

Kingdom of Thailand

FY2017 Ex-Post Evaluation of Japanese ODA Loan Project

“Chao Phraya River Crossing Bridge at Nonthaburi 1 Road”

External Evaluator: Keishi Miyazaki, OPMAC Corporation

0. Summary

The objectives of this project were to alleviate traffic congestion and to improve transportation efficiency in the Bangkok Metropolitan Area by constructing a bridge crossing the Chao Phraya River at a site in Nonthaburi Province where serious traffic congestion prevailed, thereby contributing to the activation of industries and improvement of the urban environment. The relevance is high, as the objective was consistent with Thailand’s development policies and development needs as well as with Japanese ODA policies. The efficiency of this project is fair, as although the project cost was within the plan, the project period exceeded the plan. The operation and effect indicators of this project, such as an increase in the annual average daily traffic volume, a saving in vehicle operating cost and value of travel time, have attained their target values. An alternative route connecting the west and east sides of Nonthaburi Province over the Chao Phraya River was constructed by this project, and this has alleviated traffic congestion to some extent at peak hours on the adjacent Phra Nang Klao Bridge. This project had a certain effect on the relaxation of traffic congestion and on improvement in transport efficiency. Also, on the west bank of the Chao Phraya River in Nonthaburi Province, this project had a certain positive impact on the promotion of regional development, especially housing development. No negative impact on the natural environment was observed, and land acquisition and resident resettlement were appropriately executed in accordance with the related domestic laws and regulations of Thailand. Therefore, the effectiveness and impact of this project are high. Meanwhile, no problem has been observed in the institutional, technical and financial aspects of the operation and maintenance system, and therefore, the sustainability of the project’s effect is evaluated to be high.

In light of the above, this project is evaluated to be highly satisfactory.

1. Project Description



Project Location



Maha Chesadabodindranusorn Bridge
constructed by this project

1.1 Background

In 2008, the Bangkok Metropolitan Area, ¹ comprising the Bangkok Metropolitan Administration (BMA) and its five surrounding provinces, accommodated a population of approximately 10.07 million people and was the political and economic center of Thailand. Although the population growth of the entire Bangkok Metropolitan Area had been only around 1.5% in recent years, Nonthaburi Province and Pathum Thani Province surrounding the BMA recorded a population growth of approximately 14% and 26% respectively in the five years from 2003, which indicated a rapid acceleration of suburbanization. Also, the number of registered motor vehicles in the BMA increased by 1.4 times in nine years, from 4.02 million in 1998 to 5.71 million in 2007. As indicated by these figures, along with the economic recovery of Thailand after the Asian Financial Crisis, industrial activity in urban areas was revitalized, and traffic congestion in the Bangkok Metropolitan Area became aggravated owing to a transportation system that heavily relied on automobiles. Moreover, air pollution from motor vehicles was recognized as a problem, and efforts towards reducing the environmental load became a pressing issue.

Nonthaburi Province, the target area of this project, is divided into east and west areas on either side of the Chao Phraya River. Major provincial government agencies, such as the provincial government office, police station and general hospital were located in the east area, and the

¹ The Bangkok Metropolitan Area is composed of the Bangkok Metropolitan Administration (BMA) and its five surrounding provinces (Nonthaburi Province, Samut Prakan Province, Pathum Thani Province, Samut Sakhon Province, and Nakhon Pathom Province).

population density of the east area was higher than that of the west area. While 43% of the provincial population is in the east area, it accounts for 12% of the total land area of Nonthaburi Province. On the other hand, in the west area, there had been rapid development (including past Japanese ODA Loan projects) of an expressway network and a mass transportation network² and further commercial and residential development in the area was expected.

There were three bridges, Phra Nang Klao Bridge,³ the New Phra Nang Klao Bridge, Rama V Bridge⁴ connecting the areas of Nonthaburi Province, but there was the problem of traffic congestion in the mornings and evenings. Especially, in Nonthaburi Province, there was the need for improvement of air pollution through the alleviation of traffic congestion as the maximum concentration of ozone caused by exhaust gas emissions of motor vehicles was 1.75 times that of the environmental standard.

1.2 Project Outline

The objectives of this project were to alleviate traffic congestion and to improve transportation efficiency in the Bangkok Metropolitan Area by constructing a bridge crossing the Chao Phraya River at a site in Nonthaburi Province where serious traffic congestion prevailed, thereby contributing to the activation of industries and improvement of the urban environment.

Loan Approved Amount/ Disbursed Amount	7,307 million yen / 7,306 million yen
Exchange of Notes Date/ Loan Agreement Signing Date	September 28, 2010 / September 28, 2010
Terms and Conditions	Interest Rate 0.95% Repayment Period 20 years (Grace Period 6 years) Conditions for Procurement General Untied
Borrower / Executing Agency	Kingdom of Thailand / Department of Rural Road (DRR), Ministry of Transport
Project Completion	December 2014
Main Contractors	Sumitomo Mitsui Construction Co., Ltd. (Japan) / Italian-Thai Development Public Company Limited (Thailand) (JV)
Main Consultant	—

² The Japanese ODA Loan “Mass Transit System Project in Bangkok (Purple Line) (I) (II)” (Loan Agreement Year: 2008 and 2010)

³ Phra Nang Klao Bridge was constructed by the Japanese ODA Loan “Nonthaburi and Pathumthani Bridges Construction Project” (Loan Agreement Year: 1981)

⁴ Rama V Bridge was constructed by the Japanese ODA Loan “Wat Nakorn-In Bridge and Connecting Road Construction Project (I) (II)” (Loan Agreement Year: 1995 and 1996).

Related Studies (Feasibility Studies, etc.)	<ul style="list-style-type: none"> • Feasibility study on the Chao Phraya River crossing bridges in the Bangkok Metropolitan Area (Thai government, 1995) • Preparatory survey for the Chao Phraya River crossing bridge at Nonthaburi 1 Road construction project (supplemental feasibility study) (JICA, February 2010)
Related Projects	<ul style="list-style-type: none"> • The Project for Bridge Master Plan and Bridge Maintenance Ability in Rural Area (2011-2013) • Dispatch of Advisors for “Chao Phraya River Crossing Bridge at Nonthaburi 1 Road” (May-July 2010)

2. Outline of the Evaluation Study

2.1 External Evaluator

Keishi Miyazaki (OPMAC Corporation)

2.2 Duration of Evaluation Study

This ex-post evaluation study was conducted as follows:

Duration of the Study: August 2017 - August 2018

Duration of the Field Study: November 12 – 25, 2017, March 18 – 24, 2018

2.3 Constraints during the Evaluation Study

This project identified “improvement of the urban environment” as one of its impacts, and based on the descriptions contained in the appraisal documents, it might be seen to have accounted for “improvement of air pollution caused by exhaust gas emissions of motor vehicles in Nonthaburi Province”. In order to measure the improvement effects, it was necessary to collect data on “the maximum concentration of ozone resulting from exhaust gas emissions of motor vehicles in Nonthaburi Province” before and after project implementation. However, it is uncertain whether such data could have been provided by the Ministry of Natural Resources and Environment of the Thai government. Even if data had been available, it would have been very difficult to scientifically prove a causal relationship between the project and any change in the concentration of ozone since various external factors apart from gas emissions might affect the change. Therefore, this ex-post evaluation does not verify the impact on “improvement of the urban environment”.

3. Results of the Evaluation (Overall Rating: A⁵)

3.1 Relevance (Rating: ③⁶)

3.1.1 Consistency with the Development Plan of Thailand

At the time of the appraisal, enhancement of transport and logistics efficiency and environmental protection were raised as one of the objectives of *the 10th National Economic and Social Development Plan (2007-2011)*. The Plan also indicated the necessity for qualitative and quantitative improvement of the transport and logistic network which was a primary element in the improvement of Thailand's production structure for the strengthening of the country's productivity and competitiveness. It included development of the transport network by advancing each mode of transport mode, together with connecting roads, the promotion of effective transportation to reduce production costs, and the development of an efficient transport network between the Bangkok Metropolitan Area and its vicinities.

In addition, in *the Road and Bridge Sector Master Plan (2004)*, this project was positioned as a top priority project for improvement of the transport network connecting areas on both sides of the Chao Phraya River. Moreover, *the Strategic Plan of the Ministry of Transport (2005-2009)* identified the mitigation of traffic congestion in Bangkok and its vicinities, the improvement of the road network for better mobility, and the development of a road network linking to the mass transportation network as important strategic items.

