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.

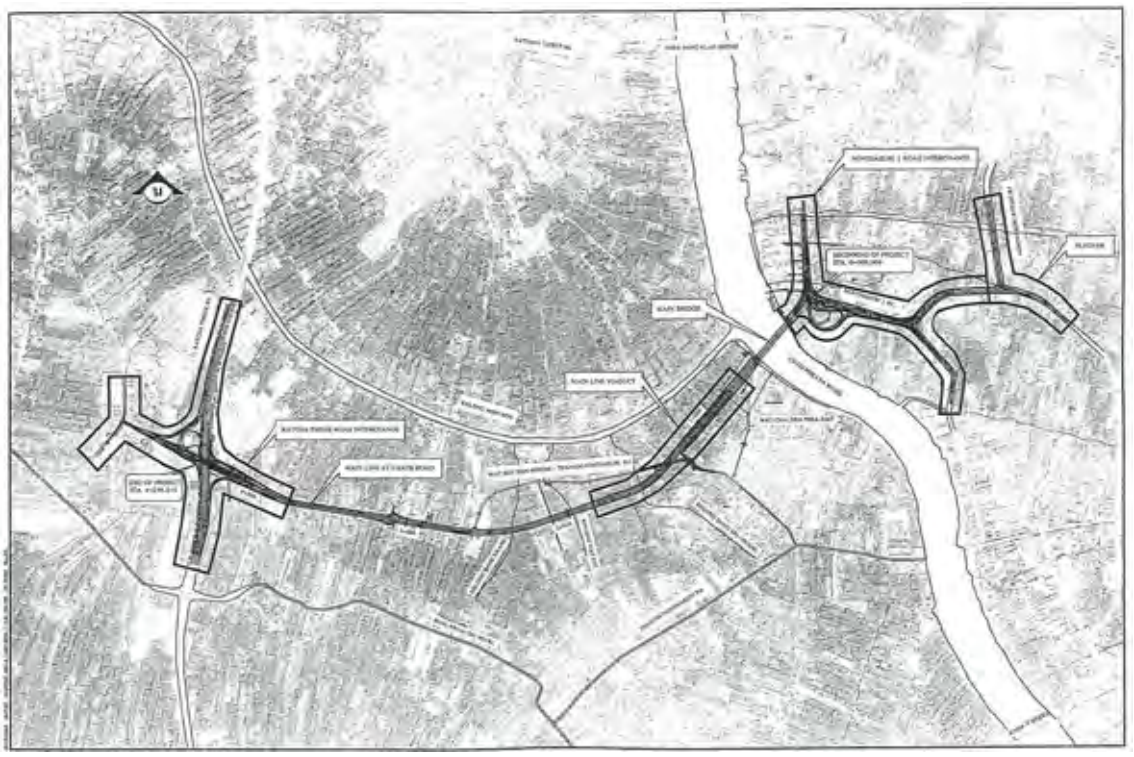


Figure 3.2.1 Planning Map of the Project

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 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.

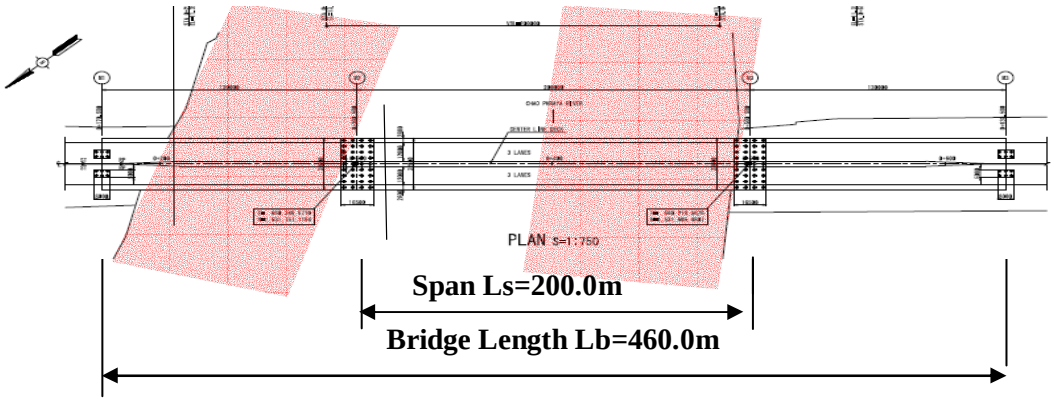


Figure 3.3.1 River Condition and Bridge Length

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.

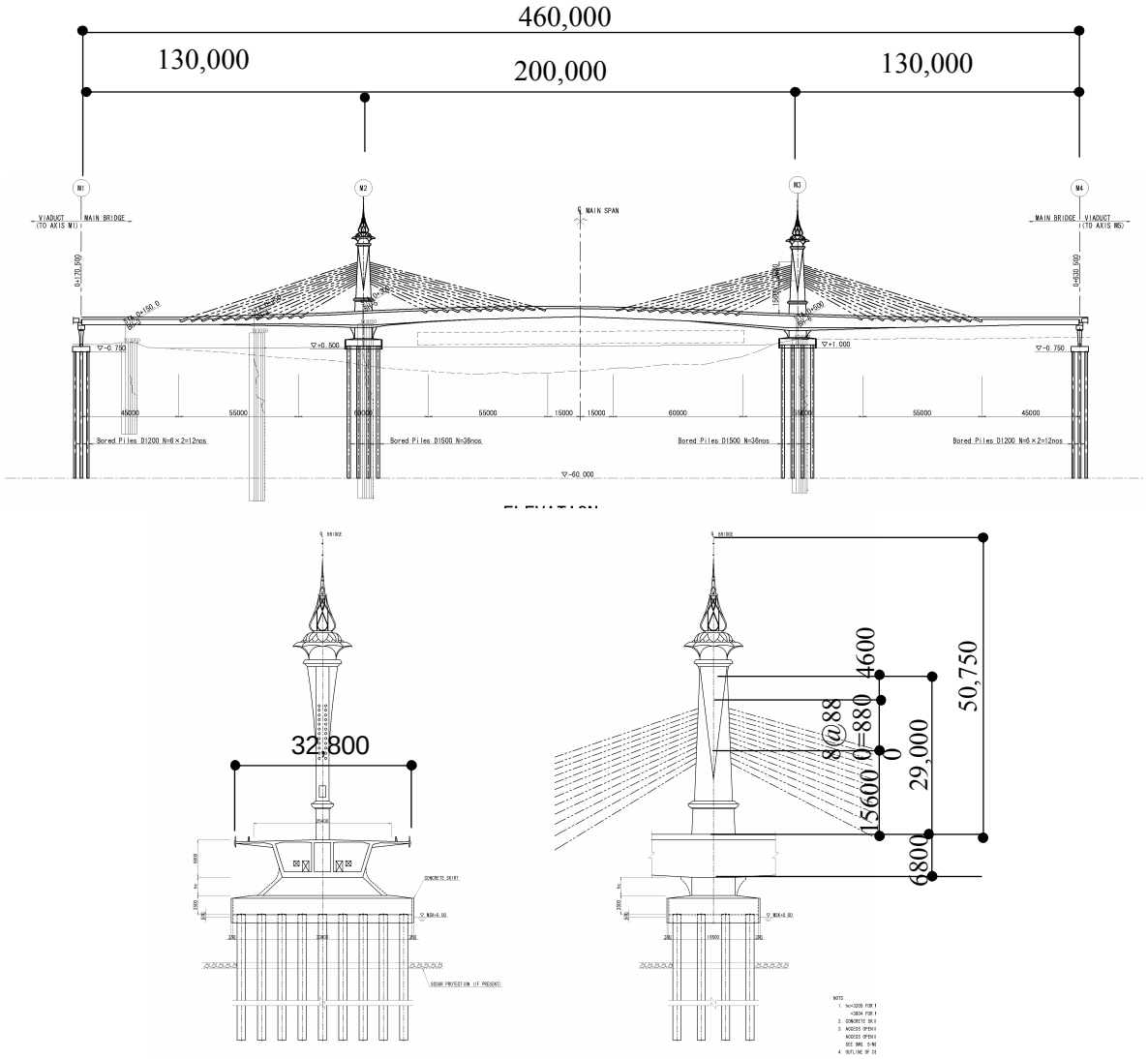


Figure 3.3.2 General Plan of Extradosed Bridge

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 σL1	Δ σL2	Δ σL3
		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

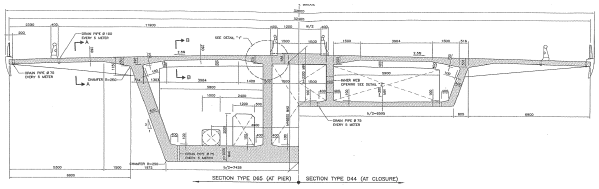
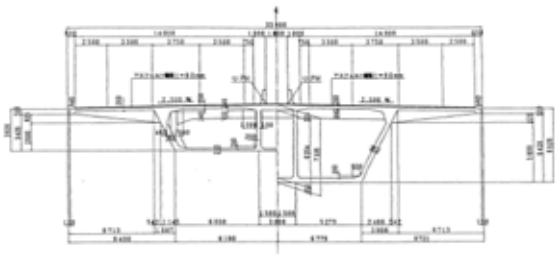
Note: The value shown in the above table is carried out based on the calculation result offered by the D/D company

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.

