LAO PEOPLE'S DEMOCRATIC REPUBLIC
MINISTRY OF PUBLIC WORKS AND TRANSPORT
DEPARTMENT OF ROADS

PREPARATORY SURVEY
ON
THE PROJECT
FOR
THE RECONSTRUCTION OF THE BRIDGES
ON
NATIONAL ROAD NO. 9
IN
THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

FINAL REPORT

FEBRUARY 2016

JAPAN INTERNATIONAL COOPERATION AGENCY

THE CONSORTIUM
OF
ORIENTAL CONSULTANTS GLOBAL CO., LTD.
AND
INTERNATIONAL DEVELOPMENT CENTER OF JAPAN

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PREFACE

Japan International Cooperation Agency (JICA) decided to conduct the preparatory survey on the Project for Improvement of National Road No. 9 as East-West Economic Corridor in Lao People's Democratic Republic (Lao PDR), and entrust the survey to the consultant(consist of Oriental Consultants Global Co., Ltd. and International Development Center of Japan).

The survey team held a series of discussions with the officials concerned of the Government of Lao PDR, and conducted field investigations. As a result of further studies in Japan, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Lao PDR for their close cooperation extended to the survey team.

February, 2016

NAKAMURA Akira
Director General,
Economic Infrastructure Department
Japan International Cooperation Agency

SUMMARY

1. Overview of the Lao People's Democratic Republic

Lao People's Democratic Republic (Lao PDR) is a landlocked country situated on the Indochina Peninsula stretching from north to south (north-south 1,000 km, east-west 100 to 450 km) bordered on the east by Vietnam, the west by Thailand, the south by Cambodia and the north by China and Myanmar. The country's total land area is 237,000 sq. km, which is almost the same as Japan's main island, Honshu. Its population is estimated to be approximately 6.77 million.

The climate of Lao PDR is influenced by tropical monsoons and divided into two seasons. Roughly April to October is the rainy season, and November to March is the dry season. The topography of the area within which National Road No. 9 is situated is flat between Savannakhet and Muang Phin, and there is mountainous terrain from Muang Phin to Densavan on the border with Vietnam. The average annual rainfall, between 1995 and 2014 measured on the level terrain in Savannakhet Province, was 1,649 mm; the highest at was approximately 1,990 mm per month, and the lowest was 1,170 mm. The average monthly rainfall was highest in August, at approximately 390 mm. Hardly any rain falls during the dry season; rainfall is less than 50 mm per month. On the other hand, the average highest temperature is over 30^0C. The lowest temperature is not lower than around 10^0C.

The country's GDP is US$12.5 billion (2015 IMF estimate), the per capita GDP is US$1,785 (2015 IMF estimate) and the growth rate of the GDP is 7.550 (2015 IMF estimate). The rate of the price escalation is 5.3%, the total trade volume of exports is approximately US$2.4 billion, and imports are approximately US$2.52 billion. The main trade items are mining, agriculture/forest, sewing, and electric power for export, investment and consumer goods for import. The main industries of Lao are service (39%), agriculture (25%), manufacturing industry (28%), and taxes/tariffs (17.6%).

2. Background, circumstances, and outlines of the requested project

Lao PDR is geographically a land-locked country and the traffic flow physically connecting it with neighboring countries via road transport is vital. Especially, National Road No. 9 (NR9), which is a part of the East-West Economic Corridor (EWEC), is an international trunk road connecting northeastern Thailand and the middle of Vietnam. This is an extremely important position to function as an important infrastructure serving ASEAN integration at the end of 2015 and the road contributing to the regional economic development of the central southern area in Laos.

Many bridges on NR9 were developed under assistance from the former Soviet Union and Vietnam in 1980s and contain many structural problems that are currently coming to the surface. Xe Kum Kam and Xe Tha Mouak Bridges, the target bridges of this project, were constructed under assistance from the Czech Republic and present issues, such as residual deflection due to the deficient load-carrying

capacity of the main girders according to the JICA study the "Preparatory Study for Improvement of Roads and Bridges in the Southern Region in Lao PDR" in 2010. These issues plus other bridge structural failures, such as breakage of main girders (pin bearing) in the middle piers, etc., make these bridges bottlenecks hindering smooth traffic flow. Their reconstruction was determined to be necessary in order to secure traffic safety. Under these circumstances, the Department of Road (DoR) requested grant aid for reconstruction of these two bridges.

The implementation of the project is to reconstruct both the Xe Kum Kam and Xe Tha Mouak bridges that secures safe and stable traffic flow on NR9 that will contribute to the development of infrastructure and economy of the surrounding regions along the EWEC.

3. Outline of survey results and substance of the project

The survey was conducted over a period of 10 months from April 2015 to January 2016. A preparatory survey team of eleven members were dispatched from April 16 to May 30, 2015, for the first field survey, and a preparatory survey outline explanatory survey team comprising five members was dispatched from September 10-20, 2015.

For the implementation of the survey, the request from the Lao side initially included both components of the replacement of two bridges namely, Xe Kum Kam and Xe Tha Mouak and the installation of weighbridge station. However, the scope of installation of a weighbridge which is supposed to be installed at the existing station nearby Donghen was excluded and added to a separate project for Improvement of Road Management Capability in Lao PDR (CaRoL) based on a discussion with MPWT (DOR) and decided by JICA. Accordingly, the project components have included Xe Kum Kam Bridge and Xe Tha Mouak Bridge.

National Road No. 9 (NR9), which is a part of the East-West Economic Corridor (EWEC), is an international trunk road. Therefore, it is preferred to recover the traffic flow which is diverted during the construction as early as possible because the one-way diversion inhibits the traffic flow. In order to reduce the period of diversion, bridge construction which can shorten the erection period is required. In addition, the target Bridges has been found that the planned high water level is higher than the bottom of existing girders based on flood record and study results. Therefore, the bridge type, which minimizes impact on surrounding approach road and reduces the height of girder, is required to apply. Finally, considering these conditions, the bridge type "Steel Concrete Composite Slab Bridge" is applied.

The on-the-job training together with the scheduled workshop scheduled in the soft components of the project will be undertaken during the construction stage. The legends of the two bridges are summarized respectively in Table 1 and Table 2.

Table 1 The Grade of Target Bridges

Name of Bridge		Xe Kum Kam Bridge	Xe Tha Mouak Bridge
Road Class		「Road Design Manual」 ASEAN Standards Class II	
Design Speed		80 km/h	80 km/h
Design Load		HS25-44	
Bridge Length		90.0 m	160.0 m
Width	Total	8.0 m	11.0 m
	Traffic Lane (Shoulder)	3.5 × 2 = 7.0 m (0.5 x 2)	3.5 × 2 = 7.0 m (0.5 x 2)
	Sidewalk	—	1.5 m × 2
Superstructure		3-span continuous steel concrete composite slab bridge	4-span continuous steel concrete composite slab bridge
Substructure		Abutment: Inverted-T type Piers: Wall type	Abutment: Inverted-T type Piers: Wall type
Foundation		Spread	Spread
Protection (Gabion)		28.8 m	31.8 m

Table 2 The Grade of Approach Roads

Name of Bridge		Xe Kum Kam Bridge	Xe Tha Mouak Bridge
Design Speed		80 km/h	80 km/h
Geometric	Crossfall	3%	
	Super-elevation	8%	8%
	Max. Grade	1.05%	1.6%
	Min. Horizontal Curve	R = 330 m	R = 345 m
	Shift	—	—
Road Length		L = 488.3 + 532.5 m	L = 554.3 + 480.7 m
Cross elements	Total	11.0 m	
	Traffic Lane	3.5 × 2 = 7.0 m	
	Shoulder	2.0 × 2 = 4.0 m (including soft shoulder)	
Pavement composition	Surface	5 cm (AC)	
	Binder	5 cm (AC)	
	Base	20 cm (Mechanical)	
	Subbase	30 cm (CR)	
	Subgrade	Design CBR = 6%	

4. Project Completion Time

The total implementation period is estimated to be 39 months including detailed design (5.0 months), tender assistance (3.0 months) and construction (31 months).

5. Project Assessment

(1) Adequacy

National Road No. 9, including both the Xe Kum Kam and the Xe Tha Mouak bridges, is a part of the East–West Economic Corridor (EWEC) connecting Mawlamyine in Myanmar, northeast Thailand, Savannakhet and Da Nang in Vietnam. The EWEC runs through inland cities such as Savannakhet and northeast Thailand to access international markets via the international seaport in Da Nang. In addition, 185 thousand people use NR9 in the eastern part of Savannakhet to access the provincial center, namely, Kaysone Phomvihane District, and these bridges are important facilities for the daily activity of village people in the vicinity area of the project.

In this study, adequacy of the projects is considered in terms of following aspects:

1) Coordination of the project with policy in Lao PDR

The 8th National Socio-Economic Development Plan (NESDP) 2016-2020 is established based on the evaluation of achievements of the previous 5-year national development plan, namely, the 7th NESDP (2011-2015), and approved by the National Assembly of Lao PDR. In the 8th NESDP, priority activities in the infrastructure sector include "Upgrade roads that connect to the neighboring countries such as the Mekong Sub-region corridors (GMS), Asian Highway, East-West Corridor, North-South Economic Corridor" and "Create comprehensive logistic systems by focusing on 4 areas: Natoei, Savannakhet, Vientiane, and Champasak" in order to achieve outcome 1, namely, "Sustained, inclusive economic growth with economic vulnerability (EVI) reduced to levels required for LDC graduation and consolidated financial, legal and human resources to support growth." In accordance with increasing importance of Savannakhet as a logistic center, strengthening of National Road No. 9, especially upgrading the bridge load-carrying capacity of the Xe Kum Kam and Xe Tha Mouak bridges is required and corresponds to the objective and context in 8th NESDP.

2) Importance of the bridges in the road netowrk in Lao PDR

The GMS consists of six countries, namely, Thailand, Vietnam, Laos, Myanmar, and China, and was established in 1992, initiated by the ADB to encourage provision of the regional transport network, economic growth promoted by regional trade and investment. For the regional cooperation, economic corridors have decided to connect major cities in the GMS, and improvement of the transport infrastructure project such as the international road network is planned and implemented. National Road No. 9, including the Xe Kum Kam and Xe Tha Mouak bridges, is a part of the EWEC and was connected with Thailand through opening the 2nd Thai-Lao Friendship Bridge (2006). In May 2015, National Road No. 12 was included in the EWEC and competed with National Road No. 9 as the transport route between Thailand and Vietnam. National Road No. 9, however, connects the international seaport in Da Nang in the central region of Vietnam, Savan-Seno Special Economic Zone in Savannakhet, and northeast Thailand, which had a population of approximately 21 million in 2010, and remains an important road of EWEC and is expected to contribute to liberalization of

regional logistics, person trip and services in accordance with ASEAN Economic Community (AEC) in the end of 2015.

The Xe Kum Kam and Xe Tha Mouak bridges are necessary for the people in eastern Savannakhet Province to access the district hospital or provincial hospital in Kaysone Phomvihane District, which influences about 185 thousand people.

3) Upgrade of the bridge load-carrying capacity

The existing restriction of an axle load 9.6 ton of Xe Kum Kam and Xe Tha Mouak Bridges are improved by the projects to 11.0 ton corresponding to deregulation of axle load of heavy vehicles in accordance with an agreement with Thailand and Vietnam in 2012.

4) Breakthrough of technological difficulties

The existing Xe Tha Muaok Bridge, which passes through the communities, is used daily by many residents for crossing the river. Considering the social impact of removing houses, the new bridge should be replaced at the same location of existing bridge. The construction of a new bridge will therefore require installation of a temporary bridge to divert the current traffic during the construction. It is preferred to recover the traffic flow as early as possible which shortening of bridge construction should be ideally considered. The steel-concrete composite slab bridge is a bridge type proposed in the study that applies technology developed by Japanese steel fabricators. This type of bridge is able to reduce effectively the depth of girders, which means minimizing influence for setting the vertical profile of the bridge, harmonizing the approach road. This type of bridge can shorten the construction period by using prefabricated steel forms split by piers to ease each erection by crane. In addition, weathering steel was applied to the steel slab frame to improve maintainability of the project. It can overcome the subject implicated for maintenance in the developing country.

5) Impact on social environment

There are no historical and cultural structures or remains or settlements of ethnic groups at the project sites and surrounding area. The National Biodiversity Conservation Area (NBCA) is distant from the project sites and influence on the natural environment is minimal.

As for the results of the environmental impact assessment, a serious impact such as land acquisition and resettlement of households is not considerable.

6) Urgency of the projects

The Xe Kum Kam and Xe Tha Mouak bridges, which have a residual bend and angular main girders at the bridge piers caused by lower strength of the main girder and a structural defect, are expected to be reconstructed in terms of traffic safety. The bridges were built 30 years earlier, and heavy vehicles exceeded the designed axle load of the existing bridges because of current deregulation through the

bridges. Urgent measures, therefore, against aging of the bridges and heavy-load vehicles exceeding existing axle load capacity are expected.

7) Coordination of the project with the policy in Japan

To achieve the Millennium Development Goals (MDGs) in Laos and national goals such as graduating from the Least Developed Country (LDC) index by 2020, the Japanese Government provides support to Lao PDR regarding four priority areas in accordance with its country assistance policy prepared by the Ministry of Foreign Affairs of Japan, namely, (i) development of an economic and social infrastructure, (ii) agricultural development and forest conservation, (iii) improvement of the educational environment, and (iv) human resource development and improvement of health care services.

The projects, reconstruction of the Xe Kum Kam and Xe Tha Mouak bridges, correspond to the context of priority area (i) development of economic and social infrastructure, namely, "Japan extends its assistance which is instrumental to strengthening ASEAN connectivity including development of infrastructure such as roads, bridges, and airports, environmental improvement in investment and trade such as logistics center which will enhance inroads of Japanese enterprises into the Lao market."

(2) Effectiveness

Quantitative effect

Quantitative effects expected by the projects are summarized in following table.

Table 3 Quantitative effects by the Projects

Index	Base Line (2015)		Target in 2022 (3 years after completion)	
AADT (Large class) (Vehicles per day)	Xe Kum Kam Xe Tha Mouak	456 452	Xe Kum Kam Xe Tha Mouak	726 724
AADT (All class) (Vehicles per day)	Xe Kum Kam Xe Tha Mouak	1,840 4,861	Xe Kum Kam Xe Tha Mouak	2,966 8,358

Source: JICA Study Team

Qualitative effect

Qualitative effects expected from the grant-aid project are listed below:

- ✓ Improvement of safety of the bridges: by the implementation of the projects, the road surface condition of the bridges and access roads are improved, road safety and comfort for through traffic are also improved. Xe Tha Mouak Bridge has the same width of sidewalks as the existing bridge; therefore, pedestrian safety is secured.
- ✓ Improvement of reliability of the bridges: about 185 thousand people in the eastern part of Savannakhet Province use the bridges to access the provincial center or Vientiane Capital;

therefore, improvement of reliability of the bridges guarantees such daily activities for people.

- ✓ Enhancement of domestic and international logistics network: by improving the bridge load capacity in accordance with regional standards agreed to with Thailand and Vietnam, Xe Kum Kam and Xe Tha Mouak bridges are expected to contribute logistically to the EWEC.

In consequence, the projects are expected to be effective.

(3) Recommendations

Maintenance of bridges is essential to ensure the soundness of bridges for a long life. In addition, the traveling of large heavy vehicles (including overloaded trucks) used in the development of mining or other quarry sites give significant impact to the bridges structurally, causing damage of expansion joints, etc., on NR9. Based on the discussions above, the following recommendations should be made:

- ✧ Conduct routine and periodic maintenance sustainably by MPWT (DOR) to ensure the safety of the facility expected in the design even in case of a future increase in large vehicles.
- ✧ Complete improvement of roads and replacement or reinforcement of bridges on NR9 in addition to the project to ensure smooth traffic on NR9.
- ✧ Facilitate reginal development as well as contribute to poverty reduction by improving the access roads branching from NR9 (EWEC) through the interior of the country, in addition to the direct benefits given to the residents alongside NR9.

Table of Contents

Survey Location Map

Perspective of the Project (Xe Kum Kam Bridge)

Perspective of the Project (Xe Tha Mouak Bridge)

List of Figures

Page

List of Tables

Page

Abbreviations

A/P	Authorization to Pay
AASHTO	American Association of State Highway and Transportation Officials
AC	Asphalt Concrete
ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
AusAID	Australian Agency for International Development
B/A	Banking Arrangement
C/S	Construction Supervision
CBR	California Bearing Ratio
D/D	Detailed Design
DMH	Department of Meteorology and Hydrology
DONRE	Department of Natural Resources and Environment
DOR	Department of Roads
DPWT	Department of Public Works and Transport
EIA	Environmental Impact Assessment
E/N	Exchange of Notes
GDP	Gross Domestic Product
GNI	Gross National Income
HIV/AIDS	Human immunodeficiency virus infection / acquired immunodeficiency syndrome
HWL	High Water Level
IDA	International Development Association
IEE	Initial Environmental Evaluation
JICA	Japan International Cooperation Agency
KFW	Kreditanstalt für Wiederaufbau
LAK	Lao Kip
M/D	Minutes of Discussion
MONRE	Ministry of Natural Resources and Environment
MPWT	Ministry of Public Works and Transport
NSEDP	National Socio-Economic Development Plan
O/D	Outline Design Study
ODA	Official Development Assistance
PC	Prestressed Concrete
PCU	Passenger Car Unit
PTI	Public Works and Transport Institute
RC	Reinforced Concrete
RAP	Resettlement Action Plan
ROW	Right of Way
RMF	Road Maintenance Fund
SIDA	Swedish International Development Agency
STEA	Science Technology and Environmental Agency

UNDP	United Nations Development Programme
VAT	Value Added Tax
WB	World Bank
WREA	Water Resources and Environment Agency

Chapter 1 Background of the Project

1.1 Background of the Project

Lao PDR is geographically a land-locked country and the traffic flow that physically connects it with neighboring countries via road transport is vital. Specifically, National Road No. 9 (NR9), which is a part of the East-West Economic Corridor (EWEC), is an international trunk road connecting northeastern Thailand and central Vietnam. This function as extremely important infrastructure serving ASEAN integration at the end of 2015, and the road contributes to the growth of regional economic development in the central southern area in Laos.

Many bridges on NR9 were developed under assistance from the former Soviet Union and Vietnam in the 1980s and contain many structural problems, which are now coming to the surface. Xe Kum Kam and Xe Tha Mouak Bridges, the target bridges of this project, were constructed under assistance from the Czech Republic, and present issues, such as residual deflection due to deficient load-carrying capacity of the main girders based on the JICA study, "Preparatory Study for Improvement of Roads and Bridges in the Southern Region in Lao PDR" in 2010. These issues, plus other structural bridge failures, such as breakage of the main girders (pin bearing) in the middle piers, etc., make these bridges bottlenecks that hinder the smooth flow of traffic. Their reconstruction was determined to be necessary in order to secure traffic safety. Under the circumstance, the Department of Road (DoR) requested grant aid for reconstructing these two bridges.

The implementation of the project is to reconstruct both the Xe Kum Kam and Xe Tha Mouak bridges, securing safe and stable traffic flow on NR9 that will contribute to the development of the infrastructure and economy of the surrounding regions along the EWEC.

1.2 Natural Conditions

1.2.1 Climate

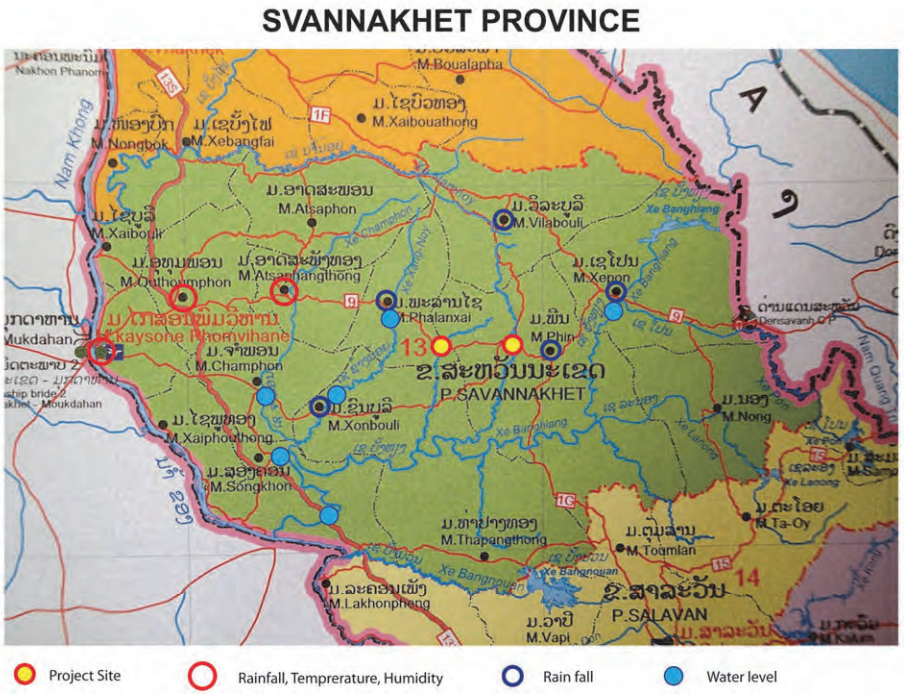
Laos is located within the sphere of the monsoonal climate characteristic of Southeast Asia, in which one year may be roughly divided into a rainy season (May to October) and a dry season (November to April). Annual rainfall occurs mostly in the rainy season, with strong squalls and high winds.

Meteorological observation records around the target area could be obtained from the Ministry of Natural Resources and Environment. Acquired data and the location map of stations are shown in Table 1.2.1 and Figure 1.2.1 respectively.

Table 1.2.1 Meteorological survey items and acquired data

Survey items	Station	Observation period	Source
Rainfall	Donghene	1995 – 2014 (20 years)	Weather bureau
	Phalanxai	1995 – 2014 (18 years *Data missing for 1995 and 1999)	Weather bureau
	Phine	1995 – 2014 (20 years)	Weather bureau
	Xepone	1995 – 2014 (20 years)	Weather bureau
	Sonnabouly	1995 – 2014 (20 years)	Weather bureau
	Vilabouli	1995 – 2008 (14 years)	Weather bureau
Temperature (mean, maximum, minimum), humidity	Atsaphangthong	2000 – 2014 (15 years)	Weather bureau

Source: Ministry of Natural Resources and Environment

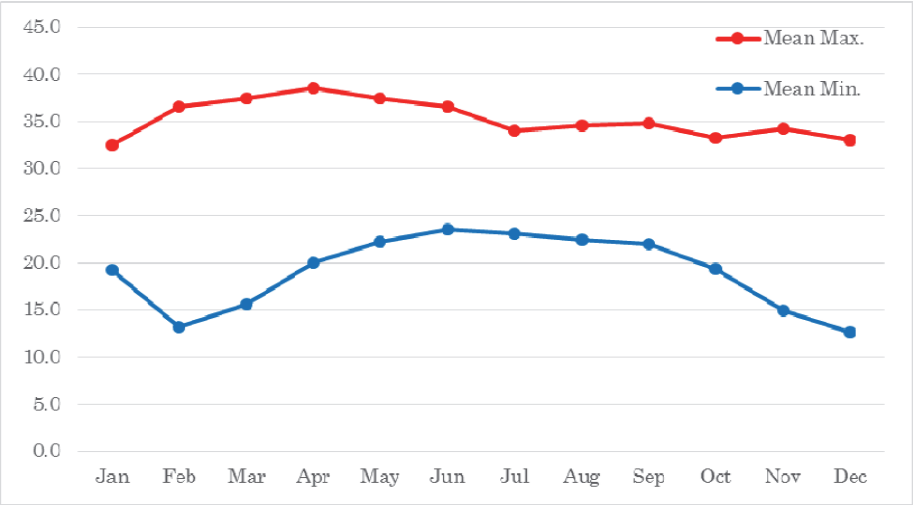


Source: Ministry of Natural Resources and Environment

Figure 1.2.1 Locations of meteorlogical observation stations

(1) Temperature

The monthly mean maximum temperature and the mean minimum temperature at the Atsaphangthong observation station for the past 15 years are shown in Figure 1.2.2. At this station, the maximum recorded temperature is 30°C or more, and the minimum temperature never drops below 10°C throughout the year. The difference between the maximum and minimum temperatures is around 10°C during the rainy season, but around 20°C during the dry season.

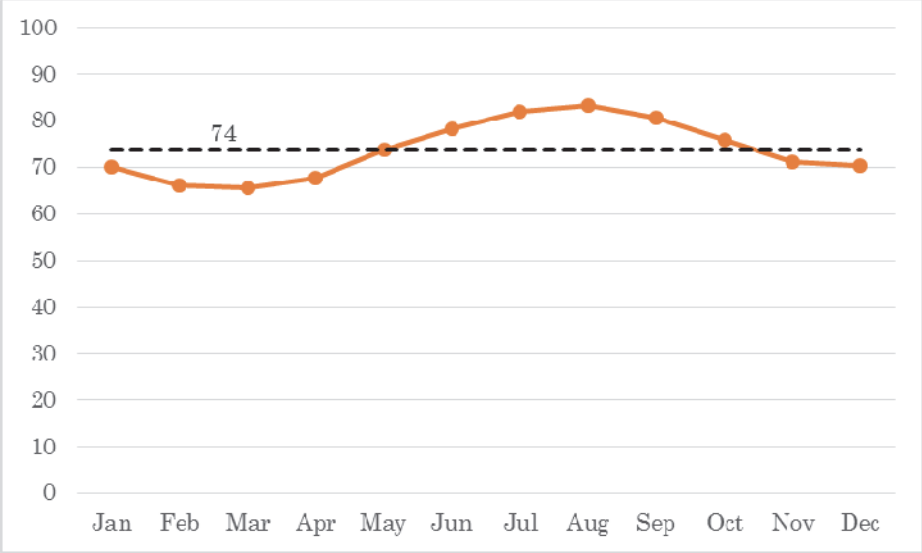


Source: Ministry of Natural Resources and Environment

Figure 1.2.2 Maximum and minimum mean temperatures, by month

(2) Humidity

The monthly mean humidity at the Atsaphangthong station for the past 15 years is shown in Figure 1.2.3. The annual mean humidity is 74%, and the difference in humidity between the dry and rainy seasons is about 17%.



Source: Ministry of Natural Resources and Environment

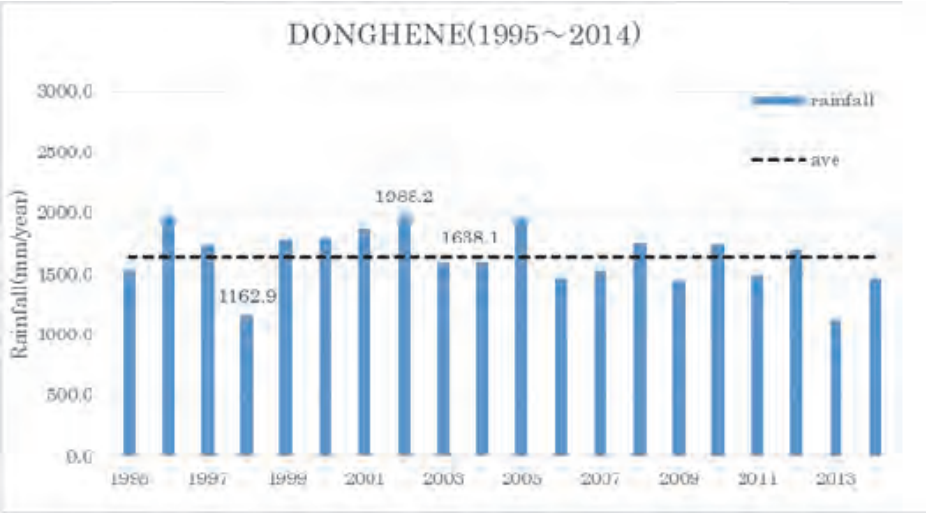
Figure 1.2.3 Mean humidity, by month

(3) Rainfall

1) Donghene Station

a) Annual rainfall

Figure 1.2.4 shows the annual rainfall at the Donghene station for the past 20 years. The annual rainfall is relatively low at about 1640 mm on average: 1990 mm in years with high rainfall and 1170 mm in years with low rainfall.

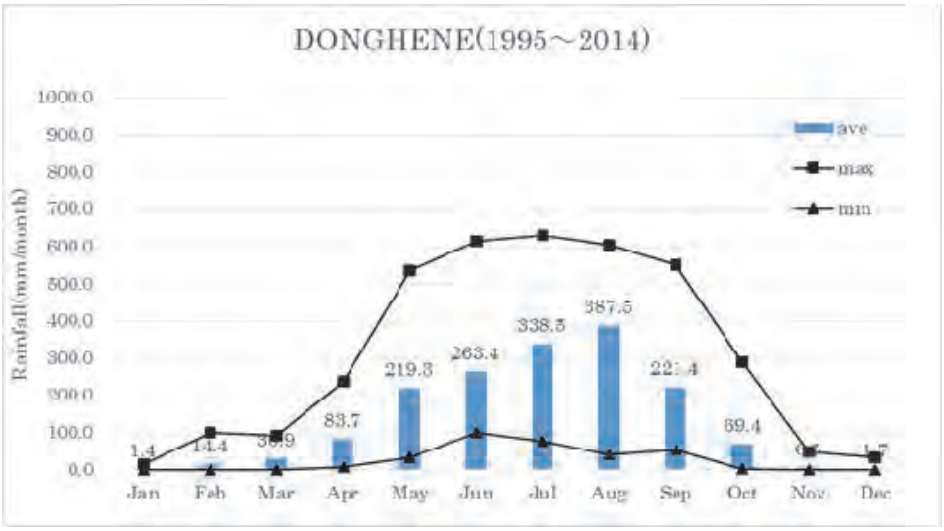


Source: Ministry of Natural Resources and Environment

Figure 1.2.4 Annual rainfall

b) Monthly rainfall

The monthly rainfall at the Donghene station is shown in Figure 1.2.5. Characteristically, the rainfall is relatively low at approximately 390 mm in months with high rainfall and about 10 mm in months with low rainfall.

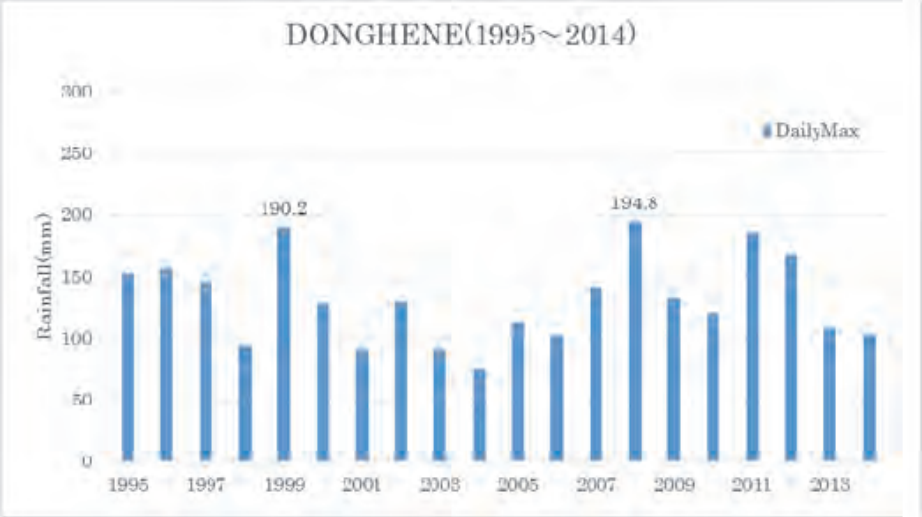


Source: Ministry of Natural Resources and Environment

Figure 1.2.5 Monthly rainfall

c) Annual maximum daily rainfall

The annual maximum daily rainfall at the Donghene station is shown in Figure 1.2.6. This is around 136 mm/day on average and around 190 mm/day at maximum. In July 2008, 194.9 mm/day was recorded.

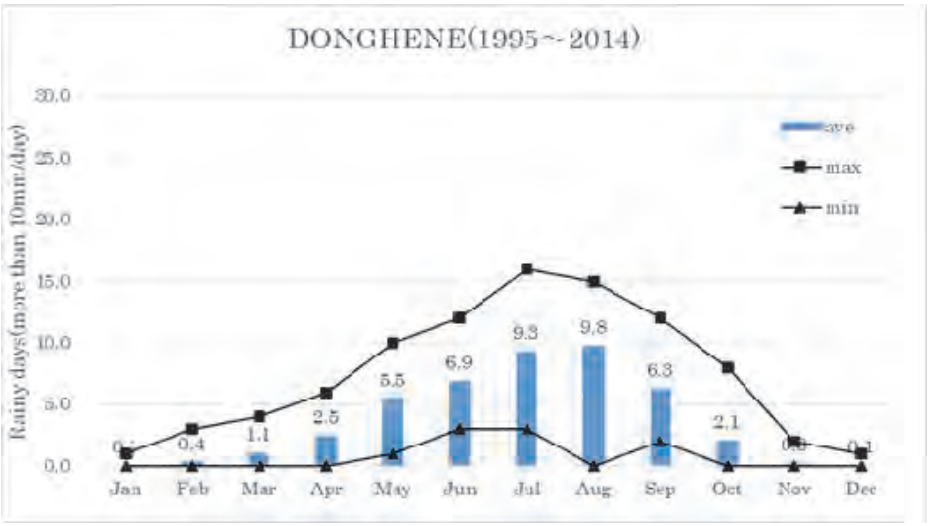


Source: Ministry of Natural Resources and Environment

Figure 1.2.6 Annual maximum daily rainfall

d) Number of days with a daily rainfall of 10 mm or more by months

The number of days with a daily rainfall of 10 mm or more by months at the Donghene station for the past two decades is shown in Figure 1.2.7. Even in July and August when the monthly rainfall is the highest in the year, the number of days registering a daily rainfall of 10 mm or more is 10 days or less.



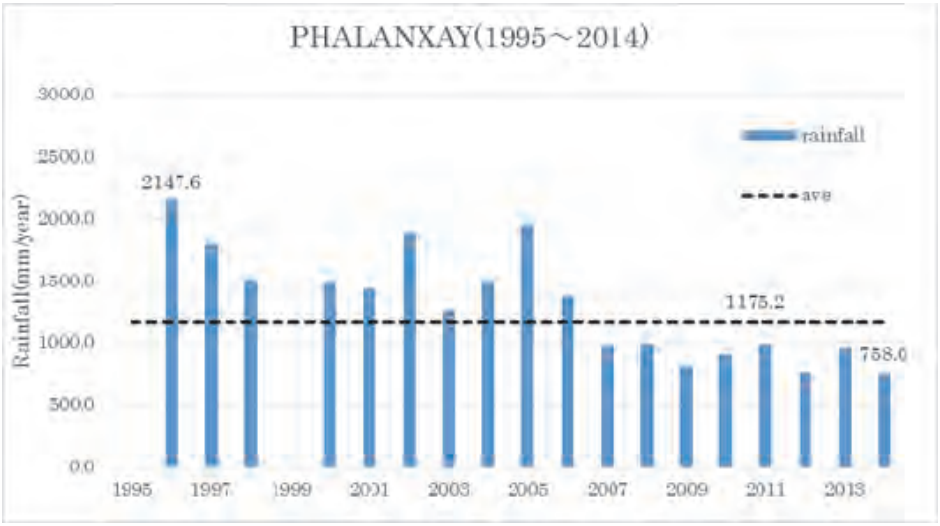
Source: Ministry of Natural Resources and Environment

Figure 1.2.7 Number of days with daily rainfall of 10 mm or more, by month

2) Phalanxai Station

a) Annual rainfall

The annual rainfall at the Phalanxai station for the past two decades is shown in Figure 1.2.8. The annual rainfall is about 1180 mm on average, ranging from 2,150 mm in years with a high rainfall to 760 mm in years with low rainfall.

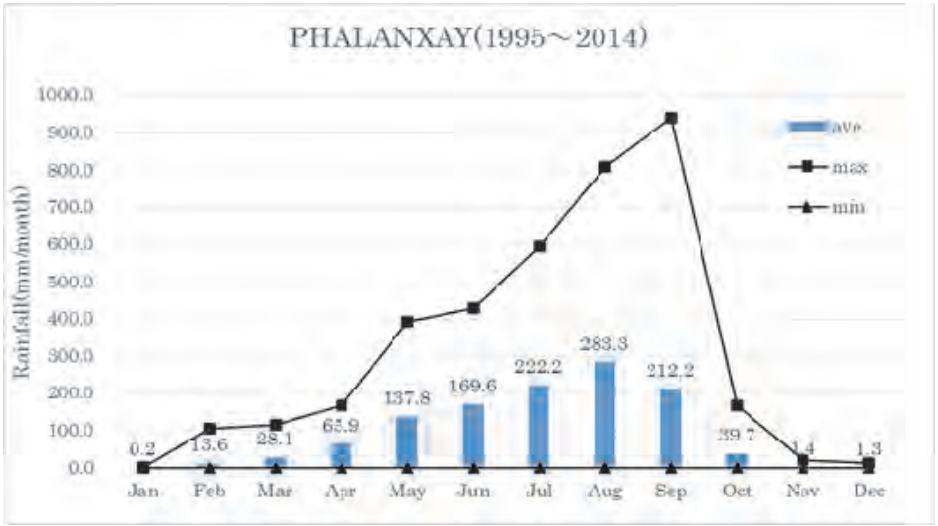


Source: Ministry of Natural Resources and Environment

Figure 1.2.8 Annual rainfall

b) Monthly rainfall

The monthly rainfall at the Phalanxai station is shown in Figure 1.2.9, which is about 280 mm in months with high rainfall and extremely low at about 10 mm in months with low rainfall.

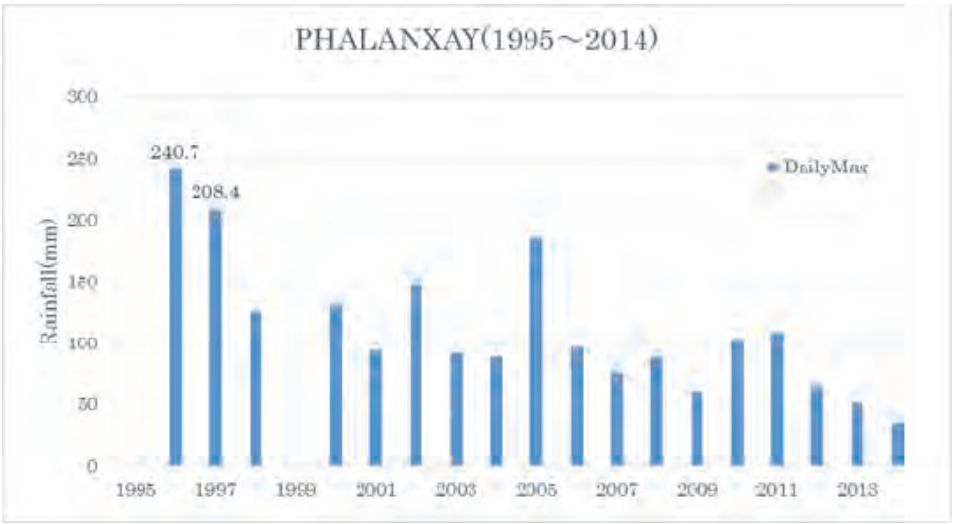


Source: Ministry of Natural Resources and Environment

Figure 1.2.9 Monthly rainfall

c) Annual maximum daily rainfall

The annual maximum daily rainfall at the Phalanxai station is shown in Figure 1.2.10, which is about 110 mm/day on average. Looking at the past two decades, 240.7 mm/day was registered in September 1996, and 208.4 mm/day in August 1997.

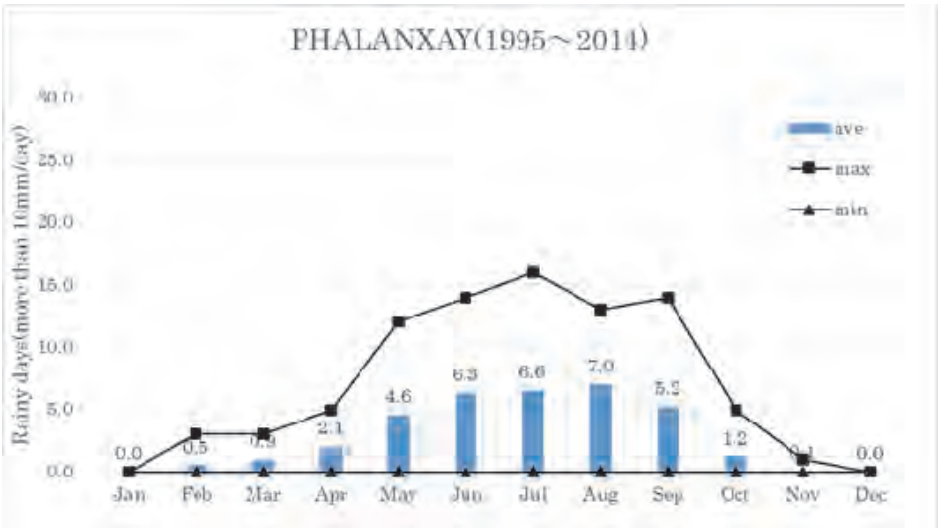


Source: Ministry of Natural Resources and Environment

Figure 1.2.10 Annual maximum daily rainfall

d) Number of days with a daily rainfall of 10 mm or more, by month

The number of days with a daily rainfall of 10 mm or more, by month, at the Phalanxai station for the past two decades is shown in Figure 1.2.11. Characteristically, even in July and August when the rainfall is the highest in the year, the number of days registering the daily rainfall of 10 mm or more is only about 7 days.



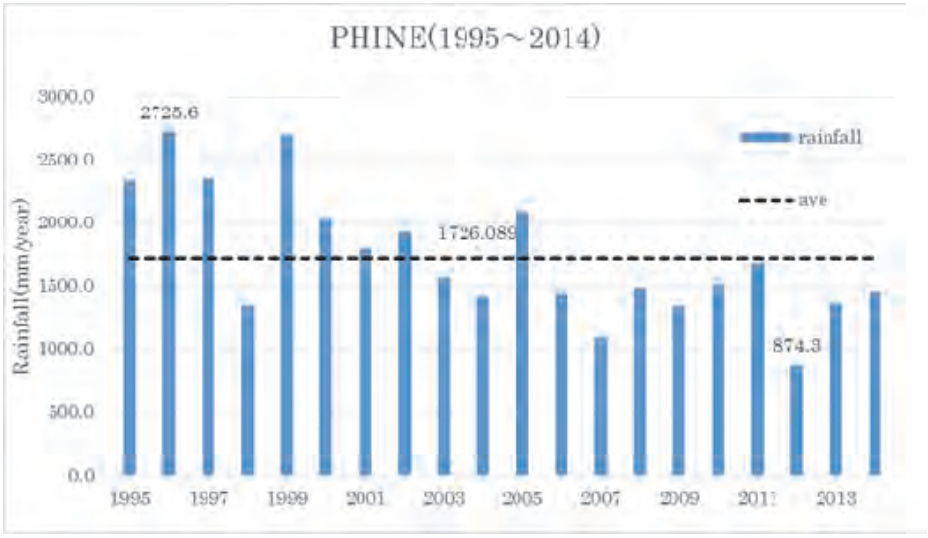
Source: Ministry of Natural Resources and Environment

Figure 1.2.11 Number of days with daily rainfall of 10 mm or more, by month

3) Phine Station

a) Annual rainfall

The annual rainfall at the Phine station for the past two decades is shown in Figure 1.2.12. The annual rainfall is about 1,730 mm on average, ranging from 2,730 mm in years with high rainfall to 870 mm in years with low rainfall.

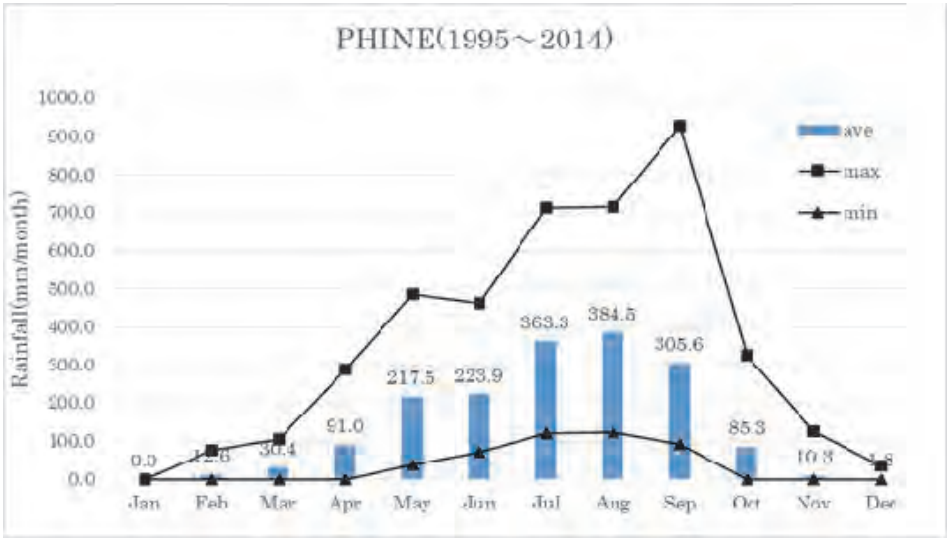


Source: Ministry of Natural Resources and Environment

Figure 1.2.12 Annual rainfall

b) Monthly rainfall

The monthly rainfall at the Phine station is shown in Figure 1.2.13, which is about 380 mm in months with high rainfall and extremely low at about 10 mm in months with low rainfall. Characteristically, the difference in rainfall between the dry and rainy seasons is large.

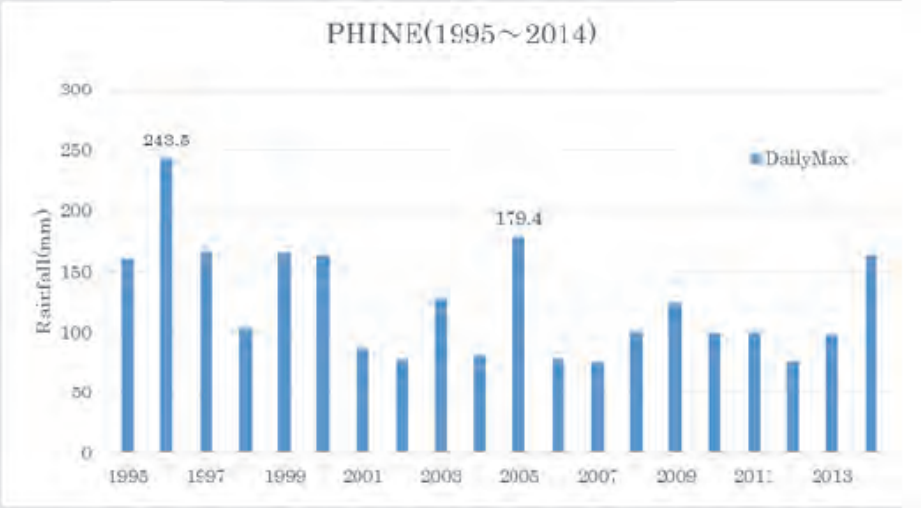


Source: Ministry of Natural Resources and Environment

Figure 1.2.13 Monthly rainfall

c) Annual maximum daily rainfall

The annual maximum daily rainfall at the Phine station is shown in Figure 1.2.14, which is about 140 mm/day on an average. Looking at the past two decades, 243.5 mm/day was registered in July 1996.

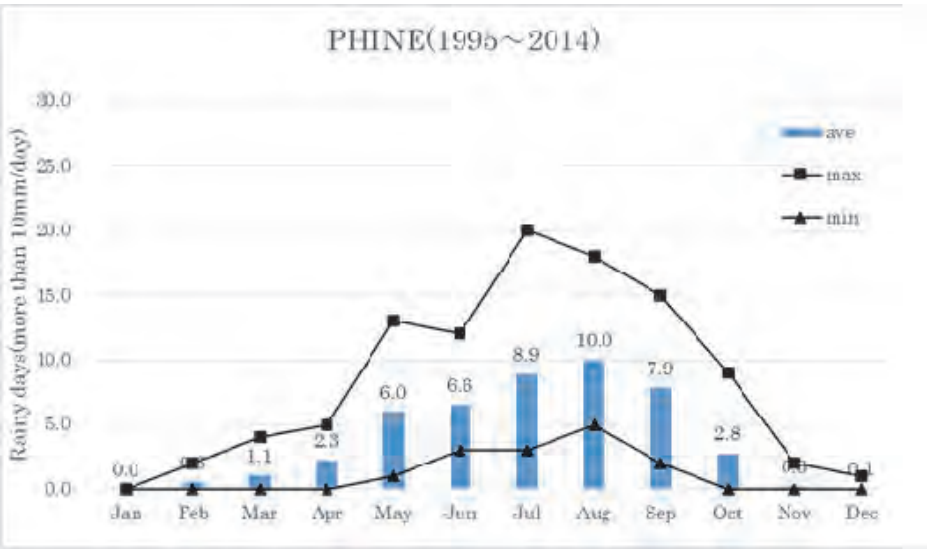


Source: Ministry of Natural Resources and Environment

Figure 1.2.14 Annual maximum daily rainfall

d) Number of days with a daily rainfall of 10 mm or more, by month

The number of days with a daily rainfall of 10 mm or more, by month, at the Phine station for the past two decades is shown in Figure 1.2.15. In August when the monthly rainfall is the highest in the year, the number of days registering the daily rainfall of 10 mm or more is about 10 days.



