Kingdom of Cambodia
Ministry of Public Works and Transport (MPWT)

THE PREPARATORY SURVEY ON THE PROJECT FOR URGENT REPLACEMENT OF BRIDGES IN FLOOD-PRONE AREAS IN THE KINGDOM OF CAMBODIA

FINAL REPORT

August 2017

Japan International Cooperation Agency (JICA)

CTI Engineering International Co., Ltd.

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PREFACE

In response to the request from the Kingdom of Cambodia, the government of Japan decided to conduct the "Preparatory Survey on the Project for Urgent Replacement of Bridges in Flood-Prone Areas of the Kingdom of Cambodia" and entrusted the survey to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a survey team headed by Mr. Ryohei Watanabe of CTI Engineering International Co., LTD. from May 2016 to July 2017.

The survey team held a series of discussions with the officials concerned of the Kingdom of Cambodia, and conducted field studies associated with various engineering surveys. The results and findings of the field studies and the analysis results carried out in Japan are compiled in this report.

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 Kingdom of Cambodia for their close cooperation extended to the survey team.

August, 2017

Itsu ADACHI
Director General
Infrastructure and Peacebuilding Department
Japan International Cooperation Agency

SUMMARY

1. Background and outline of the Project

From the Mekong River in Cambodia, it benefits from the formation of fertile soil and the fishing in the inland water. On the other hand, floods occur frequently, the percentage of the population which risked to the death by flooding is about 12% and the risk percentage against the economic scale (GDP) by flood is around 14%, These proportions are subordinate to the world.

Especially in the recent year seasonal fluctuation of water level intensified, climate change also affected, and drought and flooding are occurring repeatedly. At the flooding in 2011, due to heavy rain in Cambodia and upstream Mekong River, neighboring area of Phnom Penh flooded extensively, more than 250 people dead, 1.5 million victims and 17% of rice field were damaged. Also in the flooding in 2013, 188 people dead, more than 1.7 million people affected, more than 140,000 people evacuated, as well as infrastructure such as roads and bridges suffered.

In Cambodia, "National Strategic Development Plan (NSDP) 2014 - 2018 (NSDP: National Strategic Development Plan)" that has been enacted since 2014, establishment of good governance as the main policy is forwarded. "Reconstruction and improvement of infrastructure" sets the main issue under this policy, the improvement of roads and urban infrastructure is proceeded by the own funds and support from other countries.

Under the above circumstances, Government of Cambodian (GOC) in June 2015 made a request to Government of Japan (GOJ) for a Grant Aid Assistance to implement “The project for Urgent Replacement of Bridges in Flood- Prone Areas” on National Road No. 11 and No. 73.

2. Survey Result and Contents of the Project

The original request made by the GOC is to replacement of five bridges on National Road No. 11 and No. 73 shown in bellow table.

Table-1 Original Request from the GOC

Road Name	Name of Bridge	Length of Existing Bridge*
National Road No.11	Ba Baong No.1 Bridge	80m (100m)
	Ba Baong No.2 Bridge	80m (96m)
National Road No.73	Kompong Raing Bridge	150m (150m)
	Prek Chhloung Bridge	120m (130m)
	Peam Te Bridge	150m (170m)

* The bridge length of the existing bridge is the measured value by the investigation team and there are some differences from the content of the request letter. Number in parentheses is the bridge length in request form from Cambodia side.

Regarding the above request, before conducting preparatory survey, the GOC suggested to Japan side to undertake replacement of Kompong Raing Bridge (bridge length 150 m) on National Route

73 by GOC, not by Japan side, in consideration of urgency and replacement of three bridges, such as Prek Sandan (bridge length 30 m), Prek Rus bridge (bridge length 54 m) and Anlong Khle bridge (bridge length 42 m) which are the temporary bridges on National Road No.73, will be included in the Project instead of Kompong Raing Bridge. The Japanese side accepted to the GOC suggestion.

From the abovementioned item, the request is revised to seven bridges from original five bridges as shown below table.

Table-2 Revised Request from the GOC

Road Name	Name of Bridge	Length of Existing Bridge*
National Road No.11	Ba Baong No.1 Bridge	80m (100m)
	Ba Baong No.2 Bridge	80m (96m)
National Road No.73	Prek Sandan Bridge	30m (30m)
	Prek Rus Bridge	54m (48m)
	Anlong Khle Bridge	42m (45m)
	Prek Chhloung Bridge	120m (130m)
	Peam Te Bridge	150m (170m)

* The bridge length of the existing bridge is the measured value by the investigation team and there are some differences from the content of the request letter. Number in parentheses is the bridge length in request form from Cambodia side.

In response to the request above from the GOC, JICA dispatched the survey team to Cambodia from May 2016 to June 2017, its schedule is presented in Table-3.

Table-3 Schedule of Site Survey

Site Survey	Period
1st Site Survey	May 10th, 2016 – July 9th, 2016
2nd Site Survey	January 18th, 2017 - January 27th, 2017
3rd Site Survey	March 7th, 2017 - March 16th, 2017
4th Site Survey	June 14th, 2017 - June 23th, 2017

As a result of the field survey, the project has confirmed the relevance and effectiveness of the above-mentioned replacement of the 7 bridges and the project scope finally are as shown in table-4.

Table-4 Scope of the Project

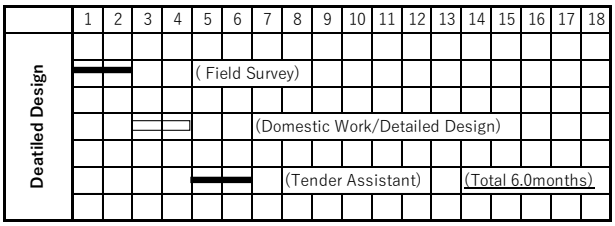
Bridge	Road	Superstructure Type, Bridge Length (L_B), Width	Total Length (L_T) (Approach road + Bridge)
Ba Baong No.2	NR11	3-span continuous PC I girder L=105m Road width 3.5m, Marginal strip 1.5m, No walkway	Total length = 720m Appr. road 328m (south side) Appr. road 287m (north side)
Ba Baong No.1	NR11	3-span continuous PC I Girder L=105m Road width 3.5m, Marginal strip 1.5m, No walkway	Total length = 685m Appr. road 289m (south side) Appr. road 291m (north side)

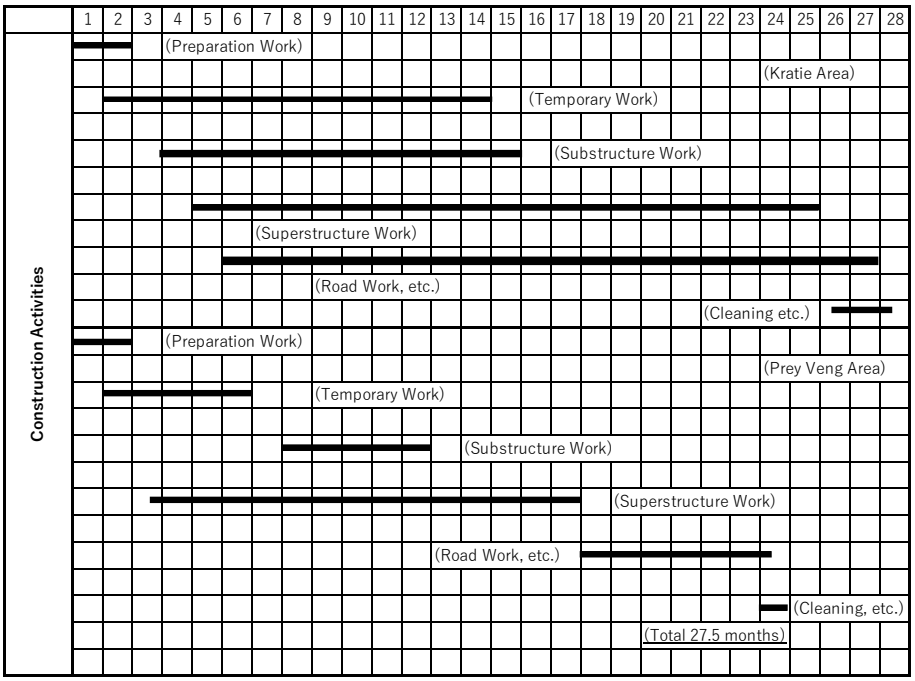
Bridge	Road	Superstructure Type, Bridge Length (L_B), Width	Total Length (L_T) (Approach road + Bridge)
Prek Sandan	NR73	Simple PC I girder, L=35m Road width 3.5m, Marginal strip 1.5m, No walkway	Total length = 450m Appr. road 213m (south side) Appr. road 202m (north side)
Prek Rus	NR73	2-span continuous PC I girder L=62m Road width 3.5m, Marginal strip 1.5m, No walkway	Total length = 505m Appr. road 240m (south side) Appr. road 203m (north side)
Anlong Khle	NR73	2-span continuous PC I girder L=48m Road width 3.5m, Marginal strip 1.5m, No walkway	Total length = 480m Appr. road 210m (south side) Appr. road 222m (north side)
Prek Chhloung	NR73	4-span continuous PC I girder, L=140m Road width 3.5m, Marginal strip 0.6m, Walkway1.0m	Total length = 554m Appr. road 200m (west side) Appr. road 214m (east side)
Peam Te	NR73	5-span continuous PC I girder, L=175m Road width 3.5m, Marginal strip 0.6m, Walkway1.0m	Total length = 700m Appr. road 326m (south side) Appr. road 199m (north side)
Total 7 bridges, total bridge length 670m, total project length 4,094m			

3. Project Implement Schedule

Table-5 represents the overall implementation schedule for detailed design and project construction for the bridge replacement work. The duration of the detailed design is estimated to be 6.0 months while the construction period is estimated to be 27.5 months, total of 33.5 months.

Table-5 Implementation Schedule





4. Project Evaluation

(1) Quantitative Effect

The bridges to be replaced in the Project are temporary bridges, and it is in dangerous situation now due to advanced deterioration and traffic of overloaded vehicles. Therefore, by implementation of the Project will be expected direct effect such as prevention of falling bridge (avoidance of human life loss). Moreover, it will be secured smoothness and safety of traffic and logistic by widening road and increasing load bearing capacity.

The quantitative effects expected by the implementation of the project is shown in Table-7.

Table-7 Expected Quantitative Effects by the Project

Indicator		Reference value (Measured in 2016)	Target value (2023) 【3 years after project completion】
Pause time before the bridge (Sec/Vehicle) *The average value of the target bridge on the weekday	NR 11	114	0
	NR 73	42～162	0
Shortening transit time of NR 11 and NR 73 (Min.) *Average value of outbound / inbound at peak time and off-peak time on weekdays	NR 11 (Prey Veng - Neak Loueng)	46	40
	NR 73 (Kratie - Boundary between Kratie Province and Tboung Khmum Province)	120	107
Number of freight vehicles of 15 tons or more (Vehicles / day)	NR 73 *Bridges on NR11 are regulated by 25 tons	0 (163)*1 *1: Actual number of vehicles of 15 ton or more measured in 2016	260
Shortening time by conversion from NR7 to NR73 of freight vehicles of 15 tons or more (Min.)	NR 73	214 (through NR 7)	140 (through NR 73)
Passenger (Mil. people / year) *From OD traffic survey of the subject area on one day (weekday)	NR 11	3.65	3.76
	NR 73	6.29	9.66
Cargo volume (Thou. Ton / year) *From OD traffic survey of the subject area on one day (weekday)	NR 11	371	504
	NR 73	325	721

(2) Qualitative Effect

i) Vulnerability to natural disasters in the project area is reduced

ii) Smoothness and safety to traffic and pedestrians improves by improvement of the load-bearing capacity and widening bridge width.

iii) Living environment in rural area will be improved by improvement of safety of the road, secure stable traffic and logistic, and promotion of local economic revitalization.

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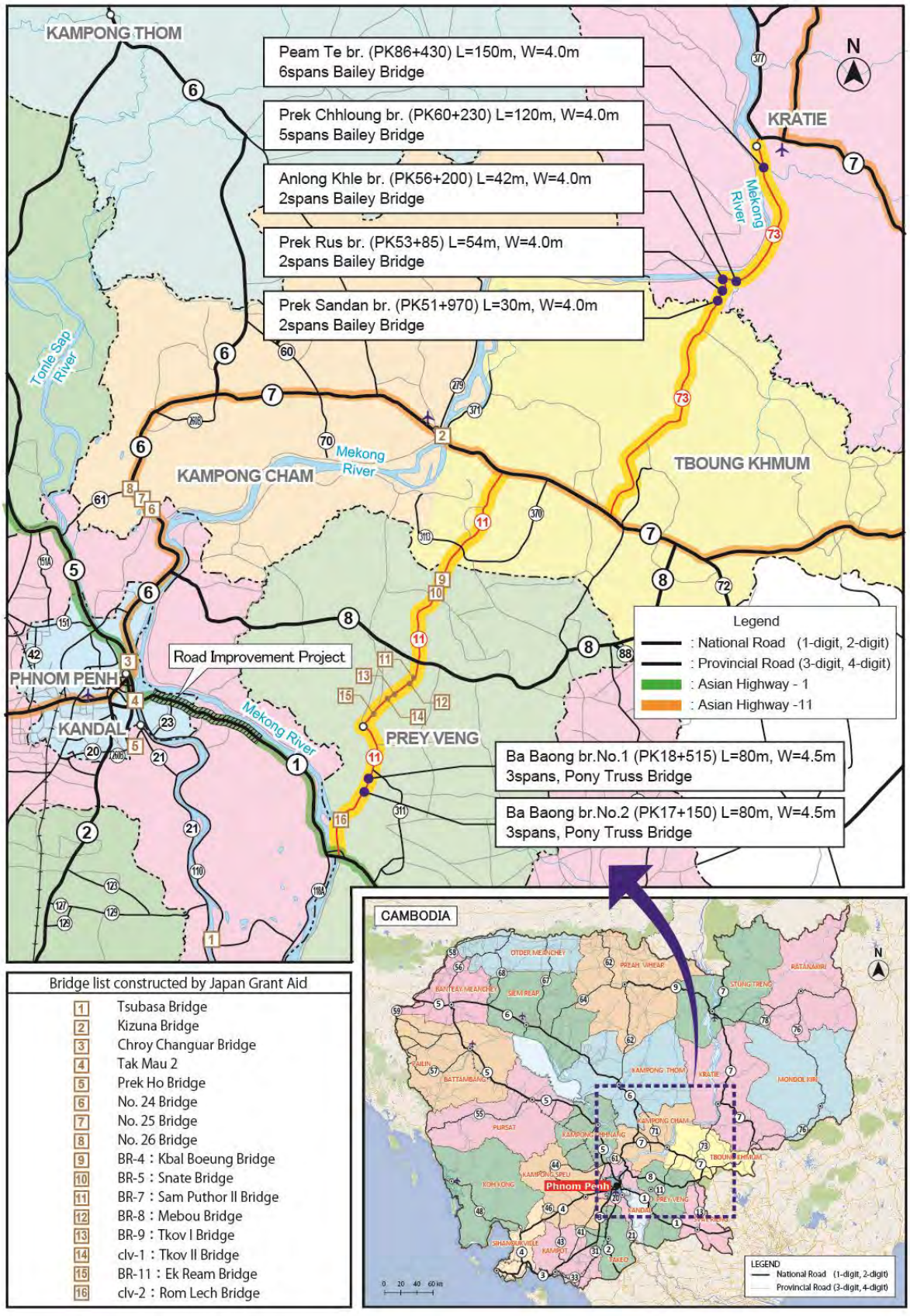

Bridge list constructed by Japan Grant Aid

1	Tsubasa Bridge
2	Kizuna Bridge
3	Chroy Changuar Bridge
4	Tak Mau 2
5	Prek Ho Bridge
6	No. 24 Bridge
7	No. 25 Bridge
8	No. 26 Bridge
9	BR-4 : Kbal Boeung Bridge
10	BR-5 : Snate Bridge
11	BR-7 : Sam Puthor II Bridge
12	BR-8 : Mebou Bridge
13	BR-9 : Tkov I Bridge
14	clv-1 : Tkov II Bridge
15	BR-11 : Ek Ream Bridge
16	clv-2 : Rom Lech Bridge

PROJECT LOCATION MAP

Perspective-1　Babaong No.2 Bridge

Perspective-2　Peam Te Bridge

Figure

Table

Abbreviations

AADT	:	Annual Average Daily Traffic
AASHTO	:	American Association of State Highway and Transportation Officials
ADB	:	Asian Development Bank
ARAP	:	Abbreviated Resettlement Action Plan
D/D	:	Detailed Design
DMS	:	Detailed Measurement Survey
DPWT	:	Department of Public Works and Transport
EIA	:	Environmental Impact Assessment
E/N	:	Exchange of Notes
ESAL	:	Equivalent Single Axle Loadings
G/A	:	Grant Agreement
GDP	:	Gross Domestic Product
HWL	:	High Water Level
IEE	:	Initial Environmental Examination
IOL	:	Inventory of Loss
IMF	:	International Monetary Fund
JICA	:	Japan International Cooperation Agency
MEF	:	Ministry of Economic and Finance
MPWT	:	Ministry of Public Works and Transport
MRC	:	Mekong River Commission
PAPs	:	Project Affected Persons
PRW	:	Provisional Road Width
RAP	:	Resettlement Action Plan
RCS	:	Replacement Cost Study
RID	:	Road Infrastructure Department
ROW	:	Right of Way
WB	:	World Bank

Chapter 1 Background of the project

1.1 Introduction

From the Mekong River in Cambodia, it benefits from the formation of fertile soil and the fishing in the inland water. On the other hand, floods occur frequently, the percentage of the population which risked to the death by flooding is about 12% and the risk percentage against the economic scale (GDP) by flood is around 14%, These proportions are subordinate to the world.

Especially in the recent year seasonal fluctuation of water level intensified, climate change also affected, and drought and flooding are occurring repeatedly. At the flooding in 2011, due to heavy rain in Cambodia and upstream Mekong River, neighboring area of Phnom Penh flooded extensively, more than 250 people dead, 1.5 million victims and 17% of rice field were damaged. Also in the flooding in 2013, 188 people dead, more than 1.7 million people affected, more than 140,000 people evacuated, as well as infrastructure such as roads and bridges suffered.

Over the long term, the National Road No. 11 and No. 73 which are the objective areas of this Project, flooded and the pavement damaged seriously. National Road No. 11 and No. 73 are main trunk roads located on the floodplain areas at the left bank of the Mekong River, as shown in the Project Map at the opening page. These are rink to National Trunk Road No. 1, No. 7 and No. 8 detouring Phnom Penh, and finally connect to Vietnam and Thailand.

In addition, it also has a function as a detour route when National Road No. 1 is blocked due to floods etc. It means an important role to alleviate the vulnerability of the road network from the natural disasters. However, in the object roads, there are some temporary bridges which have a high risk of collapse, with the cars unable to pass each other due to narrow carriageway.

In Cambodia, "National Strategic Development Plan (NSDP) 2014 - 2018 (NSDP: National Strategic Development Plan)" that has been enacted since 2014, establishment of good governance as the main policy is forwarded. "Reconstruction and improvement of infrastructure" sets the main issue under this policy, the improvement of roads and urban infrastructure is proceeded by the own funds and support from other countries.

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1.2 Requested Scope

The original request made by the GOC is to replacement of five bridges on National Road No. 11 and No. 73 shown in bellow table.

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* The bridge length of the existing bridge is the measured value by the investigation team and there are some differences from the content of the request letter. Number in parentheses is the bridge length in request form from Cambodia side.

Regarding the above request, before conducting preparatory survey, the GOC suggested to Japan side to undertake replacement of Kompong Raing Bridge (bridge length 150 m) on National Route 73 by GOC, not by Japan side, in consideration of urgency and replacement of three bridges, such as Prek Sandan (bridge length 30 m), Prek Rus bridge (bridge length 54 m) and Anlong Khle bridge (bridge length 42 m) which are the temporary bridges on National Road No.73, will be included in the Project instead of Kompong Raing Bridge. The Japanese side accepted to the GOC suggestion.

From the abovementioned item, the request is revised to seven bridges from original five bridges as shown below table.

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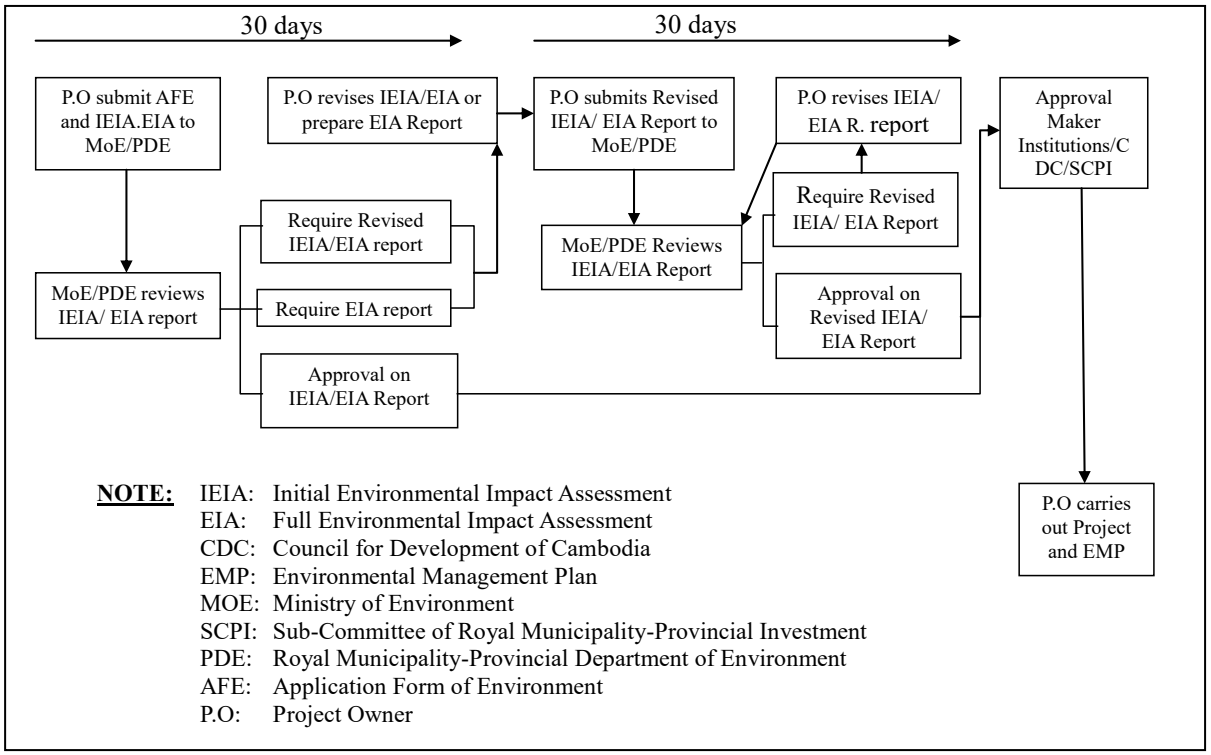
1.3 Environmental and Social Considerations

1.3.1 Environmental Impact Assessment System

Development projects with potential environmental impacts are obligated to conduct an Environmental Impact Assessment (EIA) in advance pursuant to the Chapter 3 in The "Law on Environmental Protection and Natural Resource Management, 1996". The types of projects and criteria for mandating an EIA are regulated in "Sub-decree on Environmental Impact Assessment Process, 1999". As regards road sector projects, national road construction projects with a length over 100 km and road bridge construction projects with weight over 30 tones require to conduct the EIA. Moreover, projects in protected areas also

require the EIA pursuant to "Protected Area Law, 2008"

The project with serious potential impacts must conduct the EIA. The project without serious potential impacts may conduct an Initial Environmental Impact Assessment (IEIA) and take a judgment of Ministry of Environment (MOE). Proponents of infrastructure projects conduct an IEIA at first, submit the IEIA report to MOE and take the judgement. If the study results and environmental considerations in the report are sufficient, the project is approved by MOR. If not sufficient, an EIA (Full EIA) is required. The EIA report is also submitted and taken the judgement by MOR.



Source: General Guideline for Conducting Initial and Full Environmental Impact Assessment Reports

Figure 1.3-1 IEIA/EIA Approval Procedure

1.3.2 Baseline of the Environmental and Social Condition

1.3.2.1 Vegetation

The 5 target bridges except for Peam Te bridge and Prek Chhloung bridge are located in agricultural area. Peam Te bridge and Prek Chhloung are located in urban or residential area. There are no protected areas, forests and wetlands where natural vegetation remains around the projects sites. Rare or endangered wildlife species that are important in biodiversity are unlikely to exist in the areas directly affected by the project. The vegetation around the target bridges is shown in the following Table.

Table 1.3-1 Vegetation around Project Site

Bridge Name	Outline	Dominant Tree Spices	Endangered Species
Ba Baong Bridge 1	There are no trees around the bridge. The vegetation is primarily shrubs with trivial vine.	-	No
Ba Baong Bridge 2	The bridge is located in flood-prone area with little tree/vegetation surrounding. It has only few trees at each side of the bridge growing along	*Pithecellobium dulce* *Tamarindus indica* *Samanea saman /Albizzia saman*	No

Bridge Name	Outline	Dominant Tree Spices	Endangered Species
	National Road. The vegetation is basically shrubs with minor vine.		
Prek Sandan	Surrounding of this bridge is plentiful of trees, shrubs, especially vine which climbs on trees.	*Bombax anceps pierre* *Ceiba pentandra* *Tectona grandis* *Peltophorum dasyrrhachis*	No
Prek Rus	The vegetation is same as Prek Sandan's one. There are many trees, shrubs and vines around the bridge.	*Combretum quadrangulare* *Peltophorum dasyrrhachis*	No
Anlong Khle	Surrounding of this bridge is plentiful of vegetation which is mainly shrubs and vines. Mimosa pigra that is an alien shrub species exists dominantly at both sides of the bridges.	*Peltophorum dasyrrhachis* *Tamarindus indica*	No
Prek Chhloung	The bridge is located in residential area. Gardening plants are dominant around the bridge.	*Chrysalidocarpus lutescens* *Samanea saman /Albizzia saman*	No
Peam Te	The bridge is located in residential area. Gardening plants are dominant around the bridge.	*Pithecellobium dulce* *Samanea saman /Albizzia saman*	No

1.3.2.2 Fishery Activity

Interview surveys to fisherpersons living around the target bridges were conducted to identify their fishery activates and fish species. Depending on the bridge location, the fishery activates are divided into the following 3 types.

1. Ba Baong 1 and Ba Baong 2 Bridge (National Road 11)

The bridges are located far away from households and surrounded by paddy field. In dry season, the water level at these areas is very low, stagnant or even dry up sometimes. In rainy season, the whole area surrounding the bridge is normally flooded due to high water level of lower Mekong River. As a result of Mekong River flooding, a variety of fish species has been identified at these two areas. The most dominant species are in the family of Belontidae, Toxotidae, Siluridae, Bagridae, and Cyprinidae. In addition to these dominant species, the endangered species that are listed in "Sub-decree on endangered freshwater fishery species in the Lower Mekong Basin" may exist in the area. The people living around the bridge are mostly seasonal fisherpersons. In the dry season, they do farming while they do fishing in the rainy season. These people are basically family fisherpersons who do fishing with net and some other traditional instruments. They could catch the fishes of about 2kg to 3kg per day for their consumption or sometimes selling to others in the village.

2. Prek Sandan, Prek Rus and Anlong Khle Bridge (National Road 73)

The bridges are located relatively far away from households and surrounded by paddy field. In dry season, the water level at these three bridges is very low, stagnant or even dry up. In rainy season, the area surround the bridge is normally flooded due to high water level of Mekong River. As a result of Mekong River flooding, a variety of fish species has been identified at these areas in both rainy and dry seasons (in lake or pond). In addition to common dominant species, the endangered species may exist in the area. The people living nearby the bridge are mostly farmer and construction worker. In dry

season, they work as construction worker. In rainy season, they go fishing after their work or during their free times. They can catch fishes around 0.5kg to 1kg per day for only eating in their family.

3. Prek Chhloung and Peam Te Bridge (National Road 73)

These bridges are located close to the main Mekong River course and receiving water directly from the main Mekong River in the whole year long. As the river always has water flowing in the whole year, there were always fishery activities conducted in the river in both dry and rainy seasons. Most of the people living around the bridge are seller, fisherperson, and seasonal fisherperson (They catch fishes after their work) and they live near the bridge. Some of them use nets to catch fishes for their daily life by selling them to market in the village. For example, they often catch fishes around 1kg to 2kg per day for seasonal fisherpersons and 4kg to 6kg per day for fisherpersons in the dry season but they could catch more than that in the rainy season. The most dominant species are in family of Belontidae, Cyprinidae, Channidae, Belontiidae, and Helostomatiedae. Some endangered species are also found in the areas every year. Irrawaddy dolphin (*Orcaella brevirostris*) listed as "Vulnerable species" in "International Union for Conservation of Nature Red List" has been identified in the main Mekong River.

1.3.2.3 Water Quality

Water quality in rivers or channels around the 7 target bridges is shown in the following Table. The BOD (Biochemical Oxygen Demand) levels that is an indicator of organic matter resolved biologically are low, on the other hand, the COD (Chemical Oxygen Demand) level that is an indicator of persistent organic matter and inorganic matter are high in all revers and channels. Total Coliform are found in all revers and channels. The main pollutant sources are likely to be domestic waste water or feces from livestock.

Table 1.3-2 Result of Water Quality Analysis

Sampling Date: 9~10 July, 2016

Bridge Name	pH	BOD5 (mg/L)	COD (mg/L)	Total Suspended Solid (mg/L)	Total Coliform (cfu/100mL)
Ba Baong Bridge 1	6.8	0.4	20	312	>300
Ba Baong Bridge 2	6.5	0	12	232	>300
Prek Sandan	6.2	1.3	18	79	>300
Prek Rus	7.0	2.0	17	98	>300
Anlong Khle	7.0	2.7	30	106	>300
Prek Chhloung	7.0	1.3	12	42	>300
Peam Te	6.5	1.3	28	238	>300
Environmental Standard	6.5 - 8.5	1 - 10	1 – 8 (Lake)	25 - 100	< 5,000 (River) < 1,000 (Lake)

1.3.2.4 Noise Level

Noise levels at both sides (on abutment) of the target 7 bridges are shown in the following Table. The 5 target bridges except for Peam Te bridge and Prek Chhloung bridge are located in silent agricultural

area. Peam Te bridge and Prek Chhloung are located in urban or residential area without noise sources such as factories or entertainment facilities. The measured noise levels are mainly caused by vehicle traffic. The measured noise levels are higher than Cambodian maximum permitted noise level (Residential area Daytime: 60 dB, Commercial area Daytime: 70 dB) at all measured points. The measured noise levels include impact noise over 90 dB caused by knocking bridge steel bars besides common automobile noise (engine sound and frictional sound between tires and road surface). It is known that "L Aeq Levels" used environmental evaluation indicate higher than actual nose level when impact noise was recorded.

Table 1.3-3 Noise Level

Bridge Name	Date and Time	Measuring Point	L Aeq (dB)	Max. (dB)	Min. (dB)
Ba Baong 1	14 Jun. 2016 AM11:00~12:00	Neak Loeang side	78	90	48
		Prey Veng side	77	92	49
Ba Baong 2	14 Jun. 2016 AM11:00~12:00	Neak Loeang side	83	98	49
		Prey Veng side	72	88	43
Prek Sandan	10 Jun. 2016 AM10:00~11:00	NR 7 side	81	91	40
		Krong Kracheh side	91	109	39
Prek Rus	10 Jun. 2016 AM11:00~12:00	NR 7 side	76	89	49
		Krong Kracheh side	86	101	45
Anlong Khle	10 Jun. 2016 AM11:00~12:00	NR 7 side	87	97	46
		Krong Kracheh side	101	119	48
Prek Chhloung	10 Jun. 2016 AM12:00~PM1:00	NR 7 side	80	93	49
		Krong Kracheh side	99	117	39
Peam Te	10 Jun. 2016 PM1:00~PM2:00	NR 7 side	78	89	45
		Krong Kracheh side	88	105	50

1.3.3 Potential Impact

The potential environmental and social impacts of the project is shown in the following Table.

Table 1.3-4 Potential Impacts

No.	Impact Item	Assessment		Reason / Remarks
		Pre-Construction Phase Construction Phase	Operation Phase	
Pollution				
1	Air pollution	B-	B±	**Construction Phase::** ・ Operation of construction equipment will generate dust and emission gas. ・ Traffic congestion in construction site will cause increase in exhaust gas from vehicles. ・ Dust will occur in borrow pit and quarry site. **Operation Phase:** ・ In the future, total amount of air pollutant caused by vehicle exhaust gas will increase following the increase in traffic volume. ・ However, because of improved traffic efficiency, the amount may be reduced compared to without project.
2	Water pollution	B-	C-	**Construction Phase:** ・ Turbid water caused by construction works, especially bridge constructions, is likely to affect existing surface water resources. ・ In case of accidental massive leaking of fuel or oil, water pollution including ground water may occur. ・ In case of inadequate management in borrow pit and quarry site, turbid water from borrow pit and quarry site by rainfall may cause surface water contamination. **Operation Phase:** ・ Soil runoff due to heavy rain may occur in filling or steep slope sections and turbid water may cause surface water contamination. ・ In case of inadequate management or recovery in borrow pit and quarry site, turbid water from borrow pit and quarry site by rainfall may cause surface water contamination.
3	Waste	B-	D	**Pre-Construction Phase:** **Construction Phase:** ・ Construction waste including demolished existing bridges and general waste from construction office will be generated. **Operation Phase:** ・ Considerable impact on waste is unlikely to occur.
4	Soil pollution	D	D	**Construction Phase:** ・ Because materials to cause soil pollution will not be used in the construction works, soil pollution is unlikely to occur. **Operation Phase:** ・ Because materials to cause soil pollution will not be used in the maintenance works, soil pollution is unlikely to occur.

No.	Impact Item	Assessment		Reason / Remarks
		Pre-Construction Phase Construction Phase	Operation Phase	
5	Noise and vibration	B-	B+	**Construction Phase:** ・ Construction works is likely to increase in the noise and vibration level. ・ Noise and vibration will occur in borrow pit and quarry site. **Operation Phase:** ・ Because noise and vibration from existing temporary metal bridges will decrease, these levels on bridge sides will be reduced.
6	Ground subsidence	D	D	**Construction Phase:** **Operation Phase:** ・ Because pressure of loading on road will be low, subsidence is unlikely to occur.
7	Offensive odors	D	D	**Construction Phase:** ・ Impact of offensive odors from asphalt mixing plant will be limited. ・ Because materials and equipment to cause offensive odors will not be used in the construction works, offensive odors are unlikely to occur. **Operation Phase:** ・ Because vehicles with incomplete combustion as offensive odor sources are few, exhaust gas from vehicles is unlikely to cause offensive odors.
8	Bottom sediment	B-	D	**Construction Phase:** ・ Filled soil may be eroded by rain water and flow into rivers or streams, and accumulated on the bottom. **Operation Phase:** ・ Because the construction works will not include dredging works and drainage of wastewater containing heavy metal or high-level organic substances, impacts on bottom sediment are unlikely to occur.
Natural Environment				
9	Protected areas	D	D	**Construction Phase:** **Operation Phase:** ・ There are no protected areas in and around the project site.

No.	Impact Item	Assessment		Reason / Remarks
		Pre-Construction Phase Construction Phase	Operation Phase	
10	Ecosystem	B-	D	**Construction Phase:** ・ Roadside vegetation will be lost by construction works. ・ Turbid water caused by bridge construction is likely to affect aquatic life. ・ Irrawaddy dolphin may access the construction site in Prek Chhloung and Peam Te. **Operation Phase:** ・ Because the target bridges are located in well developed area such as agricultural land and urban area, considerable impacts on ecosystem are unlikely to occur.
11	Hydrology	B-	D	**Construction Phase:** ・ Water flow in the river or stream will be altered during construction works. ・ Soil sedimentation may interfere with surface water flow of rivers and streams. **Operation Phase:** ・ Impacts caused by newly reconstructed bridges on surface water flow of rivers and streams are unlikely to occur.
12	Geographical features	D	D	**Construction Phase:** **Operation Phase:** ・ Considerable topographical change is unlikely to occur in and around construction site and borrow pits.
Social Environment				
13	Resettlement/ Land Acquisition	B-	D	**Pre-Construction Phase:** ・ Resettlement of houses and land acquisition will be required in some construction sites. Number of affected structure Babaong Bridge 2 : 5 Prek Chhloung : 5 Peam Te : 7 **Construction Phase:** ・ Temporal lease of land will be required for construction yards. **Operation Phase:** ・ Additional physical resettlement and land acquisition will not be required.
14	Poor people	B-	D	**Pre-Construction Phase:** **Construction Phase:** ・ In case of inadequate compensation for resettlement, livelihood recovery of poor people will be difficult. **Operation Phase:** ・ Impact only on poor people is unlikely to occur.

No.	Impact Item	Assessment		Reason / Remarks
		Pre-Construction Phase Construction Phase	Operation Phase	
15	Ethnic minorities and indigenous peoples	D	D	**Construction Phase:** **Operation Phase:** ・ Because of replacement project of existing bridges in arterial roads, impact on culture and lifestyle of ethnic minorities is unlikely to occur.
16	Local economies, such as employment, livelihood, etc.	B±	B+	**Pre-Construction Phase:** ・ Land acquisition and resettlement may cause livelihood degradation of Project Affected Persons (PAPs). **Construction Phase:** ・ Construction will create job opportunities to local people as unskilled labor. ・ If local fishery and water transportation activities are conducted in and around construction sites, construction works may have impact on these activities. **Operation Phase:** ・ Reduction of travel time will contribute to local economies and promote local industries.
17	Land use and utilization of local resources	B-	B+	**Construction Phase:** ・ Residential areas will be shifted to Right of Way in some construction sites. **Operation Phase:** ・ Improved transportation will contribute to effective utilization of local resources.
18	Water usage	B-	D	**Construction Phase:** ・ Construction works are likely to affect existing agricultural canals and water usage. **Operation Phase:** ・ Impacts caused by newly constructed bridges on water usage are unlikely to occur.
19	Existing social infrastructures and services	B-	B±	**Pre-Construction Phase:** ・ Relocation or protection of existing utilities, such as electric poll, water pipe and optical fiber cable will be required. **Construction Phase:** ・ Temporary traffic congestion in and around construction site will occur. **Operation Phase:** ・ Access to social services will be improved owing to improvement of existing bridges. ・ Because the road surface in both sides of the new bridges will be higher owing to raising of the bridges, the traffic across national roads, pedestrians and riders of bicycle are likely to be disturbed.

No.	Impact Item	Assessment		Reason / Remarks
		Pre-Construction Phase Construction Phase	Operation Phase	
20	Social institutions such as social infrastructure and local decision-making institutions	D	D	**Construction Phase:** **Operation Phase:** ・ Because of replacement project of existing bridges in arterial roads, considerable impact on social institutions is unlikely to occur.
21	Misdistribution of benefits and damages	C-	D	**Pre-Construction Phase:** **Construction Phase:** ・ Misdistribution of benefit among PAPs may occur. **Operation Phase:** ・ Because of replacement project of existing bridges in arterial roads, considerable impact on misdistribution of benefit is unlikely to occur.
22	Local conflicts of interest	D	D	**Construction Phase:** **Operation Phase:** ・ Because of replacement project of existing bridges in arterial roads, considerable impact on local conflict is unlikely to occur.
23	Cultural heritage	B-	B-	**Construction Phase:** ・ Gate and outer wall in a relational facility, and monuments located in bridge sides are likely to be removed. **Operation Phase:** ・ Because retaining walls with 3~4m height will be constructed in front of Preah Chan Reachea Pagoda located at Prek Chhloung bridge (National Road 73), the entrance facing the national road is likely to be disturbed.
24	Landscape	D	D	**Construction Phase:** **Operation Phase:** ・ Because there are no protected scenic view areas, considerable impact on landscape is unlikely to occur.
25	Gender	D	D	**Construction Phase:** **Operation Phase:** ・ Considerable impact only on gender is unlikely to occur.
26	Children's rights	D	D	**Construction Phase:** **Operation Phase:** ・ Considerable impact only on children's rights is unlikely to occur.
27	Infectious diseases such as HIV/AIDS	D	D	**Construction Phase:** **Operation Phase:** ・ Because of replacement project of existing bridges in developed areas, considerable impact on infectious diseases is unlikely to occur.

