
Abutment	Rectangular	-
Pier	plate, rectangula	-
Bearing	Slide bearing	Spacing is seen in side block
Barrier	Trapezoidal	Generally healthy
Railing	Steel	Generally healthy
Curb	-	-
Pavement	[✓ asphalt] · concrete	Generally healthy
Joint	drained · [✓ undrained]	leakage at end
Drainage	[✓ yes] · no	Blocked

Impressions

- Fracture of slab concrete is seen under longitudinal joint by leakage
- Difference of grade (less than 10mm?) is appeared

History of repair ;	• Additional 2-box girder was opened at 2006. Repaint ; — yy — mm
Surveyor ;	Mr,Chujo, Mr.Kudo

Present state （1 / 6）

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Patum Tani bridge				

Picture No.	1
Span	1
Member	Side view

Picture No.	2
Span	2
Member	View on road

Picture No.	3
Span	1
Member	View under bridge

Left; original bridge
Right; additional bridge

Present state (2 / 6)

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Patum Tani bridge				

Picture No.	4
Span	1
Member	Longitudinal joint

Longitudinal joint between girder

Leakage from joint

Picture No.	5
Span	1
Member	Longitudinal joint

Longitudinal joint between girder

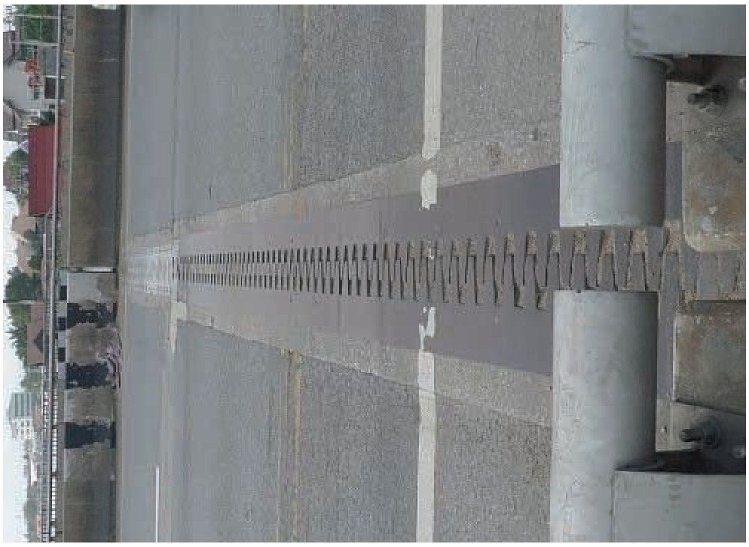
Exfoliation of concrete

Picture No.	6
Span	1
Member	Approach bridge

Limit of vehicle heignt, 3.5m

Present state （ 3 / 6 ）

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Patum Tani bridge				



Picture No.	7
Span	1
Member	Side barror

コンクリートの剥離

Picture No.	8
Span	1
Member	Expansion joint

Leakage

Picture No.	9
Span	1
Member	Longitudinal joint

Difference of grade

Present state （4 / 6）

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Patum Tani bridge				

Picture No.	10
Span	1
Member	Bearing

Deterioration of corrosion proofi

Picture No.	11
Span	1
Member	bearing

Spacing of side block

**Survey on board, 31-oct*

Picture No.	12
Span	1
Member	Bearing

Additional bridge, no movement

Present state （5 / 6）

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Patum Tani bridge				

Picture No.	7
Span	1
Member	manhole

About 5m.

Picture No.	8
Span	1
Member	Catch basin

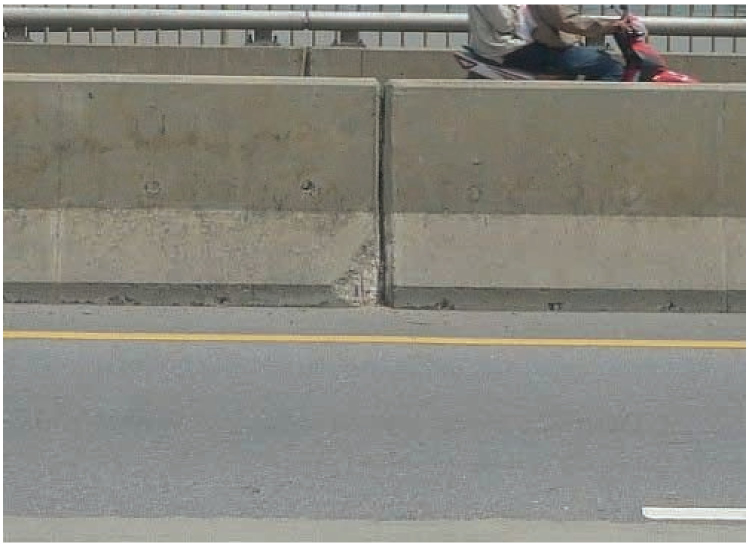
Blocking of catch basin

Picture No.	9
Span	1
Member	Walkway

Obstacle of bicycle

Present state (6 / 6)

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Patum Tani bridge				



Picture No.	10
Span	1
Member	Barrier

Chipping of barrier

Picture No.	11
Span	1
Member	Footing

Ship collision to protection

Picture No.	12
Span	1
Member	

Inspection sheet of visual survey

Bridge No. 2

Photo No. (～)

Bridge name	**Patom Thani 2 Bridge**	Route name	345	Authority	DOH	Code of authority	-
						No.	-
Place from	Amphue Lat Lun Kaeo	Distance from	km+ 0			Survey date	2009/10/28
Place to	Amphoe Mueang Pathum Thani	Distance to	km+ 0				

Bridge properties

Bridge type(1)	[✓ main road] • side road • ramp
Bridge type(2)	[✓ bridge] • viaduct • plank pass
Bridge type(3)	3-span continuous PC box girder
Total length	778.10 (m)
Span	(180) + 129.05 + 160 + 129.05 + (180) (m)
Nos. of span	3 span
Width	27.90 (m) ／ (m)
Completion	2009

Road information

Horizontal	[✓ Straight] • incli(θ = °) • Curve (R m)
Gradient	One way (↗ • ↘) [✓ parabol] ([✓ 凸] • 凹)
Nearby tunnel	yes • [✓ no] (m)
Nearby crossing	yes • [✓ no] (m)
Traffic	Much • Medium • [✓ Little]
Commercial traffic	Much • [✓ Medium] • Little

Environment

1.Urban [✓ 2.Suburbs] 3.Mountain 4.Seaside
5.Industrial 6.Harbor 7.Residential 8.Bussiness
9.Salty 10.Cold and snow 11.Heavy snow 12.Others

Under bridge

1.Shinkanser 2.Railway 3.Highway 4.Road
[✓ 5.River] 6.Lake 7.Ravine 8.Valley
9.Waterway 10.Parking 11.Bike parkin 12.Park
13.Vacant 14.Harbor Name (Chao Phraya)

Access method

Superstructure	[✓ 1.Inspection car] 2.Falsework 3.On ground 4.Ladder 5.Lift car 6.On boat 7.Special camera 8.Others( )
Substructure	[✓ 1.Inspection car] 2.Falsework 3.On ground 4.Ladder 5.Lift car [✓ 6.On boat] 7.Special camera 8.Others( )
Reason	• All bridge section is on the water • If inspection car is not available, false work will be required

Survey result

Camber deform	yes • [✓ no]
Difference in glade	yes • [✓ no]
Continuous of barrie	[✓ yes] • no
Continuous of curve	[✓ yes] • no
Noise	yes • [✓ no]
Joint: Space change	yes • [✓ no]
Joint: difference grade	yes • [✓ no]
Joint: draining damage	yes • [✓ no]
Blocked drainage	yes • [✓ no]
Crack of pavement	yes • [✓ no]
Damage of lighting	yes • [✓ no]
Damage of sign	—
Damage of handrail	yes • [✓ no]
Possibility of scour	[✓ yes] • no

Inspection way

Walkway yes • [✓ no]
Vehicle yes • [✓ no]

Height of girde about7.8m

Diagnosis

◆ Deterioration of bridge ◆
deficient • fair • [✓ good]

◆ Noticeable point ◆

Outline of damage

Item	Type	State
Main girder	PC-Box	Free lime from construction hole
Cross beam	-	-
Stringer	-	-
Cross frame	-	-
Lateral brace	-	-
Slab		Free lime from construction hole
Abutment	Rectangular	-
Pier	-	Girder directry connect to footing
Bearing	Slide bearing	Generally healthy
Barrier	Trapezoidal	Generally healthy
Railing	Steel	Generally healthy
Curb	-	-
Pavement	[✓ asphalt] • concrete	Generally healthy
Joint	drained • [✓ undrained]	Generally healthy
Drainage	[✓ yes] • no	Without catch basin