At the time of ex-post evaluation, based on the concept of "Sufficiency Economy Philosophy", *the 12th National Economic and Social Development Plan (2017-2021)* aimed at reducing inequality in income and poverty, strengthening competition, improving the natural environment, enhancing administrative efficiency, and enhancing the social status of Thailand in the international society, setting the country out to become a "high-income country" as defined by the World Bank by 2026. Under the Plan, 10 development strategies were crafted. The 7th strategy, the "Promotion of Infrastructure and Logistics" included the improvement of regional road transportation capacity, that is, bottlenecks of traffic.

Furthermore, in *the Bridge Master Plan 2031* (prepared in 2012), a construction of 10 new bridges is planned in addition to the existing 22 bridges crossing the Chao Phraya River.⁷ In the Plan, the construction of two new bridges was due to be carried out between 2012 and 2016, with one of these bridges being covered by this project. As for the other bridge (Kiret Kang Bridge), although detailed design had already been completed, the commencement of construction works had been suspended as of November 2017 as budgetary approval by National Assembly was delayed. In the Plan, a forecast of traffic movement between the areas on both sides of the Chao Phraya River was conducted, and it was concluded that in the case that the

⁵ A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory

⁶ ③: High, ②: Fair, ①: Low

⁷ Plan to build 2 bridges from 2012 to 2016, 8 bridges between 2017 and 2021, and 1 bridge from 2022 to 2031.

construction of the 10 new bridges in the Plan does not progress, the total volume of traffic crossing the Chao Phraya River would continuously increase from 1.75 million PCU⁸/day in 2011 to 2.03 million PCU/day in 2021, and to 2.36 million PCU/day in 2031 (Table 1). Thus, the necessity of fostering transportation capacity of both sides of the Chao Phraya River remains confirmed.

Table 1: Forecast of Traffic Volume crossing the Chao Phraya River

Unit: PCU/day

Item	2011	2021		2031	
	Baseline	Master Plan Not Conducted	Master Plan Conducted	Master Plan Not Conducted	Master Plan Conducted
Traffic Volume	1,775,000	2,032,000	2,273,000	2,361,000	2,614,000

Source: Bridge Master Plan 2031, Ministry of Transport

3.1.2 Consistency with the Development Needs of Thailand

At the time of the appraisal, transportation between the west bank area of Nonthaburi Province and Bangkok city was limited to only the three bridges, Phra Nang Klao Bridge, New Phra Nang Klao Bridge, and Rama V Bridge causing problems of traffic congestion in the mornings and evenings. Also, in the Bangkok Metropolitan Area, a deterioration of air pollution became a serious problem, in particular, with the maximum concentration of ozone caused by exhaust gas emissions of motor vehicles in Nonthaburi Province being 1.75 times that of the environmental standard. This was recognized as an environmental problem. To respond to this situation, in addition to the existing bridges in Nonthaburi Province, there was a need to construct new bridges in order to achieve a relaxation of traffic congestion during the morning and evening peak hours.

At the time of the ex-post evaluation, the population, the gross provincial product (GPP) and the number of registered vehicles in Nonthaburi Province had been in an upward trend (Table 2). Even with the above-mentioned Bridge Master Plan 2031, it is predicted that the total traffic volume crossing the Chao Phraya River will rise in the future.

Table 2: Population, GPP, and No. of Registered Vehicles in Nonthaburi Province

Item	2012	2013	2014	2015	2016
Population (persons)	1,141,673	1,1156,271	1,173,870	1,193,711	1,211,924
GPP (million Baht)	199,005	219,491	268,806	287,685	N.A.
No. of registered vehicles	149,644	152,323	155,06	161,090	165,544

Source: Nonthaburi Province Statistical Office.

⁸ PCU (Passenger Car Unit) represents the “number of vehicles in terms of passenger cars” calculated by converting vehicle units of different types (e.g., trucks, buses, motorcycles) into passenger car units and multiplying the latter by a certain coefficient.

Meanwhile, thanks to the Japanese ODA Loan “Mass Transit System Project in Bangkok (Purple Line) (I) (II)”, the Purple Line, a Mass Rapid Transit (MRT) line, which runs from Khlong Bang Phai station in the northwest part of Nonthaburi Province to Bang Sue station in the northern part of Bangkok city (23km) opened in August 2016 and further connected with the MRT Blue Line⁹ in August of 2017. The Purple Line is expected to accommodate commuters from Nonthaburi Province to Bangkok city, however, owing to challenges such as a lack of connectivity with other rail lines, the number of passengers has been limited to 40,000 to 50,000 per day. As explained above, the speed of modal shift is slow, the means of the transportation between Nonthaburi Province and Bangkok city still heavily relies on automobiles. Therefore, there is a continuously high need for Maha Chesadabodindranusorn Bridge constructed by this project in terms of responding to the growing volume of traffic crossing the Chao Phraya River at the time of ex-post evaluation.

3.1.3 Consistency with Japan’s ODA Policy

At the time of the appraisal, *Japan’s Economic Cooperation Program for the Kingdom of Thailand* (revised in May 2006) set “mutual benefits” as a basic attitude for cooperation and attempted to promote cooperation such as “(i) Deepening and closing of interactions between Japan and Thailand, and sharing of the societal values of both countries”, “(ii) Stability, development and peace building in the Asian region”, “(iii) Establishment of trade and investment environments and strengthening of economic cooperation”, “(iv) Transfer of knowledge, technology and the experience of Japan”, and “(v) Enhancement of Japan and Thailand’s presence in the international society”. Following the Program, JICA pursued a policy to boost the facilitation of logistics in order to revitalize economic activities in industries stated in the “Trade Promotion Program”.

Considering that this project aimed at mitigating traffic congestion and improving transportation efficiency, the project was contributing to “(iii) Establishment of trade and investment environments and strengthening of economic cooperation” as well as with *JICA’s Trade Promotion Program*. Also, the project introduced a bridge construction method named Extradosed Bridge¹⁰ which had found many practical applications in Japan, with the method being introduced in Thailand for the first time. This was consistent with “(iv) Transfer of knowledge, technology and the experience of Japan”.¹¹

⁹ Between Bang Sue station and Hua Lamphong station (20.8km).

¹⁰ The extradosed bridge is a type of prestressed concrete bridge with an outer cable structure supporting the main girder with main tower and diagonal bracing. It has characteristics which combine a cable-stayed bridge and a girder bridge.

¹¹ There is a long history between the bridges over the Chao Phraya River and the Japan's ODA. Since the first Japanese ODA loan was extended to construction of Phra Pin-Klao Bridge in 1971, the Japanese government has supported many bridge construction projects over the Chao Phraya River. The target bridge of this project is the 14th bridge constructed by the Japanese ODA loan out of 22 bridges on the river.

Taking into account the situation described above, the project was consistent with Japan's ODA Policy at the time of the appraisal.

In light of the above, this project has been highly relevant to Thailand's development plan and development needs, as well as to Japan's ODA Policy. Therefore, its relevance is high.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

A comparison between the Plan and Actual of the project output summary for the target project is shown in Table 3.

Table 3: Project Output (Plan/Actual)

Item	Plan	Actual
(1) Bridge	Total length 460 m A 6-lane	Same as planned
(2) Road	Total length: 4.3 km including the length of the bridge A 6-lane	Same as planned
(3) Interchanges	Two locations	Same as planned
(4) Flyover	One location	Same as planned
(5) Consulting services (excluded from the scope of Japanese ODA Loan)	Detailed design, assistance in procurement, construction supervision, assistance in environmental and social considerations including environmental monitoring <Work Volume> International Expert: 40 M/M Local Expert: 40 M/M Supporting Staff: 1,403 M/M	Same as planned International Expert: 40 M/M Local Expert: 40 M/M Supporting Staff: 1,436 M/M

Source: JICA internal documents and DRR internal documents

The project outputs were produced as planned. Even though the consulting services were outside the scope of the Japanese ODA Loan, the works planned were conducted with self-financing on the Thailand side.