No.	Impact Item	Assessment		Reason / Remarks
		Pre-Construction Phase Construction Phase	Operation Phase	
28	Working conditions (including occupational safety)	B-	D	**Construction Phase:** ・ Dust and emission gas caused by construction works may affect workers health. ・ Sanitary conditions around construction site may get worse due to waste from workers and toilet. ・ Because construction will include high-place works, labor accident including tumble accident may occur. **Operation Phase:** ・ Considerable impact on working conditions is unlikely to occur.
Other				
29	Accidents	B-	B-	**Construction Phase:** ・ Labor accidents may occur in construction site, especially in tree cutting, slope protection and bridge construction works. ・ Traffic accident may occur surrounding of construction site **Operation Phase:** ・ Traffic accident due to more traffic volume and faster vehicle speed may increase ratio of traffic accident.
30	Trans-boundary impacts or climate change	D	D	**Construction Phase:** ・ Operation of construction equipment will generate exhaust gas. ・ However, because the amount of exhaust gas will be limited, trans-boundary impacts including climate change will not occur. **Operation Phase:** ・ In the future, total amount of CO2 emission from vehicles will increase following the increase in traffic volume. ・ However, because the amount will be limited, trans-boundary impacts including climate change will not occur.

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected

* Impact Items refer to “JICA Guidelines for Environmental and Social Considerations April 2010”

1.3.4 Environmental Impact and Mitigation Measures

1.3.4.1 Key Environmental Impact

(1) Noise

Because hitting sounds over 90 dB from existing temporary metal bridges are include in the noise levels in addition to general automobile noise such as engine and friction sound between tiers and road surface around the target bridges, the levels of L Aeq are over the environmental standards. The noise level around the target bridges will decrease by about 5 dB owing to the newly constructed Prestressed Concrete bridges. For example, a noise level at a noise source is assumed to be set 85 dB, noise levels of the surrounding residential areas located 10 m of the source are estimated about 57 dB and likely to satisfy the standards (60 dB).

(2) Impact of on Ecosystem

Because identified plant species in the both banks of 7 target bridges are common or gardening species, impacts of the vegetation loss caused by the construction works on the ecosystem is likely to be very limited.

The target 7 bridges are located in flood areas of Mekong River. Because many fish inflow to the areas with flood in rainy season, endangered fish species may be identified in all over the flood areas. Because the Project that is replacement project of existing bridges does not cause hydrological changes and disturb migrations of fishes in rainy season, impacts on aquatic life in the operation phase are unlikely to occur.

Irrawaddy dolphin has been identified in the Mekong River abound Prek Chhloung and Peam Te. Usual habits of Irrawaddy dolphin are 20 km upstream zone of the bridges, where is a sightseeing spot. Irrawaddy dolphin may not migrate into feeder streams of Prek Chhloung and Peam Te.

(3) Impact of Construction Works on Fishery

Some local people, mainly farmers, around Ba Baong No.1 (NR 11), Ba Baong No.2 (NR 11), Prek Sandan (NR73), Prek Rus (NR73) and Anlong Khle (NR73) conduct fishery in the traditional way in rainy season. They mostly do these activities for enjoyment. The captured fishes are eaten up by themselves usually. Because the construction works will be mainly conduced in dry or low water season, the impact on the fishery is likely to be very limited.

On the other hand, some local people around Prek Chhloung (NR73) and Peam Te (NR 73) conduct fishery as their livelihood throughout the year. The construction works is likely to disturb these unlimited fishery activities.

(4) Impact of Rising Bridge

To secure vehicle travel in flood season, rising works of brides are required. Because the new Prek Chhloung bridge (NR73) located residential area will be put into approximately 2 m higher level than

the existing one, the new higher access road to the bridge will have an impact on the traffic crossing NR73. Moreover, the pedestrians and bicycle drivers will have bigger physical burdens. Because the new retaining wall with 3~4 m height will be constructed in front of Preah Chan Reachea Pagoda, the wall will have an impact on the entrance facing NR 73.

Layout of Left Bank (East Side)

Figure 1.3-2 Impact of Prek Chhloung Bridge

1.3.4.2 Mitigation Measures

The recommended mitigation measures for each identified impact item is shown in the following Table.

Table 1.3-5 Mitigation Measures

No.	Impact Item	Mitigation Measures	Cost (US$)
Pollution			
1	Air pollution	**Construction Phase:** ・ The contractor shall prepare and strictly implement dust control measures such as periodical water spray. ・ The contractor actively uses electrically-powered equipment. ・ The contractor shall maintain their construction equipment in adequate working conditions. ・ The contractor shall keep clean road surfaces. ・ The drivers of construction vehicles comply with speed limits to minimize road dust. ・ The contractor and supervision consultant shall provide prior notification to the local community on the schedule of construction activities. ・ The supervision consultant shall monitor dust, exhaust gas and complaint from the local people. If the local residents and pedestrians complain about the dust and gas, the supervision consultant and contractor should reconsider the construction technique and method. **Operation Phase:** ・ Air quality monitoring system in local cities is to be prepared in the future. ・ The regulations on emission gas and fuel quality should be strengthened as needed.	Included in construction and maintenance cast
2	Water pollution	**Construction Phase:** ・ Main construction works shall be concentrated in dry period. ・ To avoid oil leak, the contractor shall maintain their construction equipment in adequate working conditions. ・ The contractor shall strictly control waste oil and other waste. ・ The contractor will be prohibited from washing the construction tools along the rivers. ・ The supervision consultant shall consider the proper drainage plans in advance. ・ The supervision consultant and contractor should monitor and control the turbid water. If the results exceed the allowable limits, the supervision consultant and contractor should reconsider the construction technique and method. **Operation Phase:** ・ The road administrator shall monitor conditions in the riverbank and abandoned borrow pits. If the condition has a risk of soil erosion, the administrator should consider and implement the countermeasures.	Potable water quality meter: 4,000 Others: Included in construction and maintenance cast
3	Waste	**Pre-Construction Phase:** ・ PMU (Project Management Unit) in MPWT should have meetings with local government to discuss disposal methods for demolished structures, and prepare and strictly implement the proper methods.	Included in construction cast

No.	Impact Item	Mitigation Measures	Cost (US$)
		Construction Phase: ・ The contractor shall prepare and strictly implement a proper waste management plan. The plan should be approved by local government. ・ The contractor shall provide temporary sanitation facilities such as portable toilets and garbage bins to ensure that the domestic wastes to be generated by the construction personals. ・ The solid waste should be separated into hazardous, non-hazardous and reusable waste streams and stored temporary on site. ・ The contractor shall consider and implement proper re-use and recycle plans of the construction waste. ・ The supervision consultant shall monitor the waste disposal, in the event of problems, the supervision consultant and contractor should reconsider the waste disposal method.	
5	Noise and vibration	**Construction Phase:** ・ The contractor should prepare the proper work schedules not to concentrate the construction equipment at a certain point for long time around residential areas. ・ The contractor shall maintain their construction equipment in adequate working conditions. ・ Construction works shall be prohibited during night time around residential area. ・ The contractor should select quiet equipment and working methods as much as possible. ・ The contractor and supervision consultant shall provide prior notification to the local community on the schedule of construction activities. ・ The supervision consultant shall monitor noise, vibration and complaint from the local people in construction site. If the local residents and pedestrians complain about the noise and vibration, the supervision consultant and contractor should reconsider the construction technique and method. **Operation Phase:** ・ A relevant agency shall conduct interview survey on noise and vibration to the local residence.	Potable noise meter: 500 Others: Included in construction and maintenance cast
8	Bottom sediment	**Construction Phase:** ・ Main construction works shall be concentrated in dry period. ・ The supervision consultant shall consider the proper drainage plans in advance. ・ To prevent soil erosion, the riverbanks and abandoned borrow pits shall be conducted planting works.	Included in construction cast
Natural Environment			
10	Ecosystem	**Construction Phase:** ・ Vegetation loss for land clearing should be minimal and limited in the construction areas. ・ The riverbanks and abandoned borrow pits shall be conducted planting works using local plant spices as much as possible. ・ The cleared trees should be treated under guidance of local government. ・ The supervision consultant should collect information of sighting of Irrawaddy dolphin. If the sighting is identified, the supervision	Included in construction cast

No.	Impact Item	Mitigation Measures	Cost (US$)
		consultant should distribute a stuff at the confluence of Mekong River to monitor Irrawaddy dolphin. ・ If Irrawaddy dolphin comes close to the construction site, measures to turn off, such as noising, should be conducted. ・ The supervision consultant and contractor should monitor the river water quality. In the event of problems, the supervision consultant and contractor should reconsider the construction technique and method.	
11	Hydrology	**Construction Phase:** ・ The supervision consultant shall consider the proper drainage plans in advance.	Included in construction cast
Social Environment			
13	Resettlement/ Land Acquisition	**Pre-Construction Phase:** ・ Authorities concerned shall prepare and strictly implement a proper Abbreviated Resettlement Action Plan (ARAP).	Refer to the Abbreviated Resettlement Action Plan (ARAP)
14	Poor people	**Pre-Construction Phase:** ・ Authorities concerned shall prepare and strictly implement a proper ARAP.	Refer to the ARAP
16	Local economies, such as employment, livelihood, etc.	**Pre-Construction Phase:** ・ Authorities concerned shall prepare and strictly implement a proper ARAP. **Construction Phase:** ・ The contractor shall prepare and strictly implement a fair hiring plan of local people as construction workers. ・ The contractor and supervision consultant shall provide prior notification to the local community including fisherpersons on the schedule of construction activities and restricted area and period. ・ The contractor and supervision consultant should regularly hold meetings with local fisherpersons to discuss measures against impacts on fishery and for safety. The outcomes of the meetings should be reflected in the construction works immediately. ・ If a decrease in the production caused by the construction works is identified, the proper compensation shall be provided to the affected fisher persons by the entity causing the problem.	Included in construction cast
17	Land use and utilization of local resources	**Pre-Construction Phase:** ・ Authorities concerned shall prepare a proper ARAP and compensate to the property owners on the basis of the ARAP.	Refer to the ARAP
18	Water usage	**Construction Phase:** ・ The contractor and supervision consultant shall provide prior notification to users of the existing channels on the schedule of construction activities. ・ Relocation works of the channels should be conducted as needed.	Included in construction cast
19	Existing social infrastructures and services	**Pre-Construction Phase:** ・ The contractor and supervision consultant should periodically hold sufficient meetings with the utility owners in every stage. Proper relocation plans should be prepared and strictly implemented in advance of construction works.	Included in construction cast

No.	Impact Item	Mitigation Measures	Cost (US$)
		・ Construction method to secure current traffic of the bridge shall be considered. **Construction Phase:** ・ To mitigate traffic conjunction, the contractor shall prepare and strictly implement a traffic management plan around the construction site. **Operation Phase:** ・ To secure accesses to roadside structures, the service roads (side roads) shall be installed in Prek Chhloung Bridge. ・ To secure traffic crossing NR73, an under pass for pedestrians and bicycles shall be installed under the abutment of Prek Chhloung Bridge. ・ To secure traffic safety of pedestrians and bicycles, sidewalks with sufficient width shall be installed in the new bridges.	
21	Misdistribution of benefits and damages	**Pre-Construction Phase:** ・ Authorities concerned shall prepare and strictly implement a proper ARAP.	Refer to the ARAP
23	Cultural heritage	**Pre-Construction Phase:** ・ The project owner should discuss with the local residence to determine new relocation sites or compensation for the affected cultural properties. ・ If the removals are required, the removal works should respect and follow the local tradition and culture. **Operation Phase:** ・ To secure the entrance of Preah Chan Reachea Pagoda for vehicles, the service roads (side roads) shall be installed in Prek Chhloung Bridge.	Included in construction cast
28	Working conditions (including occupational safety)	**Construction Phase:** ・ The supervision consultant and contractor shall prepare and strictly implement accident prevention measures. ・ The contractor shall prepare and strictly implement dust control measures such as periodic water spray. ・ The contractors shall provide temporary sanitation facilities such as portable toilets and garbage bins for domestic waste.	Included in construction cast
Other			
29	Accidents	**Construction Phase:** ・ The contractor shall prepare and strictly implement measures for safety. ・ To prevent accidents around the construction site, the contractor should conduct traffic management and install signboards. **Operation Phase:** ・ The road administrator shall monitor conditions of traffic accident conditions. In the event of problems, the administrator consider counter measures. ・ To secure traffic safety of pedestrians and bicycles, sidewalks with sufficient width shall be installed in the new bridges.	Included in construction and maintenance cast

1.3.5 Environmental Monitoring Plan

The proposed organization for the environmental monitoring in the construction phase, monitoring plan including the operation phase and draft environmental monitoring form for pollution are shown in the following Figure and Tables. The supervising consultant accepts responsibility for the monitoring formulation, implementation and management in the construction phase.

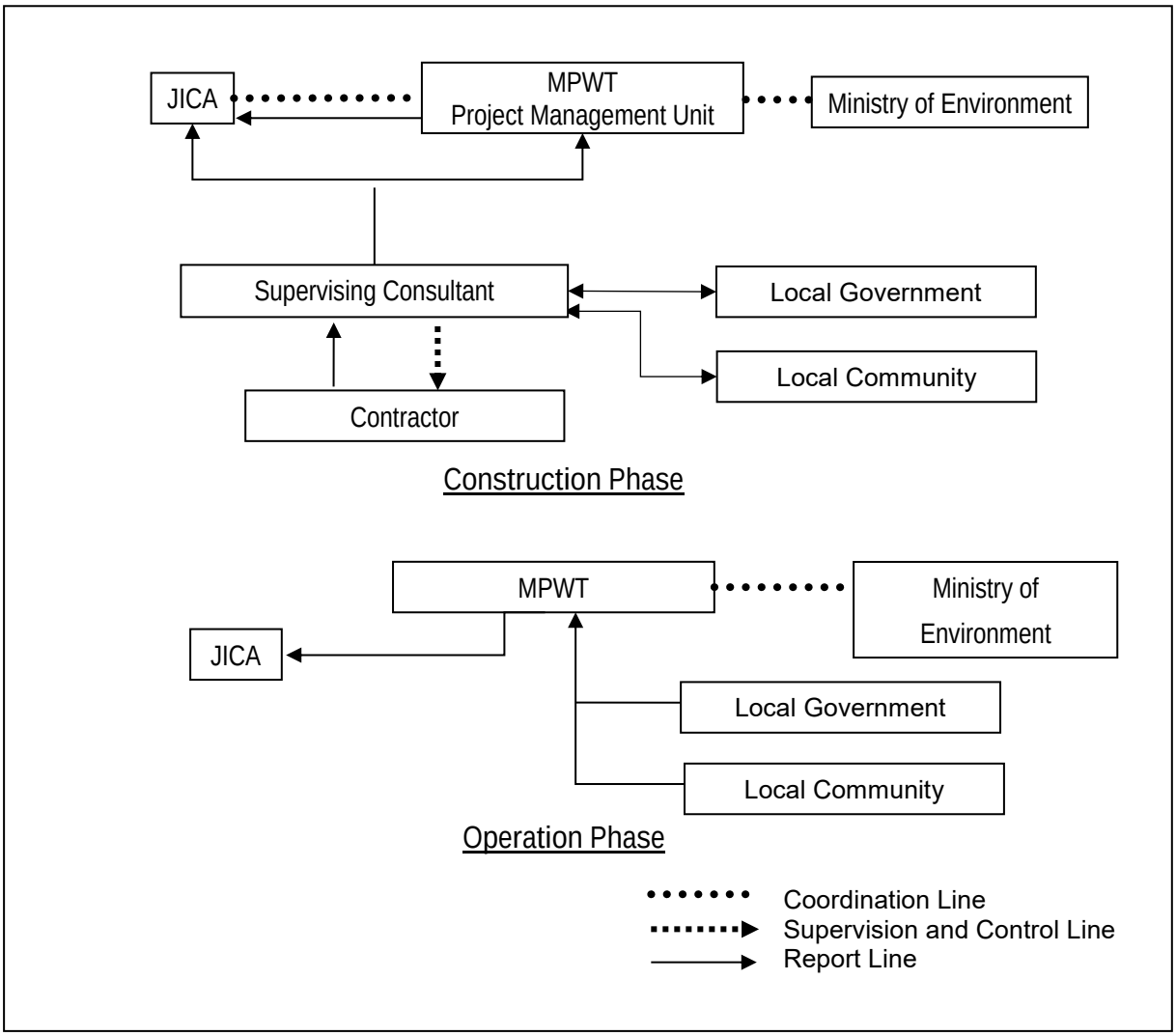


Figure 1.3-3 Proposed Organization for Environmental Monitoring

Table 1.3-6 Environmental Monitoring Plan

Category	Environmental Item	Monitoring Item/ Parameter	Responsible Person and Organization	Location	Method	Frequency
Pollution	Air pollution	**Construction Phase:** ・Dust	Supervising Consultant Contractor	In and around construction site	Visual observation and interview to pedestrians	Visual observation: Daily Interview: Monthly or as needed

Category	Environmental Item	Monitoring Item/ Parameter	Responsible Person and Organization	Location	Method	Frequency
	Water pollution	**Construction Phase:** ・ Turbidity, pH, Dissolved Oxygen (DO) ・ Turbid water	Supervising Consultant Contractor	In and around construction site	Analysis using potable water quality meter Visual observation	Water quality analysis: Weekly or as needed Visual observation: Daily
		Operation Phase: ・ Turbid water ・ Drainage conditions	MPWT	Around target bridges	Visual observation	During rainfall
	Waste	**Construction Phase:** ・ Disposal methods of construction and general waste	Supervising Consultant Contractor	Construction site and disposal site	Visual observation and meeting with contractor	Visual observation: Daily Meeting:: Monthly or as needed
	Noise and vibration	**Construction Phase:** ・ Noise level ・ Vibration	Supervising Consultant Contractor	In and around construction site	Interview to local residents and pedestrians Measurement using potable instrument	Interview: Monthly or as needed Instrumental measurement: Weekly or as needed
		Operation Phase: ・ Noise ・ Vibration	MPWT	Around target bridges	Interview to local residents and pedestrians	1 time per year for 2 years after completion Total 2 times
	Bottom sediment	**Construction Phase:** ・ Turbid water ・ Drainage conditions	Supervising Consultant Contractor	In and around construction site	Visual observation	During rainfall
Natural Environment	Ecosystem	**Construction Phase:** ・ Vegetation clearing works ・ Planting works ・ Sighting of Irrawaddy dolphin	Supervising Consultant Contractor	In and around construction site	Visual observation and meeting with contractor Collecting information from local people including fisherperson	Daily
	Hydrology	**Construction Phase:** ・ Soil runoff ・ Drainage conditions	Supervising Consultant Contractor	In and around construction site	Visual observation	During rainfall
Social	Resettlement/ Land Acquisition	**Pre-Construction Phase:** ・ Progress of resettlement action plan	MPWT	Around target bridges and relocation sites	Site survey and meeting with PAPs	Monthly or as needed

Category	Environmental Item	Monitoring Item/ Parameter	Responsible Person and Organization	Location	Method	Frequency
	Poor people	**Pre-Construction Phase:** ・ Progress of resettlement action plan	MPWT	Around target bridges and relocation sites	Site survey and meeting with PAPs	Monthly or as needed
	Local economies, such as employment, livelihood, etc.	**Pre-Construction Phase:** ・ Progress of resettlement action plan	MPWT	Around target bridges and relocation sites	Site survey and meeting with PAPs	Monthly or as needed
		Construction Phase: ・ Local economic activities including fishery ・ Employment situation of unskilled labor	Supervising Consultant Contractor	In and around construction site	Site survey and interview to local people including fisherperson and unskilled labors	Monthly or as needed
	Land use and utilization of local resources	**Pre-Construction Phase:** ・ Progress of resettlement action plan	MPWT	Around target bridges and relocation sites	Site survey and meeting with PAPs	Monthly or as needed
	Water usage	**Construction Phase:** ・ Water cannel conditions	Supervising Consultant Contractor	In and around construction site	Site survey and interview to water user	Monthly or as needed
	Existing social infrastructures and services	**Pre-Construction Phase:** ・ Relocation status of existing infrastructure facilities	MPWT	In and around construction site	Site survey and meeting with facility owners	Monthly or as needed
		Construction Phase: ・ Traffic congestion	Supervising Consultant Contractor	In and around construction site	Visual observation	Daily
	Misdistribution of benefits and damages	**Pre-Construction Phase:** ・ Progress of resettlement action plan	MPWT	Around target bridges and relocation sites	Site survey and meeting with PAPs	Monthly or as needed
	Cultural heritage	**Pre-Construction Phase:** ・ Removal or relocation works of religious structure and monument	MPWT	In and around construction site	Visual observation and meeting with contractor and local people	Visual observation: Daily Meeting: Monthly or as needed

Category	Environmental Item	Monitoring Item/ Parameter	Responsible Person and Organization	Location	Method	Frequency
		Operation Phase: ・ Utilization of access road to Preah Chan Reachea Pagoda	Local government	Preah Chan Reachea Pagoda	Interview to local people	Monthly or as needed
	Working conditions (including occupational safety)	**Construction Phase:** ・ Workplace situations ・ Implementation status of accident prevention measures	Supervising Consultant Contractor	In and around construction site	Visual observation and meeting with contractor	Daily
Other	Accidents	**Construction Phase:** ・ Implementation status of accident prevention measures	Supervising Consultant Contractor	In and around construction site	Visual observation and meeting with contractor	Visual observation: Daily Meeting: Monthly or as needed
		Operation Phase: ・ Number of traffic accident	MPWT	Target road	Site survey and traffic accident data	Monthly or as needed for 2 years after completion

Table 1.3-7 Draft Environmental Monitoring Form

Pre-Construction and Construction Phase:

(1) Response and Actions to Comments and Guidance from Government Authorities and the Public

Monitoring Items	Monitoring Results during Report Period
Number and contents of formal comments by the public	
Number and contents of formal comments by government agencies	

(2) Pollution

Item	Parameter	Environmental Standard in Cambodia	Location	Frequency	Responsible Agency	Date/Result
Air quality	Dust	-	Construction site	Every day	Supervision Consultant Construction Contractor	
Water Quality	Turbidity pH Dissolved Oxygen	- 6.5 – 8.5 2.0 – 7.5 mg/l	Construction site	Weekly or when needed	Supervision Consultant Construction Contractor	
Waste	Waste disposal	-	Construction site	Every day	Supervision Consultant Construction Contractor	
Noise	Noise level	60 dB	Construction site	Weekly or when needed	Supervision Consultant Construction Contractor	

(3) Others

Environmental Item	Monitoring Item/	Monitoring Results during Report Period	Measures to be taken
Bottom sediment	Turbid water Drainage conditions		
Ecosystem	Vegetation clearing works Planting works Sighting of Irrawaddy dolphin		
Hydrology	Soil runoff Drainage conditions		
Resettlement/ Land Acquisition	Progress of resettlement action plan		
Poor people	Progress of resettlement action plan		
Local economies, such as employment, livelihood, etc.	Progress of resettlement action plan		
	Local economic activities including fishery Employment situation of unskilled labor		
Land use and utilization of local resources	Progress of resettlement action plan		
Water usage	Water channel conditions		

Environmental Item	Monitoring Item/	Monitoring Results during Report Period	Measures to be taken
Existing social infrastructures and services	Relocation status of existing infrastructure facilities		
	Traffic congestion		
Misdistribution of benefits and damages	Progress of resettlement action plan		
Cultural heritage	Removal or relocation works of religious structure and monument		
Working conditions (including occupational safety)	Workplace situations Implementation status of accident prevention measures		
Accidents	Implementation status of accident prevention measures		

Operation Phase:

(1) Response and Actions to Comments and Guidance from Government Authorities and the Public

Monitoring Items	Monitoring Results during Report Period
Number and contents of formal comments by the public	
Number and contents of formal comments by government agencies	

(2) Pollution

Item	Parameter	Environmental Standard	Location	Frequency	Responsible Agency	Date/Result
Water Quality	Turbid water (Turbidity)	-	Around target bridges	Rainfall time	MPWT	
Noise and Vibration	Noise level Vibration Level	60 dB (Day) 45dB (Night) -	Around target bridges	2 times/year	MPWT	

(3) Others

Environmental Item	Monitoring Item/	Monitoring Results during Report Period	Measures to be taken
Cultural heritage	Utilization of access road to Preah Chan Reachea Pagoda		
Accidents	Number of traffic accident		

1.3.6 Land Acquisition and Resettlement

1.3.6.1 Range of Impact

Identified affected structures and private properties in the Provisional Road Width (PRW) are shown in the following Tables. The total number of project affected households (AHs) that have their structures, assets and lands in the PRW is 31 households. These structures and assets will need resettlement,

relocation and compensation. 17 structures are used for residence. The total number of residents to be resettled are 77 persons.

Table 1.3-8 Province, district/town located by the Bridge and Number AHs

Bridge/Commune	Total (AHs)
1. Peam Te Bridge	17
1.1 Commune: Bos Leav	10
1.2 Sangkat: Roka Kandal	7
2. Prek Chhloung Bridge	8
2.1 Commune: Chhlong	1
2.1 Commune: Praek Saman	7
3. Ba Baong No.2 Bridge	6
3.1 Commune: Ba Baong	6
Total (the Project)	31

Table 1.3-9 Number of Affected Households who will lose their Main and Other Structures

Province	Bridge	Krong/ District	Sangkat/ Commune	Number of Population to be resettled	Type of Structure				
					Main Structure				Other Structure
					House	House/ Shop	House/ Restaurant	Total	
KRATIE	Peam Te	Kratie	Roka Kandal	30	4	0	1	5	-
		Chet Borei	Bos Leav	9	2	0	0	2	2
	Prek Chhloung	Chhlong	Chhlong	4	1	0	0	1	-
			Prek Saman	17	2	1	1	4	2
PREY VENG	Ba Baong No.2	Peam Ro	Ba Baong	17	4	1	0	5	-
Total				77	13	2	2	17	4

Table 1.3-10 Number of Affected Households who will lose their Private Lands

Province	Bridge	Krong/ District	Sangkat/ Commune	Residential Land		Agricultural Land	
				AH	m^2	AH	m^2
KRATIE	Peam Te	Kratie	Roka Kandal	4	454.49	-	-
		Chet Borei	Bos Leav	7	5,430.12	-	-
	Prek Chhloung	Chhlong	Prek Saman	5	2,471.17	-	-
PREY VENG	Ba Baong No.2	Peam Ro	Ba Baong	2	19.00	1	965.14
Total				18	8,374.78	1	965.14

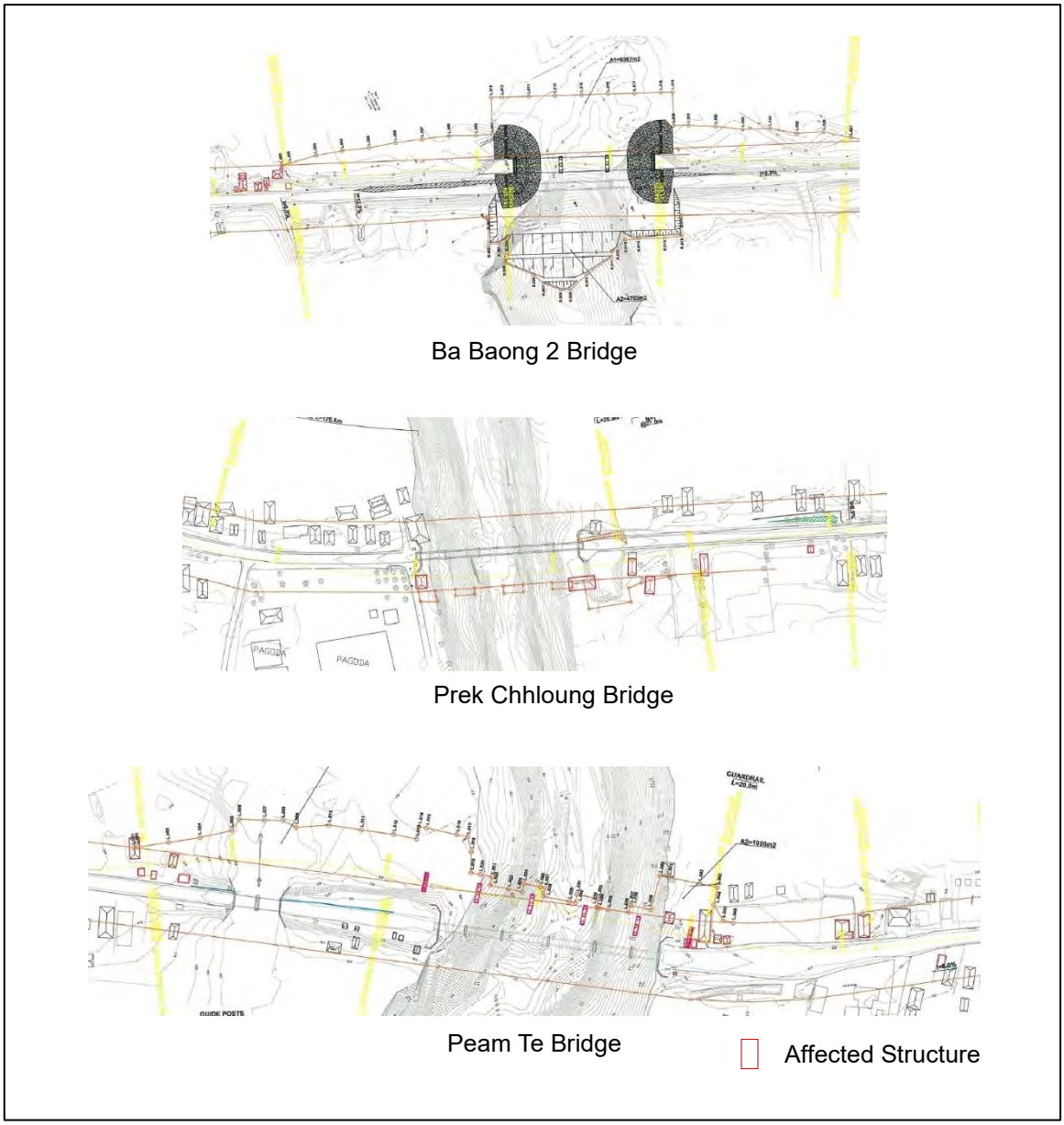


Figure 1.3-4 Location of Affected Structure

1.3.7 Contents of Compensation and Assistance

Exploitation of private lands and structures due to public projects is generally compensation in money in Cambodia. Land replacement (land to land) is considered after the Detailed Measurement Survey (DMS) conducted in the next stage. Official cut-of date is declared at the beginning of the Replacement Cost Study (RCS) also conducted in the next stage. However, the temporary cut-off date for preparation of the Abbreviated Resettlement Action Plan was set on October 13, 2016 when the Inventory of Loss (IOL) survey was commenced.

The entitlement matrix is shown in the following Table. The entitlements and assistance may be revised based on the actual status of impact in the future stage.

Table 1.3-11 Entitlement Matrix

TYPE OF LOSS	ELIGIBLE PERSONS	ENTITLEMENTS	IMPLEMENTATION ISSUES
A. LOSS OF LAND			
OUTSIDE ROW (PRIVATE LAND)			
Loss of Land (all kinds); Either Partial or Entire Land is Lost	All Affected Households (AHs) with recognized proof of ownership whose land will be acquired for the construction of the replacement bridges.	AHs have two options: ・ Land replacement (land to land): Land replacement will be provided with similar land quality and productivity potential. ・ Cash compensation at replacement cost.	・ AHs to be notified at least 90 days in advance before the start of civil works in the locality of the actual date that the land will be acquired by the project. ・ IRC will ensure payment of all compensation and allowances for which AHs are entitled to at least 30 days prior to the scheduled start of civil works. ・ IRC will support the AHs to separate or transform the affected land title certificate. Cost of the procedure will be borne by Royal Government of Cambodia (RGC).
INSIDE ROW (PUBLIC STATE LAND)			
I. Partial Loss of Residential and / or Commercial Land, in which the remaining land is STILL VIABLE for continued use	AHs with main house and/or small shop (independent/family-owned business)	・ AHs must be removed entirely from PRW and no cash compensation is available for affected land in ROW. ・ No new permanent structures are permitted to be constructed in the ROW.	・ AHs to be notified at least 90 days in advance before the start of civil works in the locality of the actual date that the land will be acquired by the project. ・ IRC will ensure payment of all compensation and allowances for which AHs are entitled to at least 30 days prior to the scheduled start of civil works. ・ Remaining ROW is still public state land.
II. Entire Loss of Residential and/or Commercial Land, or the remaining land is NOT VIABLE for continued use (Landless AHs)	AHs with main house and/or small shop (independent/family-owned business) and no more remaining land.	No cash compensation for affected land in ROW. The landless AHs have two options: ・ Self-relocation: Receive in lump sum: a) 6,533.00 per landless AH for Peam Te Bridge, and b) $3,736.50 per landless AH for Ba Baong No.2 Bridge as cash assistance for buying a land plot and preparing other basic infrastructure, plus cash compensation for their affected assets. ・ Group relocation: A resettlement site (RS) nearby existing villages will provided by the government.	・ AHs to be notified at least 90 days in advance before the start of civil works in the locality of the actual date that the land will be acquired by the project. ・ Each self-relocate landless AHs will receive the cost for resettle by calculating in average from the Cost Estimate of each RS, plus cash compensation for their affected assets. The estimate cost in each resettlement site should be updated within the updated ARAP. ・ IRC will ensure payment of all compensation and allowances for which AHs are entitled to at least 30 days prior to the scheduled start of civil works. ・ IRC will ensure allocation of cash or replacement land with sufficient time (at least 90 days) for AHs to rebuild and relocate completely before the scheduled start of civil works. ・ IRC will support the AHs to acquire land title certificate after five consecutive years of AHs' living on

TYPE OF LOSS	ELIGIBLE PERSONS	ENTITLEMENTS	IMPLEMENTATION ISSUES
			the land. Cost of the procedure will be borne by RGC. ・ Remaining ROW is still public state land.
III. Loss of Productive Land Use ; Either Partial or Entire Land is Lost	All AHs occupying land or using land in the Provisional Road Width (PRW)	・ No cash compensation is available for affected land in ROW.	・ AHs to be notified at least 90 days in advance before the start of civil works in the locality of the actual date that the land will be acquired by the project. ・ AHs will not be moved from the ROW outside the PRW without justifiable cause (i.e. unless or until the land is required by the government for the replacement bridges construction purposes). ・ Remaining ROW is still public state land.
B. LOSS OF STRUCTURES			
I. Loss of Houses or Shop/Store; Either Partial or Entire Structure is Lost	All the AHs confirmed to be residing in, doing business or having right over resources within the project affected area during the conduct of IOL and census of AH (on Cut -off Date)	・ Cash compensation at replacement cost without deduction for depreciation or salvageable materials (i.e. present cost of construction materials in the locality plus cost of labor). ・ AHs are also entitled to have transport allowance.	・ AHs to be notified at least 90 days in advance before the start of civil works in the locality of the actual date that the land will be acquired by the project. ・ AHs to get cash compensation at least 30 days ahead of civil works in the locality to allow the AHs sufficient time to gradually reorganize the house and/or shop, thereby avoiding any disruption in their livelihood. ・ AHs must completely cut, move back or relocate their houses/structures to new site within 30 days after receiving compensation. ・ If the structure is found no longer viable for living, compensation will be paid for the entire structure and the AH will also be entitled to other allowances.
	Renters	・ Renters are entitled to get allowances as below: ・ Transportation (moving) allowance: USD 40 ・ Disruption allowance: A lump sum cash assistance of USD 50 ・ Rental allowance: equivalent to two months' rent of a similar building in the locality. ・ If AH belongs to any of the vulnerable group. ・ Provision of information in finding alternate rental accommodation.	・ AHs to be notified at least 90 days in advance before the start of civil works in the locality of the actual date that the land will be acquired by the project. ・ IRC will ensure payment of all allowances for which AHs are entitled to at least 30 days prior to the scheduled start of civil works. ・ AHs that rent house and/or shop are entitled to a one time transport allowance only.
II. Other Structures (porch, extended eaves, spirit house, fence, etc.)	All the AHs confirmed to be residing in, doing business or having right over resources within the project affected area	・ Cash compensation at replacement cost without deduction for depreciation or salvageable materials	・ AHs to be notified at least 90 days in advance before the start of civil works in the locality of the actual date that the land will be acquired by the project.

TYPE OF LOSS	ELIGIBLE PERSONS	ENTITLEMENTS	IMPLEMENTATION ISSUES
	during the conduct of IOL and census of AH (Cut- off Date)	(i.e. present cost of construction materials and labor in the locality).	· IRC will ensure payment of all allowances for which AHs are entitled to at least 30 days prior to the scheduled start of civil works.
C. LOSS OF CROPS AND TREES			
I. Loss of Crops	Owners of crops regardless of land tenure status	· To the extent possible, AHs will be allowed to harvest their annual and perennial crops prior to construction. · If crops cannot be harvested due to construction schedule, AHs are entitled to cash compensation for the affected crops at replacement cost.	· Annual Crops – AHs will be given 90 days' notice that the land on which their crops are planted will be used by the project and that they must harvest their crops before the civil work.
II. Loss of Fruit or Shade Trees	Owners of trees regardless of land tenure status	· Affected trees will be compensated in cash at replacement cost.	· AHs to be notified at least 90 days in advance before the start of civil works in the locality of the actual date that the land will be acquired by the project.
D. LOSS OF COMMON PROPERTY RESOURCES			
I. Partial or Entire Loss of Community and/or Public Assets	Affected communities or concerned government agencies who own the assets	· Replacement by similar structures and quality at the area identified in consultation with affected communities and relevant authorities.	· Communities to be notified at least 90 days in advance before the start of civil works in the locality of the actual date that the land will be acquired by the project.
E. ALLOWANCES AND ASSISTANCES			
I. Transport Allowance	AHs that relocate their house or house/shop	· Shops and stalls made of light and temporary materials: USD 5 to USD 10 (depending on the scale of the structures to be relocated) · Regular shops and houses moving to residual or adjacent areas: USD 50 · Regular shops and houses relocating within the same village outside of the ROW: USD 80 · Houses relocating in another village: USD 100	· Owners of houses or houses/shops are entitled to a one time transport allowance only.
II. Allowance for Severely AHs and/or Vulnerable AHs	Severely affected households and Vulnerable AHs	· One time cash assistance equivalent to USD 120 (20$x6month) per Severely Affected households and/or Vulnerable AHs.	· As indicated above, relocating landless AHs are entitled to replacement land with title at no cost
III. Disruption Allowance	Relocating AHs to residual or adjacent areas (whose house type 2A to 2E) with floor area is less than 60m^2.	· One time cash assistance equivalent to USD 50.	· Allowance shall be paid at the same time with compensation.