Impressions

• New bridge and generally healthy

History of repair ;	Repaint ; — yy — mm
Surveyor ;	Mr,Chujo, Mr.Kudo

Present state （ 1 / 2 ）

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Patum Tani 2 bridge				

Picture No.	1
Span	1
Member	Side view

Picture No.	2
Span	2
Member	View on road

Picture No.	3
Span	1
Member	View under bridge

Present state （ 2 / 2 ）

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Patum Tani 2 bridge				

Picture No.	4
Span	1
Member	Bearing

Picture No.	5
Span	1
Member	Longitudinal joint

Lime from construction hole

Picture No.	6
Span	1
Member	Drainage

Without catch basin

Inspection sheet of visual survey

Bridge No. 3

Photo No. (～)

Bridge name	**Nonthaburi Bridge**	Route name	307	uthority	DOH	ode of authority	-
						No.	-
Place	from Phathum Thani	Distance from	km+ 0			Survey date	2009/10/28
	to Nonthaburi	to	km+ 0				

Bridge properties

Bridge type(1)	[✓ main road] · side road · ramp
Bridge type(2)	[✓ bridge] · viaduct · plank pass
Bridge type(3)	4-span steel truss
Total length	260.00 (m)
Span	65+65+65+65 (m)
Nos. of span	4 span
Width	about 13 (m) ／ (m)
Completion	1959

Road information

Horizontal	[✓ Straight] · incli(θ = °) · Curve (R m)
Gradient	One way (↗ · ↘) [✓ parabol] ([✓ 凸] · 凹)
Nearby tunnel	yes · [✓ no] (m)
Nearby crossing	yes · [✓ no] (m)
Traffic	Much · [✓ Mediun] · Little
Commercial traffi	Much · Mediun · [✓ Little]

Environ

1.Urban [✓ 2.Suburbs] 3.Mountain 4.Seaside
5.Industrial 6.Harbor 7.Residential 8.Bussiness
9.Salty 10.Cold and snow 11.Heavy snow 12.Others

Under brid

1.Shinkanser 2.Railway 3.Highway 4.Road
[✓ 5.River] 6.Lake 7.Ravine 8.Valley
9.Waterway 10.Parking 11.Bike parkin 12.Park
13.Vacant 14.Harbor Name (Chao Phraya)

Access method

Superstructure	[✓ 1.Inspection car] 2.Falsework 3.On ground 4.Ladder 5.Lift car 6.On boat 7.Special camera 8.Others( )
Substructure	[✓ 1.Inspection car] 2.Falsework 3.On ground 4.Ladder 5.Lift car [✓ 6.On boat] 7.Special camera 8.Others( )
Reason	• All bridge section is on the water • If inspection car is not available, false work will be required

Survey result

Camber deform	yes · [✓ no]
Difference in glade	yes · [✓ no]
ontinuous of barrie	[✓ yes] · no
Continuous of curve	[✓ yes] · no
Noise	yes · [✓ no]
Joint: Space change	yes · [✓ no]
Joint: difference grade	yes · [✓ no]
Joint: draining damage	[✓ yes] · no
Blocked drainage	[✓ yes] · no
Crack of pavement	[✓ yes] · no
Damage of lighting	[✓ yes] · no
Damage of sign	—
Damage of handrail	yes · [✓ no]
Possibility of scour	[✓ yes] · no

Inspection way

Walkway yes · [✓ no]

Vehicle yes · [✓ no]

Height of girde about 7m

Diagnosis

◆ Deterioration of bridge ◆

[✓ deficien] · fair · good

◆ Noticeable point ◆

- Corrosion of vertical membe
- Breaking of slab

Outline of damage

Item	Type	State
Main girder	Truss	Corrosion, Deterioration of proofing, deformation
Cross beam	I section steel	leakage
Stringer	I section steel	leakage
Cross frame	T section steel	-
Lateral brace	—	-
Slab		breaking, free lime, leakage
Abutment	Oval	-
Pier	Oval	-
Bearing	Pin bearing	Generally healthy
Barrier	Trapezoidal	Generally healthy
Railing	Steel	Generally healthy
Curb	-	-
Pavement	[✓ asphalt] · concrete	Breaking on cross beam
Joint	drained · [✓ ndrained]	Joint was filled by asphalt, leakage
Drainage	[✓ yes] · no	Under barrier. Deterioration of drain function.

Impressions

- Sever leakage was found on cross beam from broken slab
- Remarkable reduction of steel thickness and opening of vertical member
- Vertical and inclined member was deformed by collision

istory of repair ;	• Setting of barrier to protect vehicle collision to vertical member Repaint ; — yy — mm
Surveyor ;	Mr,Chujo, Mr.Kudo

Present state （1 / 19）

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Nonthaburi bridge				

Picture No.	1
Span	1
Member	Side view

**Survey on board, 31-oct*

Picture No.	2
Span	2
Member	View on road

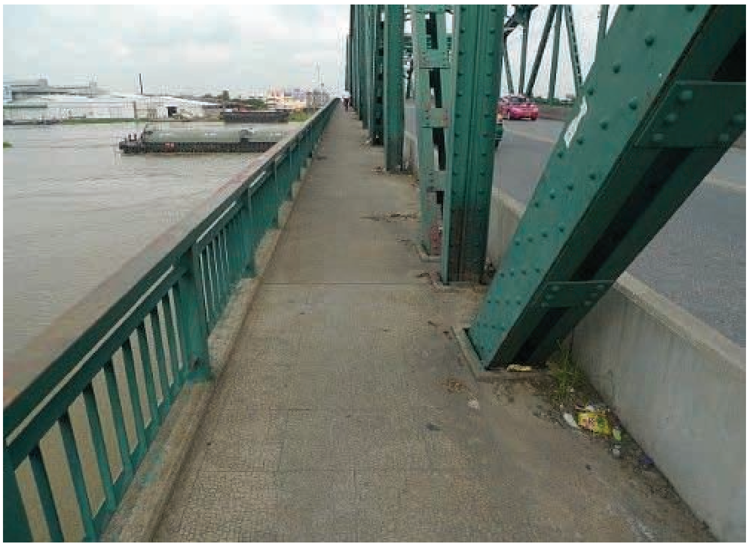
Picture No.	3
Span	1
Member	View under bridge