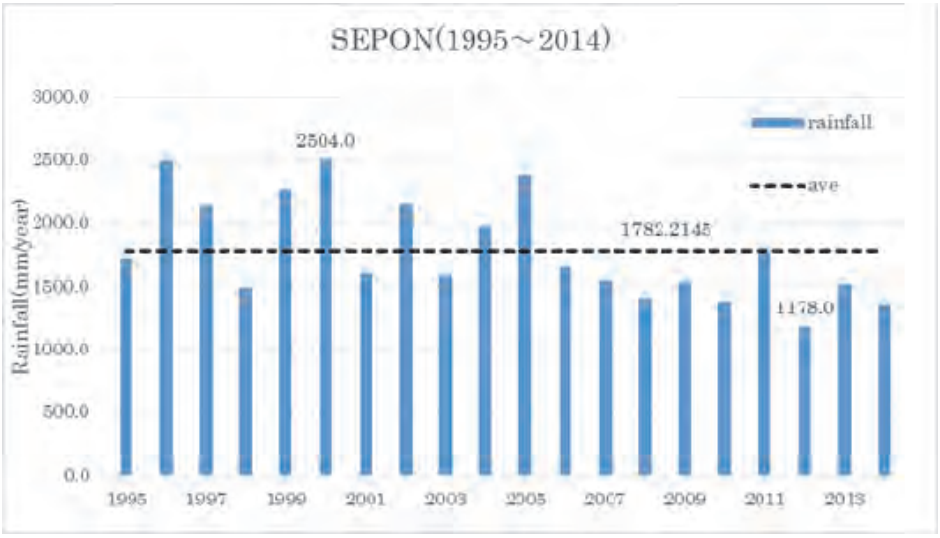
Source: Ministry of Natural Resources and Environment

Figure 1.2.15 Number of days with daily rainfall of 10 mm or more, by month

4) Xepone Station

a) Annual rainfall

The annual rainfall at the Xepone station for the past two decades is shown in Figure 1.2.16. The annual rainfall is about 1,780 mm on an average, ranging from 2,500 mm in years with high rainfall to 1,180 mm in years with low rainfall.

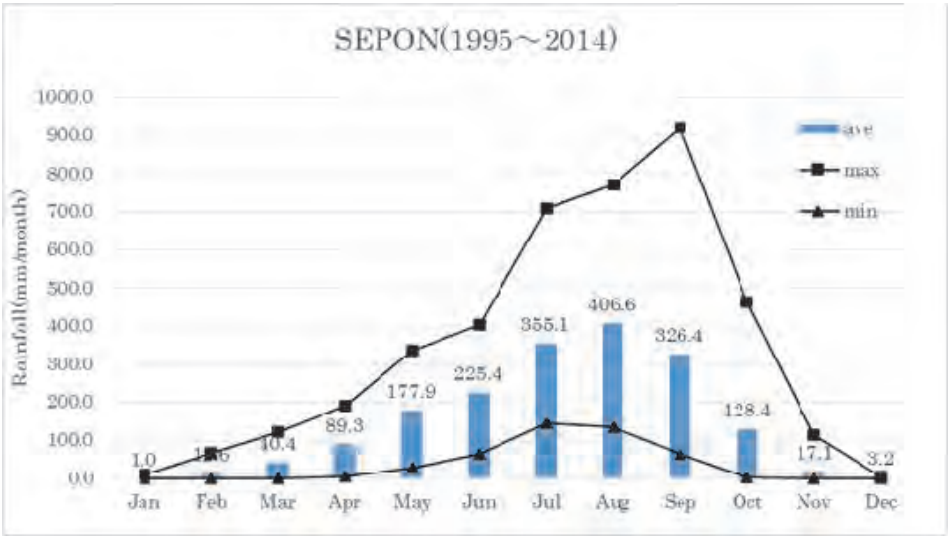


Source: Ministry of Natural Resources and Environment

Figure 1.2.16 Annual rainfall

b) Monthly rainfall

The monthly rainfall at the Xepone station is shown in Figure 1.2.17, which is about 410 mm in months with high rainfall and extremely low at about 10 mm in months with low rainfall. Characteristically, the rainfall in months with high rainfall is higher than at other stations.

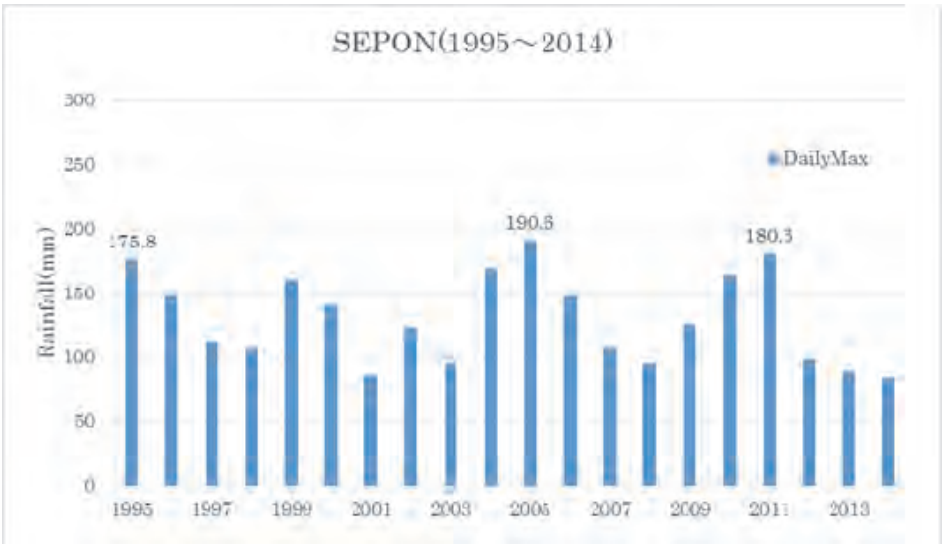


Source: Ministry of Natural Resources and Environment

Figure 1.2.17 Monthly rainfall

c) Annual maximum daily rainfall

The annual maximum daily rainfall at the Xepone station is shown in Figure 1.2.18, which is about 149 mm/day on average. Over the past two decades, the average rainfall has been increasing, though rainfall exceeding 200 mm/day has never occurred.

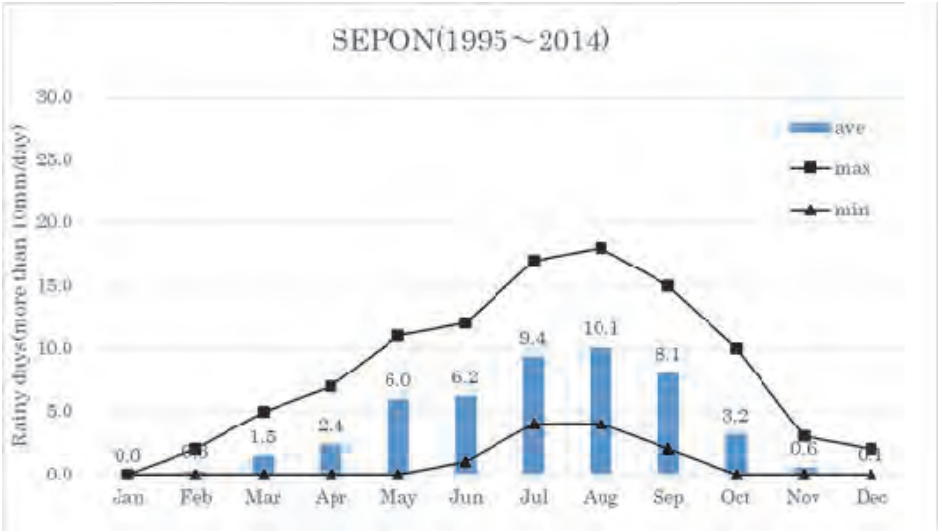


Source: Ministry of Natural Resources and Environment

Figure 1.2.18 Annual maximum daily rainfall

d) Number of days with a daily rainfall of 10 mm or more, by month

The number of days with the daily rainfall of 10 mm or more, by month, at the Xepone station for the past two decades is shown in Figure 1.2.19. In July and August when the monthly rainfall is the highest in the year, the number of days registering the daily rainfall of 10 mm or more is about 10 days.



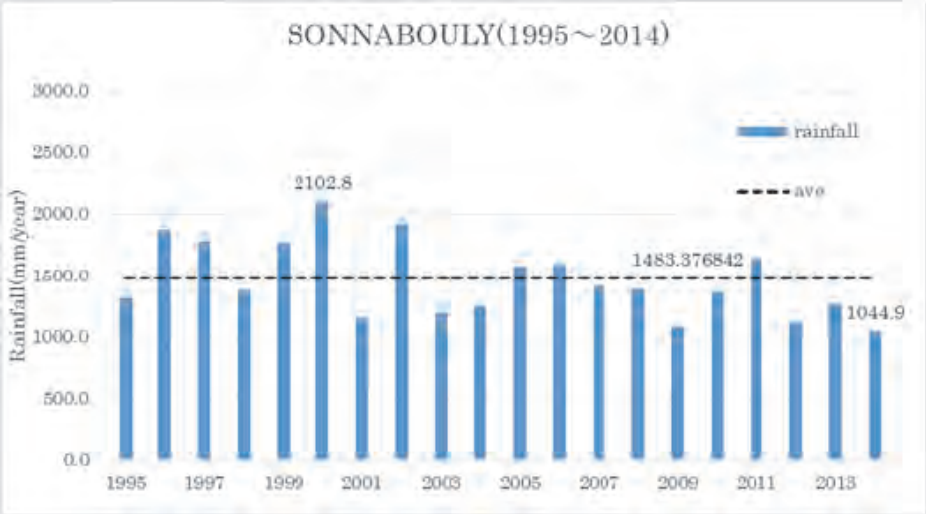
Source: Ministry of Natural Resources and Environment

Figure 1.2.19 Number of days with annual rainfall of 10 mm or more, by month

5) Sonnabouly Station

a) Annual rainfall

The annual rainfall at the Sonnabouly station for the past two decades is shown in Figure 1.2.20. The annual rainfall is about 1,480 mm on average, ranging from 2,100 mm in years with high rainfall to 1,040 mm in years with low rainfall.

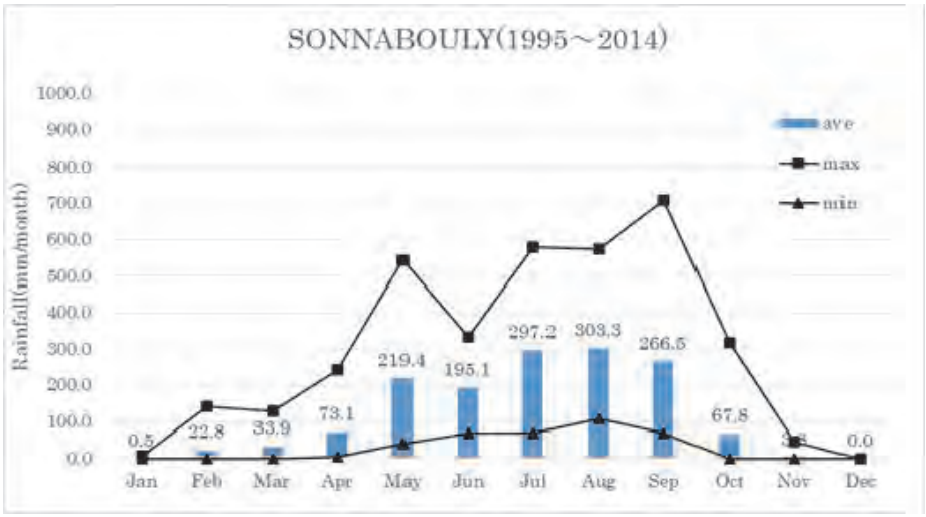


Source: Ministry of Natural Resources and Environment

Figure 1.2.20 Annual rainfall

b) Monthly rainfall

The monthly rainfall at the Sonnabouly station is shown in Figure 1.2.21, which is about 300 mm in months with high rainfall and extremely low at about 10 mm in months with low rainfall. Characteristically, the rainfall in July is lower than at other stations.

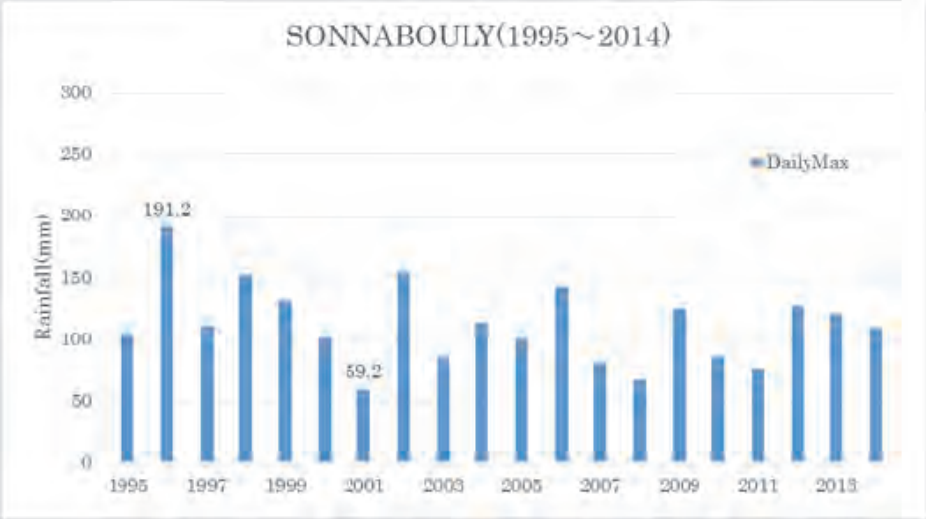


Source: Ministry of Natural Resources and Environment

Figure 1.2.21 Monthly rainfall

c) Annual maximum daily rainfall

The annual maximum daily rainfall at the Sonnabouly station is shown in Figure 1.2.22, which is about 120 mm/day on an average. Over the past two decades, rainfall exceeding 200 mm/day has never occurred. The daily maximum rainfall was low at 59.2 mm/day in 2001.

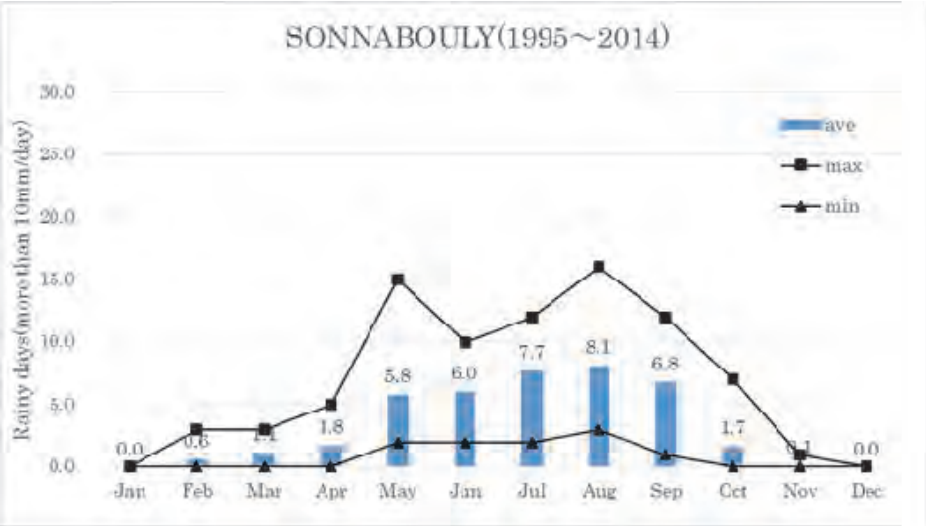


Source: Ministry of Natural Resources and Environment

Figure 1.2.22 Annual maximum daily rainfall

d) Number of days with a daily rainfall of 10 mm or more, by month

The number of days with a daily rainfall of 10 mm or more, by month, at the Sonnabouly station for the past two decades is shown in Figure 1.2.23. In July and August when the monthly rainfall is the highest in the year, the number of days registering a daily rainfall of 10 mm or more is about 8 days.



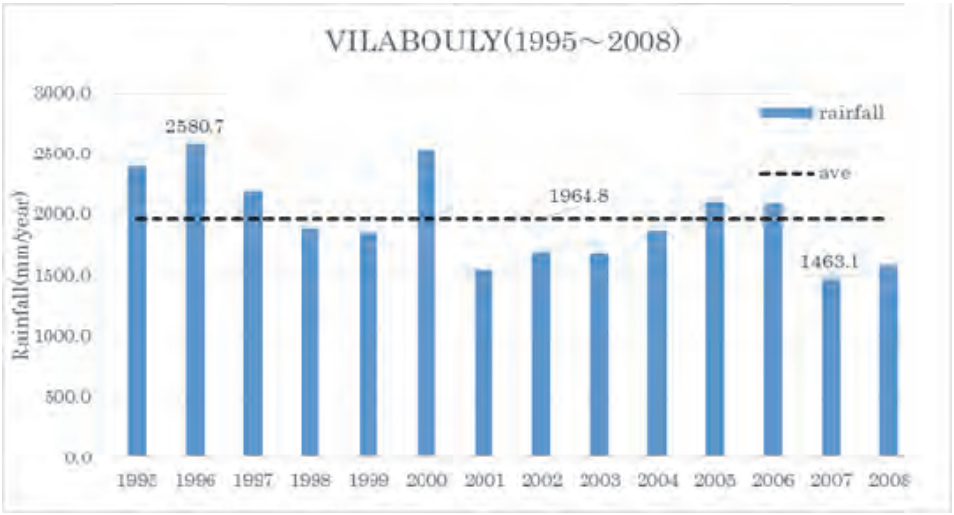
Source: Ministry of Natural Resources and Environment

Figure 1.2.23 Number of days with daily rainfall of 10 mm or more, by month

6) Vilabouli Station

a) Annual rainfall

The annual rainfall at the Vilabouli station for the past two decades is shown in Figure 1.2.24. The annual rainfall is about 1,960 mm on average, and is extremely high at 2,580 mm in years with high rainfall and 1,460 mm in years with low rainfall.

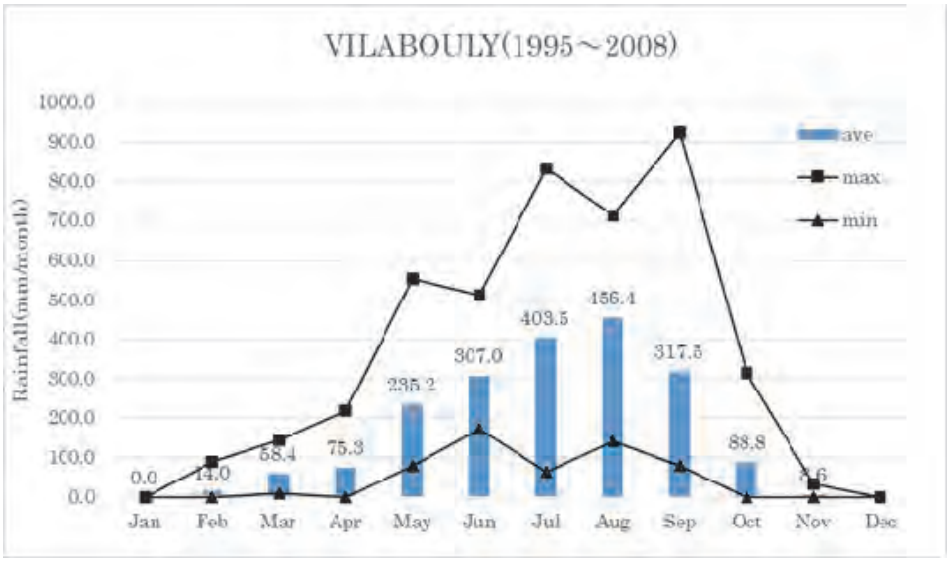


Source: Ministry of Natural Resources and Environment

Figure 1.2.24 Annual rainfall

b) Monthly rainfall

The monthly rainfall at the Vilabouli station is shown in Figure 1.2.25, which is about 457 mm in months with high rainfall and extremely low at about 10 mm in months with low rainfall. Characteristically, the rainfall in the rainy season is much higher than at other stations.

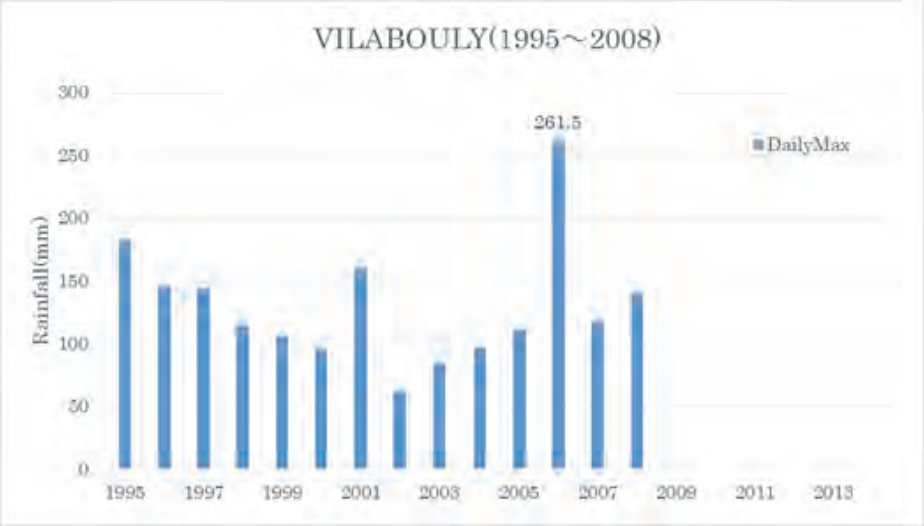


Source: Ministry of Natural Resources and Environment

Figure 1.2.25 Monthly rainfall

c) Annual maximum daily rainfall

The annual maximum daily rainfall at the Vilabouli station is shown in Figure 1.2.26, which is about 120 mm/day on an average. Looking at the past two decades, rainfall of 261.5 mm/day was registered in August 2006.

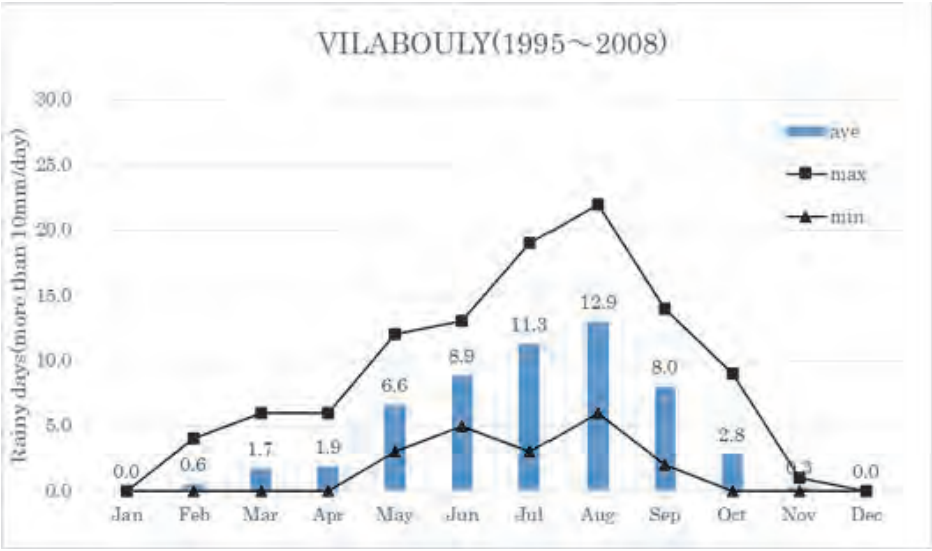


Source: Ministry of Natural Resources and Environment

Figure 1.2.26 Annual maximum daily rainfall

d) Number of days with a daily rainfall of 10 mm or more, by month

The number of days with a daily rainfall of 10 mm or more, by month, at the Vilabouli station for the past two decades is shown in Figure 1.2.27. In July and August when the monthly rainfall is the highest in the year, the number of days registering a daily rainfall of 10 mm or more is extremely large at about 13 days.



Source: Ministry of Natural Resources and Environment

Figure 1.2.27 Number of days with daily rainfall of 10 mm or more, by month

1.2.2 Hydrology

(1) Outline of the basin

1) Xe Kum Kam River

The Xe Kum Kam River, which originates in the mountains with an altitude range of from 500-400 m, runs more or less in the southwest direction and intersects with the Xe Kum Kam Bridge on National Road No. 9. Its basin is occupied mostly by arable lands, such as natural forests and paddy fields, with residential lands found only dotted along National Road No. 9. The basin is about 13 km wide in the east-west direction and about 9 km long in the south-north direction, with an area of 105.4 km^2 (Figure 1.2.28).

The bed slope is sharp, at about 1/500 from the bridge location to the middle reach and even sharper at 1/400 in the upstream area. This bed slope is equivalent to that of the middle to upstream basin of the Tone River (Gunma Prefecture) in Japan (Figure 1.2.29).

Figure 1.2.28 Xe Kum Kam River Basin Map

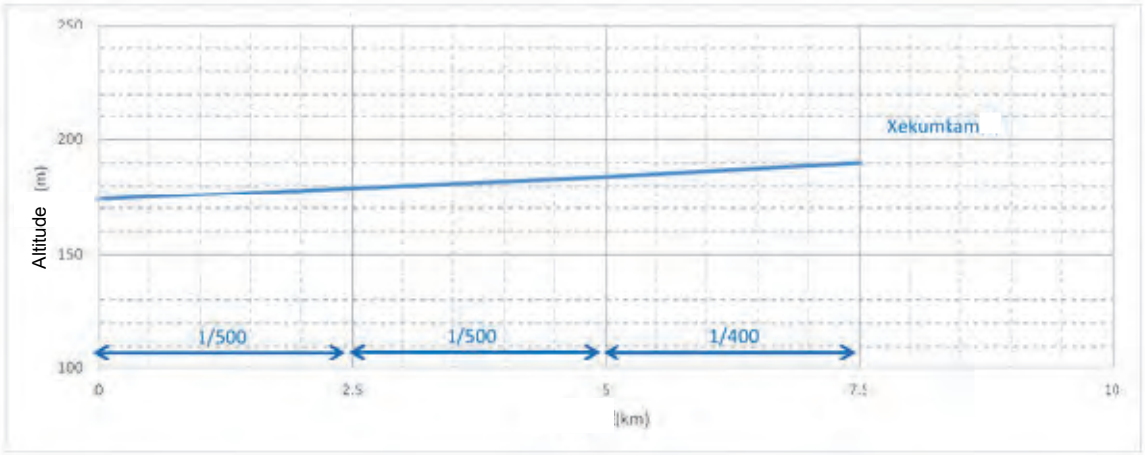


Figure 1.2.29 Xe Kum Kam River Profile

2) Xe Tha Mouak River

Xe Tha Mouak River runs down from the mountains with a 750-600 m altitude range, in an approximately southern direction. After confluence with two tributaries on its left bank, this river intersects with the Xe Tha Mouak Bridge on National Road No. 9. The basin is occupied mostly by the natural mountains and a more or less flat tree area. Arable lands, including paddy fields, etc., and residential lands are distributed along National Road No. 9. On the upstream side of the Xe Tha Mouak Bridge intersecting with National Road No. 9, the basin spreads for about 25 km in the east-west direction and about 32 km in the south-north direction, with an area of 796.7 km^2 (Figure 1.2.30).

The bed slope is relatively gentle at 1/1150 in the upstream area and 1/950 in the middle reach. The bed gradient at the bridge location is also gentle at about 1/1000, which is equivalent to the downstream area of the Tenryu River in Japan (Figure 1.2.31).

Figure 1.2.30 Xe Tha Mouak River Basin Map

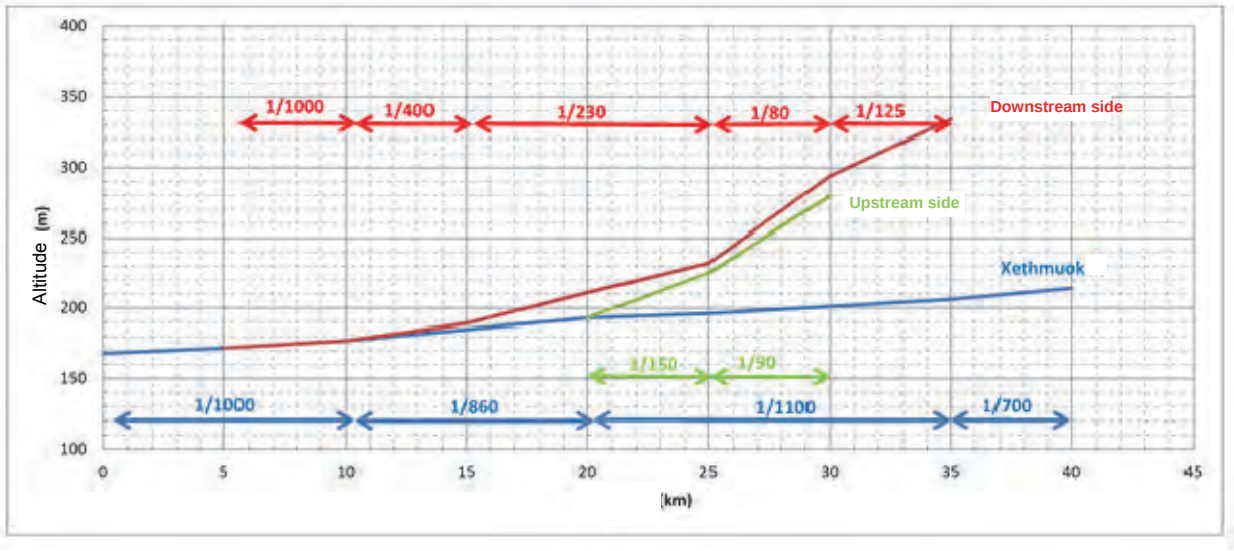


Figure 1.2.31 Xe Tha Mouak River Profile

(2) River Channel Characteristics at the Bridge Location

1) Xe Kum Kam Bridge (completed in 1985)

A visual survey around the bridge location showed exposed rocks in the riverbed, particularly on the downstream side; scouring of the riverbed is considered limited. A drilling survey of the riverbed at the pier points confirmed “concrete sub-slab, spreading concrete” at about 2 m below the existing riverbed height. It may be considered that the estimated scour depth for construction of the existing bridge was around 2 m.

The riverbank is luxuriant, particularly with shrubbery. Judging from the collapse of the bank and exposed tree roots, lateral erosion is considered highly likely. Considering the growth of vegetation as shown in Figure 1.2.32, it may be likely that the water level reaches, at least once a year, the height below which the vegetation does not grow.

Figure 1.2.32 Riverbank on the upstream side

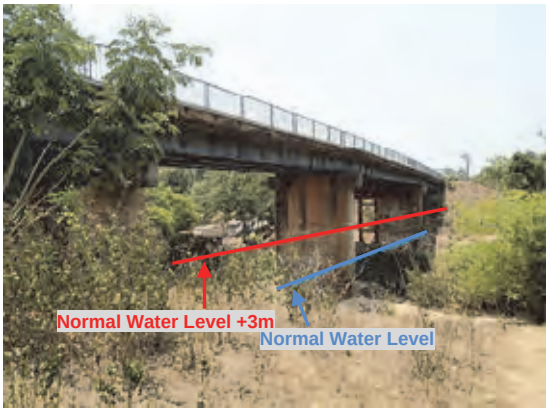


Figure 1.2.33 Trace water level known from the hearing

The existing high-water level was confirmed by a visual on-site survey and hearing, and the trace of the water level was confirmed at a height of about 3 m (the red level of Figure 1.2.33) above the

normal water level in the dry season at the existing bridge location. It was known from the hearing that the flood reached the red water-level line two years ago (2013). Collection and summarization of rainfall data of the nearby Phalanxai station revealed that the rainfall was high in 2011. Namely, the level indicated the red line may be the one left in 2011.

The blue level, 1.5 m below the red water level, is considered the average annual highest level in normal years. When the riverbank is viewed, it is known that almost no vegetation grows up to the blue level, which may mean that the water level reaches this level at least once a year.

2) Xe Tha Mouak Bridge (completed in 1984)

Visual survey around the bridge location showed sand distributed over a wide area on the river bed on upstream and downstream sides. This may suggest the necessity of paying attention to scouring of the riverbed. A drilling survey of the riverbed was performed at the piers, which revealed the mudstone layer to be about 2.4 m below the existing riverbed height. It may be determined that the scouring depth was estimated to be about 2.5 m at the time of constructing the existing bridge.

Judging from the distinctly identifiable range in which the bushes are luxuriant and the patchy growth of vegetation, lateral erosion is considered highly likely. Similar to the case of the Xe Kum Kam River (tentative name), the vegetation growth state shown in Figure 1.2.34 indicates that the water level reaches, at least once a year, the height below which the vegetation does not grow.

Figure 1.2.34 River bank on the downstream side

Figure 1.2.35 Trace water level observed in visual inspection

The existing highest water level was confirmed through a visual on-site survey and hearing, and the trace of water level was confirmed at a height of about 11.0 m (Figure 1.2.35) above the normal water level in the dry season at the existing bridge location. It was known from the hearing (from the residents who moved to Xe Kum Kam five years ago) that flooding often reached the roots of the bushes, but the temple located on the downstream right bank has never been inundated. Collection and summarization of rainfall data from the nearby Phine station in the previous two decades revealed that the year in which the rainfall was highest after the 1984 completion of the bridge was July 1996 with rainfall of 243.5 mm/day, followed by 214.8 mm/day in September 1996. Namely, the highest trace at the existing bridge is presumed to be left by flooding in July 1996.

As the river flow has not been determined for both bridges, it must be estimated through flow calculation.

(3) Rainfall Analysis

On the basis of the rainfall analysis performed using daily rainfall data from each station, the daily rainfall was calculated for each return period. The rainfall analysis was performed for both the annual maximum daily rainfall (annual value) and the higher maximum daily rainfall (non-annual value), and the conservative values were employed. The analysis result is shown in Table 1.2.2.

From the hearing survey and trace water level at the Xe Kum Kam Bridge, it was known that the flood in August 2011 is the principal flood in these years. In this event, the daily rainfall at the Phalanxai station was 109.0 mm/day and at the Phin station it was 128.2 mm/day. Namely, the average daily rainfall of the basin was 128.2 mm/day, which is estimated to be equivalent to the return period of two years.

From the hearing survey and trace water level at the Xe Tha Mouak Bridge, it was known that the flood in July 1996 was the largest ever. In this event, the daily rainfall at the Phin station was 243.5 mm/day, which is estimated to be equivalent to the return period of 50 to 60 years.

Table 1.2.2 Daily rainfall for each return period in basins

Return Period	Daily Reinfall(mm/day)		
	Phalanxai Station (Xekumkam Basin)	Phin Station (Xekumkam Basin)	Phakanxai+Phin Station (Xekumkam Basin)
1-year	51.2	61.9	56.3
2-year	92.8	129.8	110.4
3-year	117.3	147.1	131.5
5-year	148.1	166.5	156.9
10-year	189.9	190.7	190.3
30-year	256.1	227.4	242.4
50-year	286.9	244.1	266.5
100-year	328.8	266.7	299.2

Source: Study team

(4) Runoff Analysis

Flow observation has not been performed for rivers, so that the runoff at each bridge location was calculated from the rational formula. The runoff for each return period is shown in Table 1.2.3. Note that the runoff at the Xe Tha Mouak Bridge during flooding in July 1996 is estimated to be 3,700 m^3/s.

Table 1.2.3 Runoff for each return period

Return Period	Daily Reinfall(mm/day)	
	Phalanxai+Phin Station (Xekumkam Basin)	Phin Station (Xethamouk Basin)
1-year	250(216)	860(859)
2-year	450(424)	2,000(1,983)
3-year	550(504)	2,300(2,263)
5-year	650(602)	2,600(2,577)
10-year	750(730)	3,000(2,968)
30-year	950(930)	3,600(3,562)
50-year	1050(1022)	3,900(3,834)
100-year	1,150(1148)	4,200(4200)

Source: Study team

1.2.3 Topographical Features and Geological Conditions

(1) Topographical Survey

A topographical survey was conducted by sub-contractors. The contents and results of the topographical survey are as follows:

Table 1.2.4 Contents of the topographical survey

Item	Contents	Unit	Quantity
Plan survey	Xe Kum Kam Bridge: L = 1,250 m, W = 100 m Xe Tha Mouak Bridge: L = 1,350 m, W = 100 m	ha	26
Centerline profile for road	Xe Kum Kam Bridge: L = 1,250 m Xe Tha Mouak Bridge: L = 1,350 m	m	2,600
Cross section for road	Xe Kum Kam Bridge: L = 1250 m @ 20 m Xe Tha Mouak Bridge: L = 1,350 m @ 20 m	Section	130
Centerline profile for river	Xe Kum Kam Bridge: L = 550 m Xe Tha Mouak Bridge: L = 1,100 m	m	1,650
Cross section for river	Xe Kum Kam Bridge: 7 sections Xe Tha Mouak Bridge: 9 section s	Section	16

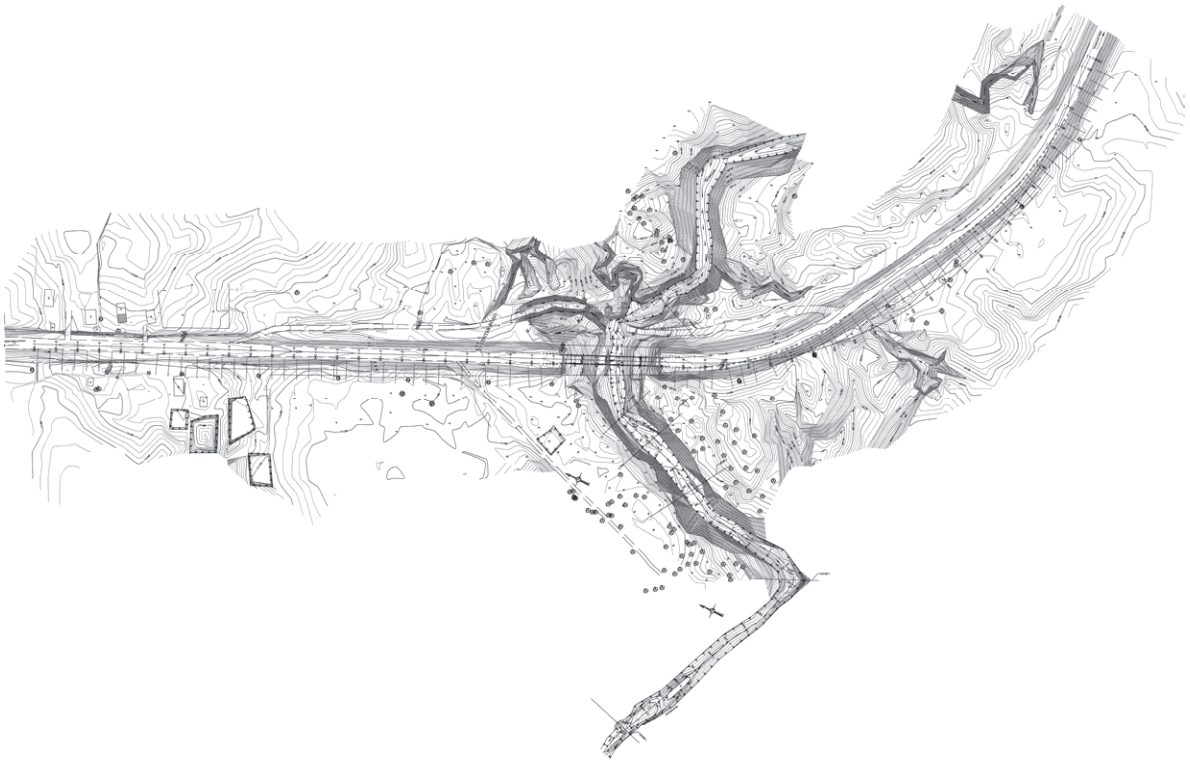


Figure 1.2.36 Map of Xe Kum Kam Bridge

Figure 1.2.37 Map of Xe Tha Mouak Bridge

(2) Geological Survey

A geological survey was conducted at a total of seven boring points. The location of boring and ground profiles is as follows:

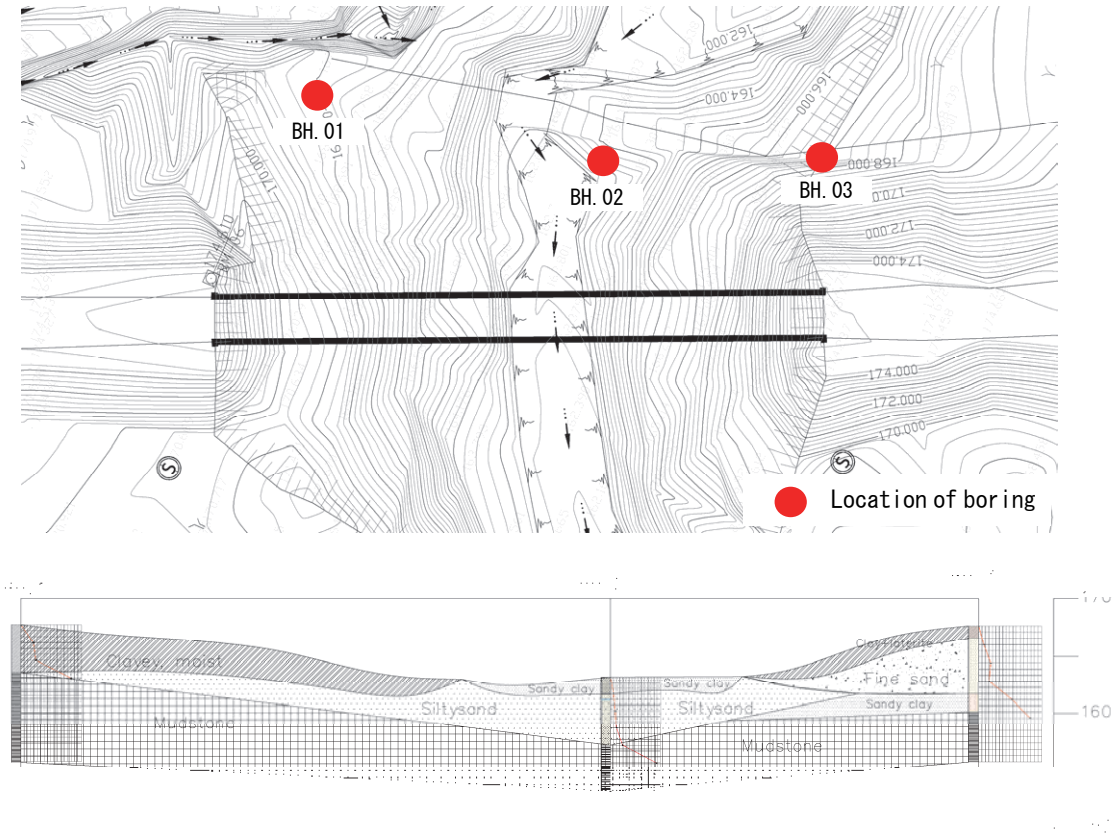


Figure 1.2.38 Location of Boring and Ground Profiles of Xe Kum Kam Bridge

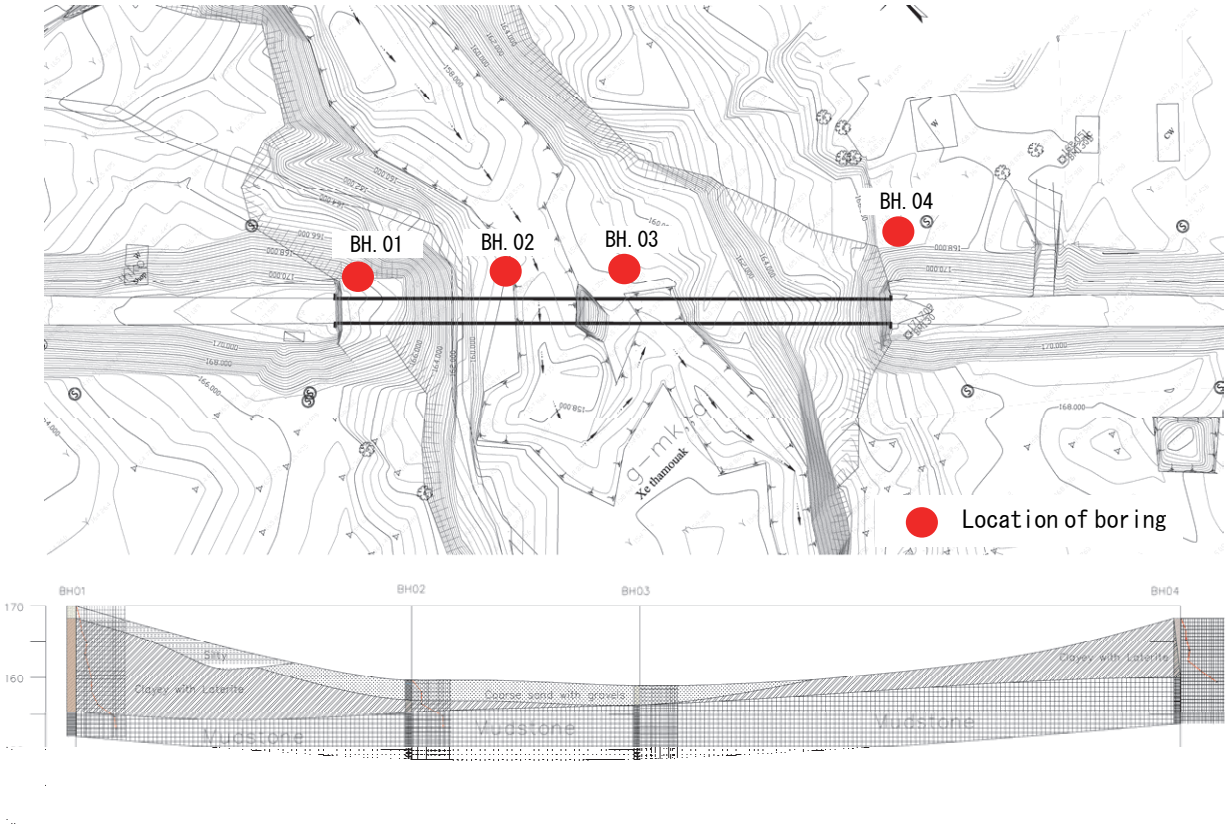


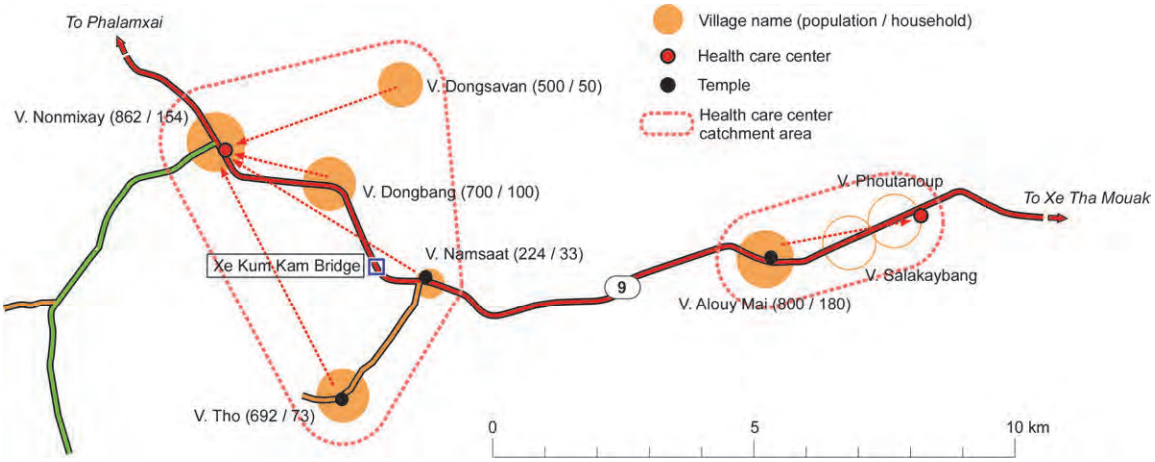
Figure 1.2.39 Location of Boring and Ground Profiles of Xe Tha Mouak Bridge

1.3 Socio-economic Conditions

To understand current socio-economic conditions at project sites and the surrounding area, an interview surveying the population, household location of medical facilities, and schools with villages in the surrounding area of the project sites was carried out.