A bridge constructed by the project (Maha Chesadabodindranusorn Bridge) utilized a bridge construction method known as extradosed bridge, which was used in Thailand for the first time. An extradosed bridge has a less oppressive feeling than a cable-stayed bridge, and where the construction is of a middle-scale bridge with a length of about 100 to 200m, the extradosed bridge is superior to bridges constructed using other methods as it also reduces construction costs. Japan has much experience of constructing extradosed bridges, as the project implementation was through a joint venture between Japanese and Thai contractors, technology transfer was made from the Japan side to the Thailand side.

At the time of the appraisal, it was planned that a JICA expert would be dispatched to the project to provide support such as (i) review of shop drawings, design change/alterations, construction methodology, and quality assurance plans, and (ii) periodic site inspections to confirm progress, safety and quality of works during project implementation. This ex-post evaluation could not confirm whether detailed activities had been carried out by the JICA expert as work completion reports were not available. However, according to interviews with people involved in the project, it seems that at least, the JICA expert was actually dispatched during project implementation and it is likely that support was provided for (ii) periodic site inspections to confirm progress, safety and quality of works. It is considered that this work played a role in complementing and supporting construction supervision and environmental monitoring in terms of quality management which were conducted under the scope of the consulting services.

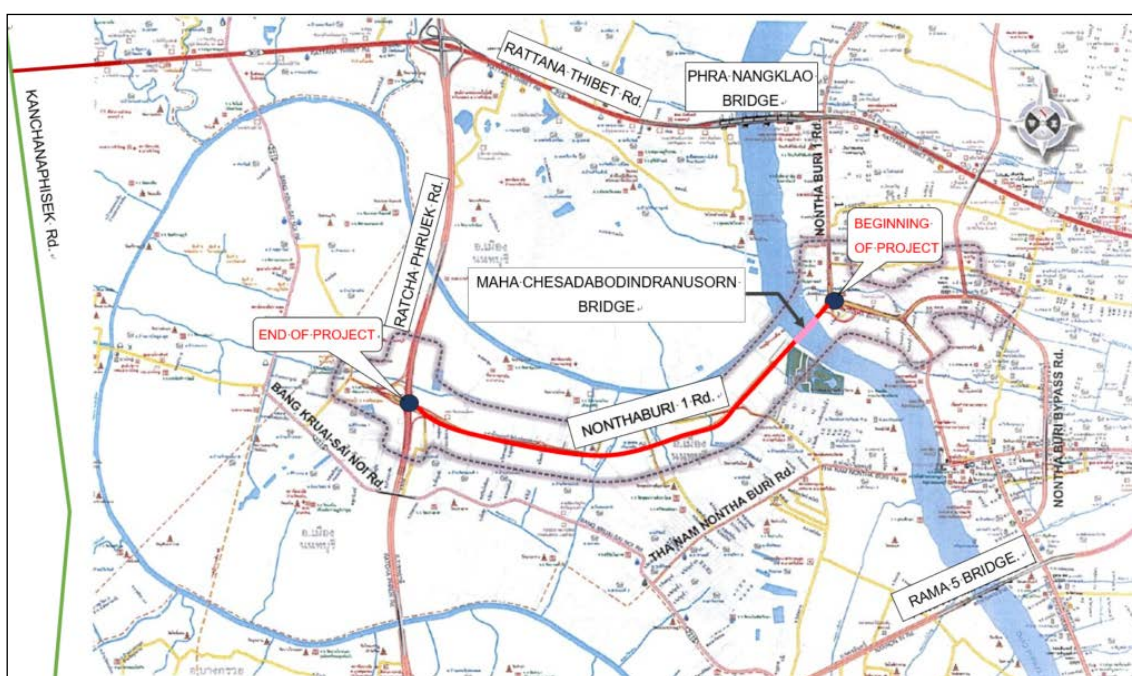


Figure 1: Project Site

3.2.2 Project Inputs

3.2.2.1 Project Cost

The actual project cost was 17,347 million yen against the planned cost of 20,470 million yen (ratio against the plan: 85%) and was within the plan (Table 4).

Table 4: Project Cost (Plan/Actual)

	Plan			Actual		
	JICA	Thai Gov.	Total	JICA	Thai Gov.	Total
	Million Yen	Million Yen	Million Yen	Million Yen	Million Yen	Million Yen
1. Civil works	7,165	3,070	10,235	7,165	3,072	10,237
2. Price escalation	89	1,518	1,607	0	0	0
3. Contingency	53	557	610	141	0	141
Subtotal	7,307	5,145	12,452	7,306	3,072	10,378
4. Consulting services	0	360	360	0	403	403
5. Land acquisition and resettlement	0	6,050	6,050	0	6,055	6,055
6. Administration costs	0	377	377	0	12	12
7. VAT	0	809	809	0	216	216
8. Import Tax	0	78	78	0	0	0
9. Interest during construction	0	300	300	0	263	263
10. Commitment charge	0	44	44	0	20	20
Total	7,307	13,163	20,470	7,306	10,041	17,347

Source: JICA internal documents and DRR internal documents

Note: The exchange rates used: 1 Baht = 2.75 Japanese yen (February 2010) at the time of the appraisal and 1 Baht = 2.88 Japanese yen (the average from 2010 to 2014) at the time of the ex-post evaluation.

The most significant factor in the reduction of the project cost was a saving in the cost of civil works. The actual total civil work cost, including price escalation and contingency, was 10,378 million yen against the planned cost of 12,452 million yen, which was a reduction of 2,074 million yen. This reduction was a result of international competitive bidding. Also, because of a change in the design, a relocation of utilities (electricity distribution lines) along with bridge/road construction works became unnecessary, and 20 million Baht (around 58 million yen) was saved, which was another factor contributing to a reduction in the project costs.

According to the DRR, an executing agency of the project, the DRR and the consultant strictly managed the project budget in cooperation with each other, issuing 39 variation orders for changes in the design and building structures so as not to exceed the budget. Also, the DRR completed payment for the constructor on time. These efforts by the executing agency for project management seem to have contributed to a project implementation within the planned budget.

3.2.2.2 Project Period

The actual project period was 52 months (from September 2010 to December 2014) against a planned project period of 38 months (from September 2010 to October 2013) (ratio against the plan: 137%). The actual therefore exceeded the planned (Table 5.)

Table 5: Project Period (Plan/Actual)

Item	Plan	Actual
Signing of L/A	September 2010	September 2010
Land Acquisition and resettlement	January 2010 - April 2011 (16 months)	January 2010 - April 2011 (16 months)
Consulting Services	November 2011 - October 2013 (24 months)	May 2012 - October 2014 (30 months)
Procurement of main contractors ^(Note)	March 2010 - April 2011 (14 months)	April 2010 - February 2012 (23 months)
Civil Works	May 2011 - October 2013 (30 months)	May 2012 - December 2014 (32 months)
Warranty Periods	October 2013 - October 2015 (24 months)	December 2014 - December 2016 (24 months)
Project Completion	October 2013	December 2014

Source: JICA internal documents, DRR internal documents

Note: The commencement for procurement of the main contractors was at the starting point of Pre- Qualification.

Of the 14-month delay in the project period, 9 months was due to a delay in procurement on the part of the main contractors, which was a significant cause. Three companies bid for the tender after the pre-qualification process, but it took a long time from the evaluation of tenders, to approval by the Government of Thailand, to the final signing of agreements with the chosen contractors. Also, a certain amount of time was taken up in passing through the approval processes within the DRR for the tender of consultants which meant a delay in the consultant starting their services. This was considered another of the reasons for the 14-months delay. It should be noted that the consulting services were mainly construction supervision and were conducted in parallel with the procurement of the main contractors. While the commencement of civil works and consulting services lagged, the lag was only 2 months, and the actual time spent on civil works was 32 months against the plan of 30 months.

The civil works for this project were completed in December 2014, and the project target bridge and road began to be utilized in the same month. By agreement, the warranty period of the contractor was 2 years after completion and, in principal, the period was from December of 2014 to December of 2016. However, in response to distortions of tiles on the bridge and laser receivers (monitoring equipment for cables) after project completion, the warranty period was extended for 6 months, and it ended in June 2017.

3.2.3 Results of Calculations for Internal Rates of Return (Reference only)

The Economic Internal Rate of Return (EIRR) for the project at the time of the appraisal was 22.1%. The preconditions for the calculation of EIRR are shown in Table 6. The Financial Internal Rate of Return (FIRR) was not calculated at the time of the appraisal. The recalculation of EIRR was conducted at the time of the ex-post evaluation, and the result was almost the same as at the time of the appraisal, showing 22.5%.