Present state （ 2 / 19）

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Nonthaburi bridge				

Picture No.	4
Span	1
Member	Side view of a span

**Survey on board, 31-oct*



Picture No.	5
Span	1
Member	Walkway

Picture No.	6
Span	1
Member	Expansion joint

Expansion joint was filled by asphalt

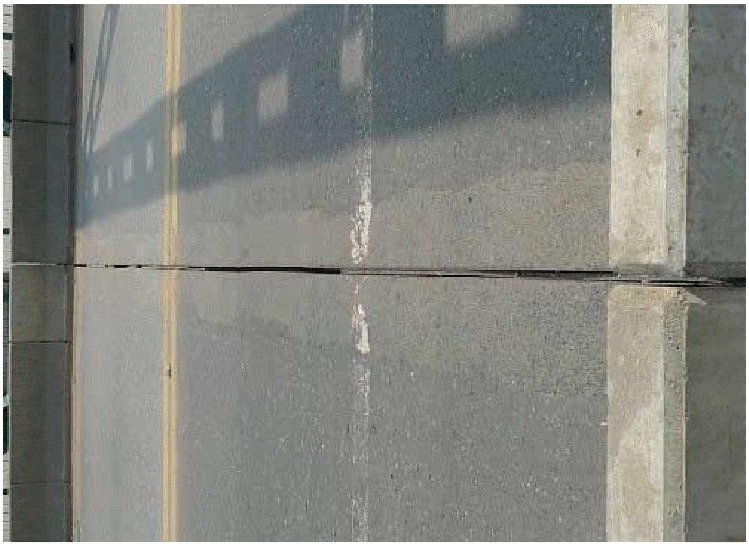
Bangkok side

Present state （３／19）

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Nonthaburi bridge				

Picture No.	7
Span	1
Member	Expansion joint

Leakage from expansion joint



Picture No.	8
Span	1
Member	Expansion joint

Thon Buri side

Picture No.	9
Span	1
Member	

Lack of rubber at end

Thon Buri side

Present state （4 / 19）

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Nonthaburi bridge				

Picture No.	10
Span	1
Member	Water supply

Water supply was removed

Limit of vehicle height, 3.0m

Picture No.	11
Span	1
Member	Newel

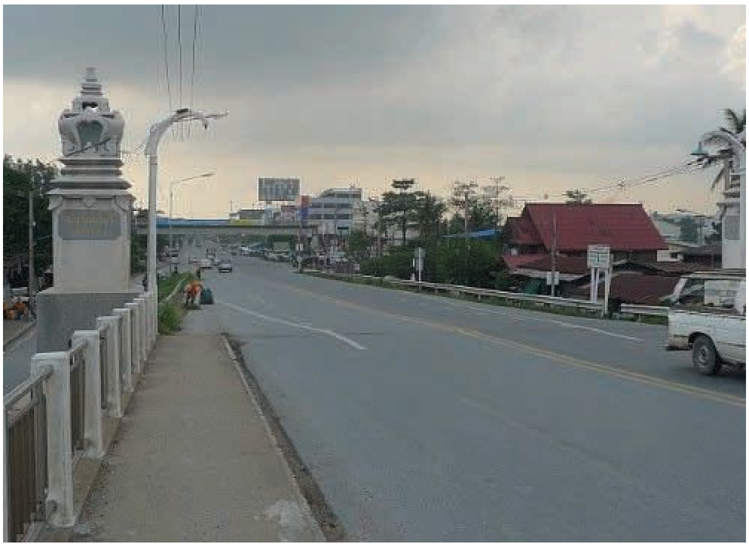
Picture No.	12
Span	1
Member	Newel

Opening of door

Erosion of abutment

Present state (5 / 19)

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Nonthaburi bridge				



Picture No.	7
Span	1
Member	Approach road

Approach road is 4 lane
Main bridge is 2 lane

Approach road of Thon Buri side i
under widening.

Picture No.	8
Span	1
Member	Bearing

Structure around bearing

Picture No.	9
Span	1
Member	Approach bridge

Corrosion on bearing

Deterioration of corrosion proofi

Present state （6/19）

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Nonthaburi bridge				

Picture No.	10
Span	1
Member	Bearing

Expansion of steel by corrosion

Deterioration of corrosion proofi

Picture No.	11
Span	1
Member	Bearing

Inclination of locker bearing
of Approach bridge

Picture No.	12
Span	1
Member	Vertical member

Gap between steel and slab
Mount up around steel member

It's good countermeasure for
corrosion proofing by water

Present state （7 / 19）

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Nonthaburi bridge				

Picture No.	13
Span	1
Member	Vertical member

Remarkable reducing of thickness of plate

Opening at bottom end

Picture No.	14
Span	1
Member	Vertical member

Enlarged photo

Opening at bottom end

Picture No.	15
Span	1
Member	Vertical member

Remarkable reducing of thickness of plate

Hole position is higher than contact section with concrete

Present state (8 / 19)

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Nonthaburi bridge				

Picture No.	16
Span	1
Member	Bearing

Remarkable reducing of thickness of plate

Picture No.	17
Span	1
Member	Vertical member

Proceeding of corrosion is differ between each member

Picture No.	18
Span	1
Member	Vertical member

Deformation by vehicle collision

Present state (9 / 19)

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Nonthaburi bridge				

Picture No.	13
Span	1
Member	Vertical member

Deformation by vehicle collision

Picture No.	14
Span	1
Member	Vertical member

Deformation by vehicle collision

Picture No.	15
Span	1
Member	Vertical member

Deformation by vehicle collision

Present state （10 / 19）

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Nonthaburi bridge				

Picture No.	16
Span	1
Member	Vertical member

Deformation by vehicle collision

Mark of reinforcement

Picture No.	17
Span	1
Member	Chord member

Deformation by vehicle collision

Picture No.	18
Span	1
Member	Vertical member

Deformation by vehicle collision

Present state （11 / 19）

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Nonthaburi bridge				

Picture No.	19
Span	1
Member	Vertical member

Deformation by vehicle collision

Picture No.	20
Span	1
Member	Bracket

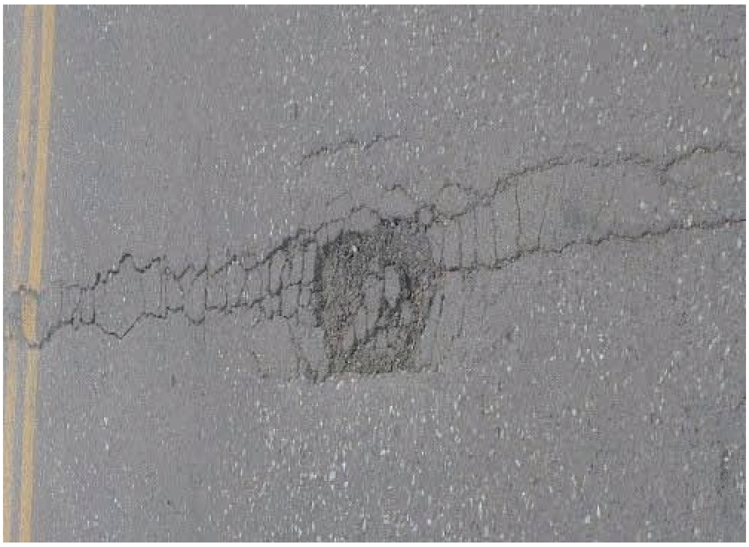
Deformation by vehicle collision

Picture No.	21
Span	1
Member	Pavement

Breaking of pavement on cross bea

Present state （12 / 19）

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Nonthaburi bridge				



Picture No.	22
Span	1
Member	Pavement

Breaking of pavement on cross bea

Severe leakage is found on
bottom slab.
It is estimated that this breakin
go through slab.

Picture No.	23
Span	1
Member	Pavement

Breaking of pavement on cross bea

Picture No.	24
Span	1
Member	Drainage

Catch basin may exist under barri

Deterioration of drain function

Present state (15 / 19)