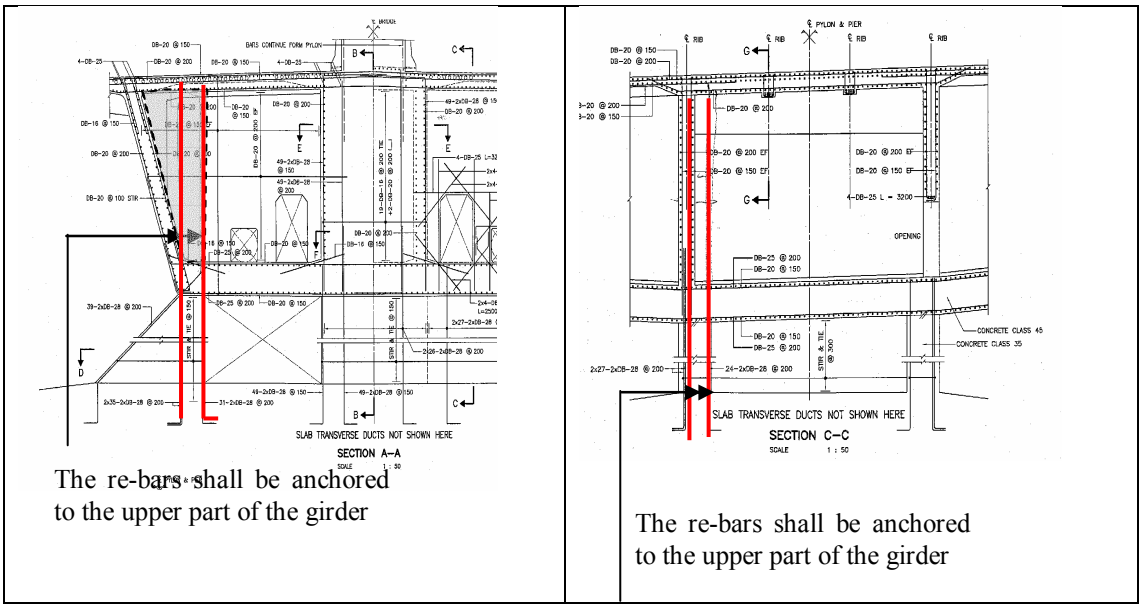


Figure 3.3.3 Connection between Superstructure and Sub-structure

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.

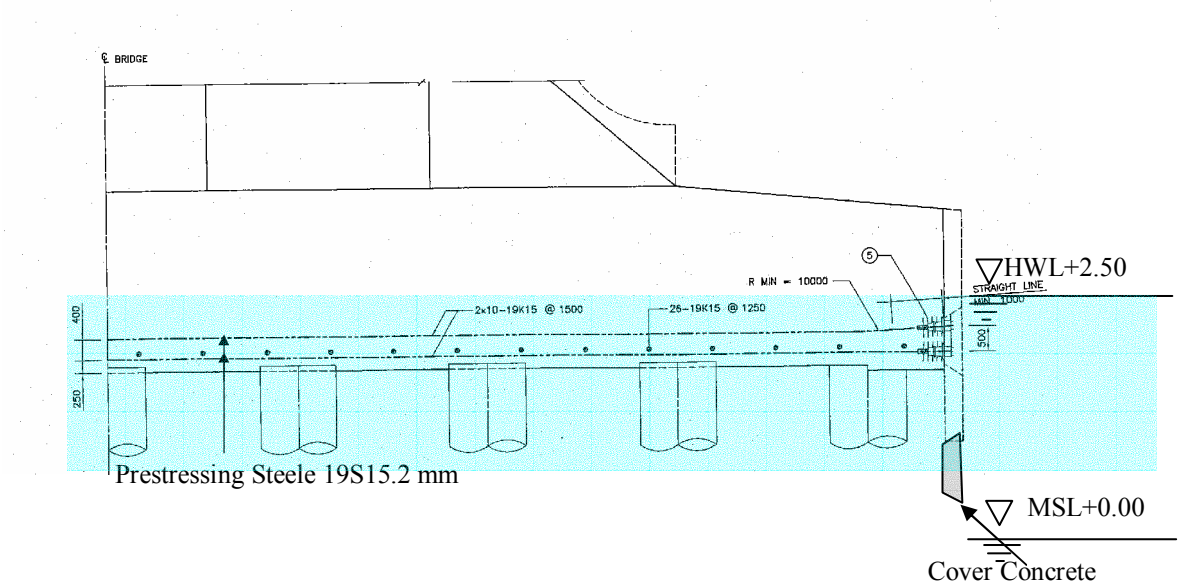


Figure 3.3.4 Prestressing Steel in the Pile Cap

(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).

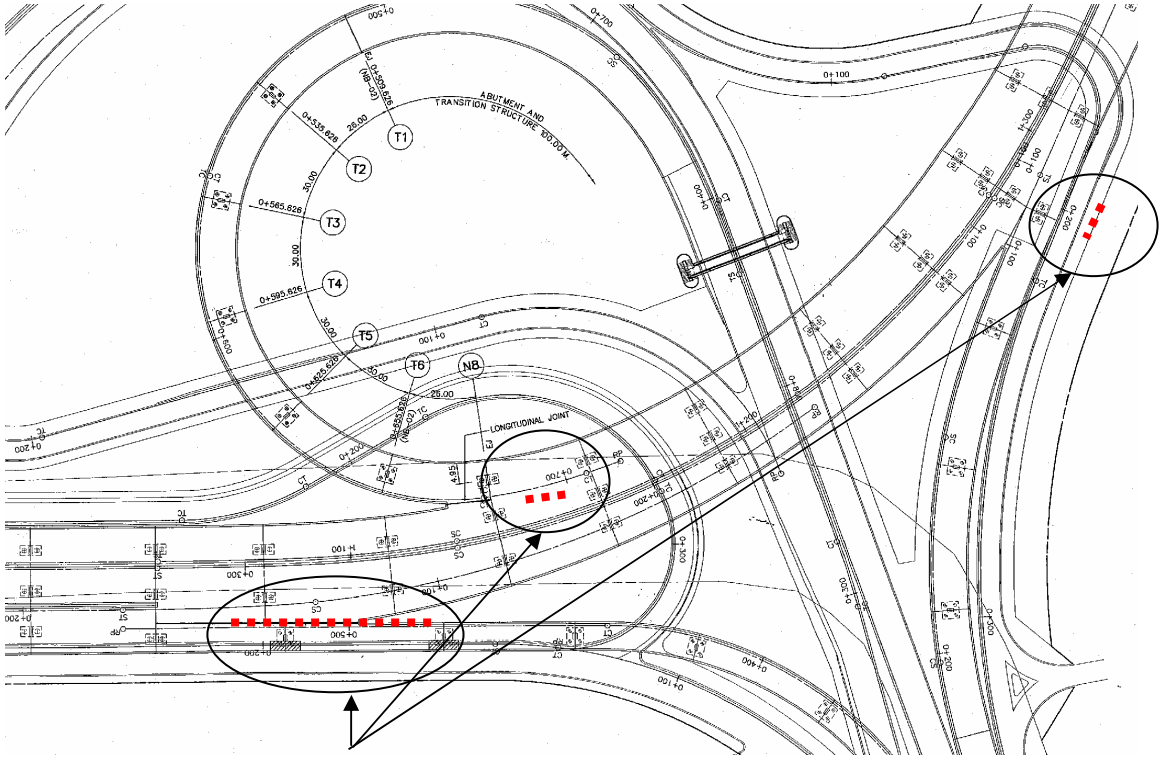


Figure 3.3.5 Longitudinal Joints in the Interchange

(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.

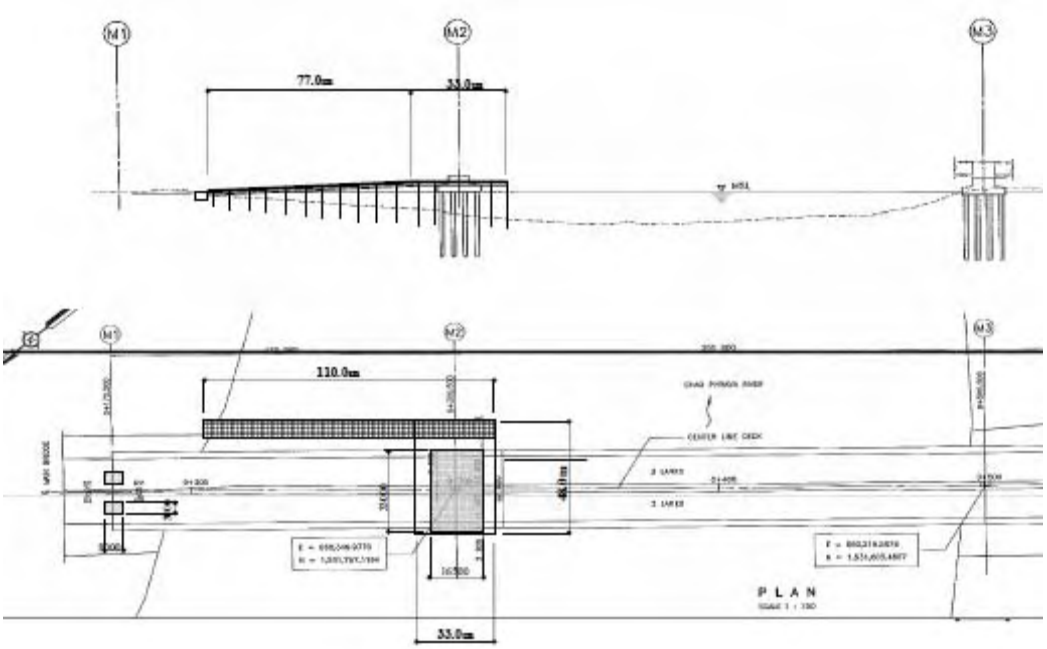


Figure 3.3.6 Construction Plan of Temporary Jetty

(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.