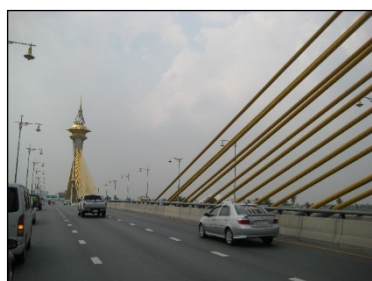
Table 6: EIRR at the Time of the Appraisal of this Project

Item	Description
Financial Internal Rate of Return (FIRR)	FIRR was not calculated because the collection of the fee was not conducted.
Economic Internal Rate of Return (EIRR)	22.1%
Cost	Project Cost (except VAT), Operation and Maintenance Cost
Benefits	Effect of savings in running costs, effect of saving in running time
Project Life	20 years

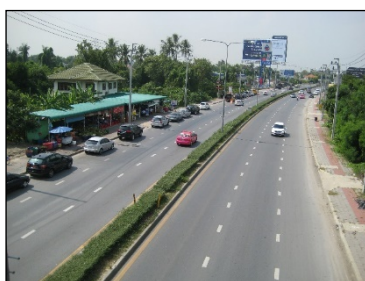
Source: JICA internal documents

In light of the above, although the project cost was within the plan, the project period exceeded the plan. Therefore, the efficiency of this project is fair.

Bridge, Road, and other facilities constructed by this project



Maha Chesadabodindranusorn Bridge



Nonthaburi 1 Road



Interchange at the east bank side

3.3 Effectiveness and Impacts¹² (Rating: ③)

3.3.1 Quantitative Effects (Operation and Effect Indicators)

(1) Annual Average Daily Traffic Volume (AADT)

For the annual average daily traffic volume (AADT), a target value of two years after project completion of the project target bridge (Maha Chesadabodindranusorn Bridge) was set at the time of the appraisal. The AADT from 2015 and 2016 for the target bridge and the adjacent Phra Nang Klao Bridge and Rama V Bridge are shown in Table 7 below.

¹² Sub-rating for Effectiveness is to be put with consideration of Impacts.

Table 7: Annual Average Daily Traffic Volume

Unit: PCU/day

	Baseline	Target	Actual	Actual	Actual	Actual
	2009	2015	2014	2015	2016	2017
	Appraisal	2 years after project completion	Project completion year	1 year after project completion	2 years after project completion	3 years after project completion
Maha Chesadabodindranusorn Bridge	—	46,800	N.A.	27,313	47,034	N.A.
(Reference)						
Phra Nang Klao Bridge (Old)	N.A.	—	N.A.	46,695	33,768	N.A.
Phra Nang Klao Bridge (New)	N.A.	—	N.A.	81,278	66,278	N.A.
Phra Nang Klao Bridge (Total)	N.A.	—	N.A.	127,973	100,046	N.A.
Rama V Bridge	N.A.	—	N.A.	84,427	85,827	N.A.

Source: JICA internal documents and DRR internal documents.

Note1: The commencement of operation of Maha Chesadabodindranusorn Bridge was December 2014.

Note2: The actual data for 2015 was measured in March 2015 (3 months after project completion), that for 2016 was measured on 23rd March 2016 (1 year and 4 months after project completion).

The AADT from 2016 for Maha Chesadabodindranusorn Bridge was 47,034 PCU/day, achieving the target value of 46,800 PCU/day in the target year (2 years after project completion). Meanwhile, the AADT for Maha Chesadabodindranusorn Bridge reached 47,034 PCU/day in 2016 from 27,313 PCU/day in 2015, an increase of 19,721 PCU/day for one year. Phra Nang Klao Bridge (the total for the old and new bridges) saw a reduction in 27,927 PCU/day from 127,973 PCU/day in 2015 to 100,046 PCU/day in 2016. Rama V Bridge saw a rise in 1,400 PCU/day for the same period.

Based on the above, it could be thought that around 70% of the reduced traffic volume for Phra Nang Klao Bridge from 2015 to 2016 might have been due to a detour to Maha Chesadabodindranusorn Bridge. On the other hand, considering that the 2016 actual value was measured in March 2016, there is little possibility that the MRT Purple Line, which opened in August 2016, had an effect on the reduction in the traffic volume of Phra Nang Klao Bridge for the same period.

It should be noted that Nonthaburi 1 Road finishes at the intersection of Ratcha Phruek Rd. at present, but that the DRR plans to extend Nonthaburi 1 Road approximately 4 km to Kanchana Phisek Rd. (National Road No. 9) running parallel to the west side of Ratcha Phruek Rd. In the future, if this plan is realized, it is expected that the traffic volume for Nonthaburi 1 Road and Maha Chesadabodindranusorn Bridge will further increase.

(2) Savings in Vehicle Operating Cost (VOC), Savings in Value of Travel Time (VOT)

For savings in vehicle operating cost (VOC) and value of travel time (VOT), target values for 2 years after project completion were set respectively at the time of the appraisal. Table 8 shows

the costs for the savings in VOC and VOT after project completion, which was calculated with the recalculation of the above-mentioned EIRR. The costs for the savings in VOC and VOT for 2 years after project completion achieved each of the target values set.

Table8: Savings in Vehicle Operating Cost and Savings in Value of Travel Time

Unit: Million Baht/year

	Baseline	Target	Actual	Actual	Actual	Actual
	2009	2015	2014	2015	2016	2017
	Appraisal	2 years after project completion	project completion year	1 year after project completion	2 years after project completion	3 years after project completion
Savings in Vehicles Operating Cost (VOC)	—	278.2	N.A.	252.5	279.6	345.6
Savings in Value of Travel Time (VOT)	—	2,064.9	N.A.	1,873.6	2,075.2	2,276.8

Source: JICA internal documents.

Note: The commencement of operation of Maha Chesadabodindranusorn Bridge was in December 2014.

(3) Traffic Volume and Volume to Capacity Ratio at Peak Hours (Additional Indicator)

The ex-post evaluation used the traffic volume and volume to capacity ratio at peak hours for Maha Chesadabodindranusorn Bridge and 2 adjacent bridges as additional indicators to measure the relaxation of traffic congestion. They were not, however, included into the operation and effect indicators set at the time of the appraisal. The results can be seen in Table 9.

The actual data for the predicted value for three years after project completion (2017) for Maha Chesadabodindranusorn Bridge and the 2 nearby bridges could not be obtained. Therefore, while referring to the predicted value for three years after project completion, it was decided that this ex-post evaluation would analyze mainly the change in traffic volume and volume to capacity ratio at peak hours for each bridge in the year 2015 to 2016.

The traffic volume at peak hours of Phra Nang Klao Bridge decreased by about 22% from 8,284 PCU/hour in 2015 to 6,494 PCU/hour in 2016, and the volume to capacity ratio at peak hours also reduced from 1.11 in 2015 to 0.87 in 2016. As of 2016, the volume to capacity ratio was less than the predicted value of 0.91 in 2017 for a temporary period of time. However, there is a possibility that the congestion of Phra Nang Klao Bridge may turn back gradually in the future. Meanwhile, the traffic volume at peak hours of Rama V Bridge decreased by about 9% from 5,714 PCU/hour in 2015 to 5,219 PCU/hour in 2016, and the volume to capacity ratio at peak hours was slightly reduced from 1.27 in 2015 to 1.16 in 2016. However, the volume to capacity ratio exceeded the baseline value of 1.01 in 2009, and it can be seen that the traffic volume at peak hours on Rama V Bridge has escalated at a level exceeding the assumption made at the time of the appraisal.

Table 9: Traffic Volume and Volume to Capacity Ratio at Peak Hours

Unit: Traffic volume at peak hours: PCU/hour,

Volume to capacity ratio at peak hours: Traffic volume/traffic capacity

	Baseline	Predicted	Actual	Actual	Actual	Actual
	2009	2016	2014	2015	2016	2017
	Appraisal	Three years after project completion	Project completion year	1 year after project completion	2 years after project completion	3 years after project completion
Maha Chesadabodindranusorn Bridge (6 Lanes)						
Peak Traffic Volume	—	3,159	N.A.	2,215	3,957	N.A.
Volume to Capacity Ratio at Peak Hours	—	0.70	N.A.	0.49	0.88	N.A.
Phra Nang Klao Bridge (10 Lanes)						
Peak Traffic Volume	2,465	6,796	N.A.	8,284	6,494	N.A.
Volume to Capacity Ratio at Peak Hours	0.82	0.91	N.A.	1.11	0.87	N.A.
Rama V Bridge (6 Lanes)						
Peak Traffic Volume	4,564	3,945	N.A.	5,714	5,219	N.A.
Volume to Capacity Ratio at Peak Hours	1.01	0.88	N.A.	1.27	1.16	N.A.