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Nonthaburi bridge				

Picture No.	25
Span	1
Member	Drainage

Drainage under barrier

Picture No.	26
Span	1
Member	slab

Crack

Free lime

Picture No.	27
Span	1
Member	Slab

Deterioration of corrosion proofi

Fracture of concrete surface

Free lime

Present state （16 / 19）

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Nonthaburi bridge				

Picture No.	28
Span	1
Member	Slab

Leakage from slab on cross beam

Picture No.	29
Span	1
Member	Slab

Leakage from slab on cross beam

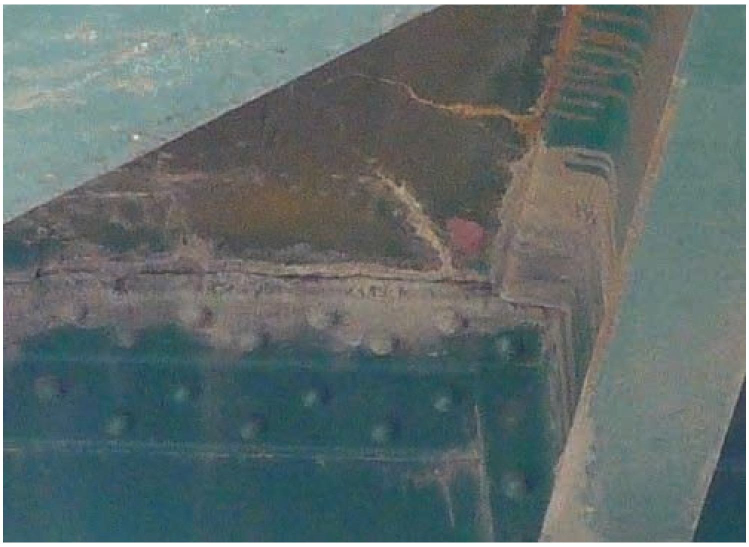
Picture No.	30
Span	1
Member	slab

Crack

Free lime

Present state （17 / 19）

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Nonthaburi bridge				



Picture No.	31
Span	1
Member	Slab

Leakage from slab on cross beam

Crack, free lime

Concrete slab was changed to dirt

**Survey on board, 31-oct*

Picture No.	32
Span	1
Member	slab

Plant

Possibility of soil dump

Picture No.	33
Span	1
Member	Slab

Reduce of thickness by corrosion

**Survey on board, 31-oct*

Present state （18 / 19）

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Nonthaburi bridge				

Picture No.	34
Span	1
Member	Approach bridge

コンクリートの剥離と補修

Picture No.	35
Span	1
Member	Chord member

防蝕性能の劣化

Picture No.	36
Span	1
Member	Lighting pole

破損

Present state （17/19）

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Nonthaburi bridge				

Picture No.	37
Span	1
Member	Substructure

**Survey on board, 31-oct*

Picture No.	38
Span	1
Member	Transverse bean

Corrosion and fall of rivet

**Survey on board, 31-oct*

Picture No.	39
Span	1
Member	Cross frame

Deformation by ship collision

2nd span from Bangkok side

**Survey on board, 31-oct*

Present state （18 / 19）

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Nonthaburi bridge				

Picture No.	40
Span	1
Member	Bottom chord

Deformation by ship collision

**Survey on board, 31-oct*

Picture No.	41
Span	1
Member	Bottom chord

Deformation by ship collision

**Survey on board, 31-oct*

Picture No.	42
Span	1
Member	Bottom chord

Deformation by ship collision

**Survey on board, 31-oct*

Present state （19 / 19）

Authority	DOH	Address	Bangkok	Data	28-Oct-09
Bridge	Nonthaburi bridge				

Picture No.	43
Span	1
Member	Slab

Fracture of concrete surface
Rock pocket

Crack

**Survey on board, 31-oct*

Picture No.	44
Span	1
Member	

**Survey on board, 31-oct*

Picture No.	45
Span	1
Member	

Inspection sheet of visual survey

Bridge No. 4

Photo No. (～)

Bridge name	RAMA IV Bridge	Route name	-	Authority	DRR	Code of authority	-
						No.	-
Place	from Anphoe Bang Bua Thong	Distance	from km+ 0			Survey date	2009/10/20
	to Anphoe Pak Kret		to km+ 0				

Bridge properties

Bridge type(1)	[✓ main road] • side road • ramp
Bridge type(2)	[✓ bridge] • viaduct • plank pass
Bridge type(3)	3-span continuous PC box girder
Total length	278.00 (m)
Span	72 + 134 + 72 (m)
Nos. of span	3 span
Width	13.65 x 2 (m) ／ (m)
Completion	2006

Road information

Horizontal	[✓ Straight] • incli(θ = °) • Curve (R m)
Gradient	One way (↗ • ↘) [✓ parabol] ([✓ 凸] • 凹)
Nearby tunnel	yes • [✓ no] (m)
Nearby crossing	yes • [✓ no] (m)
Traffic	Much • [✓ Medium] • Little
Commercial traffic	Much • [✓ Medium] • Little

Environment

[✓ 1.Urban]	2.Suburbs	3.Mountain	4.Seaside
5.Industrial	6.Harbor	7.Residential	8.Bussiness
9.Salty	10.Cold and snow	11.Heavy snow	12.Others

Under bridge

1.Shinkanser	2.Railway	3.Highway	4.Road
[✓ 5.River]	6.Lake	7.Ravine	8.Valley
9.Waterway	10.Parking	11.Bike parkin	12.Park
13.Vacant	14.Harbor	Name (Chao Phraya)	

Access method

Superstructure	[✓ 1.Inspection car] 2.Falsework 3.On ground 4.Ladder 5.Lift car 6.On boat 7.Special camera 8.Others( )
Substructure	[✓ 1.Inspection car] 2.Falsework 3.On ground 4.Ladder 5.Lift car [✓ 6.On boat] 7.Special camera 8.Others( )
Reason	• All bridge section is on the water • If inspection car is not available, false work will be required

Survey result

Camber deform	yes • [✓ no]
Difference in glade	yes • [✓ no]
Continuous of barrie	[✓ yes] • no
Continuous of curve	[✓ yes] • no
Noise	yes • [✓ no]
Joint: Space change	yes • [✓ no]
Joint: difference grade	yes • [✓ no]
Joint: draining damage	yes • [✓ no]
Blocked drainage	[✓ yes] • no
Crack of pavement	yes • [✓ no]
Damage of lighting	yes • [✓ no]
Damage of sign	—
Damage of handrail	yes • [✓ no]
Possibility of scour	[✓ yes] • no

Inspection way

Walkway [✓ yes] • no (water supply

Vehicle yes • [✓ no]

Height of girde about 5.6m

Diagnosis

◆ Deterioration of bridge ◆

deficient • fair • [✓ good]

◆ Noticeable point ◆

Generaly healthy

Outline of damage

Item	Type	State
Main girder	PC-Box	Free lime and rust from web
Cross beam	-	-
Stringer	-	-
Cross frame	-	-
Lateral brace	-	-
Slab	-	-
Abutment	-	-
Pier	Rectangular	Generally healthy
Bearing	Slide bearing	-
Barrier	Trapezoidal	Generally healthy
Railing	Steel	Generally healthy
Curb	-	-
Pavement	[✓ asphalt] • concrete	Generally healthy
Joint	drained [✓ undrained]	Generally healthy
Drainage	[✓ yes] • no	Partly blocked

Impressions

History of repair ; Repaint ; — yy — mm

Surveyor ; Mr,Chujo, Mr.Kudo

Present state （ 1 / 5 ）

Road		Address	Bangkok	Data	20-Oct-09
Bridge	RAMA IV				

Picture No.	1
Span	1
Member	View under girder

**Survey on board, 31-oct*

Picture No.	2
Span	1
Member	View on ground

Picture No.	3
Span	1
Member	Side view

**Survey on board, 31-oct*

Present state （2 / 5）

Road		Address	Bangkok	Data	20-Oct-09
Bridge	RAMA IV				

Picture No.	4
Span	1
Member	Name plate

Picture No.	5
Span	1
Member	Box-girder

Insufficiency of cover concrete

Repairing work was finished

Picture No.	6
Span	1
Member	Expansion joint

Present state （3 / 5）

Road		Address	Bangkok	Data	20-Oct-09
Bridge	RAMA IV				

Picture No.	7
Span	1
Member	桁下全景

water supply

No expanded metal plate.
It's not suitable for inspection.

Picture No.	8
Span	1
Member	slab (walkway, roadway

Ooze out of rust

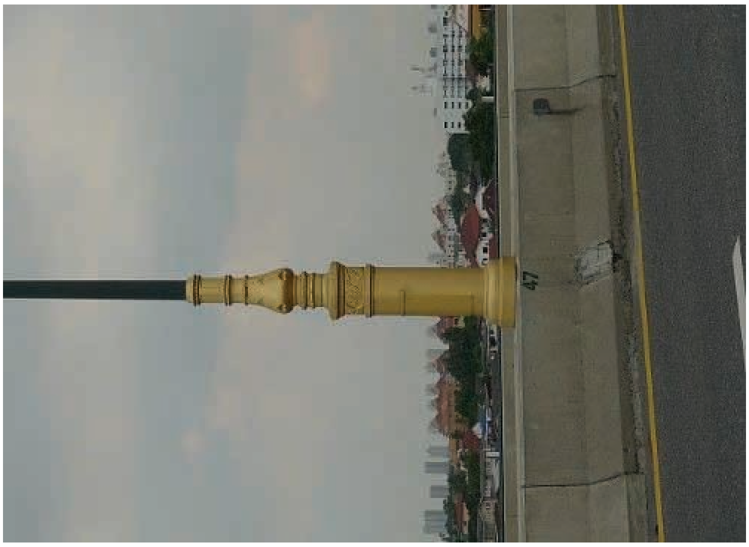
**Survey on board, 31-oct*

Picture No.	9
Span	1
Member	Bearing

Drainage function of joint is
good.

Present state （4 / 5）

Road		Address	Bangkok	Data	20-Oct-09
Bridge	RAMA IV				



Picture No.	10
Span	1
Member	Lighting pole

Mark of filling concrete at bottom of lighting pole

Possibility of fracturing in future

Picture No.	11
Span	1
Member	Catch basin

Partly blocked

Picture No.	12
Span	1
Member	View of walkway

Present state (5 / 5)

Road		Address	Bangkok	Data	20-Oct-09
Bridge	Rama IV				

Picture No.	13
Span	1
Member	Barrior

Crack.

Repariring material with permeability?