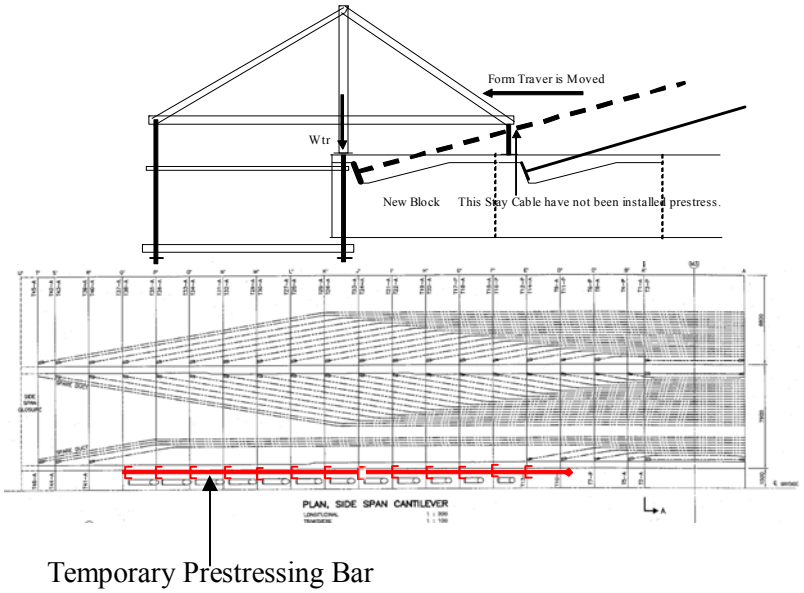


Figure 3.3.7 Temporary Prestressing Bar in Cantilever Erection

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	DESIG		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)

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.

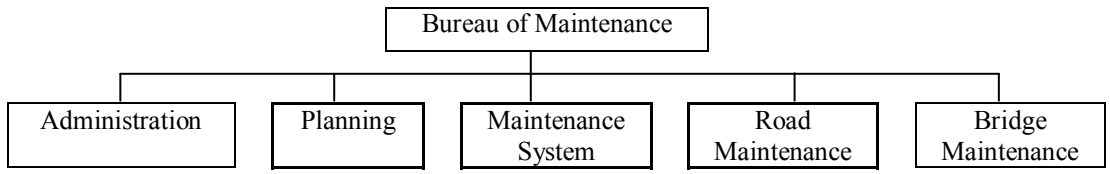
Location of the headquarters and 18 district offices are shown in Table 4.1.1. The city and region of each office are shown in the table.

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.



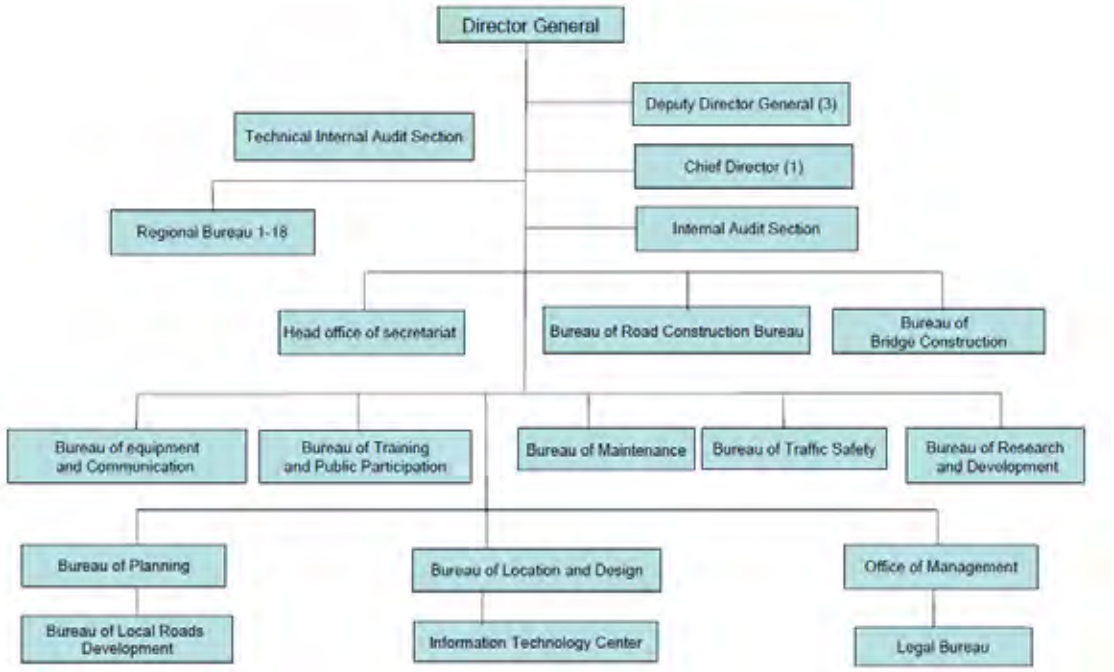


Figure 4.1.1 Organization Chart of DRR

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.

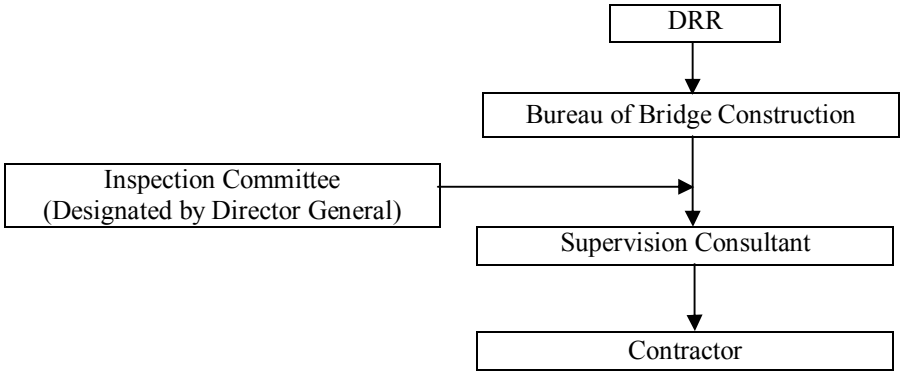
Table 4.1.2 Transition Annual Budgets of DRR, including Personnel Expenses

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

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.

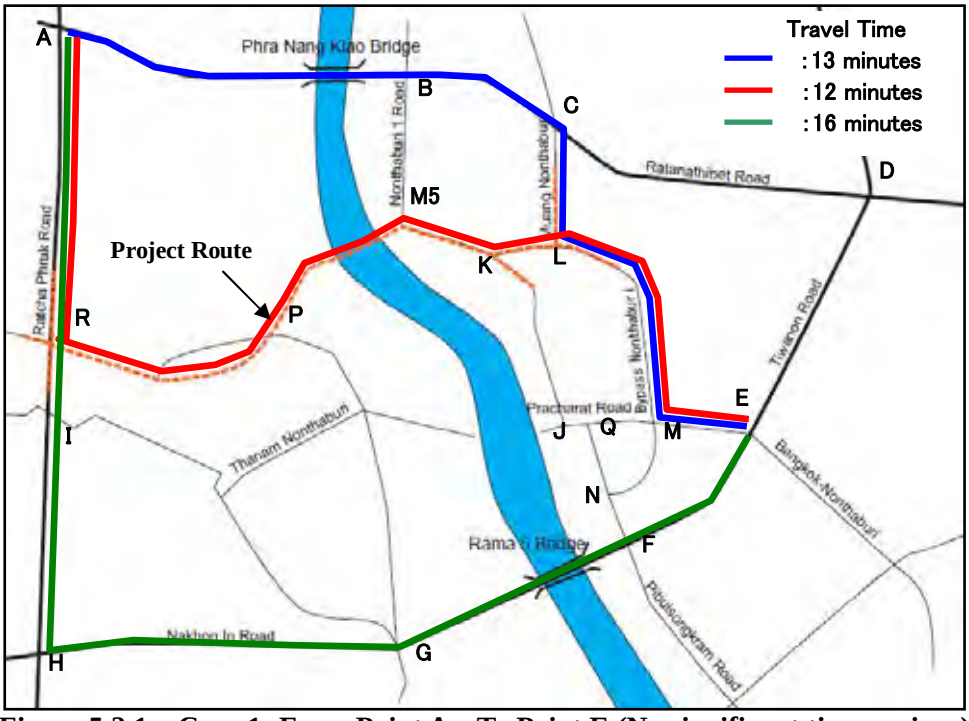


Figure 5.2.1 Case-1: From Point A – To Point E (No significant time savings)

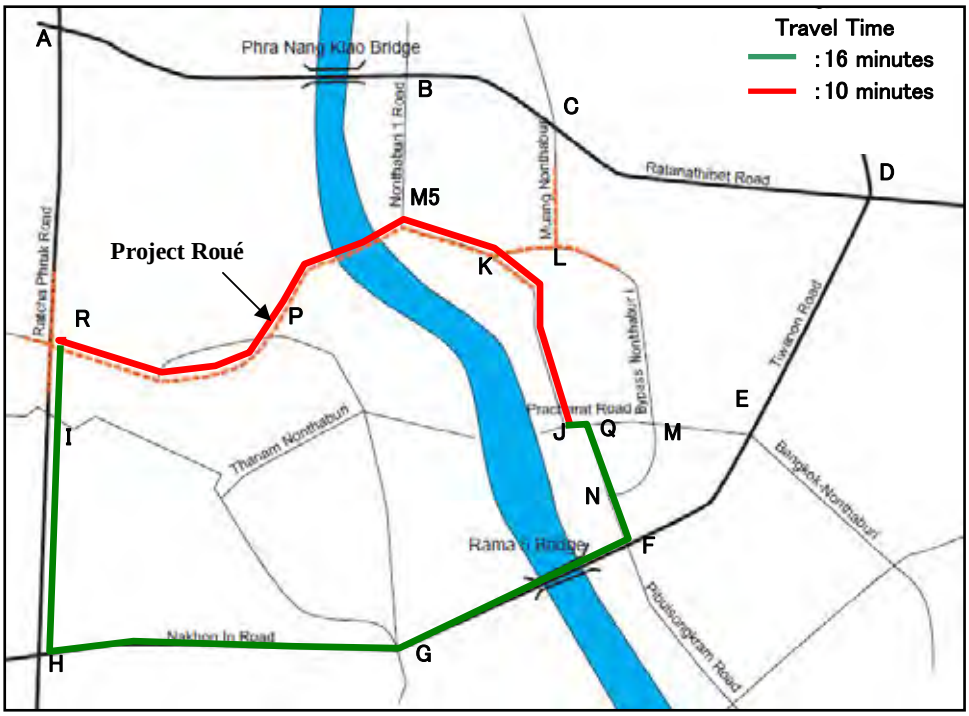


Figure 5.2.2 Case 2: From Point R – To Point J :Central area of Nonthaburi Province (about 6 minutes time savings)