TYPE OF LOSS	ELIGIBLE PERSONS	ENTITLEMENTS	IMPLEMENTATION ISSUES
	Relocating AHs to residual or adjacent areas (whose house type 2A to 2E) with floor area is 60m^2 or more.	・ One time cash assistance equivalent to USD120.	
	Relocating AHs to residual or adjacent areas (whose house type from 2F or higher)	・ One time cash assistance equivalent to USD160.	
	Relocating AHs to a new village or resettlement site	・ One time cash assistance equivalent to USD200.	
IV. Temporary loss of business income during relocation	Owners of shop who relocate their shop	・ Lump sum cash assistance of USD 70.	・ Allowance shall be paid at the same time with compensation.
V. Income Restoration Program (IRP)	Severely affected households and Vulnerable Ahs	・ An IRP will be provided during resettlement implementation.	・ In-kind assistance to strengthen or initiate income-generating activities will be provided after need assessment through consultation with eligible AHs. Forms of assistance may include, but are not limited to, agricultural extension assistance, technical and other assistance to develop existing or new income-generating activities and project-related employment. ・ Special attention to the needs of and opportunities for the vulnerable AHs.
F. TEMPORARY IMPACTS DUE TO ROAD CONSTRUCTION AND MAINTENANCE			
I. Affected Assets during construction	Owners of assets	・ Compensation for lost assets in cash at replacement cost. ・ Compensation as leasing fee based on replacement cost, and temporarily affected land will be returned to original owner/occupant.	・ Contractor will be required by contract to pay these costs. ・ Construction and maintenance will be carried out so as to minimize damage. ・ Construction will be required by contract to stay within PRW. ・ As part of the civil works contract, all access roads/driveways to properties adjacent to the road will be repaired or replaced including culverts and other facilities, to a condition equal to or better than at present. ・ The disruption period will be minimized as much as possible. ・ The contractor will reinstate the land back to its original condition before returning to the owners.
II. Damage to fields and private or community infrastructure including bund walls, drains and channels, etc.	Owners or persons using the field	・ Repair of damage or payment for repair of damage at replacement cost.	

1) Replacement cost value: Valuation of assets that helps determine the amount sufficient to replace lost assets and cover transaction costs (including “Compensation for loss of assets” and “Moving allowance” in this Matrix)

1.3.7.1 Monitoring Plan

The draft monitoring form of land acquisition and resettlement are shown in the following Table.

Table 1.3-12 Draft Monitoring Form of Land Acquisition and Resettlement

Preparation of Resettlement Site

No.	Explanation of the Site	Status Completed (date) or not)	Details	Expected Date of Completion
1.				
2.				
3.				

Public Consultation

No.	Date	Place	Contents of the construction / Main comments and answers
1.			
2.			
3.			

Resettlement Activity	Planned Total	Unit	Progress in Quantity			Progress in %		Expected Date of Completion	Responsible Organization
			During the Quarter	Till the Last Quarter	Up to the Quarter	Till the Last Quarter	Up to the Quarter		
Preparation of ARAP*									
Employment of Consultants		Man-Month							
Implementation of Census Survey									
Approval of ARAP	Date of Approval:								
Finalization of PAPs List		No. of PAPs*							
Progress of Compensation Payment (All Lots)		No. of HHs*							
Peam Te bridge		No. of HHs							
Prek Chhloung bridge		No. of HHs							
Ba Boang 2 bridge		No. of HHs							
Progress of Land Acquisition (All Lots)		ha							
Peam Te bridge		ha							
Prek Chhloung bridge		ha							
Ba Boang 2 bridge		ha							
Progress of Asset Replacement (All Lots)		No. of HHs							
Peam Te bridge		No. of HHs							
Prek Chhloung bridge		No. of HHs							
Ba Boang 2 bridge		No. of HHs							
Progress of Relocation of People (All Lots)		No. of HHs							
Peam Te bridge		No. of HHs							
Prek Chhloung bridge		No. of HHs							
Ba Boang 2 bridge		No. of HHs							
Progress of Public Asset Replacement (All Lots)		No. of Structures							
Peam Te bridge		No. of Structures							
Prek Chhloung bridge		No. of Structures							
Ba Boang 2 bridge		No. of Structures							

* : ARAP: Abbreviated Resettlement Action Plan, PAPs: Project Affected Persons, HHs: Households

Chapter 2 Contents of the Project

2.1 Basic Concept of the Project

The concept of the project is as follows.

2.1.1 Overall Goal

The overall goal of the project is to contribute to reducing vulnerability to natural disasters in the flood-prone area, and to secure smooth and stable transportation and logistics on National Road No.11 and No.73 in Cambodia.

2.1.2 Expected Outcomes

The expected outcomes of the project are to secure safety in the flood-prone area, and smooth and stable transportation and logistics on National Road No.11 and No.73 by expansion of the road width and increase of load bearing capacity by replacement of 7 temporary bridges namely Ba Baong No.1 bridge, Ba Baong No.2 bridge, Prek Sandan bridge, Anlong Khle bridge, Preak Rus bridge, Prek Chhloung bridge and Peam Te bridge located on National Road No.11 and No.73.

2.1.3 Evaluation Indicator

As a quantitative effect, indicators below will be set to confirm the project outcome.

- To increase the weight limit of the vehicle
- To increase the average driving speed
- To increase the number of passengers and the amount of transport cargo

These indicators are set as the target year for the base year before the project commencement and 3 years after the project completion.

2.2 Outline Design of the Project

2.2.1 Design Policy

(1) Condition on Flood Disaster Countermeasure

The climate of Cambodia is divided into rainy season and dry season. The rainy season is from May to October, brought by the southwest monsoon. The dry season is from November to March, brought by the Northeast monsoon and April and October are transition periods. Generally, the influence of typhoon and tropical cyclone was not significant. However, the huge typhoon has confirmed in recent year such as floods in 2011. Typhoons occurred near the Philippines and reached in Cambodia, causing the flood due to heavy rainfall at the Mekong River basin. The severe flood had been occurred in 1996, 2000, 2001 and 2011 recently. The flood is one of the natural disaster which causes most frequently.

The items to consider as flood countermeasures are as follows.

Adequate Design Flood Water Level and Freeboard

Design Flood discharge shall be calculated from the specific discharge of flood for a 50-year return period. The elevation of the bridge soffit shall be considered historical maximum flood level and forecasted fracture of water level due to climate change.

Maintaining of Capacity of Flood Discharge

The design flood discharge shall be determined based on the historical maximum flood level in conformity with the Structural Decree of River Management Facilities etc. in Japan.

The Number of Bridge Pier and Location

There is no specification regarding minimum span length in Cambodia. Therefore, the minimum span length and number of bridge pier shall be determined to avoid obstruction of river flow, as well as vessel navigation.

Freeboard

The appropriate freeboard shall be maintained in accordance with design discharge.

Location of the Abutment

The location of the abutment shall be studied to adopt as the excavated river channel.

(2) Condition on Seismic Design

The horizontal seismic coefficient of kh=0.5 shall be considered in conformity to the design specification in Cambodia.

(3) Condition on Bridge Planning

1) Condition on Bridge Location

The proposed bridge location shall be planned to utilize the function of existing National Road of NR11 and NR73 which functions as a trunk highway. The bridge location shall be studied with comparative study which considered disaster mitigation, the utilization of the traffic during construction, the function of road and river, economic aspects and socio-environmental aspects.

Among seven target bridges, three bridges namely Ba Baong Bridge No.2, Prek Chhloung Bridge and Peam Te Bridge are located near the residential area including shops and restaurants around the existing bridges. The alignment of the bridge and approached road shall be studied to minimize the negative impact to the resettlement of these houses, etc. The bridge type also shall be studied to minimize upgrading of the road surface. The stair to the bridge sidewalk shall be provided for the pedestrian to access from the houses, if necessary.

2) Condition of Bridge Profile

The High-Water Level (HWL) for the bridge design shall be determined in accordance with the water level during rainy season based on the historical metrological record and the interview survey at the site. HWL shall also be considered the increasing of water level due to climate change.

The bridge shall be maintained appropriate freeboard and the cross-sectional area of river to make the river smooth flow during flood. The freeboard also shall be considered the historical highest flood level, such as the flood in 2000 for NR11 and the flood in 1996 for NR73. The elevation of bridge soffit shall be higher than the highest water level.

3) Condition on Cross Section

The typical cross section of the bridge shall be considered following items.

- The width of carriage way, shoulder and marginal strip shall be complied with the Cambodian standard.
- The typical cross section shall be maintained the continuously of the connected existing national road.
- The width of sidewalk shall be studied in accordance with the traffic volume of the bicycle and pedestrian.

The typical cross section shall be studied based on the above mentioned basic condition and the continuously of the connected existing national road of NR11 and NR73. The sidewalk would be provided only on the Prek Chhloung Bridge and Peam Te Bridge which are located near the residential area. The sidewalk would be provided both side with width of 1.0 m.

4) Condition on Comparison Study of Bridge Type

The seven objective bridges for the Project would be constructed as one package. Therefore, these bridges shall be standardized for the both superstructure and substructure, so the construction cost could be minimized by utilizing the shared construction equipment as much as possible.

The following items shall be considered for the bridge planning such as bridge location, superstructure type, substructure type, etc.

(1) The road alignment and bridge location shall be appropriately studied in consideration with construction
(2) The external requirement of the bridge planning shall be satisfied
(3) The stability of the structure shall be satisfied and the economic aspect shall be considered
(4) The construction ability, easily and rapidity shall be considered
(5) The standardize of the structures type shall be considered
(6) The traffic safety and run-ability shall be considered
(7) The maintenance ability and easily shall be considered

5) Condition on Bridge Material in Consideration of Maintenance

The ease of the maintenance of the Bridges had been requested by the implementing agency during the series of meeting. Resulting of the comparison study which included utilization of the steel bridges, the PC I Girder bridge is recommended for the Project. Because it had disadvantage on steel bridge in difficulty of fabrication of the steel bridge in Cambodia and the cost of mobilization the steel girder to the construction site.

6) Condition on Selection of Bearing Layer

The bearing layer of the bridge foundation shall be selected based on the following item.

- The bearing layer of the bridge shall be determined based on the Standard Penetration Test (SPT). The N-value of bearing layer shall be more than or equal 30 for the sand or gravel layer and 20 for the clay layer.
- The bearing layer shall be carefully decided for gravel layer to consider the contamination of stones, possibility of scouring and the scale of the structure. The N-value of more than or equal 30 is not the absolute condition in case of gravel.
- The thin layer shall not be selected even if the N-value was satisfied.

7) Condition on Seismicity and Temperature Change

The seismic coefficient and temperature change for the bridge design shall be in comply with the Cambodian design specification (Bridge Design Standard: CAM. PW. 04.102.99, 2003).

(4) Condition on Road Planning

1) Condition on Road Alignment

The alignment and profile of approached road of the bridge determined with consideration of the location of proposed bridge and adjustment of the elevation of the road surface of the bridge.

- The road alignment shall be studied in accordance with the result of topo survey and soil investigation to minimize the land acquisition.
- The influence to the residents, shops, Pagoda, including related buildings and facilities, as well as the religious trees and etc. shall be minimized
- The design speed and road geometry shall be complied with the design standard refracted road type and class. The actual condition of existing traffic shall also be considered for the road design.
- The socially vulnerable such as children, female and etc. shall be considered in the road section with high dance of pedestrian where near residential area and pagoda.

2) Condition on Pavement Design

Asphalt concrete pavement is commonly used in Cambodia. The pavement of NR11 and NR73 is also applying the simple paving of asphalt. Therefore, the asphalt concrete pavement shall be applied for the Project.

The design of the pavement shall be applied AASHTO standard and the result of the design shall be reviewed by TA method with Japanese standard. The appropriate axial load and CBR would be applied based on the traffic survey and result of traffic forecasting with consideration of JICA's pavement design handbook, April 2015 and other relevant information which were obtained by the series of studies. The minimum thickness of the asphalt pavement shall be determined in accordance with the traffic volume, site condition etc.

The soil for the embankment shall not use the dispersive soil.

3) Consideration on Embankment and Slope Planning

The dragon hall which affect the stability of embankment were confirmed during site inspection at NR11. The occasion of dragon hall is caused by using of dispersive soil for the embankment. It was confirmed by the site inspection and interview survey that the dispersive soil was distributed along NR11. The embankment soil of for the Ba Baong No.2 Bridge and Ba Baong No.1 Bridge shall be supplied from the borrow pit along NR73. The slope of the approached road shall be protected by the appropriate measure because these bridges are located in the swamp area and the water level comes up to the nearly the road surface.

4) Consideration on Countermeasure to Soft Soil

The vicinity area of the proposed bridge is swamp and its soil condition is soft cohesive soil. The road pavement and foundation of abutment may be suffered severe damage due to the ground subsidence of embankment by the surplus load of the embankment. In case of possibility of the ground subsidence was confirmed, the residual compaction settlement shall be estimated and the necessary countermeasure shall be studied such as soil stabilization, accelerating consolidation etc.

5) Construction Condition

The appropriate construction method shall be adopted which the technologies and methods were widely used in Japan and other countries. In addition, the procedures and standards for material testing and molding inspection for quality assurance shall be specified in the specifications. The appropriate construction is planned to be implemented in considering the safety of residents and workers and the vicinity environment.

6) Natural and Site Condition

The reflection of natural conditions to the design of the bridge is an important factor directly affecting the stability and safety of the structure. The basic concept and condition of its reflection is as follows.

- The meteoritical condition would be refracted the determination of construction planning, implementing schedule, the estimation of river flow velocity, discharge and water level.
- The river condition would be considered for determination of bridge scale, span length, necessity of riverbed protection and revetment and elevation of the bridge.
- The topo and soil condition would be refracted the determination of the location of the abutment, bridge length, depth of bearing layer, estimation of bearing capacity, substructure type and construction planning.
- The extended topo map shall be used for the estimation of catchment in accordance with estimation of design discharge of the river.
- The seismic condition shall be considered for the seismic design of the substructure and foundation.

The concept of the bridge planning reflected with natural condition are as follows.

Condition on Design High Water Level and Design Discharge (Q)

- The design high water level shall be determined based on the interview survey and hydraulic analysis.

7) Consideration on Social and Environmental Condition

The Project contains the replacement of the existing bridge. Therefore, the social and the natural environment does not change significantly. However, its planning, design and construction shall be considered the following points of view so the negative impact to the natural and social environment. could be minimized.

- To minimize the land acquisition of private land as much as possible.
- To considering the negative impact to the livelihood of the residents to adopt the adequate construction method and to minimize the vibration and noise.
- In case of the proposed bridges is constructed at the other location, the existing bridge would be used as the temporally detour bridge during construction. The traffic safety and smooth traffic flow shall be maintained. Also, the temporary bridges shall be strengthened properly because the live load capacity of the existing bridge may be about 15 tons.
- To minimize river water pollution during construction.
- To conduct solid waste disposal properly.

8) Consideration of Usage of Local Contractor

From the result of the survey, it was confirmed that most of the construction material, labor including engineers could be procured in Cambodia. Therefore, Japanese contractor could procure the material and manpower in Cambodia as much as possible. However, special construction equipment, such as large cranes, erection girders, etc. for bridge construction are difficult to procure in Cambodia, so this equipment may be procured in Japan.

9) Consideration of Implementation and Operation

The maintenance work after the handover of bridge will be undertaken by Road Infrastructure Department (RID), Ministry of Public Works and Transport (MPWT). The routine maintenance will be conducted Department of Public Works and Transport (DPWT) which is managed by MPWT in each Provinces.

Therefore, the Project shall consider to selection of bridge type to minimize maintenance work as much as possible.

2.2.2 Basic Plan

(1) Scope of the Project (Project Outline)

The scope of the project is as shown in Table 2.2-1. Pre-stressed concrete type with 2-lanes will be applied to all bridges that are targeted for reconstruction such that the bridges can accommodate trailers with a maximum weight of 41 ton (HS25-44).

Table 2.2-1 Scope of the Project

Bridge	Road	Superstructure Type, Bridge Length (L_B), Width	Total Length (L_T) (Approach road + Bridge)
Ba Baong No.2	NR11	3-span continuous PC I girder L=105m Road width 3.5m, Marginal strip 1.5m, No walkway	Total length = 720m Appr. road 328m (south side) Appr. road 287m (north side)
Ba Baong No.1	NR11	3-span continuous PC I Girder L=105m Road width 3.5m, Marginal strip 1.5m, No walkway	Total length = 685m Appr. road 289m (south side) Appr. road 291m (north side)
Prek Sandan	NR73	Simple PC I girder, L=35m Road width 3.5m, Marginal strip 1.5m, No walkway	Total length = 450m Appr. road 213m (south side) Appr. road 202m (north side)
Prek Rus	NR73	2-span continuous PC I girder L=62m Road width 3.5m, Marginal strip 1.5m, No walkway	Total length = 505m Appr. road 240m (south side) Appr. road 203m (north side)
Anlong Khle	NR73	2-span continuous PC I girder L=48m Road width 3.5m, Marginal strip 1.5m, No walkway	Total length = 480m Appr. road 210m (south side) Appr. road 222m (north side)
Prek Chhloung	NR73	4-span continuous PC I girder, L=140m Road width 3.5m, Marginal strip 0.6m, Walkway1.0m	Total length = 554m Appr. road 200m (west side) Appr. road 214m (east side)
Peam Te	NR73	5-span continuous PC I girder, L=175m Road width 3.5m, Marginal strip 0.6m, Walkway 1.0m	Total length = 700m Appr. road 326m (south side) Appr. road 199m (north side)
Total 7 bridges, total bridge length 670m, total project length 4,094m			

(2) Applicable Criteria

Standards to be followed for the design purpose of the target bridges and its approach roads are listed below. Fundamentally, the existing standards available in the Kingdom of Cambodia will be applied. Other international standards such as AASHTO or Japanese Standards will be applied for items that are not covered in the Cambodian Standards

- Bridge Design Standard (CAM.PW.04.102.99), 2003
- Road Design Standard Part 1. Geometry (CAM.PW.03.101.99), 2003
- Paevment Design Standard Part2. Geometry (CAM.PW.03.101.99), 2003
- Construction Specification, 2003
- Standard Specifications for Highway Bridges : American Association of State Highway and Transportation Officials (AASHTO)
- A Policy on Geometric Design of Highways and Streets: AASHTO
- AASHTO Guide for Design of Pavement Structures: AASHTO
- Design Specifications of Highway Bridges: Japan Road Association
- Pavement Design: Japan Road Association
- Ordinance for Management of River Structures: Japan River Association

(3) Road Specification

As indicated in, roads in Cambodia are categorized into Urban Roads and Rural Roads. MPWT confirmed that both the NR11 and NR73 are categorized as Urban Road.
The Cambodian Road Standards takes traffic volume projection for 30 years after completion of the project for classifying the roads. The projection carried out using the traffic volume obtained by traffic count survey conducted under this project, the daily annual average traffic is predicted to be more than 10,000, which classifies both the roads into U5.

Table 2.2-2 Road Categories

Level	Rural Road	Urban Road
1	International Expressway	Urban Expressway
2	Highway	**Arterial**
3	Provincial Roads	Collector Roads
4	District	Local

Table 2.2-3 Traffic Volume for Classification of Roads

Area	Road Category	30 Year Projected ADT					
		All Traffic Volume	>10,000	10,000 to 3,000	3,000 to 1,000	1,000 to 150	<150
URBAN	Expressway	U6	-	-	-	-	-
	Arterial	**-**	**U5**	U4	**-**	**-**	**-**
	Collector	-	-	U4	U3	-	-
	Local	-	-	-	-	U2	U1

(4) Design Speed

Table 2.2-4 shows the standard for determining design speed. According to the table, Prek Chhloung Bridge and Peam Te Bridge lie in Area Type-II, where some extent of land acquisition and resettlement is required, while the remaining 5 bridges are in Area Type-I, where issues of land acquisition and resettlement is very less. Therefore, the design speed at Prek Chhloung Bridge and Peam Te Bridge is set to 60km/h. The rest of the bridges and its approach roads is set to 80km/h.

Table 2.2-4 Design Speed (Urban)

Design Standard	Design Speed (km/hr.)		
	Area Type I	Area Type II	Area Type III
U6	100	80	60
U5	**80**	**60**	**50**
U4	**70**	**60**	**50**
U3	60	50	40
U2	50	40	30
U1	40	30	20

Area Type I: Relatively free in road location with very little problem about to land acquisition, affected building or other socially sensitive areas.

Area Type II: Intermediate between I and III

Area Type III: Very restrictive in road location with problem about to land acquisition, affected building and other sensitive areas

(5) Geometric Condition

Geometric condition for design of bridge and approach road will be in conformity with the Road Design Standard Part 1. Geometry (CAM. PW.03.101.99), 2003. Major features of the geometric condition in correspondence with the design speed are shown in Table 2.2-5.

Table 2.2-5 Major Features of Geometric Conditions for Design of Approach Road/Bridge

Items			Design Speed (km/hr.)	
			80	60
Horizontal Alignment				
Minimum radius of curvature	Desirable (5% SE)	m	255	135
	Minimum (9%SE)	m	210	115
Maximum super-elevation		%	6.0	9.0
Minimum length of curvature		m	140	100
Minimum length of transitional curve		m	44	33
Minimum radius not requiring transitional curve		m	379	213
Minimum radius not requiring super-elevation		m	1,250	5,000
Super-elevation Runoff			$(e_1 - e_2)V_d/0.09$	$(e_1 - e_2)V_d/0.126$
Vertical Alignment				
Maximum gradient	Standard	%	4.0	5.0
	Limiting values	% (m)	5 (500)	6 (300)
		% (m)	6 (400)	7 (250)
		% (m)	7 (300)	8 (200)
Sight distance	Stopping	m	115	70
	Passing	m	550	450
Crest curve	K-value		30	15
Sag curve	K-value		28	15
Minimum vertical curvature length		m	-	-
Minimum radius not requiring widening		m	250	250

(6) Design Condition for Bridges

1) Cross section Elements

Cross section elements of all bridges to be applied will follow the standards of Cambodia and are as indicated in Table 2.2-6. The bridge will have 2-lanes each 3.5m wide with a marginal strip (marginal strip) of 0.6m. A 2.5% gradient will be applied for the cross-fall. A mounted walkway 1.0m wide will be provided on both sides of the bridges in Prek Chhloung Bridge and Peam Te Bridge taking into consideration the fact that the bridges will be used by many pedestrians as there are communities and pagodas nearby the bridges.

Table 2.2-6 Road Width on the Bridge

Items		Value	Remarks
Width of Right of Way (m)		50	One side 25m from the center line
Width on the Bridge	Width of Roadway (m)	3.50	
	Width of Side strip (m)	0.6	
	Width of Sidewalk (m)	1.00	
Cross grade (%)		2.5	

2) Design Load

Design load to be applied is shown in Table 2.2-7. A live load of AASHTO HS25 is applied to taking into consideration the high volume of overloaded vehicles as well as about the loads applied in other grant aid projects.

Table 2.2-7 Main Design Load

Design Load	Contents
(1)Live Load	AASHTO HS25 (Bigger section force is adopted compare with AASHTO HS25 and Live load type B in Japan (JRA))
(2)Seismic Load	Horizontal seismic coefficient Kh=0.05 (Cambodian Standard)
(3)Temperature Range	+8 - +42 Degree Celsius (Cambodian Standard)

3) Soil Condition

a) Estimated Geologic Profile

Based on the results of Standard Penetration Test and other tests in the laboratory in geological survey, estimated geologic profile lines are shown in Figure 2.2-1 to Figure 2.2-7.

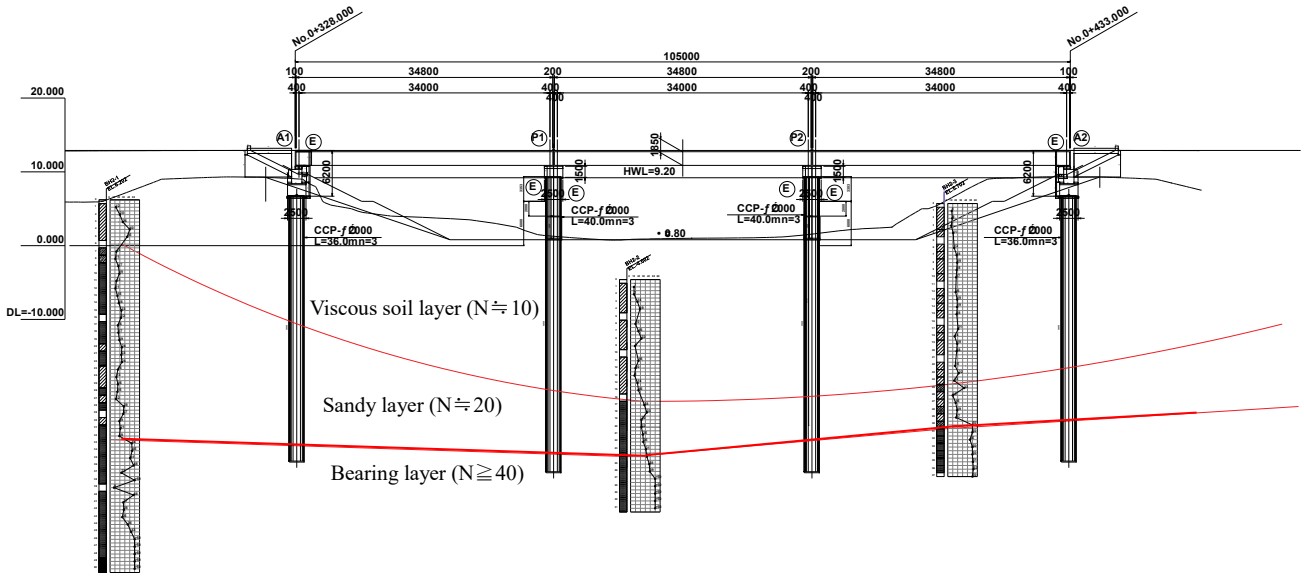


Figure 2.2-1 Estimated Geologic Profile Lines (Ba Baong No.2)

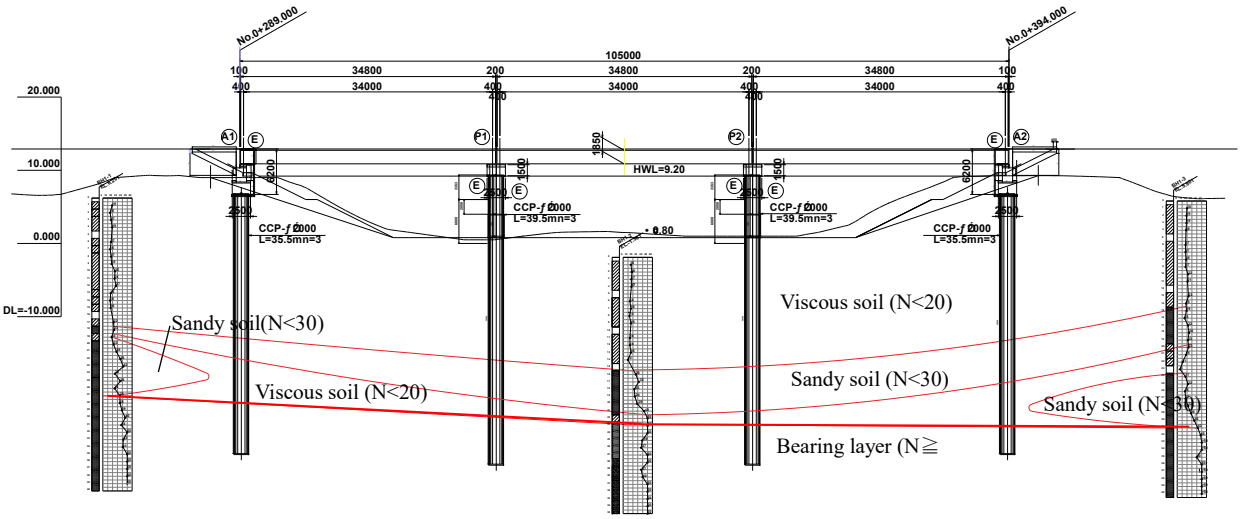


Figure 2.2-2 Estimated Geologic Profile Lines (Ba Baong No.1)

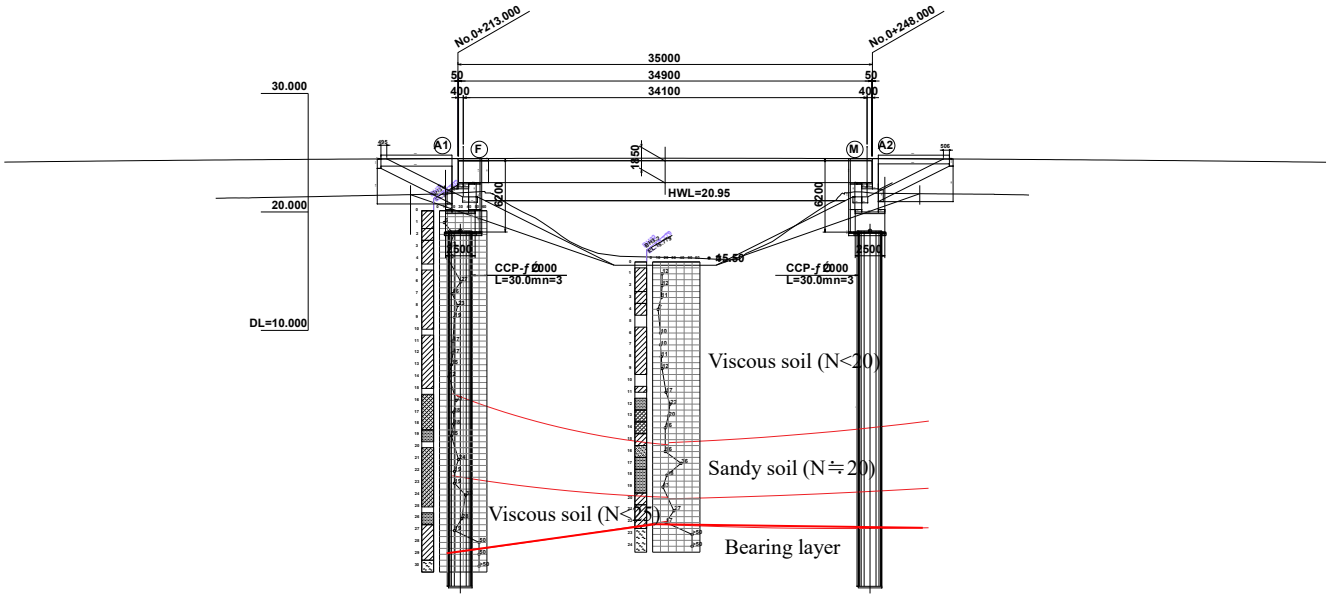


Figure 2.2-3 Estimated Geologic Profile Lines (Prek Sandan)

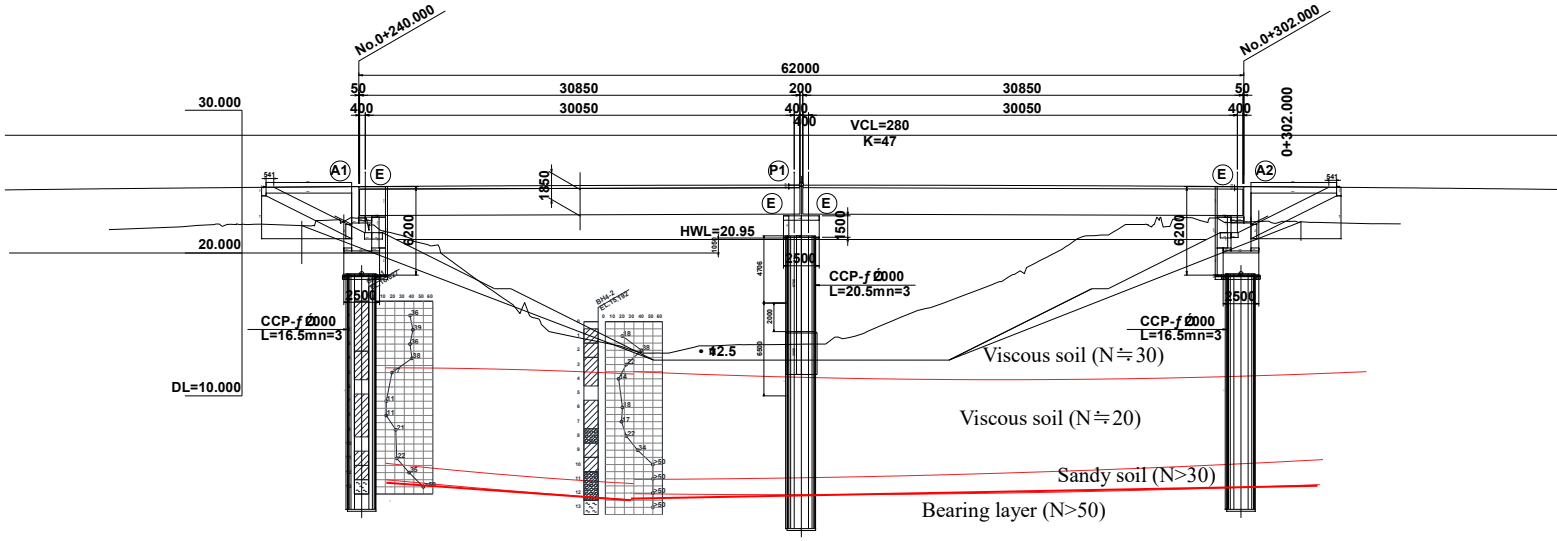


Figure 2.2-4 Estimated Geologic Profile Lines (Prek Rus)

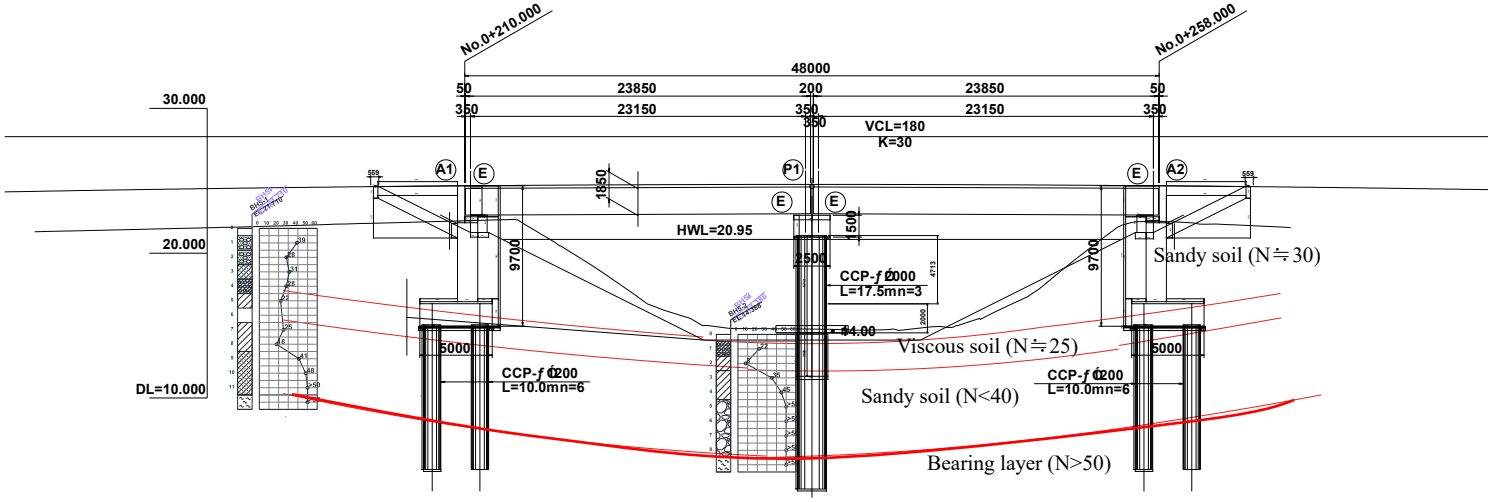


Figure 2.2-5 Estimated Geologic Profile Lines (Anlong Khle)

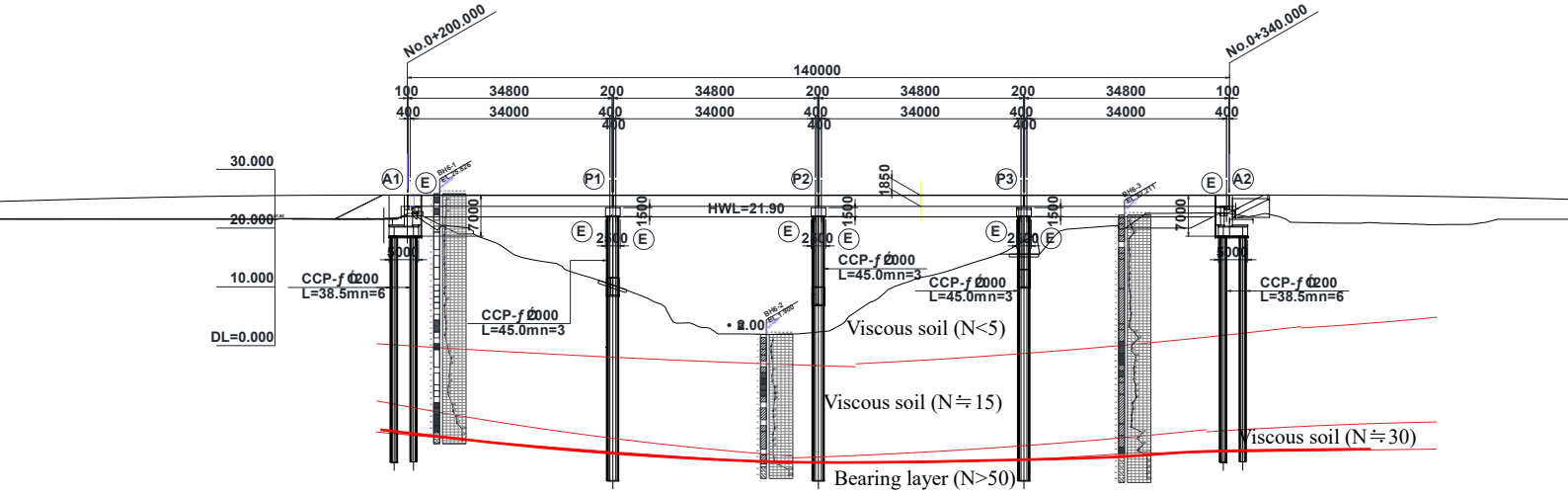


Figure 2.2-6 Estimated Geologic Profile Lines (Prek Chhloung)

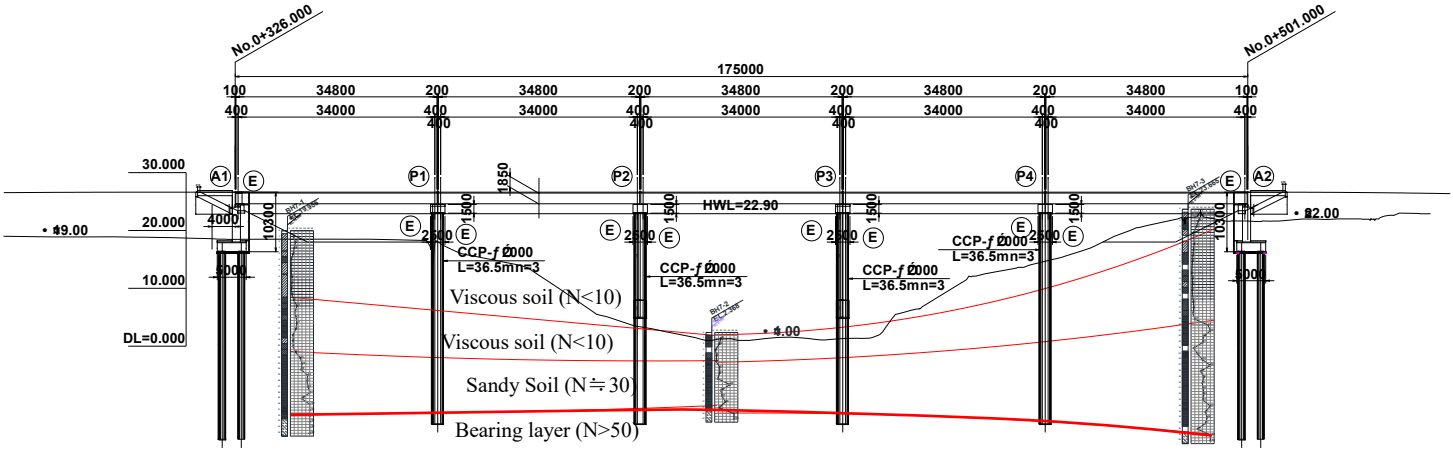


Figure 2.2-7 Estimated Geologic Profile Lines (Peam Te)

b) Measures to Soft Soil

i) Basic Approach to Soft Soil

The embankment of approach roads for Prek Chhloung Bridge and Peam Te Bridge have been designed as five (5) to eight (8) meters in height from existing ground level while approximately seven (7) meters thickness of the soft clay layer (N-value: 2 to 5) has been appeared near the ground level. Therefore, the consolidation settlement by the embankment for above two (2) bridges was examined as shown in following table.