On the western side of Xe Kum Kam Bridge, there is a small settlement consisting of several households, a small shop, and a warehouse belonging to Dongbang village, which is located about 5 km west of Xe Kum Kam Bridge. The daily activity of people in the settlement centres on Dongbang village. There is little traffic and connection between the settlement on the west side of the bridge and Nonsaath village located on the east side of the bridge.

There are two medical facilities in the vicinity of Xe Kum Kam Bridge, namely, Health Care Centers in Nomixay village west of the bridge and Phoutamoup village east of the bridge. People in Namsaat village and Tho village, a total of 916 people east of the bridge cross Xe Kum Kam Bridge to visit Health Care Center in Nomixay Bridge in general.

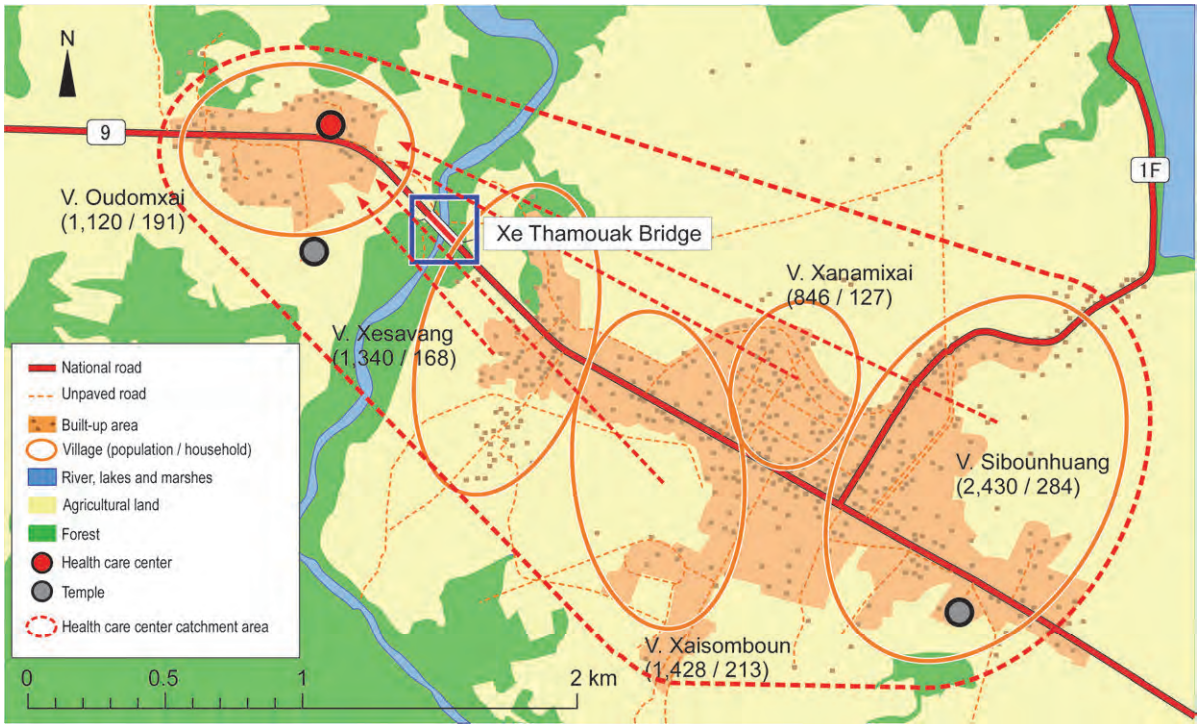


Source: Results of the Interview Surveys by the Study team

Figure 1.3.1 Medical Facility and Temple in the Vicinity of Xe Kum Kam Bridge

East of the Xe Tha Mouak Bridge, there are about 6,000 people in Xesavang, Xaisomboun, Xanamixai, and Sibounhuang villages. In the opposite direction, a population of Oudomxai on the west side of the bridge is 1,120. More than the west side of the bridge, therefore, a lot of small shops are found on the east side of the bridge, which attract villagers in Oudomxai through Xe Tha Mouak Bridge.

There is a Health Care Center in Oudomxai village that provides primary medical service to about 7,000 people in the vicinity of Xe Tha Mouak Bridge. In general, a person who requires more advanced medical care visits the District Hospital in Phin located 15 km east of Xe Tha Mouak Bridge or Savannakhet Provincial Hospital in Kaysone Phomvihane District. National Road No. 9 and bridges on it access district and provincial centres and are therefore important for people in the eastern region of Savannakhet Province.



Source: Result of the Interview Surveys by the Study team

Figure 1.3.2 Medical Facility and Temple in the Vicinity of Xe Tha Mouak Bridge

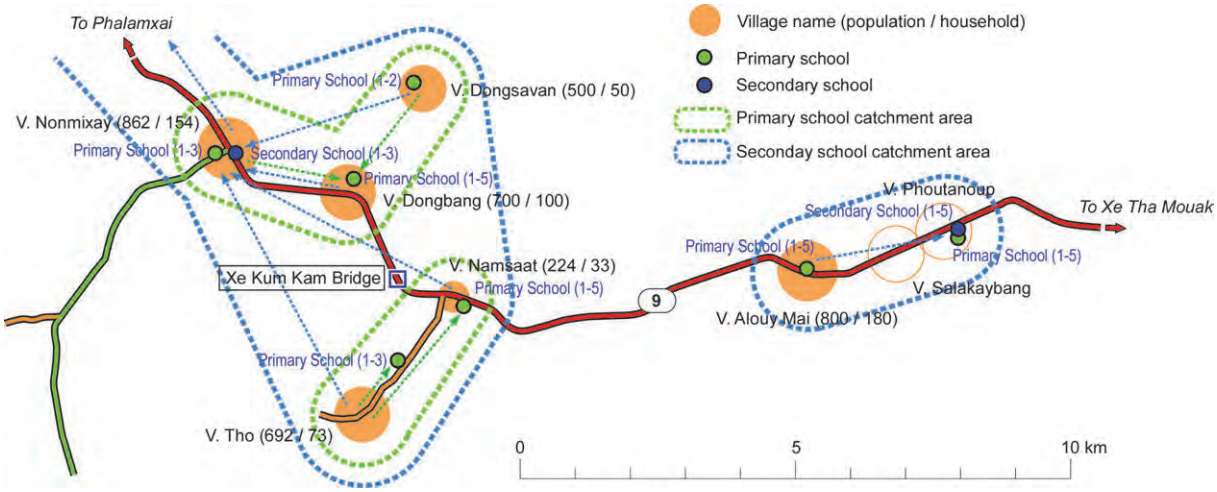
Source: Study Team

Figure 1.3.3 Health Care Centers (left: Nomixay village, right: Oudomxai village)

The period of compulsory education, namely primary education, in Laos is 5 years. According to government policy, one primary school should be established in one village. Currently, however, there are a lot of villages without a primary school or villages with schools providing only level 1-2 or 3-4 in Laos.

In the vicinity of Xe Kum Kam Bridge, all villages have one primary school including schools providing level 1-2 or 1-3 only, and the primary school catchment area is divided by Xe Kum Kam Bridge. Primary school students in this area, therefore, go to school without crossing the bridge. Secondary School is located in Phoutamoup village and Nomixay village, which attract secondary

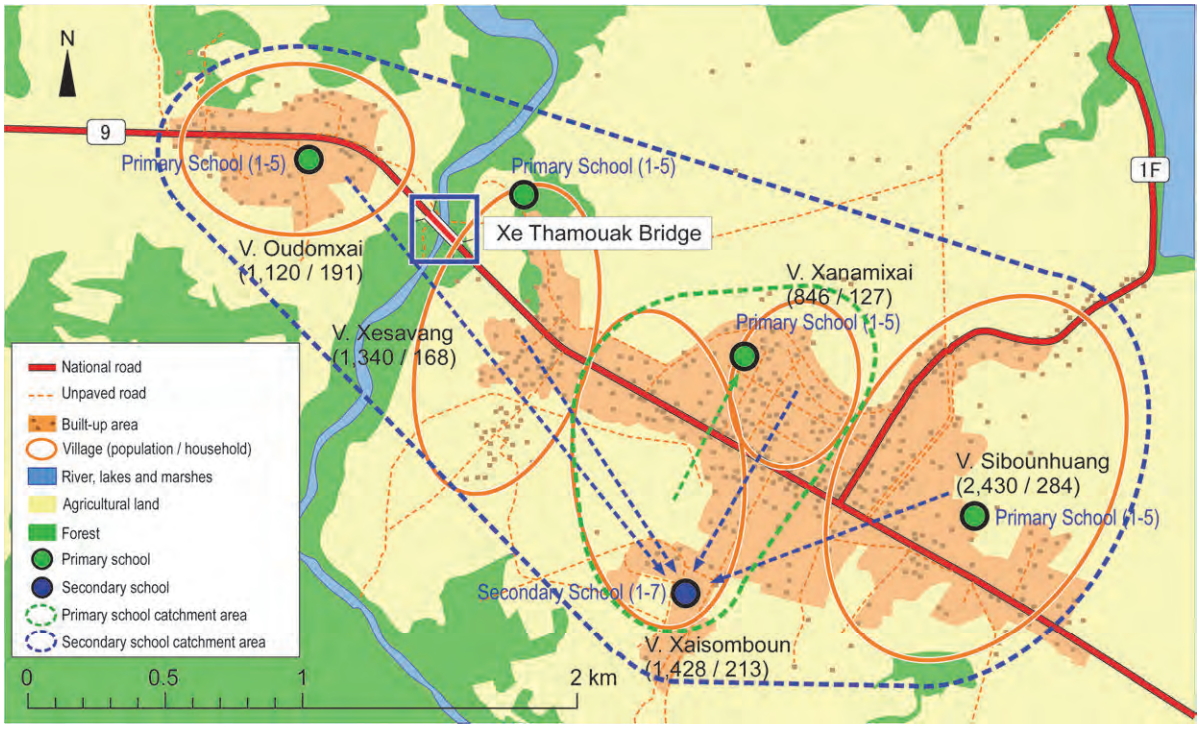
school students in Namsaat and Tho villages who cross the bridge by Sonteo or other motorized vehicles.



Source: Result of the Interview Surveys by the Study team

Figure 1.3.4 Schools in the Vicinity of Xe Kum Kam Bridge

All villages except Xaisomboun village have a primary school providing levels 1-5; therefore, there are no primary school students crossing the bridge to go to school. In Xaisoumboun village there is a secondary school that attracts students in this area.



Source: Result of the Interview Surveys by the Study team

Figure 1.3.5 Schools in the Vicinity of Xe Tha Mouak Bridge

Figure 1.3.6 Primary School (left: Dongbang village, right:Oudomxai village)

1.4 Traffic Demand Forecast

In order to understand the current traffic situation and contribute to the future traffic demand of Xe Kum Kam Bridge and Xe Tha Mouak Bridge the following are planned and implemented: (1) a driver interview survey and traffic count survey at the border crossing with Thailand and Vietnam, (2) a traffic count at major sections of National Road No. 9 for 12 hours, and (3) a pedestrian and non-motorized person trip count survey at Xe Kum Kam and Xe Tha Mouak Bridges.

1.4.1 Cross-border Traffic

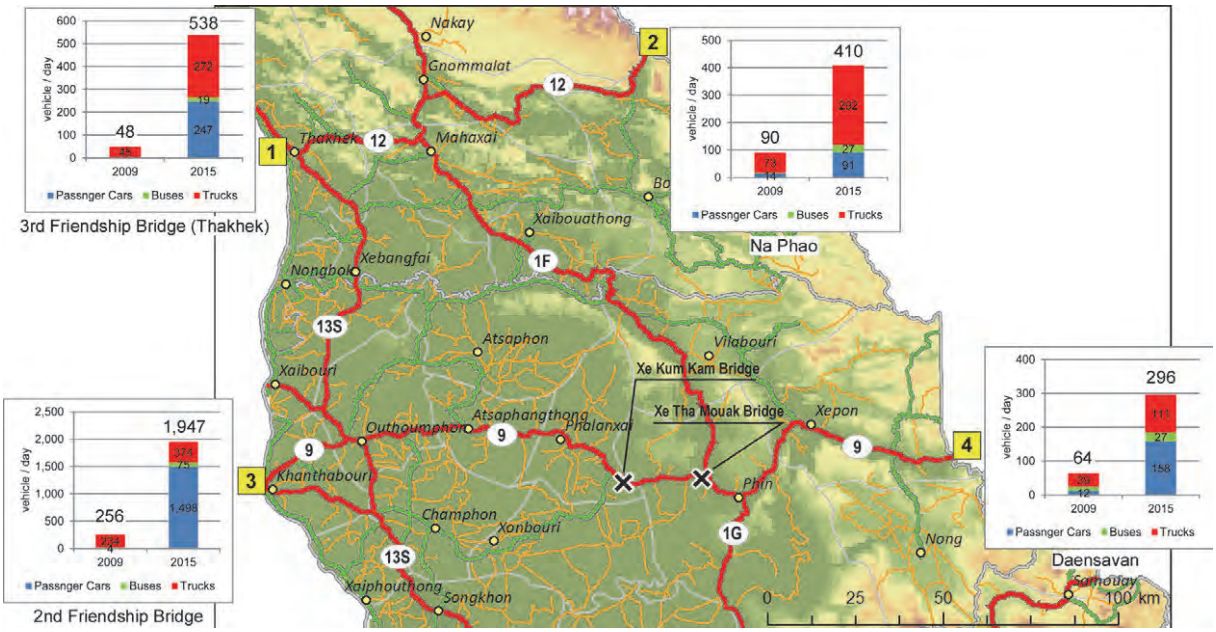
The major purpose of the interview and traffic count survey at the border crossing is to collect traffic data for National Roads No. 9 and No. 12 after the 3rd Thai-Lao Friendship Bridge opened in November 2011. The survey locations are border customs points with the Thailand National Road No. 9 and No. 12, namely, the 2nd and 3rd Thai-Lao Friendship Bridge, and border customs points with Vietnam, namely, Densawan and Na Phao.

Table 1.4.1 Survey Location and Date of Cross-Border Survey

No	Road	Location	Survey Date	Traffic Count	Driver Interview *
1	-	Thai Border (3rd Thai-Lao Friendship Bridge)	19 May 2015	6:00-18:00 (12h)	6:00-18:00 (12h)
2	NH-12	Vietnam Border (Na Phao customs)	21 May 2015	6:00-18:00 (12h)	6:00-18:00 (12h)
3	NH-9	Thai Border (2nd Thai-Lao Friendship Bridge)	12 May 2015	6:00-18:00 (12h)	6:00-18:00 (12h)
4	NH-9	Vietnam Border (Den Savan customs)	14 May 2015	6:00-18:00 (12h)	6:00-18:00 (12h)

Source: Study Team

The following figure indicates the results of the border crossing traffic count in 2015 and 2009 based on immigration statistics. A massive increase of cross-border traffic is observed at every customs point from 2009. Traffic growth from 2009 to 2015 at National Road No. 12 border is significantly larger than National Road No. 9 due to the opening of the 3rd Thai-Lao Friendship Bridge. The annual average growth rate in 2009-2015 of truck traffic volume at National Road No. 9 border crossing, namely, the 2nd Thai-Lao Friendship Bridge and Densavan are 8% and 19% respectively. The average growth rate of trucks at the 3rd Thai-Lao Friendship Bridge and Na Phao customs are 35% and 26%, respectively.



Source: Study Team, Traffic volume in 2009 is based on the Summary of Immigration Statistics, Immigration Police Department, and Ministry of Public Security

Figure 1.4.1 Cross-Border Traffic Volume

A driver interview survey in the study includes origin and destination (OD), number of passengers including driver, and type of loading commodity (trucks only) as survey items. The sample rate of the interview survey is expected to be more than 20% of traffic volume at each survey location by the type of vehicle and direction. As shown in the following table, a sample rate of passenger cars, buses, and trucks exceed the expected sample rate.

Table 1.4.2 Sample Rate of OD Interview Survey

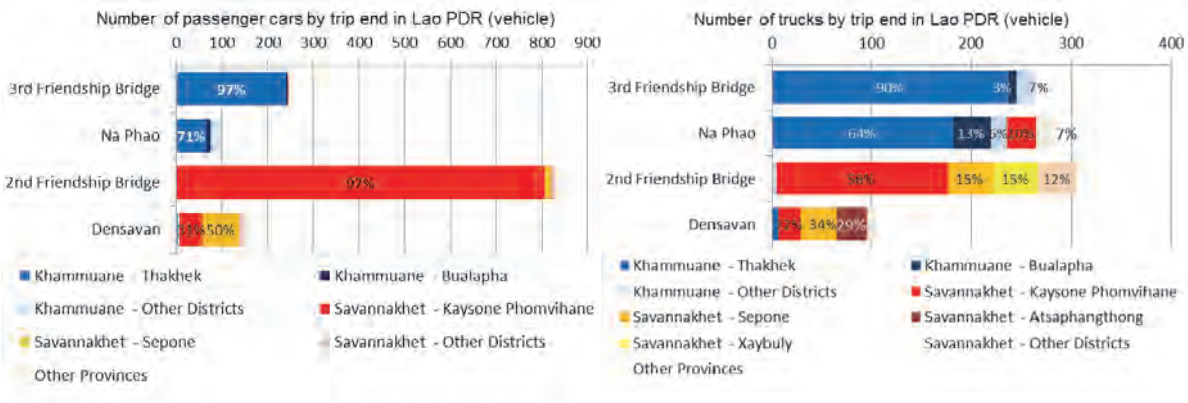
No	Survey Location	Direction name	Passenger cars	Buses	Trucks
1	3rd Thai-Lao Friendship Bridge	Inbound	73%	100%	75%
		Outbound	72%	100%	85%
2	Na Phao customs	Inbound	42%	79%	74%
		Outbound	67%	85%	86%
3	2nd Thai-Lao Friendship Bridge	Inbound	25%	49%	61%
		Outbound	17%	63%	48%
4	Den Savan customs	Inbound	57%	100%	63%
		Outbound	36%	80%	68%

Source: Study team

The results of the OD interview survey are expanded by traffic volume and by the traffic count survey, and analysed to identify characteristics of cross-border traffic.

Terminals (origin or destination) in Laos of cross-border passenger cars with Thailand through the 2nd and 3rd Thai-Lao Friendship Bridges is dominated by Thakhek (97%) and Kaysone Phomvihane districts (97%) respectively. 56% of truck traffic through 2nd Thai-Lao Friendship Bridge is generated in Kaysone Phomvihane District and the remaining 42% is generated in other districts in Savannakhet Province.

The share of terminals in Thakhek of cross-border passenger cars with Vietnam through Na Phao is 71%. Major terminals for trucks in Laos through Na Phao are Thakhek (64%), Bualapha District in Khammuane Province (13%), and Kaysone Phomvihane District (10%). The share of Kaysone Phomvihane District of passenger cars and truck trips ending in Laos from cross-border traffic through Densavan is only 31% and 22% respectively, and it is lower than the share of Sepone District bordering Vietnam.

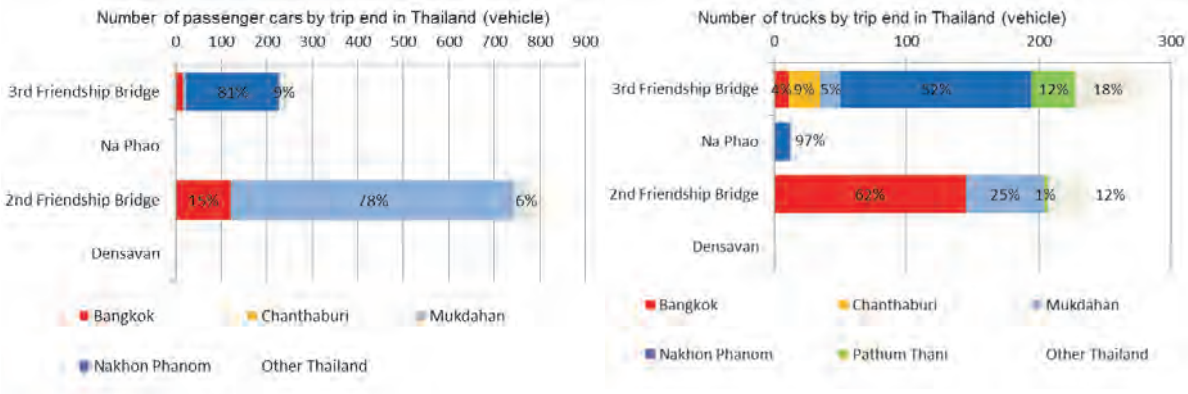


Source: Study team

Figure 1.4.2 Origin and Destination in Laos of Cross-Border Traffic (left: passenger cars, right: trucks)

Passenger car trips ending in Thailand through the 2nd Thai-Lao Friendship Bridge are occupied by Mukdahan (78%) and Bangkok (15%). Truck trips through the 2nd Thai-Lao Friendship Bridge is mainly generated by Bangkok (62%) and Mukdahan (25%).

Terminals in Thailand of passenger cars through the 3rd Thai-Lao Friendship Bridge is dominated by Nakhon Phanom (81%). Shares of Nakhon Phanom of truck terminals is 52%, and only 4% of trucks generated in Bangkok.



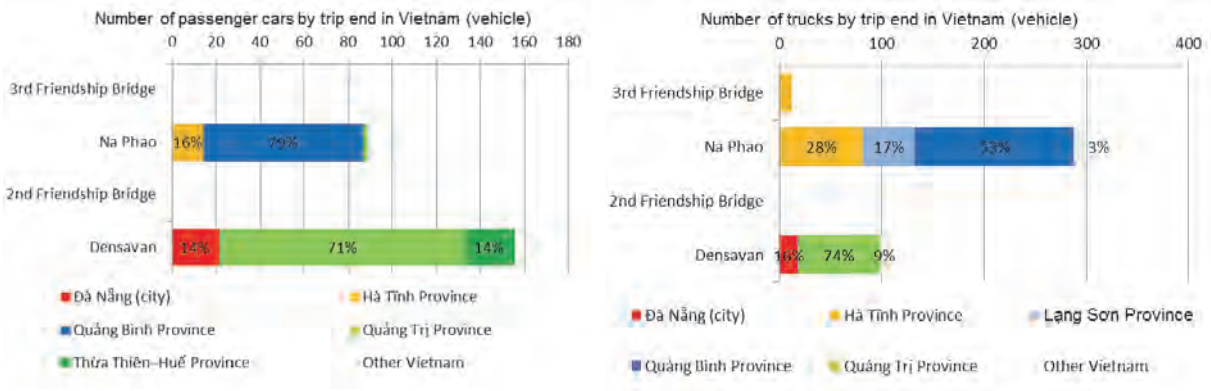
Source: Study team

Figure 1.4.3 Origin and Destination in Thailand of Cross-Border Traffic (left: passenger cars, right: trucks)

Cross-border passenger car and truck traffic through Na Phao customs is mainly generated in Quang Binh (79% and 53% respectively) and Ha Tinh, adjacent to Quang Binh (16% and 28%).

Trucks relevant to Lang Son, adjacent to the Chinese border, are 17% of trucks from/to Vietnam through Na Phao customs.

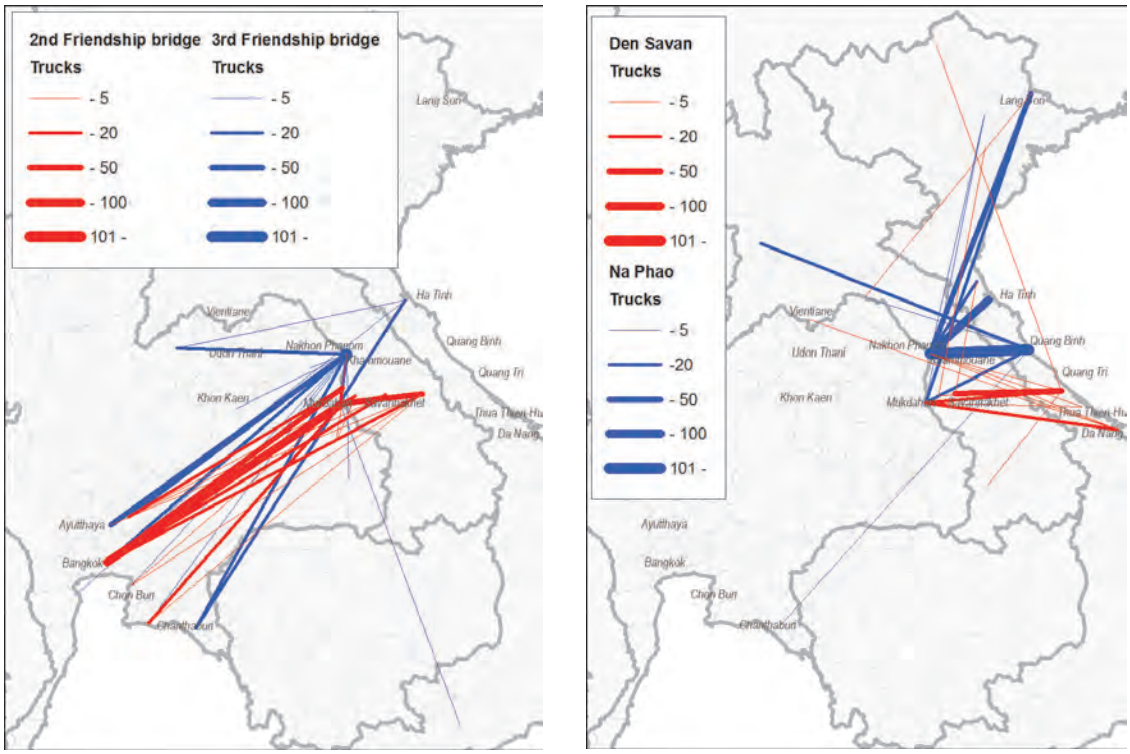
Cross-border traffic through Densavan is dominated by Quang Tri, adjacent to Sepong District (71% of passenger cars, 74% of trucks from/to Vietnam). The share of Da Nang is 14% of passenger cars and 16% of trucks from/to Vietnam.



Source: Study team

Figure 1.4.4 Origin and Destination in Vietnam of Cross-Border Traffic (left: passenger cars, right: trucks)

The following figure shows the desired line of truck traffic based on the border crossing OD interview survey: Trucks through National Road No. 12 and Na Phao customs from/to north of Quang Binh, and trucks through National Road No. 9 and Densavan customs from/to south of Quang Tri. Although the growth rate of traffic volume on National Road No. 12 is greater than National Road No.9, but National Road No. 9 cover the demand which originate/destine important city such as Bangkok and Da Nang based on traffic survey and OD survey.



Source: Study Team

Figure 1.4.5 Desired Line of Cross-Border trucks (left: 2nd and 3rd Friendship Bridge, right: Densavan and Na Phao customs)

1.4.2 Traffic Volume at Major Sections on National Road No. 9

The traffic count survey at major sections on National Road No. 9 is carried out in order to update vehicular OD matrices prepared by the "preparatory Study for Improvement of Roads and Bridges in the Southern Region in Lao PDR (JICA, 2010)" and contributes to the future traffic demand forecast of Xe Kum Kam and Xe Tha Mouak Bridges. Survey locations, therefore, are basically on the district boundaries of National Road No. 9 in accordance with zone system of existing OD matrices.

The traffic count survey is carried out over 12 hours (6:00-18:00) on a weekday by direction and type of vehicle (motorcycle, tuk-tuk, passenger cars, sonteo, medium bus, large bus, 2-axle truck, 3-or-more axle rigid truck, and semi/full trailers).

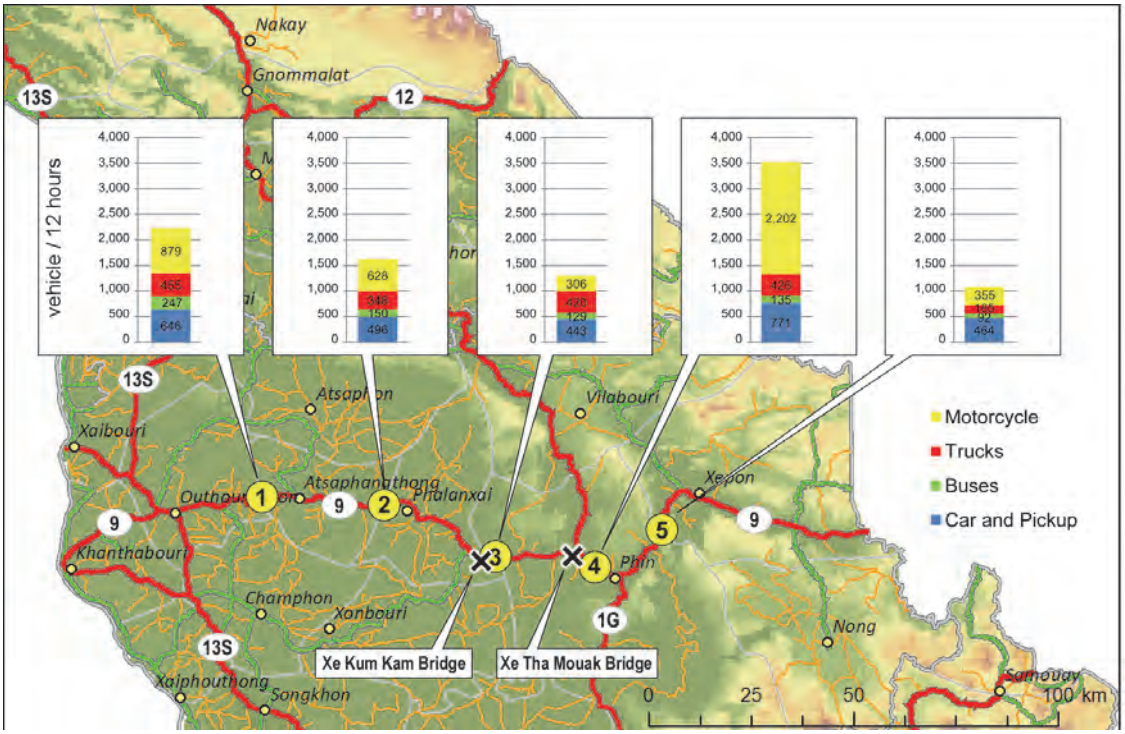
Table 1.4.3 Survey Location and Date of Traffic Count Survey at National Road No. 9

No	Road	Location	Survey Date	Traffic Count
1	NH-9	Boundary of Atsaphangthong–Outhoumphon district	14 May 2015	6:00-18:00 (12h)
2	NH-9	Boundary of Phalanxai–Atsaphangthong district	14 May 2015	6:00-18:00 (12h)
3	NH-9	Boundary of Phin–Phalanxai district, i.e., Xe Kum Kam bridge	13 May 2015	6:00-18:00 (12h)
4	NH-9	Phin between intersections with NH-1	12 May 2015	6:00-18:00 (12h)
5	NH-9	Boundary of Xepon–Phin district	12 May 2015	6:00-18:00 (12h)

Source: Study Team

The traffic volume at the road sections of National Road No. 9 becomes larger toward Savannakhet provincial center, except in survey location No. 4. Survey location No. 4 is near a built-up area of Phin; therefore, heavy short-trip motorcycle and passenger cars are observed. Traffic relevant to National Road No. 1 is also included in the traffic volume at survey location No. 4.

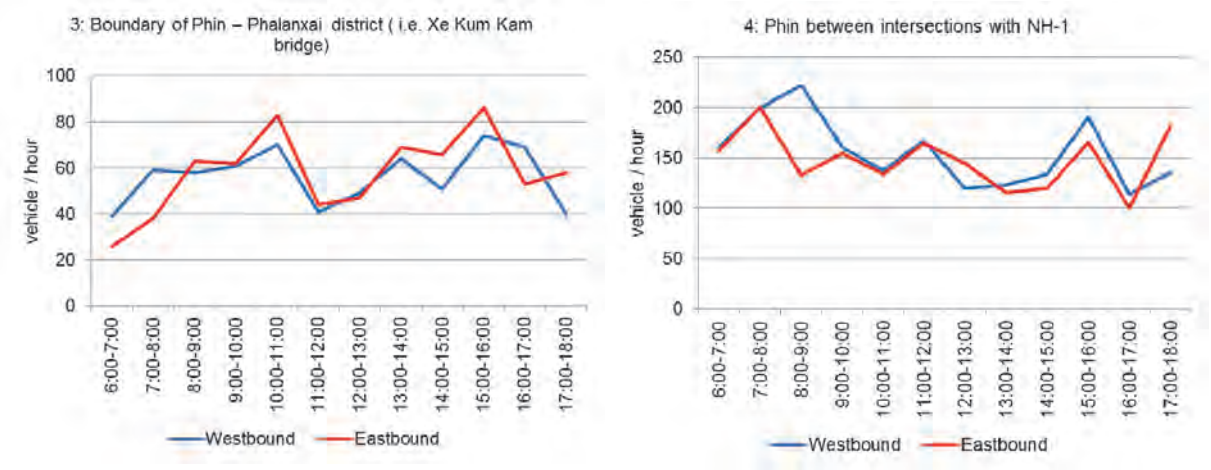
Regarding public transport, traffic volume of tuk-tuk is very small, and sonteo is a major public transport along National Road No. 9.



Source: Study Team

Figure 1.4.6 12 Hour Traffic Volume at Survey Location

As the results of analysis of hourly traffic volume by direction, a difference between hourly traffic volumes by direction is not remarkable. Peak hours at the boundary of Phin and Phalanxai Districts (Xe Kum Kam Bridge) are observed at 10:00-11:00 and 15:00-16:00. Peak hours at Phin between intersections with National Road No. 1 (near Xe Tha Mouak Bridge) are 7:00-9:00 and 15:00-16:00.

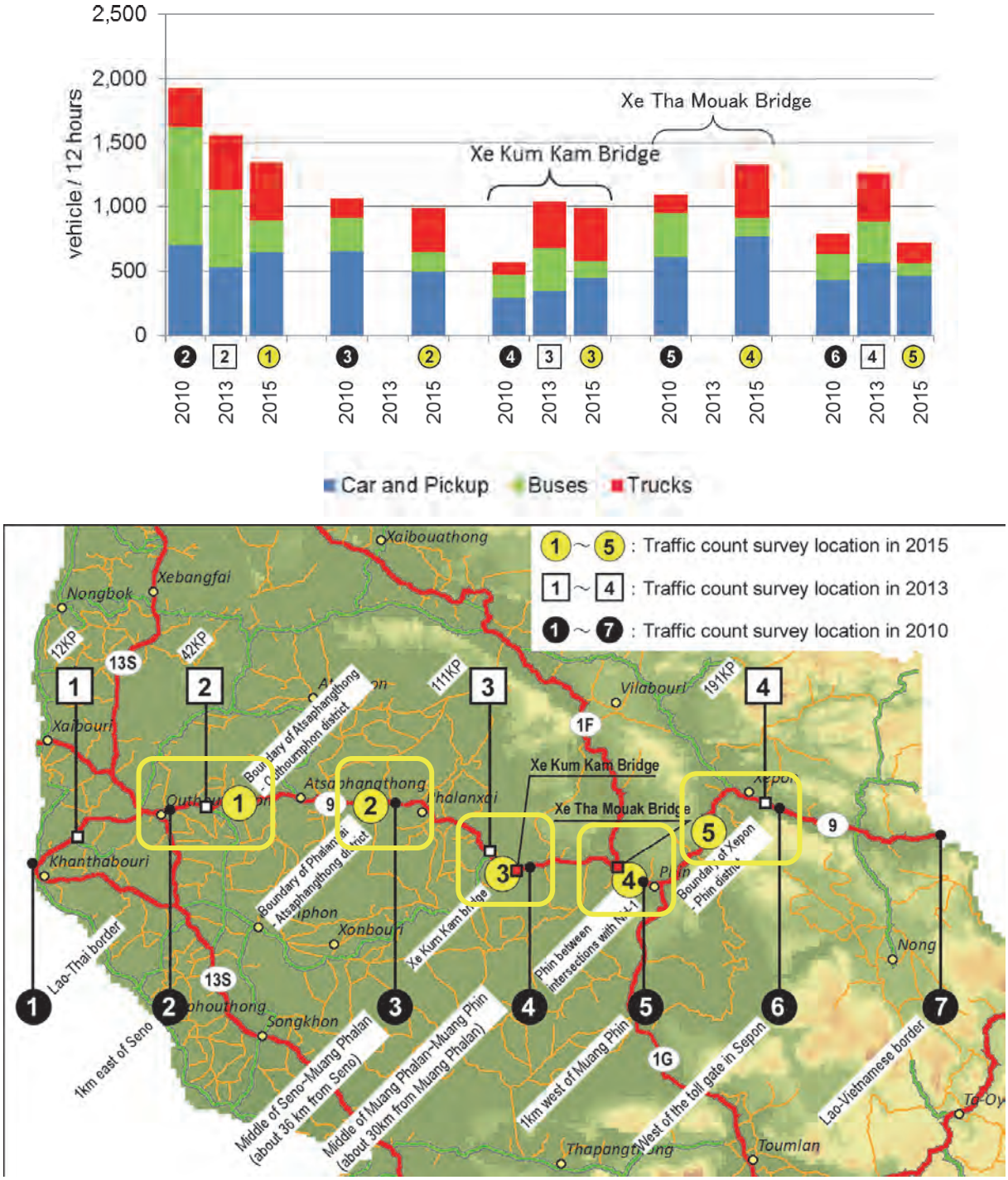


Source: Study Team

Figure 1.4.7 Hourly Fluctuation by Direction (left: Xe Kum Kam Bridge, right: near Xe Tha Mouak Bridge)

The following figure shows the traffic volume of National Road No. 9 in 2010, 2013, and 2015. Because of the difference in the objectives of traffic count survey by year, a survey is carried out at a different location by year. Traffic volume in 2015 at survey location 1 (district boundary of Atsaphangthong and Outhoumphon Districts) and 5 (district boundary of Xepon–Phin Districts) is lower than the traffic volume in 2010 and 2013, which were carried out in a built-up area.

The traffic volume at Xe Kum Kam Bridge is almost the same volume in 2013 and 2015 (1,038 vehicles/12 hours and 992 vehicles/12 hours in 2015), but the annual growth rate of passenger cars and trucks in 2013-2015 are 13% and 8% respectively.



Source: Study Team
Note: motorcycle is not included.

Figure 1.4.8 12 Hour Traffic Volume in 2010, 2013, and 2015

1.4.3 Pedestrian and Non-motorized Persons at Bridges

The pedestrian and non-motorized person trip count survey was carried out 6:00-18:00 on a weekday at Xe Kum Kam and Xe Tha Mouak Bridges in order to understand the current situation. The survey items include number of pedestrians and cyclists by direction and gender, namely, male,

female, and child. In addition to pedestrian count, a vehicle occupancy survey was carried out to estimate the number of people per trip crossing bridges by motorized transport. The vehicle occupancy survey is a sample survey to count the number of passengers, including the driver.

Table 1.4.4 Survey Location and Date of Pedestrian and Non-motorized Person Count Survey

No	Road	Location	Survey Date	Traffic Count
1	NH-9	Xe Kum Kam Bridge	13 May 2015	6:00-18:00 (12h)
2	NH-9	Xe Tha Mouak Bridge	12 May 2015	6:00-18:00 (12h)

Source: Study Team

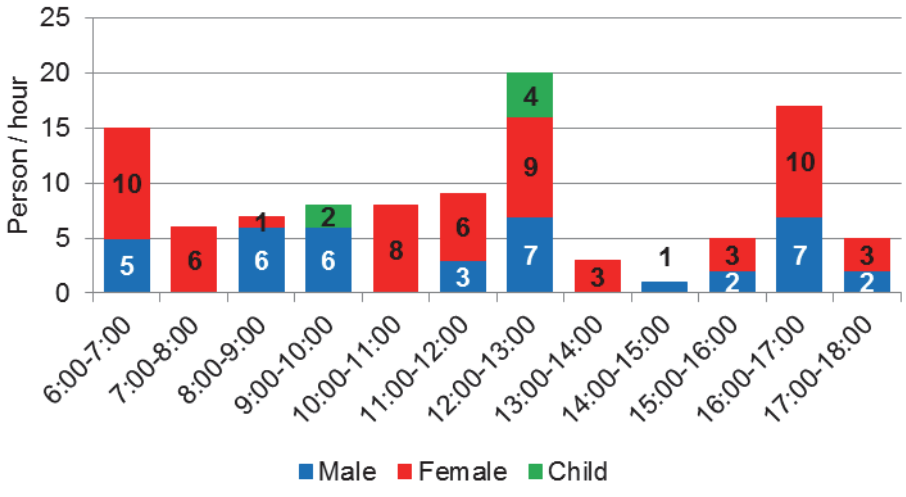
As the results of the survey, the pedestrian crossing Xe Kum Kam Bridge is too small. At Xe Tha Mouak Bridge, 104 pedestrians, including bicycles, were observed in 12 hours and more than half of the pedestrians were female. The number of children, including schoolchildren, crossing the bridge was small.

Table 1.4.5 Number of Pedestrians in 12 Hours by Bridges

		On-foot			Bicycle and other non-motorized transport			Total		
		Male	Female	Child	Male	Female	Child	Male	Female	Child
1	Xe Kum Kam bridge	1	0	0	0	0	0	1	0	0
2	Xe Tha Mouak bridge	12	43	6	27	16	0	39	59	6

Source: Study Team

The female trip is remarkable at mealtime in the morning, midday, and evening, and it is considered that that female trip is mainly made by women who have meal and shopping purposes without available motorized transport.



Source: Study Team

Figure 1.4.9 Number of Pedestrians by Hours

The following table shows the results of a vehicle occupancy survey at the bridges. The number of samples of vehicles and passengers is a total of two bridges in both directions, and vehicle occupancy rates are an average of the two bridges.

Table 1.4.6 Average Vehicle Occupancy Rates at Xe Kum Kam and Xe Tha Mouak Bridges

	Vehicle	Passenger	Occupancy
Motorcycle	2,355	3,350	1.42
Tuk Tuk	-	-	-
Cars (Sedan, 4WD, Van, Pickup)	1,153	2,296	1.99
Sonteo	175	1,136	6.49
Medium Bus (~35 seats)	35	374	10.69
Large Bus	60	1,064	17.73
Rigid Truck: 2 axles	483	1,208	2.5
Rigid Truck: 3 or more axles	194	304	1.57
Articulated Truck, Trailer	185	281	1.52
Agricultural Tractor	175	563	3.22

Source: Study team

1.4.4 Data Collection and Analysis on Existing Traffic Volume Data

To estimate the annual average daily traffic volume (AADT) based on the results of the traffic survey in 12 hours, an expansion factor to expand traffic volume from 12 hours to 24 hours and an adjustment factor to adjust fluctuation by season are calculated by the following existing data.

- 24-hour traffic volume data by the "Rehabilitation of National Road No. 9 (2013, JICA)"

Traffic volume by vehicle group and month in 2001-2007 at toll gates on National Road No. 9, namely, Donepalai and Ban Na Bo.

The expansion factor to expand to 24-hour traffic volume is calculated by a ratio of daily traffic to daytime traffic by vehicle type, based on the results of the traffic count survey in 2013. The following table shows the expansion factor by type of vehicle in accordance with existing vehicular OD matrices. The expansion factor for passenger cars is applied to motorcycles because motorcycles were not included in the traffic survey in 2013.

Table 1.4.7 Expansion Factor by Vehicle type in 2013

	Ratio of daily traffic to daytime traffic	Expansion factor for 24 hours
Passenger cars	73%	1.37
Buses	77%	1.31
Light trucks (2 axles)	77%	1.30
Heavy trucks (3+ axles)	59%	1.70
Trailers	66%	1.51

Source: Study team

The following table shows the expanded 24-hour traffic volume at major sections of National Road No. 9 in 2015.

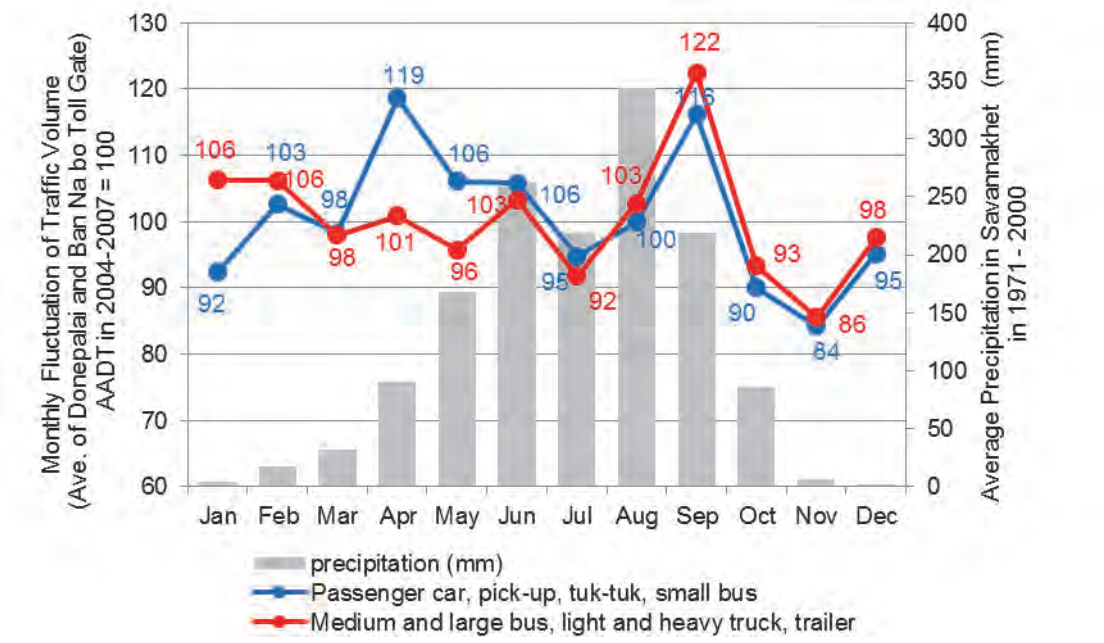
Table 1.4.8 Expanded Daily Traffic Volume by Sections of National Road No. 9

Survey Location	1) Atsaphangthong–Outhoumphon	2) Phalanxai–Atsaphangthong	3) Phin–Phalanxai (Xe Kum Kam bridge)	4) Phin between intersections with NH-1 (Xe Tha Mouak bridge)	5) Xepon–Phin
Motorcycle	1,204	860	419	3,017	486
Car	885	680	607	1,056	636
Sonteo	271	141	115	121	73
Medium bus	20	24	22	17	9
Large bus	33	31	31	39	38
Light truck (2 axles)	371	277	221	360	52
Medium truck (3+ axles)	114	80	299	105	71
Heavy truck (trailers)	175	150	126	148	141
Total (vehicle/day)	3,072	2,243	1,841	4,863	1,507
% heavy vehicles	10%	12%	25%	6%	17%
Total (PCU/day)	12,475	9,109	7,953	18,923	6,071

Source: Study team

When traffic volume fluctuates by season, traffic volume by survey should be adjusted to the AADT. Existing traffic volume data at tollgates by month in 2001-2007 is analysed to confirm monthly fluctuation at National Road No. 9.

As a result, ratios of traffic volume in May when the traffic count survey was carried out in a study to the AADT are 106% of passenger cars and light vehicles and 96% of heavy vehicles, including middle and more buses and trucks. The adjustment factor for monthly fluctuation was not applied because the difference between traffic volume in May and the AADTA is very small.



Source: Traffic volume is based on the monthly traffic volume data at Donepalai and Ban Na Bo tollgate in 2004-2007. Average precipitation is based on World Meteorological Organization data.