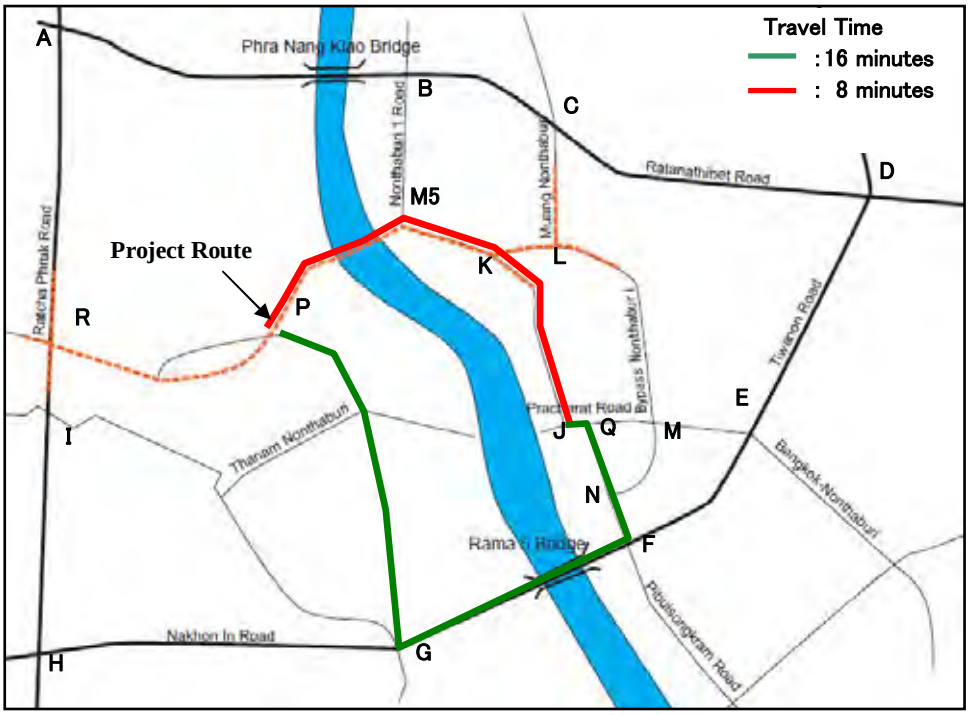


Figure 5.2.3 Case 3: From Point P – To Point J (about 8 minutes of time savings)

(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.

5) Results of Evaluation

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

Table 5.2.4 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 5.2.5 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

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.

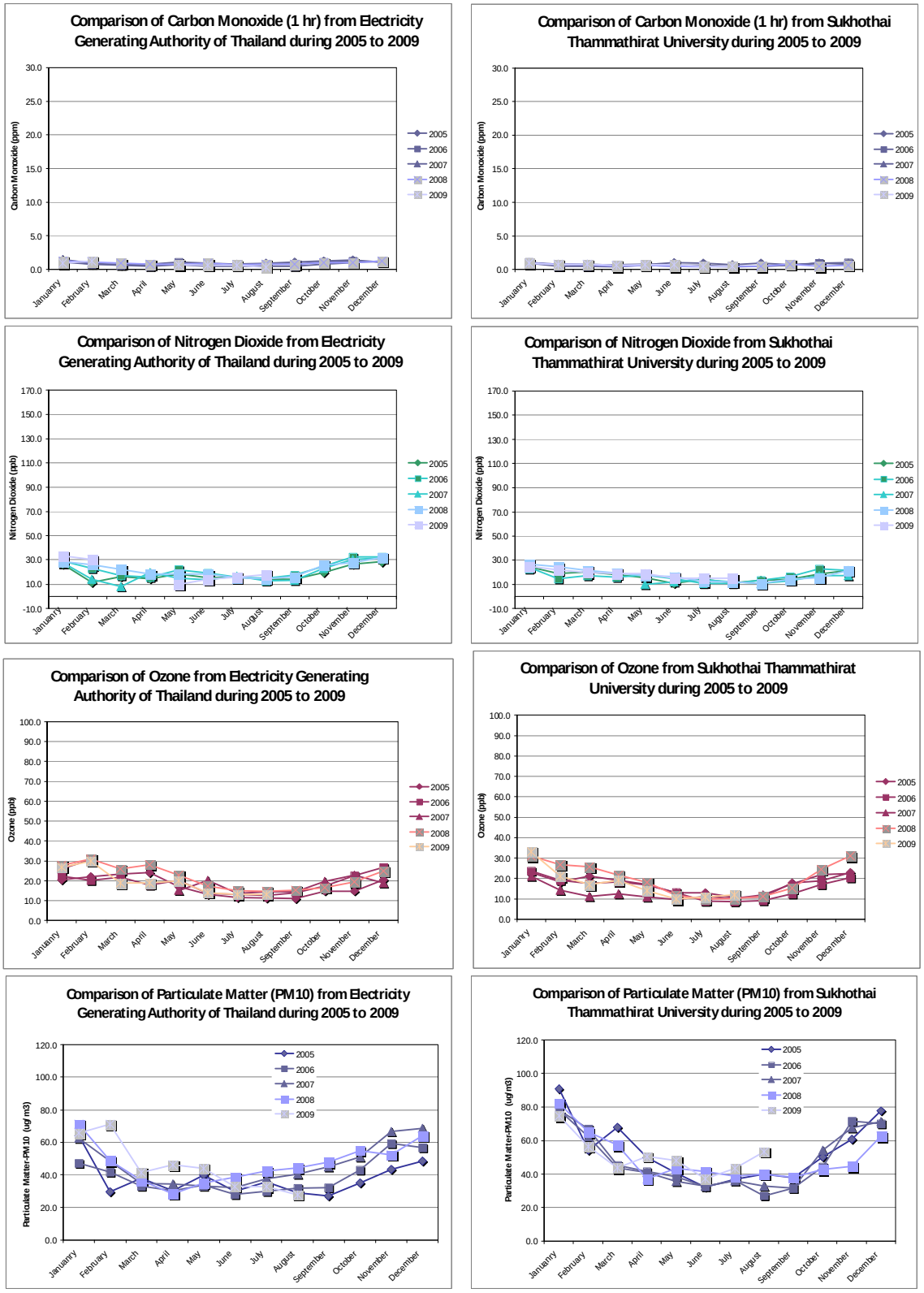


Figure 6.1.3 Air Pollution Trend in Nonthaburi Province (Monthly Average of 2005-2009)

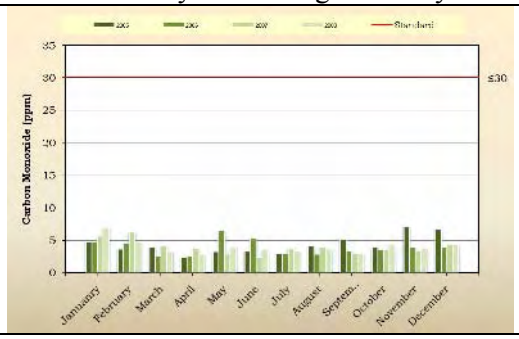
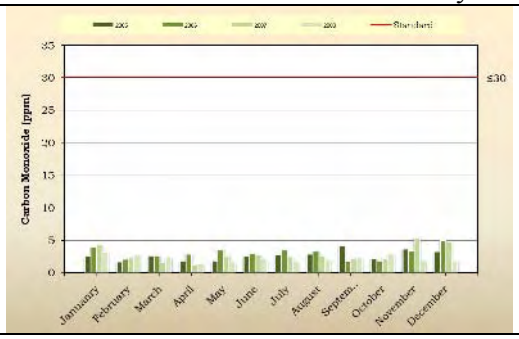
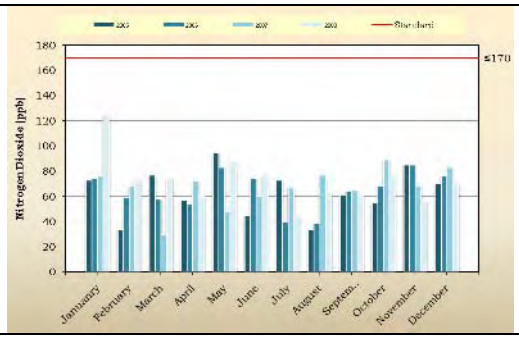
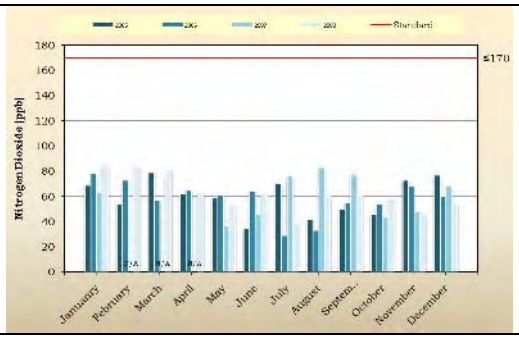
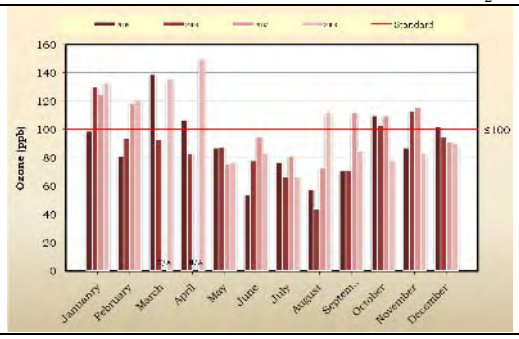
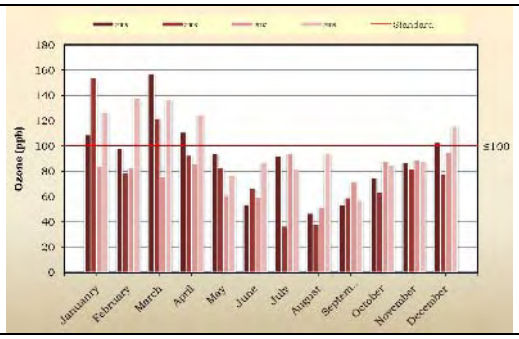
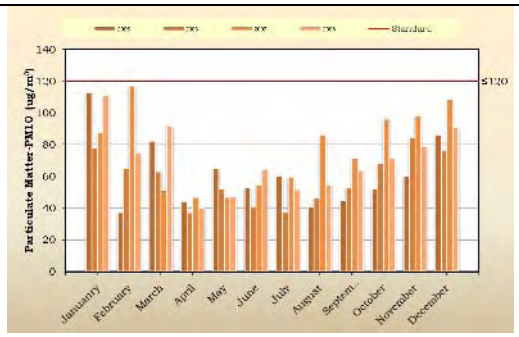
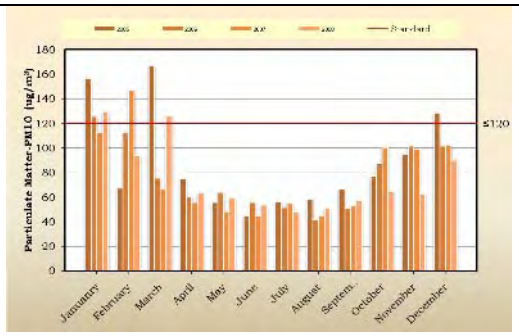
Electricity Generating Authority	Sukhothai Thammathirat University
	