Source: JICA internal documents and DRR internal documents.

Note1: The operation of Maha Chesadabodindranusorn Bridge started in December 2014.

Note2: The actual data for 2015 was measured in March 2015 (3 months after project completion), that for 2016 was measured on 23rd March 2016 (1 year and 4 months after project completion).

Note3: Peak hours are defined as morning peak hours (07:00-08:00).

Note4: The 2009 baseline data for Phra Nang Klao Bridge is only for old Phra Nang Klao Bridge (4 lanes).

Based on these facts, comparing the actual data for 2015 and 2016, it can be seen that the volume to capacity ratio at peak hours for Phra Nang Klao Bridge was eased by approximately 22% after completion of the project. This is highly likely to be because some of the traffic for Phra Nang Klao Bridge started to detour to Maha Chesadabodindranusorn Bridge. On the other hand, a notable effect on improvement of the volume to capacity ratio at peak hours for Rama V Bridge as a result of the project cannot be observed. Rather, the volume to capacity ratio at peak hours for Rama V Bridge had deteriorated in comparison with that at the time of the appraisal. Regarding the relaxation of the volume to capacity ratio at peak hours for Phra Nang Klao Bridge between 2015 and 2016, considering that the actual data for 2016 is based on the data surveyed in March 2016, there no influence of the MRT Purple Line which opened in August 2016 can be detected.

(4) Number of Traffic Accidents (Additional indicator)

This ex-post evaluation conducted data collection and analysis on the number of traffic accidents as an additional indicator, despite the fact that the indicator was not included in the operation and effect indicators set at the time of the appraisal.

In terms of the “Number of Traffic Accidents” for the target bridge and two adjacent bridges, there were difficulties in collecting data as neither the DRR nor the local police station stored accurate records. The number of traffic accidents shown in Table 10 is the traffic accident data

provided by Road Accident Victims Protection Co. Ltd.,¹³ but this covers only the number of traffic accidents for which insurance payout was requested from insurance companies. According to the data, two traffic accidents were recorded on Maha Chesadabodindranusorn Bridge, in 2015 and 2017, respectively. The primary cause of the accidents was speeding by the driver. However, as there was a DRR statement that there were a number of minor collisions with either other cars or objects, it is thought that the actual number of the traffic accidents exceeds the actual value in Table 10.

Table 10: Number of Traffic Accidents

	Unit: Number/Year							
	2010	2011	2012	2013	2014	2015	2016	2017
					Project completion year	1 year after project completion	2 years after project completion	3 years after project completion
Maha Chesadabodindranusorn Bridge	—	—	—	—	0	2	0	2
Phra Nang Klao Bridge	0	0	0	0	0	0	0	0
Rama V Bridge	0	0	0	0	0	0	0	0

Source: Road Accident Victims Protection Co. Ltd.

In 2017 the DRR started the operation of an Accident Report Management System (ARMS) which collects, records and analyzes traffic accident information for the roads under DRR management nationwide. At the moment, ARMS deals only with traffic accident data for rural roads and does not cover data for traffic accidents taking place on roads and bridges in Bangkok city, including those of the project. According to the DRR Traffic Safety Bureau, 12 bridges across the Chao Phraya River under DRR management are to be covered by ARMS from March 2018.

Meanwhile, users of Maha Chesadabodindranusorn Bridge reported that the design of the interchange on the east side of the bridge is complicated, and that it is difficult for users unfamiliar with it to use the Bridge smoothly. Also, as it is hard to read the traffic signs at the entry point from the general road to the bridge and at the branch point, there are spots where accidents frequently occur. The DRR confirmed several safety issues, including the design of the east side interchange, through an impact survey of the target bridges and roads which was carried out in 2015. Based on results of the survey some remedial measures have already been implemented such as the installation of barriers at junction and branching points of the bridge. Also, there is too much information on one signboard, making it difficult for drivers to see necessary information at a glance. The DRR therefore plans to rewrite the information on the signboards by the end of 2018 so as to make it simple and easier to comprehend.

¹³ Road Accident Victims Protection Co. Ltd is a company established based on the Protection for Motor Vehicle Accident Victims Act B.E. 2535 and provides services for motor vehicle accident victims across the country. Currently 59 insurance companies are its stockholders.

3.3.2 Qualitative Effects (Other Effects)

(1) Alleviation of Traffic Congestion

The Rattana Thibet Road, a main trunk road, where Phra Nang Klao Bridge is located, crosses from the east to the west side of Nonthaburi Province and carried a high volume of traffic on a daily basis. The traffic congestion in the direction of Bangkok is particularly intense, especially at peak hours in the morning.

According to a representative of the taxi association of Nonthaburi Province, to pass through a 4 km section from Phra Nang Klao Bridge to the Khae Rai Intersection (in the direction of Bangkok city) where the Rattana Thibet Road and the Tiwanon Road intersect, used to take 1.5 to 2 hours at morning peak hours and this was the most heavily jammed section in Nonthaburi Province. With the construction of Maha Chesadabodindranusorn Bridge and Nonthaburi 1 Road by the project, drivers became able to avoid this most congested section.

As already mentioned, it was found that the volume to capacity ratio at peak hours decreased by 22% for Phra Nang Klao Bridge during the year from 2015 to 2016. It is assumed that the development, through the project, of an alternative route providing a detour from Rattana Thibet Road, including Phra Nang Klao Bridge, had a certain effect on alleviating the traffic congestion on this road.

(2) Improvement of Transport Efficiency

In Nonthaburi Province there are many canals and water transportation using the canals is frequently used. Residents of the target area of the west bank area, therefore, generally use boats rather than using the existing busy Phra Nang Klao Bridge and Rama V Bridge when visiting the east bank area where the provincial government office, major public facilities and commercial areas are concentrated. Since the east bank area has a large market, farmers in the west area have used boats as means of transportation to carry farm products and fruit. Following completion of the project however, farmers began to use overland methods of transport, improving convenience and safety in mobility and transportation.

Also, for the west bank area of Nonthaburi Province, improvements in accessibility to the center of the Province and to the east side of the Chao Phraya River where Bangkok city is located are an absolutely necessary condition for daily commuting and economic activities. Traffic congestion on Rattana Thibet Road including Phra Nang Klao Bridge was relaxed by the project to a certain extent, and this led to shorter traveling time for users of the roads.

Thus, this project seems to have had a certain effect on improving transport efficiency between the west and the east bank areas of Nonthaburi Province on either side of the Chao Phraya River.

3.4 Impacts

3.4.1 Intended Impacts

(1) Promotion of Regional Development in the West Bank Area of the Chao Phraya River in Nonthaburi Province

<Promotion of Housing Development>

Before the project, the project target area along Nonthaburi 1 Road was mainly agricultural land. However, during the implementation of this project, housing development proceeded along Nonthaburi 1 Road in the west bank area of the Chao Phraya River, and primarily new residential areas were formed. Large-scale housing development projects were implemented at 5 locations alongside Nonthaburi 1 Road during the project, and 738 houses were constructed (Table 11). Apart from this, there were also individual houses newly constructed along the road. Following these, commercial and service industries such as restaurants, gas stations, shops and car repair shops, newly opened along the road. According to the Bang Krang Sub-District Office, the project target area has been changing

from a traditional rural community to an emerging urbanized community.

However, since, in the Nonthaburi Province land plan, the area around Nonthaburi 1 Road in the west bank area of the Chao Phraya River is designated as a low-density housing area, the purpose of land use is limited to housing, commercial and service, and the construction of factories and so on is not approved. Also, some areas are limited to agricultural land. Therefore, the target area of the project seems to have been gradually developed as a dormitory town for the Bangkok Metropolitan Area.