Figure 1.4.10 Monthly Fluctuation of Traffic Volume and Rainfall

1.4.5 Future Traffic Demand Forecast

The purposes of the future traffic demand forecast are to estimate future traffic volume at Xe Kum Kam and Xe Tha Mouak Bridges, and to evaluate economic loss in the case of a bridge closure for some reason. The future demand forecast is based on the road network and vehicular OD matrices in the Greater Mekong Subregion (GMS) prepared by the "Preparatory Study for Improvement of Roads and Bridges in the Southern Region in Lao PDR (JICA, 2010)." To build future vehicular OD matrices, existing OD matrices in 2015 are updated based on the results of the cross-border traffic OD survey and traffic volume of National Road No. 9. Based on the modified current OD matrices in 2015, the future OD matrices in 2022 (three years later after completion of the projects) and 2039 (20 years after completion of the projects) are estimated.

Existing OD matrices in 2015 are updated based on the results of the cross-border OD survey and OD matrices of the cross-border link on the road network calculated by the incremental assignment of existing vehicular OD matrices. Domestic OD pairs in the OD matrices relevant to major sections of National Road No. 9 are modified in accordance with AADT based on the traffic survey.

Annual growth rates in 2015-2025 by OD pair and vehicle type are calculated by existing OD matrices and applied to updated 2015 OD matrices in order to build OD matrices in 2022 and 2025. The annual growth rate of vehicular OD matrices in 2025-2039 for the estimation of OD matrices in 2039 is calculated by the product of the annual population growth rate by the future moderate-range population projection by UN and annual GDP growth rate by long-term GDP

growth estimation by IMF and by GMS country. The annual growth rate in 2025-2039 of cross-border vehicular trip is the geometric mean of growth rates of two countries.

Table 1.4.9 Expansion Factor and Annual Growth Rate of Future Traffic Demand in 2025-2039

GMS Country	Expansion Factor of Vehicular Trips, 2025-2039	Annual Average Growth Rate
Cambodia	3.27	8.8%
China	2.32	6.2%
Lao PDR	2.92	7.9%
Myanmar	2.66	7.3%
Thailand	1.80	4.3%
Vietnam	2.40	6.5%

Source: Study team

Assignment of vehicular OD matrices on the road network is calculated by the shortest route search by generalized cost of vehicle. Time value and vehicle operating cost (VOC) is updated to 2015 value by existing value prepared in 2010 and average inflation rate in Laos in 2010-2013.

Table 1.4.10 Time Value and VOC in 2015

No	Vehicle	Time Value (USD/hour)	Vehicle Operating Cost (USD/1,000km)	PCU
1	Motorcycle	1.53	35	0.4
2	Passenger car	4.59	274	1.0
3	Bus	1.63	453	2.0
4	Light truck (2 axles)	1.18	252	1.75
5	Medium truck (3+ axles)	2.62	413	2.3
6	Heavy truck (trailer)	5.60	441	3.2

Source: Study Team

Note: Passenger car unit (PCU) is defined by the Study Team based on the Traffic Modelling Guideline (Transport of London 2010)

Based on the results of the assignment of estimated future vehicular OD matrices on the road network, future traffic volume at Xe Kum Kam and Xe Tha Mouak Bridges are forecasted as shown in the following tables:

Table 1.4.11 Future Traffic Volume of Xe Kum Kam Bridge (Base Case)

	Daily traffic volume (vehicles/day)					Annual growth rate			
	2015	2019	2022	2025	2039	2015-2019	2019-2022	2022-2025	2025-2039
Motorcycle	419	589	757	973	2,576	8.9%	8.7%	8.7%	7.2%
Passenger car	607	780	937	1,121	2,779	6.5%	6.3%	6.2%	6.7%
Sonteo	115	148	176	204	585	6.6%	5.7%	5.3%	7.8%
Medium bus	22	28	33	39	112	6.6%	5.7%	5.3%	7.8%
Large bus	31	40	47	55	158	6.6%	5.7%	5.3%	7.8%
2 axels truck	221	280	337	405	1,101	6.1%	6.4%	6.2%	7.4%
3+ axles truck	299	390	475	580	1,515	6.9%	6.8%	6.9%	7.1%
Trailer	126	166	204	251	639	7.1%	7.1%	7.2%	6.9%
Total	1,780	2,344	2,966	3,522	9,159	7.1%	7.0%	6.9%	7.1%

Source: Study Team

Table 1.4.12 Future Traffic Volume of Xe Tha Mouak Bridge (Base Case)

	Daily traffic volume (vehicles/day)					Annual growth rate			
	2015	2019	2022	2025	2039	2015-2019	2019-2022	2022-2025	2025-2039
Motorcycle	3,017	4,245	5,457	7,028	19,095	8.9%	8.7%	8.8%	7.4%
Passenger car	1,056	1,367	1,656	1,995	5,144	6.7%	6.5%	6.5%	7.0%
Sonteo	121	156	184	215	615	6.6%	5.7%	5.2%	7.8%
Medium bus	17	22	26	30	86	6.6%	5.7%	5.2%	7.8%
Large bus	39	50	59	69	198	6.6%	5.7%	5.2%	7.8%
2 axels truck	198	249	311	357	984	5.90%	6.4%	6.2%	7.5%
3+ axles truck	267	348	425	511	1,353	6.85%	6.8%	6.9%	7.2%
Trailer	148	195	240	295	750	7.1%	7.1%	7.2%	6.9%
Total	4,800	6,550	8,358	10,389	27,906	8.1%	8.0%	8.0%	7.3%

Source: Study Team

In addition to the base case, the following two-road networks are prepared for the evaluation of bridge closures and computed.

- Case 1: Xe Kum Kam Bridge closed.
- Case 2: Xe Tha Mouak Bridge closed.

In the case of without projects, reliability of the existing two bridges decreases and the risk of bridge closures increases due to the useful life of the bridges. The economic loss caused by bridge closures and detours is calculated as a socio-economic benefit of the projects.

The following tables show an increase of vehicle-km, vehicle-hours, and estimated economic loss by detour calculated by time value and VOC.

Table 1.4.13 Increase of Vehicle-km and Vehicle-hours in Case 1: Xe Kum Kam Bridge Closed

	Increase of vehicle-km				Increase of vehicle-hour			
	2019	2022	2025	2039	2019	2022	2025	2039
Motorcycle	8,544	10,569	17,855	92,832	1,678	2,420	3,591	12,653
Passenger car	18,514	28,239	33,422	125,168	1,666	2,368	3,121	12,660
Bus	410	783	1,386	7,420	222	275	375	1,407
Light truck (2 axles)	3,150	3,784	4,516	12,074	294	396	516	1,817
Medium truck (3+ axles)	3,746	4,533	5,508	14,888	269	360	481	1,851
Heavy truck (trailers)	5,639	6,824	8,295	21,743	374	500	668	2,428

Source: Study Team

Table 1.4.14 Economic Loss per Day in Case 1: Xe Kum Kam Bridge Closed

	Cost by VOC and time lost (USD/day)			
	2019	2022	2025	2039
Motorcycle	2,870	4,079	6,128	22,628
Passenger car	12,718	18,605	23,480	92,407
Bus	548	802	1,239	5,656
Light truck (2 axles)	1,143	1,423	1,750	5,197
Medium truck (3+ axles)	2,251	2,813	3,532	10,991
Heavy truck (trailers)	4,581	5,809	7,399	23,183
Total	24,111	33,532	43,527	160,062

Source: Study team

Table 1.4.15 Increase of Vehicle-km and Vehicle-hour in Case 2: Xe Tha Mouak Bridge Closed

	Increase of vehicle-km				Increase of vehicle-hour			
	2019	2022	2025	2039	2019	2022	2025	2039
Motorcycle	73,066	93,964	128,117	411,482	4,243	5,889	8,473	34,241
Passenger car	121,254	157,214	192,679	579,202	5,257	7,058	9,261	36,686
Bus	4,593	4,953	6,569	15,088	378	452	594	2,423
Light truck (2 axles)	9,533	11,474	13,741	36,950	563	735	967	3,951
Medium truck (3+ axles)	9,902	12,061	14,741	39,075	567	738	980	4,071
Heavy truck (trailers)	13,257	16,197	19,903	50,889	724	949	1,259	5,028

Source: Study Team

Table 1.4.16 Economic Loss per Day in Case 2: Xe Tha Mouak Bridge Closed

	Cost by VOC and time lost (USD/day)			
	2019	2022	2025	2039
Motorcycle	9,041	12,291	17,439	66,790
Passenger car	57,324	75,438	95,258	326,998
Bus	2,698	2,981	3,945	10,787
Light truck (2 axles)	3,071	3,765	4,612	13,999
Medium truck (3+ axles)	5,572	6,913	8,653	26,788
Heavy truck (trailers)	9,895	12,451	15,823	50,586
Total	87,600	113,840	145,730	495,948

Source: Study team

The following table shows the average travel speed of the road network in Savannakhet Province of the base case and case 1 and 2, calculated by vehicle assignment. The travel speed of the base case decreases year by year because of an increase in traffic volume. In the case of Xe Kum Kam or Xe Tha Mouak Bridge closures, travel speed is 5-6 km/h lower than the base case.

Table 1.4.17 Average Travel Speed in Savannakhet

	Base Case	Case 1 (Link cut Xe Kum Kam)		Case 2 (Link cut Xe Tha Mouak)	
2019	45.7	41.1	(-4.6)	40.0	(-5.7)
2022	44.4	39.6	(-4.7)	38.3	(-6.1)
2025	43.0	38.2	(-4.8)	36.8	(-6.2)
2039	33.7	30.0	(-3.6)	28.5	(-5.2)

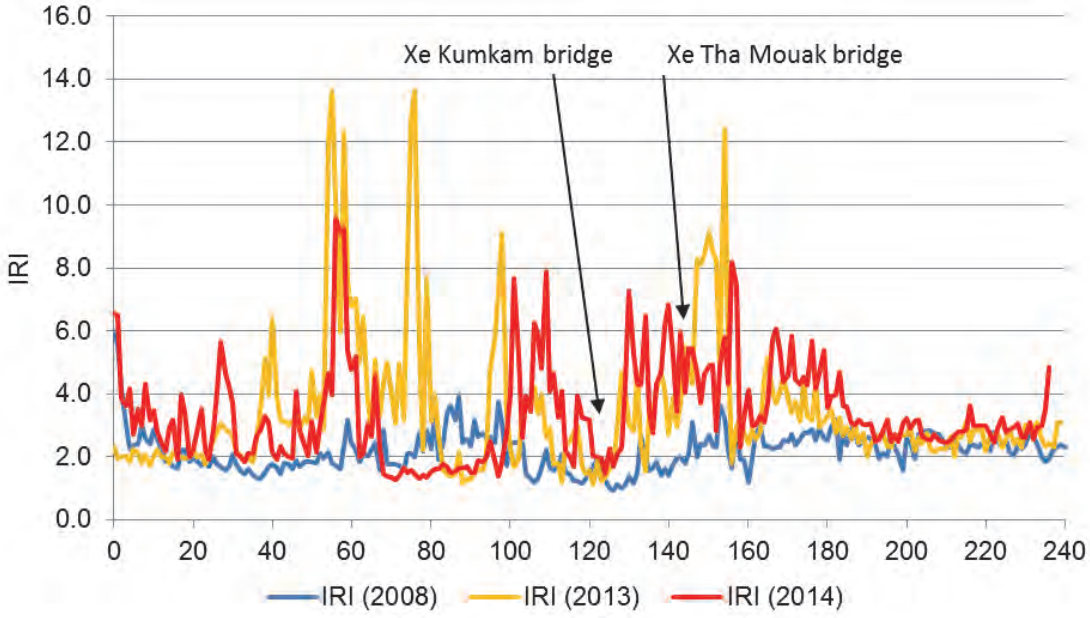
Source: Study team

As the results of the field survey at Xe Tha Mouak Bridge, many map cracks are found on the access road; furthermore, the roadbed is exposed at the foot of the bridge. Average travel speed by passenger car at this section is 25 km/h, which is almost half of 50 km/h at Xe Kum Kam Bridge. Thus, the road-user benefit generated by improvement of the bridge and access road surface is estimated particularly.

Source: Study team

Figure 1.4.11 Damaged Access Road Surface at Xe Tha Mouak Bridge

The following figure shows the International Roughness Index (IRI) included in the Road Management System (RMS) database managed by the Public Works and Transport Institute (PTI). The surface condition of National Road No. 9 is a serious problem in recent years.



Source: Study team calculated based on RMS database

Figure 1.4.12 IRI of National Road No. 9

Average IRI per 100 m at Xe Kum Kam Bridge is 2.11 and was satisfied in 2014. At Xe Tha Mouak Bridge, however, has an average IRI of 6.15. When the current road condition is improved to IRI 3.0 by the reconstruction of a 1 km section consisting of bridge and access road, the road-user cost will be reduced by about 73 USD per day in 2019, which is calculated by an economic road-user cost model prepared by HDM-4 (World Bank) and future traffic volume at Xe Tha Mouak Bridge.

Table 1.4.18 Reduction of Road User Cost by Surface Improvement

		Motorcycle	Passenger car	Bus	Light truck	Medium truck	Heavy truck	Total
Cost Saving (USD/ day)	2019	7.5	13.5	15.0	10.7	6.7	19.9	73.4
	2022	9.6	16.4	19.4	13.2	8.2	24.5	91.4
	2025	12.4	19.8	20.7	15.5	9.9	30.2	108.6
	2039	33.7	51.0	59.3	42.2	25.9	76.9	289.0

Source: Study team

1.5 Environmental and Social Considerations

1.5.1 Assessment of Environmental and Social Impact

(1) Project Component related to Environmental and Social Impact

Since this project consists of replacement of the two bridges, it is categorized as the sector of "Road, Railway, and Bridge," according to the JICA Environmental and Social Consideration Guideline (April 2010) (hereafter called "JICA Guideline"). The negative impact of natural and social environments caused by reconstruction of the bridges is assessed as small due to constructing them in existing locations. This project therefore was classified as "Category B," based on the JICA Guideline.

(2) Base Condition of the Environment

1) Natural Environment

Protected Area

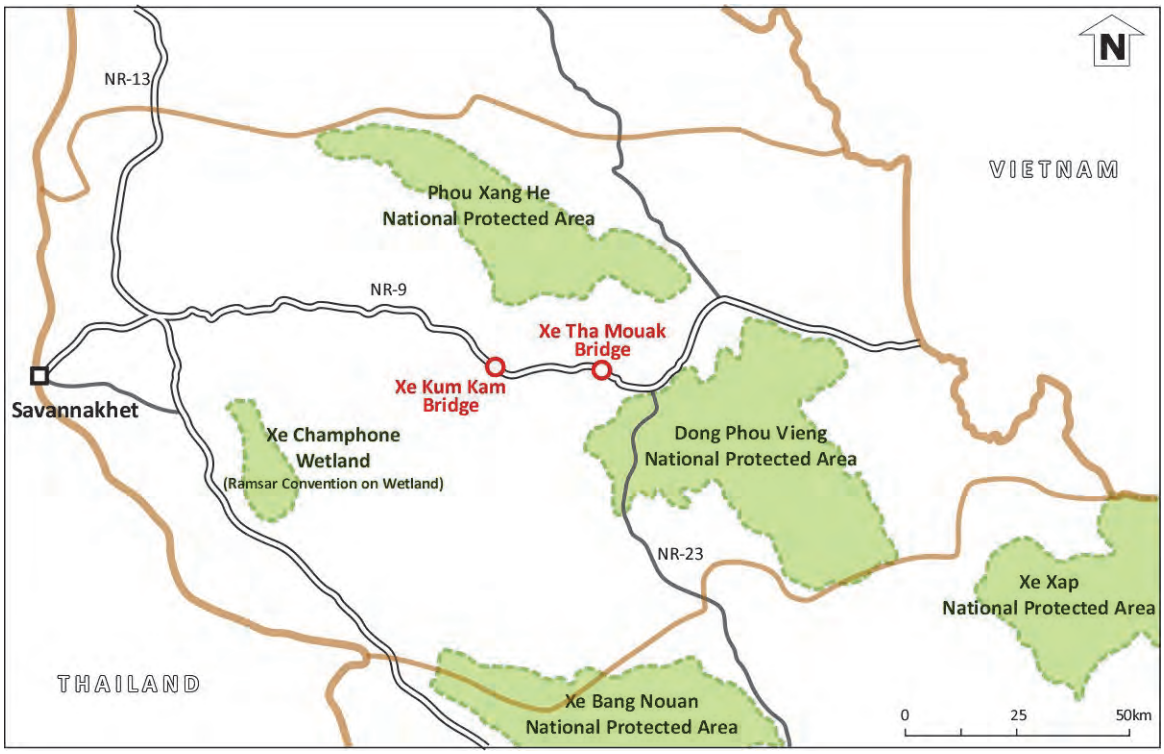
The National Protected Area (NPA) is designated in order to prevent disappearing habitats of wild animals and plants in Lao PDR. In Savannakhet Province, there are three NPAs and one swamp area designated by the Ramsar Conventions. Since the project sites are located far from these protected areas, adverse impacts are not expected.

Table 1.5.1 Protected Area in Savannakhet Province

Category	Name	Location	Area
National Protected Area	Dong Phou Vieng	Savannakhet	1,970 km^2
	Phou Xang Hae	Savannakhet	1,060 km^2
	Xe Bang Nouan	Savannakhet, Salavanh	1,335 km^2
	Xe Xap	Salavanh, Sekong	1,335 km^2
Swamp Area	Xe Champhone Wetland	Savannakhet	124 km^2

Source: Compiled by the JICA Survey Team, the Lao National Tourism Administration and「Baseline Report: Xe Champhone Wetland, Champhone and Xonbuly Districts, Savannakhet Province, Lao PDR」 2011, International Union for Conservation of Nature (IUCN)

Furthermore, the project sites do not exist in any Conservation Area or Protection Forest designated by the Province and District in Savannakhet.



Source: JICA Survey Team based on the data of UNOSAT and IUCN

Figure 1.5.1 Protection Area in Savannakhet Province

Ecosystem

Rare species could not be found in the project sites.

2) Social Environment

Population

Xe Kum Kam Bridge is located in Phalamxai District. According to the interview surveys, the following six villages with approximately 600 households and a population of 3,800 are in the area surrounding Xe Kum Kam Bridge.

Table 1.5.2 Population in Surrounding Area of Xe Kum Kam Bridge

District	Village	Population	Household
Phalamxai	Nonmixay	862	154
	Dongbang	700	100
	Dongsavan	500	50
	Nonsaat	224	33
	Tho	692	73
	Alouy Mai	800	180

Source: JICA Survey Team

Meanwhile, the Xe Tha Mouak Bridge is located in the Phin District. According to the interview surveys, the following five villages with approximately 1,000 households and a population of 7,200 are in the area surrounding Xe Tha Mouak Bridge.

Table 1.5.3 Population in the Area Surrounding Xe Tha Mouak Bridge

District	Village	Population	Household
Phin	Oudomxai	1,120	191
	Xesavang	1,340	168
	Xanamixai	846	127
	Xaisomboun	1,428	213
	Sibounhuang	2,430	284

Source: JICA Survey Team

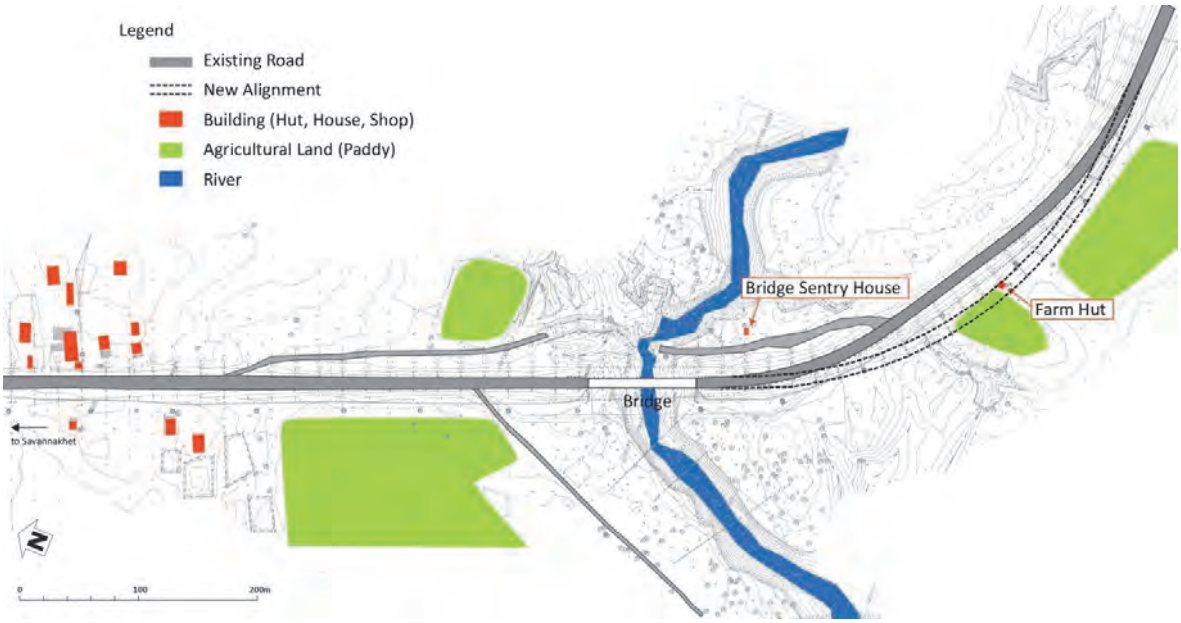
Detailed data and information of social economic data refers to Section 1.3 in this Chapter.

Road Conditions

The target bridges and their approach roads play important roles not only for the international corridor also as the backbone of road transportation for mobilization and economic activities of the local people. An approach road to Xe Kum Kam Bridge on the south side makes a tight curve and contributes to unsafe traffic. In terms of road safety, the alignment needs to be considered in order to improve an appropriate design.

Land Use

Xe Kum Kam Bridge is located in the middle of a hilly area without any houses. The land use consists mainly of a paddy field, scrub, and vacant land. An agricultural hut and some paddy areas on the south side of the bridge are anticipated to have influence on the project implementation in order to improve the broken back curve.



Source: JICA Survey Team

Figure 1.5.2 Existing Land Use in Area Surrounding Xe Kum Kam Bridge

Xe Tha Mouak Bridge is located in the middle of a settlement area with houses, shops, and agricultural huts. The land use consists mainly of paddy field, scrub, a seasonal fishpond, and vacant land.

Source: JICA Survey Team

Figure 1.5.3 Existing Land Use in the Area Surrounding Xe Tha Mouak Bridge

Use of the Rivers

According to the site and interview surveys, small-scale fishery activities for personal consumption are carried out in Kumkam and Tha Mouak rivers. However, it is confirmed that the fisheries are mainly in the upper and lower rivers, not near the bridges.

Regarding river water, two households near Xe Tha Mouak Bridge use it for domestic water such as laundry and bathing. On the other hand, no household use near Xe Kum Kam Bridge is recognized.

Ruin, Heritage, and Ethnic Minority

No ruins, heritage, or habitats of ethnic minorities are found in the project sites.

1.5.2 Legal System of Environmental Consideration in Lao PDR

The legal systems of environmental consideration are listed in following table. Implementation of an environmental impact assessment is obligated for all kinds of development projects according to Article 8 of the Environment Protection Law, and the methodologies are prescribed by Decree of Environmental Impact Assessment (112/PM). Practical approaches for environmental impact assessment are shown in the Environmental Impact Assessment Guideline, especially projects in the road sector designated by the Environmental and Social Operations Manual Road Sector.

Table 1.5.4 Legal System of Environmental Impact Assessment

Name	Year
General	
Environment Protection Law	1999 Revised 2012 Amendment 2013
EIA	
Regulation on Environmental Assessment in the Lao PDR	2002
Decree on Environmental Impact Assessment (112/PM)	2010
Environmental Impact Assessment Guidelines	2012
Environmental and Social Operations Manual: Road Sector	2009 (It will be revised in 2015)

Source: JICA Survey Team

(1) Environmental Approval

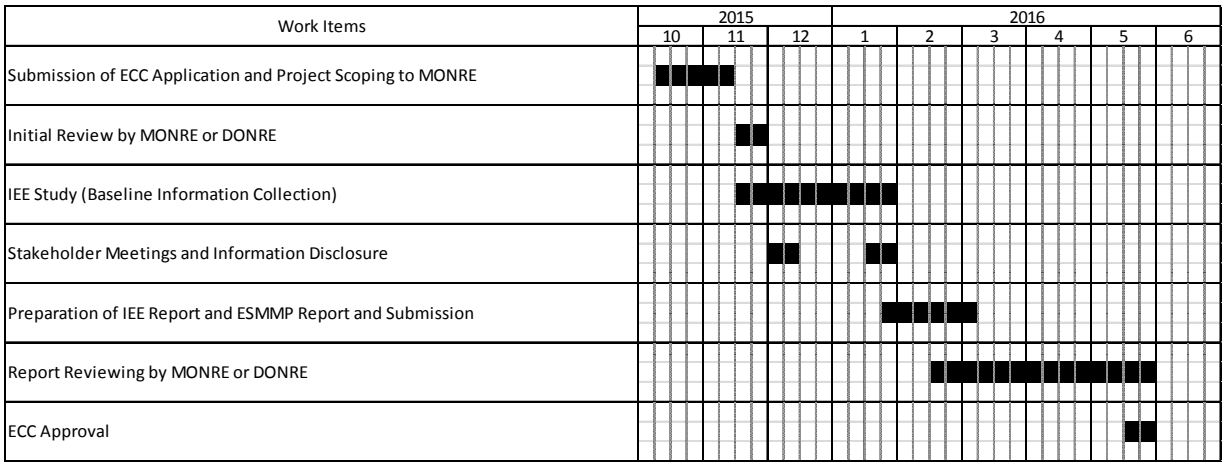
All of the investment and development projects are obligated to implement either an Initial Environmental Examination (IEE) or Environmental Impact Assessment (EIA) and then obtain an Environment Compliance Certificate (ECC) before project implementation. Every project is first categorized as Category 1 or Category 2, based on the anticipation of a negative impact on natural and social environments due to implementation. Category 1 projects are required to implement an IEE, while Category 2 does an EIA.

- Category 1 (implementation of IEE): the adverse impact on natural and social environments is anticipated as small or limited
- Category 2 (implementation of EIA): the adverse impact on natural and social environments is anticipated as large or serious

(2) Schedule of ECC for this Project

The project anticipates causing limited impact on social and natural environments in the project site and the surrounding areas. According to the EIA Guideline in Lao PDR, this project is categorized as Improvement of the Existing Road and could be classified as Category 1. The Department of Road (DOR) therefore expects to obtain an ECC through completing an IEE. Furthermore, the supervising agency might be the Department of Natural Resources and Environment (DoNRE) rather than the Ministry of Natural Resources and Environment (MoNRE), since both project sites are in Savannakhet Province.

The JICA survey team confirmed that the DOR is attempting to obtain its ECC according to the following schedule, based on the discussions.



Source: JICA Survey Team

Figure 1.5.4 Schedule of the ECC Process

1.5.3 Comparison of Alternatives

In order to decide the project alignment, four comparative alternatives were examined: 1) construction upstream, 2) same location as the existing bridge, 3) construction downstream, and 4) no project (zero option). For taking into account resettlement and land acquisition, reconstruction of the bridge in the same location as the existing bridge was selected as the most appropriate alignment through the discussions with the Lao counterparts.

(1) Xe Kum Kam Bridge

The four alternatives are described as follows.

1) Proposed Plan (same location as existing bridge)

The proposed plan consists of a new bridge constructed in the same location as the existing bridge and improving the broken back curve on NR-9 south of the bridge. Since the size of land acquisition is limited only to improving the broken back curve, the environmental impact is evaluated as small.

2) Alternative-1 Plan (upstream side of existing bridge)

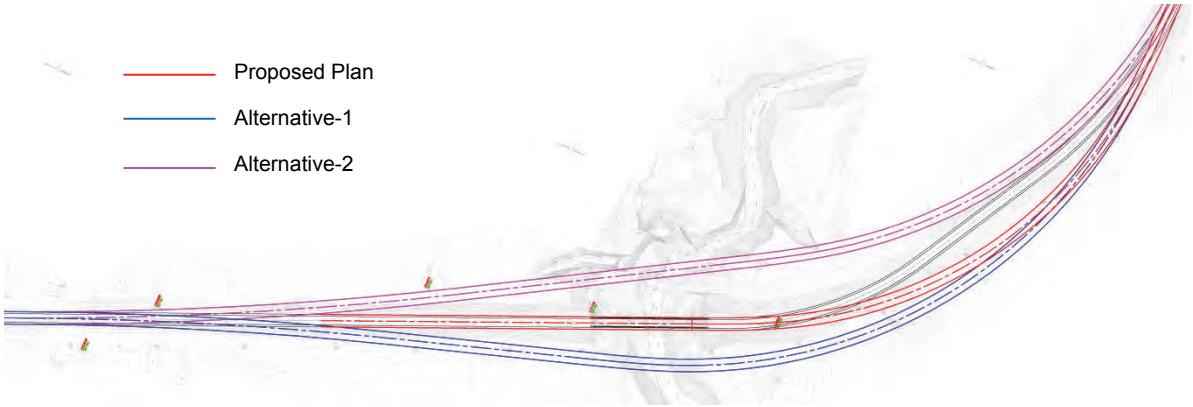
The Alternative-1 Plan consists of constructing a new bridge on the upstream side and improving the broken back curve. The land acquisition requires a large area for the entire section, construction of the bridge, and approach roads. The environmental impact is evaluated as relatively large in terms of the size of land acquisition.

3) Alternative-2 Plan (downstream side of existing bridge)

The Alternative-2 Plan consists of constructing a new bridge on the upstream side and improving the broken back curve. The land acquisition requires a large area for the entire section, the same as Alternative-1. The environmental impact is evaluated as relatively large in terms of the size of land acquisition.

4) Zero Option

Zero Option means no construction at all. The risk of traffic accidents might increase due to bridge deterioration and keeping the broken back curve of the approach road. The absence of road lighting makes it difficult to cross the bridge at night, which might disturb convenience and economic activities for road users. Social problems such as accidents and economic loss are anticipated to increase.



Source: JICA Survey Team

Figure 1.5.5 Alternative Routes: Xe Kum Kam Bridge

Table 1.5.5 Comparison of Alternatives: Xe Kum Kam Bridge

	Proposed Plan	Alternative-1 (Upstream Side)	Alternative-2 (Downstream Side)	Zero Option
Traffic Safety	• The route satisfies ASEAN Standards and takes the best alignment • Road lighting needs to be appropriately installed in order to ensure safe nighttime traffic	• The route satisfies ASEAN Standards and better alignment • Road lighting needs to be appropriately installed in order to ensure safe nighttime traffic	• The route satisfies ASEAN Standards and better alignment • Road lighting needs to be appropriately installed in order to ensure safe nighttime traffic • The length of the straight part keeps only 220m for the broken back curve (500m)	• The route does not satisfy ASEAN Standards • The bridge might fall due to deterioration • In line with increasing traffic volume, the broken back curve could cause more traffic accidents • The bridge could not provide safety in night time due to lack of road lighting
Bridge Structure	• The length of the bridge will become longer due to the substructure • The bridge alignment includes a curve	• The bridge alignment includes a curve • The length of the bridge will become longer than the existing one	• The bridge alignment includes a curve • The length of the bridge will become longer than the existing one	none
Resettlement	none	none	none	none

	Proposed Plan	Alternative-1 (Upstream Side)	Alternative-2 (Downstream Side)	Zero Option
Land Acquisition	• Small land acquisition is required for part of the broken back curve	• Large land acquisition is required for the entire section • Unused land is left between the new and existing routes	• Large land acquisition is required for the entire section • Unused land is left between the new and existing routes	none
Obstacles	• Optical fiber cable	• Optical fiber cable • Electric cable and pole	• Optical fiber cable	none
Economic Efficiency	• A temporary bridge is required during construction • Replacement of the optical fiber cable	• A temporary bridge is unnecessary • Replacement of the optical fiber cable • Large cost for land acquisition is necessary	• Temporary bridge is unnecessary • Replacement of the optical fiber cable • Large cost for land acquisition is necessary	• Requires no construction cost • Loss due to accidents and limited economic activity might occur
Construction	• The construction period will become longer due to removal of the existing bridge and construction of a temporary bridge • Substructure and pier are left in the same area	• No major problems happen because of enough distance from the earth fill	• No major problems happen because of enough distance from the earth fill	—
Evaluation	• Optimal Route			

(2) Xe Tha Mouak Bridge

The four alternatives are described as follows.

1) Proposed Plan (same location as existing bridge)

The proposed plan consists of a new bridge constructed in the same location as the existing bridge. Since no land acquisition or resettlement is required, the environmental impact is evaluated as very small.

2) Alternative-1 Plan (upstream side of existing bridge)

Alternative-1 Plan is a new bridge constructed on the upstream side of the existing bridge. Land acquisition and small-scale resettlement is required for construction of the bridge and approach roads. The environmental impact is evaluated as relatively large in terms of the size of land acquisition and resettlement.

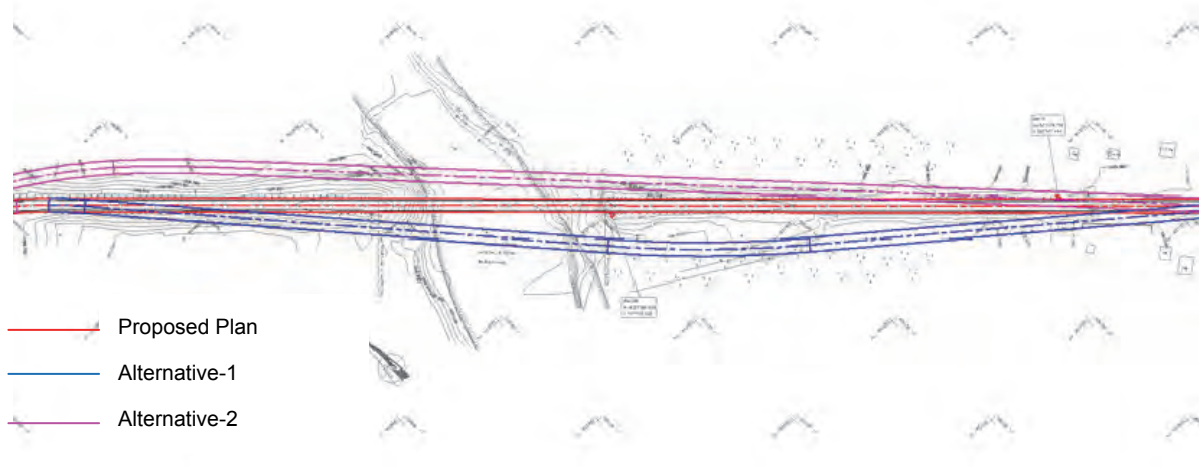
3) Alternative-2 Plan (downstream side of existing bridge)

Alternative-2 Plan is a new bridge constructed on the upstream side of the existing bridge. The land acquisition and some resettlement, more than 10 HHs, is required for construction of the bridge and

approach roads. The environmental impact is evaluated as larger than Alternative-1 in terms of size of land acquisition and resettlement.

4) Zero Option

Zero Option means no construction at all. The risk of traffic accidents might increase due to the deteriorating bridge. Besides this, the absence of road lighting makes it difficult to cross the bridge at night, which might disrupt convenience and economic activities for road users. Social problems such as accidents and economic loss are anticipated to increase.



Source: JICA Survey Team

Figure 1.5.6 Alternative Routes: Xe Tha Mouak Bridge

Table 1.5.6 Comparison of Alternatives: Xe Tha Mouak Bridge

	Proposed Plan	Alternative-1 (Upstream Side)	Alternative-2 (Downstream Side)	Zero Option
Traffic Safety	• The route satisfies ASEAN Standards and is the best alignment • Road lighting needs to be appropriately installed in order to ensure safe nighttime traffic	• The route satisfies ASEAN Standards and better alignment • Road lighting needs to be appropriately installed in order to ensure safe nighttime traffic	• The route satisfies ASEAN Standards and better alignment • Road lighting needs to be appropriately installed in order to ensure safe nighttime traffic	• The route does not satisfy ASEAN Standards • The bridge might fall due to deterioration • The bridge could not provide nighttime safety due to a lack of road lighting
Bridge Structure	• Length of the bridge becomes longer due to the the substructure • The bridge alignment is along the straight section, which benefits construction	• The bridge alignment includes a curve • Length of the bridge becomes longer than the existing one	• The bridge alignment is along a straight section, which benefits construction	none
Resettlement	none	• Low number of HHs	• Approximately 10 HHs	none

	Proposed Plan	Alternative-1 (Upstream Side)	Alternative-2 (Downstream Side)	Zero Option
Land Acquisition	none	• Requires small land acquisition	• Requires small land acquisition	none
Obstacle	• Optical fiber cable	• Optical fiber cable • Electric cable and pole	• Optical fiber cable • Electric cable and pole	none
Economic Efficiency	• A temporary bridge is required during construction • Replacement of the optical fiber cable	• A temporary bridge is unnecessary • Replacement of the optical fiber cable • Large cost for land acquisition and resettlement is necessary	• A temporary bridge is unnecessary • Replacement of the optical fiber cable • Large cost for land acquisition and resettlement is necessary	• Requires no construction cost • Loss due to accidents and limited economic activity might occur
Construction	• The construction period will become longer due to removal of the existing bridge and construction of a temporary bridge • Substructure and pier are left in the same area	• No major problems happen because of 5 m distance from the existing bridge	• No major problems happen because of 5 m distance from the existing bridge	—
Evaluation	• Optimal Route			

1.5.4 Scoping

Scoping and evaluation of negative impacts on the natural and social environment are based on the hearing and site surveys. The results of scoping and evaluation by each category are shown in the following tables.

Table 1.5.7 Results of Scoping

Impact		Xe Kum Kam Bridge		Xe Tha Mouak Bridge	
		Preparation/ Construction	Operation	Preparation/ Construction	Operation
Social Environment	Involuntary Resettlement	–	–	–	–
	Land acquisition	**B**	–	–	–
	Local economies	**B**	–	**B**	–
	Land use and utilization of local resources	–	–	–	–
	Social institutions	–	–	–	–
	Existing social infrastructures and services	**B**	–	**B**	–
	Poor, indigenous, or ethnic people	–	–	–	–
	Misdistribution of benefits and damages	–	–	–	–
	Local conflicts of interest	–	–	–	–
	Gender	–	–	–	–
	Children's rights	–	–	–	–
	Cultural heritage	–	–	–	–
	Infectious diseases such as HIV/AIDS	**B**	–	**B**	–
	Health and sanitation	–	–	–	–
	Water rights and usage	–	–	**B**	–
	Accidents	**B**	**B**	**B**	**B**

Impact		Xe Kum Kam Bridge		Xe Tha Mouak Bridge	
		Preparation/ Construction	Operation	Preparation/ Construction	Operation
Natural Environment	Topography and geology	–	–	–	–
	Soil erosion	–	–	–	–
	Groundwater	–	–	–	–
	Flow of hydrological features	–	–	–	–
	Meteorology	–	–	–	–
	Landscape	–	–	–	–
	Global warming	–	–	–	–
Pollution	Air pollution	**B**	–	**B**	–
	Water pollution	**B**	–	**B**	–
	Soil pollution	–	–	–	–
	Waste	**B**	–	**B**	–
	Noise and vibration	**B**	**B**	**B**	**B**
	Ground subsidence	–	–	–	–
	Offensive odor	–	–	–	–
	Bottom sediment	–	–	–	–

Note: A is “Serious impact”, B is “Limited impact”, － is “No Impact”

Table 1.5.8 Evaluation of Negative Impacts: Xe Kum Kam Bridge

Impact		Construction	Operation	Evaluation
Social Environment	Involuntary Resettlement	–	–	Construction/Operation Phases: No resettlement required
	Land acquisition	**B**	–	Construction Phase: Small-scale land acquisition is required
				Operation Phase: No negative impact occurs after opening the new bridge
	Local economies	**B**	–	Construction Phase: Some small-scale fishing for private consumption is conducted upstream and downstream of the bridge.
				Operation Phase: No negative impact occurs after opening the new bridge
	Land use and utilization of local resources	–	–	Construction/Operation Phases: No negative impact for land use
	Social institutions	–	–	Construction/Operation Phases: No negative impact for social institutions
	Existing social infrastructures and services	**B**	–	Construction Phase: Existing bridge is removed. However, a temporary bridge will be provided instead of the existing one.
				Operation Phase: No negative impact occurs after opening the new bridge
	Poor, indigenous, or ethnic people	–	–	Construction/Operation Phases: No ethnic or indigenous people live on the site
	Misdistribution of benefits and damages	–	–	Construction/Operation Phases: No negative impact for misdistribution of benefits and damages
	Local conflicts of interest	–	–	Construction/Operation Phases: No local conflicts of interest are expected

Impact		Construction	Operation	Evaluation
Social Environment	Gender	–	–	Construction Phase: No negative impact on gender. Moreover, positive employment of women who live in or near the site is enhanced.
				Operation Phase: No negative impact on gender because the design of the new bridge is prepared for taking into account gender and vulnerable groups.
	Children's rights	–	–	Construction/Operation Phases: No harm for children's rights
	Cultural heritage	–	–	Construction/Operation Phases: No cultural heritages exist at the site
	Infectious diseases such as HIV/AIDS	**B**	–	Construction Phase: Many seasonal workers will be hired. Since they tend to be young and sexually active in general, spread of infectious diseases is anticipated.
				Operation Phase: No negative impact on local health
	Health and sanitation	–	–	Construction/Operation Phases: No dangerous chemicals are employed for the construction.
	Water rights and usage	–	–	Construction/Operation Phases: No negative impact on water rights and usage
	Accidents	**B**	**B**	Construction Phase: Traffic accidents may occur due to construction vehicles or/and the temporary bridge. A small possibility of UXO is considered.
				Operation Phase: Vehicle speed may increase and rising accidents is anticipated.
Natural Environment	Topography and geology	–	–	Construction/Operation Phases: No negative impact on topography and geology since the size of construction is small.
	Soil erosion	–	–	Construction/Operation Phases: No negative impact on erosion since the size of construction is small.
	Groundwater	–	–	Construction/Operation Phases: No negative impact on groundwater since the size of construction is small.
	Flow of hydrological features	–	–	Construction/Operation Phases: No negative impact on flow of hydrological features since the size of construction is small.
	Meteorology	–	–	Construction/Operation Phases: No negative impact on meteorology since the size of construction is small.
	Landscape	–	–	Construction/Operation Phases: Bridge replacement does not harm the landscape
	Global warming	–	–	Construction/Operation Phases: No negative impact on global warming

Impact		Construction	Operation	Evaluation
Pollution	Air pollution	**B**	―	Construction Phase: Decrease of air quality is expected temporarily due to earthworks and/or construction vehicles.
				Operation Phase: No major air pollution is expected from bridge replacement.
	Water pollution	**B**	―	Construction Phase: Muddy water is temporarily expected by earthworks of pier construction. Domestic water is caused by the contractor camp.
				Operation Phase: No major water pollution is expected after construction.
	Soil pollution	―	―	Construction/Operation Phases: No negative impact on soil pollution because the construction will not employ any dangerous chemicals.
	Waste	**B**	―	Construction Phase: Construction debris and soil disposal will occur. Domestic waste will come from the contractor camp.
				Operation Phase: No waste is expected by bridge replacement
	Noise and vibration	**B**	**B**	Construction Phase: Some noise and vibration are expected from construction vehicles and earthwork.
				Operation Phase: Increasing noise and vibration is expected from rising traffic speed.
	Ground subsidence	―	―	Construction/Operation Phases: No negative impact on ground subsidence since the size of construction is small.
	Offensive odor	―	―	Construction/Operation Phases: No offensive odor because the construction will not employ any dangerous chemicals.
	Bottom sediment	―	―	Construction/Operation Phases: No negative impact occurs on bottom sediment since the size of construction is small.

Note: A is “Serious impact”, B is “Limited impact”, ― is “No Impact”

Table 1.5.9 Evaluation Negative Impact: Xe Tha Mouak Bridge

Impact		Construction	Operation	Evaluation
Social Environment	Involuntary Resettlement	―	―	Construction/Operation Phases: No resettlement required
	Land acquisition	**B**	―	Construction/Operation Phases: No land acquisition required
	Local economies	**B**	―	Construction Phase: Some small-scale fishing for private consumption is conducted upstream and downstream of the bridge.
				Operation Phase: No negative impact after opening the new bridge
	Land use and utilization of local resources	―	―	Construction/Operation Phases: No negative impact on land use

Impact		Construction	Operation	Evaluation
Social Environment	Social institutions	–	–	Construction/Operation Phases: No negative impact on social institutions
	Existing social infrastructures and services	**B**	–	Construction Phase: Existing bridge is removed. However, a temporary bridge will be provided instead of the existing one.
				Operation Phase: No negative impact after opening the new bridge
	Poor, indigenous, or ethnic people	–	–	Construction/Operation Phases: No ethnic or indigenous people live on the site.
	Misdistribution of benefits and damages	–	–	Construction/Operation Phases: No negative impact on misdistribution of benefits and damages
	Local conflicts of interest	–	–	Construction/Operation Phases: No local conflicts of interest are expected
	Gender	–	–	Construction Phase: No negative impact on gender. Moreover, positive employment of women who live in near the site is enhanced.
				Operation Phase: No negative impact on gender because the design of the new bridge is prepared for taking account of gender and vulnerable groups.
	Children's rights	–	–	Construction/Operation Phases: No harm is caused in children's right
	Cultural heritage	–	–	Construction/ Operation Phases: No cultural heritages exist on the site
	Infectious diseases such as HIV/AIDS	**B**	–	Construction Phase: Many seasonal workers will be hired. Since they tend to be young and sexually active in general, spread of infectious diseases is anticipated.
				Operation Phase: No negative impact occurs on local health
	Health and sanitation	–	–	Construction/Operation Phases: No dangerous chemicals are employed for the construction.
	Water rights and usage	**B**	–	Construction Phases: Two households use the river water for daily activities except drinking.
				Operation Phases: No influence on water rights and usage after construction
	Accidents	**B**	**B**	Construction Phase: Traffic accidents may occur due to construction vehicles and/or the temporary bridge. A small possibility of UXO is considered.
				Operation Phase: Vehicle speed may increase and rising accidents are anticipated.
Natural Environment	Topography and geology	–	–	Construction/Operation Phases: No negative impact on topography and geology since the size of construction is small.
	Soil erosion	–	–	Construction/Operation Phases: No negative impact on erosion since the size of construction is small.

Impact		Construction	Operation	Evaluation
Natural Environment	Groundwater	—	—	Construction/ Operation Phases: No negative impact on groundwater since the size of construction is small.
	Flow of hydrological features	—	—	Construction/ Operation Phases: No negative impact on flow of hydrological features since the size of construction is small.
	Meteorology	—	—	Construction/Operation Phases: No negative impact on meteorology since the size of construction is small.
	Landscape	—	—	Construction/Operation Phases: Bridge replacement does not harm the landscape
	Global warming	—	—	Construction/Operation Phases: No negative impact on global warming
Pollution	Air pollution	**B**	—	Construction Phase: A temporary decrease of air quality is expected due to earthworks and/or construction vehicles.
				Operation Phase: No major air pollution is expected from bridge replacement.
	Water pollution	**B**	—	Construction Phase: Muddy water is expected by earthworks of pier construction temporarily. Domestic water is caused by the contractor camp.
				Operation Phase: No major water pollution is expected after construction.
	Soil pollution	—	—	Construction/Operation Phases: No negative impact on soil pollution because that the construction will not employ any dangerous chemicals.
	Waste	**B**	—	Construction Phase: Construction debris and soil disposal will occur. Domestic waste will come from the contractor camp.
				Operation Phase: No waste is expected by bridge replacement
	Noise and vibration	**B**	**B**	Construction Phase: Some noise and vibration is expected from construction vehicles and earthwork.
				Operation Phase: Increasing noise and vibration is expected due to rising traffic speed.
	Ground subsidence	—	—	Construction/Operation Phases: No negative impact on ground subsidence since the size of construction is small.
	Offensive odor	—	—	Construction/ Operation Phases: No offensive odor because the construction will not employ any dangerous chemicals.
	Bottom sediment	—	—	Construction/Operation Phases: No negative impact occurs on bottom sediment since the size of construction is small.

Note: A is “Serious impact”, B is “Limited impact”, — is “No Impact”

1.5.5 Evaluation and Mitigation Measures

Expected negative impacts are evaluated on the basis of site and interview surveys. Appropriate mitigation measures are also considered in the following table.