CO Average 1 Hour	
	
NO_2 Average 1 Hour	
	
Ozone Average 1 Hour	
	
PM_{10} Average 24 Hour	

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-2.

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

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-5.

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	✔ War Reparation
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	✔ War Reparation
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	✔ War Reparation 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-6.

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

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

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

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)	$\mu g/m^3$			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)	$\mu g/m^3$			120	50	120				
CO (1 hr)	ppm			30	-	30				
NO_2 (1 hr)	$\mu g/m^3$			320	200	320				
Operation										
TSP (24 hr)	$\mu g/m^3$			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)	$\mu g/m^3$			120	50	120				
CO (1 hr)	ppm			30	-	30				
NO_2 (1 hr)	$\mu g/m^3$			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.

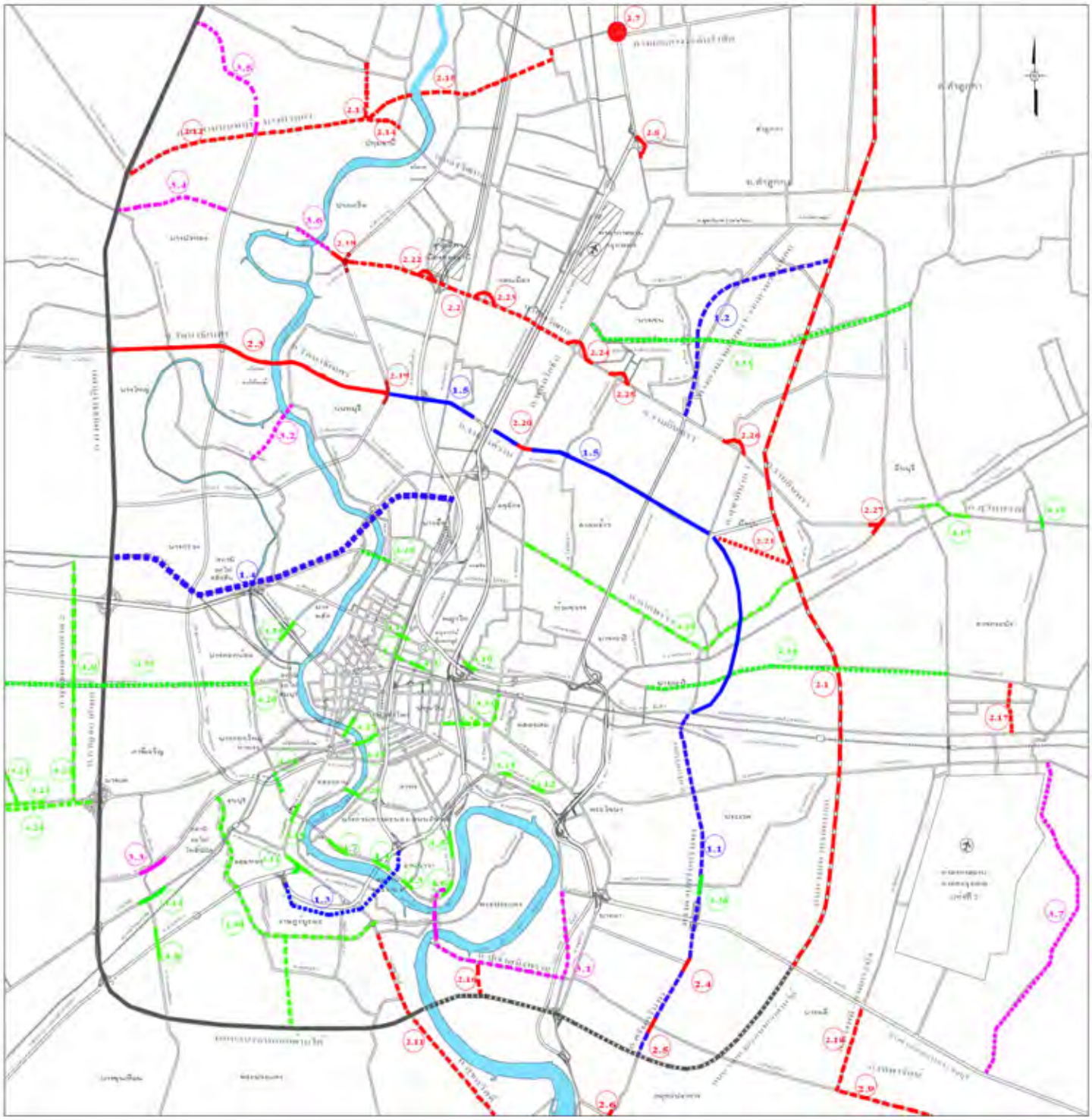
4. Reporting period to JICA

(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-3

Updated List of Projects under the Commission of Management of Land Traffic's Resolution No. 1/2547



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-4

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.