<Population Growth>

The area of Nonthaburi 1 Road covered by the project belongs to the administrative division of the Bang Krang Sub-District in the Mueang Nonthaburi District. The registered population in the area expanded by more than 2,200 in the five years from 2012 to 2017. This is on a par with the 40% of the 5,757 increase in the Mueang Nonthaburi District during the same period. The annual average population growth rate in the Bang Krang Sub-District during the same period was 2.4%, exceeding that of 1.5% in Nonthaburi Province (Table 12).

Table 11: New Housing Projects

Name of Housing Projects	No. of Houses
Thanasiri Ratchaphruek – Thanam Non	175
CASA Villa-Ratchaphruek-Rama 5	133
Manthana - Ratchaphruek	206
Bangkok Boulevard	161
Airi (Ananda)	63
Total	738

Source: Survey by the evaluator



New Housing Project (Thanasiri)

Table 12: Population in the Bang Krang Sub-District and Nonthaburi Province

Unit: Persons

Item	2012	2013	2014	2015	2016	2017	Growth rate
Bang Krang Sub-District ^(Note)	19,631 (9,806)	20,007 (10,181)	20,678 (10,457)	21,151 (11,665)	21,592 (11,808)	21,887 (11,986)	2.4%
Nonthaburi Province	1,141,673	1,151,271	1,173,870	1,193,711	1,211,924	N.A.	1.5%
- Mueang Nonthaburi District	357,355	358,006	359,882	362,450	363,112	N.A.	0.4%
- Bang Kruai District	116,261	118,981	122,033	125,549	129,439	N.A.	2.7%
- Bang Yai District	126,562	130,826	135,171	138,982	143,094	N.A.	3.1%
- Bang Bua Thong District	252,179	255,655	59,337	263,625	268,521	N.A.	1.6%
- Sai Noi District	59,494	60,322	61,229	62,573	63,865	N.A.	1.8%
- Pak Kret District	229,822	232,481	236,218	240,532	243,893	N.A.	1.5%

Source: Bang Krang Sub-District Office and Nonthaburi Province Statistical Office.

Note: Bang Krang Sub-District belongs to Mueang Nonthaburi District. The numbers enclosed in brackets is the number of households.

<Rise in Land Prices>

Before and after implementation of the project, land prices along Nonthaburi 1 Road rose sharply. This ex-post evaluation surveyed land price data (official price) after completion of the project in 2012 and 2016 at 3 selected places along Nonthaburi 1 Road, to find that prices had risen 1.3 to 1.5 times in 4 years (Table 13). However, the land price shown below is the official price, and the market price actually traded is higher than this. According to the Bang Krang Sub-District Office, although the land price (market price) for the areas within 100 meters of Nonthaburi 1 Road was 5-6 million Baht/rai (1 rai = 1,600 m²) before the project, it is currently 35-45 million Baht/rai, about a 7-fold increase. According to the Nonthaburi Real Estate Association, not only this project, but the opening of the MRT Purple Line in August 2016 was also a factor in the recent rise in land price.

Table 13: Official Land Price at Selected 3 Locations along Nonthaburi 1 Road

Unit: Tarangwah, 1 Tarangwah=4m²

Item	Location	2012	2016	Plot No.
Gas Station	Approximately 1.8 km from the intersection with Ratcha Phruet Road	19,500	30,000	23
Bang Krang Sub-District Office	Approximately 1.3 km from the intersection with Ratcha Phruet Road	20,000	30,000	34, 35
Commercial Building	Approximately 500 m from the intersection with Ratcha Phruet Road	30,000	40,000	92

Source: Department of Land, Nonthaburi Province.

<Increase in Tax Revenue>

In the five years from 2012 to 2017, the tax revenues of the Bang Krang Sub-District increased by about 1.8 times. This increase had been largely due to a rise in the tax revenues from land and housing taxes following the advance of housing development (Table 14).

Table 14: Tax Revenue of Bang Krang Sub-District

Item	Unit: 1,000Baht					
	2012	2013	2014	2015	2016	2017
Land and Housing Tax	2,161	3,054	3,840	4,580	4,850	4,984
Local Maintenance Tax	161	138	120	119	135	110
Signboard Tax	2,173	3,207	3,412	3,758	2,952	3,014
Total	4,495	6,399	7,372	8,457	7,937	8,108

Source: Bang Krang Sub-District Office

<Promotion of the Regional Economy>

According to the taxi association of Nonthaburi Province, the route newly constructed by the project between both areas of the Chao Phraya River within the Province has enabled taxies to conduct their businesses more efficiently. Additionally, through the housing development in the area alongside Nonthaburi 1 Road, new customer segments have appeared, and the number of passengers and taxi company sales within the Province have increased. For the taxi company interviewed, there had been a 50 to 60 increase in the number of passengers per shift (12 hours for a shift and 2 shifts per day) and sales had risen by 20 to 25% since the project.

To sum up, in the area surrounding Nonthaburi 1 Road targeted by the project, positive impacts were observed such as the promotion of housing development, population growth, rises in land price, and increases in tax revenue and in the sales for taxi companies in the Province. Therefore, this project is considered to have brought a certain positive impact on the promotion of regional development in the west bank area of the Chao Phraya River in Nonthaburi Province.

3.4.2 Other Positive and Negative Impacts

(1) Impacts on the Natural Environment

This project was given a Category A based on the *JBIC Guidelines for Confirmation of Environmental and Social Considerations* (April 2002) for the bridge sector and the sensitive sectors, characteristics and areas (large-scale involuntary resettlement). An Environmental Impact Assessment (EIA) report on this project was not obligatory under Thai domestic law but was prepared in October 2005. However, it was assumed that the project area was not located in or near sensitive areas such as national parks and that therefore undesirable effects on the natural environment were minimal.

During project implementation, an environmental monitoring and an analysis for air, noise and vibration were conducted by the contractor every 3 months, and its monitoring results satisfied the environmental standard value of Thailand. This ex-post evaluation checked documents including the environmental monitoring report and interviewed related persons. It was found that environmental monitoring was carried out according to prescribed procedures, and it was confirmed that no particular problems with air, noise and vibration, occurred during

implementation. Environmental monitoring was conducted by the DRR for two years after completion of the project, but periodic environmental monitoring has not been implemented since then. The DRR is to take necessary measures each time there is a complaint about the environment from the local administration or residents. However, at the time of the ex-post evaluation, there had been no complaints about the environment related to the project.

Therefore, no negative impact on the natural environment is observed.

(2) Land Acquisition and Resettlement

In this project, land acquisition of about 23 ha occurred, which affected 447 households. Of these, 133 households were subject to resettlement (Table 15). The resettlement procedure was based on the resettlement implementation plan, and the resettlement of all 133 households was physically completed before the start of construction.

Table 15: Land Acquisition and Resettlement associated with this Project

Target Area	Private Land	Affected Households	Resettled Households
Interchange at the starting point	4.87 ha	78	43
Interchange at the ending point	6.78 ha	120	34
Bridge and Access Road	11.39 ha	249	56
Total	23.04 ha	447	133

Source: JICA internal documents

Compensation procedures for the land acquisition and resettlement were conducted in accordance with related laws such as *the Land and Property Exploitation Act BE 2530*¹⁴ and the guidelines of the Ministry of Transport. The compensation was basically a monetary compensation based on a replacement cost. The project did not prepare a resettlement area for resettled residents. The targets of compensation included land, buildings, trees, crops, moving costs, a certain amount of income losses to business owners, and compensation for tenants. The income restoration programs for resettled residents were not conducted.

On the other hand, according to the DRR, 47 lawsuits concerning the land acquisition and resettlement of the project have been filed against them, and 39 cases were pending at the administrative tribunal at the time of ex-post evaluation. The purpose of the lawsuits is mainly to demand an increase in the compensation price due to dissatisfaction with the proposed compensation price. However, these did not result in delays in land acquisition.

¹⁴ Based on the Land and Property Exploitation Act BE 253, the Compensation Estimation Committee was established, and the Committee verified the land ownership and evaluated the compensation price. The Committee members were the Governor of Nonthaburi Province, and representatives of Nonthaburi Land Department Officer, related municipality and district governments, DRR, and so on.

(3) Measures against Communicable Diseases such as HIV/AIDS

In this project, programs for measures against communicable diseases such as HIV/AIDS were implemented for construction workers as follows (Table 16).