Table 1.5.10 Expected Impacts and Mitigation Measures: Xe Kum Kam Bridge

Impact		Construction	Operation	Evaluation	Mitigation Measure
Social Environment	Land acquisition	**B**	–	Construction Phase: Land acquisition is required for improvement of the broken back curve. Since the size of land acquisition is small, so is the impact.	Appropriate compensation based upon discussion between the land owner and relevant agencies is carried out.
	Local economies	**B**	–	Construction Phase: Some small-scale fishing for private consumption is conducted upstream and downstream of the bridge. However, the impact can be evaluated since the fishing areas are not near the bridge.	Information distribution of the construction site and schedule for local people is carried out. Access to the river is kept open during construction.
	Existing social infrastructures and services	**B**	–	A temporary bridge will be provided instead of the existing bridge. The impact on social services is evaluated as limited.	Information distribution of the construction site and schedule is carried out for road users. Traffic controllers are employed for guiding the temporary bridge.
	Infectious diseases such as HIV/AIDS	**B**	–	Construction Phase: Many seasonal workers will be hired. Since they tend to be young and sexually active in general, spread of infectious diseases is anticipated. The impacts can be reduced by mitigation measures.	Conditions of construction worker employment are considered based on discussion with the contractor and local Women's Union. Education of health and sanitation to the workers is carried out.
	Accidents	**B**	**B**	Construction Phase: Traffic accidents may occur due to construction vehicles and/or temporary bridge. A small possibility of UXO is considered. The number of accidents can be reduced through mitigation measures.	Signboards for construction and night lighting will be installed. Information for the schedule and temporary bridge is distributed to road users before construction. A fence for the construction site is installed to deter of local people. Construction vehicles are carefully controlled and managed by the contractor. Education about UXO to all construction workers is carried out prior to construction. In case UXO is found, a professional company is employed for treatment, and information is distributed to local residents.
				Operation Phase: Vehicle speed may increase and rising accidents are anticipated. Improvement of the broken back curve may contribute to a reduction in traffic accidents.	Signboards for traffic speed and road lighting facilities are installed. Traffic management is carried out.

Impact		Construction	Operation	Evaluation	Mitigation Measure
Pollution	Air pollution	**B**	―	Construction Phase: A temporary decrease of air quality is expected due to earthworks and/or construction vehicles.	Routine water sprinkling and management of construction vehicles such as idling off are conducted to decrease air pollution.
	Water pollution	**B**	―	Construction Phase: Temporary muddy water is expected from earthworks of the pier construction. Domestic water is use by the contractor camp.	Oil fence or/and a pollution control net is applied for the pier construction. Maintenance of construction vehicles is carried out for preventing oil leaking from vehicles. Septic tanks are installed at the construction yard and contractor camp.
	Waste	**B**	―	Construction Phase: Construction debris, soil disposal, and domestic waste from the contractor camp will occur.	Recycling is enhanced. The other waste is disposed of according to the rule of solid waste disposal in Lao PDR. Domestic waste from the contractor camp and drain oil from construction vehicles is disposed of by professional firms.
	Noise and vibration	**B**	**B**	Construction Phase: Some noise and vibration are expected from construction vehicle and earthwork.	Construction and earthwork are forbidden at night. Using noise and vibration reducing vehicles are enhanced.
				Operation Phase: Increasing noise and vibration is expected from rising traffic speed.	Traffic signboards are installed and traffic management is carried out.

Note: A is “Serious impact”, B is “Limited impact”, ― is “No Impact”

Table 1.5.11 Expected Impacts and Mitigation Measures: Xe Tha Mouak Bridge

Impact		Construction	Operation	Evaluation	Mitigation Measure
Social Environment	Local economies	**B**	―	Construction Phase: Some small-scale fishing for private consumption is conducted upstream and downstream of the bridge. However, the impacts can be evaluated as minimal since the fishing site is not near the bridge.	Information distribution of the construction place and schedule for local people is carried out. Access to the river is kept open during the construction.
	Existing social infrastructures and services	**B**	―	A temporary bridge will be provided instead of the existing bridge. The impact on social services is evaluated as limited.	Information distribution of the construction place and schedule is carried out for road users. Traffic controllers are employed for guiding the temporary bridge.
	Infectious diseases such as HIV/AIDS	**B**	―	Construction Phase: Many seasonal workers will be hired. Since they tend to be young and sexually active in general, spread of infectious diseases is anticipated. The impact can be reduced by mitigation measures.	Condition of construction worker employment is considered based on discussion with the contractor and the local Women’s Union. Health education and sanitation for the works is carried out.

Impact		Construction	Operation	Evaluation	Mitigation Measure
Social Environment	Water rights and usage	**B**	―	Construction Phase: Two households use the river water for daily activities except drinking.	The locations of water intake are moved with on the basis of discussion with the affected households.
	Accidents	**B**	**B**	Construction Phase: Traffic accidents may occur due to construction vehicles and/or the temporary bridge. A small possibility of UXO is considered. The number of accidents can be reduced by mitigation measures.	Signboards of construction and night lighting are installed. Information for the schedule and temporary bridge is distributed to road users before construction begins. A fence around the construction site is installed to deter entrance of local people. Construction vehicles are well controlled and managed by contractor. Education about UXOs is provided to all construction workers prior to construction. In case a UXO is found, a professional company is employed for treatment, and information is distributed to local residents.
				Operation Phase: Vehicle speed may increase and rising accidents are anticipated.	Signboards for traffic speed and road lighting facilities are installed. Traffic management is carried out.
Pollution	Air pollution	**B**	―	Construction Phase: A temporary decrease of air quality is expected due to earthworks and/or construction vehicles.	Routine water sprinkling and management of construction vehicles such as idling off are conducted to decrease air pollution.
	Water pollution	**B**	―	Construction Phase: Temporary muddy water is expected from earthworks of the pier construction. Domestic water is used by the contractor camp.	Oil fence and/or a pollution control net is applied for pier construction. Maintenance of construction vehicles is carried out for preventing oil leaking from vehicles. Septic tanks are installed at the construction yard and contractor camp.
	Waste	**B**	―	Construction Phase: Construction debris, soil disposal, and domestic waste from the contractor camp will occur.	Recycling is enhanced. The other waste is disposed of according to the rules of solid waste disposal in Lao PDR. Domestic waste from the contractor camp and drained oil from construction vehicles are disposed of by professional firms.
	Noise and vibration	**B**	**B**	Construction Phase: Some noise and vibration are expected from construction vehicles and earthwork.	Construction and earthwork are forbidden at night. Using noise and vibration reducing vehicles are enhanced.
				Operation Phase: Increased noise and vibration is expected due to rising traffic speed.	Traffic signboards are installed and traffic management is carried out.

Note: A is "Serious impact", B is "Limited impact", ― is "No Impact"

1.5.6 Environmental Management and Monitoring Plan

Environmental management and monitoring plan are proposed as follows.

Table 1.5.12 Environmental Management Plan

Impact		Mitigation	Implementation Body	Responsible Agency	Cost
Social Environment	Land Acquisition (only Xe Kum Kam Bridge)	Preparation Phase: Appropriate compensation based upon discussion between the land owner and relevant agencies will be carried out.	DOR, DPWT OPWT	DOR	Budget of DOR
	Local economies	Preparation and Construction Phases: Information distribution of the construction site and schedule for local people will be carried out. Access to the river will be kept open during construction.	Contractor	DOR, DPWT	Included in Construction Cost
	Existing social infrastructures and services	Preparation and Construction Phases: Information distribution of the construction place and schedule will be carried out for road users. Traffic controllers will be employed for guiding the temporary bridge.	Contractor	DOR, DPWT	Included in Construction Cost
	Infectious diseases such as HIV/AIDS	Preparation and Construction Phases: Condition of construction worker employment is considered based on discussion with the contractor and the local Women's Union. Education of health and sanitation to the works is carried out.	Contractor	DOR, DPWT	Included in Construction Cost
	Water rights and usage (only Xe Tha Mouak Bridge)	Preparation Phase: The locations of water intake will be moved on the basis of discussion with the affected households.	Contractor	DOR, DPWT	Included in Construction Cost
	Accidents	Construction Phase: Signboards for construction and night lighting will be installed. Information for the schedule and temporary bridge will be distributed to road users before construction. The fence of construction site will be installed to deter entrance of local people. Construction vehicles are well controlled and managed by the contractor. Signboards for traffic speed and road lighting facilities are installed. Traffic management is carried out. Education about the UXOs to all construction workers is carried out prior to construction.	Contractor	DOR, DPWT	Included in Construction Cost
		In case a UXO is found, a professional company is employed for treatment, and information is distributed to local residents.	Contractor	DOR, DPWT	Budget of DOR
		Operation Phase: Signboards for traffic speed and road lighting facilities are installed. Traffic management is carried out.	DPWT, Traffic Police	DOR, MPWT	Budget of Road Maintenance

Impact		Mitigation	Implementation Body	Responsible Agency	Cost
Pollution	Air pollution	Construction Phase Routine water sprinkling and management of construction vehicles such as idling off will be conducted.	Contractor	DOR, DPWT	Included in Construction Cost
	Water Pollution	Construction Phase: Oil fence and/or a pollution control net will be applied for the pier construction. Maintenance of construction vehicles will prevent oil leaking from vehicles. Septic tanks will be installed at the construction yard and contractor camp.	Contractor	DOR, DPWT	Included in Construction Cost
	Waste	Construction Phase: Waste will be disposed of according to the rules of solid waste disposal in Lao PDR. Domestic waste from the contractor camp and drain oil from construction vehicles will be disposed of by professional firms.	Contractor	DOR, DPWT	Included in Construction Cost
	Noise and vibration	Construction Phase: Construction and earthwork will be forbidden during the night. Using noise and vibration reducing vehicles will be enhanced.	Contractor	DOR, DPWT	Included in Construction Cost
		Operation Phase: Traffic signboards will be installed and traffic management will carry out.	DPWT, Traffic Police	DOR, MPWT	Budget of Road Maintenance

Table 1.5.13 Monitoring Plan

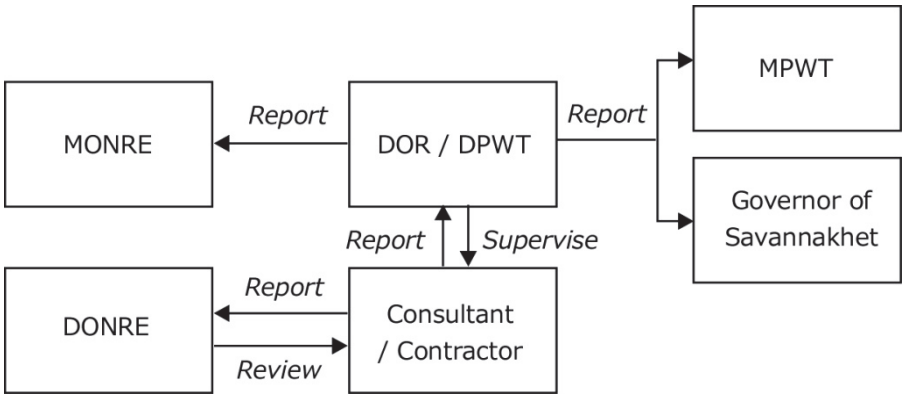
Impact	Monitoring	Location	Frequency	Implementation Body
Preparation and Construction Phases				
Land Acquisition (only for Xe Kum Kam Bridge)	Discussion with stakeholders for consensus, appropriate compensation	-	Before construction	DOR, DPWT OPWT
Air Quality	TSP, PM10, CO, NO_2, SO_2	Near the project site	2 times/year	Contractor
Water Quality	pH, SS	River	2 times/year	Contractor
Waste	Carrying record	Near the project site	1 times/month	Contractor
Noise and vibration	Noise and vibration level	Near the project site	2 times/year	Contractor
Accident	Record of accidents	Near the project site	2 times/year	Contractor
Operation Phase				
Accident	Record of accidents	Near the bridge	-	DPWT

1.5.7 Implementation Structure and Budget

Implementation structure of environmental monitoring in the construction phase is illustrated in the following figure. The mitigation measures and monitoring surveys basedpon the environmental

management plan shall be carried out by the contractor and consultant under supervision of the project owner, DOR and DPWT. The contractor and consultant will report progress and results of environmental management to DOR and DONRE regularly. Responding to the report from the contractor, DOR will report to high-level agencies including MPWT, MONRE and Savannakhet Provincial Office.

The cost of mitigation measures and environmental management shall be included in the construction cost.



Source: JICA Survey Team

Figure 1.5.7 Implementation Structure of Environmental Monitoring

DPWT and OPWT shall handle grievances from the local people and give necessary instructions to the contractor as the need arises. Information regarding the grievance system will be distributed to the local people by the contractor prior to the start of construction.

1.5.8 Land Acquisition

(1) Legal System of Land Acquisition and Resettlement

The legal systems of land acquisition and resettlement are listed in following table.

Table 1.5.14 Legal System of Land Acquisition and Resettlement

Name	Year
Regulations on Management of Protected Areas and Animals	2003
Land Law	2003 Amendment 2008
Decree on the Compensation and Resettlement of the Development Project	2005
Regulations for Implementing Decrees on Compensation and Resettlement of People Affected by Development Projects	2006
Technical Guidelines on Compensation and Resettlement in Development Projects	2005

Source: JICA Survey Team

(2) Land Acquisition

In case the project implementation requires land acquisition and/or resettlement, the project owner is obligated to prepare a Land Acquisition and Compensation Report (LACR) and/or a Resettlement Plan (RP) and submit it with the IEE or EIA report to the supervisory agency.

In the road sector project, the census survey of affected people (AP) shall be carried out after setting a new centerline and recognition of the ROW. After achieving a consensus based upon a discussion among the stakeholders (such as a the project owner, relevant agencies, village leaders, and Aps) the compensation rate will be determined for taking into account the base rate of the region.

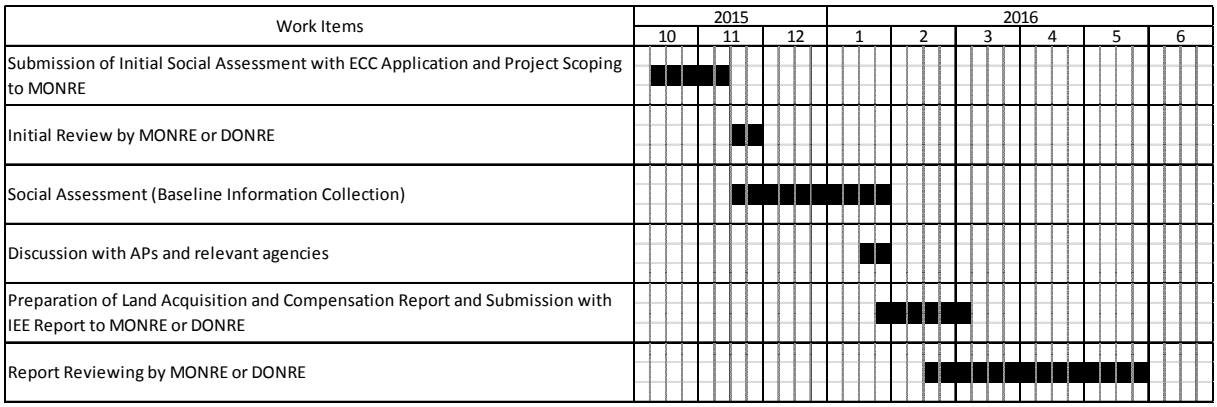
(3) Implementation Structure and Schedule of Land Acquisition

Implementation of this project does not require any resettlement; however, it requires small-scale land acquisition in order to improve the broken back curve at Xe Kum Kam Bridge. The required land is owned by one landowner who lives near the bridge with four family members.

The discussion among the stakeholders, including DOR, DPWT, OPWT, DONRE, District Government Staff, and the landowner, shall be carried out for achieving consensus for the project implementation. After the discussion, the LACR will be prepared and submitted with the IEE report. In order to prepare the LACR, detailed surveys including an inventory of losses (IOL) are necessary. At this time, the scale of land acquisition is identified to be roughly 8,100 sq. mi., including paddy fields, one agricultural hut, and some fences.

Figure 1.5.8 Photos: The Area of Land Acquisition

The JICA survey team confirmed that the DOR has attempted to prepare the LACR using the following schedule based on discussions.



Source: JICA Survey Team

Figure 1.5.9 Schedule for a Process of Land Acquisition

(4) Cost

The compensation and survey costs regarding the land acquisition will be covered by the budget of the DOR agreed to with the MD.

1.5.9 Stakeholder Meetings

In order to distribute the project implementation and to be aware of the opinions of the local people, stakeholder meetings were conducted with support from the counterparts. The agenda and major discussions are written in the following boxes.

(1) Xe Kum Kam Bridge

Date	5 August 2015, from 8:45 to 10:00
Venue	The temple near Xe Kum Kam Bridge
Attendants	Lao Government Staff including DOR, DPWT, OPWT, Phalamxai District Village Leaders, leader of the Woman's Union, local residents JICA Survey Team Total: 23 attendants
Agenda	1. Background of the Project 2. Contents and Schedule of the Project 3. Necessary Land Acquisition and Construction Site 4. Exchange Opinions among the Stakeholders 5. Opinions about Gender Issues
Discussions	<u>Bridge Replacement Project</u> • All attendants expressed understanding of the importance of NR-9 and agreed with the project implementation. • Local residents proposed appropriate land for the construction yard and workers' camp. They requested to have discussions again before construction. <u>Access Road to the Bridge</u> • Attendants agreed with improving the broken back curve since many traffic accidents occur due to a sharp curve. • The affected landowner agreed with the project implementation. She requested the DOR to pay appropriate compensations for her land.

	Use of the River • Some farmers tend to fish in the agricultural off-season, an average of two or three people per day. The fishing spots are upstream and downstream of the bridge, but not near the bridge. The fishing spot is small scale and only for individual consumption. • Local residents do not use the river water. Concerning the Spread of Infections, including HIV/AIDS, by the Workers • Local residents are not concerned about it. • The local Woman's Union is doing education and information distribution to the local people about protection from HIV/AIDS, prevention of drug use, sanitation, and equality of the sexes with support from international NGOs such as World Vision and Save the Children. • Before starting construction, the Woman's Union wants to discuss with the contractor and enlighten the workers. Concerning Human Trafficking after Improving NR-9 as an International Corridor • Since no human trafficking has occurred in this area, local residents are not concerned about it. Even though the traffic volume will increase in the future, they do not fear it. • The Woman's Union also has distributed information about human trafficking and preventative measures. Others • The stakeholder requests hiring local residents for the construction work.

Figure 1.5.10 Photo: Stakeholder Meeting at Xe Kum Kam Bridge

(2) Xe Tha Mouak Bridge

Date	6August 2015, from 9:00 to 10:30
Venue	A house near Xe Tha Mouak Bridge
Attendants	Lao Government Staff including DOR, DPWT, OPWT, Phin District Village Leaders, Leader of the Woman's Union, Local Residents, JICA Survey Team Total: 18 attendants
Agenda	1. Background of the Project 2. Contents and Schedule of the Project 3. Necessary Land Acquisition and Construction Site 4. Exchange Opinions among the Stakeholders 5. Opinions about Gender Issues
Discussions	Bridge Replacement Project • All attendants expressed understanding of the importance of NR-9 and agreed with the project implementation. • Local residents requested to share the detailed information and have discussions again before construction. Use of the River • Some farmers tend to fush during the agricultural off-season, an average of two or three people per day. The fishing spots are upstream and downstream of the bridge, but not near it. The fishing is small scale and only for individual consumption. • During the dry season, some local people take sand from the bottom of the river for housing construction; however, the locations are not near the bridge. • Two households use the river water for daily life water such as laundry and bathing, but not drinking. The locations of water intake are near the bridge. One resident requested us to be aware of his pump during the construction. Concerning the Spread of Infections, including HIV/AIDS, by the Workers • Local residents are not concerned about it. • The local Woman's Union is doing education and information distribution regarding protection from HIV/AIDS, prevention of drug use, and sanitation. • Before starting the construction, the Woman's Union wants to discuss with the contractor and enlighten the workers. In particular, a limit of entering the residential area at night needs to be set, based on the discussion. Concerning Human Trafficking after Improvement of NR-9 as the International Corridor • Since no human trafficking has occurred in this area, local residents are not concerned about it. Even though the traffic volume will increase in the future, they do not fear it. Others • The villagers want to hear ideas from the contractor about improvement of their public infrastructure if possible.

Figure 1.5.11 Photo: Stakeholder Meeting at Xe Tha Mouak Bridge

Chapter 2 Contents of the Project

2.1 Basic Concept of the Project

2.1.1 Background and Objective of the Project

(1) Current Condition

Lao PDR is a landlocked country and its transportation network with neighboring countries, particularly in view of the importance of physical distribution by road, is extremely important. National Road No. 9 constitutes a part of the east-west economic corridor, which traverses Indochina. This arterial road connects eastern Thailand and central Vietnam and is positioned as vital infrastructure contributing to the economic integration of ASEAN. Trade, investment, and economic development in the central regions of Lao PDR are being advanced by making use of this east-west economic corridor.

Due to these circumstances, funds from Japan's Grant Aid and the Asian Development Bank (ADB) already improved National Road No. 9 over the entire 244 km as 2 lanes of asphalt concrete road. Subsequent to completion of the improvement works, necessary maintenance and repairs have been carried out by the Lao PDR side. However, initial measurements, taken from the deterioration of the road surface, were not quite sufficient and, for other reasons, the degree of damage became conspicuous. The funds required to carry out repairs on National Road No. 9 take up more than 20% of the country's road maintenance and repair budget. This economic burden has become increasingly problematic. Furthermore, the Second Mekong International Bridge and other factors have led to intensified traffic density. Now that National Road No. 9 is positioned as an international arterial highway, its axle load limit has been relaxed from 9.1 to 11 tons based through an international agreement with Thailand and Vietnam, and the situation is that smooth traffic is being hampered by damaged road surfaces.

(2) The Development Plan

The development plan established by Laos, the Seventh National Socio-Economic Development Plan (2011-2015), sets up four targets: ① securing stable economic growth (GDP growth rate at 8% and per-capita GDP at $1,700), ② achievement of MDGs by 2015 and departure from the LDC by 2020, ③ securing sustainable economic growth associated with the cultural and social development, securing natural resources and environmental conservation, and ④ political stability, maintenance of peace and social order, and enhancement of its role in international society.

(3) Objective of the Project

The reconstruction of two bridges (Xe Kum Kam Bridge and Xe Tha Mouak Bridge) on National Road No. 9 (hereinafter referred to as "the Project") targets improved performance of these bridges and contributes to realization of smooth and stable traffic on National Road No. 9.

2.2 Outline Design of Japanese Assistance

2.2.1 Design Policy

2.2.1.1 Basic Policy

Basic policy for this project is to confirm the necessity and relevance of the requested project and conduct basic designs appropriate for the grant aid project, establish an implementation plan, and estimate the project cost.

2.2.1.2 Policy concerning natural conditions

(1) Policy for the river plan

1) Xe Kum Kam Bridge

a) Scale of the plan: The planned scale of the bridge must be such as to ensure dealing with a return period of 100 years.

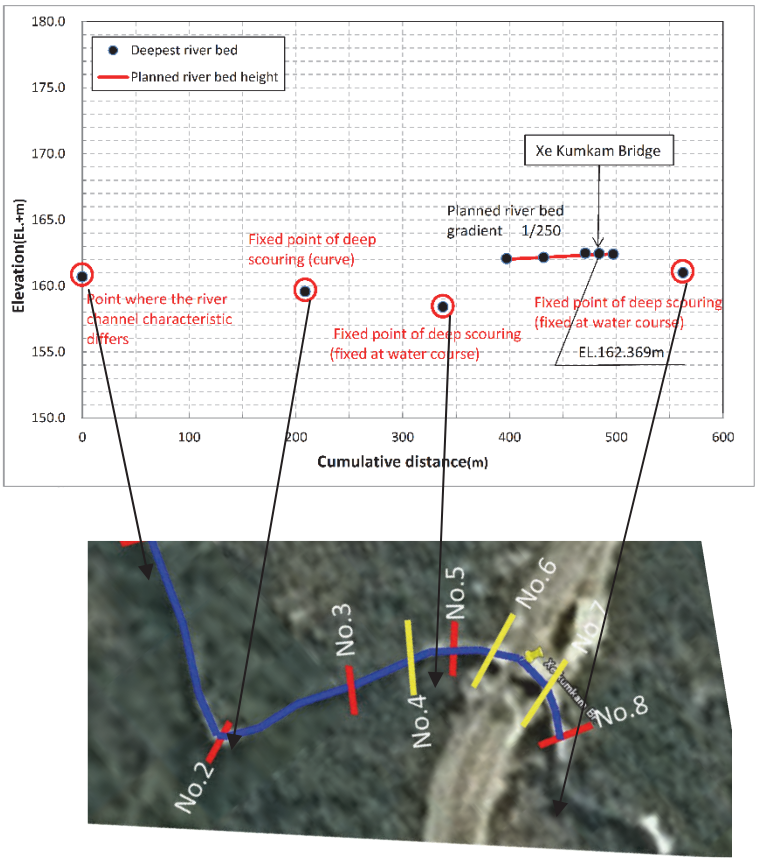
b) River planning section: The river section must be planned on the basis of the following basic conditions, with the river channel planned with multiple sections with a gradient of 1:2.

- The section to which the planning section is to be applied is a bridge protective revetment provided for the 10 m section on the upstream and downstream sides of the bridge location.
- The river width at the height of a low-flow channel shoulder is nearly equivalent to the width of the existing channel. In consideration of accessibility to water, the gradient of revetment is to be 1:2, nearly equivalent to the existing gradient.
- In consideration of the existing low-flow channel, the direct height of revetment must be around 4 m, with a secured footing depth of 1 m.
- The freeboard of the levee is planned to be 1 m, according to the Government Ordinance for Structural Standards for River Administration Facilities, etc.

c) Planned height of riverbed

A year-long river survey has not been performed at the bridge location. Since the factors causing lowering of the riverbed, such as gravel digging, etc., are not confirmed, the riverbed is considered stable. Fixed deep-scouring points identified through on-site visual inspection in the outer bank of the curve on the upstream and downstream sides of the survey area will be taken into account for setting the planned riverbed height. Since locations with exposed rocks could be confirmed around the bridge location, the possibility of rapid progress of riverbed scouring is considered low. Consequently, the planned riverbed height is to be a deepest bed height of the existing river channel. Considering that the scouring points may shift due to

shifting of the sand banks during flooding, the line enveloping the deepest riverbed from the profile of the deepest riverbed within the survey area is taken as a planned riverbed height. The planned riverbed height is therefore established as EL + 162.369 m (Figure 2.2.1).

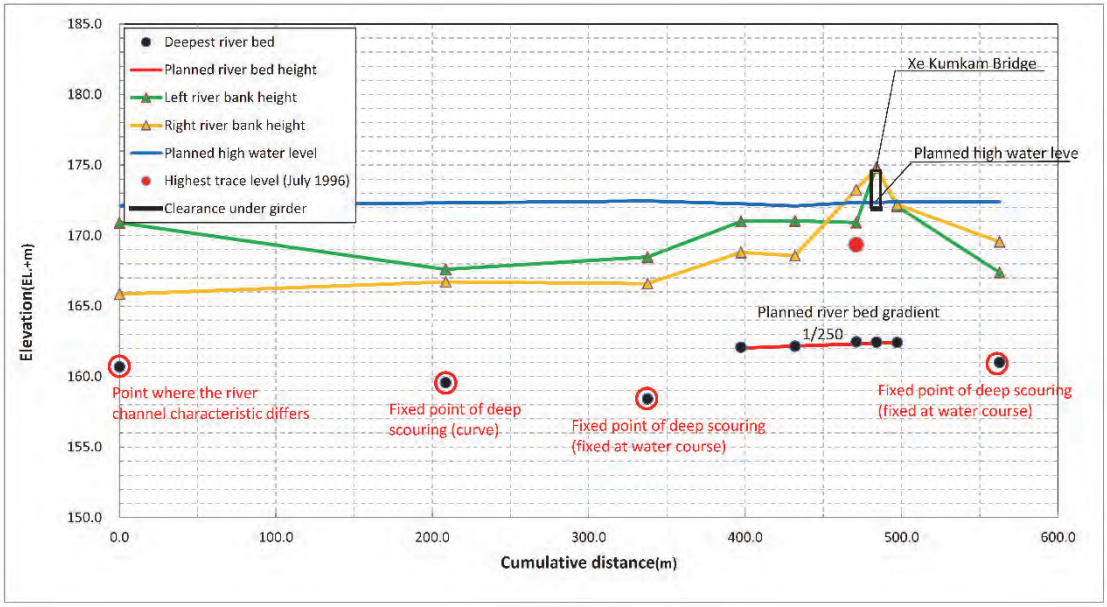


Source: Study team

Figure 2.2.1 Profile of planned riverbed height (Xe Kum Kam Bridge)

d) Planned high water level

The non-uniform flow was calculated for the river channel after the development of the revetment (Figure 2.2.2). As is known from Figure 2.2.2, the calculated water level at the bridge location when the planned flow is 1.150 m^3/s is EL + 172.343 m, which is taken as the planned high-water level. The clearance under the girders of the existing bridge is EL + 171.9 m (the bridge face height of EL 175.8 m – girder thickness of 3.9 m), which is 0.443 m lower than the planned high-water level. Namely, the water level may rise above the clearance under the girders during a 100-year flood.



Source: Study team

Figure 2.2.2 Profile of planned high-water level (Xe Kum Kam Bridge)

e) Design flow velocity

The design flow velocity is 2.44 m/s, the maximum value of calculated flow velocity on the upstream and downstream sides of the bridge location.

Table 2.2.1 Result of flow velocity at design flow at the bridge location (Xe Kum Kam Bridge)

No.	Name of section	Bridge location	Flow velocity (m^3/s)	Max flow velocity (m^3/s)
1	CROSS1		2.71	
2	CROSS2		2.15	
3	CROSS3		1.57	
4	CROSS4		2.61	
5	CROSS5		3.16	
6	CROSS6	10 m on the downstream side	2.37	
7	ROAD	Bridge location	2.44	2.44
8	CROSS7	10 m on the upstream side	2.18	
9	CROSS8		2.49	

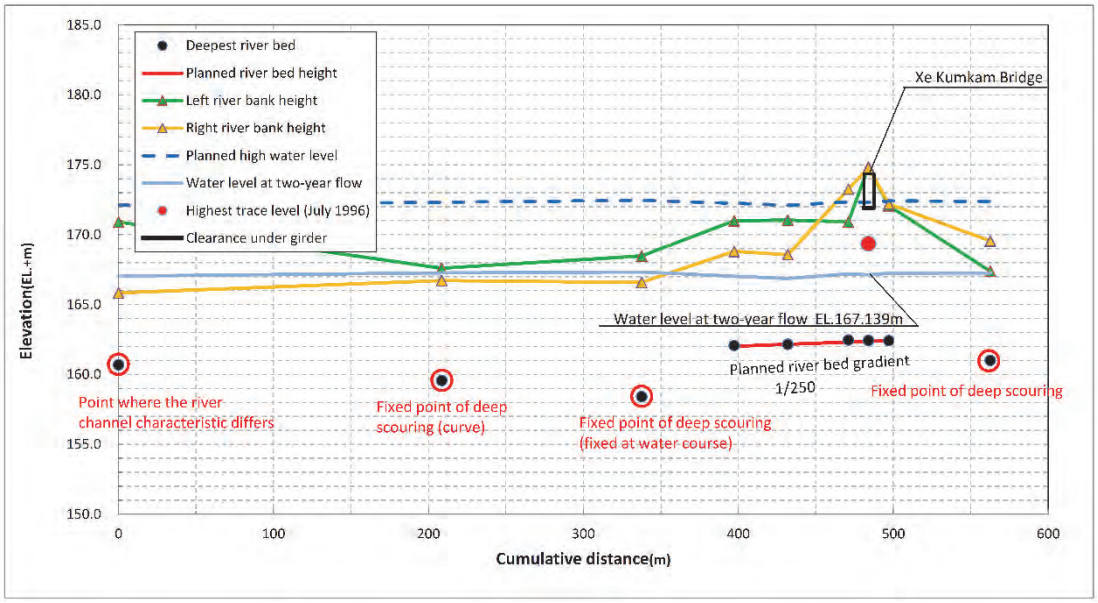
Source: Study team

f) Runoff during construction

For the temporary piers during bridge reconstruction, two years are estimated after start of the work. The temporary piers provided during the construction period are to be exposed to at least two rainy seasons.

Accordingly, the temporary piers are to be installed at a level higher than the water level of the two-year flow. To determine the installation height of temporary piers, the non-uniform flow

was calculated for the existing river channel (Figure 2.2.3). From Figure 2.2.3, the planned high-water level at the bridge location at the two-year flow of 450 m^3/s is EL + 167.139 m is taken as a reference water level for the height of temporary piers.



Source: Study team

Figure 2.2.3 Profile of water level at two-year flow (Xe Kum Kam Bridge)

Table 2.2.2 Calculation results by return period at the bridge location (Xe Kum Kam Bridge)

No.	Return period	Flow m^3/s		Calculated flow (EL + m)
		Runoff	Planned flow	
1	1-year	216	250	165.950
2	2-year	424	450	167.139
3	3-year	504	550	168.655
4	5-year	602	650	169.321
5	10-year	730	750	169.940
6	30-year	930	950	171.405
7	50-year	1022	1,050	171.883
8	100-year	1,148	1,150	172.343

Source: Study team

2) Xe Tha Mouak Bridge

a) Scale of plan: The planned scale of the bridge must be such as to ensure dealing with a return period of 100 years.

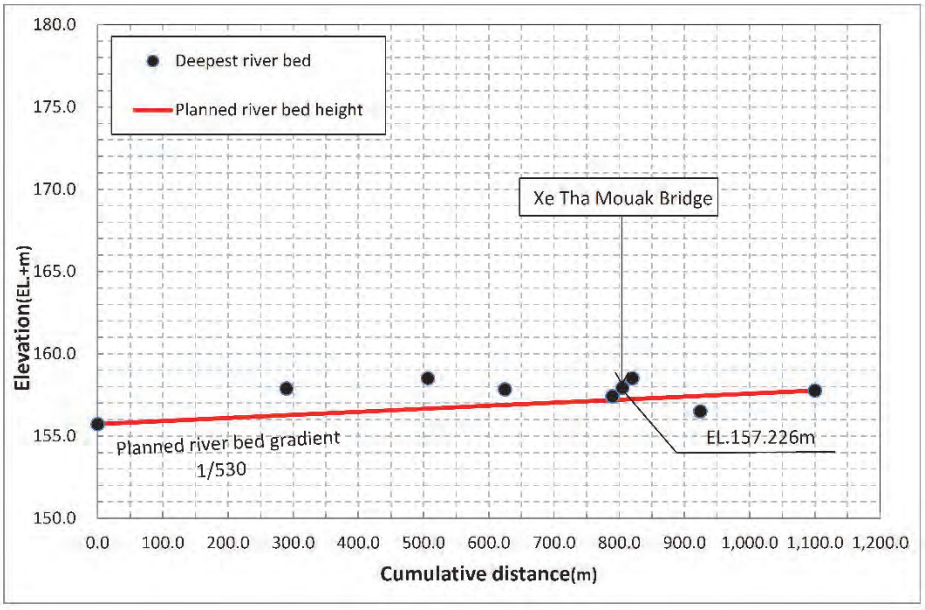
b) River planning section: The river section must be planned on the basis of the following basic conditions, with the river channel planned with multiple sections with a gradient of 1:2.

- The section to which the planning section is to be applied is a bridge protective revetment provided for the 10 m section on upstream and downstream sides of the bridge location.

- The river width at the height of the low-flow channel shoulder is nearly equivalent to the width of the existing channel. In consideration of accessibility to water, the gradient of revetment is to be 1:2, nearly equivalent to the existing gradient.
- In consideration of the existing low-flow channel, the direct height of revetment must be around 4 m, with a secured footing depth of 1 m.
- The freeboard of the levee is planned to be 1.2 m according to the Government Ordinance for Concerning Structural Standards for River Administration Facilities, etc.

c) Planned height of the riverbed

A year-long river survey has not been performed at the bridge location. Since the factors causing lowering of the riverbed, such as gravel digging, etc., is not confirmed, the riverbed is considered stable. On-site visual inspection did not confirm any sign of localized riverbed scouring or bank erosion. This river was visually confirmed to be a sand river. In this type of river, the deepest position is likely to shift through one time of flooding. Therefore, the deepest riverbed of the existing river channel is taken for the planned riverbed height. As the scouring points are shifted due to shifting of sand banks during flooding, it is not appropriate to use the deepest riverbed at the bridge location as it is. The line enveloping the deepest riverbed from the profile of the deepest riverbed within the survey area is taken as a planned riverbed height. Consequently, the planned riverbed height at the bridge location is established as EL + 157.226 m (Figure 2.2.4).



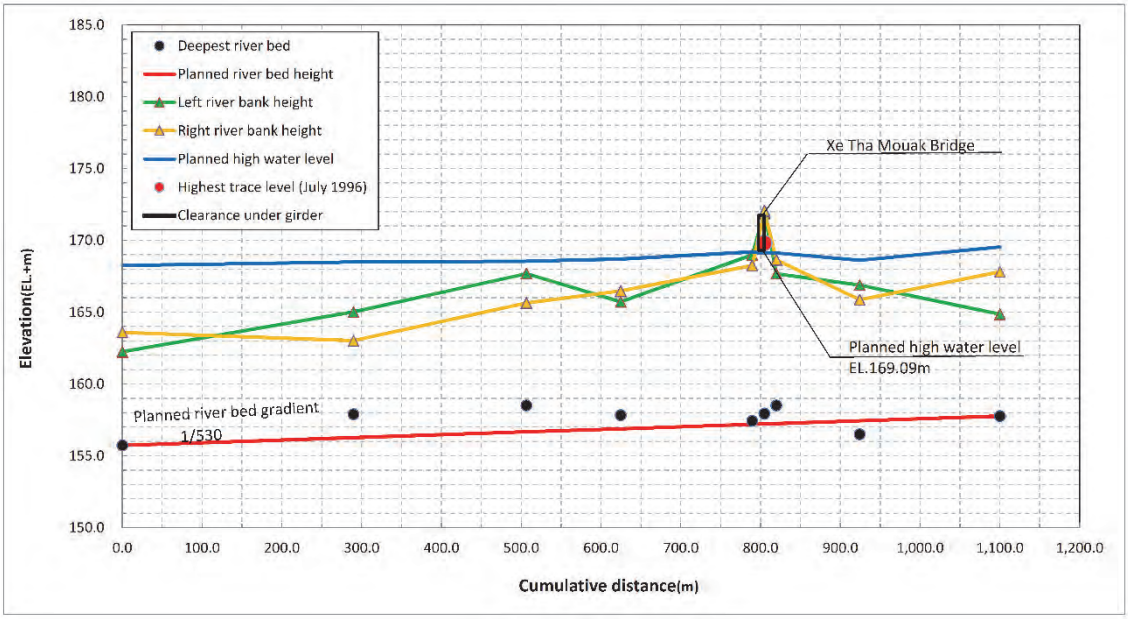
Source: Study team

Figure 2.2.4 Profile of the planned riverbed height (Xe Tha Mouak Bridge)

d) Planned high-water level

The non-uniform flow was calculated for the river channel after development of revetment

(Figure 2.2.5). As is known from Figure 2.2.5, the planned water level at the bridge location when the planned flow is 3,950 m^3/s is EL + 169.09 m, which is taken as the planned high-water level. The clearance under the girder of the existing bridge is EL + 169.504 m (the bridge face height of EL 172.533 m – girder thickness of 3.029 m), which is lower than the planned high-water level. The highest trace level (as of July 1996) is EL + 169.814 m, which exceeds the clearance under the girder during flooding, as is confirmed through visual inspection.



Source: Study team

Figure 2.2.5 Profile of the planned high water level (Xe Tha Mouak Bridge)

Table 2.2.3 Calculation results by return period at the bridge location (Xe Tha Mouak Bridge)

N0.	Return period	Flow m^3/s		Calculated flow (EL.+m)
		Runoff	Planned flow	
1	1-year	933	950	164.299
2	2-year	1,932	1,950	166.499
3	3-year	2,184	2,200	166.934
4	5-year	2,464	2,500	167.414
5	10-year	2,817	2,850	167.872
6	30-year	3,349	3,350	168.453
7	50-year	3,593	3,600	168.719
8	100-year	3,920	3,950	169.090

Source: Study team

e) Design flow velocity

The design flow velocity is 3.16 m/s by employing the maximum value of calculated flow velocity on upstream and downstream sides of the bridge location.

Table 2.2.4 Results of calculated water level by return period (Xe Tha Mouak Bridge)

No.	Name of section	Flow m^3/s	Flow velocity (m^3/s)	Max flow velocity (m^3/s)
		Runoff		
0	CROSS1		2.40	
2	CROSS2		2.63	
3	CROSS3		3.39	
4	CROSS4		3.42	
5	CROSS5	10 m on the downstream side	2.78	3.16
6	CROSS6	Bridge location	3.16	
7	ROAD	10 m on the upstream side	3.10	
8	CROSS7		4.81	
9	CROSS8		3.73	

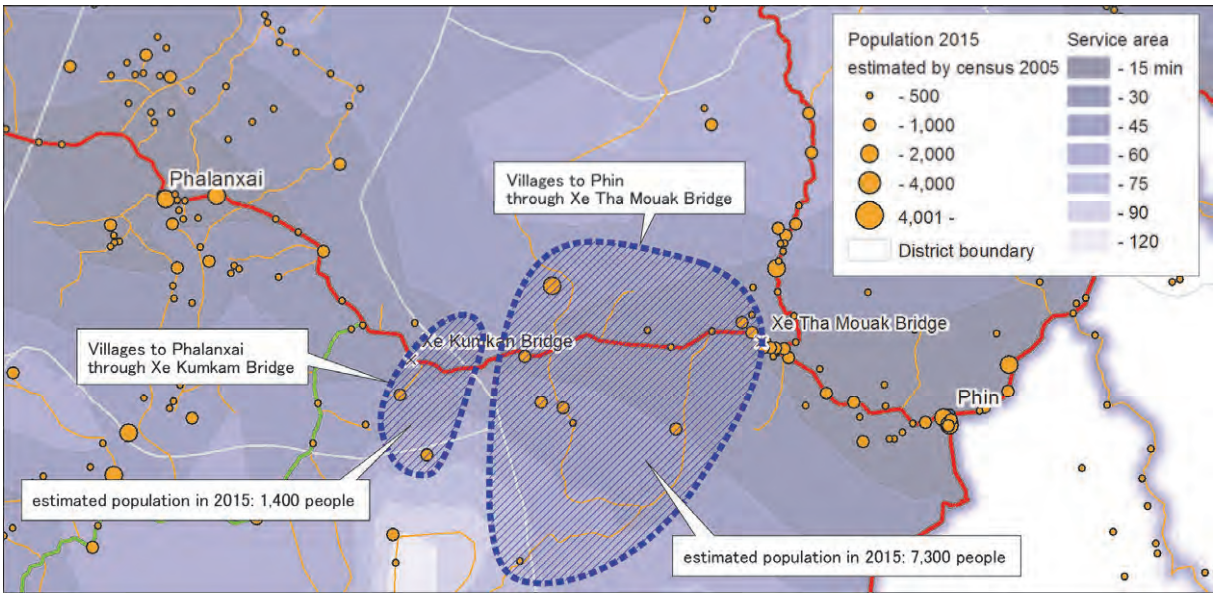
Source: Study team

2.2.1.3 Policy concerning social and economic conditions

Resettlement and land acquisition should be minimized at the stage of planning of reconstruction of the bridge and building a provisional bridge, access road, and temporary area for construction work. And after completion of the projects, the site including the existing access road and temporary area for construction work also should be minimized.

National Road No. 9 is a part of the East-West Economic Corridor crossing the Indochina peninsula, an important road not only domestically] but also as an international highway. The current truck volume through the bridges is more than 600 vehicles per day and measures during construction work for such heavy vehicle traffic should be considered. Reconstruction of Xe Tha Mouak Bridge in the vicinity of the built-up area requires appropriate measures during construction work to secure the safety of pedestrians and bicycles.

About 185 thousand people in eastern Savannakhet Province (Phin, Sepone, Nong, Vilabuly Districts) require the bridges to access Kaysone Phomvihane District, the provincial center of Savannakhet and Vientiane Capital, through National Road No. 13. About 1,400 people in the vicinity of Xe Kum Kam Bridge and about 7,300 people in the vicinity of Xe Tha Mouak Bridge cross the bridges to access the district hospital. During construction work, measures for emergency transport should be considered.



Source: Study team

Figure 2.2.6 Service Area from the District Hospital and Population through Bridges

2.2.1.4 Policy concerning circumstances of construction

As for UXOs, the GOL requires a search UXOs. If there are UXOs in the construction area, removal of the UXO by the GOL is required before construction commencement.

Equipment and materials, excluding steel and bridge accessories, are currently available on the domestic market because of various ongoing road and bridge projects. In addition, although it has just started, leasing is now possible in Lao PDR. Accordingly, construction equipment and materials for the Project should be basically procured from the domestic market as much as possible.

2.2.1.5 Policy regarding utilization of local contractors

Bridges constructed by local contractors have been carried out financing from the Lao government so far. Specifically, I-type girders manufactured with reinforced concrete have been built frequently. As shown in Figure 2.2.7 of the Sedong Bridge located on 15A, this prestressed concrete bridge was built by Lao's contractor. High technical performance of the bridge construction work, including prestressed concrete by Lao's contractors, has been confirmed, excluding high quality control. Regarding pavement work, the paving technique of the DBST is able to be performed by Lao's contractors. However the asphalt concrete technique paved by Lao's contractors is being mastered for consistent performance under the Japanese contractors from planning to maintenance. Furthermore, there is an association for the contractors named Lao Construction Association, which comprises 38 companies.

Figure 2.2.7 Bridge Techniques by Lao's Contractor (Sedong Bridge on 15A)

On the other hand, Lao's consultants, who are part civil and part architect, have mainly carried out the matters of a topographic survey, geotechnical survey, traffic volume survey including an O-D survey, and an environmental survey as the local consultant. Therefore, engineers who are assigned as the road designer, the highway specialist, and the bridge engineer have been limited. There is an association for the consultants named Association of Architects and Civil Engineers with 148 participating companies.

2.2.1.6 Policy regarding Operation and Maintenance

Laos will superintend the implementation and O&M of the Project, whereas the provincial office of the MPWT–that is, the Department of Public Works and Transport of Savannakhet (DPWT)–will be responsible for the O&M of the bridge and roads. The Department of Public Works and Transport of Savannakhet (DPWT) maintain the bridges and road on National Road 9. The required skills for maintenance would be secured because Savannakhet province is a pilot province for the project for improving road management capability in Lao PDR, and technical transfer is progressing. However, since the bridges on National Road 9 will be required to be replaced in the future, technical transfer of skills for bridge replacement will be conducted through the implementation of the project.

2.2.1.7 Policy regarding the setting of the facility grade

The target facilities under the project will include the construction of a new bridge, their approach roads, and other necessary appendages. Also, the facilities to maintain the function of community life, including access steps to the river, etc., will be included in the project.

The outline design of target bridges with their approach roads will be conducted in compliance with the Road Design Manual in Lao PDR. The Manual specifies the geometric standards and loading conditions (live load only); however, there are no detailed configurations such as loading combinations, so other design configurations will be employed from those specified in the ASEAN standards and Japanese standards, as follows.