Picture No.	14
Span	1
Member	

Chipped concrete around drainage

**Survey on board, 31-oct*

Picture No.	15
Span	1
Member	Substructure

**Survey on board, 31-oct*

Inspection sheet of visual survey

Bridge No. 5

Photo No. (～)

Bridge name	New Phra Nangklao Bridge	Route name	-	Authority	DOH	Code of authority	-
						No.	-
Place	from Anphoe Bang Bua Thong	Distance	from km+ 0			Survey date	2009/10/24
	to Anphoe mueang Nonthaburi		to km+ 0				

Bridge properties

Bridge type(1)	[✓ main road] • side road • ramp
Bridge type(2)	[✓ bridge] • viaduct • plank pass
Bridge type(3)	5-span continuous PC box girder
Total length	329.10 (m)
Span	50.55 + 72 + 84 + 72 + 50.55 (m)
Nos. of span	5 span
Width	10.9 x 2 (m) ／ (m)
Completion	2008

Road information

Horizontal	[✓ Straight] • incli(θ = °) • Curve (R m)
Gradient	One way (↗ • ↘) [✓ parabol] ([✓ 凸] • 凹)
Nearby tunnel	yes • [✓ no] (m)
Nearby crossing	yes • [✓ no] (m)
Traffic	Much • [✓ Medium] • Little
Commercial traffic	Much • [✓ Medium] • Little

Environment

[✓ 1.Urban]	2.Suburbs	3.Mountain	4.Seaside
5.Industrial	6.Harbor	7.Residential	8.Bussiness
9.Salty	10.Cold and snow	11.Heavy snow	12.Others

Under bridge

1.Shinkansen	2.Railway	3.Highway	4.Road
[✓ 5.River]	6.Lake	7.Ravine	8.Valley
9.Waterway	10.Parking	11.Bike parkin	12.Park
13.Vacant	14.Harbor	Name (Chao Phraya)	

Access method

Superstructure	[✓ 1.Inspection car] 2.Falsework 3.On ground 4.Ladder 5.Lift car 6.On boat 7.Special camera 8.Others( )
Substructure	1.Inspection car 2.Falsework [✓ 3.On ground] 4.Ladder 5.Lift car [✓ 6.On boat] 7.Special camera 8.Others( )
Reason	• All bridge section is on the water • If inspection car is not available, false work will be required

Survey result

	Camber deform	yes • [✓ no]
	Difference in glade	yes • [✓ no]
	Continuous of barrie	[✓ yes] • no
	Continuous of curve	[✓ yes] • no
	Noise	yes • [✓ no]
Joint	Space change	yes • [✓ no]
Joint	difference grade	yes • [✓ no]
Joint	draining damage	yes • [✓ no]
	Blocked drainage	yes • [✓ no]
	Crack of pavement	yes • [✓ no]
	Damage of lighting	yes • [✓ no]
	Damage of sign	―
	Damage of handrail	yes • [✓ no]
	Possibility of scour	[✓ yes] • no

Inspection way

Walkway yes • [✓ no]

Vehicle yes • [✓ no]

Height of girde about 10m

Diagnosis

◆ Deterioration of bridge ◆

deficient • fair • [✓ good]

◆ Noticeable point ◆

Generally healthy

Outline of damage

Item	Type	State
Main girder	PC-Box	Generally healthy
Cross beam	-	-
Stringer	-	-
Cross frame	-	-
Lateral brace	-	-
Slab		Generally healthy
Abutment	-	-
Pier	2plate, oval	-
Bearing	Slide bearing	-
Barrier	Trapezoidal	Generally healthy
Railing	Steel	Generally healthy
Curb	-	-
Pavement	[✓ asphalt] • concrete	Generally healthy
Joint	drained [✓ undrained]	-
Drainage	[✓ yes] • no	Partly blocked

Impressions

History of repair ;	Repaint ; ― by ― mm
Surveyor ;	Mr,Chujo, Mr.Kudo

Present state （１／３）

Authority	DOH	Address	Bangkok	Data	24-Oct-09
Bridge	New Phra Nangklao Bridge				

Picture No.	1
Span	1
Member	Side view

Picture No.	2
Span	1
Member	View on road

Picture No.	3
Span	1
Member	View under girder

Present state (2 / 3)

Authority	DOH	Address	Bangkok	Data	24-Oct-09
Bridge	New Phra Nangklao Bridge				

Picture No.	4
Span	1
Member	Pier

Pier height is low
The structure may occure large
moment after shirinkage, creep
and temperature.

Continuous careful checking is
required.

Picture No.	5
Span	1
Member	Drainage

Parts for water sprinkling
Garbage

Picture No.	6
Span	1
Member	Drainage

Present state (3 / 3)

Authority	DOH	Address	Bangkok	Data	24-Oct-09
Bridge	New Phra Nangklao Bridge				

Picture No.	7
Span	1
Member	Drainage

Partly blocked

Picture No.	8
Span	1
Member	

Picture No.	9
Span	1
Member	

Thon Buri side

Inspection sheet of visual survey

Bridge No. 6

Photo No. (～)

Bridge name	Pra Nangklao Bridge	Route name	-	Authority	DOH	Code of authority	-
						No.	-
Place	from Anphoe Bang Bua Thong	Distance	from km+ 0			Survey date	24-oct-2009
	to Anphoe mueang Nonthaburi		to km+ 0				

Bridge properties

Bridge type(1)	[✓ main road] · side road · ramp
Bridge type(2)	[✓ bridge] · viaduct · plank pass
Bridge type(3)	5-span continuous PC box girder
Total length	330.00 (m)
Span	51 + 72 + 84 + 72 + 51 (m)
Nos. of span	5 span
Width	21.80 (m) ／ (m)
Completion	1985

Road information

Horizontal	[✓ Straight] · incli (θ = 1.5 °) · Curve (R m)
Gradient	One way (↗ · ↘) [✓ parabol] ([✓ 凸] · 凹)
Nearby tunnel	yes · [✓ no] (m)
Nearby crossing	yes · [✓ no] (m)
Traffic	Much · [✓ Medium] · Little
Commercial traffi	Much · Medium · [✓ Little]

Environm

[✓ 1.Urban]	2.Suburbs	3.Mountain	4.Seaside
5.Industrial	6.Harbor	7.Residential	8.Bussiness
9.Salty	10.Cold and snow	11.Heavy snow	12.Others

Under brid

1.Shinkansen	2.Railway	3.Highway	4.Road
[✓ 5.River]	6.Lake	7.Ravine	8.Valley
9.Waterway	10.Parking	11.Bike parkin	12.Park
13.Vacant	14.Harbor	Name (Chao Phraya)	

Access method

Superstructure	[✓ 1.Inspection car] 2.Falsework 3.On ground 4.Ladder 5.Lift car 6.On boat 7.Special camera 8.Others( )
Substructure	[✓ 1.Inspection car] 2.Falsework 3.On ground 4.Ladder 5.Lift car [✓ 6.On boat] 7.Special camera 8.Others( )
Reason	・All bridge section is on the water ・If inspection car is not available, false work will be required

Survey result

Camber deform		yes · [✓ no]
Difference in glade		yes · [✓ no]
Continuous of barrie		[✓ yes] · no
Continuous of curve		[✓ yes] · no
Noise		yes · [✓ no]
Joint	Space change	[✓ yes] · no
	difference grade	yes · [✓ no]
	draining damage	[✓ yes] · no
Blocked drainage		[✓ yes] · no
Crack of pavement		yes · [✓ no]
Damage of lighting		[✓ yes] · no
Damage of sign		—
Damage of handrail		yes · [✓ no]
Possibility of scour		[✓ yes] · no

Inspection way

Walkway yes · [✓ no]

Vehicle yes · [✓ no]

Height of girde about 10m

Diagnosis

◆ Deterioration of bridge ◆

deficient · [✓ fair] · good

◆ Noticeable point ◆

- Hinge is removed
- Leakage from water supply

Outline of damage

Item	Type	State
Main girder	PC-Box	Much water is flowed inside of box by leakage of water supp
Cross beam	-	-
Stringer	-	-
Cross frame	-	-
Lateral brace	-	-
Slab		leakage from medium
Abutment	Rectangular	-
Pier	!plate, rectangula	-
Bearing	Slide bearing	move to center (not critical)
Barrier	Trapezoidal	Generally healthy
Railing	Steel	Generally healthy
Curb	-	-
Pavement	[✓ asphalt] · concrete	Generally healthy
Joint	drained · [✓ undrained]	leakage
Drainage	[✓ yes] · no	Partly blocked

Impressions

- Vertical movement is occurred independently at hinge of center
- Free lime from construction joint
- Breaking of ship protection