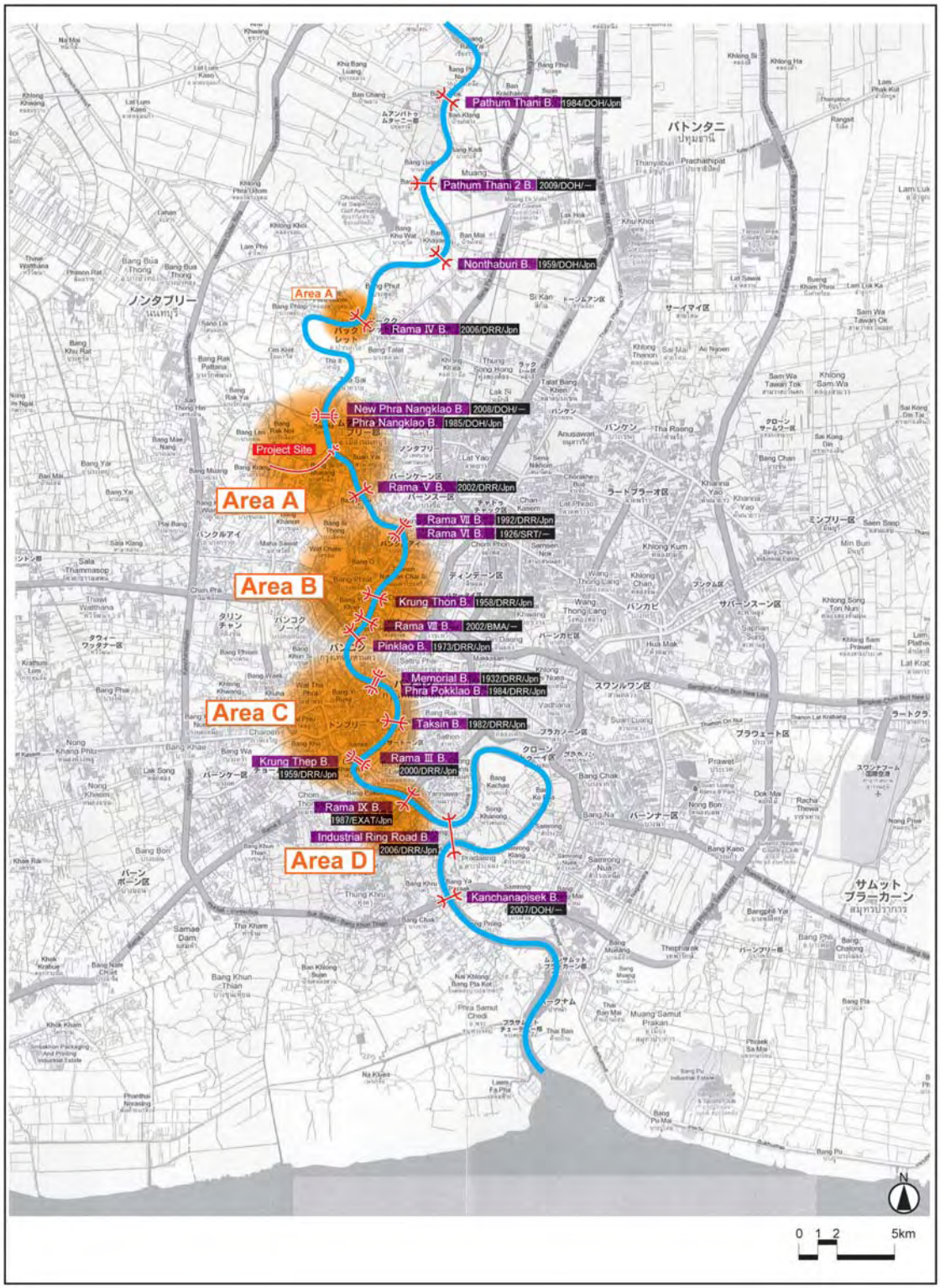
Table The Survey Areas of Interview

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》

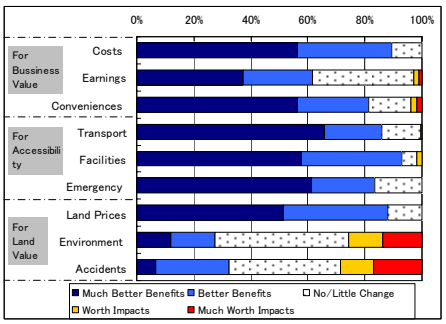


《The Questionnaire Form》

	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

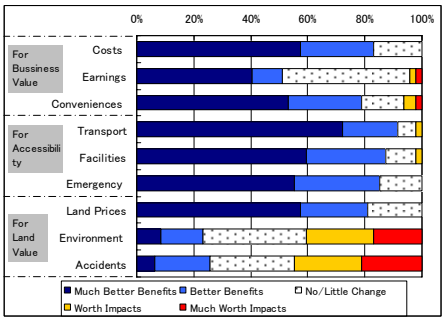
1) The Results for all bridges



《for all bridges》

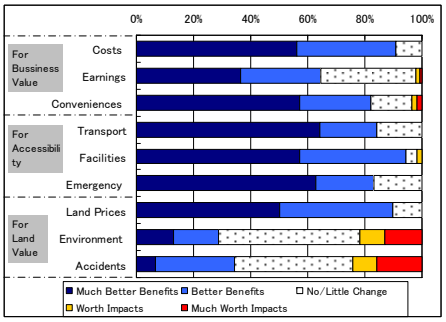
All Answers	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Convenience	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	56%	37%	56%	66%	58%	61%	52%	12%	7%
Better Benefits	33%	24%	25%	20%	35%	22%	36%	16%	26%
No/Little Change	11%	36%	15%	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》

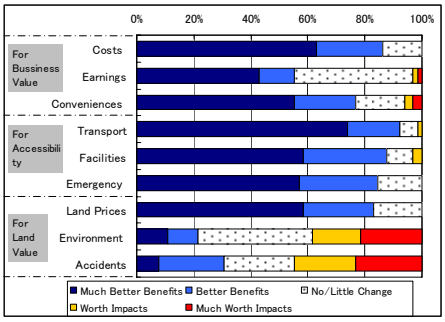
New Bridge	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	57%	40%	53%	72%	60%	55%	57%	9%	6%
Better Benefits	26%	11%	26%	19%	28%	30%	23%	15%	19%
No/Little Change	17%	45%	15%	6%	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》

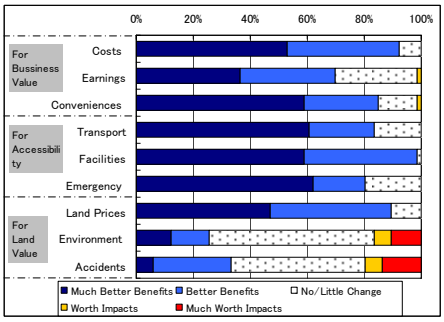
The Other Bridges	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	56%	37%	57%	64%	57%	63%	50%	13%	7%
Better Benefits	35%	28%	25%	20%	37%	20%	40%	16%	28%
No/Little Change	9%	33%	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



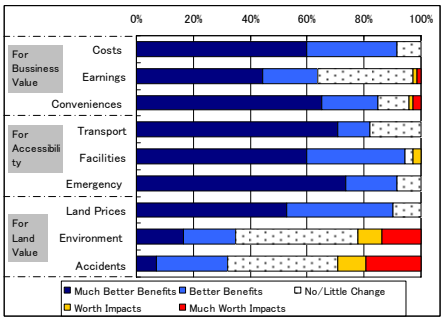
《in area A》

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%



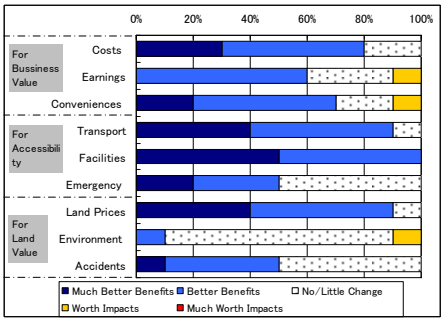
《in area B》

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》

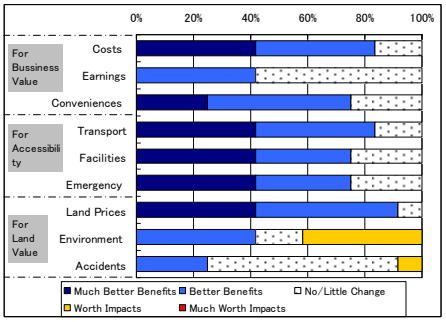
Area C	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	60%	44%	65%	71%	60%	74%	53%	17%	7%
Better Benefits	32%	19%	19%	11%	35%	18%	38%	18%	25%
No/Little Change	8%	33%	11%	18%	3%	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》

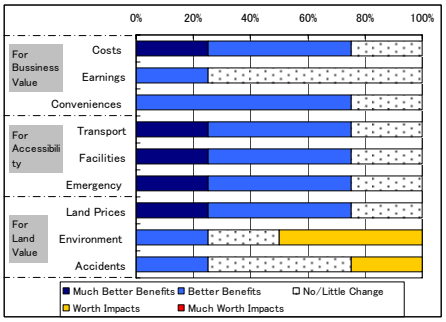
Area D	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	30%	0%	20%	40%	50%	20%	40%	0%	10%
Better Benefits	50%	60%	50%	50%	50%	30%	50%	10%	40%
No/Little Change	20%	30%	20%	10%	0%	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》

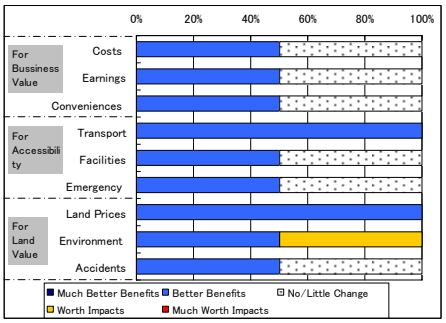
Japanese Companies	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	42%	0%	25%	42%	42%	42%	42%	0%	0%
Better Benefits	42%	42%	50%	42%	33%	33%	50%	42%	25%
No/Little Change	17%	58%	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》

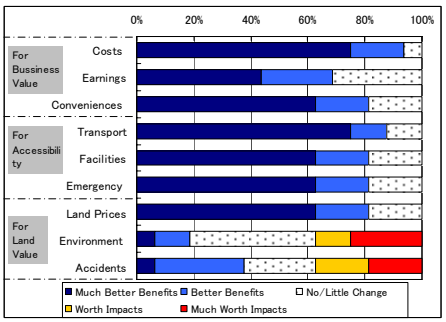
Japanese Companies (New Bridge)	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	25%	0%	0%	25%	25%	25%	25%	0%	0%
Better Benefits	50%	25%	75%	50%	50%	50%	50%	25%	25%
No/Little Change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