Table 2.2.5 The Grade of Target Bridges

Name of Bridge		Xe Kum Kam Bridge	Xe Tha Mouak Bridge
Road Class		「Road Design Manual」 ASEAN Standards Class II	
Design Speed		80 km/h	80 km/h
Design Load		HS25-44	
Bridge Length		90.0 m	160.0 m
Width	Total	8.0 m	11.0 m
	Traffic Lane (Shoulder)	3.5×2 = 7.0 m (0.5 x 2)	3.5×2 = 7.0 m (0.5 x 2)
	Sidewalk	―	1.5 m x 2
Superstructure		3-spanned continuous steel-concrete composite slab bridge	4-spanned continuous steel-concrete composite slab bridge
Substructure		Abutment: Invert T type Piers: Wall type	Abutment: Invert T type Piers: Wall type
Foundation		Spread	Spread
Protection (Gabion)		28.8 m	31.8 m

Table 2.2.6 The Grade of Approach Roads

Name of Bridge		Xe Kum Kam Bridge	Xe Tha Muoak Bridge
Design Speed		80 km/h	80 km/h
Geometric	Crossfall	3%	
	Superelevation	8%	8%
	Max. Grade	1.05%	1.6%
	Min. Horizontal Curve	R = 330 m	R = 345 m
	Shift	―	―
Road Length		L = 488.3 + 532.5 m	L = 554.3 + 480.7 m
Cross elements	Total	11.0 m	
	Traffic Lane	3.5 x 2 = 7.0 m	
	Shoulder	2.0 x 2 = 4.0 m (including soft shoulder)	
Pavement composition	Surface	5 cm (AC)	
	Binder	5 cm (AC)	
	Base	20 cm (Mechanical)	
	Subbase	30 cm (CR)	
	Subgrade	Design CBR = 6%	

2.2.1.8 Policy regarding construction methods and schedule

(1) Construction method

1) Superstructure

Both the existing bridges of Xe Kum Kam Bridge and Xe Tha Muoak Bridge are simple steel girder bridges with RC slab. Both of them have very unique shapes with abrupt bending girders at the bearing shoes on the middle piers (the bending shape of the steel girder seems to be from the original design, which hinders smooth travelling of the vehicles on the bridges). Currently, both bridges have limited overhead clearance from flood water levels during the rainy season so that

those cannot secure enough clearance if new bridges were designed applying a deeper girder depth than the existing girder depth. The vertical alignment of the bridges shall be adjusted with the profile of the existing approach road in order to not affect the height of roadside facilities accessing local houses as well as private land. Accordingly, considering the constraints of the vertical alignment of the bridges, the girder depth shall be minimized in the design. A comparative study on optional bridge types has been conducted to find a suitable bridge configuration. As a result, it was recommended to apply the Steel-Concrete Composite Slab Bridge, which was developed in Japan to minimize the depth of girders by effectively managing the sectional force in combination with the composite structure and continuous configuration of the bridge structure. The span arrangements of both bridges have also been carefully studied to secure an adequate span length for the discharge volume of river water at the 100-year return period. The separate pieces of steel form, which are to be prefabricated in the factory and hauled to the site, can be lifted up by a single crane. Therefore, this bridge type can provide advantages in saving both costs and time for the erection of the superstructure and also secure quality control of the superstructure by prefabricating the steel forms in the manufacturer.

2) Foundation/Substructure

As a result of the geotechnical survey, both the bridge sites have found sound rock at a very shallow position, thereby the spread foundations have been applied reasonably. Since both the bridges will be replaced at the existing locations, temporary bridges shall be installed to divert the existing traffic before constructing the bridge. The temporary bridges will be erected on the upstream side of the existing bridge and a temporary construction road will be constructed on the downstream side. Scouring of the embankment skirt surrounding the abutment is assumed and that needs to protect it by installing a gabion. Also, the gabion can be applied around the piers to protect the riverbed from scouring from severe current water.

3) Approach Roads

Some sections of the existing approach roads have insufficient vertical gradient to discharge runoff water so that the modification of the vertical alignment is required to keep at least a minimum drain grade (0.3%) in accordance with the specifications stipulated in the Japanese Road Ordinance. The installation of a side ditch at the necessary sections will facilitate the drainage of runoff water to protect the pavement structure from damage caused by water on the road. Installation of a slope protection measure of the embankment should be considered in order to keep their stability. The asphalt concrete will be applied to follow the practice of the current pavement structure of NR9. The pavement composition with thickness of each pavement layer shall be decided to meet the requirements of ESAL from the traffic demand forecast for a 10-year design period in accordance with the AASHTO-93.

(2) Construction Schedule

Tropical monsoon weather brings warm temperatures throughout the year in Lao PDR. The weather is split with a rainy season (from May to October) and a dry season (from November to April). The annual average temperature is approximately 30 degrees Celsius, in which it exceeds 30 degrees from March to May. The lowest temperature, below 15 degrees, can be observed around Savanakhet and Xephon. The annual rainfall around Savannakhet and Xeno has been recorded between 1,500 and 2,000 mm. The establishment of a construction schedule shall be carefully examined for the different work rates between the two separate seasons, especially the timing of bridge foundation work and pavement work, which will be critical to the quality of the work depending on the weather conditions.

2.2.1.9 Policy related to environmental and socal considerations

In order to minimize the effects on the natural and social environments, the following measures will be taken into account and reflected in the design and construction:

- Minimization of the amount of cutting
- Minimization of resettlement and site acquisition
- Controlling the dust from the earthworks and construction vehicles
- Employ the low-noise and -vibration vehicles
- Control the emission of contaminants
- Control water pollution of the rivers
- Employ traffic management for reducing traffic disturbance
- Enlighten safety and sanitary controls on the contractors and works
- Arrangement of access to the rivers for local river users

2.2.2 Basic Plan

2.2.2.1 Overall Plan

(1) Selection of route and new bridge location

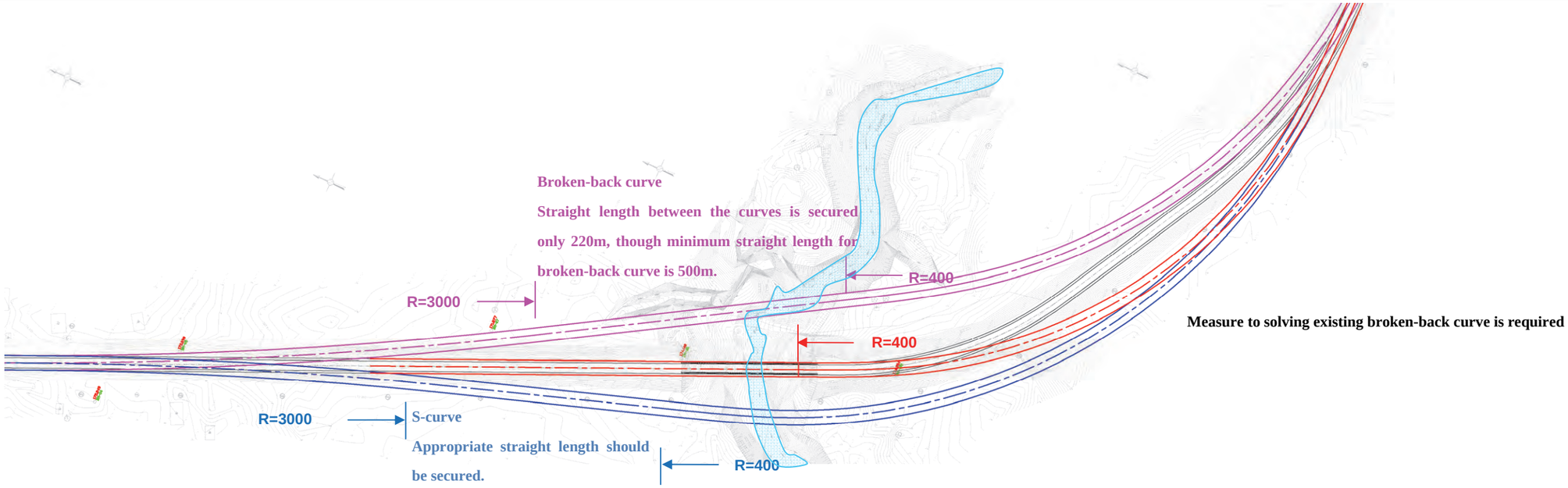
1) Xe Kum Kam Bridge

When the alignment is to be studied, the proposals for comparison are to be extracted by taking into account the following points:

- Compliance with the ASEAN Highway Standards Class II requirements of geometric design
- Elimination of the existing broken-back curves
- Securing of the required straight length so as to avoid the existing bridge, the straight section has to be inserted between the curve determined after elimination of the broken-back curve and the curve connecting to the existing straight section

- Securing of 5 m spacing as construction allowance when the existing bridge is to be avoided

On the basis of the above policy, comparison was done among three routes shown in Figure 2.2.8, and Option-B (bridge construction at the current bridge location) was selected as the optimum one.

	Plan A: Shift the bridge toward the south side of the existing location		Plan B: Relocate at the existing location		Plan C: Shift the bridge toward the north side of the existing location	
Overall view						
Road alignment	✓ Solving existing broken-back curve is required ✓ Shift the alignment to the south side of the existing bridge ✓ West side: Appropriate straight length is secured between transition curves for S-curve ✓ East side: One single curve is applied to avoid broken-back curve		✓ Solving existing broken-back curve is required ✓ Alignment passes through existing bridge location after reconstruction		✓ Solving the existing broken-back curve is required ✓ Shift the alignment to the north side of the existing bridge ✓ West side: Appropriate straight length is secured between transition curves for S-curve ✓ East side: One single curve is applied to avoid broken-back curve	
Travel safety	✓ The alignment is slightly worse than that of Plan B ✓ Installation of lighting facilities is needed to secure safe traveling on the bridge	○	✓ Satisfy ASEAN Highway Standards and mostly following the existing alignment is better than other alternatives ✓ Installation of lighting facilities is needed to secure safe traveling	◎	✓ The alignment is slightly worse than that of Plan B ✓ Installation of lighting facilities is needed to secure safe travel ✓ Straight length between the curves is secured for only 220 m, though the minimum straight length for a broken-back curve is required to be more than 500 m	△
Bridge structure	✓ Whole bridge section is located in the curved section ✓ New bridge length will be longer than the existing one due to wider river section	○	✓ New abutment structures should be constructed behind the existing abutment that is required for longer bridges than the existing one ✓ Some parts of the bridge section are located in the curved section	○	✓ Some parts of bridge section are located in the curved section ✓ New bridge length will be much longer than the existing one due to crossing over the meandering river	○
Affected houses	✓ None ✓ Huge area affected by new alignment ✓ The area between existing alignment and new alignment will be disused	×	✓ None	◎	✓ None ✓ Huge area affected by new alignment ✓ The area between existing alignment and new alignment will be disused	×
Utilities to be relocated	✓ Optical fiber cables ✓ Electric cable/line	△	✓ Optical fiber cables	○	✓ Optical fiber cables (if removing the existing bridge)	◎
Economy	✓ The existing bridge can be operative as a temporary bridge during the construction of the new bridge ✓ Relocation of optical fiber cables and electric cable/line is needed ✓ Land acquisition is required for whole strech of new alignment	△	✓ A temporary bridge is needed during the construction period because a new bridge is constructed after the existing bridge is removed ✓ Relocation of optical fiber cables is needed ✓ Land acquisition is limited: only required for remedying the broken-back section on the approach road	△	✓ The existing bridge can be operative as a temporary bridge during the construction of the new bridge ✓ Relocation of optical fiber cables is needed ✓ Land acquisition is required for the whole stretch of the new alignment	△
Constructability	✓ Superior to Plan B because adequate distance from the existing bridge can be secured during construction of the new bridge	◎	✓ The construction period is longest among alternatives because removal of existing bridge and construction of a temporary bridge are needed ✓ Technical consideration should be required for the demolishment of existing substructures	△	✓ Superior to Plan B because it is an adequate distance from the existing bridge can be secured during construction of the new bridge	◎
Evaluation			**Recommended by the Study Team**			

Source: JICA Study Team

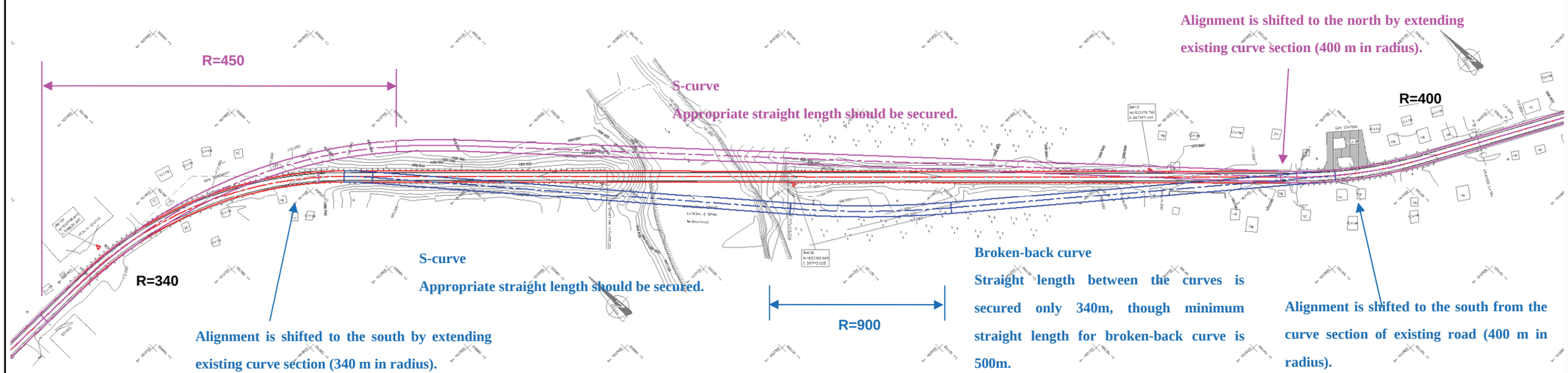
Figure 2.2.8 Comparison among route alternatives (Xe Kum Kam Bridge)

2) Xe Tha Mouak Bridge

When the alignment is to be studied, the proposals for comparison are to be extracted by taking into account the following points:

- Compliance with the ASEAN Highway Standards Class II requirements of geometric design
- Comparison of alignment on the extended line from the existing curve with the use of the existing curve element
- Securing of 5 m spacing as construction allowance when the existing bridge is to be avoided

On the basis of the above policy, comparison was done among three routes shown in Figure 2.2.9, and Option-B (bridge construction at the current bridge location) was selected as the optimum one.

	Plan A: Shift the bridge toward the south side of the existing location		Plan B: Relocate at the existing location		Plan C: Shift the bridge toward the north side of the existing location	
Overall view						
Road alignment	✓ The approach road connects to the curvde section of the existing road at both the starting point and the ending point ✓ Shift the alignment to the south side of the existing bridge		✓ Alignment passes through existing bridge locations after reconstruction		✓ At the end point, the alignment is shifted to the north by extending the existing curve. And at the starting point, the alignment connects to the existing road by inserting the curve section of 450 m in radius ✓ Shift the alignment to the north side of the existing bridge	
Travel safety	✓ The alignment is slightly worse than that of Plan B ✓ Straight length between the curves is secured only 340m, though minimum straight length for broken-back curve is required more than 500m ✓ Installation of lighting facilities is needed to secure safe traveling on the bridge	△	✓ Satisfies the ASEAN Highway Standards and mostly follows the existing alignment, which is better than other alternatives ✓ Installation of lighting facilities is needed to secure safe travel on the bridge	◎	✓ Satisfy ASEAN Highway Standards ✓ Installation of lighting facilities is needed to secure safe travel on the bridge	○
Bridge structure	✓ Some parts of bridge section are in curved section however skew angle of bridge sharper and wider river width need a longer bridge than the exiting one	△	✓ New abutment structure should be constructed behind the existing abutment that is required for longer bridges than the existing one ✓ The whole bridge section is located in a straight section; therefore, the configuration of the bridge is almost same as the existing bridge	○	✓ The whole bridge section is located in a straight section; however the skew angle for the new bridge is sharper than the existing bridge	△
Affected houses	✓ Removal of few houses including new house under construction is required and that gives slightly higer impact to social environment	△	✓ None	◎	✓ Removal of about 10 houses, including a new house under construction, is required, which gives higher impact to the social environment	×
Utilities to be relocated	✓ Optical fiber cables ✓ Electric cable/line	△	✓ Optical fiber cables	○	✓ Optical fiber cables (when removing the existing bridge) ✓ Electric cable/line	△
Economy	✓ The existing bridge can be operative as a temporary bridge during the construction of the new bridge ✓ Relocation of optical fiber cables and electric cable/lines is needed ✓ Resettlement is required for the removal of a few houses	△	✓ A temporary bridge is needed during the construction period because the new bridge is constructed after the existing bridge is removed ✓ Relocation of optical fiber cables is needed	△	✓ The existing bridge can be operative as a temporary bridge during the construction of new bridge ✓ Relocation of optical fiber cables and electric cable.lines is needed ✓ Resettlement is required for the removal of about 10 houses	△
Constructability	✓ Superior to Plan B because an adequate distance from the existing bridge can be secured during construction of the new bridge	◎	✓ The construction period is the longest among alternatives because removal of the existing bridge and construction of a temporary bridge are needed ✓ Technical consideration should be required for the demolishment of existing substructures	△	✓ Superior to Plan B because an adequate distance from the existing bridge can be secured during construction of the new bridge	◎
Evaluation			**Recommended by the Study Team**			

Source: JICA Study Team

Figure 2.2.9 Comparison among route alternatives (Xe Tha Mouak Bridge)

(2) Design Standards

1) Road design standards

The Road Design Manual (1996) has been developed as the design standard for roads in Laos. This standard is employed concerning the geometric road design and the standard values of ASEAN Highway Standards are also satisfied. Note that, for matters not specifically described in these standards, the Japanese design standard (Explanation and Operation of the Road Structure Ordinance, February 2004, the Japan Road Association) will be applied. The Pavement Design Manual (AASHTO, 1993) will be applied for pavement design.

2) Bridge design standards

The Road Design Manual (1996) is applied for the bridge design. Note that, for matters not specifically described in the standards, the Japanese standards, Specifications for Highway Bridges Part I-V 2012.3, Japan Road Association, will be applied.

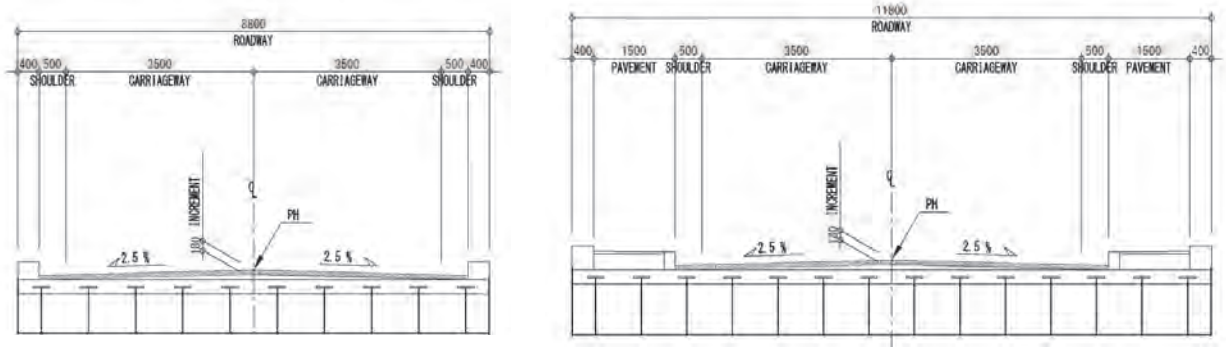
(3) Alignment and cross section

1) Road vertical alignment and horizontal alignment

Road vertical alignment is to be designed considering the existing road elevation behind bridge abutments. The vertical alignment for the Xe Kum Kam Bridge is planned as a crest shape with the crest at the middle of the bridge section. The horizontal alignment for the bridge is planned to solve the existing broken-back curve and to have a smooth clothoid curve. For the design of the Xe Tha Mouak Bridge, the same design concept as the Xe Kum Kam Bridge can be applied.

2) Typical bridge cross section

The typical bridge cross section is shown in Figure 2.2.10. Sidewalks with a 1.5 m width are installed only for the Xe Tha Mouak Bridge. Width of the wheel guard is 400 mm according to Japanese standards. And a pedestrian-vehicle combination guardrail is applied.



(Xe Kum Kam Bridge) (Xe Tha Mouak Bridge)

Source: JICA Study Team

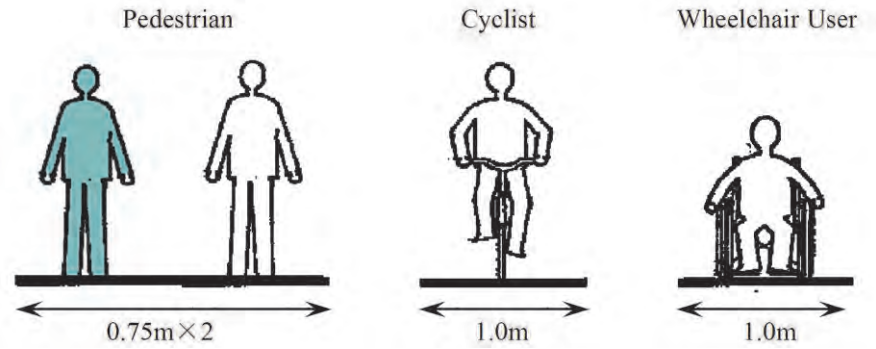
Figure 2.2.10 Typical bridge cross section

3) Width of sidewalk

Many people are living near the Xe Tha Mouak Bridge and there are sidewalks on the existing bridge. The Lao side is requesting installation of a sidewalk on the new bridge as well; therefore, installation of a sidewalk on the Xe Tha Mouak Bridge should be planned considering the environment of the neighborhood.

On the other hand, there are not side walk at the Xe Kum Kam Bridge, there are only inspection space (width 40 cm). Installation of a sidewalk at the Xe Kum Kam Bridge should not be planned considering number of pedestrian (1 person/day). However, installation of inspection space will be discussed with The Lao side at detail design stage.

Regarding the sidewalk width, a width of 1.5 m is considered applicable here as a safe width allowing two pedestrians to pass by safely (1.5 m = 0.75 m x 2) and allowing bicycles and wheelchairs to pass (1.0 m or more) in the case of comparison with Japanese standards (see Figure 2.2.11).



Source: Road Structure Ordinance, Japan

Figure 2.2.11 Width occupied by road users

4) Constant for design

The standard and specified design strength of materials used are as shown below. For the concrete, the minimum specified strength value of plain concrete, reinforced concrete, and pre-stressed concrete is used. Regarding reinforcement, the reinforcement manufacturing plant in Lao is inspected and the Japanese reinforcement specifications are appropriate for the material strength; data obtained in the plant are assumed and adopted.

Table 2.2.7 Concrete specified strength

Use classification	Specified design strength (N/mm^2)
Plain concrete	18
Reinforced concrete	21
Pre-stressed concrete	30

Source: Specifications for Highway Bridges

Table 2.2.8 Specifications of reinforcement

Yield point strength (N/mm^2)	
Round steel	σpy > 235
Deformed bar（SD295）	295 < σpy < 390
Deformed bar（SD345）	345 < σpy < 440

Source: Specifications for Highway Bridges

Table 2.2.9 Specifications of steel

Minimum tensile strength（N/mm^2）	
SS400, SM400	410
SM490, SM490Y	500
SM520	530

Source: Specifications for Highway Bridges

5) Unit weight

The unit weights used in the design calculation are summarized below.

Table 2.2.10 Unit weight (kN/m^3)

Use classification	Unit weight
Plain concrete	23.0
Reinforced concrete	24.5
Pre-stressed concrete	24.5
Pavement	22.5

Source: Specifications for Highway Bridges

Ground	Soil	Loose	Dense
Natural ground	Sand and gravel	18	20
	Sandy	17	19
	Clay	14	18
Embankment	Sand and gravel	20	
	Sandy	19	
	Clay	18	

Source: Specifications for Highway Bridges

6) Allowable values

The allowable values used in the design calculations are summarized below.

Table 2.2.11 Allowable compressive stress for the reinforced concrete structure (N/mm^2)

Type of stress \ Specified design concrete strength	21	24	27	30
1) Bending compressive stress	7.0	8.0	9.0	10.0
2) Axial compressive stress	5.5	6.5	7.5	8.5

Source: Specifications for Highway Bridges

Table 2.2.12 Allowable compressive stress for the pre-stressed concrete structure (N/mm^2)

Type of stress \ Specified design concrete strength			30	40	50	60
Immediately after pre-stressing	Bending compressive stress	1) For rectangular section	15.0	19.0	21.0	23.0
		2) For T-shaped and box-shaped section	14.0	18.0	20.0	22.0
	3) Axial compressive stress		11.0	14.5	16.0	17.0
Others	Bending compressive stress	4) For rectangular section	12.0	15.0	17.0	19.0
		5) For T-shaped and box-shaped section	11.0	14.0	16.0	18.0
	6) Axial compressive stress		8.5	11.0	13.5	15.0

Source: Specifications for Highway Bridges

Table 2.2.13 Allowable stress of reinforcing bar (N/mm^2)

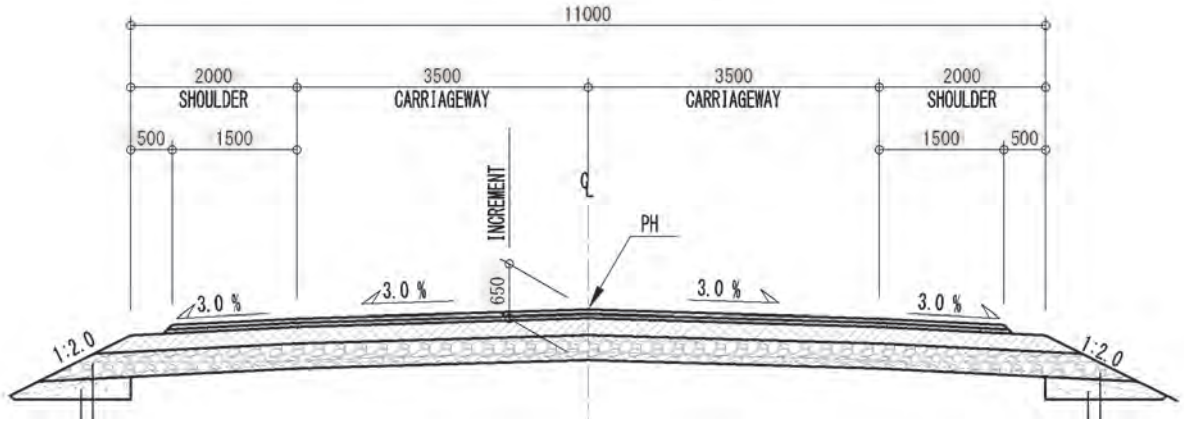
Stress, type of members \ Type of reinforcing bar			SD295	SD345
Tensile stress	1) Principal load other than live load and impact		100	100
	2) Basic value of allowable stress when the load combination does not take the effect of collision load or earthquake into account	General members	180	180
		Slab and slab bridge with a span length of 10 m or less	140	140
	3) Basic value of allowable stress when the load combination takes into account the effect of collision load or earthquake	Consideration in the axial direction of girder	180	200
		Others	180	200
	4) Basic value of allowable stress when the length of reinforcement lapped joint or development is calculated		180	200
5) Compressive stress			180	200

Source: Specifications for Highway Bridges

2.2.2.2 Road Plan

(1) Road Formation

The road formation in Figure 2.2.12 shall be adopted for the approach roads.



Source: JICA Study Team (Based on Road Design Manual (1996))

Figure 2.2.12 Typical Cross-section for the Approach Road

(2) Geometric Standards

Geometric design will be in accordance with the Road Design Manual (1996). Table 2.2.14 shows the values for major geometric design items. Regarding longitudinal gradients, a gradient of less than 5% shall be applied in order to avoid the deceleration of heavy vehicles, which according to the traffic count survey are numerous.

Table 2.2.14 Geometric Standards

Road Class		Class II (Design traffic volume 3,000 - 8,000PCU/day)
Terrain classification		Level
Number of lanes		2
Width of lanes (m)		3.5
Width of shoulder (m)		1.5
Cross fall		3.0% (throughway), 5.0% (shoulder)
Maximum super-elevation		10%
Maximum gradient		5%
Design speed (km/h)		80
Minimum curve radius (m)		250
Minimum curve radius without super-elevation (m)		4,000
Minimum radius of vertical curve (m)	Crest	5,000
	Sag	2,000
Minimum vertical curve length (m)		70
Width of RoW (m)		50

Source: JICA Study Team

(3) Pavement Design

1) Design Method

Design for the asphalt pavement is conducted by applying AASHTO, which was applied in many of Japan's grant aid projects including previous projects on this road. The required pavement strength, which is called the Structure Number (SN), will be calculated using the following formula in this method. The estimated accumulative axle loads of heavy vehicles (i.e., damage to pavement: W18) in the design/analysis period and bearing capacity of the subgrade (M_R) are principal factors to determine the SN.

$$\log_{10}(W18) = Z_R \times S_0 + 9.36 \times \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left(\frac{\Delta PSI}{4.2-1.5}\right)}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 \times \log_{10}(M_R) - 8.07$$

W18: Accumulative axle loads (number of single axles passing with 18 kip (= 8.16 ton) weight in design/analysis period)

M_R: Resilient coefficient of subgrade (CBR × 1500)

SN: Structure Number (Required strength of whole pavement structure)

Z_R: Reliability coefficient

S_0: Standard deviation (Asphalt pavement = 0.45)

⊿PSI: Difference between initial serviceability index and terminal serviceability index of pavement (initial: P0 = 4.2, terminal: Pt = 2.5, P0 - Pt = 1.7)

Pavement structure with a strength of more than the computed SN will be determined by applying the following formula.

$$SN_p = a_1 \times D_1 + a_2 \times D_2 + a_3 \times D_3 \times m_3 + a_4 \times D_4 \times m_4$$

SN_p Structure Number of determined pavement structure

a_n Material coefficient of each layer (wearing course - sub-base course)

D_n Thickness of each layer (inches)

m_n Drainage coefficient of each layer

2) Design Conditions

Design conditions were revised according to a survey of this project in order to conduct pavement design. Comparisons of the conditions between previous projects and this project are shown in Table 2.2.15.

Table 2.2.15 Comparison of Pavement Design Conditions

Item		Previous	This Project	Remarks
1. Design variable	Design period	10 years	10 years	
	Reliability (R)	85%	85%	
	Standard deviation (Z0)	0.45	0.45	
2. Serviceability	Initial serviceability (P0)	4.2	4.2	
	Terminal serviceability (Pt)	2.5	2.5	
3. Damage factor of design vehicle	Large bus (2-axles)	1.005	1.005	
	Truck	0.113	0.171	
	Large truck (2-axles/4 wheels)	0.899		
	Large truck (2-axles/6 wheels)	2.558		
	Large truck (3-axles or more/6 wheels or more)		2.225	
	Large truck (3-axles or more/10 wheels or more)			
	Trailer (3-axles or more/18 wheels or more)	3.955	4.810	
	Trailer (3-axles or more/22 wheels or more)			
	Double trailer	6.469		
4. Accumulative axle load in design period (W18)		2.88×106	4.41×10^6 3.45×10^6	Xe Kum Kam bridge Xe Tha Mouak bridge
5. Characteristics of material	Design CBR of subgrade	5-6	5-6	
	Coefficient of wearing course (AC)	0.42	0.42	
	Coefficient of binding course (AC)	0.42	0.42	
	Coefficient of base course (mechanically stabilized crushed stone)	0.135	0.135	
	Coefficient of sub-base course (crushed stone)	0.108	0.108	
6. Drainage coefficient	Base course	1.00	1.00	
	Sub-base course	0.95	0.95-1.00	

Design Period

The design period is revised to 10 years because pavement design manuals such as AASHTO, Japan and Lao PDR designate 10 years in principle.

Reliability

Reliability (R) is the probability that the pavement structure will fulfill the desired performance under the estimated traffic volume and environment in the design period. R is classified according to the required function (i.e., importance) of the road in the AASHTO method. Table 2.2.16 shows recommended values of R. Further, the Reliability coefficient (Z_R) is determined according to classified R as shown in Table 2.2.17.

Table 2.2.16 Recommended R by Road Function

Function	Recommended R (%)	
	Urban	Rural
Inter-state road & expressway	85 – 99.9	80 – 99.9
Arterial road	80 – 99	**75 – 95**
Collector road	80 – 95	75 – 95
Rural road	50 – 80	50 – 80

Source: AASHTO pavement design manual

Table 2.2.17 Reliability Coefficient (ZR) by Determined R

R (%)	Z_R
50	0.000
60	-0.253
70	-0.524
75	-0.674
80	-0.841
85	**-1.037**
90	-1.282
95	-1.645
99.9	-3.090

Source: AASHTO pavement design manual

Damage Factor of Design Vehicle

The damage factor (DF) for each design vehicle is determined to estimate accumulative axle loads (W18) in the design period. The DF was computed by the AASHTO method on the basis of the axle load survey results in 2013 at the weigh station owned by DPWT Savannakhet along National Road 9. Since classification of vehicles was different from the classification in 2013, the DF was calculated proportionally based on traffic volume. Comparison of the DF by vehicle type between the survey in 2013 and this project is shown in Table 2.2.18

Table 2.2.18 Comparison of DF by Vehicle Type

Vehicle Type	Previous	Survey in 2013	This Project
Large bus (2-axles)	1.005	1.005	1.005
Truck	0.113	0.113	0.171
Large truck (2-axles/4 wheels)	0.899	0.899	
Large truck (2-axles/6 wheels)			
Large truck (3-axles or more/6 wheels or more)	2.558	2.225	2.225
Large truck (3-axles or more/10 wheels or more)			
Trailer (3-axles or more/18 wheels or more)	3.955	3.887	4.810
Trailer (3-axles or more/22 wheels or more)			
Double trailer	6.469	5.959	

Cumulative Axle Loads in Design Period

Cumulative axle loads (W18) in the design period are estimated by DF and traffic volume forecast on the road. The result is shown in Table 2.2.19.

Table 2.2.19 AADT of Design Vehicle (number/day･2 directions) & Cumulative Axle Loads (W18) (Xe Kum Kam Bridge)

		Large bus	Light truck	Medium truck	Heavy truck	Total
Daily traffic volume (vehicle/day)	2015	31	221	299	126	1,840
	2019	40	280	390	166	2,421
	2020	43	297	417	178	2,594
	2021	45	318	446	190	2,784
	2022	47	338	476	204	2,976
	2023	50	359	509	218	3,182
	2024	53	382	543	234	3,402
	2025	55	405	580	251	3,628
	2026	59	435	621	268	3,882
	2027	64	467	665	287	4,154
	2028	69	502	713	307	4,445
Total (2019-2028)		525	3783	5360	2303	
Total yearly traffic volume		191,573	1,380,893	1,956,491	840,468	
DF		1.005	0.171	2.225	4.810	
W18(Both direction)		192,531	235,483	4,353,193	4,042,902	8,824,109
W18(One direction)						**4,412,054**

Table 2.2.20 AADT of Design Vehicle (number/day･2 directions) & Cumulative Axle Loads (W18) (Xe Tha Mouak Bridge)

		Large bus	Light truck	Medium truck	Heavy truck	Total
Daily traffic volume (vehicle/day)	2015	39	198	267	148	4,863
	2019	50	249	348	195	6,632
	2020	53	264	372	209	7,169
	2021	56	282	395	223	7,764
	2022	59	300	422	239	8,364
	2023	62	319	451	256	9,012
	2024	66	339	481	275	9,710
	2025	69	357	511	295	10,500
	2026	74	383	547	315	11,245
	2027	80	412	586	337	12,042
	2028	86	442	628	360	4,238
Total (2019-2028)		656	3346	4741	2705	
Total yearly traffic volume		239,480	1,221,399	1,730,317	987,228	
DF		1.005	0.171	2.225	4.810	
W18(Both direction)		240,678	208,285	3,849,955	4,748,857	9,047,775
W18(One direction)						**4,523,887**

Design CBR of Subgrade

According to results of the survey, the CBR of the existing subgrade was more than 19%. However, the result of the design CBR value of the survey in 2013 was 6% in target section. Therefore, design CBR value of this project is 6%, considering the safety side.

Material Coefficients of Pavement Layers

Each pavement layer has its own material coefficient depending on characteristics and strengths of applied material. Each coefficient is determined by nomograph to convert the physical characteristics (e.g., elastic modulus, CBR) into the material coefficient in the AASHTO manual. Each material coefficient to apply for the Project is shown in Table 2.2.21.

Table 2.2.21 Material Coefficient of Each Layer

Layer	Material	Coefficient
Wearing course	Asphalt mixture	0.420
Binding course	Asphalt mixture	0.420
Base course	Mechanically stabilized crushed stone	0.135
Sub-base course	Recycled material (cement stabilized)	0.140
Sub-base course	Crushed stone	0.108

Drainage Coefficient of the Pavement Layer

Target section is a fill section and not a flood area. Therefore, drainage coefficients of each layer will be used as 1.0.

Structure Number

The required Structure Number follows:

- Required Structure Number: 4.52 x 106

3) Pavement design

Pavement thickness of each layer was determined considering the required structure number and minimum thickness mentioned in AASHTO. Pavement structures of each approach road are shown in Table 2.2.22.

Table 2.2.22 Pavement structure

Layer	Material	Coefficient	Drainage Coefficient	Thickness(cm)	Total SN	Required SN	Min. Thickness(cm)
Surface	AC	0.420	1.00	5.00	4.03	3.98	9
Binder	AC	0.420	1.00	5.00			
Base	Mechanically stabilized crushed stone	0.140	1.00	20.00			15
Sub Base	Crushed stone	0.108	1.00	30.00			15

(4) Earth Structure

The applicable slope gradients are dependent on the height of both cut and embankment sections as summarized in Table 2.2.23.

Table 2.2.23 Slope Gradient for Cut & Embankment Sections

	Soil type	Gradient		Remarks
		(H＜6m)	(6m＜H＜10m)	
Embank-ment	Normal	1:1.5	1:2.0 Height of berm shall be set every 5 m	Refer to Road Design Manual
Cut	Normal	1:1.0	1:1.0 Height of berm shall be set every 5 m	Ditto
	Rock -weathered -fresh	1:0.5 1:0.3	Height of berm shall be set every 5 m	Ditto

Source: JICA Study Team

(5) Facilities

The lighting plan folows specifictions for road lighting in Japan. The conditions are as follows :

Table 2.2.24 Average Surface brightness

Class \ Condition		A	B	C
Highway		1.0	1.0	0.7
		-	0.7	0.5
National road	Trunk road	1.0	0.7	0.5
		0.7	0.5	-
	Sub trunk road	0.7	0.5	0.5
		0.5	-	-

Source: Specifications for Lighting

- Xe Kum Kam Bridge: condition C (there is almost no light along the roadside)
  National road/trunk road: 0.5 cd/m^2
- Xe Tha Mouak Bridge: condition A (there is light continuously along the roadside)
  National road/trunk road: 1.0 cd/m^2

2.2.2.3 Bridge Plan

(1) Design Condition

1) Hydrological Condition

a) Return Period

Return period of each river is instituted in Lao. The Mekong River, which is the largest, is instituted in a 100-year return period. Other general rivers (under the Hinhouep Bridge and the Sekong Bridge) are instituted in a 50-year return period. However, according to the maximum records, the highest water level surveyed by visual observation and hearing of the Xe Tha Mouak Bridge has flown over the girder. Therefore, although these bridges are for general river,

the 100-year return period is applied to calculate a planned high water level for The Xe Tha Mouak Bridge. In addition, from the fact that Xe Kum Kam Bridge also locate in the same water system, a 100-return period is applied for Xe Kum Kam Bridge as the same conditions.

b) Estimated High-water Discharge Volume

Estimated high-water discharge volume of both Bridges calculated by a 100-year return period is shown in Table 2.2.25.

Table 2.2.25 Estimated High-water Discharge Volume

Bridge Name	Return Period	Estimated Highest Water Level (m)	Estimated High-water Discharge Volume (m^3/s)
Xe Kum Kam Bridge	1/100	EL.172.343	1,153
Xe Tha Mouak Bridge	1/100	EL.169.090	3,950

Source: JICA Study Team

c) Design Flow Velocity

Design flow velocity in the 100-year return period for bridge planning is shown in Table 2.2.26.

Table 2.2.26 Design Flow Velocity

Bridge Name	Return Period	Design Flow Velocity (m/s)
Xe Kum Kam Bridge	1/100	2.44
Xe Tha Mouak Bridge	1/100	3.16

Source: JICA Study Team

d) Clearance

Based on the estimated high-water discharge volume inTable 2.2.25, clearance should be kept at the height of the estimated highest water level in accordance with the Standard of MLIT in Japan. Furthermore, in order to keep the dam-up caused by debris such as driftwood, this clearance should be considered to be more than 50 cm high. Clearance of both bridges is shown in Table 2.2.27.

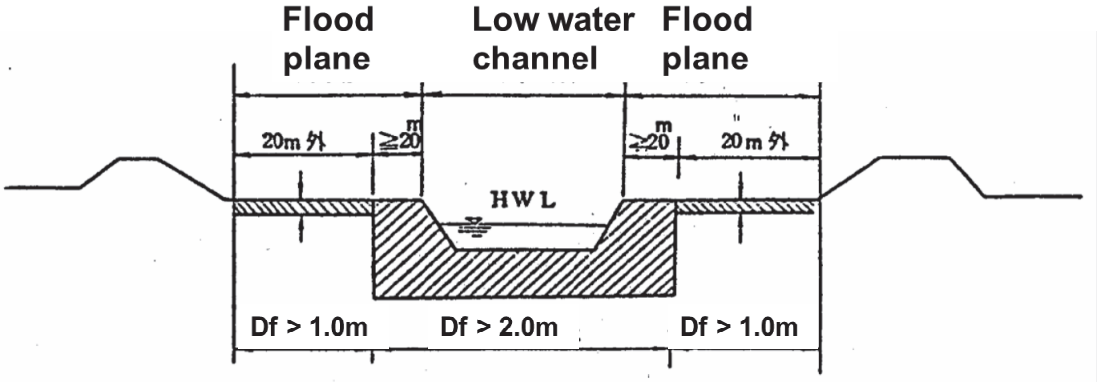
Table 2.2.27 Clearance

Bridge Name	Clearance (m)	Q: Estimated High-water Discharge Volume (m^3/s)
Xe Kum Kam Bridge	1.00 + 0.50 = 1.50	in case of $500 \leqq Q < 2,000$
Xe Tha Mouak Bridge	1.20 + 0.50 = 1.70	in case of $2,000 \leqq Q < 5,000$

Source: JICA Study Team

e) Penetration Depth

Penetration depth of the foundation in the main stream of the river should at least be kept more than 2 m depth shown in Figure 2.2.13.



Source: MLIT

Figure 2.2.13 Penetration Depth

f) Blocking Rate Caused by Structures in the River

National Highway No. 9 is an important trunk road connecting Thailand and Vietnam in Lao. The blocking rate caused by structures in the river is kept at less than 5% in the Standard of MLIT in Japan. The blocking rate is calculated using the following formula.

$$\text{Blocking Rate} = \frac{\text{Sum of structure width}}{\text{River Width}} \times 100\ (\%) < 5\ \%$$

g) Requested Span Length

Requested span length is calculated using the following formula as shown in Figure 2.2.14 based on the Standard of MLIT.

$L = 20 + 0.005Q$ （$L \leqq 70$ m）

Here,

L: Requested span length (m)

Q: Estimated High-water Discharge Volume (m^3/s)

Bridge Name	Q: Estimated High-water Discharge Volume (m^3/s)	Requested Span Length (m)
Xe Kum Kam Bridge	1,153	More than 26.0
Xe Tha Mouak Bridge	3,950	More than 40.0

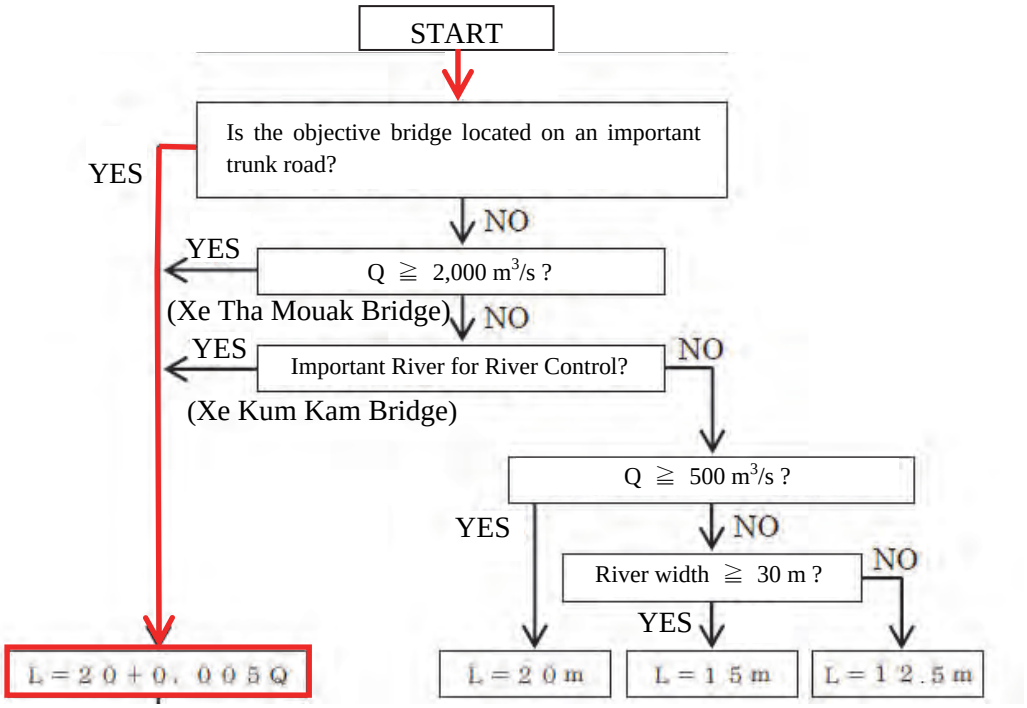


Figure 2.2.14 Calculation Flowchart of Requested Span Length

(2) Load Condition

1) Dead Load

Dead load of each material is shown in Table 2.2.28 stipulated in the Japanese Standard.

Table 2.2.28 Unit Weight

Material Content	Unit weight (kN/m^3)
Steel	77.0
Forged steel	71.0
Reinforced concrete	24.5
Plain concrete	23.0
Cement mortar	21.0
Asphalt concrete	22.5
Sand, gravel	20.0
Sandy soil	19.0
Clay soil	18.0

Source: MLIT

2) Live Load

Pursuant to the Road Design Manual (1996) in Lao, the live load shall be used HS25-44.

3) Impact

The impact of the live load shall be considered. Calculation of the impact shall apply the Japanese Standard. And then the impact of the live load should not be applied to the design of the sub-structure.

4) Earth Pressure

Earth pressure shall appropriately consider the type of structure and the earth conditions based on the Japanese Standard.

5) Water Pressure

The pressure of the water shall appropriately consider the change of the water level, flow velocity, scouring, and shape/measurement size of the pier based on the Japanese Standard.

6) Buoyancy and Uplift

Buoyancy and uplift shall appropriately consider the pore water and the change of the water level.

7) Wind Load

Wind load is not considered on this Project because there is no influence to the objective bridges.

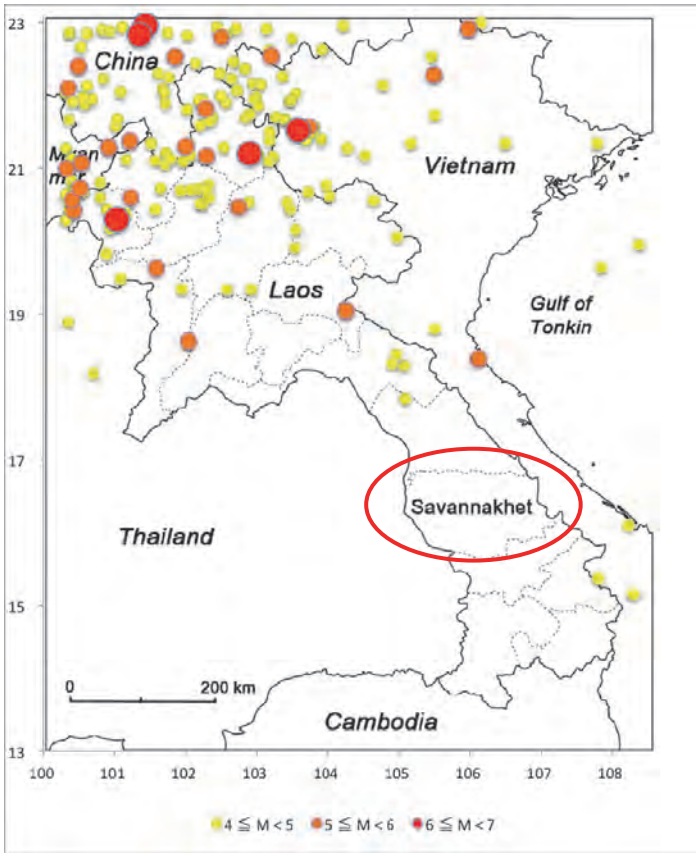
8) Thermal Force

An annual average lowest temperature is approximately 36 degrees (monthly average highest temperature: 39 degrees in April) and an annual average lowest temperature is approximately 20 degrees (monthly average lowest temperature: 13 degrees in December) along the objective area. As the result of each temperature, an annual average temperature is 28 degrees. Therefore, the thermal force shall be considered as ±15 degrees as an annual average temperature in consideration with the difference of a monthly average highest temperature and a monthly average lowest temperature.