History of repair ;	Repaint ; — yy — mm
Surveyor ;	Mr,Chujo, Mr.Kudo

Present state （1 / 10）

Authority	DOH	Address	Bangkok	Data	24-Oct-09
Bridge	Phra NangKlao Bridge				

Picture No.	1
Span	1
Member	Side view

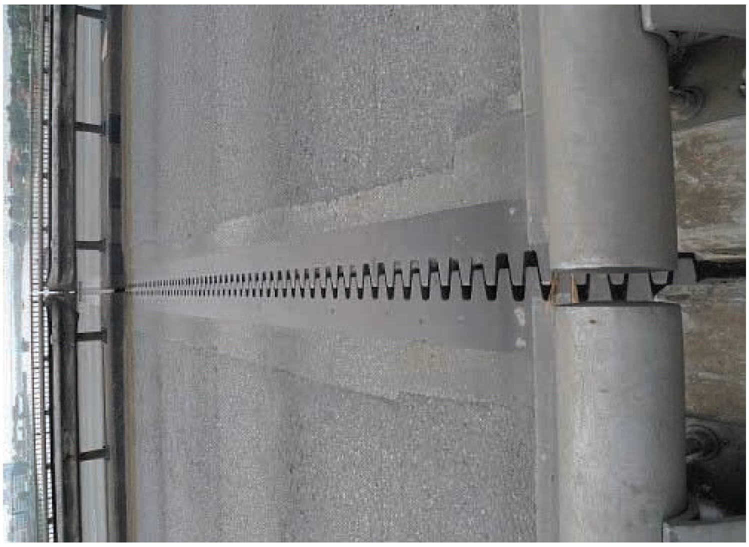
**Survey on board, 31-oct*

Picture No.	2
Span	2
Member	View on road

Picture No.	3
Span	1
Member	View under bridge

Present state (2 / 10)

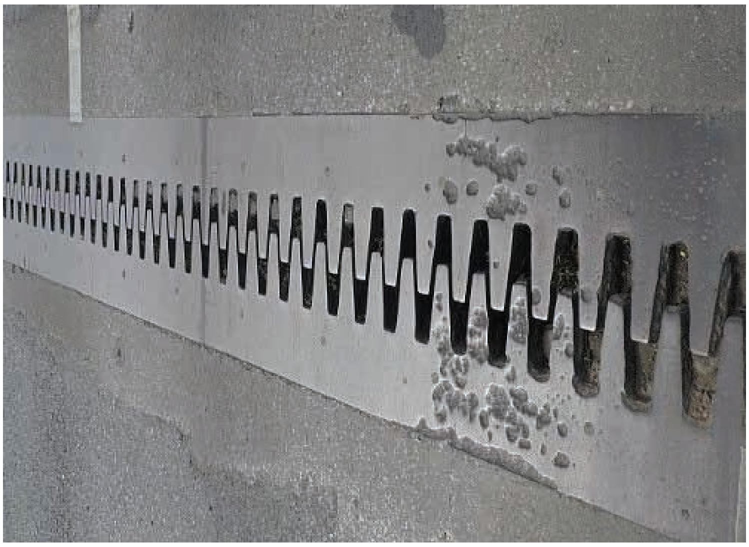
Authority	DOH	Address	Bangkok	Data	24-Oct-09
Bridge	Phra NangKlao Bridge				



Picture No.	4
Span	1
Member	Hinge

Joint on hinge part

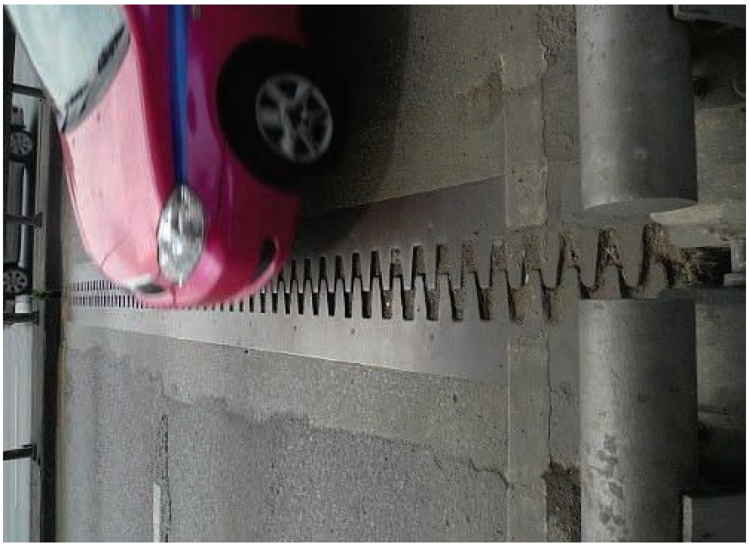
Vertical movement independently
especially in upstream girder



Picture No.	5
Span	1
Member	Expansion joint

Spacing is widen

Bangkok side



Picture No.	6
Span	1
Member	Expansion joint

Spacing is widen

Thon Buri side

Present state （3 / 10）

Authority	DOH	Address	Bangkok	Data	24-Oct-09
Bridge	Phra NangKlao Bridge				

Picture No.	7
Span	1
Member	Water supply

Leakage inside of PC-box girder

Picture No.	8
Span	1
Member	Bearing

Movement of girder
Thon Buri side

effect of shrinkage and creep

Picture No.	9
Span	1
Member	Bearing

Movement of girder

Bangkok side is lager than Thonbu

Present state （ 4 / 10）

Authority	DOH	Address	Bangkok	Data	24-Oct-09
Bridge	Phra NangKlao Bridge				

Picture No.	10
Span	1
Member	Bearing

Deterioration of corrosion proofi

Picture No.	11
Span	1
Member	Expansion joint

Deterioration of drain function

Leakage from medium

Picture No.	12
Span	1
Member	Pylon

Present state （5 / 10）

Authority	DOH	Address	Bangkok	Data	24-Oct-09
Bridge	Phra NangKlao Bridge				

Picture No.	7
Span	1
Member	Expansion joint

Deterioration of drain function

Picture No.	8
Span	1
Member	Drainage

Blocking of catch basin

Picture No.	9
Span	1
Member	Drainage

dirt

Present state （ 6 / 10 ）

Authority	DOH	Address	Bangkok	Data	24-Oct-09
Bridge	Phra NangKlao Bridge				

Picture No.	10
Span	1
Member	Manhole

graffiti

Manhole can be access by ladder

Picture No.	11
Span	1
Member	Manhole

With a key

Picture No.	12
Span	1
Member	Lighting pole

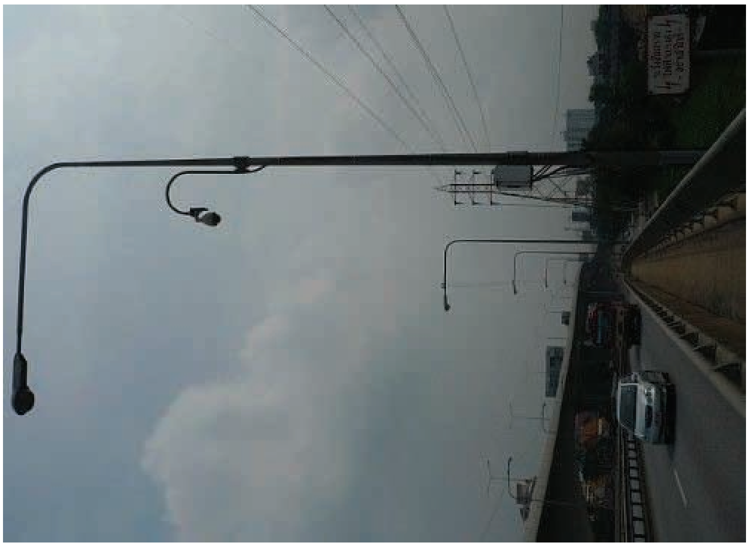
Damaged

Present state （7 / 10）

Authority	DOH	Address	Bangkok	Data	24-Oct-09
Bridge	Phra NangKlao Bridge				

Picture No.	13
Span	1
Member	

Repair of electric cable



Picture No.	14
Span	1
Member	Monitoring camera

Picture No.	15
Span	1
Member	Management office

Present state （ 8 / 10 ）

Authority	DOH	Address	Bangkok	Data	24-Oct-09
Bridge	Phra NangKlao Bridge				

Picture No.	16
Span	1
Member	Footing

Footing is close to new pra nangklao bridge at Thonburi side

Picture No.	17
Span	1
Member	View of footing

**Survey on board, 31-oct*

Picture No.	18
Span	1
Member	Water supply

Much water from manhole due to leakage of water supply

**Survey on board, 31-oct*

Present state （ 9 / 10 ）

Authority	DOH	Address	Bangkok	Data	24-Oct-09
Bridge	Phra NangKlao Bridge				

Picture No.	7
Span	1
Member	PC-box

Free lime from construction joint

**Survey on board, 31-oct*

Picture No.	8
Span	1
Member	Hinge

Lack of pin

Vertical movement is occurred independently

**Survey on board, 31-oct*

Picture No.	9
Span	1
Member	PC-box

Nest and droppings

**Survey on board, 31-oct*

Present state （10 / 10）

Authority	DOH	Address	Bangkok	Data	24-Oct-09
Bridge	Phra NangKlao Bridge				

Picture No.	10
Span	1
Member	Footing

Breaking and movement

**Survey on board, 31-oct*

Picture No.	11
Span	1
Member	

Picture No.	12
Span	1
Member	

Inspection sheet of visual survey

Bridge No. 7

Photo No. (～)