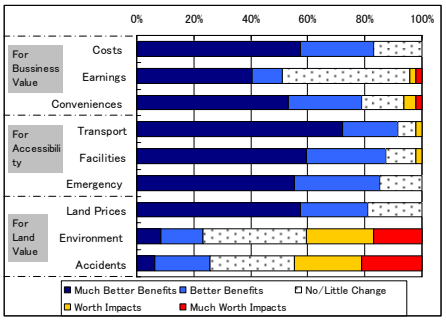
《about Rama 4 Bridge》

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%



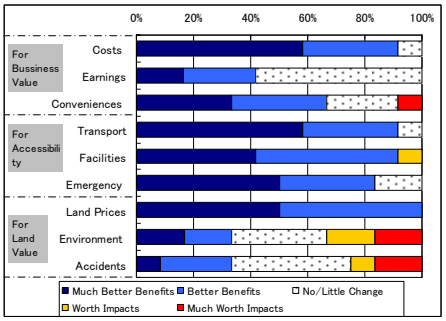
《about Phra Nakgklao Bridge》

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%



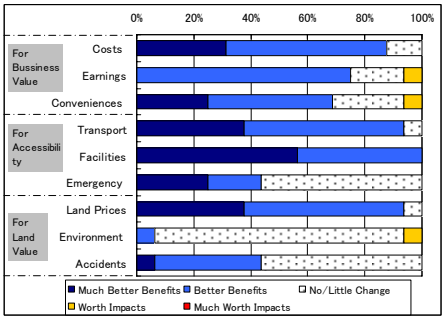
《about New Bridge》

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%



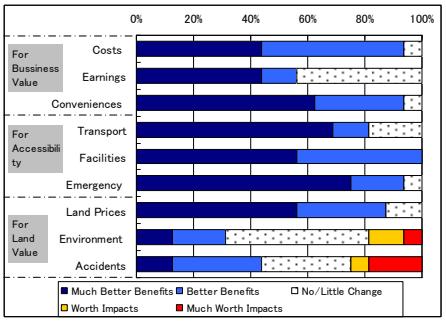
《about Rama 5 Bridge》

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%



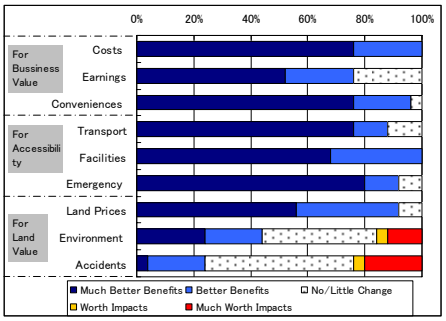
《about Rama 7 Bridge》

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%



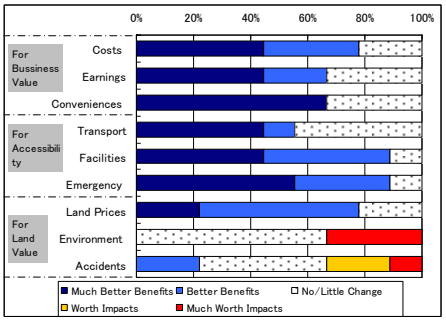
《about Krung Thon Bridge》

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%



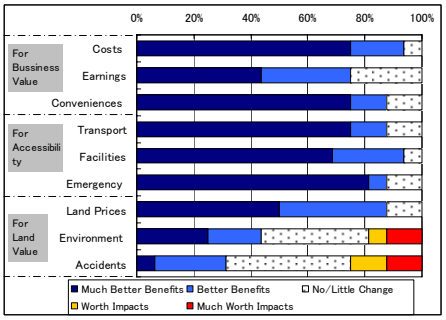
《about Rama 8 Bridge》

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%



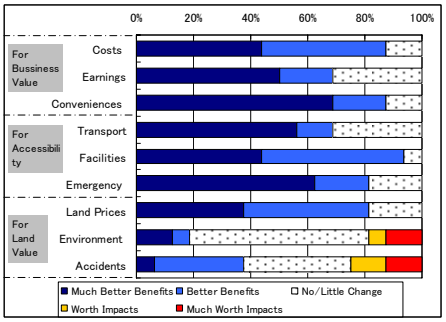
《about Pinklao Bridge》

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%



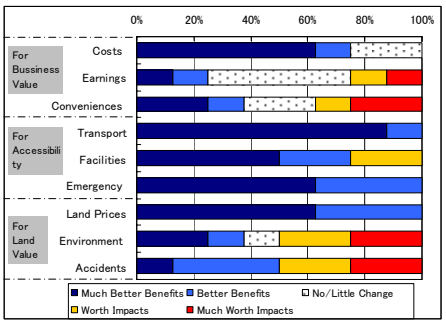
《about Memorial Bridge》

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%



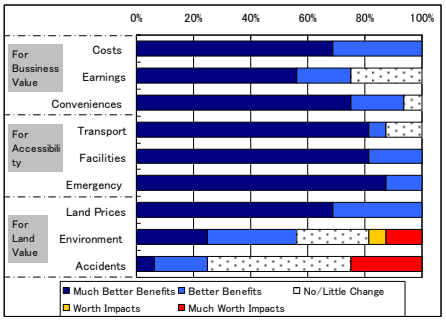
《about Phra Pokklao Bridge》

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%



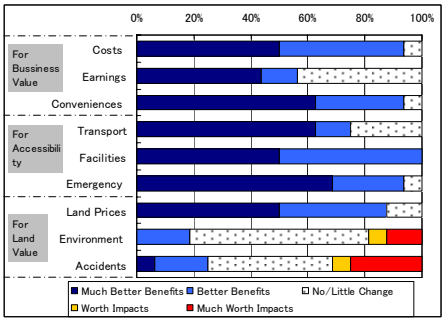
《about Taksin Bridge》

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%



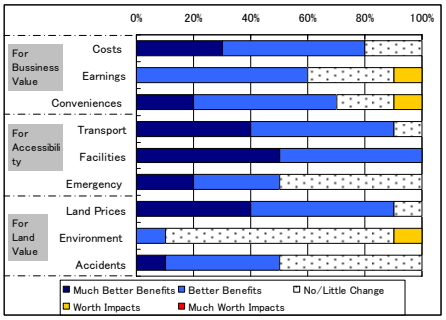
《about Rama 3 Bridge》

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》

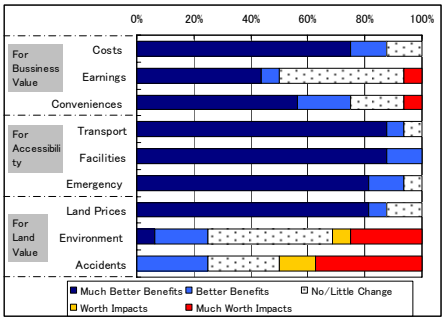
Krung Thep	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	50%	44%	63%	63%	50%	69%	50%	0%	6%
Better Benefits	44%	13%	31%	13%	50%	25%	38%	19%	19%
No/Little Change	6%	44%	6%	25%	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》

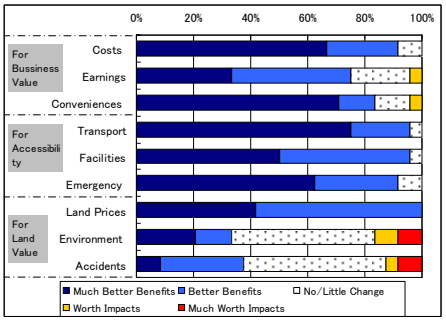
Rama 9	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	30%	0%	20%	40%	50%	20%	40%	0%	10%
Better Benefits	50%	60%	50%	50%	50%	30%	50%	10%	40%
No/Little Change	20%	30%	20%	10%	0%	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



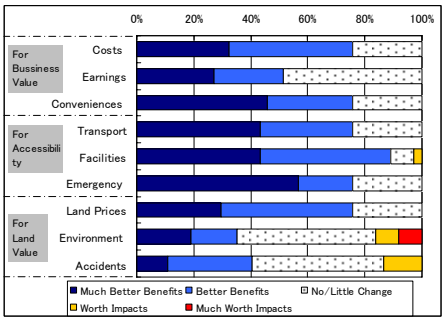
《from Apartments》

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%



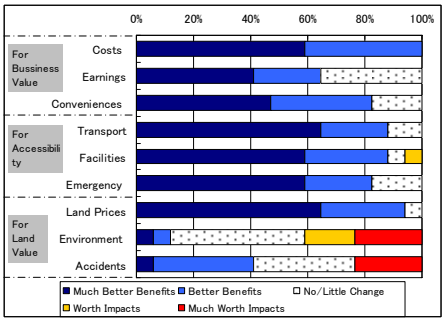
《from Automobile Companies》

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%



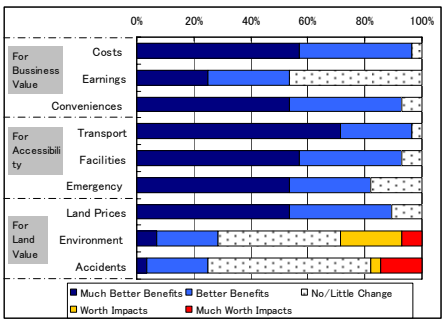
《from normal Companies》

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%



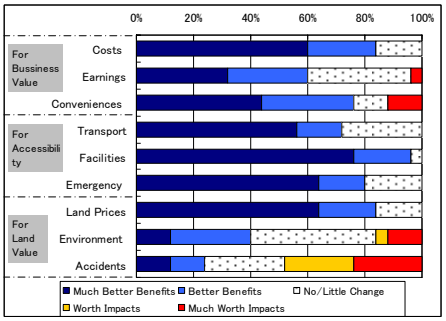
《from Condominiums》

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%



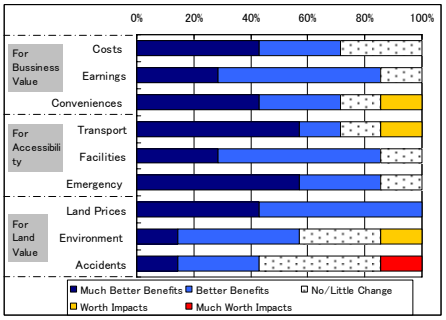
《from Factories》

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%



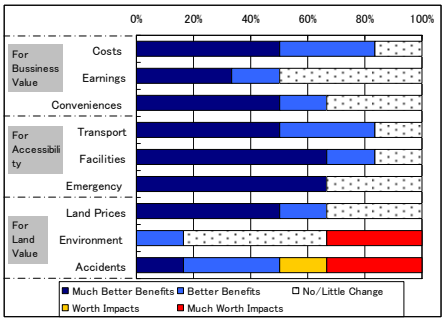
《from Gas Stations》

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%



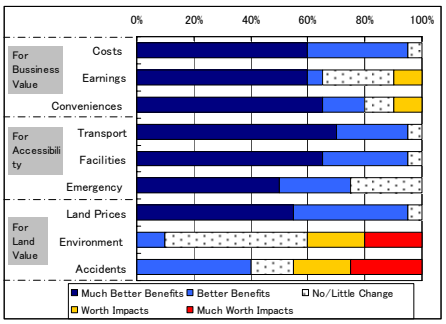
《from Hotels》

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%



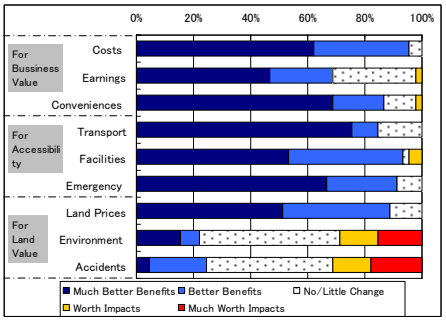
《from Museums》

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》

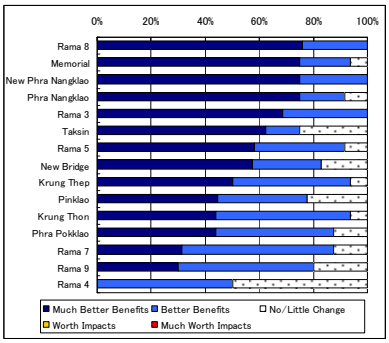
Restaurant	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	60%	60%	65%	70%	65%	50%	55%	0%	0%
Better Benefits	35%	5%	15%	25%	30%	25%	40%	10%	40%
No/Little Change	5%	25%	10%	5%	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》