9) Seismic Load

A distribution map of earthquakes between 1975 and June 2015 that are over a magnitude (M) 4.0 in Lao is shown in Figure 2.2.15. Earthquakes in Lao have occurred at the Northern and Central areas near the border of Thailand, Myanmar, China, and Vietnam. However, there has been no occurrence of the earthquakes around the Project area and Savannakhet Province so far (See Figure 2.2.15, "○" marked). On the other hand, magnitude and earthquakes are classified in Table 2.2.29. Frequency of the occurrence in Japan is sampled as the relationship of the earthquake scale and the magnitude in Table 2.2.30.

Based on the records of the earthquake, there has no seismic load in Savannakht province. However the very minor earthquakes are expected to occur around the Project area. Therefore, the seismic coefficient shall be set at 0.06 against the vertical load although the friction coefficient of the slide bearing is set at 0.05 against the vertical load.



Source: JICA Survey Team

Figure 2.2.15 Distribution map of Earthquakes in Lao

Table 2.2.29 Classification of Earthquakes by Magnitude (M)

Mega Earthquake	8 ≦ M
Great Earthquake	7 ≦ M
Moderate Earthquake	5 ≦ M < 7
Minor Earthquake	3 ≦ M < 5
Micro Earthquake	1 ≦ M < 3
Ultra-micro Earthquake	1 < M

Source: National Research Institute for Earth Science and Disaster Prevention

Table 2.2.30 Relationship of Earthquake Scale and Magnitude (M)

Scale		M	Outline of Earthquake (in case of earthquake occurred at shallow depth)	Earthquake Occurrence in around Japan
Great Earthquake	Mega Earthquake	9	occurrence mega diastrophism in around several hundred kilometer or 1,000 kilometer, catastrophe and/or giant tsunami in wide area	once a several hundred years
		8	catastrophe in wide area if earthquake occurred in land, large tsunami if earthquake occurred at seabed	once a ten years
		7	large damage in wide area if earthquake occurred in land, tsunami if earthquake occurred at seabed	around once or twice a year
Moderate Earthquake		6	small damage around the epicenter, large damage in case of ground condition if the area is near M7	around 10～15 times a year
		5	minor damage or some damage in case of ground condition if the area is near around epicenter	around 10 times a month
Minor Earthquake		4	macroseismic area at the epicenter, macro damage at the epicenter if the hypocenter is very shallow	around 10 times a day
		3	rarely macroseismic area at the epicenter	around several times a day
Micro earthquake		2	rarely macroseismic area if the hypocenter is very shallow	around 10 times a hour
		1	insensitive to quake to the people	around once or twice a minute
Ultra-micro Earthquake		0	insensitive to quake to the people	occurrence in countless
		-1	insensitive to quake to the people	

Source: National Research Institute for Earth Science and Disaster Prevention

10) Collision Load

Since there is some possibility of collisions with the piers during flooding, a collision load shall be appropriately considered based on the Japanese Standard.

(3) Bridge Basic Plan

1) Basic Policy

The basic policy and its contents are described in Table 2.2.31. The objective bridges shall be planned based on the basic policy. The scale and type of the objective bridges are decided in this chapter.

Table 2.2.31 Basic Policy of the Bridge Plan

Policy of the Planning	Contents of the Policy
① Suitable Alignment and Bridge Location	In order to keep an economical bridge length and safe and comfortable travelling, a suitable road alignment and bridge location shall be considered.
② Economy	Selection of the bridge material/type shall consider not only the economy of construction costs but also the life cycle cost spent for maintenance.
③ Workability	The bridge plan shall prioritize safety first and select the bridge type of exact erection method. Furthermore, the bridge plan shall consider the road users and surrounding people.
④ Scenery	The bridge plan shall be considered in harmony with the surrounding natural environment.
⑤ Aseismicity	The bridge plan shall adequately consider the aseismatic design. The Second International Bridge, the Hinghuep Bridge, and the Sekong Bridge consider the horizontal coefficient set by 0.06 as the seismic load.
⑥ Clearance	The bridge plan shall consider the influence of flooding and debris in the river. Therefore, clearance shall be analyzed based on rainfall and hydrological data.
⑦ Seasonal Changes	The bridge plan shall be studied in consideration with both rainy and dry seasons for the plan of road elevation and erection method.
⑧ Construction Space	The bridge plan shall be studied in consideration with no affect to road users for the limited construction yard.
⑨ Transportation for Construction	Transportation issues restrict length, height, and weight of bridge; members and materials shall be surveyed on the bridge plan.
⑩ Traffic safety during Construction	The bridge plan shall consider road users during construction work, erection of temporary bridge, and preparation of temporary yard.
⑪ Social Vulnerability	Based on the results of a social condition survey, a bridge plan shall decide the sidewalk on the bridge and bridge composition with enough discussion with Lao side.

2) Flowchart of Bridge Plan

Selection process for bridge type is shown in Table 2.2.32.

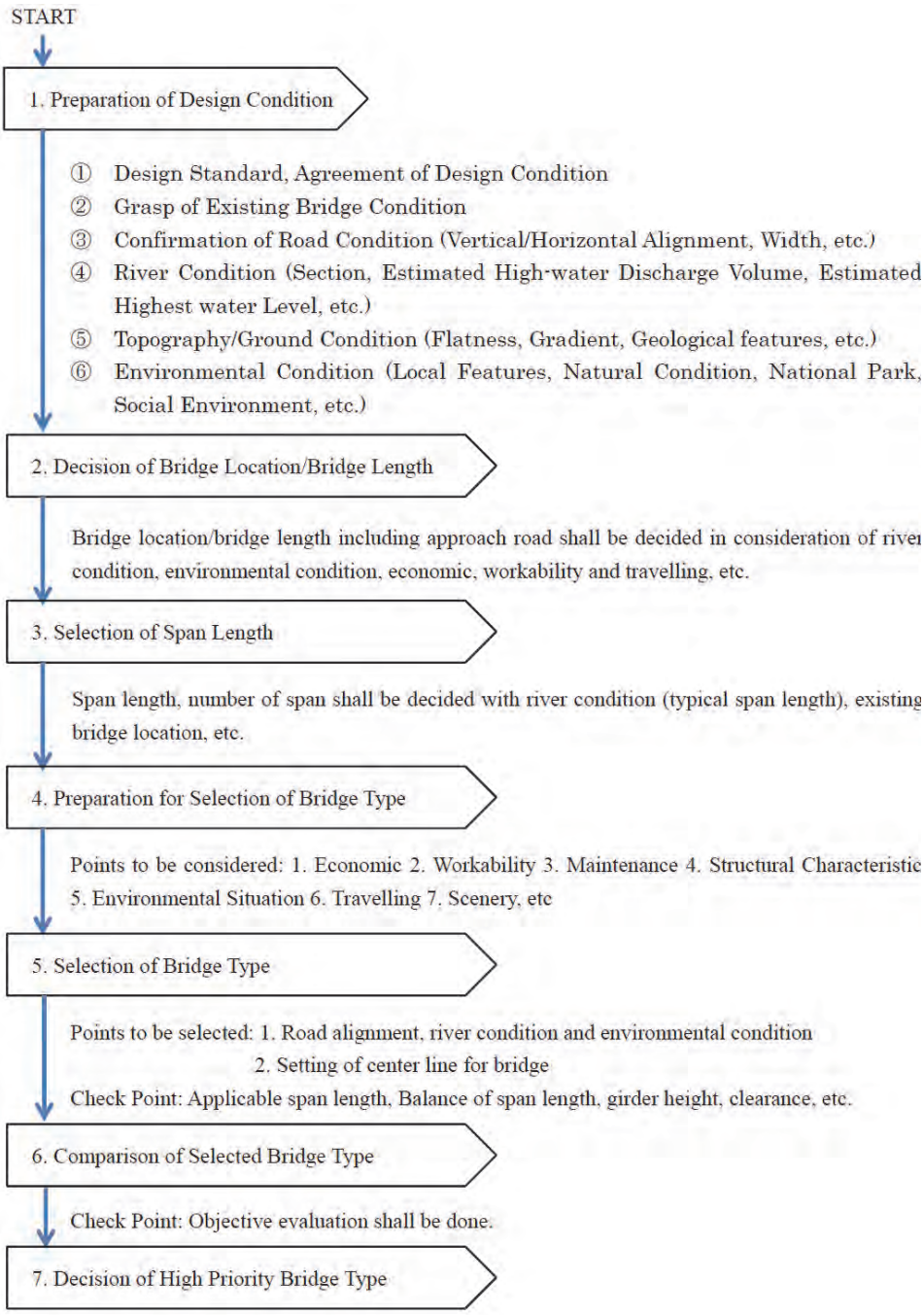


Figure 2.2.16 Flowchart for Selection Process for Bridge Type

3) Plan for Selection of Bridge Location

a) Selection Policy

The plan for the bridge location shall be selected based on the following policies:

【Basic item】

- Location considers approach road alignment for safe and smooth traffic.
- Location allows construction space that does not disturb road users.

【Item considered objective area】

- Location does not require the removal of residences and buildings surrounding the existing bridge.
- Location does not hinder the optical fiber cable along NR No. 9.
- Location keeps the intersection angle between the river and bridge due to the curve of the river.

b) Proposal of Bridge Location

Both f Xe Kum Kam Bridge and Xe Tha Mouak Bridge have been accepted at the existing location because there is enough space for the construction yard and no affected facilities and so on. The evaluation result is shown in clause 2.2.2.1.

c) Study for Abutment Location and Bridge Length

For both existing abutments, there have been no records of over-flowing so far. Therefore, the requested span length shall be considered an estimated high-water discharge volume. The result of the calculation of the requested span length and flooding area, abutment location of both Xe Kum Kam Bridge and Xe Tha Mouak Bridge are the same as the existing location. The bridge lengths are shown below:

- Xe Kum Kam Bridge: 90.0 m
- Xe Tha Mouak Bridge: 160.0 m

4) Study for Bridge Material and Bridge Type

a) Bridge Type of the Superstructure and Each Span Length

In the preceding clause 3) c) Study for the Abutment Location and Bridge Length, bridge length of Xe Kum Kam Bridge will be 90.0 m long and Xe Tha Mouak Bridge will be 160.0 m long. In the preceding clause 2.2.2.3 (1) 1) g) Requested Span Length, the requested span length of Xe Kum Kam Bridge will be more than 26.0 m long and Xe Tha Mouak will be more than 40.0 m long.

Selected bridge material and bridge type are shown below. The applicable bridge type is shown in Table 2.2.32 for the superstructure.

【Xe Kum Kam Bridge】

2-Span Type: 2 @ 45.0m = 90.0m (I-type steel-girder bridge, box-type steel-girder bridge, deck-box-type steel-girder bridge, connected T-type PC-girder bridge, box-type PC-girder bridge)

3-Span Type: 3 @ 30.0 m = 90.0 (I-type steel-girder bridge, connected T-type PC-girder bridge, hollow-slab-type PC-girder bridge, box-type PC-girder bridge)

【Xe Tha Mouak Bridge】

3-Span Type: 3 @ 53.3 m ≒ 160.0 m (I-type steel-girder bridge, box-type steel-girder bridge, deck-box-type steel-girder bridge, box-type PC-girder bridge)

4-Span Type: 4 @ 40.0 m = 160.0 m (I-type steel-girder bridge, box-type steel-girder bridge, deck-box-type steel-girder bridge, connected T-type PC-girder bridge, box-type PC-girder bridge)

Table 2.2.32 Applicable Bridge Type and Span Length

Type			Shape	Election Method	Span 20 40 60 80 100	Ratio Height/Span
Steel Bridge	Girder Type	I-typed		Truck Crane		1/16～1/22
		Box typed		Truck Crane/ Launching		1/20～1/30
		Steel deck box typed		Truck Crane/ Launching		1/22～1/28
	Truss Type			Tower Crane		1/7.0～10.0
	Arch Type			Tower Crane		1/5.3～76.3

Type			Shape	Election Method	Span 20 40 60 80 100	Ratio Height/Span
Concrete Bridge	RC	T-typed		Fix typed support		1/8～1/11
	Pre-tension	Slab typed		Truck crane		1/14～1/25
	Post-tension	Connected T-typed		Gantry crane/ erectiongirder		1/13～1/17
	(site product)	Slab typed		Fix typed support		1/20～1/24
		Box typed		Fixed typed support Launching		1/16～1/22

Source：MLIT, Planning Manual

@30.0m
@40.0m
@45.0m
@53.3m
Applicable span length

The erection method for a hollow-slab-type PC-girder bridge and box-type PC-girder bridge is the fixed typed support in Table 2.2.32. Both bridge types are impossible to erect by using scaffolding in the river through rainy and dry seasons. Therefore a box-typed PC-girder bridge shall be erected using the launching method. However, a hollow slab-type PC-girder bridge is impossible to erect using the launching method. Consequently, this type shall be omitted from this study.

As previously stated, a steel-concrete composite slab bridge will be applicable and recommendable as Japanese technology except for Table 2.2.32. This type shall be considered for Xe Kum Kam Bridge and Xe Tha Mouak Bridge in this study.

b) Span Type

In the preceding clause a) Bridge Type of the Superstructure and Each Span Length, Xe Kum Kam Bridge has been selected as a 2-span type and 3-span type. Xe Tha Mouak has been selected as a 3-span type and 4-span type. The span length of each bridge is shown in Table 2.2.33 from the viewpoint of bridge type. As a result of these considerations, Xe Kum Kam Bridge is suitable for a 3-span type, and Xe Tha Mouak Bridge is suitable for a 4-span type.

Table 2.2.33 Span Type

		Xe Kum Kam Bridge (Bridge length: 90.0m)		Xe Tha Mouak Bridge (Bridge length: 160.0m)	
		2-Span Type	3-Span Type	3-Span Type	4-Span Type
Span length (m)		45.0	30.0	53.3	40.0
Girder height (m)	Steel I type*)	2, 9	1, 9	3, 4	2, 5
	PC box type*)	3, 5	2, 3	4, 1	3, 1
Number of piers (No.)		1	2	2	3
Influence on the vertical road alignment		Long approach road for keeping clearance ×	No problem ○	Long approach road for keeping clearance ×	No problem ○
Influence on the substructure/construction period		Large size because of one pier △	There are two piers, but not much influence on the construction period △	Large size because of two piers △	There are three piers, but not much influence on the construction period △
Cost of superstructure		Too costly, around 20-30% more than 3-Span Type ×	Economical ○	Too costly, around 15-25% more than 4-Span Type ×	Economic ○
Total evaluation		×	○	×	○

○: Highly effective, △: Effective, ×: Ineffective

*) Steel I type: Ratio of Girder Height/Span Length (1/16),
PC box type: Ratio of Girder Height/Span Length (1/13)

c) Selection of Bridge Type

In the preceding clause b) Span Type, Xe Kum Kam Bridge is rated highly effective for the 3-span type, and Xe Tha Mouak is rated highly effective for the 4-span type. Bridge types are selected for both bridges as below.

【Xe Kum Kam Bridge】

Alternative 1: 3-span continuous I-type steel-girder bridge 3 @ 30.0 m = 90.0 m
Alternative 2: 3-span connected T-type PC-girder bridge 3 @ 30.0 m = 90.0 m
Alternative 3: 3-span continuous box-type PC-girder bridge 3 @ 30.0 m = 90.0 m
Alternative 4: 3-span continuous steel-concrete composite slab bridge 3 @ 30.0 m = 90.0 m

【Xe Tha Mouak Bridge】

Alternative 1: 3-span continuous I-type steel-girder bridge	4 @ 40.0 m = 160.0 m
Alternative 2: 3-span connected T-type PC-girder bridge	4 @ 40.0 m = 160.0 m
Alternative 3: 3-span continuous box-type PC-girder bridge	4 @ 40.0 m = 160.0 m
Alternative 4: 3-span continuous steel-concrete composite slab bridge	4 @ 40.0 m = 160.0 m

d) Comparison of Selected Bridge Type

The span types of Xe Kum Kam Bridge and Xe Tha Muoak Bridge are different, but the bridge types are the same. Therefore, the bridge type compares the following four alternatives shown in Table 3.2.2.10. The contents of the comparison table are shown in a sample of Xe Tha Muoak Bridge because it is the same bridge type as Xe Kum Kam Bridge.

Alternative 1: 3-span continuous I-type steel-girder bridge
Alternative 2: 3-span connected T-type PC-girder bridge
Alternative 3: 3-span continuous box-type PC-girder bridge
Alternative 4: 3-span continuous steel-concrete composite slab bridge

For the results of the comparison of the four (4) alternatives, Alternative 4 is selected as the highest priority because of its:

① Economics for river planning and vertical road alignment of approach road because of the lowest girder height
② Small size of substructure because of the lightest superstructure
③ Short construction period
④ Possibility for using Japanese technology

	Steel Type		Concrete Type				Composite type	
	Alternative 1 I-typed girder bridge		Alternative 2 PC T-typed girder bridge		Alternative 3 PC box-typed girder bridge		Alternative 4 Composite typed slab bridge	
Sample of Bridge								
Characteristics	・Sub-structure's shape can be reduced more than 20% ・Height difference between existing road elevation and H.W.L will be 2.8m high ・Girder height will be 2.2m high (ratio of girder height/span: 1/18) ・Existing road elevation is requested to raise up more than 0.7m high	×	・Girders can be fabricated at the site yard ・Height difference between existing road elevation and H.W.L will be 2.8m high ・Girder height will be 2.7m high (ratio of girder height/span: 1/15) ・Existing road elevation is requested to raise up more than 1.2m high	×	・Bending and tortional stiffness are the highest ・Height difference between existing road elevation and H.W.L will be 2.8m high ・Girder height will be 2.5m high (ratio of girder height/span: 1/16) ・Existing road elevation is requested to raise up more than 1.0m high	×	・Girder height is the lowest ・Bottom slab plate can use for form, then it is possible for rapid construction ・Height difference between existing road elevation and H.W.L will be 2.8m high ・Girder height will be 1.2m high (ratio of girder height/span: 1/33) ・Existing road elevation can be kept	◎
Workability	・Girders will be erected by crawler crane (150t type) ・Construction period will be longer than Alternative 4 (26 months) because of the cast-in-place of steel beams and reinforced concrete slab with suspended form	○	・Girders will be erected by combining with gantry crane and erection girder ・Construction period will be the longest (30 months) because of the cast-in-place of reinforced concrete beams and slab with suspended form	×	・Girders will be erected by incremental launching method ・Construction period will be longer than Alternative 1 (28 months)	△	・Girders will be erected by crawler crane (150t type) ・Construction period will be the shortest (24 months) because of no need for slab form work	◎
Economy	・Superstructure will be costly because of import of steel material ・Project cost will be higher than Alternative 2 Unit cost of superstructure: USD1,850/m2 Project cost: USD3,460～3,710/m2	△	・Superstructure will be the most economical ・Pier width of longitudinal direction will be the widest because of two bearing shoes for each girder Unit cost of superstruture: USD1,610/m2 Prject cost: USD3,140～3,380/m2	○	・Erection equipment is the most costly ・Project cost is the highest Unit cost superstrutire: USD2,010/m2 Project cost: USD3,620～4,030/m2	×	・Superstructure will be the most costly because of import of steel material ・Project cost will be more cheaper than Alternative 3 Unit cost of superstructure: 2,010/m2 Project cost: USD3,620～3,870/m2	△
Maintenance	・It will be maintenancwe free because of atmaspheric corrosion resistant steel ・Maintenance cost will be reduced because of continuous girder (no expansion joints on the girder)	○	・It will be maintenance free because of concrete material ・Maintenance cosnt will be more costly than other alterntives because of two bearing shoes on the pier	△	・It will be maintenancwe free because of concrete material ・Maintenance cost will be reduced because of continuous girder (no expansion joints on the girder)	○	・It will be maintenancwe free because of atmaspheric corrosion resistant steel ・Maintenance cost will be reduced because of continuous girder (no expansion joints on the girder)	○
Technology Transfer	×		×		×		◎	
Total Judgement	・Construction period will be longer than Alternative 4 because of many cast-in-place works		**・It will be the most economical** **・However girder height will be the highest and it will be reconsidered road elevation** **・Construction period will be the longest because of many cast-in-place works**		**・It will be the most costly**		・Project cost will be costly than Alternative 1 and 2 ・However existing road elevation will be kept **・Construction period will be the shortest** **・Japanese technology will be transferred**	
	×		×		×		**◎ (Shortest construction period)**	
Evaluation	In case of composite typed slab bridge ・Economy : Girder height can be reduced and it will be the most suitable type for river planing and road elevation planing ・Workability : combination of slab form, the shortest construction period type and high safety type ・it is possible to transfer of Japanese technology							

◎: Very High Effectiveness ○: High Effectiveness △: Effectiveness ×: Ineffectiveness

Table 2.2.34 Comparison of Bridge Types

(4) Type of Substructure and Foundation

a) Formation Level of Footing

The formation level of the footing is important to set directly on the bearing stratum. The N value of Xe Kum Kam Bridge and Xe Tha Mouak Bridge is as below, composed of mudstone in which the N value is more than 70 as shown in Figure 2.2.17 and Figure 2.2.18. The formation level of each substructure is set for the following reasons:

【Xe Kum Kam Bridge】

- A1 Abutment: The abutment height will be around 10.5 m high for direct setting on the bearing stratum. The applied abutment type will be the inverted-T type. The embedment depth will be around 7 m.
- P1 Pier: In order to avoid scouring, the embedment height will be set around 2 m deep in the riverbed.
- P2 Pier: In order to avoid scouring, the embedment height will be set around 8 m deep in the riverbed due to the incline of the riverbed from the A2 abutment.
- A2 Abutment: The abutment height will be around 15 m high for direct setting on the bearing stratum. The applied abutment type will be the inverted-T type of the maximum height. The embedment height will be around 9 m deep.

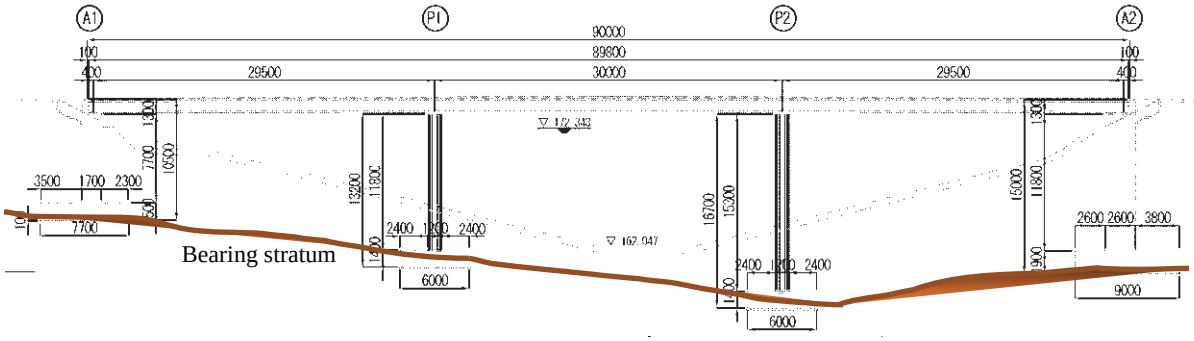


Figure 2.2.17 Formation Level of Footing for Xe Kum Kam Bridge

【Xe Tha Mouak Bridge】

- A1 Abutment: The abutment height will be around 15 m high for a direct setting on the bearing stratum. The applied abutment type will be the inverted-T type of the maximum height. Embedment depth will be around 7 m.
- P1 Pier: In order to avoid scouring, the embedment height will be set around 7 m deep in the riverbed.

- P2 Pier: Due to the shallow riverbed, the embedment height will be set around 1 m deep in the riverbed. The revetment surrounding the pier shall be set in the riverbed to avoid scouring.
- P3 Pier: In order to avoid scouring, embedment height will be set around 2 m deep from the riverbed. The revetment surrounding the pier shall be set in the riverbed to avoid scouring.
- A2 Abutment: The abutment height will be around 12 m high for direct setting on the bearing stratum. The applied abutment type will be the inverted-T type. The embedment height will be around 9 m deep.

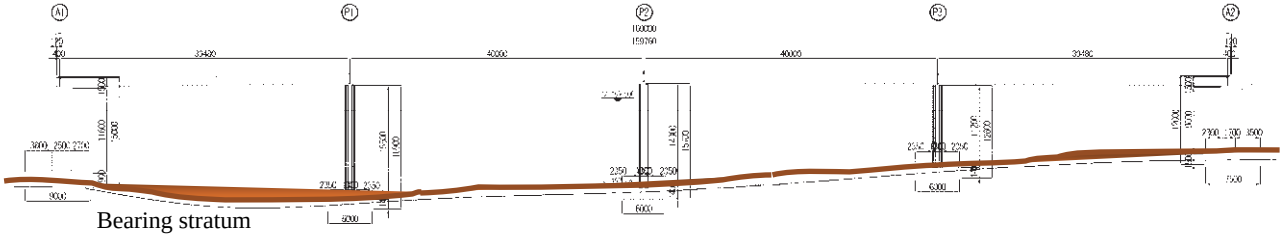


Figure 2.2.18 Formation Level of Footing for Xe Tha Mouak Bridge

b) Selection of Substructure Type

The substructure type will be selected based on Table 2.2.35 and Table 2.2.36. The selected abutment will be the inverted-T type due to a height between 10.0 m and 15.0 m high. The pier will be oval type due to setting in the river.

Table 2.2.35 Selection of Abutment Type

Type	Height (m) 10	20	30	Remarks
Inverted T Type	6 12 15			
Rigid Frame Type	15			
Box Type	12 15 20			
With Pile Type	h: 6 7 H:			

Source: MLIT

Table 2.2.36 Selection of Pier Type

Type	Height (m) 10	20	30	Remarks
Column Type Pier Type				(including hollow type)
Rigid Frame Type (1 layer)	5	15		
Rigid Frame Type (2 layers)		15	25	
2 Columns Type		15		

Source: MLIT

c) Selection of Foundation Type

The selected foundation type will be a spread foundation because both Xe Kum Kam Bridge and Xe Tha Mouak Bridge are located in the shallow bearing stratum and are able to conform directly to the ground conditions.

2.2.2.4 Revetment Plan

(1) Revetment construction range

The revetment is to be provided for the purpose of protecting the banks in the vicinity from the impact of the constructed abutment. In accordance with the Government Ordinance for Structural Standards for River Administration Facilities, etc., the revetment must cover a range of 10 m or more upstream and downstream from both ends of the abutment (Figure 2.2.19).

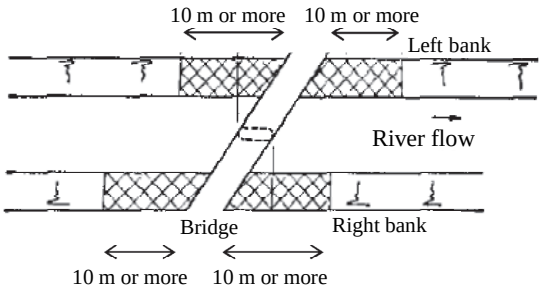


Figure 2.2.19 Revetment length required as the bridge is constructed

(2) Revetment structure

The revetment is to be so structured as to prevent erosion of the riverbanks occurring along the changing flow and to ensure harmony with the surrounding landscape and maintenance and management of the river banks. The structure of the revetment must also be determined by taking into account the availability of materials and future maintainability in Laos. Selection of the revetment works must start with extraction of the candidate works on the basis of the segment (flow classification) and representative flow velocity as well as the slope gradient at the planned

site (Table 2.2.37, Table 2.2.38). Final selection is to be made after comprehensive consideration of the local river conditions (the river profile, with/without rolling stones), care for conservation and maintenance of the landscape, maintenance and controllability, economic feasibility, etc. Table 2.2.37 and Table 2.2.38 show the relationship between the typical revetment works and corresponding flow velocity.

The target river is equivalent to the river channel of the natural levee zone. The design flow velocity during flooding is 2.5–3.2 m/s and not so high, so that there is almost no damage to the revetment from rolling stones. The bed materials consist mainly of sand, so that the "iron gabion," which is the standard revetment of Laos and superior in economy and maintainability, will be employed. Iron gabion flat pitching work will be employed for the revetment in the lower portion of the compound cross-section and iron gabion type multistage masonry will be used for the revetment in the upper portion. The outline views and features of the revetment works are summarized in Table 2.2.39.

(3) Footing depth of revetment

The visual inspection at the site showed no riverbank erosion or riverbed scour around the existing piers. However, in the case of a sand-bottomed river, the scoured portion during flooding may be refilled after the flood. Therefore, scouring during flooding will be dealt with by providing iron gabion flat pitching work.

Table 2.2.37 Revetment works vs design flow velocity (1)

Segment			Typical restoration work				Design flow velocity (m/s)
River channel in mountainous area	Valley bottom plain River channel in the alluvial fan	Natural levee Delta	Material	Structure		Method	2 3 4 5 6 7 8 –
			Stones	Natural stones (mortar)	1	Cyclopean masonry (mortar)	4-8
					2	Quarry stone masonry (mortar)	4-8
					3	Kenchi-ishi masonry (mortar)	4-8
				Natural stone (dry)	4	Cyclopean masonry (dry)	5
					5	Quarry stone masonry (dry)	5
					6	Kenchi-ishi masonry (dry)	5
					7	Coupled field stone (dry masonry)	4-8
			Concrete	Concrete block (pitching)	8	Concrete block pitching	4-8
					9	Porous concrete block pitching	4-8
					10	Grating crib works	4-8
				Articulated concrete mattress	11	Articulated concrete mattress	5
					12	Large articulated concrete mattress	5
					13	Porous articulated concrete mattress	5
			Gabion	Gabion	14	Gabion with vegetation	5
				Gabion (flat pitching work)	15	Iron gabion flat pitching work	5
				Bag	16	Coupled bag (gravel)	5
			Wood	Log grating	17	Log grating (including the single grating crib works)	4
				Fascine grating crib works	18	Fascine grating crib works	4
					19	Fascine fence	4
					20	Wood grating	4
				Pile-hurdle works	21	Pile hurdle	4
					22	Plate fence	4
			Sheets	Geotextile	23	Geotextile	3
					24	Vegetation mat	3
				Block sodding	25	Block mat	4
					26	Plant stone net	1
			Vegetation	Block sodding	27	Block sodding	2

* The scope of application of the table above is for reference only. Any reasonable methods applicable to the design flow velocity may be positively employed.
* Select an appropriate method by taking into account the considerations of the restoration work.
* Grating crib works: This is a method in which a lining material changes the design flow velocity (8 m/s for concrete lining material and 5 m/s for natural stone (dry)).

Source: Basic Policy of Restoration from Disaster to Protect Beautiful Mountains and Rivers, MLIT

Table 2.2.38 Revetment works vs design flow velocity (2)

Segment			Typical restoration work				Design flow velocity (m/s)
River channel in mountainous area	Valley bottom plain River channel in the alluvial fan	Natural levee Delta	Material	Structure		Method	2 3 4 5 6 7 8 –
			Stones	Natural stones (mortar)	1	Cyclopean masonry (mortar)	4-8
					2	Quarry stone masonry (mortar)	4-8
					3	Kenchi-ishi masonry (mortar)	4-8
				Natural stone (dry)	4	Cyclopean masonry (dry)	5
					5	Quarry stone masonry (dry)	5
					6	Kenchi-ishi masonry (dry)	5
					7	Coupled field stone (dry masonry)	8
					8	Anchor type dry masonry	8
			Concrete	Concrete block (mortar)	9	Concrete block mortar masonry	4-8
					10	Porous concrete block mortar masonry	4-8
				Concrete block (dry)	11	Concrete block dry masonry	5
					12	Porous concrete block dry masonry	5
			Gabion	Gabion (multistage)	13	Iron gabion type multistage masonry	6.5
					14	Panel frame work (ductile panel)	4.5
			Wood	Log grating	15	Log grating (including the single grating crib works)	4
				Wood block	16	Wood block	4
				Pile-hurdle works	17	Pile hurdle	4
					18	Plate fence	4

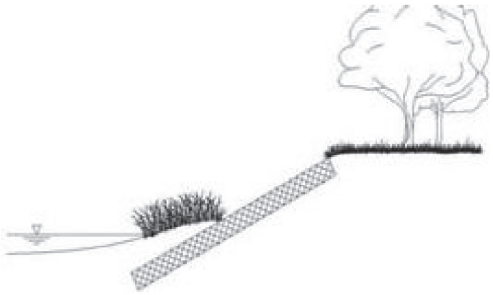
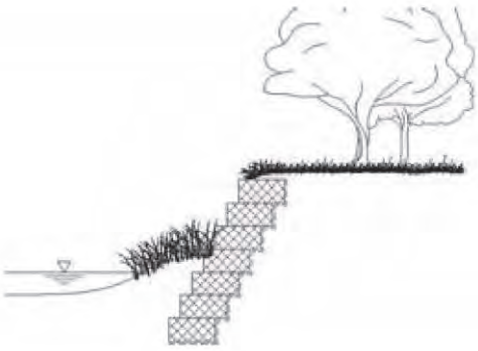
* The scope of application of the table above is for reference only. Any reasonable method applicable to the design flow velocity may be positively employed.

* Select an appropriate method by taking into account the considerations of the restoration work.

Note: To ensure restoration of vegetation, use surplus soil as much as possible to cover the slope shoulder and water edge.

Source: Basic Policy of Restoration from Disaster to Protect Beautiful Mountains and Rivers, MLIT

Table 2.2.39 Features of the employed revetment works

Compound cross-section	Lower stage	Upper stage
Revetment works	Iron gabion flat pitching works	Iron gabion type multistage revetment
Outline		
Features	The structure entails gabions formed from iron wires packed with stones that are arranged on the slope over which cover gabions are placed This method protects the gentle slope surface from erosion by resisting the dragging force by means of a dead weight of packed materials (stone, etc.) The structure allows permeability Used in rivers with fewer rolling stones or for protection of the river bank located lower than the protected lowland	The structure entails gabions formed from iron wires packed with stones that are arranged on the slope over which cover gabions are placed This method retains the steep slope by its own weight The structure allows provision of a gap or permeability Used in rivers with fewer rolling stones or for protection of the river bank located lower than the protected lowland Not recommended for locations subject to wheel load or in the embanked reach

Source: Study team

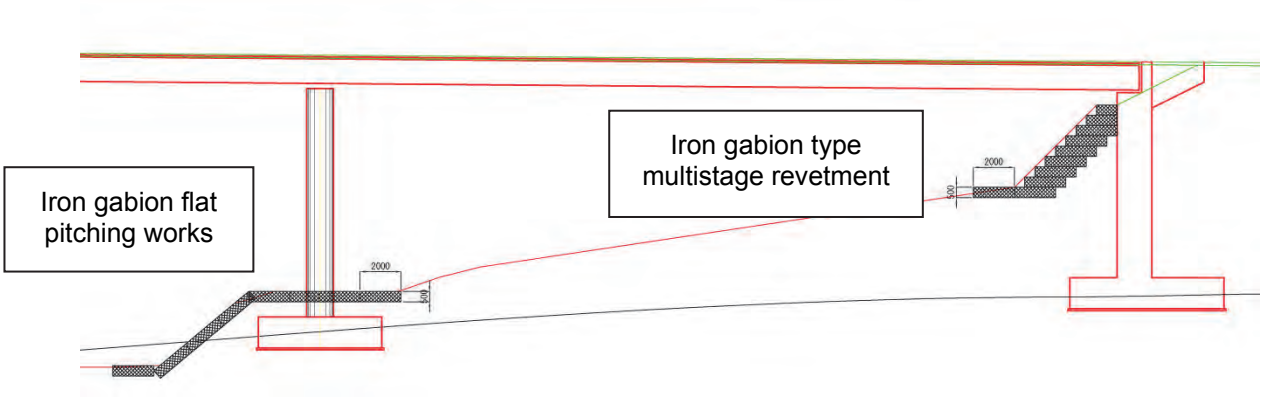


Figure 2.2.20 Typical installation of an iron gabion flat pitching revetment and an iron gabion type multistage revetment

2.2.3 Outline Design Drawings

Outline design drawings for both Xe Kum Kam Bridge and Xe Tha Mouak Bridge with respective approach roads are to be provided in the table below.

Table 2.2.40 List of Drawings for Xe Kum Kam Bridge

No	Title of Drawings
1	Alignment Layout (1)
2	Alignment Layout (2)
3	Plan (1)
4	Plan (2)
5	Profile (1)
6	Profile (2)
7	Typical Cross Section
8	Withdrawal (1)
9	Withdrawal (2)
10	Temporary
11	Details of Drainage Ditch
12	Guide Post
13	Guardrail
14	Guardrail End Rail Treatment
15	Street Lighting Pole
16	Road Markings (1)
17	Road Markings (2)
18	Traffic Signs
19	General View of the Bridge (1)
20	General View of the Bridge (2)
21	Bridge Structure General Drawing (Reference Drawing)
22	General Structural View (A1)
23	General Structural View (P1)
24	General Structural View (P2)
25	General Structural View (A2)
26	Approach Slab

Table 2.2.41 List of Drawings for Xe Tha Mouak Bridge

No	Title of Drawings
1	Alignment Layout (1)
2	Alignment Layout (2)
3	Plan (1)
4	Plan (2)
5	Profile (1)
6	Profile (2)
7	Typical Cross Section
8	Withdrawal (1)
9	Withdrawal (2)
10	Temporary
11	Details of Drainage Ditch

No	Title of Drawings
12	Guide Post
13	Guardrail
14	Guardrail End Rail Treatment
15	Street Lighting Pole
16	Road Markings (1)
17	Road Markings (2)
18	Traffic Signs
19	General View of the Bridge (1)
20	General View of the Bridge (2)
21	Bridge Structure General Drawing (Reference Drawing)
22	General Structural View (A1)
23	General Structural View (P1)
24	General Structural View (P2)
25	General Structural View (P3)
26	General Structural View (A2)
27	Approach Slab

2.2.4 Implementation Plan

2.2.4.1 Implementation Policy

(1) Basic Policy

The implementation policy has been established as follows in line with the framework of the Japan grant aid assistance project.

- Ownership of the facilities under the project will be handed over to DPWT Savannakhet from MPWT after its completion. Reginal Road Maintenance Office No. 3 will be also in charge of road maintenance for National Road No. 9, so coordination between these relevant organizations should be important for a smooth implementation.
- The maximum local utilization, including equipment, materials, and people, should contribute to the generation of employment opportunities and technical knowledge transfer to the domestic market.
- The construction schedule should be established taking into account the river water level during the rainy season under weather conditions around the project site divided into two seasons: rainy (May to October) and dry (November to April).
- The staff arrangements for Japanese experts for the contractor side should be appropriately arranged and the local staff should reasonably also give input on useful timing. The technical experts including the bridgework foreman, special bridge skilled worker (steel girder erection), and mechanical & electrical skilled worker should be appropriately deployed respectively, focused on the superstructure works (Steel-Concrete Composite Girder Bridge).

- The superstructure works will be conducted by the crane erection method using temporary construction roads provided on the upstream side of the bridge. The steel girder frame, which is manufactured and hauled to the site, will be erected on the substructure during the low water (dry) season. The slab concrete can be cast during the rainy season using a curing sheet for concrete covering steel on the steel frame girder after it is erected.
- Foundation and substructure works should be completed during the dry season. The excavation height of abutment will be more than 10 meter from the supporting rock substratum so that the temporary cofferdam should be installed before excavation. Piers should be constructed on the temporary island provided its height is more than the highest water level during the dry season.
- Safety should be a priority during the works, especially that of local residents and traffic. It is also important to minimize the impact to natural and social environments around the site.

(2) Setting of Construction Schedule

The construction schedule has been established based on project implementation using the A-type national debt (A Kokusai). As a result, the total construction period is assumed to be 31 months, commencing in September 2016 and completed by the end of March 2019.

(3) Work Sequences and methodology

1) Overall flow of Works

The overall flow of the works will be indicated in Figure 2.2.21.

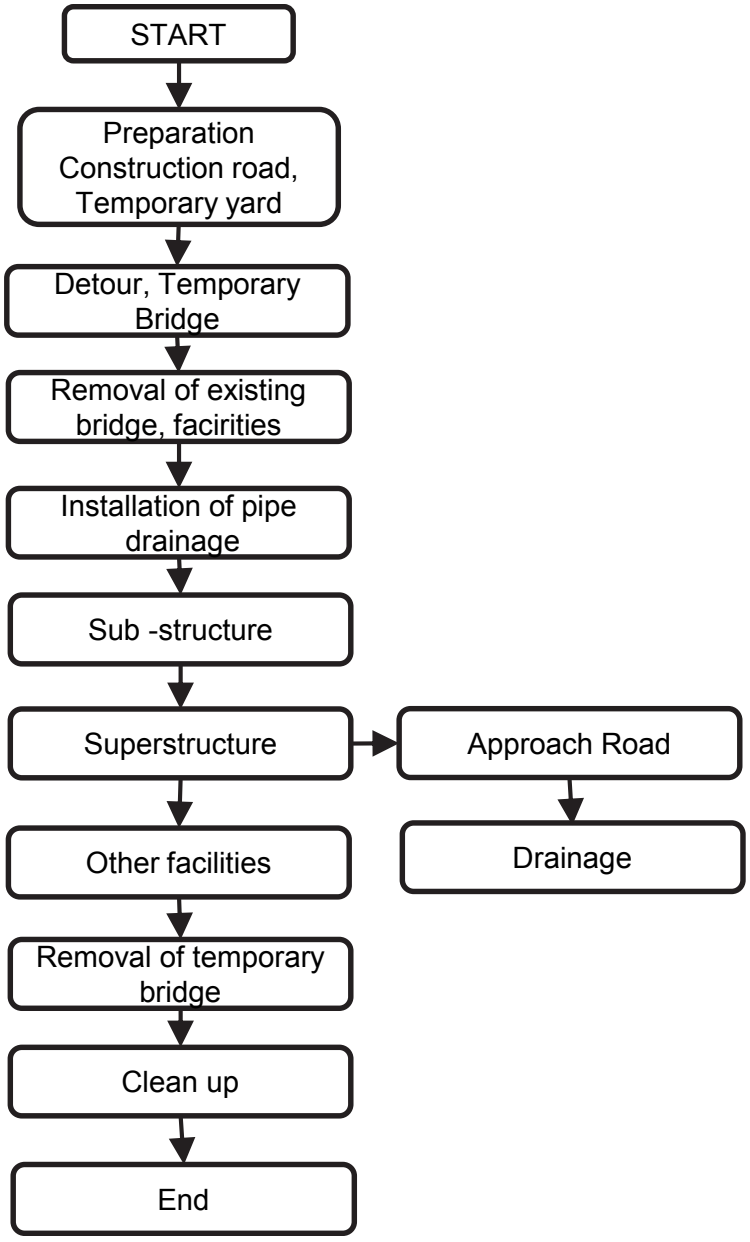


Figure 2.2.21 Construction flow

2.2.4.2 Implementation Conditions

(1) Secure Safety during the Works

The following bullet points shall be conducted to secure the safety of works during the construction.

- Traffic controllers shall be deployed at both ends of the temporary detour bridge to maintain the safety of traffic diversion during the works.
- Monitoring and an emergency contact system shall be established prior to the works in the river taking into consideration flooding or other unforeseeable events.

(2) Environmental Mitigation Measures during the Works

The following items shall be conducted to mitigate the impact on the surrounding environment during construction:

- Reduce the occurrence of dust by watering the temporary yard and roads, and control speed of construction vehicles.
- Control noise and vibration from construction machinery by stopping the works in both early morning and night.
- Provide the provisional pump and tanks for the events to prevent outflowing of muddy water from the construction site to the river during foundation and substructure works.

(3) Procurement of Import Items

The import items, including construction equipment, materials, and other goods, will be procured from the neighboring country's seaports, such as Lamchaban and Bangkok in Thailand, and Hanoi and Da Nang in Vietnam. The import items for the grant aid assistance project should be exempt from local taxation. The master list for imported items shall be prepared and submitted to the MPWT and the contractor shall get approval from the Ministry of Finance prior to the procurement of items in accordance with the tax law in Lao PDR.

(4) The Obligatory Undertakings of Lao Side

The resettlement and land acquisition that is critical to the implementation of the project shall be undertaken by the Lao side. In this project, the resettlement of local residents will not occur; however, the land acquisition of necessary ROW and the removal of some obstacles will be required to improve the road alignment of the access road for Xe Kum Kam Bridge. In addition, temporary construction yards shall be also provided by the Lao side prior to the commencement of works. These obligations shall be duly coordinated and undertaken by the MPWT (DOR) before commencement of the works on site.

2.2.4.3 Scope of Works

To implement the Project under Japan's Grant Aid scheme, there are some works that both the GOJ and GOL must do.

Table 2.2.42 Tasks of the Japanese & Lao PDR Sides

Responsibilities of the Japanese Side	Responsibilities of the Lao PDR Side
- Construction of bridges, approach roads, and other necessary facilities	- Land acquisition for construction and the securing of land necessary for temporary facilities, such as girder manufacturing yards, stockpiled areas for materials and equipment, etc.
- Provision of a temporary construction yard and temporary roads to substructures and their removal (however, the construction yard on the right bank will remain after construction)	- Compensation for relocation of houses.
- Procurement of the materials, equipment, and labor required for the above construction work	- Removal or relocation of public utilities, such as electricity and telephone poles, etc.
- Supervision of the above construction work	- Exemption from taxes on materials and equipment imported for the Project and from custom clearance expenditures
- Consultancy services required for Project implementation	- Exemption from customs fees and taxation for Japanese and third party nationals entering Loa PDR to work for the Project, as well as exemptions from any other financial obligations
	- Installation of road signs along the new approach roads
	- Provision of a power distribution facility for lighting on the new bridge

2.2.4.4 Construction Supervision

(1) Detailed Design Service

After the field survey, the detailed design, including the quantitative calculations and preparation of tender documents, will also be carried out.

(2) Supervision Service

1) Approval of the work plan and shop drawings

The consultant supervisor will give approval for the work plan, schedule, and shop drawings, which are submitted by the Contractor if they comply with the agreement, contract drawings, and specifications.

2) Progress Control

The consultant supervisor will receive the report on the progress of works from the contractor and will give instructions to the contractor regarding necessary measures for the work to be completed within the contract period.

3) Quality Inspection

The consultant supervisor will check the materials and quality of works to determine if they comply with the contract drawings and specifications and will give approval if appropriate.

4) Actual measurement inspection

The consultant supervisor will check the completed products to determine if the actual measurement complies with the drawings and quantities as well as satisfies the specifications.

5) Issuing of certificates

The consultant supervisor will issue the necessary certificates on the completed amount, the work completion, and the acceptance of inspection.

6) Submitting reports

The consultant supervisor will check the contents of the monthly reports, the completion drawings, and the completion photos submitted by the contractor before submitting them to MPWT.

(3) Work Supervision System

A consultant office will be borrowed near the site. Additionally, to submit the monthly report, the consultant should go to Savannakhet (which is about 450 km from the Capital city of Vientiane) where the DPWT Savannakhet, a branch office of the project implementing agency, MPWT is situated. It will take about two hours by car from the site to Savannakhet, so no liaison office will be located in Savannakeht since it will be completed within half a day even when the round-trip is taken into account. The place of accommodation will be in Vientiane when reporting to the implementing agency (MPWT).

2.2.4.5 Quality Control Plan

The quality control of works will follow the Road Design Manual (1996) since the manual provides the standard technical specifications and quality control methods. However, for the items not contained in this manual, AASHTO or the Japanese standards or other international test methods will apply.

For the job mix design of pavement, all possible mix options shall be attempted and the final mixing of pavement shall be determined after the trial. The quality control methods are shown in Table 2.2.43.

Table 2.2.43 Quality control methods

Type of work concerned	Control items	Quality control test, inspection, etc.	Test frequency and timing
1) Earth works, asphalt pavement, subgrade, base course, backfilling of structures	Material control	CBR test, soil test (specific gravity, grain size, liquid limit・plastic limit, density), aggregate test (specific gravity, grain size distribution, strength, water absorption), bituminous material (quality certificate, component analysis table)	Before execution of work
	Daily control	Compaction density test, bituminous material (stability, flow value, porosity, Marshall test, temperature)	During execution of the work, at the time of mixing

Type of work concerned	Control items	Quality control test, inspection, etc.	Test frequency and timing
2) Concrete	Batcher plant performance inspection	Weighing instrument, mixing performance test	Before execution of work and once a month
	Material control	Cement・admixture (quality certificate, component analysis table), aggregate test (specific gravity, grain size, strength, water absorption, alkali-aggregate reaction)	Before execution of the work, at change of material
	Concrete mixing test (test mixing)	Slump, air content, temperature, test piece strength	Before execution of the work
	Daily control	Fresh concrete (air content, slump, temperature)	During execution of the work
		Witness test (compaction, curing, removal of laitance)	During execution of the work
		Concrete specimen (strength test, preparation of control chart)	At seven and 28 days after placement
3) Reinforcing bars	Material control	Quality certificate (mill sheet), tensile test result	Before execution of the work
	Daily control	Witness inspection (cover, arrangement, wrap length)	During execution of the work

In addition, the draft allowable tolerances of measurement control for works are given in Table 2.2.44.