Bridge name	**RAMA V Bridge**	Route name	-	Authority	DRR	Code of authority: - No.: -
Place	from Anphoe Bang Bua Thong to Anphoe mueang Nonthaburi	Distance	from km+ 0 to km+ 0			Survey date: 2009/10/20

Bridge properties

Bridge type(1)	[✓ main road] • side road • ramp
Bridge type(2)	[✓ bridge] • viaduct • plank pass
Bridge type(3)	3-span continuous PC box girder
Total length	320.00 (m)
Span	95 + 130 + 95 (m)
Nos. of span	3 span
Width	11.7 x 2 (m) ／ (m)
Completion	2002

Road information

Horizontal	[✓ Straight] • incli(θ = °) • Curve (R m)
Gradient	One way (↗ • ↘) [✓ parabol] ([✓ 凸] • 凹)
Nearby tunnel	yes • [✓ no] (m)
Nearby crossing	yes • [✓ no] (m)
Traffic	Much • [✓ Medium] • Little
Commercial traffic	Much • [✓ Medium] • Little

Environment

[✓ 1.Urban]	2.Suburbs	3.Mountain	4.Seaside
5.Industrial	6.Harbor	7.Residential	8.Bussiness
9.Salty	10.Cold and snow	11.Heavy snow	12.Others

Under bridge

1.Shinkanser	2.Railway	3.Highway	4.Road
[✓ 5.River]	6.Lake	7.Ravine	8.Valley
9.Waterway	10.Parking	11.Bike parkin	12.Park
13.Vacant	14.Harbor	Name (Chao Phraya)	

Access method

Superstructure	[✓ 1.Inspection car] 2.Falsework 3.On ground 4.Ladder 5.Lift car 6.On boat 7.Special camera 8.Others( )
Substructure	1.Inspection car 2.Falsework 3.On ground 4.Ladder 5.Lift car [✓ 6.On boat] 7.Special camera 8.Others( )
Reason	• All bridge section is on the water • If inspection car is not available, false work will be required

Survey result

Camber deform		yes • [✓ no]
Difference in glade		yes • [✓ no]
Continuous of barrier		[✓ yes] • no
Continuous of curve		[✓ yes] • no
Noise		yes • [✓ no]
Joint	Space change	yes • [✓ no]
	difference grade	yes • [✓ no]
	draining damage	yes • [✓ no]
Blocked drainage		[✓ yes] • no
Crack of pavement		yes • [✓ no]
Damage of lighting		yes • [✓ no]
Damage of sign		—
Damage of handrail		yes • [✓ no]
Possibility of scour		[✓ yes] • no

Inspection way

Walkway yes • [✓ no]

Vehicle yes • [✓ no]

Height of girde about5.5m

Diagnosis

◆ Deterioration of bridge ◆

deficient • fair • [✓ good]

◆ Noticeable point ◆

Outline of damage

Item	Type	State
Main girder	PC-Box	Free lime, scratch due to ship collision
Cross beam	-	-
Stringer	-	-
Cross frame	-	-
Lateral brace	-	-
Slab	-	-
Abutment	Rectangular	-
Pier	Rectangular	-
Bearing	Slide bearing	-
Barrier	Trapezoidal	Generally healthy
Railing	Steel	Partly stolen
Curb	-	-
Pavement	[✓ asphalt] • concrete	Generally healthy
Joint	drained • [✓ undrained]	Spacing is extended
Drainage	[✓ yes] • no	Blocked

Impressions

• Scratch was seen under girder in center span

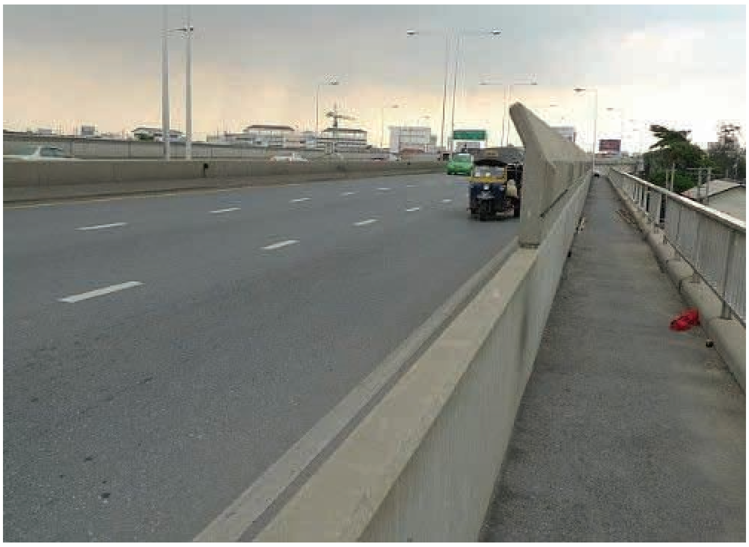
• Spacing of expansion joint increase about 5cm after completion.

History of repair ;	Repaint ; — yy — mm
Surveyor ;	Mr,Chujo, Mr.Kudo

Present state (1 / 10)

Road		Address	Bangkok	Data	20-Oct-09
Bridge	Rama V				

Picture No.	1
Span	1
Member	View under girder



Picture No.	2
Span	1
Member	View on road

Picture No.	3
Span	1
Member	Side view

**Survey on board, 31-oct*

Present state （2 / 10）

Road		Address	Bangkok	Data	20-Oct-09
Bridge	Rama V				

Picture No.	4
Span	1
Member	Manhole

No key

Picture No.	5
Span	1
Member	Manhole (walkway side)

With key

Picture No.	6
Span	1
Member	Manhole

About 6m height

Lift car or ladder is needed to access

Present state （3 / 10）

Road		Address	Bangkok	Data	20-Oct-09
Bridge	Rama V				

Picture No.	7
Span	1
Member	Catch basin

Blocking

Part without noise barrier is cleaned and has no blocking

Picture No.	8
Span	1
Member	lab (walkway, roadway

Electric and communication line

Picture No.	9
Span	1
Member	Girder

Defect of construction?

Present state （4 / 10）

Road		Address	Bangkok	Data	20-Oct-09
Bridge	Rama V				

Picture No.	10
Span	1
Member	Expansion joint

Leaving of form work

Picture No.	11
Span	1
Member	Expansion joint

Spacing is expanded 5cm

Picture No.	12
Span	1
Member	Handrail

Joint is off by unusual movement

Present state （5 / 10）

Road		Address	Bangkok	Data	20-Oct-09
Bridge	Rama V				

Picture No.	7
Span	1
Member	walkway

Less than 2m

Inspection vehicle cannot park in walkway

Picture No.	8
Span	1
Member	Handrail

Stolen of stainless handrail

Picture No.	9
Span	1
Member	Pier head

Genellary healthy

Present state （6/10）

Road		Address	Bangkok	Data	20-Oct-09
Bridge	Rama V				

Picture No.	10
Span	1
Member	Water supply

Walkway of water supply
will be available to use for
detailed survey of slab at center

Picture No.	11
Span	1
Member	Girder

Scrach by ship collision

**Survey on board, 31-oct*

Picture No.	12
Span	1
Member	Footing

**Survey on board, 31-oct*

Inspection sheet of visual survey

Bridge No. 8

Photo No. (～)

Bridge name	RAMA 7 Bridge	Route name	-	Authority	DRR	Code of authority	-
						No.	-
Place	from Khat Bang Phlat	Distance	from km+ 0			Survey date	2009/10/20
	to Khet Dusit		to km+ 0				