Table 2.2-8 Expected Consolidation Settlement for Prek Chhloung Br. and Peam Te Br.

Name of Bridge	Location	Condition of the Ground	Height of Embankment	Output
Prek Chhloung Bridge	A1 Abutment	N-value : 4 to 5 Thickness : 7m	5m	Settlement : 28cm Consolidation Time : 58-yr Residual Settlement: 3.5cm
	A2 Abutment			
Peam Te Bridge	A1 Abutment	N-value : 2 to 4 Thickness : 7m	8m	Settlement : 84cm Consolidation Time : 10-yr Residual Settlement : 20cm
	A2Abutment		6m	Settlement : 66cm Consolidation Time : 10-yr Residual Settlement : 20cm

Note)Residual Settlements are estimated as 3 years after the Construction Work.

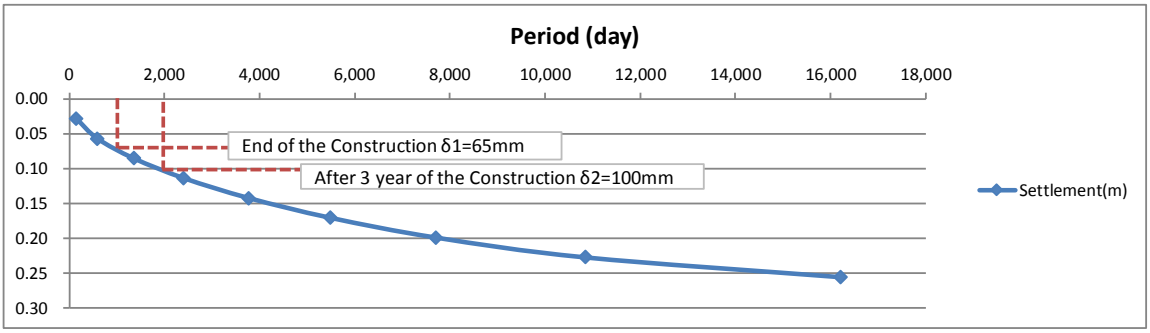


Figure 2.2-8 Consolidation Settlement Curve for Prek Chhloung Bridge.

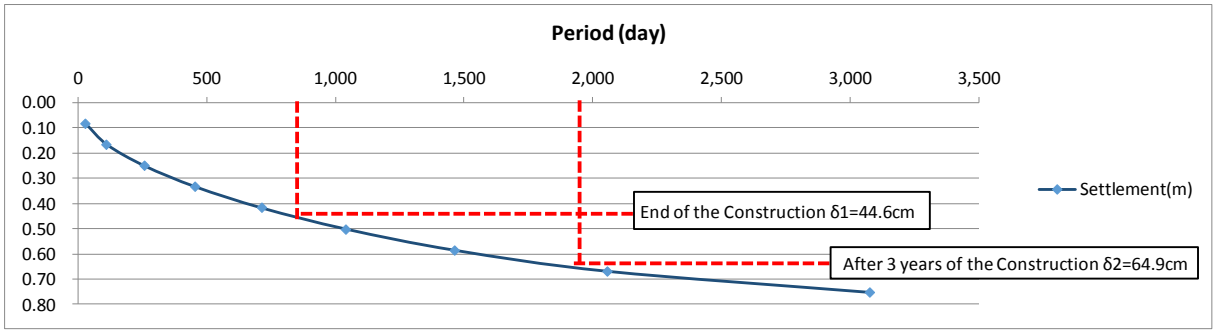


Figure 2.2-9 Consolidation Settlement Curve for Peam Te Bridge(Approach Road; A1 side)

Based on above analysis, the Prek Chhloung Bridge would not require any treatment and measures to the soft soil since the residual settlement value (3.5cm) estimated as three (3) years after completion of the Project is smaller than allowable settlement value defined by Japanese Standard.
However, Peam Te Bridge of which settlement is estimated as twenty (20) cm more than the allowable settlement would require countermeasures to control the consolidation settlement.

Table 2.2-9 Allowable Residual Settlement

Applicable Location	Allowable Residual Settlement Value 3-year after Construction
Front and behind of structure supported by pile foundation such as bridge and culvert.	10cm or less
Earthwork embankment other than above	30cm or less

Source：『Road Earthwork Manual for Soft Soil Treatment (2012)』(Japan Road Association)

ii) Countermeasure to Consolidation Settlement

Based on the above examination, the soft soil treatment shall be applied to the ground of approach road at Peam Te Bridge. Typical Countermeasures to the consolidation settlement are introduced in Table 2.2-10 below. As the result of comparison study on counter measures to be applied for the project site as shown in Table 2.2-12, "Soil Treatment (1) Facilitation of Consolidation by Vertical Drain Method" would be the most appropriate for the Project in terms of the cost and period. The Vertical Drain is applied to the extent of 150m behind of A1 abutment and 20m behind of A2 abutment, where the height of embankment is four (4) meters or higher i.e. residual settlement within three (3) years after the construction could be ten (10) centimeter or more.

Table 2.2-10 Typical Countermeasures to the Consolidation Settlement

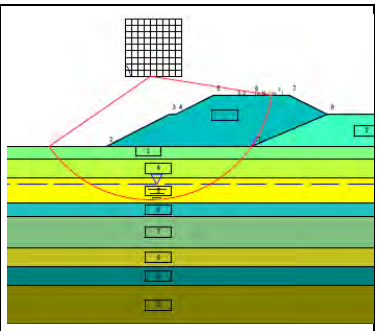
Pre-Loading Method:	Self-weight of embankment for approach road with some more with some excessive weight is loaded until the consolidation would be completed.
Light Weight Fill Material:	Light weight material will be filled to the approach road to mitigate the consolidation settlement.
Soil Treatment Work:	Vertical Drain Method shall be applied to facilitate the consolidation. Note: Deep Layer Mixing Method is to apply to prevent the lateral displacement by embankment load at the A1 side of Peam Te Bridge as well as to shorten the construction period.

iii) Stability of Embankment on Soft Soil

Embankment of approach road with 8 meters in height at A1 abutment side of the Peam Te Bridge would not be able to ensure the stability in bearing capacity due to soft soil as shown in Case-1 of Table 2.2-11 below. Therefore "Stepwise Embankment" shall be applied to the specific area. As shown in Case-2 below, the stability can be secured by constructing the embankment in 3 steps, namely, embankment up to 6m in height as 1st step, up to 8m after 80% consolidation (53 days after 1st step) as 2nd step and opening of the traffic after 90% consolidation (48 days after 2nd step) as 3rd step.

Table 2.2-11 Stepwise Embankment and its Stability

Case	Embankment Step	Safety Factor	
Case-1	Embank up to 8m in height at once.	Fs=0.95 (NG)	
Case-2	STEP-1: Embank by 6m in height	Fs=1.24 (OK)	
	STEP-2: Embank up to 8 m in height after 53 days (80% of consolidation)	Fs=1.20 (OK)	
	STEP-3: Opening of the Road after 48 days (90% of consolidation)	Fs=1.25 (OK)	



Analysis of Circular Slip by Embankment

Allowable Safety Factor for Circular Slip; During Construction Fs≧1.10, Before Opening Fs≧1.25

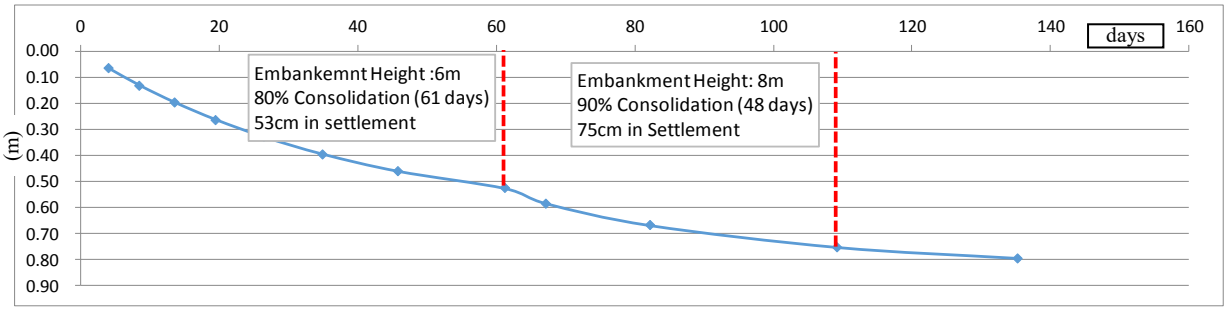
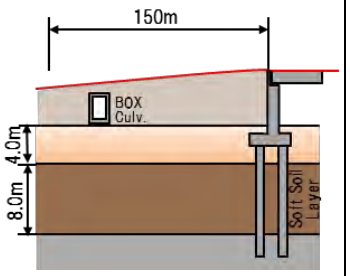
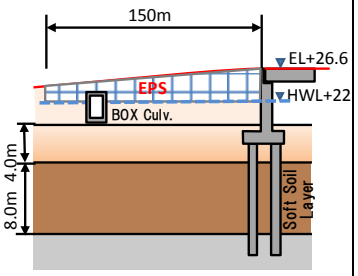
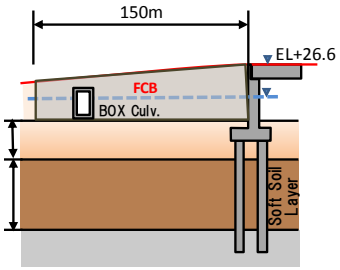
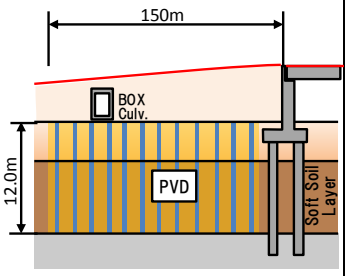
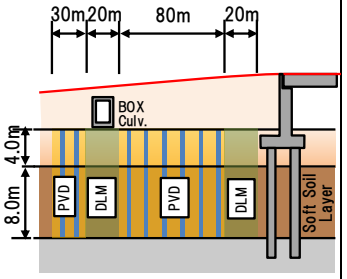


Figure 2.2-10 Consolidation Settlement Curve by Stepwise Embankment (with Vertical Drain) at A1 side of Peam Te Bridge

iv) Specific Requirement for Additional Soil Investigation

Above all study on measures to soft soil has been based on the consolidation test carried out at one boring survey near A1 abutment of Peam Te Bridge. It is therefore required to conduct additional consolidation test and other physical test at A2 abutment side at the time of detailed design survey during the implementation of the Project to review and ensure the settlement control proposed by this study.

Table 2.2-12 Comparison Table of Consolidation Measures (Peam Te Bridge)

	Pre-Loading Method	Light Weight Fill (1)	Light Weigh Fill (2)	Soil Treatment (1)	Soil Treatment (2)
	Pre-loading by self-weight of road embankment	Expanded Polystyrene Filling (EPS Method)	Foamed Cement Banking (FCB Method)	Prefabricated Vertical Drain Method (PVD Method)	Vertical Drain Method + Deep Layer Mixing Method (PVD&DLM)
Image					
Figure	The Consolidation will be progressed by Pre-Loading with self weight of roadway embankment. Settlement (at Abutment)： 83cm Settlement (at BOX Culv.)： 46cm	To lighten the embankment, the Expanded Polystyrene Block (0.2kN/m^3) will be used for embankment material. Since buoyance force in the water would be very strong, it cannot be applied below HWL. Settlement (at Abutment) ：54cm Settlement (at Box Culv.) ：24cm	The stabilized light embankment (6kN/m^3) is constructed by using Foamed Cement Concrete. Settlement (at Abutment)：32cm Settlement (at Box Culv.)：19cm	Vertical drain with plastic material is applied to **accelerate the consolidation** by self-weight of road embankment. After completion of the consolidation settlement, the foundation of abutment will be constructed. Settlement (at Abutment)： 83cm Settlement (at BOX Culv.) ： 46cm	Vertical drain is applied with the Deep layer mixing at the behind of abutment to interrupt effect of lateral displacement to the pile foundations by the consolidation. **Road embankment can be constructed without waiting period** for consolidation settlement. Vertical drain under the box culvert is to prevent the differential settlement.
Period	**Consolidation Period：5.1 years**	**Consolidation Period：6 years**	**Consolidation Period: 4.0 years**	**Consolidation Period：6.0 Month**	**Deep Layer Mixed 1.0 Month**
Quantity /additional Cost	Embankment ；27,000m3	Embankment : 17,400m^3 EPS Method : 9,600m^3	Embankment : 8,145m^3 Foamed Cement Bank ：18,855m^3	Embankment : 27,000m^3 Vertical Drain : 3000 m^2	Embankment : 27,000m^3 (1) Vertical Drain : 2200m2 (2) Deep Layer Mixed Improve Ratio 50％: 400m^2 (A1) Improve Ratio30％: 400m^2 (Box Culv.)
	Additional Cost 0 Million JPY	**209 Million JPY** (Exclusive of cost for Vertical Drain Work)	**197 Million JPY** (Exclusive of cost for Vertical Drain Work)	**44 Million JPY**	**83 Million JPY**
Evaluation	Not Applicable	Not Applicable	Not Applicable	**Good**	Fair
	Although Pre-loading can progress the consolidation, it will take more than 5 years to settle, which is hardly implemented under Japan's Grant Aid System.	The highest construction cost and the longest construction period. Vertical drain work shall be supplemental applied to shorten the construction period.	The second highest construction cost with 2-year consolidation period. Vertical drain work shall be supplemental applied to shorten the construction period.	The lowest construction cost with 6-month waiting period for consolidation. Uncertainty of expected consolidation period can be controlled by surcharge with periodic measurement of elevation.	The shortest construction period with second lowest construction cost. Construction period can be assured because abutment and its pile foundation can be constructed without waiting period of the consolidation. However, environmental monitoring for underground water is required for contamination by deep layer mixing.

4) River Condition

a) Design High Water Level (HWL) and Design Discharge

The recorded maximum flood water levels of 1996 Flood and 2000 Flood were adopted as the HWLs of the Bridge No.24, 25 and 26 of NR6A and the three bridges of NR1 respectively.

The HWL of the eight bridges of NR11 (constructed in 2015) is set at the estimated flood water level of 2011 Flood based on the questionnaire survey on flood water level. As NR11 passes in the left bank flood plain of the Mekong River from north (around Kampong Cham) to south (Neak Loueng), the flood water level along the NR11 is affected by the flood water level in the Mekong River at Kampong Cham in the northern part and is affected by the flood water level at Neak Loueng in the southern part. The maximum flood water level of 1996 Flood at Kampong Cham is El. 15.21m, and that of 2000 Flood at Neak Loueng is El. 7.79m. At Neak Loueng, difference of the maximum water level of 2000 Flood and that of 2011 Flood (El. 7.74m) is 5cm. At Kampong Cham, difference of the maximum water level of 1996 Flood and that of 2011 Flood is 9cm. Although the applied HWL of the maximum inundation water level of 2011 Flood for the eight bridges of NR11 is 6cm to 9cm lower than the recorded maximum flood, the differences are small. Hence, it can be said that the applied HWL is almost equivalent to the recorded maximum water level.

Table 2.2-13 HWLs and Design Discharges of the Target Seven Bridges

Bridge	HWL (Upstream WL) (El.m)	Downstream WL (El.m)	Design Discharge (m^3/s)	Remark
NR11:	**Design Flood of the Equivalent Flood as 2000 Flood**			
Ba Baong No.1	9.20 (Mekong River Side/ Western Side WL)	8.40 (Eastern side WL of the Road)	1,060 + 210/2 =1,165	As Ba Baong No.1 and No.2 Bridges are nearby and the inundation water is continuous, the HWL and the downstream WL are set as common between these Bridges. The overflow discharge over the Road between these Bridges is added into the Design Discharges of these Bridges.
Ba Baong No.2	9.20 (Mekong River Side/ Western Side WL)	8.40 (Eastern side WL of the Road)	1,370 + 210/2 =1,475	
NR73:	**Design Flood of the Equivalent Flood as 1996 Flood**			
Peam Te	22.90 (HWL, Mekong River side WL)	22.70 (Inundation WL in the tributary side)	4,000	During reverse flow from the Mekong River to the tributary.
<Reference>	22.70 (Inundation WL in the tributary as assumption)	21.70 (WL in the Mekong River side)	6,100	During normal flow of the tributary to the Mekong River for flowing back inundation water to the Mekong River in the recession period of the WL of the Mekong River.
Prek Chhloung	21.90 (HWL, Mekong River side WL)	21.70 (Inundation WL in the tributary side)	2,800	During reverse flow from the Mekong River to the tributary.
<Reference>	21.70	20.70	4,750	During normal flow of the tributary to the Mekong River for flowing back inundation water to the

Bridge	HWL (Upstream WL) (El.m)	Downstream WL (El.m)	Design Discharge (m^3/s)	Remark
	(Inundation WL in the tributary as assumption)	(WL in the Mekong River side)		Mekong River in the recession period of the WL of the Mekong River.
Anlong Khle	20.95	20.45	450	As the inundation waters in the northeast side and southwest side of Anlong Khle, Prek Rus and Prek Sandan Bridges are nearby and continuous in general, HWL and the downstream inundation WL of these Bridges are set as common between these Bridges.
Prek Rus	20.95	20.45	550	
Prek Sandan	20.95	20.45	240	

b） Freeboard between Bottom of Bridge Beam and the Design High Water Level

The freeboards between bottom of bridge beam and design HWL of the target seven bridges are set considering the basic freeboard based on the design flood discharges, probable flood water level of 50-year return period, which is common in Japan, and possibility of water level rise by climate change.

Freeboard between Bridge Beam Bottom and the Design HWL = Basic Freeboard + (Bigger one among the (Difference between the 50-year Return Period of Flood Water Level and the Recorded Maximum Water Level (HWL)) and (Water Level Rise within future 20 years by Climate Change)).

By setting the freeboard based on the above method, even in the case of occurring water level rise by climate within 20 years from now, at least, it will be possible to ensure the Basic Freeboard. As a reference, increasing amount of discharge of the Mekong River and water level rise in the flood plain by Climate Change in the Year 2060 is estimated by the Mekong River Commission (MRC). Year 2060 is 40 years later from the completion of construction of the Bridges by this Project. Considering the uncertainty of the projection of the Climate Change and sustainability of the condition of roads based on estimation of traffic conditions, it is proposed to include the water level rise within 20-year from now by Climate Change (see Figure 2.2-11).

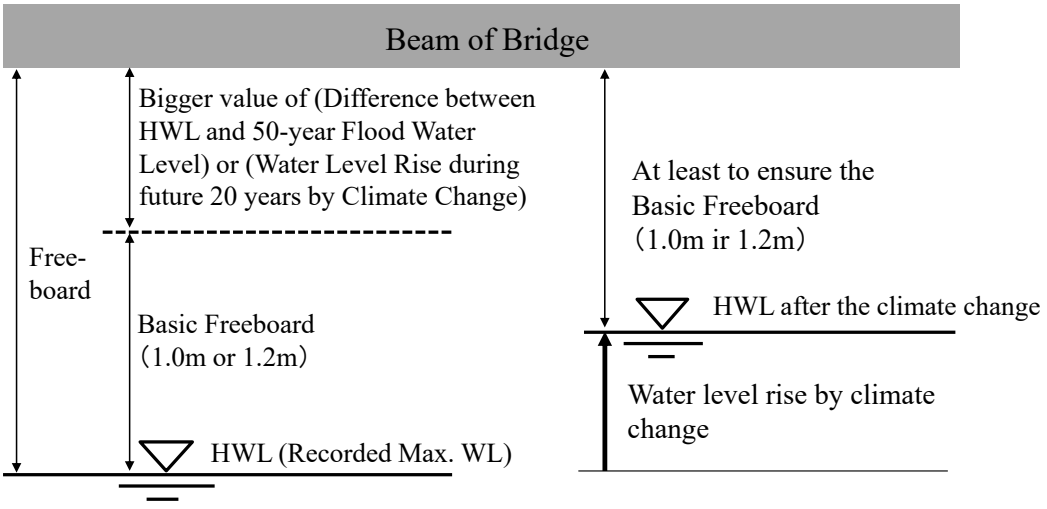


Figure 2.2-11 Concept of Setting Freeboards

Basic Freeboard :

The target two bridge of NR11 (Ba Baong No.1 Bridge and Ba Baong No.2 Bridge) and the target three bridges of NR73 (Prek Sandan Bridge, Prek Rus Bridge and Anlong Khle Bridge) are in the road dike stretches, which cross the flood plains. So, the upstream water level and downstream water level of the neighboring bridges are estimated to be almost the same upstream water levels and almost the same downstream water levels respectively. Hence, the design flood discharge passing through each Bridge is calculated by considering the difference of upstream and downstream water levels. The Basic Freeboard of each Bridge is set based on the design flood discharge. Then same Basic Freeboard are set for the above two Bridges of NR11 and same Basic Freeboard are set for the above three Bridges of NR73 respectively considering the design flood discharges of these bridges.

For Peam Te Bridge and Prek Chhloung Bridge, which are located along the Mekong River, HWLs are set based on the water level of the Mekong River during reverse flow condition from the Mekong River. The Basic Freeboards for these Bridges are set based on the design flood discharge of the reverse flow conditions.

Water Level Difference between the 50-year Return Period of Flood Water Level and the Recorded Maximum Water Level:

The Target Two Bridges of NR11:

Water level difference between the 50-year return period of flood water level and the Recorded maximum water level at Neak Loueng is (El. 7.80m – El. 7.79m = 0.01m), which is almost equal to 0m.

The Target 5 Bridges of NR73:

Water level difference between the 50-year return period of flood water level and the Recorded maximum water level at Kratie is (El. 23.30m – El. 22.92m = 0.38m), which is about 0.40m.

Estimated Water Level Rise Height during Future 20 Years by Climate Change:

1) Target Two Bridges of NR11

The Mekong River Commission (MRC) estimated the height of water level rise of 100-year return period in Year 2060 by the medium scenario of climate change comparing the water level of 100-year return period in Year 2014 at Prey Veng. The estimated value is 0.10m*). As the water level at Prey Veng is almost same for the floods with more than 20-year return period of flood water level, it can be supposed that water level rise of 0.10m will be occurred in Year 2060 (44 year later). Based on this, the water level rise after 20 years becomes about 5cm, which is set at 10cm considering 10cm interval of water level difference.

*) MRC ; "Initial Studies to Demonstrate the Formulation of Strategic Directions to Manage Existing, Future & Residual Flood Risks in the Lower Mekong Basin
Task 1C Report: Existing Flood Behavior and Possible Future Flood Behavior under Inferred Climate Change in transboundary floodplains in Cambodia and the Vietnam Mekong Delta, including the Tonle Sap Lake Area, 2015"

2) Target Five Bridges of NR73:

In the above Report of MRC, it is estimated that the 100-year return period of flood discharge will be increased from 67,851m3/s in Year 2014 to 77,157m3/s in Year 2060. However, as the existing water level – discharge data and curve (H-Q Curve) is available up to around 40,000m3/s only, this curve cannot be applied for 60,000 to 80,000m3/s due to low accuracy of water level estimation based on the H-Q Curve.

On the other hand, MRC estimated water level rise of the 100-year return period of inundation water level under medium scenario in Year 2060 in the flood plain around Kratie at 1.42m. In the meantime, by deducting the difference of the 100-year return period of flood water level in Year 2060 from the water level of equivalent flood as 1996 Flood (El. 23.40 – 22.92 = 0.48m), the water level rise in 2060 is estimated at 0.94m (=1.42 – 0.48m). Based on this, it is estimated that the water level rise within 20-years from now is estimated at 0.94/2 = 0.46 ≒ about 0.50m.

3) Height of the Freeboard and Elevation of the Bottom of the Beams of the Target Seven Bridges

It is proposed to set the height of freeboard and elevation of bottom of the beams of the target seven Bridges as shown in Table 2.2-14.

Table 2.2-14 Freeboard Height and Elevation of Bottom of the Beams of the Subject Bridges

Bridge	HWL (El.m)	Design Discharge (m^3/s)	Freeboard				Bottom Elevation of Beam (El.m)	Remarks
			Basic Freeboard (m)	Difference between 50-year Return Period of WL and the Recorded Max. WL (HWL) (m)	Water Level Rise in 20 Years by Climate Change (m)	Total (m)		
NR11:								
Ba Baong No.1	9.20	1,165	1.0	0	0.1	1.1	10.30	
Ba Baong No.2	9.20	1,475	1.0	0	0.1	1.1	10.30	
NR73:								
Peam Te	22.90	4,000	1.2	0.4	0.5	1.7	24.60	Reverse Flow
<Reference>	22.70	6,100	1.5	0.4	0.5	2.0	24.70	Normal flow
	As the freeboard of normal flow is almost same as that of reverse flow, freeboard of reverse flow is to be adopted.							
Prek Chhloung	21.90	2,800	1.2	0.4	0.5	1.7	23.60	Reverse flow
<Reference>	21.70	4,750	1.2	0.4	0.5	1.7	23.40	Normal flow
	As the freeboard of normal flow is smaller than that of reverse flow, freeboard of reverse flow is to be adopted.							
Anlong Khle	20.95	450	1.0	0.4	0.5	1.5	22.45	
Prek Rus	20.95	550	1.0	0.4	0.5	1.5	22.45	
Prek Sandan	20.95	240	1.0	0.4	0.5	1.5	22.45	

c） Reference span length

To maintain a smooth flow of the river during the flood, reference span length shall be calculated by the following formula in accordance with the Structural Decree of River Management Facilities etc. in Japan.

Reference span length： L=20+0.005Q

(L : Reference span length (m), Q : Design flood flow rate (m^3/sec))

d） Impediment ratio of river flow

In decision of number and width of bridge pier, it is in accordance with t the Structural Decree of River Management Facilities etc. in Japan, impediment ratio of river flow calculated from following formula should be less than 5 %.

Maximum impediment ratio of river flow： S=5.0%

$S=\Sigma W_0/Wr$

(S: Impediment ratio of river flow, ΣW_0: Total width of bridge pier in right angle direction of river flow, Wr: Width of H.W.L)

5) Materials

Criteria for construction materials shall be basically complied “Construction Specification 2003” in Cambodia. Items not described in the specification in Cambodia should be referenced past Japan Grant Aid Project. Specification of main construction material is shown in Table 2.2-15.

Table 2.2-15 Main Construction Materials

Materials	Main use element
Concrete (Compressive Strength：45N/mm^2)	Prestressed concrete girder
Concrete (Compressive Strength：40N/mm^2)	Deck slab
Concrete (Compressive Strength：32N/mm^2)	Substructure of bridges, Other concrete structures
Concrete (Compressive Strength：18N/mm^2)	Lean concrete
Deformed Bar (Grade 400: Equivalent to JIS SD 390)	Reinforced concrete structures (D10 - D32)

6) Design Criteria (Approach Road)

a） **Cross Section Elements**

Figure 2.2-12 shows the cross-section elements of approach roads. These values apply to all approach roads of all target bridges. A width of 3.5m was applied based on the road design standards of Cambodia. Widths 1.5m for hard shoulder and 1.0m for soft shoulder are applied taking the condition of slopes in addition to the values recommended in the same standard. Altogether, the cross-section elements are;
Total width = 12.0m (Traffic lanes: 3.5m x 2, Hard shoulder: 1.5m x 2, Soft shoulder1.0m x 2)

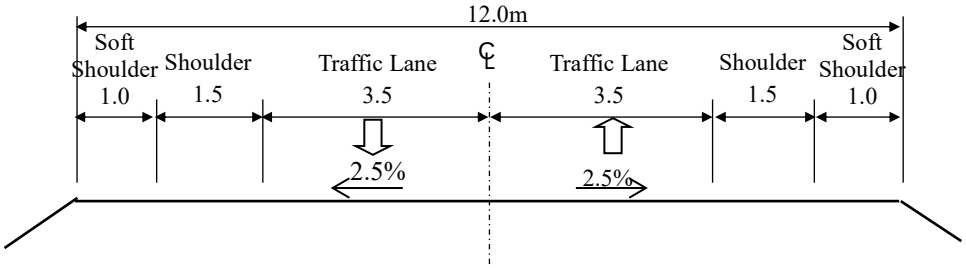


Figure 2.2-12 Cross Section Elements

b) **Geometric Elements**

Geometric elements to be applied are as prescribed in Section 2.2.2(5) .

c) **Pavement**

Asphalt concrete will be applied for pavement of all approach roads. The traffic loads to be used for the design (calculation) of pavement will be based on the traffic forecasted for the performance period of 20 years after opening of the roads to traffics.

(7) Traffic Demand Forecast

1) Outline of Traffic Survey

To understand the traffic situation on the subject roads and estimate future traffic demand, traffic surveys which are 1) Traffic Count Survey, 2) Roadside OD Interview Survey, 3) Axle Load Survey and 4) Travel Speed Survey was carried out. Outline of traffic survey and survey location are shown in Table 2.2-16 and Figure 2.2-13, respectively.

Table 2.2-16 Outline of Traffic Survey

Survey	Objective of Survey	Survey Contents	Remarks
1. Traffic Count Survey	To understand the traffic information at subject road to estimate future traffic volume for road design	・Location: 6 stations (Weekday: 1 day, 24 hours) ・Vehicle Type: 10 Types	-
2. Roadside OD Interview Survey	To understand the OD trip pattern on subject road	・Location: 6 stations (Weekday: 1 day, 24 hours) ・Vehicle Type: 10 Types ・No. of Sample: more than 30% (Target)	Applied Interview Method
3. Axle Load Survey	To understand existing axle load on subject road	・Location: 3 stations (Weekday: 1 day, 24 hours) ・No. of Sample: more than 50% (Target)	Observed by truck scale equipment
4. Travel Speed Survey	To understand travel speed on subject road and calculate operation and efficient indicators	・Route: 2 routes (Weekday: 1 day, Morning Peak, Off Peak and Evening Peak) ・Probe Survey (Utilizing GPS)	Observed by GPS

Source: JICA Survey Team

		
Traffic Count Survey	Roadside OD Interview Survey	Axle Load Survey

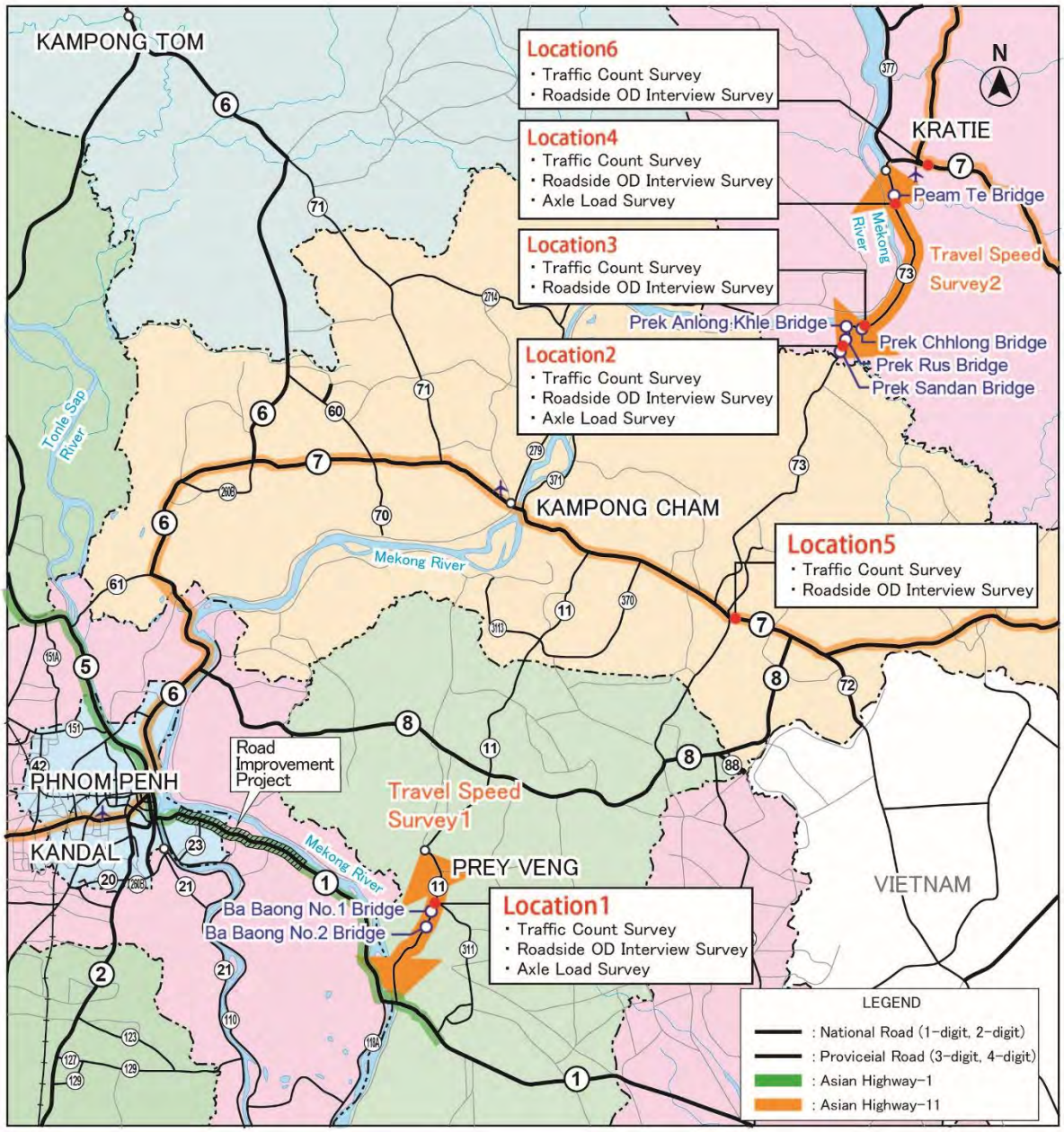


Figure 2.2-13 Traffic Survey Location

2) Result of Traffic Survey

a) Traffic Count Survey

Result of Traffic count survey is shown in Table 2.2-17. Initially, traffic count survey had conducted on subject roads where are National Road 11 (hereafter NR11) and National Road 73 (hereafter NR73). However, heavy vehicle traffic is diverted from NR73 into National Road 7 (hereafter NR7). Thus, traffic survey was conducted NR11, NR73 and NR7 (connecting point between NR73 and NR7).

Traffic volume on NR11 and NR73 is ranging by 4,141 veh/day to 5,867 veh/day, and heavy vehicle ratio is ranging by 2.1% to 6.0%. characteristic of traffic on NR11 and NR73 shows high motorcycle ratio cause by internal traffic (short trip).

Table 2.2-17 Result of Traffic Count Survey

Unit: Veh/day

Location	National Road	Motorcycle	Passenger Car	Bus	Truck	Total	Heavy Vehicle Ratio
Location-1	NR11	2,146	752	195	1,047	4,141	6.0%
Location-2	NR 73	2,368	862	969	416	4,615	3.5%
Location-3	NR 73	3,470	1,125	938	334	5,867	2.1%
Location-4	NR 73	3,165	1,043	960	418	5,586	4.0%
Location-5	NR7	3,281	1,714	1,134	1,229	7,358	6.9%
Location-6	NR7	4,133	729	390	299	5,551	4.0%

b） Roadside OD Interview Survey

Roadside OD interview survey was conducted on NR11, NR73 and NR7 shown in Figure 2.2-13. Sample rate is more than 50%, it is available number for traffic analysis.

Table 2.2-18 Sample Rate

	No. of Sample	Traffic Count	Sample Rate
Station1	1,334	3,234	41.2%
Station2	2,497	4,615	54.1%
Station3	1,914	5,867	32.6%
Station4	2,189	5,586	39.2%
Station5	2,215	7,358	30.1%
Station6	2,132	5,551	38.4%

Figure 2.2-14 shows trip purpose by survey locations calculated by result of roadside OD interview survey. Total traffic of 38% to 41% is business trip, followed by 6% to 27% is commuter trip, 23% to 33% is private trip and tourism and school is less than 10%.