Table 2.2.44 Allowable Tolerances of Measurement Control (Draft)

Works	Description	Item	Allowable Tolerances	Remarks
Earth Works	Subgrade (Road Bed)	Plan	More than 0 cm	20 m interval
		Width	More than -10 cm	〃
	Subbase	Plan	More than -2.5 cm	〃
		Finished thickness	More than -5 cm	〃
		Width	More than -10 cm	〃
Pavement	DBST/AC	Width	More than 0 cm	〃
		Thickness	More than 0 cm	〃
Foundation	Spread type	Bottom footing level	Below specified height	4 m mesh
Concrete Structure	Footing/Pile cap	Plan	±5 cm	
		Thickness	±75 mm or±3%	
	Pier, Abutment, Retaining wall	Horizontal Deviation	±30 mm	
		Plan	-30 mm～+10 mm	
		Length (Top/bottom)	±30 mm	
		Dimension	-10 mm～+20 mm Or ±2%	
	Slab	Length	-25 mm～+30 mm	
		Width	0～+30mm	
		Slab, curb height	-20 mm～+20 mm	
		Thickness	-10 mm～+20 mm	
Steel Structure	Girder	Length	-25 mm～+30 mm	

2.2.4.6 Procurement Plan

(1) Conditions

1) Engineers & Technicians

In the past, many Lao engineers graduated from universities in Russia and Eastern Europe. However, recently, many young Lao engineers are graduating from universities in Thailand, Australia, the U.S., Japan, and China, and most of them possess basic engineering knowledge and skills in addition to good English speaking and writing skills.

On the other hand, changes in higher education have been proceeding in Lao PDR, and 3 colleges and 8 higher educational institutes were integrated into Lao PDR's first university in 1995. Lao University comprises 10 faculties, including engineering and architecture, and many students graduate from the engineering and science fields.

2) Skilled Labor from Third Countries

It is not difficult for skilled labor from a third country to obtain a work visa for ODA projects. Recently, many engineering firms have moved into the Lao market because the GOL welcomes advanced technology from foreign countries. However, it is difficult for unskilled labor from a third country to obtain a work visa.

3) State of Labor-related Laws

When employing local workers, the enterprises are governed by the employment act, the "LABOUR LAW OF LAO PEOPLE'S DEMOCRATIC REPUBLIC." This was adopted by the National Congress on March 14, 1994, and promulgated on April 21 of the same year by Executive Order No. 24. Important requirements related to this project are summarized in Table 2.2.45.

Table 2.2.45 Outline of the labor law of Lao PDR

Item	Description
1) Payroll system	• The wage・payroll system need not be a uniform system, but should be easy to understand and simple. The labor or labor union representatives have the right to negotiate with the employer concerning wages and salaries. The government or agency concerned regularly establishes the minimum wage of each area. The employer must not set the minimum wage lower than the level stipulated regularly by the government. • The minimum wage and payroll system established regularly for each office is subject to inspection and control of the government.
Minimum wage	• LAK 900,000 (dated April 1, 2015) Note however that this is stipulated as applying to the eight-hour workday and does not include overtime work, assistance for dining, insurance, and other subsidies. This minimum wage is not applicable to payment of government employees or contract staff, party members, etc.
2) Working hours	• 48 hours per week
3) Weekly day-off and public holidays	• The workers have the right to take one whole day of every week as a day-off for refreshment. The day-off is set on Sunday or another day of the week according to the agreement between workers and the employer. Public holidays are stipulated by the government.

Item	Description
4) Annual holidays	• For workers working under an indefinite employment agreement or under an agreement exceeding one year, 15 days of annual holiday leave must be granted after working for one year. For workers engaged in hard work or work possibly hazardous to one's health, as stipulated in Article 25 of this Law, an 18-day paid leave must be granted. Weekly days off and public holidays are not counted in the annual holidays.
5) Sick leave	• The worker on a salary system is granted fully paid sick leave for the annual limit of 30 days by submitting a medical certificate from a doctor. This is applicable to workers working for 90 days or more, regardless of whether they are hourly-rated, daily paid, piecework payment, or contract-based workers. When the sick leave period exceeds 30 days, the worker concerned accepts compensation on the basis of the social security program. The stipulation of this article does not apply to on-the-job injuries/sickness.
6) Compensation for on-the-job injuries	On-the-job injuries mean an accident that caused injury to a worker, making him/her crippled or physically handicapped, and in certain cases, caused death, as follows: (I) While the worker is executing his job duty on the job site or other location under instruction of the employer or supervisor. (II) Entertainment facilities, dining halls, and other locations under the responsibility of the operator. Occupational diseases of all kinds are also considered to be on-the-job injuries. The labor management agency must cooperate with the health management agency and the labor union to specify the types of occupational diseases. Injuries occurring during the course of a job executed without instructions from the employer or representatives and for personal purposes are not handled as on-the-job injuries.
	The employer must provide rapid and adequate assistance to workers suffering on-the-job injuries. In addition, the actual doctor's bill verified by a doctor's certificate must be born by the employer or social security funds for: (I) Medical treatment fees and the doctor's bill inside and outside the hospital, including surgical costs (II) Hospital charges and costs for other clinics (III) Cost of treatment made by the doctor, assistant doctor, and dedicated practitioner (expenses for complementary are medicine included) When the worker is killed as a result of on-the-job injuries, the employer must pay the condolence money of the amount equivalent to the wage or salary for at least six months. In addition, the bereaved family has the right to receive a given amount of benefit. When the worker was killed working under instructions of the employer, the cost to transport the body to the bereaved family must be born by the employer.
	The compensation for an on-the-job injury is determined as follows: The worker suffering an on-the-job injury is eligible for receiving the regular wage or salary for a maximum of six months throughout treatment and rehabilitation by the doctor. When the period exceeds 6 months to reach 18 months, the worker is eligible for receiving only 50% of the regular wage or salary. When the period exceeds 18 months, the beneficiary will be provided from the social security foundation. When, as a result of an on-the-job injury, the worker has a part of his body mutilated or the worker is crippled or killed, the employer must pay the specified compensation to the worker or his/her bereaved family. When the employer has reserved the compensation fund or social security fund according to Clause 48 or when the employer takes out insurance from an insurance company for the worker, the above beneficiary must be paid as specified at the responsibility of the compensation fund or the insurance company.
7) Allowance for overtime work	• For overtime work during the day of a normal workday, extra wages at 150% of the normal hourly rate will be paid. • For overtime work during the night of a normal workday, extra wages at 200% of the normal hourly rate will be paid. • For overtime work during the day of a weekly holiday or public holiday, extra wages at 250% of the normal hourly rate will be paid. For the same circumstance at night, extra wages at 300% will be paid. • Workers working the night shift from ten o'clock in the afternoon to five o'clock in the morning the next day will have an extra wage of at least 115% of the normal hourly rate.

Item	Description
8) Retirement・dismissal	• Termination of the employment agreement The employment agreement can be terminated on the basis of agreement of both parties regardless of whether the agreement is limited or infinite. When an infinite employment agreement is to be terminated by one party, the advance notice must be made no later than 45 days for professional engineers and no later than 15 days for blue-collar workers. In the case of parties of employment agreement with a limited period, the desire for continuation/termination must be mutually noted not later than 15 days before the date of termination. When continuation of the agreement is desired, both parties must conclude a new employment agreement. The employment agreement for the task whose amount has been specifiedis terminated by the completion of the task. The employment agreement is terminated by the death of the worker.
	• Termination of the employment agreement by dismissal When the worker does not have the required expertise or capability, or the worker is not in a healthy state and thus cannot continue the work, or when the employer thinks it necessary to reduce the number of workers to improve the operation environment, the employer can terminate the employment agreement by dismissal. When the worker does not have the required expertise or capability or is not in a healthy state, the employer can order the worker to stop working. The employer can also terminate the agreement. In such a case, the employer must explain the reason to terminate the agreement and give at least a 45-day advance notice. In the advance notice period, the employer must grant the worker one workday per week as a paid day-off to search for another job. However, before termination of the employment agreement, the employer must consider adequate relocation appropriate to the capacity and health of the worker concerned. The agreement can be terminated only when a job appropriate to the worker is not available. When the office thinks it necessary to reduce the number of workers to improve the operation environment, the employer must prepare the list of affected workers through negotiation with the labor union or labor representatives and must notify the competent labor management agency. Concurrently, the employer must provide a 45-day advance notice of dismissal as well as an explanation. If the employment agreement is to be terminated for either one of the above reasons, the employer must pay compensation appropriate to the working period of the worker. The amount of compensation must be equivalent to 10% of the monthly wage for the number of employment months and must be paid at the time of dismissal. For workers working for three years or more, the compensation must be equivalent to 15% of the same monthly wage for each month worked. For the worker whose salary is not fixed and who works in the piecework system, the compensation is calculated on the basis of the average of wage/salary received for the three months before termination.
9) Pension system	• There are two types: Employees Provident Fund (EPF) and Employees Trust Fund (EPF). • Allotment for the employer and employee is as follows: (A) EPF: Share of employer ＝ 12% of the total sum of salary, share of employee ＝ 8% of the total sum of salary (B) ETF: Share of employer ＝ 3% of the total sum of aid

Source: Labour Law of Lao PDR, Ministry of Health and Labour, 2004

In the National Assembly held in December 2008, the amended labor law was adopted and promulgated by Executive Order on January 16, 2007. This amendment was made after 13 years of promulgation of the original one through addition and alteration to a considerable degree, with the number of Clauses increasing from 62 to 77. Alterations related to this project implementation are shown below:

The overtime hours were increased from the original 30 hours a month to 45 hours (Clause 18).

Regarding the workers, the advance notification to terminate the agreement with blue-collar workers was changed from a 15-day advance notice to a 30-day advance notice (Clause 28).

The employment percentage of foreign workers must be 10% or less of the total number of workers for blue-collar workers and 20% or less of the total number of workers for white-collar workers (Clause 25).

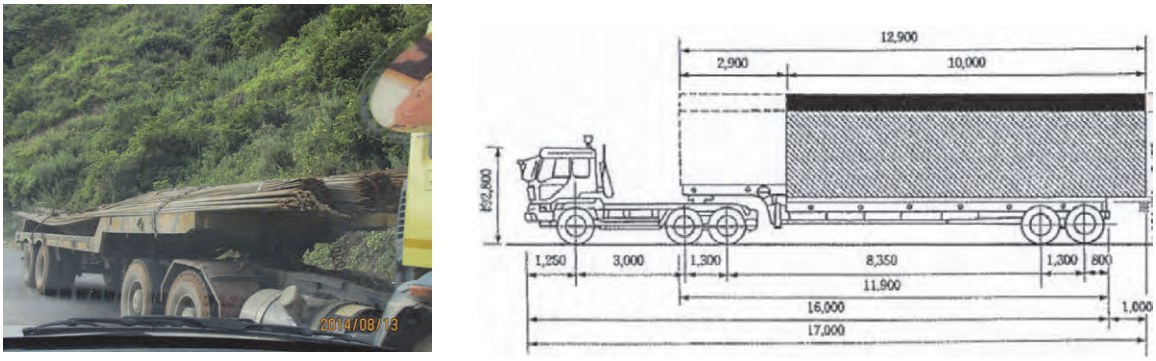
(2) Procurement Conditions of Materials and Equipment

1) Transportation of Materials and Equipment

There is no steel manufacturer in Laos so that the steel materials shall be imported from other countries, particularly the bridge accessories should be imported from Japan. These imported materials and equipment will be transported via the international seaports such as Leamchaban in Thailand and Da Nang in Vietnam. The distance from Leamchaban port to the project site would be around 650 km and 350 km from Da Nang port.

The available domestic materials in Laos would be procured from a single source of Vientiane so that the transport distance would be more than 600 km. It is assumed that the import from another country via Da Nang would be more reasonable taking into account the transport distance.

National Road No. 9 is overlapped by the GMS East West Economic Corridor (EWEC), so transportation vehicles should be controlled in line with the ASEAN regulation or bilateral agreement between the concerned countries. Some semi-trailers travelling on NR9 that were observed during the site survey are given in Figure 2.2.22.



Source: Left: JICA Study Team/ Right: Design Data Book

Figure 2.2.22 Transport Vehicle (Semi-Trailer)

2) Procurement of Construction Materials and Equipment

a) Materials

The procurement sources for major construction materials are shown in Table 2.2.46.

Table 2.2.46 Procurement Sources of Major Construction Materials

Name	Specification	Source			Remarks
		Laos	Japan	Third Country	
Borrow		○			
Asphalt Concrete	For pavement	○			Available plant on site used for current pavement works
Emulsion		○			Import from Thailand or Vietnam
Aggregate	Crushed stone	○			
Cement	Portland cement	○			
Admixture	Water reducer		○		
Fine aggregate	Sand	○			
Coarse aggregate	Crushed stone	○			
Cobble stone	20～25cm	○			
Corrugated pipe	Diam. 2 m		○		
Re-bar	IS-415, IS-500	○			
PC Strand			○		
Duct			○		
Handrail	Aluminum		○		
Shoe	Incl. shoe accessary		○		
Expansion joint			○		
Gully on bridge	With drain pipe		○		
Gabion		○			Import from Thailand or Vietnam
Plywood		○			
Supporting steel	H-shaped steel, angle and steel pipe, etc.		○		Import from Thailand or Vietnam
Scaffolding	Timber board, separator form, cramp, etc.	○	○		Scaffolding and formwork accessories to be procured from Japan
Wood	Form wood, temporary wood	○			
Sand bag		○			
Fuel		○			

Source: JICA Study Team

b) Procurement of Construction Machinery

General construction equipment can be procured from the general contractors in Laos. Reinforcing bar, bridge accessories, large-scale cranes, and other special machinery shall be procured from Japan or other third countries such as Vietnam and Thailand. For the

procurement from Japan, Da Nang seaport would be the closest for the travelling distance from the site via NR9 beyond the country's border, so the transport cost could be reduced. The procurement sources of major construction equipment are presumed as shown in Table 2.2.47.

Table 2.2.47 Procurement Sources for Major Construction Machinery

Name	Specification	Source			Remarks
		Laos	Japan	Third country	
Bulldozer	15, 21 ton	○			Earthworks
Backhoe	0.8 m^3	○			Earthworks
Clamshell	0.4 m^3		○		Foundation
Giant breaker	1,300 kg	○			Earthworks
Wheel loader	1.4 m^3	○			Hauling works
Dump truck	10 ton	○			Earthworks
Truck	4～4.5 ton	○			Hauling works
Rafterain crane	16, 25 ton	O			Sub & superstructure
Truck crane	200 t		○		Erection of girders
Boring machinery	55 kW		○		Foundation pile
Piler	φ1000		○		Foundation pile
Motor grader	3.1 m	○			Pavement
Road roller	10～12 ton	○			Pavement
Tire roller	8～20 ton	○			Earthworks, pavement
Vibration roller	0.8～1.1 ton	○			Earthworks, pavement
Tampa	60～100 kg	○			Earthworks, pavement
Concrete mixer	0.5 m^3	○			Concrete works
Water sprinkler	10 m^3	○			Earthworks, pavement
Air compressor	5 m^3/min		○		Earthworks
Generator	75 kva 以下		○		
Vibration hummer			○		Temporary bridge
Downhole hummer			○		Temporary bridge

Source: JICA Study Team

c) Customs Clearance for the Vietnamese Border

Densavanh is the border town on the Lao side adjacent with Laobao, the border town on the Vietnam side; each has a customs checkpoint. Several freight forwarders are engaged around the area for providing transportation. The customs clearance for entry/exit of goods and parcels shall be inspected in accordance with the official process. The goods arriving from Japan will be unloaded and inspected preliminarily at Da Nang port in Vietnam and hauled to Densavanh. The full inspection shall be conducted in Densavanh. Note that a single window system has been placed at this international boarder.

	
Lao side border gate	Vietnam side border gate

Figure 2.2.23 International Border between Lao and Vietnam

This project will use the construction materials produced or procurable within Lao PDR as much as possible. The procurement conditions, quality of materials, and information of possible suppliers are provided below.

1. Cement

There is a cement plant constructed with investment from China about 80 km along the road northward from Xeno. Initially, this plant supplied cement mainly to construct infrastructure in Lao PDR under assistance from China. In line with a recent demand growth in the market, the product of this cement plant is marketed along with Lao-cement. On the other hand, there is also the cement refining plant invested in by Thailand at the Km 59 point along NR-9. The cement produced in Thailand is transported as clinker and refined into cement at this plant for bagging and shipment.

2. Ready-mixed Concrete

There are several ready-mixed concrete plants in the suburb of Savannakhet. The average distance to the site is about 80 km and will take about one and a half hours by car. Since this project consists of a major road improvement, only a small amount of concrete will be used for the facilities, such as gutters, culverts, etc. Job mixing is considered practical by using a portable mixer for concrete supply.

3. Coarse Aggregates (for concrete and asphalt)

The existing crusher plant nearest to the project site is the one belonging to Khunxay Phatana, which is currently undertaking maintenance of National Road No. 9. This is in the vicinity of the construction equipment workshop, and both are located in the backside of the temporary yard of the company. Sandstone quarried from the surrounding bedrock is used for aggregate.

4. Fine Aggregate for Concrete & Asphalt

Fine aggregate and sand from the Mekong River are widely available in the domestic market. However, it is necessary to test the materials in the laboratory in order to confirm their quality, as it varies widely.

5. Embankment Materials

It has been confirmed that embankment materials of good quality are available from a borrow pit near the Project site. Accordingly, it is not necessary to get permission for taking these materials because it's owned by the GOL.

6. Bituminous Materials

There is an asphalt plant owned by Khunxay Phatana co. ltd. and Road No. 8 enterprise near the site.

7. Steel Materials (Re-bar, PC bars, & cables)

For re-bar less than 20 mm in diameter, which would be limited to use for small RC structures such as drainage facilities, local materials are sufficient. However, for the bridge structure, steel materials will be procured from Thailand for reasons of quality and stability of supply. For other steel materials, including sheet piles and structural members for girder fabrication equipment, these shall also be procured from Thailand.

8. Wood

Wood is basically available from the domestic market. However, thick plywood for formwork will be procured from Thailand.

9. Procurement Source of Major Materials

The procurement sources for major materials are summarized in Table 2.2.48.

Table 2.2.48 Procurement Sources of Major Materials

Name	Locally procured	Procured from third County	Procured in Japan	Remarks
Cement	○	○		For high strength: Thai product For others: Lao product
Concrete admixture	○			Imported from Thailand
Reinforcement	○	○		Large diameter ones from Thailand
Structural steel	○			Imported from Thailand
PC bar & cables		○	○	Procured from Thailand or Japan
Bituminous materials	○			Imported from Thailand
Crushed stone, sand	○			
Forms (plywood)	○			Imported from Thailand
False work & scaffolding		○		Procured from Thailand
RC pipe	○			
Expansion joint		○		Procured from Thailand
Bearing		○		Procured from Thailand

(3) Construction Machinery and Equipment

1) Procurement Condition of Construction Machinery in Lao PDR

Due to the many recent road and bridge projects in Lao PDR, common construction machinery and equipment is available in the domestic market mainly from local contractors. However, the availability of special machinery or equipment is limited. Below, the procurement conditions of major machinery and equipment are described in detail.

2) State Enterprises

State enterprises own many types of construction machinery and equipment for road and bridge projects. Some of them may be available for the Project. But, the machinery and equipment is not always well maintained.

3) Private Contractors

Although common construction machinery and equipment are basically available, there is a limited amount. As for special machinery and equipment, such as a crane with a 50-ton lifting capacity, large vibrating hammers, or jet-water digging machines, they are scarce and shall be procured from Thailand.

4) Procurement of Plants

There are several plants for asphalt, concrete, and aggregate crushing around Vientiane. There are also a few concrete batching plants around Savannakhet, but the available asphalt plant adjacent to the site that is owned by Road No. 8 and the Kunxay Company is being used for on-going road works undertaken by the Lao side. It is therefore planned that the asphalt plant for this project is to be procured around the site in Savannakhet Province.

5) Procurement Sources for Major Machinery & Equipment

Table 2.2.48 Procurement Sources of Major Machinery and Equipment summarizes the procurement sources for major machinery and equipment for the Project.

Table 2.2.49 Procurement Source of Major Machinery and Equipment

	Item	Q'ty	Specification	Domestic	Imported
Ⅰ.	Earth Work, Cofferdam Work				
1	back hoe	4	0.7m3	○	
2	dump truck	8	11.0t	○	
3	crawler crane	2	60t mechanical		○
4	truck crane	2	25t	○	
5	truck crane	2	45t		○
6	vibro hammer	2	90kw		○
7	electric generator	2	400KVA		○
8	water-jet	2	150kg/cm2		○
9	clamshell bucket	2	0.6m3		○
10	giant rock breaker	2	600kg		○
11	rock breaker	6	B30		○
12	crawler drill	2	150kg		○
13	air compressor	4	7m3	○	
14	submersible pump	4	φ4″	○	
15	submersible pump	12	φ6″		○
16	electric generator	4	45KVA	○	
17	road roller	2	1.0t	○	
18	impact tamping rammer	2	60kg	○	
19	earth auger machine	2	φ1200		○
20	hydraulic jacked pile driver	2	φ1200		○
21	φ1200 casing	2	φ1200		○
22	hammer grab bucket	2	φ1200		○
23	core barrel bucket	2	φ1200		○
24	slurry plant	2			○
25	tremie pipe	2			○
26	welding machine	4		○	
27	gas cutter	2		○	
Ⅱ.	Concrete Work, PC Work				
28	electric generator	2	75KVA	○	
29	concrete mixer	2	0.5m3	○	
30	batching plant	2	0.5m3		○
31	cement silo	2	200t		○
32	aggregate weigher	2	Double scalepan		○
33	agitator car	6	5.0m3	○	
34	concrete bucket	4	0.5m3	○	
35	crawler crane	2	60t mechanical		○
36	concrete pump	2	90m3/h	○	
37	electric vibrator	16	φ48mm		○
38	electric vibrator	8	φ58mm		○
39	electric converter	12			○
40	bar cutter	2	C-42	○	
41	bar bender	2	B-42	○	
42	submersible pump	4	φ4″	○	
43	welding machine	5		○	
44	electric generator	2	250KVA	○	
45	jet washer	2			○

	Item	Q'ty	Specification	Domestic	Imported
Ⅲ.	Road Construction Work				
46	road roller	1	10.0t	○	
47	road roller	1	1.0t	○	
48	distributor	1	1000L	○	
49	macadam roller	1	10.0t	○	
50	asphalt finisher	1	4.0t	○	
51	rubber-tyred roller	1	10.0t	○	
52	watering cart	1	2000L	○	
53	bulldozer	1	D-4	○	
54	motorgrader	1	3.5m	○	
55	asphalt cutter	1		○	
56	core piece cutter	1		○	
Ⅳ.	PC-girder fabrication, Extruded Construction Method				
57	rolley hoist	1	2.8ton		○
58	portal crane	4	5t		○
59	air vibrator	12			○
60	electric vibrator	8	φ58mm		○
61	electric converter	12			○
62	bar cutter	2	C-42		○
63	bar bender	2	B-42		○
64	hydraulic jack	8	60t		○
65	journal jack	14	30t		○
66	hydraulic pump	8	C-42		○
67	jack & pump for tensioning	2	195t		○
68	jack & pump for steel bar	2	φ32mm		○
69	grout mixer	2			○
70	grout pump	2			○
71	form units	1			○
72	concrete pump	2	90m3/h		○
73	jack for extrusion	2	170ton-500stroke		○
74	hydraulic unit	1			○
75	prestressing steel bar	4	φ32mm,L=20m		○
76	tensioning bracket	2			○
77	reaction pedestal	2			○
78	guide beam jack	2	50ton-200stroke		○
79	bent piers	1			○
80	sliding expansion bearing	4			○
81	vertical jack	2	600ton-70stroke		○

2.2.4.7 Soft Component (Techinical Assistance) Plan

There are 51 existing bridges located on NR9 in which one of the bridges has collapsed and the road has been closed since 2009. The closure of traffic flow due to bridge collapse significantly damages the economic activities of Laos as well as negatively impacting the lifeline for the emergency status since the land-locked country of Laos relies solely on land transportation. In 2010, upon responding to the request from Lao side, a soundness survey for the bridges on NR9 was conducted by the JICA Study for the Improvement of Roads and Bridges in the Southern Region of Laos. As a result of the survey, it was revealed there are so many damaged RC bridges that need repair in addition to the necessary replacement of the two objective bridges. Since 2011, the technical transfer scheme has been started under the technical cooperation project for road maintenance, called as CaRoL. The program has been conducted through the implementation of OJT and a workshop for bridge maintenance activities to secure bridge maintenance routines. However, it needs more time and continuous training opportunities to improve the knowledge and secure the systematic routine of bridge maintenance in the counterpart. To follow up the activities of CaRoL and facilitate the training program, the comprehensive technical transfer program from planning of the replacement of bridge to the maintenance works will be provided as the soft component of the two bridges project. The contents of the soft components are as follows:

- Establishment of an implementation plan for soft components activities
- Workshop for bridge planning, construction, and maintenance
- Safety control during construction
- Monitoring and preparing an evaluation report

Note that the inputs of Japanese experts would be assigned during the periods of detailed design and construction supervision respectively.

- Bridge Maintenance Expert: 1.0 MM
- Bridge Construction Expert: 5.0 MM

2.2.4.8 Implementation Schedule

Figure 2.2.24 shows the tentative Project implementation schedule based on the Study's results. Followed by the Exchange of Notes, the detailed design, the preparation of tender documents and then tendering will be carried out, to be followed by construction.

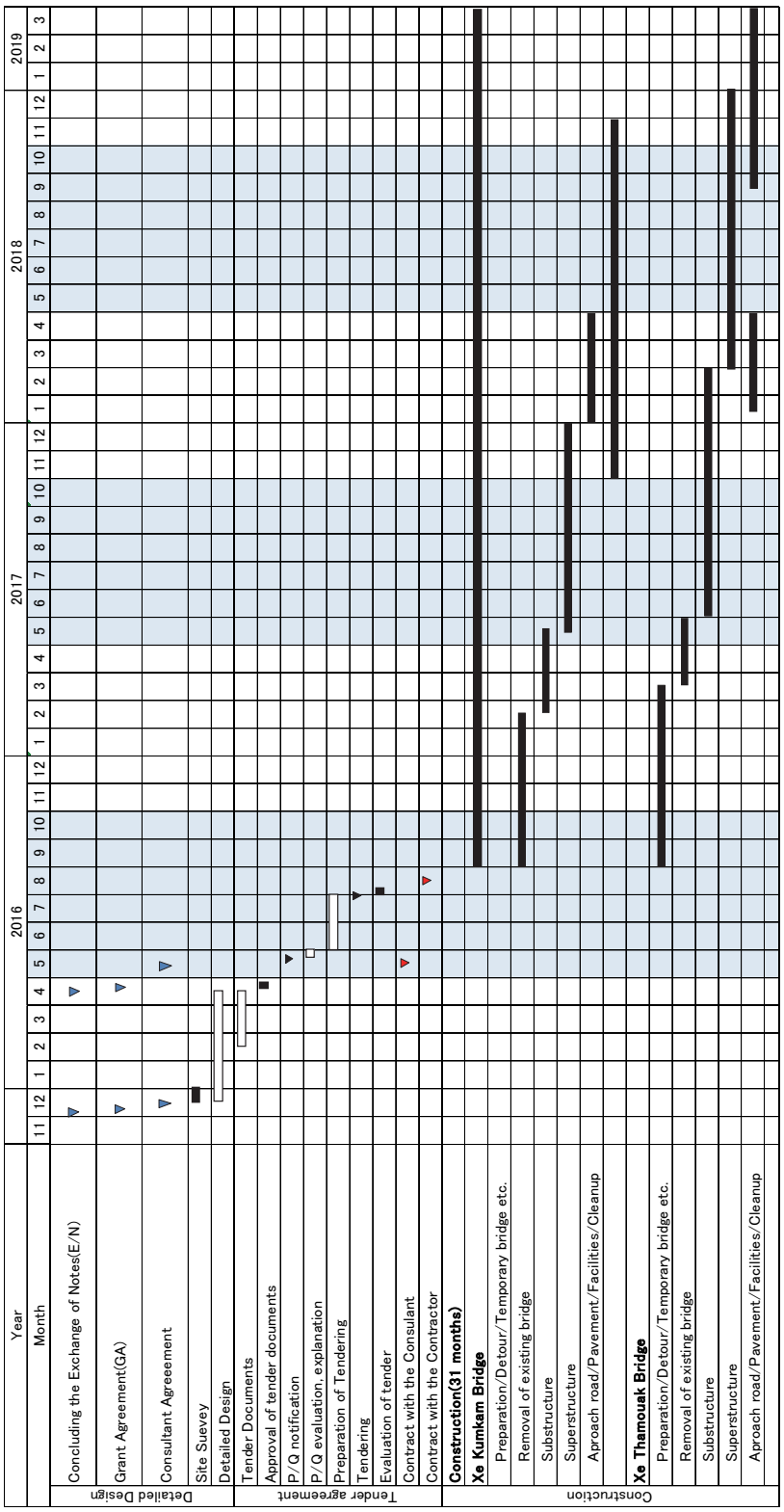


Figure 2.2.24 Tentative Project Implementation Schedule

2.3 Obligations of the Recipient Country

The obligations of the GOL are listed below:

- Compensation for relocation of houses from construction sites and provision of new land for new settlers with the required infrastructure
- Acquisition of construction sites and land necessary to perform temporary works (stockpiling material and equipment, repairing equipment and materials such as formwork & re-bars)
- Removal or relocation of public utilities, such as electric cables, UXO, and telephone cables
- Permission for obtaining borrowed materials
- Tax exemptions on materials and equipment imported for the Project and prompt customs clearance
- Exemptions from custom fees and taxation for Japanese and third party nationals entering Lao PDR to work for the Project and exemption from any other financial obligations
- Installation of road signs along the new approach roads
- Ensurance that the Facilities be maintained and used properly and effectively for the implementation of the Project
- Bearing of all expenses, other than those covered by the Grant

2.4 Project Operation & Maintenance Plan

2.4.1 Operation and Maintenance System

The proper maintenance and operation of the new bridge and approach roads are vital in order to secure their function over a long period of time. Preparation of a manual for bridge maintenance and execution of workshops was conducted thus far in the project for improvement of road maintenance capability in Lao PDR. For this reason, required maintenance skills for these facilities will be secured. Accordingly, it has been deemed that a new system or organization for maintaining the new facilities is not required

2.4.2 Maintenance Method

The maintenance target of this project is not only bridge structures but also approach roads. Manuals prepared in the project for improvement of road maintenance capability in Lao PDR mention the flow of periodic inspection, evaluation, and rehabilitation. Proper maintenance is required to reliably implement the maintenance activities by using manuals. The flow of inspection and rehabilitation of bridge structures and approach roads are shown as follows:

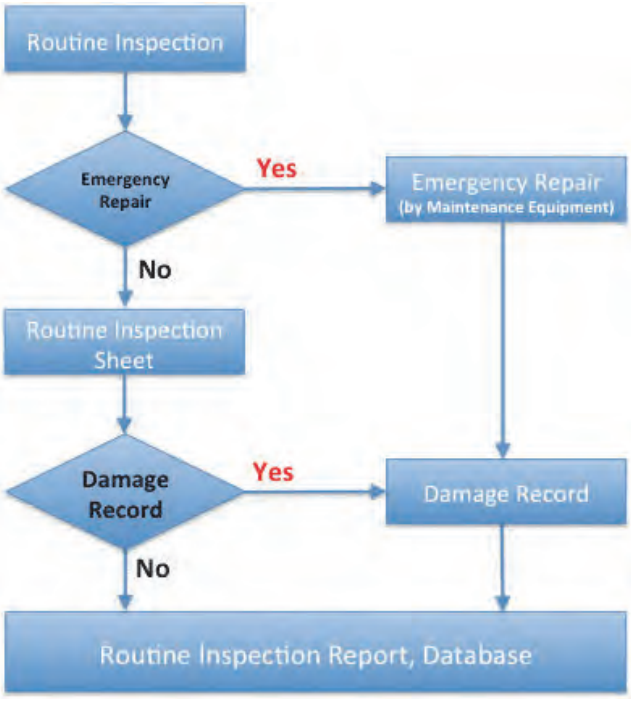


Figure 2.4.1 Routine maintenance flow for the bridges

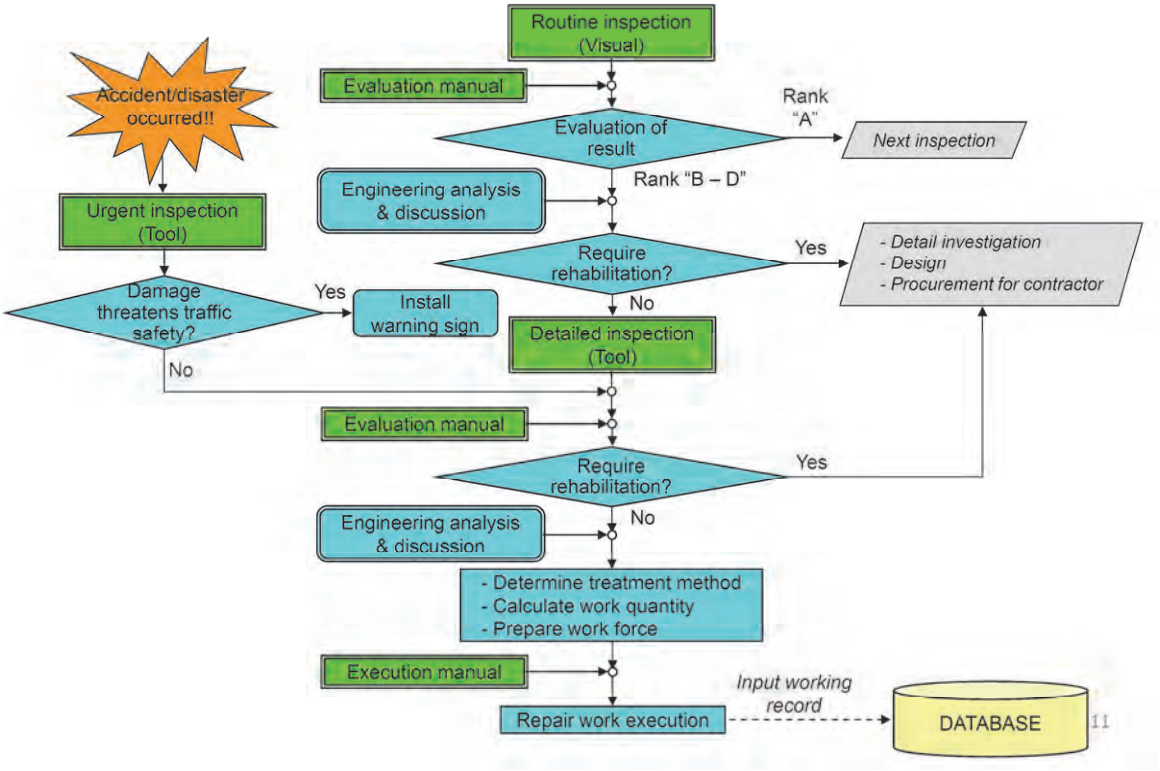


Figure 2.4.2 Maintenance flow for roads

2.5 Project Cost Estimation

2.5.1 Initial Cost Estimation

(1) Cost Estimation

The total costs of the Project under Japan's Grant Aid scheme are summarized in Table 2.5.1. This cost estimate is provisional and will be further refined by the GOJ when approving the Grant. In addition, these approximate Project costs do not represent the maximum amount of Japan's Grant Aid to be contained in the Exchange of Notes.

Approximate Project Costs: 2,465.7 Million Japanese Yen

Table 2.5.1 Approximate Project Cost (unit: Japanese Yen)

Project Cost		Million Japanese Yen
Xe Kum Kam Bridge	Substructure Superstructure Approach roads Revetment Other facilities	821.1
Xe Tha Mouak Bridge	Substructure Superstructure Approach roads Revetment Other facilities	1,352.4
Tendering Support & Construction Supervision		292.2
Total Cost		2,465.7

(2) Premises of Estimation

- Time of estimate: May 2015
- Exchange rate: 1US$ = JPY120.55
- Implementation period: Tendering process & construction period shown in Implementation Schedule
- Others: On the condition that the Project is implemented with Japanese Grant Aid. The above-mentioned exchange rate is to be reviewed by the Government of Japan.

(3) Cost Borne by Lao PDR Government

The approximate costs required for the tasks to be undertaken by the GOL are shown in Table 2.5.2.

Table 2.5.2 Approximate Costs to Be Borne by Lao Government

Item	USD	(million Yen)	Remarks
Land acquisition	73,000	(8.8)	
Construction yard (temporary)	25,000	(3.0)	31 months
Removal/relocation of public utility	64,000	(7.7)	
UXO Survey	42,000	(5.1)	
Bank charges	18,000	(2.2)	
Exemption of VAT (Reimbursable)/Import duty and customs	1,082,000	(130.4)	
Total	1,304,000	(157.1)	

* The above-mentioned costs are estimates subject to review.

2.5.2 Operation & Maintenance Cost

The following maintenance costs shown in Table 2.5.3 will be borne by the GOL for 10 years after commencement of the operation.

Table 2.5.3 Operation & Maintenance for Project Road

Period	Works	Specification		Unit	Quantity	Unit Price (Kip)	Frequency	Total (Kip)
Routine Maintenance (Every year)	Cleaning, etc.		Every year	Lot	1	4,400,000	10	44,000,000
	Repair of Pave.	1% of total area	Every year	m^2	231	120,000	9	249,976,800
	Sub Total							293,976,800
Periodic Maintenance (10th year)	Repair of Pave.	As overlay	Once every 10 years	m^2	20,666	120,000	1	2,479,920,000
	Slope repair	5% of total area	Every 5 years	m^2	1,047	24,000	2	50,232,000
	Marking		Every 5 year	m	7,375	4,000	2	59,000,000
	Repair of Pave. on bridge	As overlay	Once every 10 years	m^2	2,480	120,000	1	297,600,000
	Gabion	5% of total area	10years	m^2	403	320,000	1	128,800,000
	Sub Total							3,015,552,000
Operating Cost		10% of the sub total		Lot				330,952,880
10 years total operating and maintenance cost								3,640,481,680
(average maintenance cost per year)								364,048,168

Chapter 3 Project Evaluation

3.1 Preconditions

The preconditions necessary for Project implementation will be as follows. Furthermore, the compensation on land acquisition and the documents approved by the relevant organizations are necessary in principle to be completed by the time of the announcement of prequalification for contractors after the E/N.

- ✧ In order to implement the project, land acquisition of approximately 0.81 ha is required by the MPWT (DOR). Land acquisition and payment of compensation shall be completed by the time of the announcement of prequalification for contractors.
- ✧ MPWT (DOR) should conduct an IEE and obtain environmental clearance from the DoNRE for the implementation of the project.
- ✧ MPWT (DOR) should support and coordinate, as the executing agency, the conduct of UXO discovery and acquisition of permission for the development of a rock quarry and borrow pit as designated by the contractor.
- ✧ Cooperation and support for customs clearance and tax exemption for procurement materials and equipment (expedition of the approval process for the list of imported materials and equipment) for the project needs to be executed rapidly.
- ✧ VAT (10%) is currently exempted from the Japan grant aid project that should be kept during the implementation of the project.
- ✧ After completion of the project, maintenance work by MPWT (DOR) is required in order to ensure smooth traffic and the life of the road and structures for the project. MPWT (DOR) should secure the personnel and budget necessary for sustainable maintenance work.

3.2 Necessary Inputs by Recipient Counutry

Necessary inputs for the realization and sustainability of the Project effects are as follows:

- ✧ Lao PDR needs to secure the budget described in Chapter 2.3 in order to execute the project smoothly.
- ✧ To ensure the permanent function of the bridges for project, Lao PDR needs to place to personnel continuously perform maintenance work and secure the budget mentioned in Chapter 2.4 after the completion of the project.
- ✧ The MPWT (DOR) needs to procure and conduct an environmental and social considerations survey (IEE) in order to subsequently obtain environmental clearance for secure land acquisition and implementation of the project.

3.3 Important Assumptions

Important assumptions for the realization and sustainability of the Project effects are as follows:

- ✧ Conduct sustainable maintenance (routine and periodic maintenance) to ensure the soundness of the facility as expected in the design based on a further increase of traffic volume after completion of the project located on ASEAN-EWEC
- ✧ Ensure a strict enforcement for control of overloaded vehicles to secure design life of the bridges with its approach roads designed in conformity with the live load of AASHTO (HS25-44)
- ✧ Encounter neither unpredicted flooding and variation of environmental change around the project site nor change for any relevant legislation by the Lao Government
- ✧ Complete improvement of roads and replacement or reinforcement of bridges on NR9 in addition to the project to ensure a smooth traffic on NR9.

If the above important assumptions are conducted properly, the intended Project effects shall be realized.

3.4 Project Evaluation

3.4.1 Relevance

National Road No. 9, including both the Xe Kum Kam and the Xe Tha Mouak bridges, is a part of the East-West Economic Corridor (EWEC) connecting Mawlamyine in Myanmar, northeast Thailand, Savannakhet, and Da Nang in Vietnam. The EWEC runs through inland cities such as Savannakhet and northeast Thailand to access international markets via the international seaport in Da Nang. In addition, 185 thousand people in the eastern part of Savannakhet use NR9 to access the provincial center, namely, Kaysone Phomvihane District, and these bridges are important facilities for the daily activity of village people in the vicinity of the project.

In this study, adequacy of the projects is considered in terms of the following aspects.

(1) Coordination of the project with the policy in Lao PDR

The 8th National Socio-Economic Development Plan (NESDP) 2016-2020 is established based on the evaluation of achievements of the previous 5-year national development plan, namely, the 7th NESDP (2011-2015), and is approved by the National Assembly of Lao PDR. In the 8th NESDP, priority activities in the infrastructure sector include “Upgrade roads that connect to the neighboring countries such the Mekong Sub-region corridors (GMS), Asian Highway, East-West Corridor, North-South Economic Corridor” and “Create comprehensive logistics systems by focusing on 4 areas: Natoei, Savannakhet, Vientiane and Champasak” in order to achieve outcome 1, namely, “Sustained, inclusive economic growth with economic vulnerability (EVI) reduced to

levels required for LDC graduation and consolidated financial, legal and human resources to support growth." In accordance with the increasing importance of Savannakhet as a logistical center, strengthening National Road No. 9, especially, upgrading the bridge load-carrying capacity of Xe Kum Kam and Xe Tha Mouak bridges is required and corresponds to the objective and context in the 8th NESDP.

(2) Importance of the bridges in the road netowrk in Lao PDR

The GMS consists of six countries, namely, Thailand, Vietnam, Laos, Myanmar, and China, and was established in 1992, initiated by the ADB to encourage the provision of a regional transport network and economic growth promoted by regional trade and investment. For regional cooperation, economic corridors have decided to connect major cities in the GMS, and improvement of the transportation infrastructure project such as international road networks is planned and implemented. National Road No. 9 including Xe Kum Kam and Xe Tha Mouak Bridges is a part of the EWEC and was connected with Thailand through opening the 2nd Thai-Lao Friendship Bridge (2006). In May 2015, National Road No. 12 was included in the EWEC and competed with National Road No. 9 as the transport route between Thailand and Vietnam. National Road No. 9, however, connects the international seaport in Da Nang, the central region of Vietnam, Savan-Seno Special Economic Zone in Savannakhet, and northeast Thailand has a population of approximately 21 million in 2010, remains an important road of EWEC and expected to contribute to liberalization of regional logistics, person trip and services in accordance with ASEAN Economic Community (AEC) in the end of 2015.

The Xe Kum Kam and Xe Tha Mouak bridges are necessary for the people in eastern Savannakhet Province to access to district hospital or provincial hospital in Kaysone Phomvihane District, which influences about 185 thousand people.

(3) Upgrade of the bridge load-carrying capacity

Existing restrictions of axle load 9.6 ton on the Xe Kum Kam and Xe Tha Mouak bridges are improved by the projects to 11.0 ton corresponding to deregulation of the axle load of heavy vehicles in accordance with an agreement with Thailand and Vietnam in 2012.

(4) Breakthrough of technological difficulties

In terms of the steel-concrete composite slab bridge, which is the bridge type proposed in the study, Japanese companies have technical advantages. Steel-concrete composite slab bridges enable a lower girder height against rivers with high water levels and reduce influence on access roads and the surrounding environment, and constructed rapidly to avoid construction work in the rainy season. In addition, Xe Tha Mouak bridge will require temporary closure during construction due to replacement of the bridge at the same place. It is expected that a steel-concrete composite slab

bridge will contribute to early recovery of traffic flow by shortening the erection time for the superstructure.

(5) Impact on the social environment

There are no historical and cultural structures or remains or settlements of ethnic groups at the project sites and surrounding areas. The National Biodiversity Conservation Area (NBCA) is distant from the project sites and influence on the natural environment is minimal.

As for the results of the environmental impact assessment, a serious impact such as land acquisition and resettlement of households is not considerable.

(6) Urgency of the projects

Xe Kum Kam and Xe Tha Mouak Bridges, which have a residual bend and angular main girders at the bridge piers caused by lower strength of the main girder and a structural defect, are expected to be reconstructed in terms of traffic safety. The bridges were built 30 years earlier, and heavy vehicles exceeded designed axle load of the existing bridges because of current deregulation through the bridges. Urgent measures, therefore, against aging of the bridges and heavy-load vehicles exceeding existing axle load capacity are expected.

(7) Coordination of the project with policy in Japan

To achieve the Millennium Development Goals (MDGs) in Laos and national goals such as graduating from the Least Developed Country (LDC) index by 2020, the Japanese Government provides support to Lao PDR regarding four priority areas in accordance with its country assistance policy prepared by Ministry of Foreign Affairs of Japan, namely, (i) development of an economic and social infrastructure, (ii) agricultural development and forest conservations, (iii) improvement of the educational environment and (iv) human resource development and improvement of health care services.

The projects, reconstruction of Xe Kum Kam and Xe Tha Mouak Bridges, correspond to the context of priority area (i) development of economic and social infrastructure, namely, “Japan extends its assistance which is instrumental to strengthening ASEAN connectivity including development of infrastructure such as roads, bridges, and airports, environmental improvement in investment and trade such as a logistics center which will enhance inroads of Japanese enterprises into the Lao market.”

3.4.2 Effectiveness

(1) Quantitative Effect

The quantitative effects expected by the projects are summarized in following table.

Table 3.4.1 Quantitative effects by the Projects

Index	Base Line (2015)		Target in 2022 (3 years after completion)	
AADT (Large class) (Vehicles per day)	Xe Kum Kam Xe Tha Mouak	456 452	Xe Kum Kam Xe Tha Mouak	726 724
AADT (All class) (Vehicles per day)	Xe Kum Kam Xe Tha Mouak	1,840 4,861	Xe Kum Kam Xe Tha Mouak	2,966 8,358

Source: JICA Study Team

(2) Qualitative Effect

Qualitative effects expected from the grant-aid project are listed below:

- ✓ Improvement of safety of the bridges: by the implementation of the projects, the road surface condition of bridges and access roads are improved, road safety and comfort for through traffic are also improved. Xe Tha Mouak Bridge has the same width of sidewalks as the existing bridge; therefore, pedestrian safety is secured.
- ✓ Improvement of reliability of the bridges: about 185 thousand people in the eastern part of Savannakhet Province use the bridges to access the provincial center or Vientiane Capital; therefore, improvement of reliability of the bridges guarantees such daily activities for people.
- ✓ Enhancement of domestic and international logistics network: by improving the bridge load capacity in accordance with regional standards agreed to with Thailand and Vietnam, Xe Kum Kam and Xe Tha Mouak bridges are expected to contribute logistically to the EWEC.

Consequently, the projects are expected to be effective.