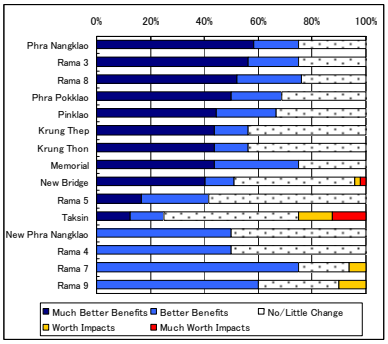
Shop	For Bussiness Value			For Accessibility			For Land Value		
	Costs	Earnings	Conveniences	Transport	Facilities	Emergency	Land Prices	Environment	Accidents
Much Better Benefits	62%	47%	69%	76%	53%	67%	51%	16%	4%
Better Benefits	33%	22%	18%	9%	40%	24%	38%	7%	20%
No/Little Change	4%	29%	11%	16%	2%	9%	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)



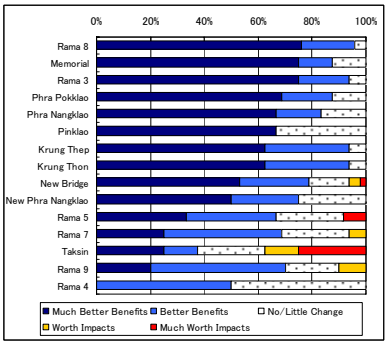
《about Reduce Costs (fuel, time, etc)》

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%



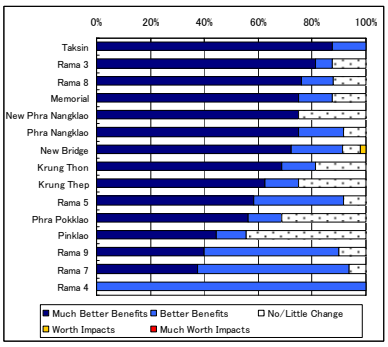
《about Increase Earnings, Sales and/or A Number of Customers》

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%



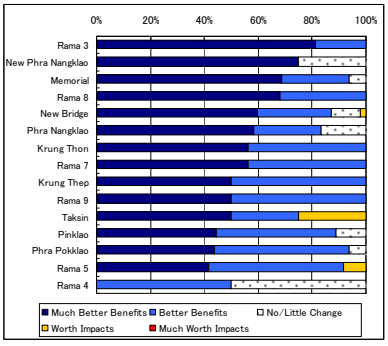
《about Improve Conveniences for Employees and/or Business Customers》

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%



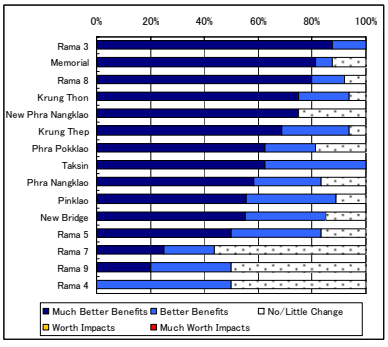
《about Reduce Times for Transport》

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%



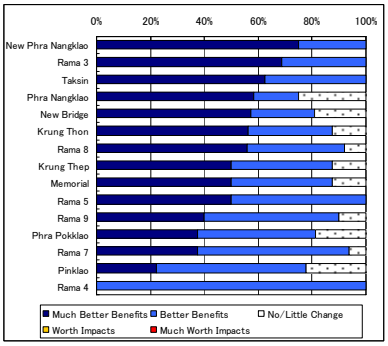
《about Improve Access to Useful Facilities》

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%



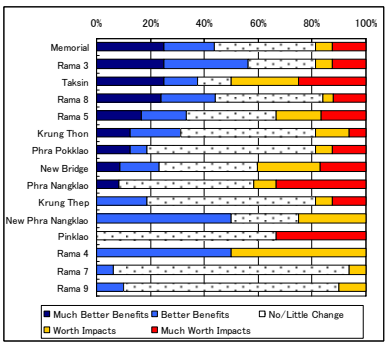
《about Improve Access in Emergency (hospital)》

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%



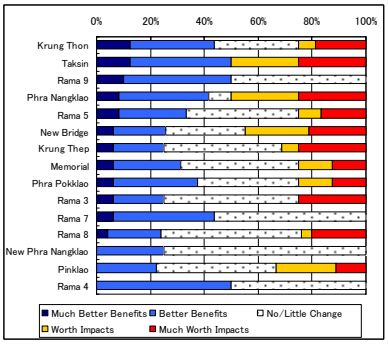
《about Increase Land Prices》

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)》

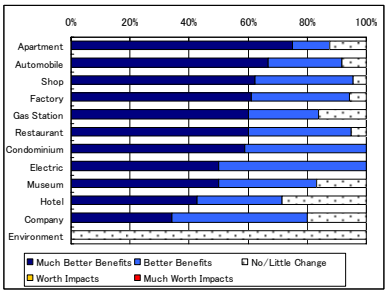
Environment	Much Better	Better Benefits	No/Little Change	Worth Impacts	Much Worth Impacts	Total
Memorial	25%	19%	38%	6%	13%	100%
Rama 3	25%	31%	25%	6%	13%	100%
Taksin	25%	13%	13%	25%	25%	100%
Rama 8	24%	20%	40%	4%	12%	100%
Rama 5	17%	17%	33%	17%	17%	100%
Krung Thon	13%	19%	50%	13%	6%	100%
Phra Pokklao	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》

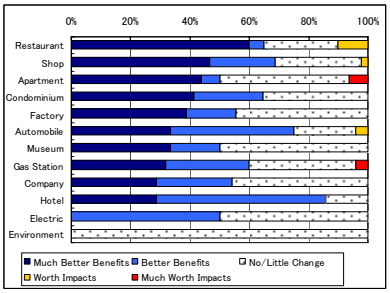
Accidents	Much Better	Better Benefits	No/Little Change	Worth Impacts	Much Worth Impacts	Total
Krung Thon	13%	31%	31%	6%	19%	100%
Taksin	13%	38%	0%	25%	25%	100%
Rama 9	10%	40%	50%	0%	0%	100%
Phra Nangklao	8%	33%	8%	25%	25%	100%
Rama 5	8%	25%	42%	8%	17%	100%
New Bridge	6%	19%	30%	23%	21%	100%
Krung Thep	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)



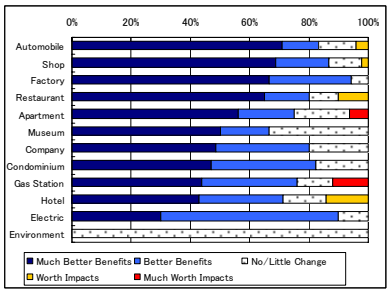
《about Reduce Costs (fuel, time, etc)》

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%



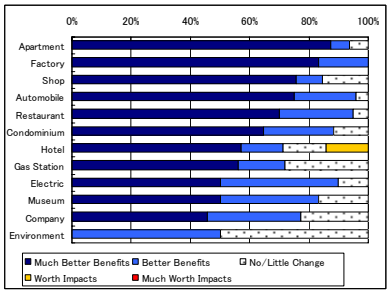
《about Increase Earnings, Sales and/or A Number of Customers》

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%



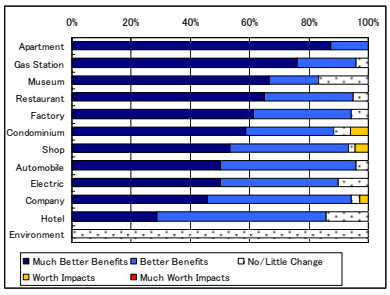
《about Improve Conveniences for Employees and/or Business Customers》

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%



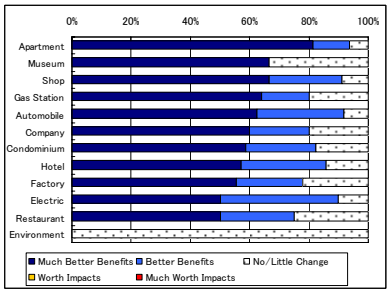
《about Reduce Times for Transport》

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%



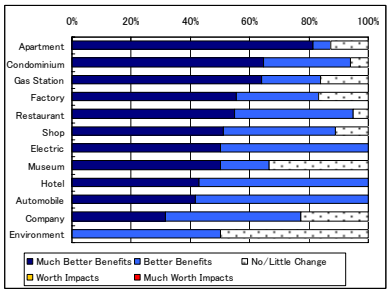
《about Improve Access to Useful Facilities》

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%



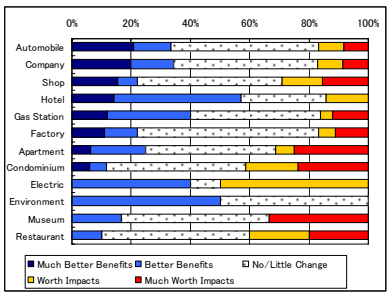
《about Improve Access in Emergency (hospital)》

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%



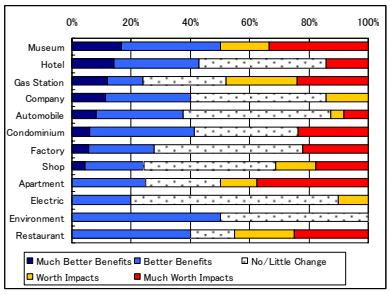
《about Increase Land Prices》

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-5

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.

<u>October 24 (Sat), 2009</u>

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.

October 27 (Tue), 2009

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.

October 31 (Sat), 2009

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.

November 01 (Sun), 2009

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.