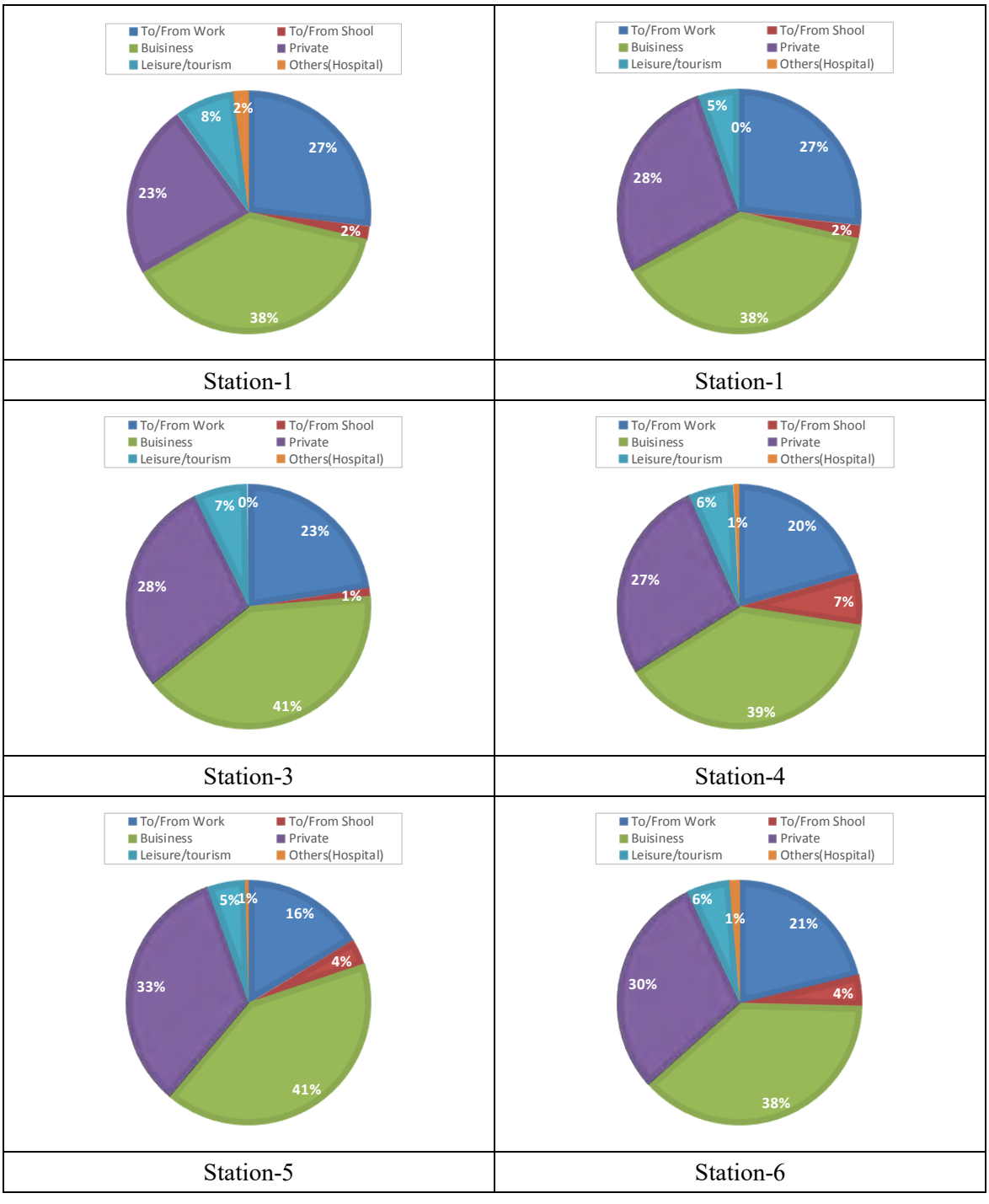


Figure 2.2-14 Ratio of Trip Purpose by Survey Locations

Figure 2.2-15 shows desired line passing NR11 and NR73 by vehicle type. Characteristic of each desired line is shown as following;

Motorcycle

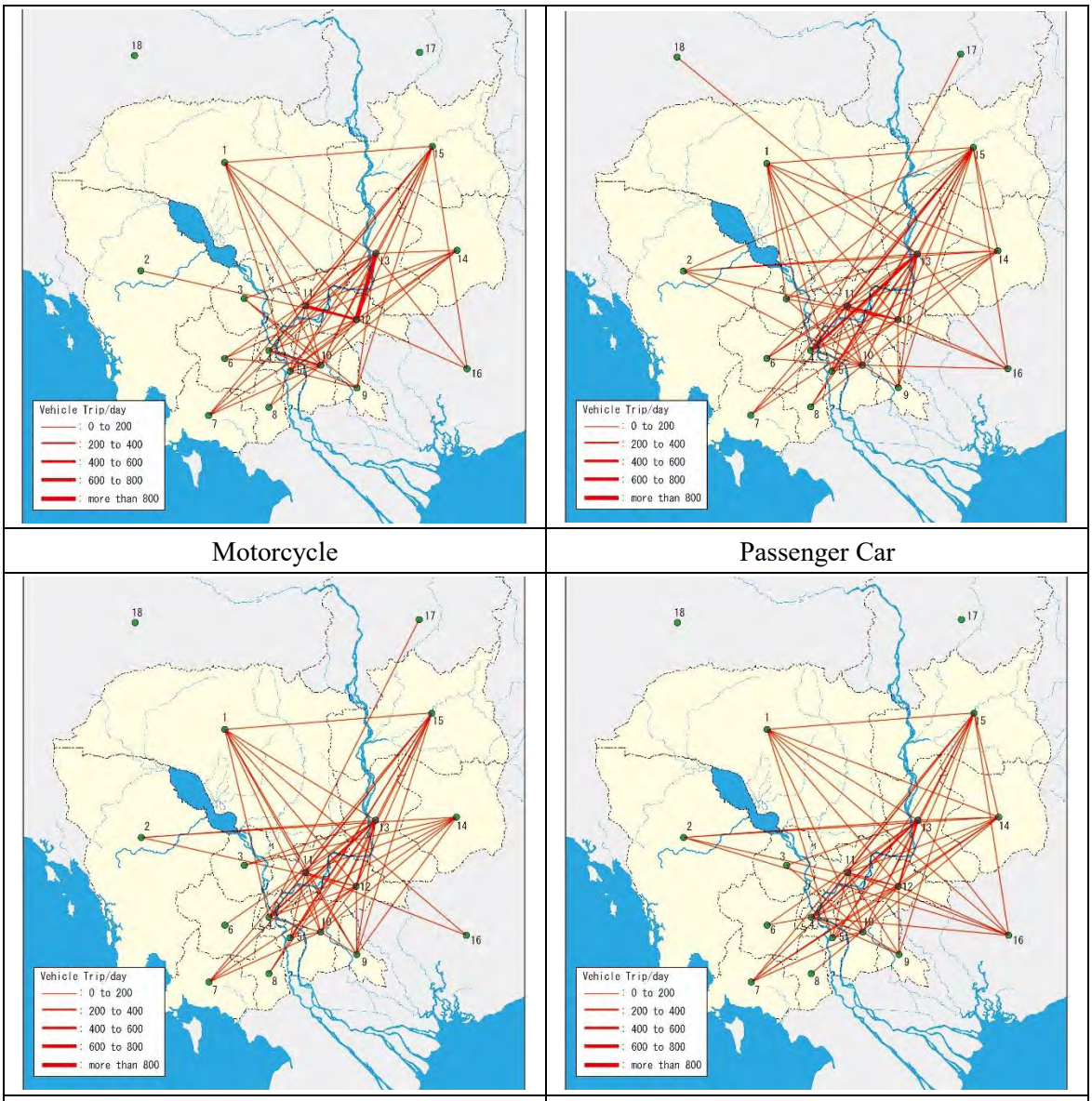
Internal traffic is high caused by short trip. However, traffic passing neighbor province also shows in desired line, especially from Kratie Province to Kampong Chang Province, Prey Veng Province to Neak Loeang.

Passenger Car

Traffic passing from Prey Veng Province and Kratie Province to Phnom Penh is very high. And, traffic passing from/to Vietnam, Laos and Thailand were observed at desired line.

Bus and Truck

Basically, many bus and truck is concentrating from each province to Phnom Penh is showed at desired line. Bus traffic passing from/to Vietnam and Laos and Truck traffic passing from Kratie Province to Kampong Chang Province shows at desired line. These situations are occurring due to tourism trip and construction material delivering to development area in Kampong Chang Province.



Motorcycle | Passenger Car

Bus | Truck

Note 1：Banteay MeanChey, Kampong Thom, Preah Vihear, Siem Reap, Oddar Meanchey、2：Battambang, Koh Kong, Pursat, Paillin、3：Kampong Chhnang、4：Phnom Penh、5：Kandal、6：Kampong Speu、7：Kampot, Kep, Preah Sihanouk、8：Takeo、9：Svay Reang、10：Prey Veng、11：Kampong Cham、12：Tboung Khmun、13：Kratie、14：Mondul Kiri、15：Ratanak Kiri, Stung Treng、16：Vietnam、17：Laos、18：Thailand

Figure 2.2-15　Desired Line by Vehicle Type

c) Axle Load Survey

Axle load survey was conducted by portable axle load measurement on NR11 and NR73 due to understand existing situation of axle load. Outline of axle load survey shows in below.

Outline of Axle Load Survey	
Type of Vehicle	Truck Traffic (not including Bus)
No. of Sample	It is difficult to observe all vehicle's axle load; sample rate was set 35% to 50%.
Methodology	Axle load was utilized Portable Axle Load Measurement by axle.
Survey Duration	1 weekday and 24 hours

The axle weight regulation and total weight regulation of trucks stipulated by the laws of Cambodia are shown below.

The Axle Weight Regulation	The Total Weight Regulation
1. Front Wheel (Single): less than 6 tons	1. 2 axle truck: less than 16 tons
2. Front Wheel (Tandem): less than 11 tons	2. 3 axle truck: less than 25 tons
3. Rear Wheel (Single): less than 10 tons	3. 4 axle truck: less than 30 tons
4. Rear Wheel (Tandem): less than 18 tons	4. 4 axle trailer and semi-trailer: less than 35 tons
5. Rear Wheel (Tridem): less than 24 tons	5. 5 axle or more trailer and semi-trailer: less than 40 tons

Source: Law on Road, 2014

The methodology of counting overloaded trucks is shown below. And. result of counted overload is shown in Table 2.2-19.

1. Sample of observed truck (a) by axle load survey was classified by axle and further classified them into axle type.
2. Observed truck was classified single axle, tandem axle and tridem axle.
3. Truck exceeding the axle weight regulation and total weight regulation was extracted.
4. At that time, the overloaded on the empty truck should be deleted to have a possibility unexpected value.
5. Truck exceeding the axle weight regulation or total weight regulation was defined observed overloaded truck (b). And, truck exceeding both regulation counted one (1) due to avoid duplication.
6. Expansion rate of truck by axle was calculated by (a) and (b).
7. The number of overloaded truck (e) was calculated by expansion rate and observed overloaded truck.
8. Rate of overloaded truck was calculated by truck observed in the traffic count survey (d) and total traffic observed in the traffic count survey (f).

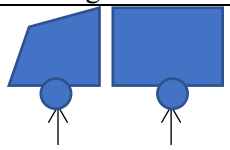
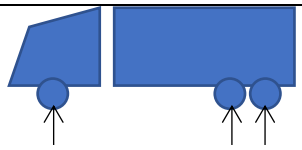
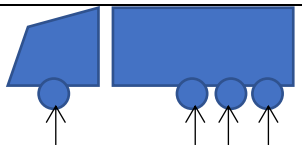
Single Axle	Tandem Axle	Tridem Axle
		
Single Single	Single Tandem	Single Tridem

Table 2.2-19 Number of Overloaded Truck and Its Ratio

Location-1

Vehicle Type	Type of Axle[1]	Observed Truck[2]			Expanded Truck by Traffic Count Survey[3]			Rate of exceeded reguration truck volume[4]		
		Truck Volume (veh/day)	Overloaded Truck (veh/day)	Rate	Truck Volume (veh/day)	Overloaded Truck (veh/day)	Rate	Result of Traffic Count Survey (veh/day)	Overloaded Truck (veh/day)	Rate
		(a)	(b)	(b)/(c)	(d)	(e)	(e)/(f)	(f)	(e)	(e)/(f)
Motorcycle	–	–	–	–	–	–	–	1935	–	–
Passenger Car	–	–	–	–	–	–	–	648	–	–
Bus	–	–	–	–	–	–	–	176	–	–
Others	–	–	–	–	–	–	–	30	–	–
2 Axle Truck	1.1	137	27	19.7%	334	66	19.8%	334	66	19.8%
3 Axle Truck	1.2	31	16	51.6%	62	32	51.6%	62	32	51.6%
4 Axle Truck	1.1.2	9	3	33.3%	16	5	31.3%	79	38	48.1%
	1.3	1	0	0.0%	2	0	0.0%			
5 Axle Truck	1.2.2	15	6	40.0%	27	11	40.7%			
	1.1.3	8	4	50.0%	14	7	50.0%			
	2.3	10	7	70.0%	18	13	72.2%			
6 Axle Truck	1.2.3	1	1	100.0%	2	2	100.0%			
Total		212	64	30.2%	475	136	28.6%	3264	136	4.2%

Expansion Rate			
	Observed Truck Volume (veh/day)	Result of Traffic Count Survey (veh/day)	Expansion Rate
2 Axle Truck	137	334	2.44
3 Axle Truck	31	62	2.00
4 or more Axle Truck	44	79	1.80
Total	212	475	2.24

Location-2

Vehicle Type	Type of Axle[1]	Observed Truck[2]			Expanded Truck by Traffic Count Survey[3]			Rate of exceeded reguration truck volume[4]		
		Truck Volume (veh/day)	Overloaded Truck (veh/day)	Rate	Truck Volume (veh/day)	Overloaded Truck (veh/day)	Rate	Result of Traffic Count Survey (veh/day)	Overloaded Truck (veh/day)	Rate
		(a)	(b)	(b)/(c)	(d)	(e)	(e)/(f)	(f)	(e)	(e)/(f)
Motorcycle	–	–	–	–	–	–	–	2368	–	–
Passenger Car	–	–	–	–	–	–	–	862	–	–
Bus	–	–	–	–	–	–	–	969	–	–
Others	–	–	–	–	–	–	–	0	–	–
2 Axle Truck	1.1	103	34	33.0%	271	89	32.8%	271	89	32.8%
3 Axle Truck	1.2	28	11	39.3%	79	31	39.2%	79	31	39.2%
4 Axle Truck	1.1.2	11	9	81.8%	18	15	83.3%	66	43	65.2%
	1.3	0	0	0.0%	0	0	0.0%			
5 Axle Truck	1.2.2	19	9	47.4%	31	15	48.4%			
	1.1.3	10	8	80.0%	17	13	76.5%			
	2.3	0	0	0.0%	0	0	0.0%			
6 Axle Truck	1.2.3	0	0	0.0%	0	0	0.0%			
Total		171	71	41.5%	416	163	39.2%	4615	163	3.5%

Expansion Rate			
	Observed Truck Volume (veh/day)	Result of Traffic Count Survey (veh/day)	Expansion Rate
2 Axle Truck	103	271	2.63
3 Axle Truck	28	79	2.82
4 or more Axle Truck	40	66	1.65
Total	171	416	2.43

Location-4

Vehicle Type	Type of Axle[1]	Observed Truck[2]			Expanded Truck by Traffic Count Survey[3]			Rate of exceeded reguration truck volume[4]		
		Truck Volume (veh/day)	Overloaded Truck (veh/day)	Rate	Truck Volume (veh/day)	Overloaded Truck (veh/day)	Rate	Result of Traffic Count Survey	Overloaded Truck (veh/day)	Rate
		(a)	(b)	(b)/(c)	(d)	(e)	(e)/(f)	(f)	(e)	(e)/(f)
Motorcycle	–	–	–	–	–	–	–	3165	–	–
Passenger Car	–	–	–	–	–	–	–	1043	–	–
Bus	–	–	–	–	–	–	–	960	–	–
Others	–	–	–	–	–	–	–	72	–	–
2 Axle Truck	1.1	91	24	26.4%	264	70	26.5%	264	70	26.5%
3 Axle Truck	1.2	32	19	59.4%	93	55	59.1%	96	55	57.3%
4 Axle Truck	2.1	1	0	0.0%	3	0	0.0%	58	21	36.2%
	1.1.2	10	5	50.0%	21	11	52.4%			
	1.3	1	1	0.0%	2	2	0.0%			
5 Axle Truck	1.2.2	10	2	20.0%	21	4	19.0%			
	1.1.3	4	1	25.0%	10	2	20.0%			
	2.3	2	1	0.0%	4	2	0.0%			
6 Axle Truck	1.2.3	0	0	0.0%	0	0	0.0%			
Total		151	53	35.1%	418	146	34.9%	5658	146	2.6%

Expansion Rate			
	Observed Truck Volume (veh/day)	Result of Traffic Count Survey (veh/day)	Expansion Rate
2 Axle Truck	91	264	2.90
3 Axle Truck	33	96	2.91
4 or more Axle Truck	27	58	2.15
Total	151	418	2.77

1) 1, 2 and 3 means Single Axle, Tandem Axle and Tridem Axle, respectively.
2) 30% of total truck was observed in Axle Load Survey.
3) Observed truck was expanded by truck observed in Traffic Count Survey.
4) Ratio of overloaded truck was calculated by total traffic volume observed in Traffic Count Survey.

d) Travel Speed Survey

Travel speed survey was conducted on subject road at morning peak, evening peak and off peak. The characteristic of travel speed on NR11 and NR73 is shown in below.

NR11

- Overall, travel speed was observed by average 50 km/h because of few bottle necks on NR11.
- At the morning peak and off peak in direction-1, travel speed seems decreasing before the subject bridge (9km to 10km) caused by deceleration and temporary stop of alternate traffic.
- Likewise, at the off peak and evening peak in direction-2, travel speed seems decreasing before the subject bridge (18km to 19 km).

NR73

- Average travel speed was observed by average 40 km/h caused by bottle neck point which subject bridge and town.
- At the morning peak and evening peak, travel speed was observed significantly decreasing caused by temporary stop of alternate traffic before the subject bridge (3km to 4km).

- Likewise, travel speed was observed significantly decreasing caused by temporary stop of alternate traffic before the subject bridge (29km to 30km).
- Travel speed was observed decreasing between Prek Chhloung Bridge and Anlong Khle Bridge.

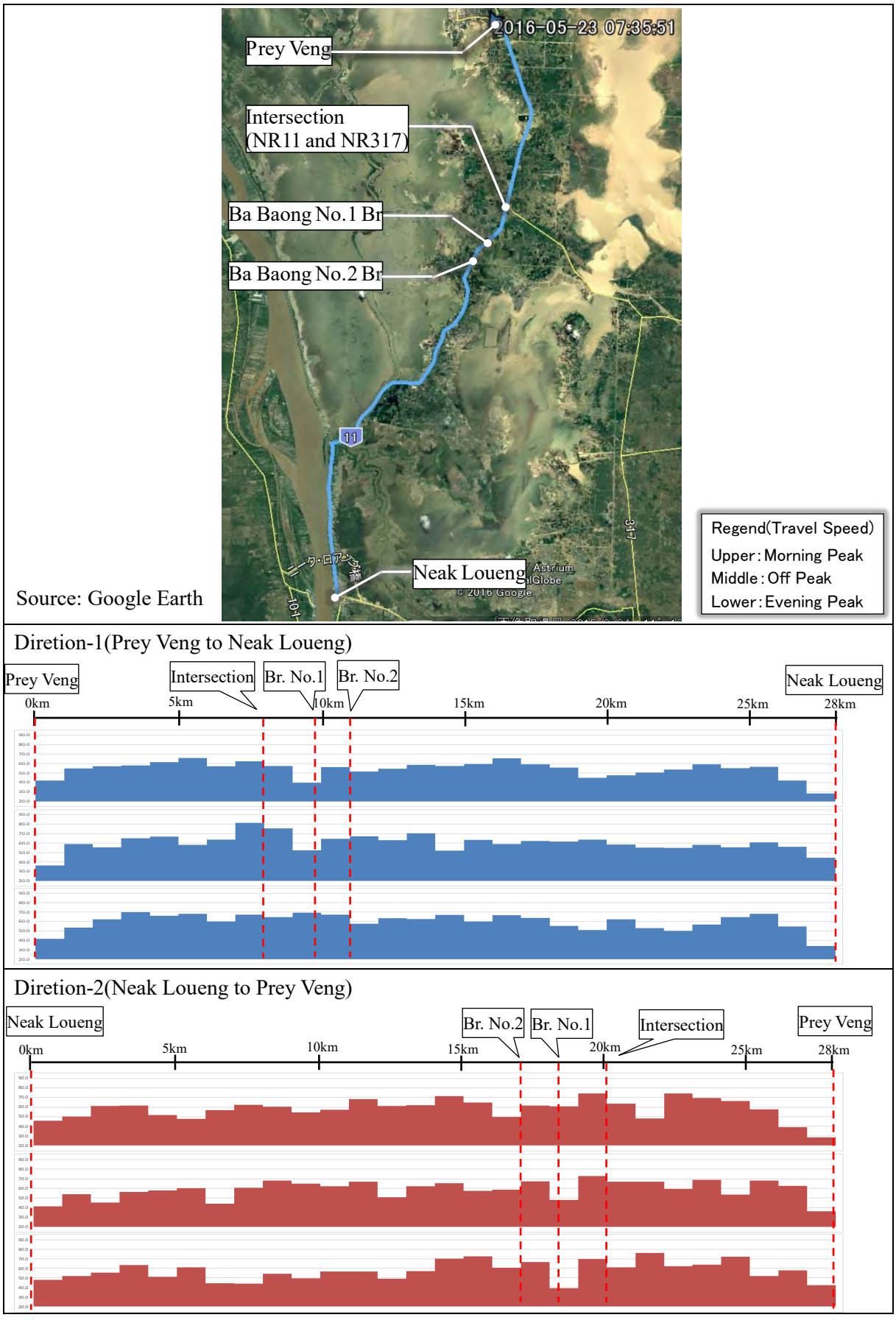


Figure 2.2-16 Result of Travel Speed Survey on NR11

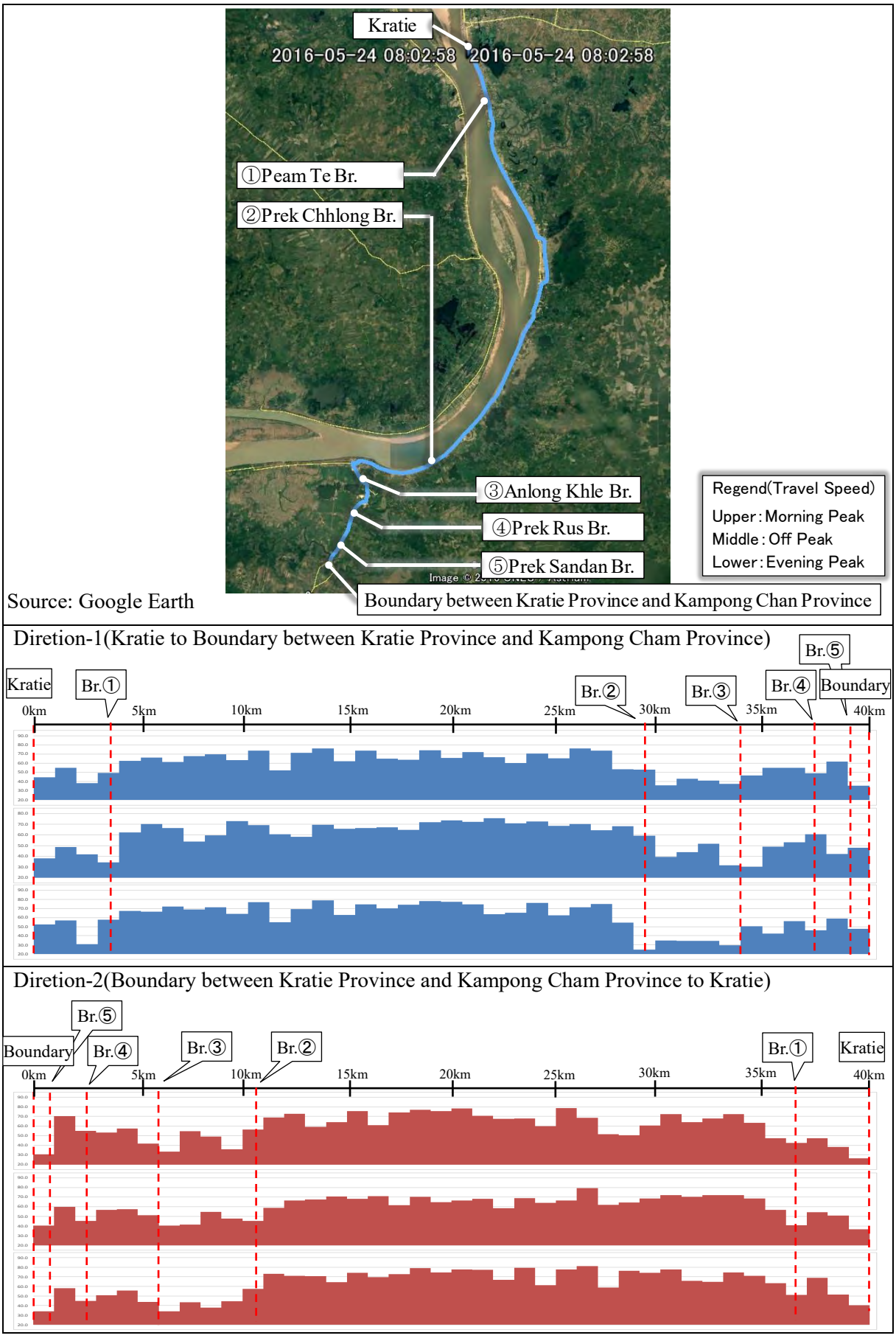


Figure 2.2-17 Result of Travel Speed Survey on NR73

3) Future Traffic Demand Forecast

a) Methodology of Future Traffic Demand Forecast

Future traffic demand forecast on single road was conducted following steps.

1. Base traffic volume: Result of observed traffic count data in 2016

Step-1: Estimation of growth rate (Short, Medium and Long) surrounding area of subject road by socio-economic flamework (Population and GRDP)

Step-2: Estimation of development traffic volume in subject area

Step-3: Estimation of diverted traffic volume (From NR7 to Subject Road, To Highway from Subject Road)

2. Estimation of future traffic volume on subject road: Future traffic volume (from 2016 to 2050) is estimated based on above Stepp -1 to Tep-3.

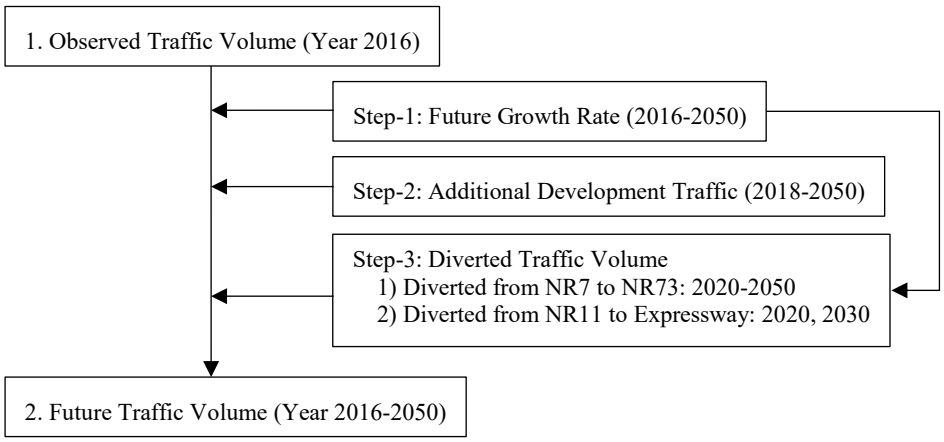


Figure 2.2-18 Methodology of Traffic Demand Forecast

b) Base Traffic Volume

Base traffic volume was classified by subject bridges based on observed traffic volume conducted in 2016. These traffic volumes shall be based for future traffic volume.

Table 2.2-20 Population Projection in Cambodia and Province

Unit: Veh/day

Survey Location	Road	Motorcycle	Passenger Car	Bus	Truck	Total
Location-1 (Ba Baong No.1 Br, Ba Baong No.2 Br)	NR11	2,146	752	195	1,047	4,141
Location-2 (Prek SandanBr, Prek Rus Br, Anlong Khle Br)	NR 73	2,368	862	969	416	4,615
Location-3 (Prek Chhloung Br.)	NR 73	3,470	1,125	938	334	5,867
Location-4 (Peam Te Br)	NR 73	3,165	1,043	960	418	5,586

c) Step-1: Future Socio-Economic Flamework

Future socio-economic flamework was estimated by projection of population and GRDP in Kratie Province and Prey Veng Province.

Based on "Statistical Bureau, Ministry of Internal Affairs and Communications, POPULATION PROJECTIONS FOR CAMBODIA, 2008-2030", projection of population in Cambodia was verified. Projection of population in Cambodia is 13.89 million persons in 2008, 15.41 million persons in 2015, annual growth rate of population is increased by 1.51%. And, annual growth rate of population in Kratie Province and Prey Veng Province is calculated 1.9% and 0.03%, respectively. Although rate of population growth in Prey Veng is tended to be low, rate of population growth in Kratie Province is tended to be higher than Cambodia (Table 2.2-21).

Annual growth rate of GRDP in Kratie Province and Prey Veng Province is 5.34% and 5.28%, they show high growth rate than Phnom Penh City (4.75%) as shown in . Further, there is no statistical data of GRDP in Cambodia, GRDP in Cambodia was calculated based on JICA Survey "Preparatory Survey for National Road No.5 Improvement Project in the Kingdom of Cambodia".

Table 2.2-21 Population Projection in Cambodia and Province

YEAR	2008	2011	2015	2020	2025	2030
Cambodia	13,868,227	14,521,275	15,405,157	16,505,156	17,519,272	18,390,683
Banteay Meanchey	701,786	806,780	883,494	954,979	1,017,936	806,780
Battambang	1,061,336	1,215,605	1,327,559	1,430,656	1,519,185	1,215,605
Kampong Cham	1,739,254	1,741,350	1,726,096	1,697,381	1,648,438	1,741,350
Kampong Chhnang	488,999	542,731	577,366	606,608	628,577	542,731
Kampong Speu	742,235	797,830	831,537	860,721	882,184	797,830
Kampong Thom	653,684	684,795	701,861	716,222	724,456	684,795
Kampot	606,516	625,526	648,799	680,238	716,987	625,526
Kandal	1,309,915	1,443,102	1,544,180	1,636,320	1,716,290	1,443,102
Koh Kong	121,624	149,516	171,920	195,307	218,811	149,516
Kratie	330,480	376,941	408,639	438,429	465,960	376,941
Mondul Kiri	63,263	80,771	94,648	110,063	126,725	80,771
Phnom Penh	1,374,451	1,835,090	2,126,617	2,334,053	2,450,717	1,835,090
Preah iii	177,176	196,714	211,488	227,372	243,681	196,714
Prey Veng	980,790	983,163	1,000,313	1,036,847	1,089,316	983,163
Pursat	411,171	447,504	479,585	515,170	553,067	447,504
Ratanak Kiri	155,773	179,463	196,570	214,792	233,141	179,463
Siemreap	928,065	1,096,482	1,213,200	1,319,807	1,414,727	1,096,482
Preah Sihanouk	229,205	272,933	305,149	334,827	360,684	272,933
Stung Treng	115,610	132,976	148,356	166,680	187,442	132,976
Svay Rieng	499,820	503,432	514,333	533,401	559,726	503,432
Takeo	874,711	886,096	909,643	948,239	997,025	886,096
Oddar Meanchey	192,375	252,826	294,030	332,105	365,010	252,826
Kep	37,016	46,098	56,839	71,168	88,797	46,098
Pailin	72,971	107,433	132,932	157,888	181,801	107,433

Source: Statistical Bureau, Ministry of Internal Affairs and Communications, POPULATION PROJECTIONS FOR CAMBODIA, 2008-2030

Table 2.2-22 GRDP Projection in Province

Province	GRDP (Unit: Million USD)					Periods			
	2012	2018	2023	2028	2033	2012-2018	2018-2023	2023-2028	2028-2033
Banteay Meanchey	439	668	915	1225	1580	7.25%	6.49%	6.01%	5.22%
Battambang	575	883	1215	1625	2100	7.41%	6.59%	5.99%	5.26%
Kampong Cham	757	1046	1322	1613	1897	5.54%	4.79%	4.06%	3.30%
Kampong Chhnang	226	336	454	592	753	6.83%	6.20%	5.45%	4.93%
Kampong Speu	353	527	719	935	1176	6.91%	6.41%	5.39%	4.69%
Kampong Thom	257	383	516	664	820	6.88%	6.14%	5.17%	4.31%
Kampot	235	351	486	640	831	6.92%	6.72%	5.66%	5.36%
Kandal	997	1451	1938	2562	3280	6.45%	5.96%	5.74%	5.07%
Koh Kong	87	143	208	293	397	8.63%	7.78%	7.09%	6.26%
Kratie	150	228	320	434	563	7.23%	7.01%	6.28%	5.34%
Mondul Kiri	33	58	91	136	190	9.85%	9.43%	8.37%	6.92%
Phnom Penh	3429	5192	7033	9213	11618	7.16%	6.26%	5.55%	4.75%
Preah Vihear	69	113	166	231	304	8.57%	8.00%	6.83%	5.65%
Prey Veaeng	367	530	718	944	1221	6.32%	6.26%	5.63%	5.28%
Pursat	176	270	375	510	677	7.39%	6.79%	6.34%	5.83%
Ratanak Kiri	67	111	167	236	314	8.78%	8.51%	7.16%	5.88%
Siemreap	510	797	1119	1526	1995	7.72%	7.02%	6.40%	5.51%
Preah Sihanouk	227	354	491	663	865	7.69%	6.76%	6.19%	5.46%
Stung Treng	52	85	128	186	255	8.53%	8.53%	7.76%	6.51%
Svay Rieng	206	297	398	522	674	6.29%	6.03%	5.57%	5.24%
Takeo	338	500	685	901	1167	6.74%	6.50%	5.63%	5.31%
Otdar Meanchey	100	173	258	361	478	9.57%	8.32%	6.95%	5.78%
Kep	17	32	53	84	126	11.12%	10.62%	9.65%	8.45%
Pailin	53	96	144	211	292	10.41%	8.45%	7.94%	6.71%

Source: Preparatory Survey for National Road No.5 Improvement Project in the Kingdom of Cambodia

In above socio-economic flamework, annual growth rate from 2016 to 2020 and from 2021 to 2050 was estimated by short (a year growth rate), medium (5 years growth rate) and long (10 years growth rate) as shown in below table. Future growth rate of population was applied to motorcycle, passenger car and bus, future growth rate of GRDP was applied to truck.

Table 2.2-23 Annual Growth Rate of Population by Short, Medium and Long

	Traffic Demand Forecast Period	Applied Period	Annual Growth Rate of Population	Annual Growth Rate of GRDP
Kratie (NR73)	2016-2020	2011-2020	1.72%	7.17%
	2021-2050	2021-2030	1.30%	6.30%
Prey Veng (NR11)	2016-2020	2011-2020	0.22%	7.04%
	2021-2050	2021-2030	0.89%	6.42%

d） Step-2: Development Plan

Figure 2.2-19 shows development plan in intersection between NR73 and NR7. Development area is about 20 ha, residential area, commercial area and government office is planning in this area. Now, construction is ongoing.

Source: Google Earth

Figure 2.2-19 Development Plan (Intersection between NR73 and NR7)

Future attraction and generation traffic volume related on this development project was calculated by "Large-Scale Development Area Related Transportation Planning Manual (Ministry of Land, Infrastructure and Transport)". Trip pattern is utilizing surrounding OD pattern. Attraction and generation traffic volume was calculated from three categories of "Work Area", "Commercial Area" and "Residence Area". Development traffic was assumed 30% in 2018, 50% in 2019, 70% in 2020, 90% in 2021 and 100% in 2022. This development traffic volume was considered maximum capacity, annual growth rate of population and GRDP were not applied. Result of development traffic volume is shown in Table 2.2-24.

Working Area

TVW = A×α1×α2 / C (Conversion factor) (veh/day) (Formula-1)

Where;

A: Basic unit of generation and attraction by category (4,500 persons)

α1: Modification rate of floor area (0.75 (minimum))

α2: Modification rate of distance from station (0.7 (minimum)

C: 1.3 person/veh for Working Area

Commercial Area

TVC = 10,600×α1×α2 / C (veh/day) (Formura-2)

Where;

10,600 persons: Basic unit of local area

α1: Modification rate of floor area (0.8 (minimum))

α2: Modification rate of distance from station (0.9 (minimum))

C: 1.4 person/veh for Commercial Area

Residence Area

TVR = 700 / C (veh/day) (Fromura-3)

Where;

700 persons: Basic unit of local area

C: 1.5 person/veh for Residential Area

Table 2.2-24 Demand of Development Traffic Volume

	Demand of Development Traffic Volume (Veh/day)				
Development Rate	30%	50%	70%	90%	100%
Year	2018	2019	2020	2021	2022～2050
Passenger Car	+166	+276	+387	+497	+553
Bus	+199	+332	+465	+598	+664
Truck	+86	+143	+200	+257	+285
Total	+450	+751	+1,051	+1,351	+1,502

Note: Development traffic volume is excluding motorcycle because of very far from development area to subject bridges.
Source: Large-Scale Development Area Related Transportation Planning Manual (Ministry of Land, Infrastructure and Transport) and result of OD survey

e) Step-3: Diverted Traffic Volume

i) Diverted from NR7 to NR73 from 2020

It is expected that traffic from/to north of Kratie from/to south and west of Kampong Cham using NR7 will be diverted to NR73 from 2020. Thus, diverted traffic from NR7 was estimated by result of OD survey and added to subject bridges from 2020. In addition, this diverted traffic volume was applied to use annual growth rate calculated at step-1.

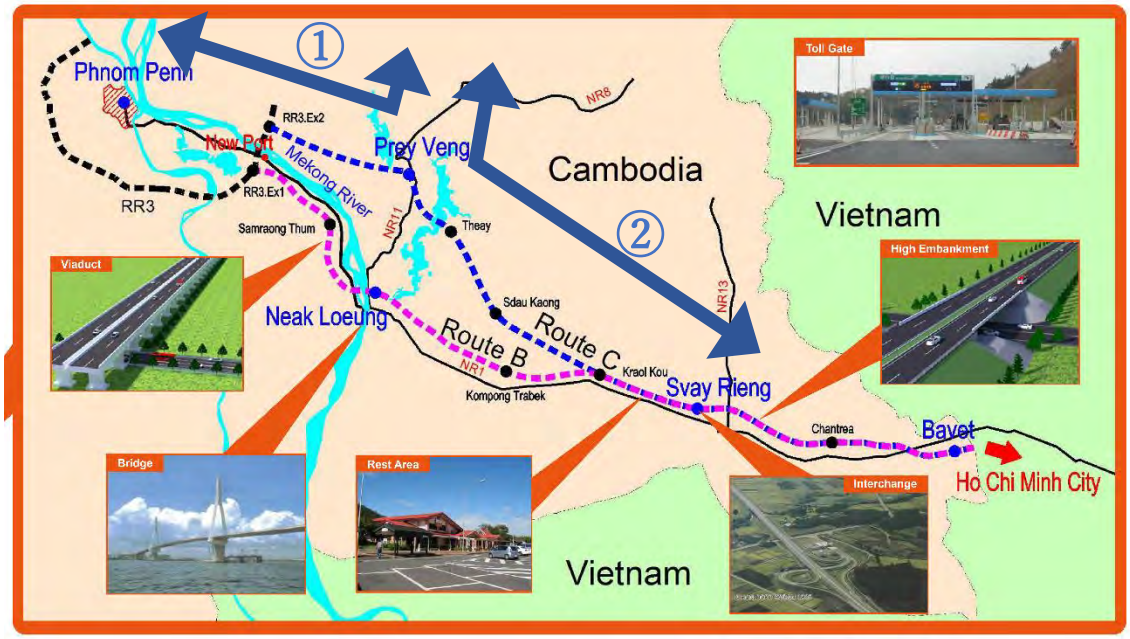
Table 2.2-25 Estimation of Diverted Traffic Volume from NR7 to NR73 (2016)

Direction on NR7	Passenger Car	Bus	Truck	Total
From North of Kratie to South and West of Kampong Cham (North to South)	+14	+20	+25	+60
From South and West of Kampong Cham to North of Kratie (South to North)	+33	+61	+76	+171
Total	+48	+82	+101	+231

Note: Motorcycle was excluded because of short trip vehicle
Source: Result of OD Survey

ii) Diverted from NR11 to Expressway

Expressway is planning by expressway project (Phnom Pehn-Ho Chi Minh City Expressway Project) connecting between Phnom Penh in Cambodia and Ho Chi Minh in Vietnam as shown in Figure 2.2-20. It is easy to access from north of Prey Veng to Phnom Penh and Bavet (national border). Thus, future traffic volume assumed to be used expressway was estimated from result of roadside OD interview survey. In addition, Phnom Penh-Prey Veng (①) and Prey Veng-East of Neak Loeung are going to open in 2020 and 2030, respectively.



Source: Phnom Penh-Ho Chi Minh City Expressway Project by JICA Study

Figure 2.2-20 Phnom Penh-Ho Chi Minh City Expressway Project

Traffic volume assumed to be used expressway was calculated 246 veh/day (①from north of Prey Veng to Phnom Penh) and 14 veh/day (②from north of Prey Veng to west of Neak Loeung). Based on this result, future traffic demand on NR11 is estimated.

Table 2.2-26 Traffic Volume Assumed to be Used Expressway

Direction	Passenger Car	Bus	Truck	Total
①From North of Prey Veng to West of Phnom Penh (2020)	-30	-95	-122	-246
②From North of Prey Veng to East of Neak Loeung (2030)	-9	-5	-0	-14
Total	-39	-100	-122	-261

Source: Result of Roadside OD Interview Survey

a) Step-4: Estimation of Future Traffic Volume

Based on above Step-1 to Step-3, future traffic volume on NR11 and NR73was estimated from year 2016 to year 2050 as shown in Table 2.2-27.

Traffic volume in location-1 (NR11) is estimated ranging 5,041 veh/day to 11,739 veh/day in year 2050. Further, location-2 (NR73) is ranging 8,410 veh/day to 12,355 veh/day in year 2050, location-3 (NR73) is ranging 10,340 veh/day to 13,632 veh/day in year 2050 and location-4 (NR73) is ranging 9,996 veh/day to 14,018 veh/day in year 2050.