Table 16: Prevention Program for Communicable Diseases such as HIV/AIDS

Contents	Timing, Times, Others
Implementation of baseline survey	November 2012
Implementation of advocacy campaigns for HIV/AIDS prevention	5 times
Implementation of institutional capacity building workplace policy	4 times
Implementation of peer education	23 times
Implementation of condom promotion	Distribution of 9,000 condoms
Monitoring and evaluation for preventive activities	2 times (Nov. 2013, Jan. 2014)

Source: DRR internal documents.

(4) Safety Management

One Thai worker was injured during the construction work on the elevated road on August 20, 2013, and thereafter, the worker died in hospital.¹⁵ After the accident occurred, in addition to the existing safety and health committee consisting of representatives of each company/contractor of the joint venture, a safety management committee, which mainly consists of the project managers and vice project managers, was established to analyze the causes of the accident, review the work process, hold safety management workshops, and to provide safety education to strengthen the safety supervision system.

In light of the above, the expected effects of this project have been mostly realized as planned. Therefore, the effectiveness and impacts of this project are high.

3.5 Sustainability (Rating: ③)

3.5.1 Institutional / Organizational Aspect of Operation and Maintenance

The operation and maintenance of the project facilities is handled by the Road Maintenance Bureau under the Department of Rural Roads (DRR), Ministry of Transportation. The DRR started maintaining the project facilities on July 15 2017 when the facilities were officially handed over from the contractor to the DRR after completion of the defect liability period. In the Road Maintenance Bureau, there are seven divisions: (i) planning, (ii) road maintenance, (iii) administrative, (iv) road assets, (v) system development, (vi) bridge maintenance (target area:

¹⁵ While pulling up a gondola lift for stretching work along with precast concrete construction works, the place to pull up the lift became skewed to one side of the girder for construction. The lock of wire rope caught the girder and the lift tipped to the wrong angle. However, the worker continued to hang the lift from the crane to the girder. Thereafter, the catch was disengaged during the work, the lift sprang up and he was injured when it smashed against the girder. The reason for the accident was considered to be a lack of communication between him and the operator.

the Bangkok Metropolitan Area), and (vii) bridge maintenance (target area: the whole country, excluding the Bangkok Metropolitan Area).

The Ratcha Phruek Road Maintenance Sub-office, which is the site office of the DRR, takes the responsibility for daily inspection of the target facilities. There are 20 staff members in the sub-office. None of them are bridging engineers, but the sub-office is able to inspect the bridge in cooperation with technical staff dispatched from the Road Maintenance Bureau. Meanwhile, the bridge has a monitoring system for its cable, which is managed by the Bridge Construction Bureau.

The total number of DRR staff is 4,700, including the 173 staff in the Road Maintenance Bureau. The DRR organogram is illustrated in Figure 2. According to the DRR, there is no major concern about the sufficiency of the number of staff. Therefore, no major issues have been observed in terms of the institutional aspects of operation and maintenance in the DRR.

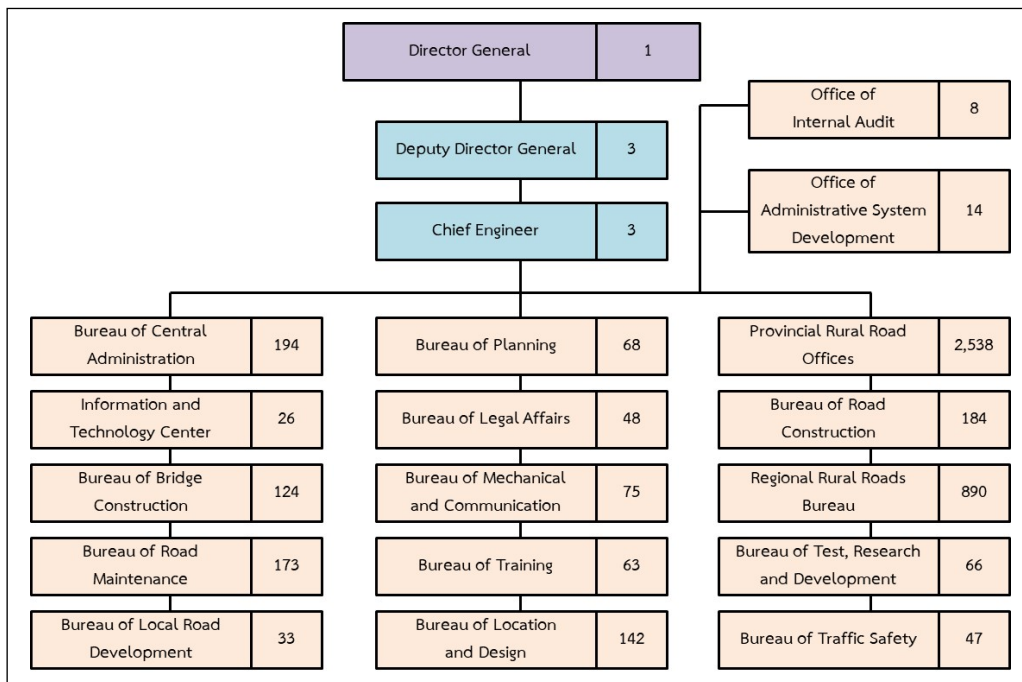


Figure 2: DRR Organogram

3.5.2 Technical Aspect of Operation and Maintenance

The Road Maintenance Bureau has a sufficient technical level with sufficient experience in maintaining local roads and small and medium-sized local bridges. In the Bureau, there is equipment for bridge maintenance, and the Training Bureau regularly conducts training on the maintenance of local roads and local bridges, on inspection of bridge damage, on the operation of maintenance equipment, and so on. Meanwhile, the specialized technology of large bridges such as Maha Chesadabodindranusorn Bridge is owned by the Bridge Construction Bureau

which operates and maintains large-scale bridges in cooperation with the Road Maintenance Bureau. On Maha Chesadabodindranusorn Bridge, a monitoring system for the tension and deflection of its cables has been installed, and the bridge is continuously monitored by the DRR site office (sub-office) and the Bridge Construction Bureau. This project provided training on monitoring systems to the DRR, and the DRR acquired the skills necessary for operation methods.

Two JICA Technical Cooperation projects, “A Survey for the Bridge Maintenance Planning (the Chao Phraya River crossing bridges) (2010-2011)” and “the Project for Bridge Master Plan and Ability Bridge Maintenance in Rural Area (2011-2013)” were conducted. In these technical cooperation projects, the following capacity development of DRR staff was carried out: (i) Formulation of a long-term bridge maintenance and management plan for 12 bridges managed by the DRR including Chao Phraya River Bridge, (ii) Preparation of a bridge inspection plan for 8,000 bridges under DRR jurisdiction in the Bangkok Metropolitan Area, (iii) Support for developing a Bridge Maintenance Management System (BMMS), and (iv) Preparation of a flood recovery countermeasure manual. According to the DRR, the methods of maintaining a cable-stayed bridge as passed on through the technical cooperation projects is useful because there was hitherto no experience in the DRR. The "Bridge Inspection Manual" created by the technical cooperation projects has also been in use continuously. The BMMS, however, is not currently used for various reasons. The DRR independently invented a new BMMS integrated with the database within the DRR and this is used at present.

The DRR has been conducting inspections of bridge damage and an evaluation survey¹⁶ from 2016 to 2018 for 12 bridges over the Chao Phraya River which are under DRR management, entrusting this to Thammasat University. The survey of 7 bridges have already been completed, and those of the remaining 5 bridges, including the target bridge for this project, are due to be completed by September 2018. Maintenance plans and maintenance budget plans for the 12 bridges, including the target bridge of the project, will be formulated later, based on the above survey results. Also, after the completion of this survey, training for technology transfer of bridge maintenance will be provided by Thammasat University to DRR staff. Thus, no major issues have been observed in terms of the technical aspects of operation and maintenance in the DRR.

3.5.3 Financial Aspect of Operation and Maintenance

The maintenance budget for roads and bridges under the DRR nationwide is shown in Table 17. According to the DRR Financial Bureau, the required maintenance budget was received and allocated based on the accumulation for each project every year, and there has been no problem with the allocation of the maintenance budget throughout the DRR. Although at the time of the

¹⁶ Development of Finite Element Monitoring Bridge Health and Evaluation System (Phase I, Phase II, and Phase III).

appraisal, an annual maintenance cost of 15 million Baht (about 5 million yen) was assumed for the project facilities, the DRR only started to maintain the project facilities officially after the termination of the warranty period in July 2017. The maintenance of the project facilities at the time of the ex-post evaluation was limited only to daily maintenance, and no significant expenditure has occurred so far.