Bridge properties	Bridge type(1)	[✓ main road] • side road • ramp
	Bridge type(2)	[✓ bridge] • viaduct • plank pass
	Bridge type(3)	3-span continuous PC box girder
	Total length	290.00 (m)
	Span	85 + 120 + 85 (m)
	Nos. of span	3 span
	Width	14.45 x 2 (m) ／ (m)
	Completion	1992
Road information	Horizontal	[✓ Straight] • incli(θ = °) • Curve (R m)
	Gradient	One way (↗ • ↘) [✓ parabol] ([✓ 凸] • 凹)
	Nearby tunnel	yes • [✓ no] (m)
	Nearby crossing	yes • [✓ no] (m)
	Traffic	Much • [✓ Medium] • Little
	Commercial traffi	Much • [✓ Medium] • Little

Environ	[✓ 1.Urban]	2.Suburbs	3.Mountain	4.Seaside
	5.Industrial	6.Harbor	7.Residential	8.Bussiness
	9.Salty	10.Cold and snow	11.Heavy snow	12.Others
Under brid	1.Shinkanser	2.Railway	3.Highway	4.Road
	[✓ 5.River]	6.Lake	7.Ravine	8.Valley
	9.Waterway	10.Parking	11.Bike parkin	12.Park
	13.Vacant	14.Harbor	Name (	Chao Phraya)

Access method	Superstructure	[✓ 1.Inspection car] 2.Falsework 3.On ground 4.Ladder 5.Lift car 6.On boat 7.Special camera 8.Others( )
	Substructure	1.Inspection car 2.Falsework 3.On ground 4.Ladder 5.Lift car [✓ 6.On boat] 7.Special camera 8.Others( )
	Reason	• All bridge section is on the water • If inspection car is not available, false work will be required

Survey result	Camber deform	yes • [✓ no]
	Difference in glade	yes • [✓ no]
	ontinuous of barrie	[✓ yes] • no
	Continuous of curve	[✓ yes] • no
	Noise	yes • [✓ no]
	Joint: Space change	yes • [✓ no]
	Joint: difference grade	yes • [✓ no]
	Joint: draining damage	[✓ yes] • no
	Blocked drainage	[✓ yes] • no
	Crack of pavement	yes • [✓ no]
	Damage of lighting	yes • [✓ no]
	Damage of sign	—
	Damage of handrail	[✓ yes] • no
	Possibility of scou	[✓ yes] • no
Inspection way	Walkway yes • [✓ no]	
	Vehicle yes • [✓ no]	
	Height of girde	about 8.9m
Diagnosis	◆ Deterioration of bridge ◆	deficien • fair • [✓ good]
	◆ Noticeable point ◆	• Damage of drainage of joint

Outline of damage	Item	Type	State
	Main girder	PC-Box	free lime, leakage from water supply
	Cross beam	-	-
	Stringer	-	-
	Cross frame	-	-
	Lateral brace	-	-
	Slab		free lime, leakage (approach span)
	Abutment	-	-
	Pier	Rectangular	-
	Bearing	Slide bearing	-
	Barrier	Trapezoidal	Generally healthy
	Railing	Steel	Generally healthy
	Curb	-	-
	Pavement	[✓ asphalt] • concrete	Generally healthy
	Joint	drained • [✓ ndrained]	leakage
	Drainage	[✓ yes] • no	Blocked

Impressions

• Damage of drainage of joint. Around bearing, It should check influence of leackage f

• Continuous drain from manhole of center span. Leakage of water supply might make dam inside of girder.

istory of repair ;		Repaint ;	— yy — mm
Surveyor ;	Mr,Chujo, Mr.Kudo		

Present state (1 / 6)

Authority	DRR	Address	Bangkok	Data	20-Oct-09
Bridge	Rama VII				

Picture No.	1
Span	1
Member	View under girder

Picture No.	2
Span	1
Member	View on road

Picture No.	3
Span	1
Member	Side view

Present state （２／６）

Authority	DRR	Address	Bangkok	Data	20-Oct-09
Bridge	Rama VII				

Picture No.	4
Span	1
Member	Water supply

Picture No.	5
Span	1
Member	Handrail

Antitheft welding

Picture No.	6
Span	1
Member	Lighting pole

Deformation of bolt

Present state （ 3 / 6 ）

Authority	DRR	Address	Bangkok	Data	20-Oct-09
Bridge	Rama VII				

Picture No.	7
Span	1
Member	Catch basin

Partly blocked

Picture No.	8
Span	1
Member	Expansion joint

Deterioration of drain fanction

Picture No.	9
Span	1
Member	Expansion joint

Deterioration of drain fanction

Present state （ 4 / 6 ）

Authority	DRR	Address	Bangkok	Data	20-Oct-09
Bridge	Rama VII				

Picture No.	10
Span	1
Member	End pier

Corrosion of steel plate at base

Picture No.	11
Span	1
Member	End pier

Corrosion of steel plate at base

Picture No.	12
Span	1
Member	Approach bridge

Free lime

Present state (5 / 6)

Authority	DRR	Address	Bangkok	Data	20-Oct-09
Bridge	Rama VII				

Picture No.	7
Span	1
Member	Approach bridge

Settlement around pier

Picture No.	8
Span	1
Member	Approach bridge

Deterioration of drain function

First one is good. 2nd, 3rd drain
is blocked

Picture No.	9
Span	1
Member	Site management office

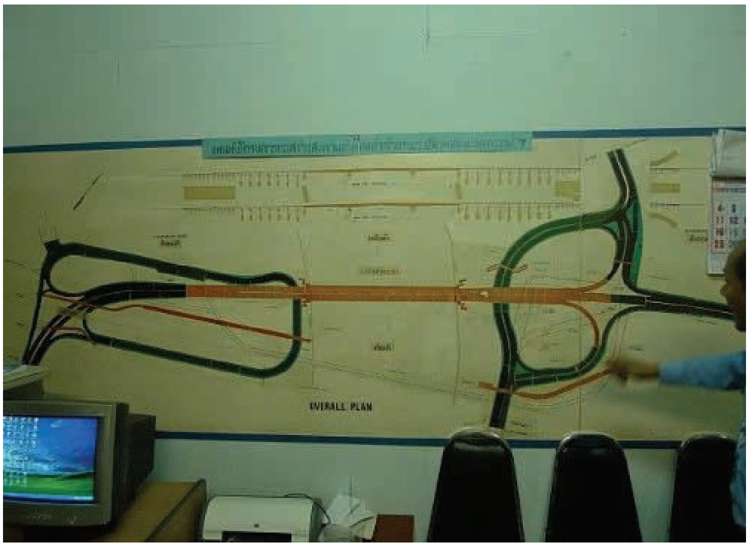
Management office
Technical 1 person
Labor 15 person

Management of bridge and park

They send report of bridge
once a week to DRR

Present state (6 / 6)

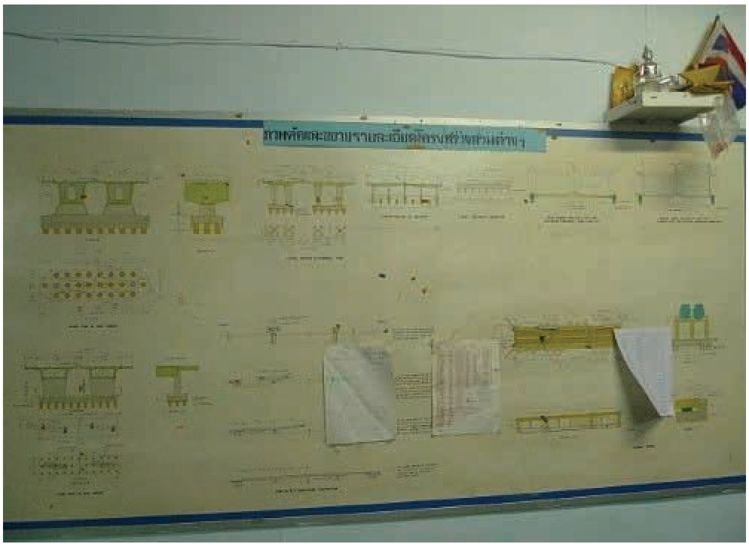
Authority	DRR	Address	Bangkok	Data	20-Oct-09
Bridge	Rama VII				



Picture No.	10
Span	1
Member	Site management office

Management area is yellow section

Green section is managed by BMA



Picture No.	11
Span	1
Member	Site management office

Picture No.	12
Span	1
Member	Site management office

Present state （７／７）

Authority	DRR	Address	Bangkok	Data	20-Oct-09
Bridge	Rama VII				

Picture No.	7
Span	1
Member	Substructure

Picture No.	8
Span	1
Member	

Picture No.	9
Span	1
Member	