According to future development plan, development of agriculture and industry, traffic volume will be drastic increased in the future. Thus, it is recommended to design standard for traffic volume on NR11 and NR73 exceeding 10,000 veh/day for road design

Table 2.2-27 Estimated Future Traffic Volume on NR11 and NR73 (Year 2020 to 2050)

Veh/day

Year	2020	2025	2030	2035	2040	2045	2050
Location 1 (NR11)	4,186	4,777	5,533	6,513	7,796	9,489	11,739
Location 2 (NR73)	6,095	7,068	7,701	8,482	9,464	10,721	12,355
Location 3 (NR73)	7,418	8,443	9,116	9,920	10,896	12,106	13,632
Location 4 (NR73)	7,212	8,261	8,975	9,843	10,918	12,275	14,018

(8) Planning of Approach Road

1) Horizontal Alignment

Bridges Prek Sandan, Prek Rus and Anlong Khle that are relatively short in length are reconstructed at the location of the corresponding existing bridges. The alignments of the bridges are straight. However, the curves on the approach roads are small and were modified to satisfy the design requirements. On the other hand, the alignments of bridges Ba Baong No.2, Ba Baong No.1, Prek Chhloung and Peam Te are shifted from the existing locations taking into consideration the river condition, erosion of river banks, detours to be provided during construction etc. The alignments are shifted to the west side in case of Bridges Ba Baong No.2, Ba Baong No.1 and Peam Te. Whereas the alignment of Prek Chhloung is shifted to the north side.

2) Vertical Alignment

The design elevations of the target bridges are shown in Table 2.2-28. The finished levels of the bridges are higher than the existing to a range of 2.3m to 3.7m. Provision of smaller vertical grades will require longer approach roads and is desirable to be avoided. However, this will create a hump like alignment given that the existing alignment is almost flat. Therefore, maximum grade of 3% is applied so that the vertical alignment is in line with other sections of the road. Thus, the length of approach road can be shortened by providing a bigger vertical grade.

Table 2.2-28 List of Elevations of Target Bridges

	Existing Ground Elevation (m)	HWL (m)	Freeboard (m)	Pier Height		Girder Bottom Elevation (m)	Girder Height (m)	Deck Slab Thickness (m)	Pavement Thickness (m)	Finished Level (m)	Remarks
				Coping (m)	Bearing (m)						
NH 11											
1. Ba Baong 2 Bridge	9.27	9.20	1.10	1.50	0.10	10.80	1.60	0.25	0.05	12.90	Coping + bearing height to be adopted as it is higher than freeboard
2. Ba Baong 1 Bridge	9.26	9.20	1.10	1.50	0.10	10.80	1.60	0.25	0.05	12.90	
NH 73											
3. Prek Sandan Bridge	21.6	20.95	1.50	-	-	22.45	1.60	0.25	0.05	24.50	
4. Prek Rus Bridge	22.4	20.95	1.50	1.50	0.10	22.55	1.60	0.25	0.05	24.65	
5. Anglong Khle Bridge	22.2	20.95	1.50	1.50	0.10	22.55	1.60	0.25	0.05	24.65	
6. Prek Chhloung Bridge	21.9	21.90	1.70	1.50	0.10	23.60	1.60	0.25	0.05	25.62	Freeboard height is adopted at it is higher than coping + bearing height
7. Peam Te Bridge	22.9	22.90	1.70	1.50	0.10	24.60	1.60	0.25	0.05	26.62	

3) Cross Section

Typical cross section of approach roads of bridges that are to be constructed at same location of the existing bridge (Prek Sandan Bridge, Prek Rus Bridge and Anlong Khle Bridge) is shown in Figure 2.2-21, while the typical cross section of approach roads of bridges that are to be constructed at a different location (next to the existing bridge) is shown in Figure 2.2-22.

The approach roads are provided with a 2.5% cross-fall as required for flexible pavement roads by the Road Design Standard of Cambodia. The sections where the alignment is curved is super-elevated. The super-elevation is provided as with respect to the correspondent radius of curvature.

Conditions to be applied on embankment slopes also follow the standards of Cambodia. A grade of 1:2.0 (V:H) is applied for embankment slopes with provision of 2m wide berms at every 5m height from the road surface. In addition, bench cuts for preventing settlement and displacement after construction are provided where the existing ground exceeds the grade of 1:4.0.

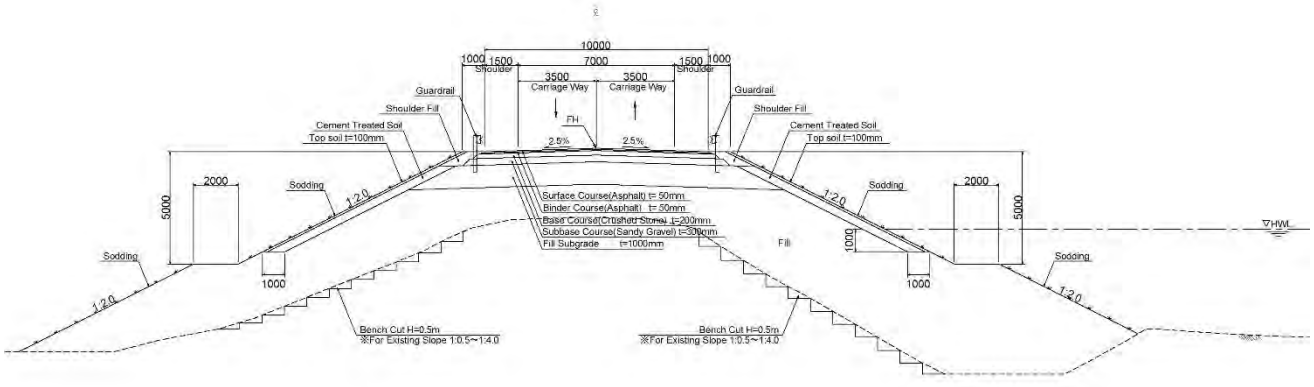


Figure 2.2-21 Typical Cross-section of Approach Road (Reconstruction at Existing Bridges)

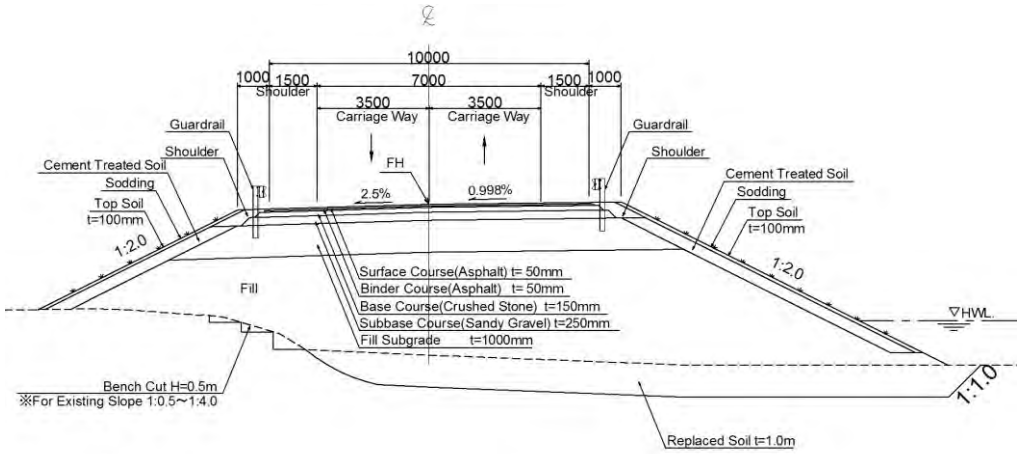


Figure 2.2-22 Typical Cross-section of Approach Road (Reconstruction Near the Existing Bridges)

4) Pavement Design

a) Performance Period

The performance period for the design of the pavement is taken as 15 years after the completion of the construction based on the standards of Cambodia. The completion of construction is expected in August 2020.

b) Calculation

The Structural Numbers (SN) required for the asphalt pavement of approach roads of each bridge are calculated from the following formula.

$$\mathrm{Log}_{10}(W_{18}) = Z_R \times S_0 + 9.36 \times \mathrm{Log}_{10}(SN+1) - 0.20 + \frac{\mathrm{Log10}\{\Delta PSI/(4.2-1.5)\}}{0.40 + \{1094/(SN+1)^{5.19}\}} + 2.32 \times \mathrm{Log}_{10}(M_R) - 8.07$$

c) Design Traffic Volume

Design traffic volume for each traffic category for the target year 2035 is shown in Table 2.2-29. These traffic volumes are predicted from the traffic count data conducted in May 2016, assuming 2020 as the service year.

Table 2.2-29 Design Traffic Volume (2035)

Bridge Name	Average Daily Traffic Volume (2035: predicted from traffic count data of May 2016)				
	Car, Taxi, Minibus	Bus	Light Truck	Heavy Truck	Trailer
Ba Baong No.2 and No.1	12,695	2,432	22,959	4,262	5,430
Prek Sandan, Prek Rus, Anlong Khle	26,100	30,030	13,238	4,068	3,155
Prek Chhloung	1460	1319	377	103	74
Peam Te	1374	1342	415	151	91

d） Equivalent Single Axle Load Conversion Factors

The equivalent single axle load conversion factors for each vehicle is shown in Table 2.2-30. These factors are referred from those applied in Thailand taking into consideration that the vehicle types in Cambodia are similar to those in Thailand.

Table 2.2-30 Equivalent Single Axle Load Conversion Factors

Vehicle Types	Car, Taxi, Minibus	Bus	Light Truck	Heavy Truck	Trailer
ESAL Factors	0.0038	0.53	0.53	3.49	6.84

e） Input Parameters and Calculation Result

Input parameter and results of pavement design calculation are presented in Table 2.2-31.

Table 2.2-31 Design Inputs and Calculation Results

1 **Input Parameter**

1) Design Life: 15 years (Technical Note)
2) Reliability: 80% (National Road)
3) Standard Normal Deviation(ZR): -0.841
4) Standard Deviation (So): 0.49
5)Design Serviceability Loss: 1.7 (Initial (4.2) – Terminal (2.5))
6) Resilient Modulus: 1500*CBR
7) Drainage Factor: 1.1

② **Calculation Result**

Route	Bridge Name	Accumulated Axle Load for 15 years (W18)	Subgrade CBR (%)*	Surface Course (cm)	Binder Course (cm)	Base Course (cm)	Subbase Course (cm)	Required SN 'A'	Calculated SN 'B'	Remarks
				Asphalt		Crushed Stone	Gravel			
NR-11	**Ba Baong No.2**	11,949,790	10	50	50	200	250	3.763	3.989	
	Ba Baong No.1									
NR-73	**Prek Sandan**	10,715,662	10	50	50	200	250	3.699	3.870	
	Prek Rus									
	Anlong Khle.									
	Prek Chhloung	8,939,106	10	50	50	150	250	3.566	3.675	
	Peam Te	10,816,656	10	50	50	200	250	3.705	3.979	Soil improvement

*: *AASHTO's equation for Modulus of Resilient is effective for subgrade CBR less than 10%. Therefore, the maximum value of CBR to be applied is taken as 10.*

f） Verification of Pavement Thickness by TA Method of Japan

Verification of pavement thickness is done for the results obtained for approach road of Ba Baong No.2 Bridge where the accumulated axle load is highest and Prek Chhloung Bridge that has the least thick pavement structure.

- Equivalent Single Wheel Load Repetitions

- The number of equivalent single wheel load repetition for a range of design traffic volume is taken as the Equivalent Single Axle Load (Accumulated axle load) given in Table 2.2-31, which for Ba Baong No.2 is 11,949,790 and for Prek Chhloung is 8,939,106. Reliability, Performance Period and Subgrade CBR Value

  Reliability: 90%
  Performance Period:15 years
  Subgrade CBR：10%

- Required Equivalent Thickness (RET) using TA Method

For the reliability of 90%, CBR 10% and total equivalent single wheel load repetition (N) N=11,949,790 and N=8,939,106 for Ba Baong No.2 Bridge and Prek Chhloung Bridges respectively, the RET is calculated by using the formula given by the Asphalt Pavement Design Guideline of Japan as follows;

$$\text{For 90\% Reliability} \quad T_A = \frac{3.84N^{0.16}}{CBR^{0.3}}$$

Using the formula above, the RETs of the pavement for Ba Baong No.2 and Prek Chhloung are calculated 26.10 and 24.92 respectively.

- Verification of Pavement Structure

The pavement structure (thickness) derived from AASHTO calculation is shown in Table 2.2-32. The values after conversion is smaller than the RETs of the TA Method. In general, the pavement structure dereived from the TA method of Japan is reported to be between 0% - 20% stronger than the pavement calculated from AASHTO method. The RET of Ba Baong No.2 (26.10) is about 12.27% bigger than the value after conversion (23.25). Similarly, the RFT of Prek Chhloung (24.92) is about 15.63% bigger than the value after conversion (21.55). Both the calculations justify the pavement structure calculated for approach roads of all bridges are reasonable.

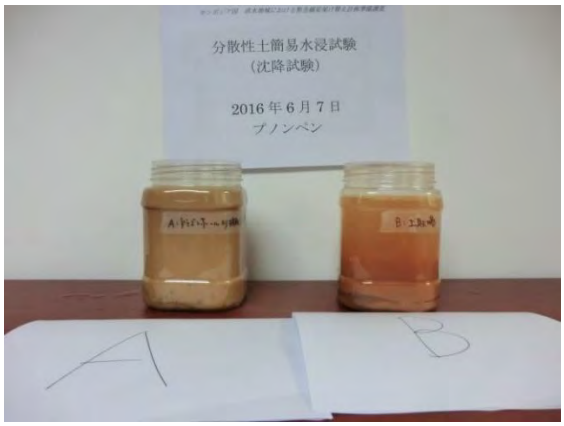
Table 2.2-32 Pavement Structure Calculated Using TA Method

Pavement Structure	Conversion Factor	Ba Baong Bridge		Chhloung Bridge	
		Pavement Thickness (cm)	After Conversion	Pavement Thickness (cm)	After Conversion
Surface course (Bituminous asphalt)	1.00	5	5.0	5	5.0
Binder course (Bituminous asphalt)	1.00	5	5.0	5	5.0
Base course (Crushed stone)	0.35	20	7.0	20	5.25
Subbase course (Sandy Gravel)	0.25	25	6.25	25	6.25
TOTAL		55	23.25	55	21.55

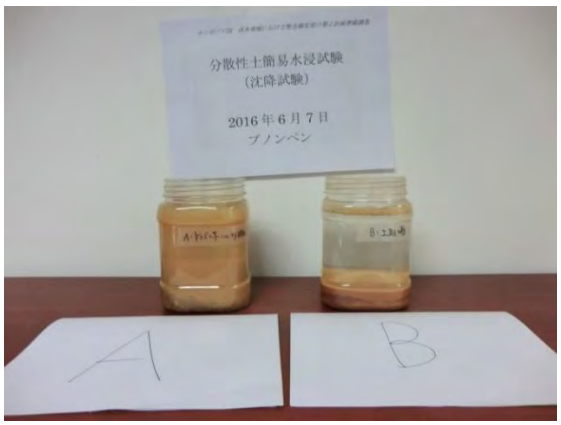
Judgement:	The RETs for Ba Baong No.2 and Prek Chhloung are 12.27% and 15.63% bigger than its corresponding values after conversion. Therefore, the pavement structure for approach roads are considred reasonable.

5) Fill Material

To enhance the durability of the roads, it is utterly important to take necessary measures against Dragon Holes if dispersive soil commonly distributed in Cambodia is to be used for fill material. Dragon holes are prominent along NR11. One of the main reasons for the occurrence of dragon holes is the application of this dispersive soil. Therefore, avoidance application of dispersive soil for fill material has been taken as one of the policies in this project. As such measure, soil is planned to be procured from the borrow pit area located in NR73. The simple test conducted during the first field survey has confirmed that the soil procurable here is not dispersive soil.



Picture: After Mixing
(Left: soil from NR11, Right: Borrow pit soil from NR73)



24 hours after Mixing
(Left: soil from NR11, Right: Borrow pit soil from NR73)

6) Slope Protection

During rainy season, approach roads of the target bridges submerge in water. The water level rises almost up to the top of the slope. The fluctuation of the water level in association with the waves produced by winds tend to inflict damages on the slopes by washing away the fill material, which is of high concern. Provision of gabion mats on the slopes of the approach roads of Ba Baong No.2 and Ba Baong No.1 at the Mekong River side is evident as measures taken against such potential damages.

Similarly, gabion mats, as shown in Figure 2.2-23 are planned to be provided on the approach road slopes on the Mekong River side of Ba Baong No.2 and Ba Baong No.1. On the opposite side, provision of 30cm wide cement treated soil is planned, which is covered with top soil and further protected by applying sodding. The provision of cement treated soil layer (t=30cm), top soil and sodding are applied at slopes on both side of the approach road for other 5 bridges.

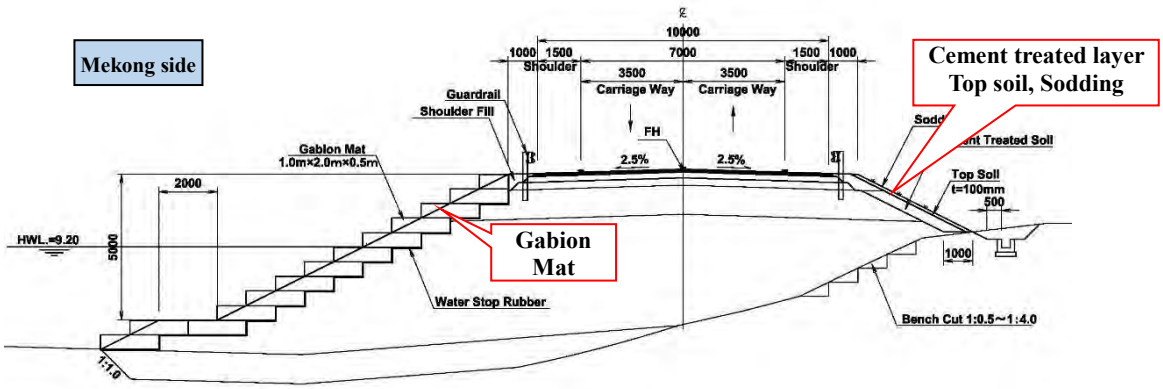


Figure 2.2-23 Slope Protection Works

7) Embankment/Dyke

Wet stone masonry is provided around the abutment to prevent from possible erosion of the earth during flood period. Stone masonry is provided up to a distance of 10m from the edge of the stairs.

8) River Bed Protection

River bed protection works are planned for protecting the foundations of the abutment and piers. The area to be protected is as shown in Figure 2.2-24.

The existing river bed of bridges, Ba Baong No.2 and Ba Baong No.1 have been significantly scoured. If left unattended, the scouring of the river beds is anticipated to grow bigger. Therefore, to prevent from advancement of scouring, the river beds are planned to be protected by gabions to the height equal to the existing river bed level at the upstream and downstream.

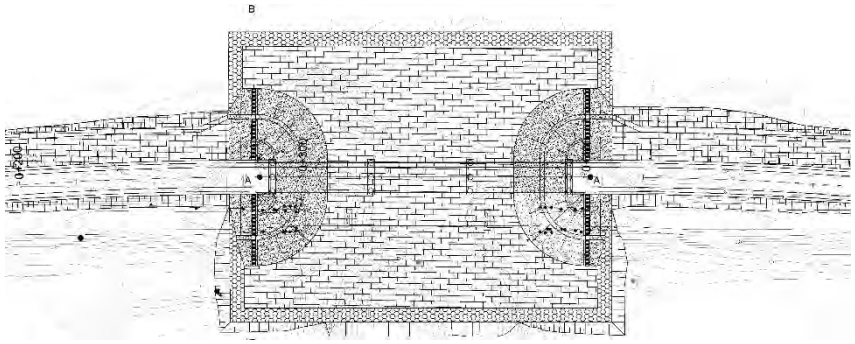


Figure 2.2-24 River Bed Protecting Work of Bridges Ba Baong No.2 and Ba Baong No.1

The river bed of Prek Chhloung Bridge and Peam Te Bridge are under water even during dry season. This makes provision of gabion mats difficult. Also, as scouring at these piers are not so significant. Therefore, rip-rap (Boulders) are planned to be dumped for 5m around the piers for protection of the river bed. At piers where water subsides during dry season, the river bed is protected using wet masonry works. The area to be protected is similar to other piers.

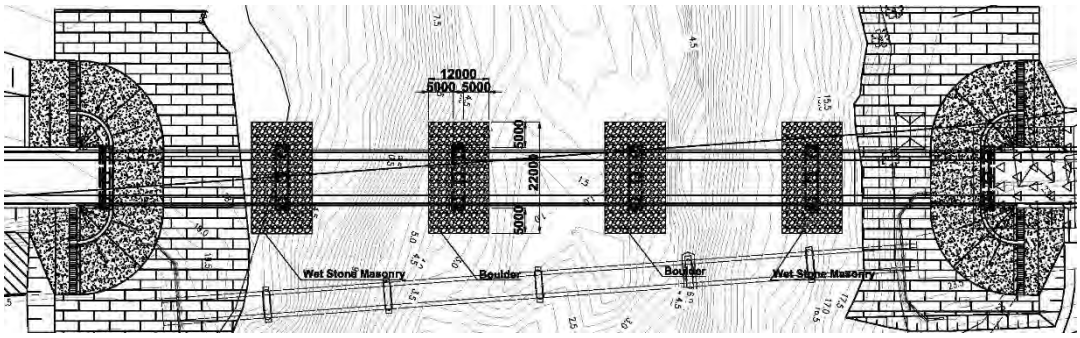


Figure 2.2-25 River Bed Protection of Prek Chhloung Bridge and Peam Te Bridge

The river bed of bridges Prek Sandan, Prek Rus, and Anlong Khle are without or with very less water and the river width is also relatively small. Therefore, gabion mats are planned for protection of river bed for these bridges. Gabion mats will be provided up to 10m away from the end of the embankments and rip-raps for a width of 5m will be provided for protection of the gabion mats. Illustrates the protection method and the area of the protection works.

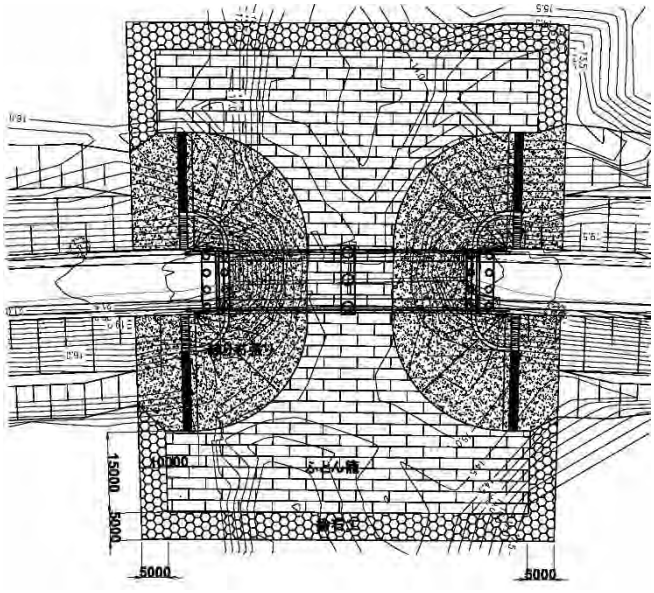


Figure 2.2-26 River Bed Protection of Bridges Prek Sandan, Prek Rus and Anlong Khle

9) Box Culvert

There is a 30m long existing bridge at about 120m south (Phnom Penh side) of Peam Te Bridge that spans across flood area to allow passage for the flood to flow to the other side of the road. As the new bridge location requires realignment of the approach road, an opening having equal capacity (equivalent area of flow) of this bridge will be required for securing the flow of the flood water during flood time. To secure such opening, a box culvert 10m x 5m (width x height) is planned. Figure 2.2-27 gives the outline (cross section) of the box culvert to be provided.

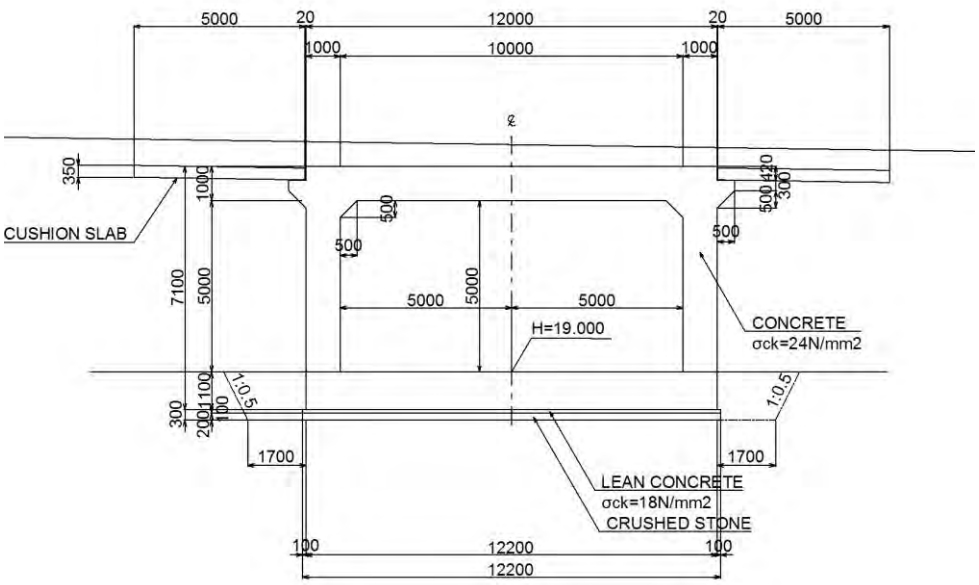


Figure 2.2-27 Cross section of the Planned Box Culvert

10) Road Ancillaries

a） Retaining Walls and Stairways

The approach road at the Phnom Penh side of Prek Chhloung Bridge runs along a settlement (community) including a Pagoda. Here, retaining walls are provided to reduce the impact area such that the resettlement is minimized. A 5m wide roads are provided next to the retaining for access of the locals. As consideration to the pedestrians, stairways, one on each side of the road, are also provided.

b） Guidepost

Guideposts are provided at the outer edge of horizontal curvatures with the purpose to raise early awareness of the drivers for safe negotiation of the curves. The guardrails are decorated with reflectors for better visibility during the night time.

c） Guardrails

Guardrails are provided for a length of 20m from the bridge. The main purpose for its provision is to protect the bridge as well as to prevent direct collision of vehicles with the bridge railings. It also serves for preventing the vehicles from skidding off.

Guardrails are also provided at along the retaining wall section at Prek Chhloung Bridge for preventing the vehicles from skidding off.

d） Traffic Signs

Regulatory traffic signs (maximum speed) and warning signs (curve ahead) are provided at all target bridges. Warning sings to attract drivers' attention such as slow down and pedestrian crossings ahead are additionally provided at school zones near Anlong Khle Bridge.

e） Pavement Markings

The following pavement markings are provided.

- Centerline: 15cm width, Yellow color (with reflector studs at an interval of 25m)
- Edge line: 10cm, White color
- Pedestrian crossing: Only at school zone near Anlong Khle Bridge

(9) Bridge Planning

1) Location

Location of new bridge should be considered with secure the function as national road and safety for public transportation during construction. Three options below have been studied in reference of site survey result.

Option-1 : Upstream side
Option-2 : Existing location
Option-3 : Downstream side

Comparing the above three options at each bridge in consideration with obstacles, environmental impact, road alignment, construction period, economic efficiency and hydrological, location of new each bridge is shown in Table 2.2-33. (Comparison of each bridge's replaced location is referred to Appendix-3.)

The Survey Team discussed with MPWT regarding location of new bridges, and obtained his agreement basically.

Table 2.2-33 Location of New Bridge

Bridge	Location of New Bridge
Ba Baong No.2	Upstream side (Mekong river side)
Ba Baong No.1	Upstream side (Mekong river side)
Prek Sandan	Existing location
Prek Rus	Existing location
Anlong Khle	Existing location
Prek Chhloung	Upstream side
Peam Te	Downstream side

2) Bridge Length and Span Length

To decide the length of each bridge shall be secured design flow capacity of the river which is calculated from hydrological analysis.

Regarding to Ba Baong No.2 bridge and Ba Baong No.1 bridge located on National Road No.11, the survey team obtained testimony from neighborhood resident that is flood water level was over the road surface when large flood in 2011. Amount of overflow then was calculated by testimony of neighborhood and hydrological analysis, and it is considered in determining the bridge length.

About the bridges located along National Road No.73 also, the high-water level was estimated from the flood marks and the interview in the field survey, the design flow rate and the flow velocity were calculated, and the bridge length that can secure this river flow.

Reference span length of each subject bridge which is calculated from the Structural Decree of River Management Facilities etc. in Japan, is shown in Table 2.2-34. Although reference span length of Peam Te Bridge is 40m, if span length 40m, superstructure type will be deferent other bridge. Therefore, span length of Peam Te Bridge was decided 35m. Even if the reference span length of Peam Te Bridge is 35 m, impediment ratio of river flow is less than 5.0%, and there is no influence on the river flow.

Minimum bridge length and span length should be secured existing bridge length and span length. Although the water streams under Prek Sandan Bridge, Prek Rus Bridge and Anlong Khle Bridge are not categorized the river if in accordance with the Structural Decree of River Management Facilities etc. in Japan because of few river flows. However, these water stream are near Mekong River, and much river water from Mekong River will become inflow when flood. Moreover, there is high possibility to deposit driftwood around bridge pier when the falling water level. Therefore, the span lengths of these three bridges also decide in accordance with reference span length in the Structural Decree of River Management Facilities etc. in Japan.

Span arrangement was decided in consideration with reference span length which is from the Structural Decree of River Management Facilities etc. in Japan.

Bridge length and span arrangement of each subject bridge is indicated in Table 2.2-34.

Table 2.2-34 Bridge Length and Span Arrangement of Each Subject Bridge

Bridge	Length of Existing Bridge (m)	Design flow capacity (m3/s)	Reference Span Length※1 (m)	Length of New Bridge (m)	Span Arrangement (m)
Ba Baong No.2	80	1,475	27.4	105	3@35
Ba Baong No.1	80	1,165	25.8	105	3@35
Prek Sandan	30	240	21.2	35	1@35
Prek Rus	54	550	22.8	62	2@31
Anlong Khle	42	450	22.3	48	2@24
Prek Chhloung	120	2,800	34.0	140	4@35
Peam Te	150	4,000	40.0	175	5@35※2

※1 Recommended value by the Structural Decree of River Management Facilities etc. in Japan.

※2 Maximum span length is decided 35m length in consideration with workability, economic efficiency and impediment ratio of river flow (less than 5%).

3) Superstructure

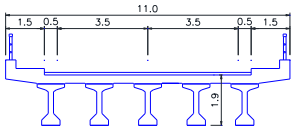
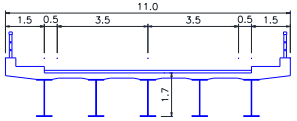
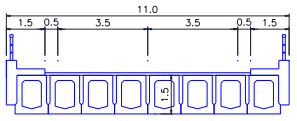
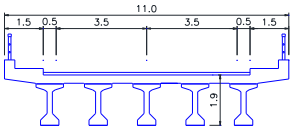
In selection of superstructure type, it was comprehensively examined about items indicated below.

- Design flood capacity
- High Water Level
- Freeboard height
- Required span length
- Impediment ratio of river flow
- Procurement circumstances of construction materials
- Economic Efficiency
- Workability
- Maintenance
- Environmental impact

There are seven bridges in the Project, its span length of subject bridge is 21.5m to 35.0m. Therefore, to unify superstructure type is more cost efficient from aspect of procurement circumstances of construction materials and facilities. Based on the above idea, following four options shown in Table 2.2-35 were studied in selection of superstructure. In the result, Option-4 Prestressed Concrete I-shape Girder is comprehensively the best option, it is adopted to superstructure type in the Project.

Option-1 : Semi-integral Abutment (Prestressed concrete girder)
Option-2 : Steel I-shape girder
Option-3 : Prestressed concrete hollow slab
Option-4 : Prestressed concrete I-shape girder

Table 2.2-35 Comparison of superstructure type

Superstructure Type	Option-1 Semi-Integral Abutment (PC girder)		Option-2 Steel I-shape Girder		Option-3 Prestressed Concrete Hollow Slab		Option-4 Prestressed Concrete I-shape Girder	
Cross section								
Structure (Score: 15)	The superstructure height is the same as Option-4. This option is based on the assumption that the backfill soil pressure assumed by design work reliably. And quality control and ensure of backfill soil in construction work is difficult.		It is a simple and good in structure. The height of the superstructure is about 1.7m, and the influence on the connecting road is medium.		It is a simple and good in structure. The height of the superstructure is about 1.5m, and the influence on the connecting road is the smallest.		It is a simple and good in structure. But the height of the superstructure is about 1.9m, and the influence on the connecting road is the largest. It is 40cm different high than option-3.	
	8 / 15	Poor	10 / 15	Poor	15 / 15	Good	10 / 15	Poor
Roadability (Score: 5)	It is excellent roadability because of no expansion joint		It is inferior than Option-1 because expansion joint is on the abutments		It is inferior than Option-1 because expansion joint is on the abutments		It is inferior than Option-1 because expansion joint is on the abutments	
	5 / 5	Good	3 / 5	Poor	3 / 5	Poor	3 / 5	Poor
Workability (Score: 15)	Embankment at the backside of the abutment must be according to the construction order envisaged in the design, the construction period will be longer because this work is after the construction of the concrete structures.		It is possible to erect steel girder by general method using a crane, no need special erection method.		It is not easy to diagnose the hollow part, and it is difficult to secure quality in on-site production.		It is good workability because there are some track records in Cambodia by Japan Grant Aid Project.	
	5 / 15	△	15 / 15	Good	5 / 15	Poor	15 / 15	Good
Economic Efficiency (Score: 50)	It is generally difficult to secure the bearing force in case of the 35m span length with single-row pile foundation. In this case, economic efficiency is equivalent to Option-4 because bearings at the abutment are needed.		It is difficult to fabricate steel member in Cambodia, and needs to fabricate in abroad country and to be transported to the site. It means the costliest option.		It is necessary to manufacture many girders. Expensive than option-4.		It is the most economical superstructure type that satisfies the reference span length.	
	50 / 50	Good	30 / 50	Poor	40 / 50	Poor	50 / 50	Good
Maintenance (Score: 15)	It is excellent in maintainability because the expansion joint can be omitted		It is a humid tropical climate and is concerned about corrosion on steel member. And, periodic repainting is necessary, and maintenance property is inferior to other options.		The place that can be inspected is only the under surface of the bridge, the inner cracks etc. cannot be visually confirmed and it is inferior in maintainability.		It is possible to inspect the side and bottom surface of the girder, and the trouble can be visually confirmed. Excellent maintainability.	
	15 / 15	Good	5 / 15	Poor	5 / 15	Poor	12 / 15	Good
Total Evaluation	83 / 100	Second	63 / 100	Fourth	78 / 100	Third	90 / 100	Best

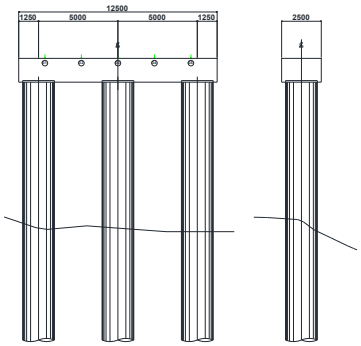
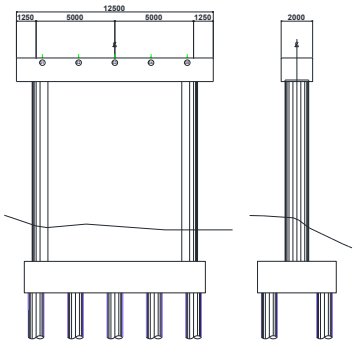
4) Substructure (Pier)

In selection of substructure type of bridge pier, 2 options indicated below was compared with 5 aspects, structure, hydraulic characteristics, workability, economic efficiency and maintenance. Comparison of substructure is shown in Table 2.2-36. In result, Option-1 pile vent type is adopted as substructure (pier).

Option-1 Pile vent type

Option-2 Concrete wall type + Cast-in-place pile

Table 2.2-36 Comparison of Substructure (Pier)

	Option-1 Pile vent type	Option-2 Concrete wall type + Cast-in-place pile
Structural Conceptual Figure		
Structure	It is inferior than Option-2. But it satisfies Cambodian criteria, design horizontal seismic coefficient kh=0.05.	It is Excellent in earthquake resistance compared to Option-1.
Hydraulic characteristics	There is concern for scouring by the water flow around the bridge piers, but it is possible to cope with the protection work.	Concern about scouring around the bridge piers is smaller than Option-1.
Workability	Construction period is shorter than Option-2 because it is possible to construct pile and pier continuously.	Construction period is longer than Option-1 because it is necessary to install pile cap between pile and pier body.
Economic Efficiency	Generally cheaper than Option-2.	It is more expensive because it needs much concrete and rebar than option-1.
Maintenance	Same as Option-2 because both are constructed by concrete.	Same as Option-1 because both are constructed by concrete.
Evaluation	Recommend	Not Good

5) Substructure (Abutment)

Cantilever type abutment is adopted to all bridges because it is generally inferior as structure and workability. Foundation type is pile foundation in single row, its diameter will be 2,000 mm same as pile vent type pier. If this pile foundation is not satisfied in structural design, 2 rows cast-in-pile foundation with 1,200 mm diameter will be adopted in consideration with procurement in Cambodia.

(10) Removal Plan for Existing Bridge

Regarding to four bridges, Ba Baong No.2 Bridge and Ba Baong No.1 Bridge which are pony truss bridge and Prek Chhloung Bridge and Peam Te bridge which are large bailey bridge, it plans to construct

new bridge beside existing bridge. Existing bridge is used for traffic during new bridge construction, and after new bridge construction it will be removed. Other three bridges, Prek Sandan Bridge, Prek Rus Bridge and Anlong Khle Bridge which are small bailey bridge, new bridges will be constructed same location of existing bridges. Therefore, diversion road will be constructed firstly, after that, existing bridge will be removed.

		
i) Pony Truss Ba Baong No.2 Ba Baong No.1	ii) Small Bailey Bridge Prek Sandan Prek Rus Anlong Khle	iii) Large Bailey Bridge Prek Chhloung Peam Te

Photo 2.2-1 Situation of the Existing Bridges

(11) Operation Plan for Existing Bridge during Construction

Status of existing bridges and maintenance

Existing bridges are two pony truss bridges and 5 bailey bridges. All existing bridge have steel deck slab without pavement. Steel deck slab has already damaged, and vibration occurs when vehicles passed. And, losing bolts is confirmed on some bailey bridges. That is, appropriate maintenance work has not carried out.

Maintenance work during construction

Maintenance work during construction should be by DPWT who originally has responsibility for maintenance. But the Contractor also needs to inspect because the vehicles for construction work also pass existing bridge. If necessary, it is desirable the Contractor supports for maintenance work with DPWT.

Reinforcement during construction

Existing bailey bridges need to place in service as public transport and transport for construction machines and materials during construction period. The bridges on National Road No.73 have a regulation which traffic vehicles weight limit less than 15 tons. The structure of these bridges is Double-Single structure with single lane. Load capacity of these bridges is possible AASHTO HS-25 in 33m span length. The span lengths of these five bridges located on National Road No.73 have 30m in maximum.

However, vehicles exceeding the HS-25 equivalent will pass on existing bridges during the construction period, then temporally support for reinforcement will be installed at the middle of the span. The proposal for reinforcement is indicated in Figure 2.2-28. This reinforcement work is included in cost burden by Japan side because it is for the vehicles for construction and technical difficulty level is high.