As described above, based on the results of the damage inspection and evaluation survey currently underway, a maintenance budget plan for Maha Chesadabodindranusorn Bridge will be formulated after September 2018. Beyond the fiscal year of 2019, the maintenance budget of the facilities will be formally incorporated as part of the DRR budget.

Table 17: Operation and Maintenance Budget of DRR

Unit: Million Baht

	2014		2015		2016		2017	
	Budget	Actual	Budget	Actual	Budget	Actual	Budget	Actual
Maintenance fee of more than 10 million Baht per project ^(Note1)	3,465	3,465	4,400	4,400	4,322	4,322	5,500	5,500
Maintenance fee of less than 10 million Baht per project ^(Note2)	11,181	11,181	12,254	12,254	11,046	11,046	10,324	10,324
Total	15,850	15,850	16,654	16,654	15,369	15,369	15,824	15,824

Source: DRR

Note1: Regular inspections, emergency inspections, large-scale repairs such as overlay

Note 2: Mainly daily inspections

Table 18 shows the profit and loss statements of the DRR for the past three years from 2015 to 2017. Although the budget revenue and borrowing from the government, which was the main source of the revenue, varied from year to year, the over 50,000 million Baht revenue was secured every year. As for expenses, there were fluctuations every year, but personnel expenses, pensions, utility expenses, depreciation expenses and other expenses have been increasing every year. As the infrastructure assets such as roads and bridges owned by the DRR increased from 157,750 million Baht in 2015 to 174,957 million Baht in 2017, the depreciation expenses also increased, from 16,927 million Baht in 2015 to 18,917 million Baht in 2017. However, every year, the revenue exceeded the expenditure, and the marginal profit was carried forward to the next fiscal year. Meanwhile, the long-term debt declined from 11.6 million Baht in 2015 to 9.2 million Baht in 2017.

Thus, no major issues have been observed in terms of the financial aspects of operation and maintenance in the DRR.

Table 18: Profit and Loss Statement of the DRR

Unit: Baht

	2015	2016	2017
Revenue			
Budget revenue	53,277,568,186	47,272,851,395	50,344,855,746
Income from loans and other government revenues	2,909,540,962	12,481,817,750	300,108,715
Income from subsidies and donations	1,756,204	2,341,290	1,737,187
Other Income	0	0	49,858,753
Total	56,188,865,352	59,757,010,435	50,696,560,401
Expense			
Staff costs	2,195,700,010	2,310,237,142	2,342,165,436
Pensions	225,265,997	278,450,819	301,127,589
Remuneration	869,350	1,348,473	630,436
Usability costs ^(Note1)	17,974,210,045	21,800,533,323	18,646,232,257
Material costs	1,006,791,275	1,201,027,013	1,196,911,649
Utility costs	79,228,029	79,907,302	80,997,820
Depreciation	16,927,753,686	18,125,828,752	18,917,466,737
Cost of subsidies and donations ^(Note2)	251,473,528	206,218,297	166,761,403
Other expenses	59,395,492	29,151,325	43,901,169
Total	38,720,687,412	44,032,702,446	41,696,194,496
Balance (Profit/Loss)	17,468,177,940	15,724,307,989	9,000,365,905

Source: DRR

Note 1: Usability costs includes training costs, traveling costs, maintenance costs, lump-sum costs, consulting service fees, meeting costs, public relations costs, etc.

Note 2: The registration and membership fees for member organizations.

3.5.4 Status of Operation and Maintenance

As mentioned above, the DRR has officially been in charge of the maintenance of the project facilities since July 2017. The maintenance at the time of the ex-post evaluation was limited to daily maintenance, but the facilities are kept in a good condition. The maintenance plan for Maha Chesadabodindranusorn Bridge will be put together after September 2018.

Thus, no major issues have been observed in terms of the status of operation and maintenance in the DRR.

No major problems have been observed in the institutional, technical, financial aspects and current status of the operation and maintenance system. Therefore, sustainability of the project effects is high.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The objectives of this project were to alleviate traffic congestion and to improve transportation efficiency in the Bangkok Metropolitan Area by constructing a bridge crossing the Chao Phraya River at a site in Nonthaburi Province where serious traffic congestion prevailed, thereby contributing to the activation of industries and improvement of the urban environment. The

relevance is high, as the objective was consistent with Thailand's development policies and development needs as well as with Japanese ODA policies. The efficiency of this project is fair, as although the project cost was within the plan, the project period exceeded the plan. The operation and effect indicators of this project, such as an increase in the annual average daily traffic volume, a saving in vehicle operating cost and value of travel time, have attained their target values. An alternative route connecting the west and east sides of Nonthaburi Province over the Chao Phraya River was constructed by this project, and this has alleviated traffic congestion to some extent at peak hours on the adjacent Phra Nang Klao Bridge. This project had a certain effect on the relaxation of traffic congestion and on improvement in transport efficiency. Also, on the west bank of the Chao Phraya River in Nonthaburi Province, this project had a certain positive impact on the promotion of regional development, especially housing development. No negative impact on the natural environment was observed, and land acquisition and resident resettlement were appropriately executed in accordance with the related domestic laws and regulations of Thailand. Therefore, the effectiveness and impact of this project are high. Meanwhile, no problem has been observed in the institutional, technical and financial aspects of the operation and maintenance system, and therefore, the sustainability of the project's effect is evaluated to be high.

In light of the above, this project is evaluated to be highly satisfactory.

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

(1) Improvement of safety measures at the interchange of the target bridge

The designs of the junction and branching points in the east area interchange of the Maha Chesadabodindranusorn Bridge of the project are complicated, and users who are unfamiliar with them have difficulty in getting used to them. This is also a risk that causes accidents. For this reason, the DRR will install barriers at the junction and branching points and plans to take measures such as improving road signs during the year 2018. It is expected that the DRR will continue to improve the safety of the target bridges and roads of the project.

(2) Establishment of a method for recording and managing of traffic accident information

On the target bridges and roads, the DRR did not conduct the recording and managing of the number of accidents at the target bridges. In Thailand, organizations such as the police, the Department of Highways (DOH), the Ministry of Transportation, the Expressway Authority of Thailand (EXAT), the Ministry of Health (records of injured persons mainly sent to hospitals) and insurance companies, collect and record information on traffic accidents. However there is no system that can share and comprehensively use this information.

The DRR started the operation of an Accident Report Management System (ARMS) from 2017, and it is planned to include as subjects of ARMS the 12 bridges across the Chao Phraya River under DRR control since March 2018.

Recording and analyzing traffic accidents including the causes of accidents, damage and occurrence points is important for improving the safety of bridges and roads. It is recommended that the DRR utilize and expand ARMS and that it consider cross-organizational sharing and use of traffic accident information on roads and bridges in cooperation with related organizations such as local police authorities and insurance companies.

4.2.2 Recommendations to JICA

None

4.3 Lessons Learned

None

End

Comparison of the Original and Actual Scope of the Project

Item	Plan	Actual
1. Project Outputs		
(1) Bridge	Total length: 460 m A 6-lane	Same as planned
(2) Road	Total length: 4.3 km including the length of the bridge A 6-lane	Same as planned
(3) Interchange	Two locations	Same as planned
(4) Flyover	One location	Same as planned
(5) Consulting Service (excluded from the scope of Japanese ODA Loan)	Detailed design, Assistance for procurement, Construction supervision, Assistance for environmental and social considerations including environmental monitoring <Work Volume> International Experts: 40 M/M Local Experts: 40 M/M Supporting Staff: 1,403 M/M	Same as planned International Experts: 40 M/M Local Experts 40 M/M Supporting Staff: 1,436 M/M
2. Project Period	September 2010 – October 2013 (38 months)	September 2010 – December 2014 (52 months)
3. Project Cost		
Amount Paid in Foreign Currency	1,121 million yen	N.A.
Amount Paid in Local Currency	19,349 million yen (7,036 million baht)	N.A. N.A.
Total ODA Loan Portion	20,470 million yen 7,307 million yen	17,347 million yen 7,307 million yen
Exchange Rate	1 baht = 2.75 yen (As of February 2010)	1 baht = 2.88 yen (Average between 2010 and 2014)
4. Final Disbursement	January 2017	