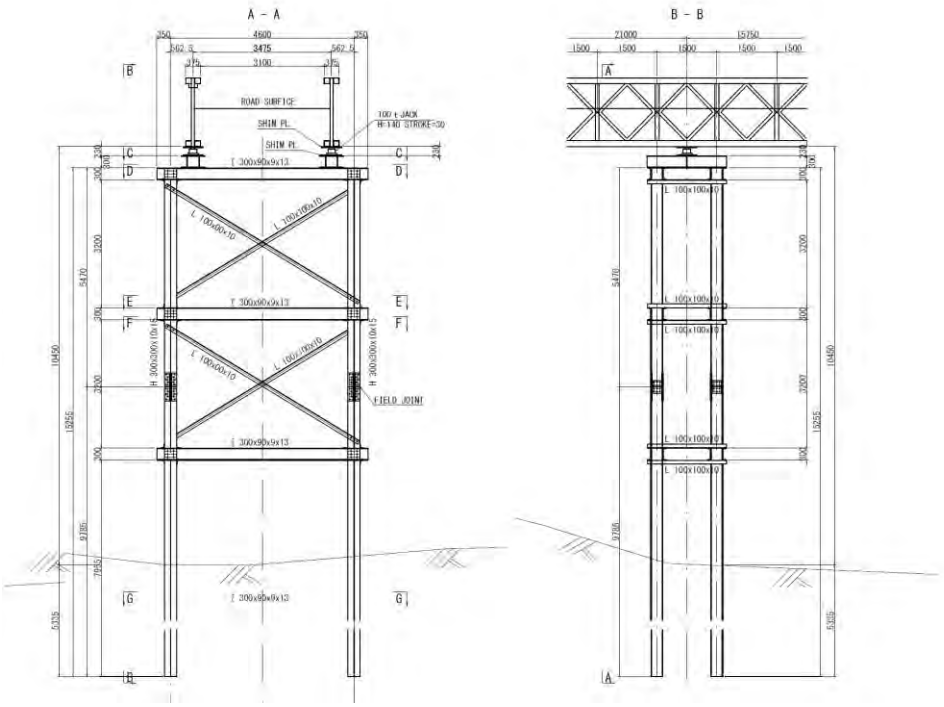


Figure 2.2-28 Reinforcement plan during construction

Removal work after the Project

Existing bridges and existing roads that become obstacles with the construction work for new bridge will be demolished by Japan side. On Prek Chhloung Bridge and Peam Te Bridge, existing superstructure bailey bridge will be removed by Japan side, and substructure concrete pier will be demolished by Cambodia side. On other five bridges, superstructure and substructure will be demolished by Japan side.

Burden work by Cambodia side is indicated in Table 2.2-37.

Table 2.2-37 Burden work by Cambodia (After construction work)

Bridge	Burden work by Cambodia
Peam Te	To remove five existing bridge piers and approach roads
Prek Chhloung	To remove four existing bridge piers and approach roads

(12) Accessories on Bridge

1) Bridge Railing

Bridge railings are two types according to the presence or absence of a sidewalk on the bridge. Both are made of concrete, if without sidewalk, concrete wall type will be applied, and if with sidewalk,

concrete lattice type will be applied (Refer Photo 2.2-2). Both are indicated in Bridge Standard Drawings in Cambodia.

(a) In case of without sidewalk

(b) In case of with sidewalk

Photo 2.2-2 Bridge Railing

2) Bearing

Rubber pad bearing will be installed because it has vertical force support function, rotary function and horizontal force support function.

3) Expansion Joint

Since superstructure type of all subject bridges are connected prestressed concrete girders, expansion joint is only on the abutment. Kind of expansion joint is rubber joint in consideration with low noise, water stop, workability and a lot of traffic of motorcycles which are characteristics of Cambodia.

4) Unseating prevention device

Unseating prevention device such like using in Japan will not be installed to all the bridges in the Project because horizontal seismic coefficient Kh=0.05 is very small. The anchor bars inserted in the end cross beam assume for the displacement limiting function.

5) Drainage

Steel drainage pipe with a diameter 100mm will be installed at the road edge for drainage for road surface with appropriate intervals (approximately 10m interval). Bottom end of the drainage pipe should be under the bottom of girder in order not to induce soiling and damage to superstructure.

6) Sidewalk on the bridge

On Prek Chhloung Bridge and Peam Te Bridge, sidewalks which width is 1.0m will be installed both side of the roadway. Sidewalk structure is mount up type, it has 20cm height step.

7) Bridge Name Plate

Bridge name plate will be installed two locations, A1 side and A2 side, on each bridge. It should be installed facing the traveling vehicle on the side of the lane of each bridge.

8) Approach slab

Approach slab will be installed at backside of each abutment for preventing subsidence of backfill soil. Its length is 5.0m, width depends matched road width.

9) Inspection passage

Inspection passage will be installed for inspecting around bearing on all lateral beam of bridge pier at Prek Chhloung Bridge and Peam Te Bridge since pier height of these bridge is high, and it is difficult to inspect visually in direct.

10) Other

Water supply pipe and communication cable etc. attaching on existing bridges will be installed on new bridges again after new bridges construction by cost burden of the business operator. Installation way may be assumed to be installed on steel bracket which is attached on bridge railing, then the weight of the steel bracket is considering in design.

In consideration of the surrounding situation and maintainability, no lighting equipment is installed.

2.2.3 Outline Design Drawing

2.2.3.1 List of Outline Design Drawings

Table of Contents of Outline Design Drawings is indicated in Table 2.2-38. Outline design drawings is attached in the Appendices.

Table 2.2-38 Table of Contents of Outline Design Drawings

No.	Contents		No.
1	BA BAONG NO.2 BRIDGE	GENERAL PLAN	1
2		GENERAL PROFILE	1
3		GENERAL VIEW OF BRIDGE	1
4		STRUCTURAL DRAWING OF SUPERSTRUCTURE OF BRIDGE	2
5		STRUCTURAL DRAWING OF BRIDGE ABUTMENT AND PIER	2
6		TYPICAL CROSS SECTION OF APPROACH ROAD	1
7		CROSS SECTION OF APPROACH ROAD	4
8		PLAN OF APPROACH ROAD (ANCILLARY)	1
9		REVETMENT AND RIVER BED PROTECTION	6
10	BA BAONG NO.1 BRIDGE	GENERAL PLAN	1
11		GENERAL PROFILE	1

No.	Contents		No.
12		GENERAL VIEW OF BRIDGE	1
13		STRUCTURAL DRAWING OF SUPERSTRUCTURE OF BRIDGE	2
14		STRUCTURAL DRAWING OF BRIDGE ABUTMENT AND PIER	2
15		TYPICAL CROSS SECTION OF APPROACH ROAD	1
16		CROSS SECTION OF APPROACH ROAD	4
17		PLAN OF APPROACH ROAD (ANCILLARY)	1
18		REVETMENT AND RIVER BED PROTECTION	6
19	PREK SANDAN BRIDGE	GENERAL PLAN	1
20		GENERAL PROFILE	1
21		GENERAL VIEW OF BRIDGE	1
22		STRUCTURAL DRAWING OF SUPERSTRUCTURE OF BRIDGE	1
23		STRUCTURAL DRAWING OF BRIDGE ABUTMENT AND PIER	2
24		TYPICAL CROSS SECTION OF APPROACH ROAD	1
25		CROSS SECTION OF APPROACH ROAD	4
26		PLAN OF APPROACH ROAD (ANCILLARY)	1
27		REVETMENT AND RIVER BED PROTECTION	4
28	PREK RUS BRIDGE	GENERAL PLAN	1
29		GENERAL PROFILE	1
30		GENERAL VIEW OF BRIDGE	1
31		STRUCTURAL DRAWING OF SUPERSTRUCTURE OF BRIDGE	2
32		STRUCTURAL DRAWING OF BRIDGE ABUTMENT AND PIER	2
33		TYPICAL CROSS SECTION OF APPROACH ROAD	1
34		CROSS SECTION OF APPROACH ROAD	5
35		PLAN OF APPROACH ROAD (ANCILLARY)	1
36		REVETMENT AND RIVER BED PROTECTION	4
37	ANLONG KHLE BRIDGE	GENERAL PLAN	1
38		GENERAL PROFILE	1
39		GENERAL VIEW OF BRIDGE	1
40		STRUCTURAL DRAWING OF SUPERSTRUCTURE OF BRIDGE	1
41		STRUCTURAL DRAWING OF BRIDGE ABUTMENT AND PIER	2
42		TYPICAL CROSS SECTION OF APPROACH ROAD	1
43		CROSS SECTION OF APPROACH ROAD	5
44		PLAN OF APPROACH ROAD (ANCILLARY)	1
45		REVETMENT AND RIVER BED PROTECTION	4
46	PREK CHHLONG BRIDGE	GENERAL PLAN	1
47		GENERAL PROFILE	1
48		GENERAL VIEW OF BRIDGE	1
49		STRUCTURAL DRAWING OF SUPERSTRUCTURE OF BRIDGE	2
50		STRUCTURAL DRAWING OF BRIDGE ABUTMENT AND PIER	4
51		TYPICAL CROSS SECTION OF APPROACH ROAD	1
52		CROSS SECTION OF APPROACH ROAD	3
53		PLAN OF APPROACH ROAD (ANCILLARY)	1

No.	Contents		No.
54		REVETMENT AND RIVER BED PROTECTION	3
55		ACCESS ROAD (PEDESTRIAN) AND RIVER BED PROTECTION	1
56		L-SHAPED RETAINING WALL	3
57	PEAM TE BRIDGE	GENERAL PLAN	1
58		GENERAL PROFILE	1
59		GENERAL VIEW OF BRIDGE	1
60		STRUCTURAL DRAWING OF SUPERSTRUCTURE OF BRIDGE	2
61		STRUCTURAL DRAWING OF BRIDGE ABUTMENT AND PIER	4
62		TYPICAL CROSS SECTION OF APPROACH ROAD	1
63		CROSS SECTION OF APPROACH ROAD	5
64		PLAN OF APPROACH ROAD (ANCILLARY)	1
65		REVETMENT AND RIVER BED PROTECTION	3
66		GENERAL VIEW OF CULVERT (10.0 X 5.0)	2
67		PLAN OF PAPER DRAIN	1
68	OUTLINE OF ROAD	DETAIL OF ASPHALT PAVEMENT	1
69	ANCILLARIES	GUARDRAIL LAYOUT ON BRIDGE	1
70		DELINEATIONS AND GUIDEPOSTS	1
71		LANE MARKINGS AND ROAD STUD REFLECTOR	1
72		TRAFFIC SIGN AT SCHOOL APPROACH AND CROSSWALK MARKING	1
73		TRAFFIC SIGN	1
74		OUTLINE OF DRAINAGE STRUCTURE	1

2.2.3.2 Matters to be responded to detailed design time

MPWT requested 2 items below to Japan side when discussion of outline design with JICA team. These items will be considered when detailed design stage.

- Bridge railing should not be continuous, and expansion joint should be inserted above the pier.
- Water level marking should be painted on the both face side of pier which is located in both side of the channel.

2.2.4 Implementation Plan

2.2.4.1 Implementation Policies

The basic policies for implementation of the project are as follows:

- This project will be implemented under the Grant Aid Scheme of the Government of Japan (GOJ) in accordance with the Grant Agreement (G/A) and the Exchange of Notes (E/N) between the Kingdom of Cambodia and the GOJ.
- The executing agency for the implementation of the project is Ministry of Public Works and

Transport (MPWT) of the Kingdom of Cambodia.

- The Consulting services including detailed design, tender-related works and construction supervision services, will be provided by a Japanese consulting firm in accordance with the consultancy contract that shall be signed with the Kingdom of Cambodia.
- The construction works will be executed by a Japanese construction firm that shall be selected through pre-qualification and bidding, in accordance with the construction work contract that shall be signed between the said construction firm and the Kingdom of Cambodia.

The basic policies for the construction/procurement of this project are as follows:

- The equipment, materials and labor for construction shall be, to the possible extent, procured locally. In case where local procurement is not possible, they shall be procured either from a third country or from Japan where it is most economical provided the required quality and supply quantity are secured.
- Construction methods and the construction processes shall be adequately determined taking the local climate, topography, geology and natural conditions including the characteristics of nearby rivers into consideration.
- The contractor's site organization shall be planned to satisfy the established construction specifications and construction management standards set for this project. Likewise, the consultant's organization shall be based on such specified project management standards.
- To ensure safety during construction, an appropriate traffic management plan including deployment of traffic personnel at vantage positions, providing detour roads and traffic informative signs shall be considered.
- Environmental protection works shall be set up to reduce the influence of construction activities including measures against river water contamination or sediment discharge into the river during the excavation, proper management of borrow pits, proper disposal of construction waste at areas designated by the Kingdom of Cambodia.
- Since this project is under the vulnerability mitigation for natural disaster of Grant Aid Scheme, implementation method shall be planned to complete, to the possible extent, in shortest period.

2.2.4.2 Implementation Conditions

(1) Considerations on the Natural Conditions

In general, climate of Cambodia changes from May to October by south-west monsoon to rainy season and, the water level of Mekong River is raised during the rainy season and overflown water extends nearby all captioned bridges. Dry season lies from November to April. In recent years, there were great size of flood occurred in 1996, 2000 and 2011. Considering the situations, the substructure works are to be completed during the dry season, and to maintain the safety and quality of the works and minimize the cost of temporary works.

(2) Detour Plan of Public Traffic During Construction

For those bridges, which replaced bridge would be same horizontal alignment such as Anlong Khle Bridge, Prek Rus Bridge and Prek Sandan Bridge, the detour roads, for dry season and wet season, are planned. The basic plan of detouring public traffic is shown on Figure 2.2-29.

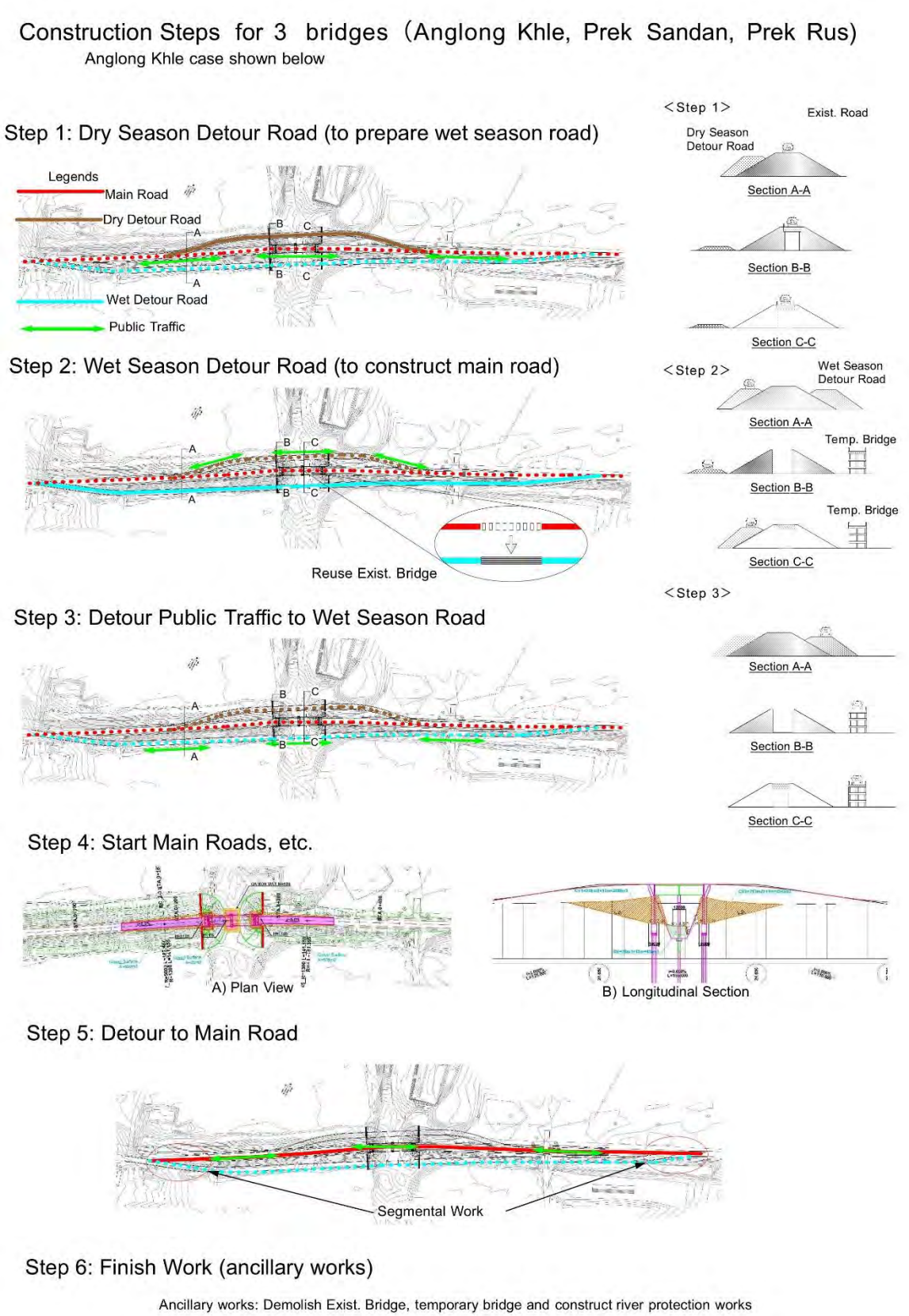


Figure 2.2-29 Detouring Plan of Public Traffic

(3) Arbitrary Temporary Work and Designated Temporary Work

The policy of temporary work in terms of weather arbitrary or designated one is described on the Table 2.2-39.

Table 2.2-39 Extent of Arbitrary and Designated Temporary Work

Activity	Bridge Name, Parts	Arbitrary Temporary Work	Designated Temporary Work	Remarks
Detour Roads (Open to public traffic)	AK, PR, PS (New bridge is planned at same horizontal alignment)		○	Indicate Consultant' Plan as a reference in the Tender Documents
Enforcement Method of Existing Bridge	PT, PC	○		Indicate enforcement conditions and consultant's plan, as a reference, in Tender documents
Reuse of Existing Bridges for Detour Roads (the part of the detour road for crossing river)	AK, PR, PS (New bridge is planned at same horizontal alignment)	○	△	Designated: to re-use the existing bridge, Arbitrary: how to use the existing bridge (enforcement conditions are indicated in Tender documents)
Temporary Construction Road (Not open to public traffic)	All bridges (PT,PC, AK, PR, PS, BB1, BB2)	○		Same as for previous Grant Aid project. However, the area will be limited due to UXO/Mine investigation
Temporary Soil Support	All bridges (PT, PC, AK, PR, PS, BB1, BB2)	○		Same as for previous grand Aid project. Indicate, however, consultant's plan as a reference.

PT: Peam Te Br., PC: Prek Chhloung Br.,
AK: Anlong Khle Br., PR: Prek Rus Br., PS: Prek Sandan Br.,
BB1: Ba Baong No.1 Br., BB2: Ba Baong No.2 Br.

2.2.4.3 Major Undertakings in Procurements by Each Government

Major undertakings by each government is shown below. Table 2.2-40.

Table 2.2-40 Obligation of by Each Government

Item	Description	Obligation		Remarks
		Japan	Cambodia	
To secure lands, relocate affected houses			○	
To procure materials and equipment's	To procure materials and equipment's to the sites	○		
	To clear customs of imported materials and equipment's		○	To assist the custom clearance (prepare the documents by GOJ side)
Preparation Work	To secure temporary lands required for construction		○	Temporary Yards (both sites), temporary detour roads (land)

Item	Description	Obligation		Remarks
		Japan	Cambodia	
	To relocate utilities installed at each exist. Bridge		○	Power lines, water lines, etc.
	To prepare items not shown above for preparation work	○		
Relocation/Removal of Obstacles for construction	To relocate obstacles on roads and bridges		○	Electrical poles, communication cables, etc.
Enforcement of Exist. Bridges and Detouring of Public Roads, etc. for Construction	To enforce the exist. Brides for construction purpose	○		
	To demolish/remove temporary bridges	○		
Main Construction Works	To build new bridges and new roads	○		Bridges, Roads, River Protections (River Bank, road slopes)
After the Project, temporary roads and detour roads	To demolish/remove the superstructures on existing bridges	○		
	To demolish/ remove temporary bridges	○		
	To demolish/remove piers of exist. Bridges (Limited)		○	
	To demolish/remove piers and abuts of exist. bridges	○		Piers of Peam Te and Prek Chhloung (9 nos. piers; 5 nos of Peam Te, 4 nos of Prek Chhloung)
Re-relocation of Utilities installed on the New/replaced Bridges	Power Lines, Water lines		○	

2.2.4.4 Procurement and Construction Supervision

Basically, the Japanese Consultant will enter into agreement with the Kingdom of Cambodia to undertake the detailed design, assist in the contractor bidding process and construction supervision of the project.

(1) Detailed Design

The major works to be carried out by the Consultant during the detailed design stage include the followings:

- Undertake consultations with concerned authorities of Cambodia and carry out field surveys.
- Detailed design and drawings preparation
- Project cost estimate

The duration to carry out the detailed design work is about 4 months.

(2) Bidding Process

The major tasks to be undertaken between the time of inviting contractors to bid and the time for signing of contract for construction includes:

- Preparation of bid documents (in parallel with the detailed design).
- Bid announcement
- Pre-qualification of bidders
- Bidding
- Evaluation of bid documents
- Preparation of Contract Agreement

The duration of the bid-related activities is about 3 months.

(3) Construction Supervision

The Consultant will supervise the contractor's planning and implementation of the construction contract. The major tasks under this stage include:

- Verification/Approval of related surveys and quantities
- Review/Approval construction plans
- Quality Control
- Process Control
- Work Output Control
- Safety Management
- Turnover Inspection and Acceptance

The duration of construction supervision is approximately 27.5 months.

The construction supervision team shall consist of: 1-Resident/Chief Engineer (Japanese), 1-Bridge Engineer/Superstructure (Japanese Engineer), 2-Site Inspectors (Local), 2-Clerk of Works (Local) and 2-Utility Personnel (Local). In addition, the Chief Engineer will attend assistance at construction start, completion and construction quality control meetings and may dispatch Inspector/s for turnover inspection.

During the construction, the Resident Engineer try to avoid the occurrence of any accidents by consulting with a safety officer from the Contractor especially for detouring public traffics.

2.2.4.5 Quality Control Plan

The tasks to be carried out for quality control during the construction period are as follows:

- In-situ Bored Pile
- Concrete Works
- PC-girder production
- Reinforcement Bars and Formworks
- Earthwork
- Pavement Works
- Expansion Joints and Bearings Installation

Based on the above, the quality control of main items for concrete works is prescribed in Table 2.2-41 while the quality control of main items for pavement is prescribed in Table 2.2-42.

Table 2.2-41 Quality Control Plan of Concrete Works

Item	Test Item	Test Method (Specifications)	Test Frequency
Cement	Cement Property/Physical Test	AASHTO M85	One before trial mix and once every 500m3 batch of concrete; or once during production of cement (Mill sheet)
Aggregate	Property/Physical Test	AASHTO M6	Once before trial mix and every once every 500m3 batch of concrete; and every change of source/quarry location (check supplier data)
	Property/Physical Test	AASHTO M80	Once before trial mix and every once every 500m3batch of concrete; and every change of source/quarry location (check supplier data)
	Sieve Analysis	AASHTO T27	Once a month
	Alkali-silica Reactive Test (Mortar Bar Method)	ASTM C1260	Once before trial mix and every change of source/quarry location (check supplier data)
	Mineral Composition Test	ASTM C295	Once before trial mix and every change of source/quarry location (check supplier data)
Water	Water Quality Test	AASHTO T26	Once before trial mix and when necessary
Admixture	Quality Test	ASTM C494	Once before trial mix and when necessary (Mill sheet)
Concrete	Slump Test	AASHTO T119	Once every 75m3 or per batch
	Air Content Test	AASHTO T121	Once every 75m3 or per batch
	Compressive Strength Test	AASHTO T22	6 samples per batch or 6 samples for every 75m3 of concrete (3 samples each for 7-day strength and 28-day strength)
	Temperature	ASTM C1064	Once every 75m3 or per batch

Table 2.2-42 Quality Management Plan for Earthwork and pavement Work

Item	Test Item	Test Method (Specifications)	Test Frequency
Embankment	Density Test (Compaction)	AASHTO T191	Every 500m2
Base course	Material Test (Sieve Analysis)	AASHTO T27	Once before placing and once every 1,500m3 or change in source/quarry location
	Material Test (CBR Test)	AASHTO T193	Once before placing and once every 1,500m3 or change in source/quarry location
	Dry Density Test (Compaction)	AASHTO T180	Once before placing and twice every 1,500m3 or change in source/quarry location
	Field Density Test Compaction)	AASHTO T191	Every 500m2
Asphalt Pavement	Material Testing (Sieve Analysis)	AASHTO M43, M80	Once before placing and once every 1,500m3 or change in source/quarry location
	Material Testing (density and percentage of absorption)	AASHTO T84	Once before placing and once every 1,500m3 or change in source/quarry location
	Density-in -situ examination	AASHTO T209	Every 200m
	Temperature survey		Every truck

2.2.4.6 Procurement Plan

(1) Procurement of Major Construction Materials

The major construction materials to be procured, based on filed research for procurement are as follows shown in Table 2.2-43.

Table 2.2-43 Procurement Area of Major Construction Materials

Item		Procurement area			Procurement Reason	Procurement Routes
Item Name	Description	Local	Japan	Third Countries		
Material for structure						
Cement	Bulk	○				Phnom Penh
Reinforcing Bars	D10～D32	○				Phnom Penh
Gabion	2m(L)x1m(W)x0.5m(H)	○				Phnom Penh
Guard Rail	Steel	○				Phnom Penh
Bitumen		○				Phnom Penh
Aggregate for Concrete	3/4" to 3/8"	○				Near construction site
Aggregate for Concrete	Crushed stone dust	○				Near construction site
Rocks	150mm to 500mm	○				Near construction site
Borrow Soil	Proper soils	○				Near Construction site
Joint Fill Material	Bituminous t=20mm		○			
PC Cable	12S12.7BL, 7S12.7BL		○			
Sheath for PC	φ35～70mm		○			
PC fixture			○			
Expansion Joints	Expand 25 to 100mm		○			
Rubber bearings	120 to 150t		○			
Paper Drain	Biodegradable plastic		○			
Temporary Materials						
Fuels, oils and lubricants		○				Near construction site
Timber Formwork		○				Near Construction site
Temporary Steel	H Steel Beam, etc.	○				Phnom Penh
Steel Sheet pile	Type II	○				Phnom Penh
Deck Panels		○				Phnom Penh

1) Procurement of Special Materials

Special materials which cannot be sourced out in Cambodia include bituminous joint fill material, PC steels, PC fixture device, expansion joints, rubber bearings, paper drains materials. These materials are appropriate to be procured in Japan.

a） Joint fill materials(bituminous)

In Cambodia, there no bituminous joint fill material produced nor available and the dissolvable bitumen are used instead of that. Thus, it is appropriate to procure from Japan since there are risks on the quality of the fill materials if such is procured from third country.

b） PC cable, sheath and fixtures

PC cables and its accessories are very important material to connect RC girders in structurally sound manner. In Cambodia, these materials are imported from oversea since it cannot be sourced out locally. In addition, such is required to have high quality to keep durability and strength of girders. Thus, it is appropriate to procure such from Japan to secure the quality and timely delivery.

c） Bearing and Expansion Joints

Bridge bearings transmit superstructure reactions to substructure, expansion joints provide mechanism for joint movements at girder ends due to temperature changes and protects the joint from vehicular traffic. These bridge accessories are important parts of the bridge that significantly influence bridge durability.

However, these accessories are basically not available in Cambodia and to ensure quality of materials and timely delivery, it is appropriate to procure such from Japan.

d） Paper drains

The paper drain is used to collect ground water in short time as necessary within the clay contained soil and to drain out at surface. It cannot be sourced out in Cambodia and the drain materials must be biodegradable after the drainage use from the environmental point of view. It is appropriate to procure such from Japan since the materials are in common use in Japan and the timely delivery is expected in Japan.

e） Aggregates for concrete and base course material

These aggregates are to be procured from nearby quarries to each site. In case of Peam Te, the quarry located along National Road N7, approximately 85km away while other quarry located in south west from the bridges in Kratie. For Prey Veng area, the quarry located in south east near N1 road, approximately 30km away from the bridges.

2) Waste Landfill (Disposal Area)

The debris of concretes and asphalts material which produced from demolitions of existing bridges and roads are to be transported to the waste landfill area at Kratie City, approximately 33km from the temporary yard in Kratie and approximately 230km from the temporary yard in Prey Veng.

(2) Procurement of Major Construction Equipment

It is relatively easier to procure construction equipment and machineries in common since such are available in Cambodia. However, special equipment and machineries are planned to be procured from Japan. Construction equipment and machineries to be procured is summarized in Table 2.2-44.

Table 2.2-44 Major Construction Equipment to be procured

Item		Rent/ Buy	Where to Procure			Reason for Procurement	Procurement Route
Item Name	Specification		Local	Japan	Other Country		
Backhoe	0.45m^3	Rent	○				Phnom Penh
Backhoe	0.8m^3	Rent	○				Phnom Penh
Dump Truck	10t Cap.	Rent	○				Phnom Penh
Bulldozer	21t	Rent	○				Phnom Penh
Tire Roller	8～20t	Rent	○				Phnom Penh
Road Loader	10～12t	Rent	○				Phnom Penh
Motor Grader	W=3.1m	Rent	○				Phnom Penh
Truck Crane	25～50t	Rent	○				Phnom Penh
Truck Crane (rough terrain type)	50t	Rent	○				Phnom Penh
Crawler Crane	65t	Rent	○				Phnom Penh
Vibro Hammer	90KW	Rent	○				Phnom Penh
Heavy Weigh Breaker	1300kg	Rent	○				Phnom Penh
Vibration Roller	3 to 4t (drive type)	Rent	○				Phnom Penh
Batcher Plant	Batch type	Rent	○				Phnom Penh
All casing bored pile machine (percussion type)	Dia. 1.2m	Rent	○				Phnom Penh
All casing bored pile machine (Hydraulic circulating type)	Dia. 2m	Lease		○		Not Available	Japan to Sihanoukville/ Phnom Penh Port
Erection Girder for PC beams	Girder	Lease		○		-ditto-	-ditto-
Crane for PC beams production	Gantry crane	Lease		○		-ditto-	-ditto-
Paper Drain Installation Machine	Depth 30m	Lease		○		-ditto-	-ditto-

(3) Temporary Yards

Temporary Yards

From the reasons described below, two (2) temporary yards are required to have own site offices, material stock yards and working spaces, one in Kratie and other in Prey Veng. Figure 2.2-30 represents the arrangement of the temporary yard.

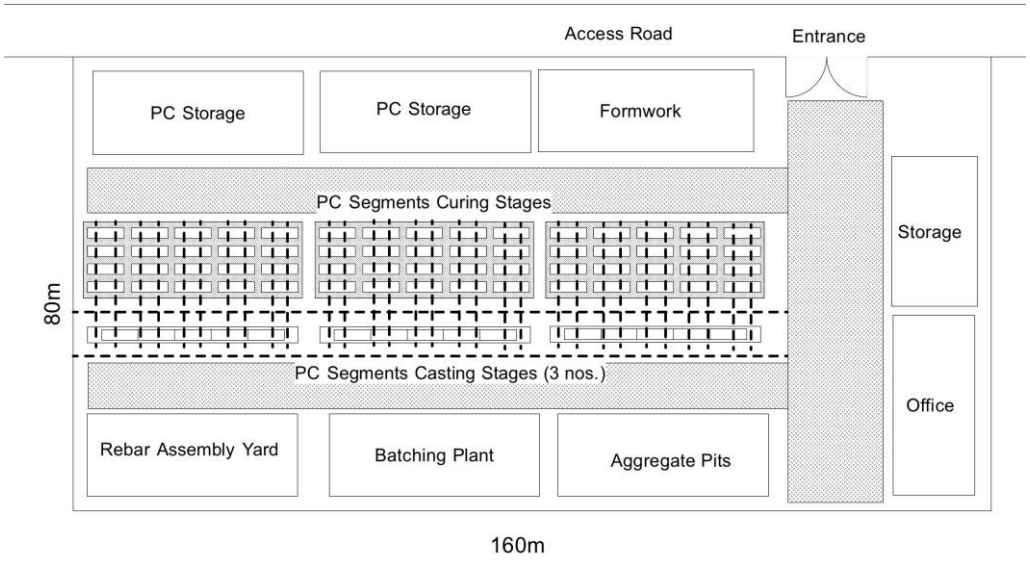


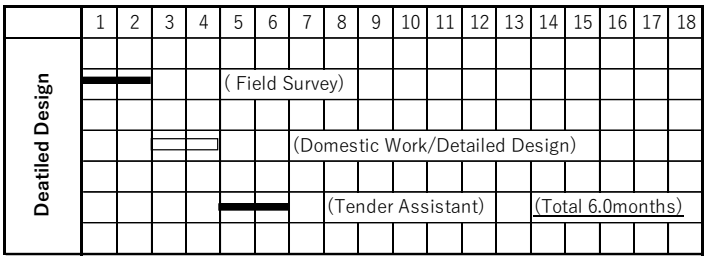
Figure 2.2-30 Temporary Yard Arrangement

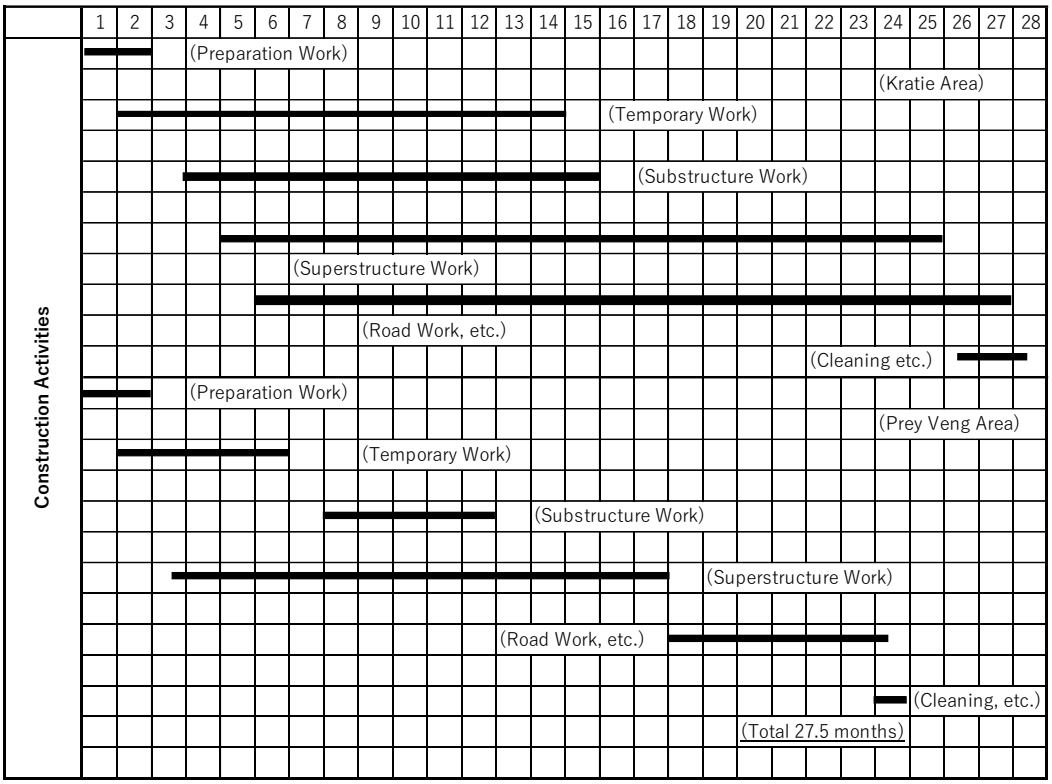
- The PC girders are planned to produce in each temporary yard within quality control manner to keep up timely delivery to each bridge.
- There are approximately 180km away from both temporary yards and it is important to supervise each bridge construction activity in close distance to maintain high quality of construction works.

2.2.4.7 Implementation Schedule

Table 2.2-45 represents the overall implementation schedule for detailed design and project construction for the bridge replacement work. The duration of the detailed design is estimated to be 6.0 months while the construction period is estimated to be 27.5 months, total of 33.5 months.

Table 2.2-45 Implementation Schedule





2.3 Obligations of Recipient Country

The undertakings required from the GOC for the smooth execution of this project are as follows:

- To acquire land for construction and to relocate affected houses;
- To secure land for construction yard, stock yard, site office, yard, and detour routes;
- To secure borrow pits, spoil-banks, and indutrial waste disposal areas;
- To provide electrical power to the site offices;
- To relocate all utilites including underground utilities that will diturbe the Project works and to install/hang the utilites along the new bridges as required.
- To remove the existing boundary wall of Pagoda, located at reft bank of the Preck Chhloung, gantry entrance gates and all other diturbed items such as trees, etc. including to rebuild the same at new locations.
- To bear the cost of bank charges such as the Advising Commission and Payment Commission to the Japanese bank where an account related to the project is opened.
- To arrange and do quick and smooth custom declaration and import tax formalities for all iimported materials and equipment arrive from Japan and any other third countries.
- To take necessary action for tax exemption for such as VAT of all materials and goods purchased locally, Japanese contractor's corporate tax and income tax for all employee, including Japnese staff, local staff and staff employed from third countries.
- To investigate and remove all UXO and Mines in all the construction areas.
- To obtain necessary permits that would allow the personnels engaged in the construction work such as the supervision engineer, construction workers etc. for the construction of thei project.
- To assist to achieve necessary permits/certificate for envirionmental issues, construction of bridges, working inside river, earthwork and public traffic detouring, etc.
- To use new bridges with approach roads properly and maintain in proper manner after the end of construction of those structures.
- To demolish and remove parts of existing bridegs such as five (5) piers of Prek Peam Te and four (4) piers of Prek Chhloung after the new bridges being completed.
- To assisit to solve all problems raised with nearby residents and other public during the implementation stage of the Project.
- To bear all the expensese, other than those to be borned by the Grant Aid, necessary for construction of facilities.
- To monitor, analize and take actions as necessary based on the result of testing/measuring of air quality, water quality etc. during and after the construction (public use) in reference to social and environment isuues.

2.4 Project Operation and Maintenance Plan

The Ministry of Public Works and Transport (MPWT) oversees the operation and maintenance for all roads and bridges and the Department of Public Works and Transport (DPWT) executes the periodical inspection, routine maintenance and repair. There are 103 officials in MPWT, of which 61 officials are engineer.

Road/ bridge maintenance work conducted by DPWT is shown below. Most of the works are carried out by subcontracting.

Periodical Inspection	: Regular inspections of roads and bridges
Routine Maintenance	: Clearing etc. of drainage, pavement, expansion joints device, shoulder
Repair Works	: Pavement, drainage, bridge facilities, shoulder, slope

The bridges to be constructed in this project is durable and strong against the environment in Cambodia and serious technical problems as well as major repair is not expected to occur in the immediate future. Routine maintenance, however, is encouraged to promote durability of the bridges. With that in mind, it is important to allocate budget for operation and maintenance.

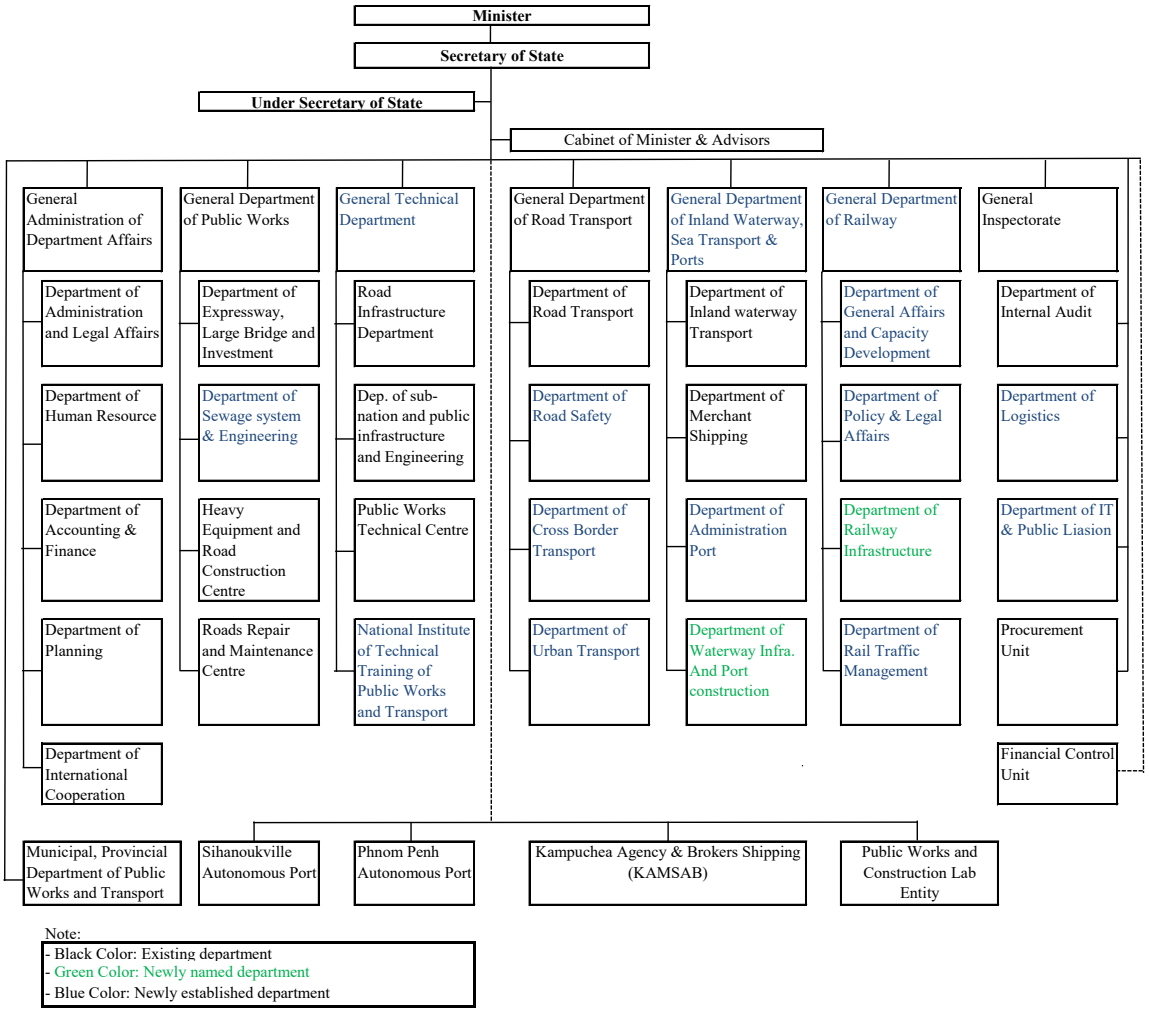


Figure 2.4-1 Organization Framework

As shown on Figure 2.4-1, the department in charge within MPWT for operation and maintenance is the General Department of Public Works (GDPW), and the Road Repair and Maintenance Center (RRMC) takes administrative works.

In the department/center, local DPWT in each Province carries out inspection, routine maintenance and repairs.

Departments in charge of DPWT in Kratie Province and in Prey Veng Province is shown in the Figure 2.4-2 and Figure 2.4-3, respectively. Five (5) bridges are within Kratie Province while two (2) bridges are within Prey Veng Province.

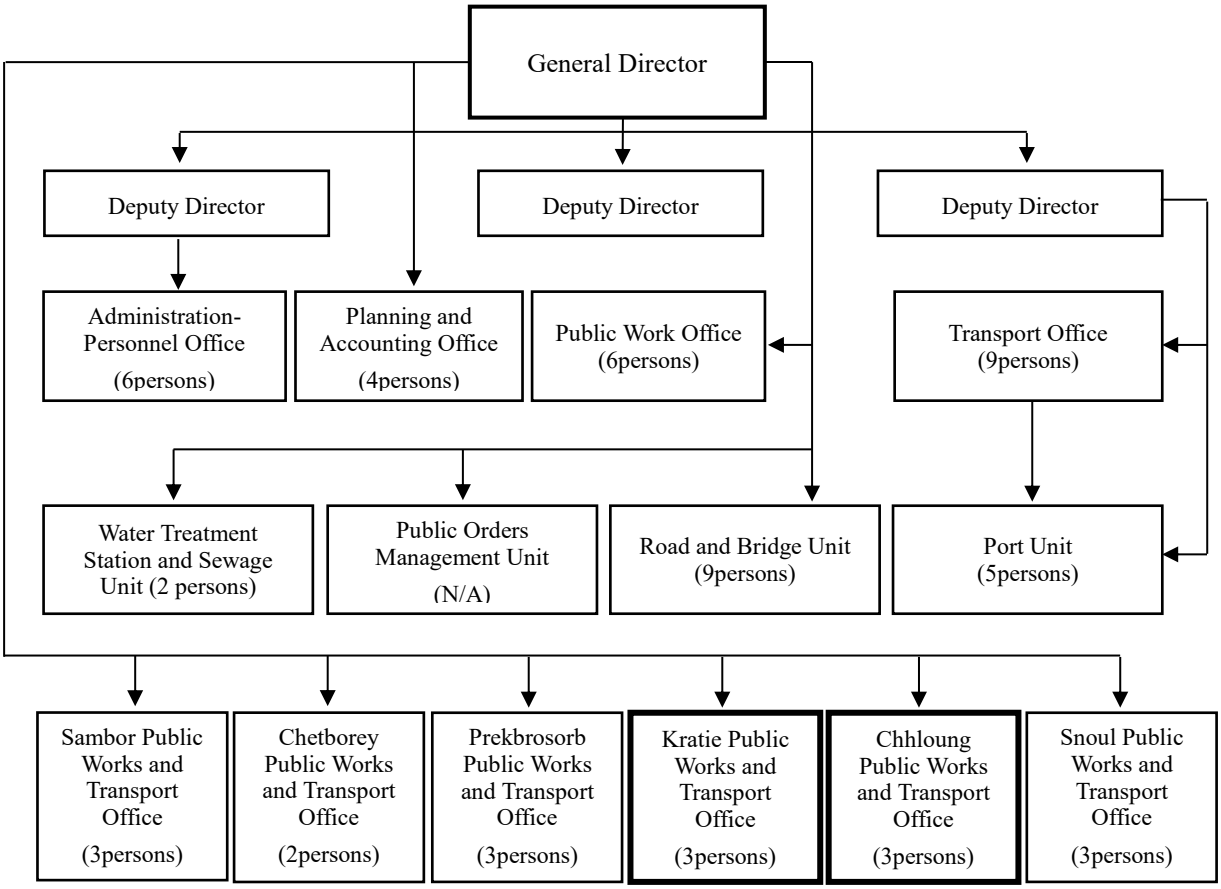


Figure 2.4-2 Department in Charge of Maintenance in Kratie Province

For those bridges in Kratie Province, as stated above, the six local offices oversee bridge maintenance. Namely, Peam Te is taken care of maintenance by the Kratie Works and Transport Office while Prek Chhloung and other three bridges is by Chhloung Public Works and Transport Office.

For two bridges (Ba Baong No.1 and Ba Baong No.2) is taken care of maintenance by Prey Veng Public Works and Transport Office.

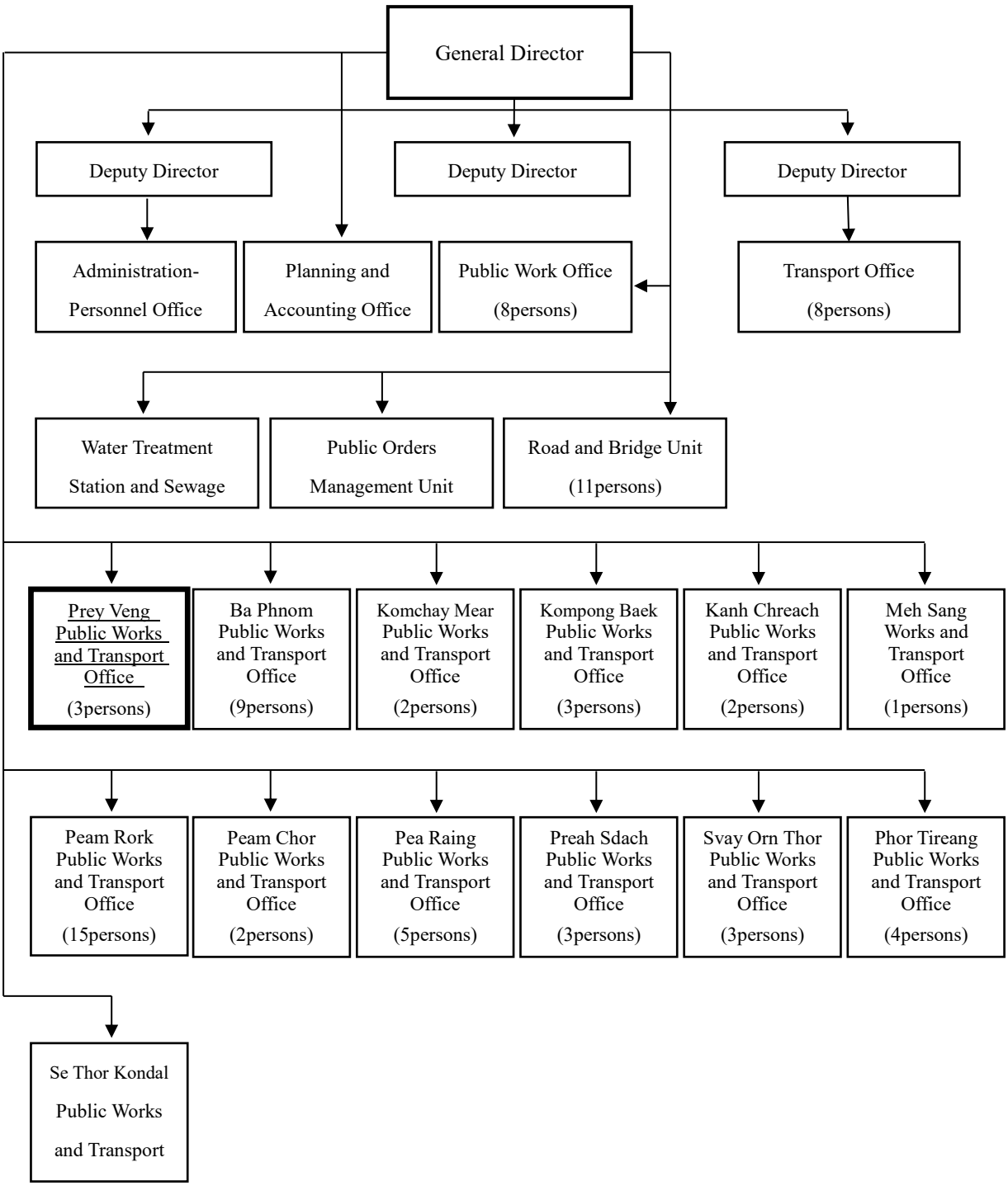
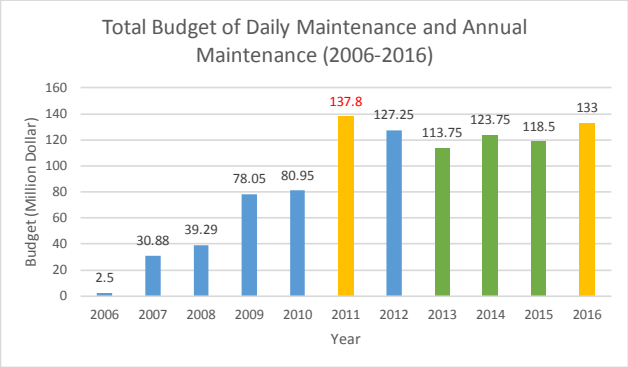


Figure 2.4-3 Department in Charge of Maintenance in Prey Veng Province

The annual budgets for MPWT for past 10 years are shown in Figure 2.4-4. The budget of MPWT is relatively kept constant budget even though there are varies after the sudden increase in 2011. The latest budget is almost 4 times increase of one in 10 years ago.

In the Ministry budget, it is conformed that daily maintenance has been spending annually and the annual expenditure has increased in recent years as the budget increases. In addition, emergency maintenance budget has allocated. It is well expected that there would be any problems for operation and maintenance of those seven (7) bridges to be constructed in this project.



Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total Budget (Million Dollar)	2.5	30.88	39.29	78.05	80.95	137.8	127.25	113.75	123.75	118.5	133
Increase rate (%)		1135.2%	27.23%	98.65%	3.72%	70.23%	-7.66%	-10.61%	8.79%	4.24%	12.24%
Daily Maintenance (Chapter61)		5.73	8.81	17.14	17.86	16.1	15.75	20	23	30.75	31.25
Annual Maintenance (Chapter61)		12.2	14.29	13.29	15	26.59	32.5	37.5	27	14	18.25
New Construction (Chapter21)		8.93	11.9	45.24	45.24	50	51.25	51.25	61.25	61.25	70
Maintenance after Flooding		2.44	2.38			41.45	23.75				
Emergency Maintenance		1.59	1.9	2.38	2.86	3.66	4	5	12.5	12.5	13.5

Figure 2.4-4 Annual Budget of MPWT

Road maintenance work, including bridges, conducted by MPWT is shown below. Most of the works are done by subcontracting.

- Pavement repair
- Road structure repair
- Cleaning on pavement surface and drainage
- Traffic signal and street lighting
- Bridge inspection and repair

2.5 Project Cost Estimate

2.5.1 Initial Cost Estimation

(1) Japan's Contribution

The cost borne by the Japanese's Grant Aid is not shown in this report due to the confidentiality.

(2) Cambodia's Contribution

The cost to be borne by the Government of Cambodia is estimated to be about 1.93 million US dollars (213.4 million Japanese Yen). Breakdown is presented in Table 2.5-1.

Table 2.5-1 Project Cost Borne by Cambodia Government

Item	Cost (US$)	Cost (Japanese Yen)
1 Bank Charges	US$74,000.00	¥8,200,000-
2 Land Acquisition/ Secure Temporary Construction Yard (Rental etc.)	US$632,000.00	¥69,800,000-
3 Invest & treat UXO/Mines	US$600,000.00	¥66,300,000-
4 Relocations of utilities (lighting, communication cables, etc.)	US$191,000.00	¥21,100,000-
5 Buildings, houses and shop removal and compensations	US$210,000.00	¥23,200,000-
6 Removal of existing bridges (2 bridges)※	US$225,000.00	¥24,800,000-
Total	US$1,932,000.00	¥213,400,000-

Note: * removal cost after the new bridges are to be constructed.

(3) Cost Estimation Condition

Cost estimation Date	:	January 2017
Foreign Exchange rate	:	US$1.00=110.41 JPY
Construction Period	:	Schedule of construction supervision is shown in the implementation schedule
Others	:	The project is carried out based on the Japanese Government's Grant Aid Schedule

2.5.2 Operation and Maintenance Cost

Table 2.5-2 represents operation and maintenance cost for one bridge and connecting road. Since operation and maintenance works are conducted by subcontracting, there are no technical problems on maintenance work.

Table 2.5-2 Maintenance Item for Bridges to be checked and Annual Maintenance Cost

	Facility Name	Items to be checked	Frequency	Personnel	Equipment	Total Number	Cost (US$)
Periodic Inspection	Pavement Drainage Structure River Bank Protection Bridge Facility	Cracks etc. Sediment Deposition/Obstacle Damage/Deformation/Peeling etc. Cracks/Damage etc. Utility/Handrails	12times/year 1 day/time	2 persons	Scoop/Hammer/ Sickle/Barricade Pickup	24 persons/year 12 vehicles/year	1,200 2,400
						Subtotal	**3,600**
	Facility Name	Items to be checked	Frequency	Personnel	Equipment	Total Number	Cost (US$)
Routine Maintenance	Pavement Drainage Expansion Joints Bridge	Cleaning Removal of Obstacle or sediment Removal of Obstacle or sediment Cleaning	4 times/year 2 days/time	5 persons	Scoop/Barricade/ Mower/ Broom /Tool Small Truck	40persons/year 8 vehicles/year	2,000 1,600
						Subtotal	**3,600**
	Facility	Items to be checked	Frequency	Personnel	Equipment	Total Number	Cost (US$)
Repair	Pavement Drainage Structure Bridge Facility Road surface signs and lines	Cracks etc. Damage repair Damage repair Damage repair (Handrails) Repair lane marks	1 time/year 4 days/time	6 persons	 Compactor Small Truck Concrete Lane Marking	24 persons/year 4 vehicles/year 4 vehicle/year 1.0m3/year 5.0m/year	1,200 300 600 400 300
						Subtotal	**2,800**
						Total	**10,000**

Table 2.5-3 Maintenance Item for Roads to be checked and Annual Maintenance Cost

	Facility	Items to be checked	Frequency	Personnel	Equipment	Total Number	Cost (US$)
Periodic Inspection	Pavement Shoulder/ Slope Drainage	Cracks etc. Damage part/Deformation/ Peeling etc. Sediment Deposition/ Obstacle	12 times/year 1 day/time	2 persons	Scoop/Hammer/ Sickle etc. Pickup	24 persons/year 12 vehicles/year	1,200 2,400
						Subtotal	**3,600**
	Facility	Items to be checked	Frequency	Personnel	Equipment/ Materials	Total Number	Cost (US$)
Routine Maintenance	Shoulder/Slope	Mowing/Cleaning	4 times/year 2 days/time	5 persons	Scoop/Barricade/ Mower/Broom/ Tool Small Truck	40 persons/year 8 vehicles/year	2,000 1,600
						Subtotal	**3,600**
	Facility	Items to be checked	Frequency	Personnel	Equipment/ Materials	Total number	Cost (US$)
Repair	Pavement Shoulder/Slope Road Facility	Crack/Damage Damage part etc. Damage part etc.	1 time/year 4 days/times	6 persons	 Compactor Small Truck Asphalt mix Line marks	24 persons/year 4 vehicles/year 4 vehicles/year 3.0m^3/year 10m/year	1,200 300 600 900 300
						Subtotal	**3,300**
						Total	**10,500**

Chapter 3 Project Evaluation

3.1 Preconditions

3.1.1 Preconditions for Project Implementation

The Project preconditions related to the required undertakings from the GOC are as follows:

i) To secure land for construction yard, stock yard, borrow pits, spoiled-banks and industrial waste disposal areas within 4 months after E/N;

ii) To relocate all utilities including underground utilities that will disturb the Project works and to install/hang the utilities along the new bridges as required within 4 months after E/N;

iii) Any necessary actions for tax exemption shall be taken keeping to the regulations of E/N and G/A;

iv) Quick and smooth customs declaration and important tax formalities shall be totally finished when imported materials or goods arrive from Japan and any other third countries;

v) This project does not require to process the EIA procedure. However, to monitor, analyze and take actions as necessary based on the result of testing/measuring of air quality, water quality etc. during and after the construction (public use) in reference to social and environment issues. The environmental mitigation measures and monitoring plan is described in 1.3.4 and 1.3.5 of their Report for your reference.

vi) To obtain necessary permits for taking borrow pits and cutting trees which disturb the facilities within 4 months after E/N;

vii) To assist to solve all problems raised with nearby residents and other public during the implementation stage of the Project.

3.1.2 External Condition for Achievement of the Overall Goal of the Project

3.1.2.1 Important Assumptions

After the Project completion, bridges and roads maintenance is necessary not only to provide smooth flow of traffic but also to prolong the life of the structures and the roads. Maintenance work includes daily or routine maintenance, removal of obstacles, cleaning, etc. Periodic inspection shall be carried-out and if damage is observed to structures and pavements essential repairs will be undertaken appropriately. Therefore, it is an important assumption that Cambodia to secure an annual maintenance budget to maintain and repair the facilities (Bridges:

10,000USD/bridge; Roads: 10,500USD/road). As noted in the earlier sections, the allocation of operation and maintenance budget in Cambodia is considered possible.

3.1.2.2 External Condition

To derive benefit from the entire Project and to make it sustainable, the necessary external condition are described below:

① On NR No.11, the government of China intends to improve the road on entire stretch of the NR No. 11 in near future, which will contribute the increase of traffic volume and increase the benefit of the Project.

② On NR No.73, the timely completion and proper maintenance of the replacement of the Kampong Raing Bridge, which is being undertaken by GOC and closely positioned to the target bridges, will contribute additional benefit and its sustainability of the Project.

3.2 Project Evaluation

3.2.1 Relevance

i) Beneficiaries of the Project are general citizens including the poor in eastern rural areas in Cambodia. Its number is very large.

ii) The Project is required immediately because to contributes correcting the poverty gap, enhancement of national logistic network and improvement of the living environment of the residents.

iii) Operation and maintenance after the Project can be implemented by Cambodia side under its own budget and staff without the need for very advance skill and technology.

iv) The purpose of the Project matches with the goals and policy of national development plan of Cambodia.

v) The Project is not a highly profitable project because it is a bridge replacement project in rural areas.

vi) Negative environmental and social impacts of the Project are relatively small.

vii) The Project has the necessity and advantage of using Japanese bridge construction technology, and it is possible to implement without difficulties by Japan Grant Aid system.

3.2.2 Effectiveness

(1) Quantitative Effect

The bridges to be replaced in the Project are temporary bridges, and it is in dangerous situation now due to advanced deterioration and traffic of overloaded vehicles. Therefore, by implementation of the Project will be expected direct effect such as prevention of falling bridge (avoidance of human

life loss). Moreover, it will be secured smoothness and safety of traffic and logistic by widening road and increasing load bearing capacity.

The quantitative effects expected by the implementation of the project is shown in Table 3.2-1.

Table 3.2-1 Expected Quantitative Effects by the Project

Indicator		Reference value (Measured in 2016)	Target value (2023) 【3 years after project completion】
Pause time before the bridge (Sec/Vehicle) *The average value of the target bridge on the weekday	NR 11	114	0
	NR 73	42～162	0
Shortening transit time of NR 11 and NR 73 (Min.) *Average value of outbound / inbound at peak time and off-peak time on weekdays	NR 11 (Prey Veng - Neak Loueng)	46	40
	NR 73 (Kratie - Boundary between Kratie Province and Tboung Khmum Province)	120	107
Number of freight vehicles of 15 tons or more (Vehicles / day)	NR 73 *Bridges on NR11 are regulated by 25 tons	0 (163)*1 *1: Actual number of vehicles of 15 ton or more measured in 2016	260
Shortening time by conversion from NR7 to NR73 of freight vehicles of 15 tons or more (Min.)	NR 73	214 (through NR 7)	140 (through NR 73)
Passenger (Mil. people / year) *From OD traffic survey of the subject area on one day (weekday)	NR 11	3.65	3.76
	NR 73	6.29	9.66
Cargo volume (Thou. Ton / year) *From OD traffic survey of the subject area on one day (weekday)	NR 11	371	504
	NR 73	325	721

(2) Qualitative Effect

iv) Vulnerability to natural disasters in the project area is reduced

v) Smoothness and safety to traffic and pedestrians improves by improvement of the load-bearing capacity and widening bridge width.

vi) Living environment in rural area will be improved by improvement of safety of the road, secure stable traffic and logistic, and promotion of local economic revitalization.

Appendices

Appendix-1:
Member List of the Study Team

【Member List of the Study Team】

Name	Designation	Affiliation
KAWAHARA Shuntaro	Team Leader	JICA
KAWASAKI Yoshihiro	Planning Coordinator	JICA
KANYAMA Yohei	Planning Coordinator	JICA
WATANABE Ryohei	Chief Consultant/ Bridge Planning 1	CTI Engineering International Co., Ltd.
OKAZAKI Akio	Deputy Chief Consultant/ Bridge Planning 2	CTI Engineering International Co., Ltd.
TSUCHIDA Takayuki	Bridge Design 1	CTI Engineering International Co., Ltd.
WATANABE Masatoshi	Bridge Design 2	CTI Engineering International Co., Ltd.
SHRESTHA Robinson	Road Design 1	CTI Engineering International Co., Ltd.
TERAOKA Yusuke	Road Design 2	CTI Engineering International Co., Ltd.
SUNOUCHI Noriaki	Natural Condition Survey (Topographic, Geological)	CTI Engineering International Co., Ltd.
FURUKAWA Takashi	Hydraulic and Hydrologic Analysis	CTI Engineering International Co., Ltd.
KANEKO Hiroshi	Traffic Survey/ Analysis	CTI Engineering International Co., Ltd.
NISHI Shuichi	Construction Planning/ Estimate	CTI Engineering International Co., Ltd.
WATANABE Kanji	Social Environment Consideration	CTI Engineering International Co., Ltd. (SOWA Consultants Inc.)

Appendix-2:
Study Schedule

【Study Schedule】

Preparatory Survey Schedule (First Field Survey)

No	Date	Day	Content of Survey												
			Mr. Kawahara	Mr. Kawasaki	Mr. R. Watanabe	Mr. Okazaki	Mr. Tsuchida	Mr. M. Watanabe	Mr. Shrestha	Mr. Teraoka	Mr. Sunouchi	Mr. Furukawa	Mr. Kaneko	Mr. Nishi	Mr. K. Watanabe
			Team Leader	Planning Coordinator	Chief Consultant/Bridge Planning 1	Deputy Chief Consultant/Bridge Planning 2	Bridge Design 1	Bridge Design 2	Road Design 1	Road Design 2	Natural Condition Survey (Topographic, Geological)	Hydraulic and Hydrologic Analysis	Traffic Census/Estimate Future Traffic Volume	Construction Planning/Estimate	Social Environment Consideration
1	5/10	Tue			Arr. Phnom Penh		Arr. Phnom Penh		Arr. Phnom Penh	Arr. Phnom Penh			Arr. Phnom Penh		
2	11	Wed			Explanation/discussion on the Inception Report		Explanation/discussion on the Inception Report		Explanation/discussion on the Inception Report	Explanation/discussion on the Inception Report			Explanation/discussion on the Inception Report		
3	12	Thu			Documentation		Documentation		Meeting with MPWT	Documentation			Meeting with MPWT		
4	13	Fri	Arr. Phnom Penh	Arr. Phnom Penh	Documentation		Documentation		Documentation	Documentation			Documentation		
5	14	Sat			Site Survey		Site Survey		Site Survey	Site Survey			Site Survey		
6	15	Sun													
7	16	Mon			Documentation		Documentation		Documentation	Documentation			Documentation		
8	17	Tue			MPWT		MPWT		MPWT	Documentation			Discussion with Local Consultant		
9	18	Wed			Embassy of Japan in Cambodia		Embassy of Japan in Cambodia		Site Survey	Site Survey			Site Survey		
10	19	Thu			MPWT		MPWT		MPWT	Documentation			Documentation		

No	Date	Day	Content of Survey												
			Mr. Kawahara	Mr. Kawasaki	Mr. R. Watanabe	Mr. Okazaki	Mr. Tsuchida	Mr. M. Watanabe	Mr. Shrestha	Mr. Teraoka	Mr. Sunouchi	Mr. Furukawa	Mr. Kaneko	Mr. Nishi	Mr. K. Watanabe
			Team Leader	Planning Coordinator	Chief Consultant/Bridge Planning 1	Deputy Chief Consultant/Bridge Planning 2	Bridge Design 1	Bridge Design 2	Road Design 1	Road Design 2	Natural Condition Survey (Topographic, Geological)	Hydraulic and Hydrologic Analysis	Traffic Census/Estimate Future Traffic Volume	Construction Planning/Estimate	Social Environment Consideration
11	20	Fri	Dep. Phnom penh	Dep. Phnom penh	Documentation		Documentation		Documentation	Documentation	Arr. Phnom Penh		Documentation	Arr. Phnom Penh	
12	21	Sat													
13	22	Sun													
14	23	Mon			Documentation		Documentation		Documentation	Documentation	Documentation	Arr. Phnom Penh	Documentation	Documentation	
15	24	Tue			Documentation		Documentation		Documentation	Documentation	Documentation	Data Collection	Documentation	Documentation	
16	25	Wed			Documentation		Documentation		Documentation	Documentation	Documentation	Data Collection	Documentation	Documentation	
17	26	Thu			Site Survey		Site Survey		Site Survey	Site Survey	Site Survey	Site Survey	Site Survey	Site Survey	
18	27	Fri			Site Survey		Site Survey		Site Survey	Site Survey	Site Survey	Site Survey	Leave for JPN	Site Survey	
19	28	Sat			Site Survey		Site Survey		Site Survey	Site Survey	Site Survey	Site Survey	Arr. at JPN	Site Survey	
20	29	Sun													
24	30	Mon			Documentation		Documentation		Documentation	Documentation	Site Survey	Documentation		Documentation	
25	31	Tue			Documentation		Documentation	Arr. Phnom Penh	Documentation	Documentation	Site Survey	Documentation		Documentation	
26	6/1	Wed			Documentation		Documentation	Documentation	Site Survey	Site Survey	Site Survey	Site Survey		Site Survey	Arr. Phnom Penh
27	2	Thu			Documentation		Site Survey			Site Survey	Documentation	Site Survey			Documentation
28	3	Fri			MPWT		Site Survey	Site Survey	MPWT	Documentation	Documentation	Site Survey		Site Survey	Documentation
29	4	Sat					Site Survey	Site Survey		Documentation	Documentation	Site Survey		Site Survey	Documentation
30	5	Sun													

No	Date	Day	Content of Survey												
			Mr. Kawahara	Mr. Kawasaki	Mr. R. Watanabe	Mr. Okazaki	Mr. Tsuchida	Mr. M. Watanabe	Mr. Shrestha	Mr. Teraoka	Mr. Sunouchi	Mr. Furukawa	Mr. Kaneko	Mr. Nishi	Mr. K. Watanabe
			Team Leader	Planning Coordinator	Chief Consultant/Bridge Planning 1	Deputy Chief Consultant/Bridge Planning 2	Bridge Design 1	Bridge Design 2	Road Design 1	Road Design 2	Natural Condition Survey (Topographic, Geological)	Hydraulic and Hydrologic Analysis	Traffic Census/Estimate Future Traffic Volume	Construction Planning/Estimate	Social Environment Consideration
31	6	Mon			Documentation		Leave for JPN	Documentation	Documentation	Leave for JPN	Documentation	Documentation		Data Collection	Documentation
32	7	Tue			Documentation		Arr. at JPN	Documentation	Documentation	Arr. at JPN	Documentation	Documentation		Data Collection	Documentation
33	8	Wed			Documentation			Documentation	Documentation		Documentation	Documentation		Data Collection	Documentation
34	9	Thu			Documentation			Documentation	Documentation		Documentation	Site Survey		Documentation	Documentation
35	10	Fri			Documentation			Documentation	Documentation		Documentation	Site Survey		Documentation	Documentation
36	11	Sat			Site Survey			Documentation	Site Survey		Site Survey	Documentation		Documentation	Documentation
37	12	Sun													
38	13	Mon			Documentation			Documentation	Documentation		Documentation	Data Collection		Data Collection	Documentation
39	14	Tue			Documentation			Documentation	Documentation		Documentation	Data Collection		Data Collection	Documentation
40	15	Wed			Documentation	Arr. Phnom Penh		Documentation	Documentation		Documentation	Data Collection		Site Survey	Documentation
41	16	Thu			Documentation	Internal Meeting		Documentation	Documentation		Documentation	Documentation		Site Survey	Documentation
42	17	Fri			Meeting with MEF Leave for JPN	Meeting with MEF		Documentation	Leave for JPN		Leave for JPN	Documentation		Site Survey	Documentation
43	18	Sat			Arr. JPN	Internal Meeting		Internal Meeting	Arr. JPN		Arr. JPN	Documentation			Documentation
44	19	Sun													

No	Date	Day	Content of Survey												
			Mr. Kawahara	Mr. Kawasaki	Mr. R. Watanabe	Mr. Okazaki	Mr. Tsuchida	Mr. M. Watanabe	Mr. Shrestha	Mr. Teraoka	Mr. Sunouchi	Mr. Furukawa	Mr. Kaneko	Mr. Nishi	Mr. K. Watanabe
			Team Leader	Planning Coordinator	Chief Consultant/Bridge Planning 1	Deputy Chief Consultant/Bridge Planning 2	Bridge Design 1	Bridge Design 2	Road Design 1	Road Design 2	Natural Condition Survey (Topographic, Geological)	Hydraulic and Hydrologic Analysis	Traffic Census/Estimate Future Traffic Volume	Construction Planning/Estimate	Social Environment Consideration
45	20	Mon				Data Collection		Data Collection				Leave for JPN		Documentation	Site Survey
46	21	Tue				Site Survey		Site Survey				Arr. at JPN		Documentation	Site Survey
47	22	Wed				Site Survey		Site Survey						Documentation	Site Survey
48	23	Thu				Data Collection		Data Collection						Documentation	Site Survey
49	24	Fri				Data Collection		Data Collection						Documentation	Site Survey
50	25	Sat				Internal Meeting		Internal Meeting						Documentation	Site Survey
51	26	Sun													
52	27	Mon				Meeting with MPWT		Meeting with MPWT						Leave for JPN	Documentation
53	28	Tue				Meeting with MPWT		Meeting with MPWT						Arr. at JPN	Documentation
54	29	Wed				Site Survey		Data Arrangement							Leave for JPN
55	30	Thu				Site Survey		Data Arrangement							Arr. at JPN
56	7/1	Fri				Meeting with MPWT		Meeting with MPWT							
57	2	Sat				Data arrangement		Data arrangement							
58	3	Sun				Internal Meeting		Internal Meeting							

No	Date	Day	Content of Survey												
			Mr. Kawahara	Mr. Kawasaki	Mr. R. Watanabe	Mr. Okazaki	Mr. Tsuchida	Mr. M. Watanabe	Mr. Shrestha	Mr. Teraoka	Mr. Sunouchi	Mr. Furukawa	Mr. Kaneko	Mr. Nishi	Mr. K. Watanabe
			Team Leader	Planning Coordinator	Chief Consultant/Bridge Planning 1	Deputy Chief Consultant/Bridge Planning 2	Bridge Design 1	Bridge Design 2	Road Design 1	Road Design 2	Natural Condition Survey (Topographic, Geological)	Hydraulic and Hydrologic Analysis	Traffic Census/Estimate Future Traffic Volume	Construction Planning/Estimate	Social Environment Consideration
59	4	Mon				Meeting with MPWT		Meeting with MPWT							
60	5	Tue				Meeting with MPWT		Meeting with MPWT							
61	6	Wed				Meeting with MPWT		Meeting with MPWT							
62	7	Thu				Meeting on T/N		Meeting on T/N							
63	8	Fri				Signing on T/N Leave for Japan		Signing on T/N Leave for Japan							
64	9	Sat				Arrive at JP		Arrive at JP							

【Remarks】(Alphabetical order)

EoJ : Embassy of Japan
MPWT : Ministry of Public Works and Transport
JICA : Japan International Cooperation Agency
MEF : Ministry of Economy and Finance
T/N : Technical Note:

【Preparatory Survey Schedule (Second Field Survey)】

No.	Date	Day	Contents of Survey
			Mr. NISHI Shuichi
			Construction Planning/ Estimate
1	2017 1/18		Arrive at Phnom Penh
2	19	Thur.	Discussion with suppliers and Visit supplier offices
3	20	Fri.	Discussion with local contractors and Visit contractor offices
4	21	Sat.	Visit Asphalt plants in Phnom Penh and Data Collection
5	22	Sun	Documentation
6	23	Mon	Site Survey and Visit Asphalt Plant at Tboung Kmom
7	24	Tue	Discussion with local companies and visit site
8	25	Wed	Visit piling companies on going site and Data collection
9	26	Thur.	Meeting with MPWT and Data collection
10	27	Fri.	Arrive at Japan

- 【Remarks】(Alphabetical order)
- MPWT : Ministry of Public Works and Transport

【Preparatory Survey Schedule (Third Field Survey)】

No	Day and Date	Team Members			Stay
		Mr. WATANABE Ryohei	Mr. ROBINSON Shrestha	Mr. WATANABE Kanji	
1	Mar. 7 (Tue)	Arrive in Cambodia			Phnom Penh
2	Mar. 8 (Wed)	Meeting with MPWT at10:00			Phnom Penh
3	Mar. 9 (Thu)	Site Survey of Bridges along NR. 11			Kratie
4	Mar. 10 (Fri)	Site Survey of Bridges along NR. 73			Kratie
5	Mar. 11 (Sat)	Site Survey of Bridges along NR. 73			Phnom Penh
6	Mar. 12 (Sun)	Internal Meeting			Phnom Penh
7	Mar. 13 (Mon)	Meeting with MPWT, Data collection		Meeting with MEF	Phnom Penh
8	Mar. 14 (Tue)	Meeting with MPWT, Data collection		Meeting with MEF	Phnom Penh
9	Mar. 15 (Wed)	Report to JICA Cambodia Office, Leaving from Phnom Penh			Overnight flight
10	Mar. 16 (Thu)	Arrive in Japan			—

【Remarks】(Alphabetical order)

MPWT : Ministry of Public Works and Transport
JICA : Japan International Cooperation Agency
MEF : Ministry of Economy and Finance

【Preparatory Survey Schedule (Explanation of Draft Final Report)】

No	Day and Date	Team Members				Stay
		Mr. KAWAHARA Shuntaro	Mr. KANYAMA Yohei	Mr. WATANABE Ryohei	Mr. TSUCHIDA Takayuki	
1	Jul. 14 (Wed)			Arrive in Cambodia		Phnom Penh
2	Jul. 15 (Thu)			Meeting with MPWT at 9:00 and 14:30		Phnom Penh
3	Jul. 16 (Fri)			Site Survey of Bridges along NR. 11 and NR. 73		Phnom Penh
4	Jul. 17 (Sat)			Internal Meeting		Phnom Penh
5	Jul. 18 (Sun)	Arrive in Cambodia, Internal Meeting		Internal Meeting		Phnom Penh
6	Jul. 19 (Mon)	Meeting with MPWT at 9:00, Meeting with MEF at 15:00				Phnom Penh
7	Jul. 20 (Tue)	Meeting with MPWT at 10:00, Discussion of MD with MPWT at 14:30				Phnom Penh
8	Jul. 21 (Wed)	Signing of MD 9:00, Discussion with MEF at 15:00				Phnom Penh
9	Jul. 22 (Thu)	Report to JICA Cambodia Office at 8:00, Report to EOJ at 11:00, Leaving from Phnom Penh				Overnight flight
10	Jul. 23 (Fri)	Arrive in Japan				―

【Remarks】(Alphabetical order)

EoJ : Embassy of Japan
MPWT : Ministry of Public Works and Transport
JICA : Japan International Cooperation Agency
MEF : Ministry of Economy and Finance

Appendix-3:
List of Parties Concerned in the Recipient Country

【Lists of Parties Concerned in the Recipient Country】

Embassy of Japan in Cambodia	
CHIBA Taizo	Second Secretary
JICA Cambodia Office	
SUGANO Yuichi	Chief Representative
ITO Koji	Senior Representative
FUKUZAWA Daisuke	Representative
Ms. Seng Solady	Program Officer, Infrastructure Division
KUME Hidetoshi	JICA Expert (Transport Policy Advisor)
Ministry of Public Works and Transport (MPWT)	
Mr.Tauch Chankosal	Secretary of State
Mr. Nou Vaddhanak, Msc.	Director General, General Directorate of Techniques
Mr.Kem Borey	Director General, Directorate of Public Works
Mr. Heng Rathpiseth	Director of Road Infrastructure Department
Mr. Mr. Nay Chamnang	Ex. Director of Road Infrastructure Department
Mr. Chhim Phalla	Director of International Cooperation Department
Mr. Sreng Sros	Director, DPWT of Kratie Province
Mr. Chao Sopheak Phibal	Deputy Director, Roads and Infrastructure Department
Mr. Nin Menakak	Deputy Chief of Planning and Technical Office
Mr. Khuon Kompheak	Chief of Road Traffic Safety Environment and Public Awareness Office, MPWT
Mr. Kem Socheat	Chief of Technical Planning of Road and Bridge Office
Ministry of Economic and Finance (MEF)	
Mr. Hem Vanndy	Under Secretary of State
Mr. Tauch Chan Kresna, Ph. D	Deputy Director General, General Department of International Cooperation and Debt Management
Mr. Soan Serivathanak	Director of Department of Resettlement No.2
Mr. Yos Sovanna	Deputy Chief of Office of Bilateral Cooperation 1
Mr. Nou Phyrith	Technical Officer, Office of Bilateral Cooperation 1
Mr. Ngy Laymithuna	Technical Official of Bilateral Cooperation Division

DPWT: Department of Public Works and Transport