PACKAGE B

THE URGENT BRIDGE REHABILITATION PROGRAM

CHAPTER B-1 INTRODUCTION

1.1 General

The Urgent Bridge Rehabilitation Program was selected as one of the highest priority projects in Master Plan and therefore the pre-feasibility was conducted.

1.2 Purpose of Pre-feasibility Study

The purpose of this Pre-feasibility Study is to comprehensively evaluate the feasibility of this program.

1.3 Project Description for the Urgent Bridge Rehabilitation Program

The selected eight (8) bridges in this program are all temporary, and located on 1- and 2-Digit national roads in southeast region in Cambodia. The improvement target of these bridges is to be permanent structure with sufficient bridge capacity and standard.

Br. No.	Rd. No.	STA.	Width (m)	Length (m)	Bri. Capa. (ton)	Y2005 AADT (PCU)	Structural Condition		
							Superstructure	Substructure	Evaluation
1	3	025+927	4.50	37.00	15	5,169	Bailey +Steel Deck	Conc. Abutment	Poor
2	3	105+985	4.20	48.00	15	3,090	Bailey	Conc. Pier +Steel Pile	Poor
3	7	277+200	4.50	130.00	15	2,099	Bailey +Timber Deck	Concrete	Poor
4	11	084+900	5.40	42.20	15	2,087	I-Steel +Timber Deck	Timber	Very poor
5	11	088+094	5.40	84.20	15	2,087	I-Steel +Timber Deck	Timber	Very poor
6	11	089+060	4.90	45.20	15	2,087	I-Steel +Timber Deck	RC wall Pier +Timber	Very poor
7	11	103+475	4.85	48.00	15	1,765	I-Steel +Timber Deck	Timber	Very poor
8	33	036+540	4.20	30.00	5	713	Bailey	Conc. Abutment	Very poor

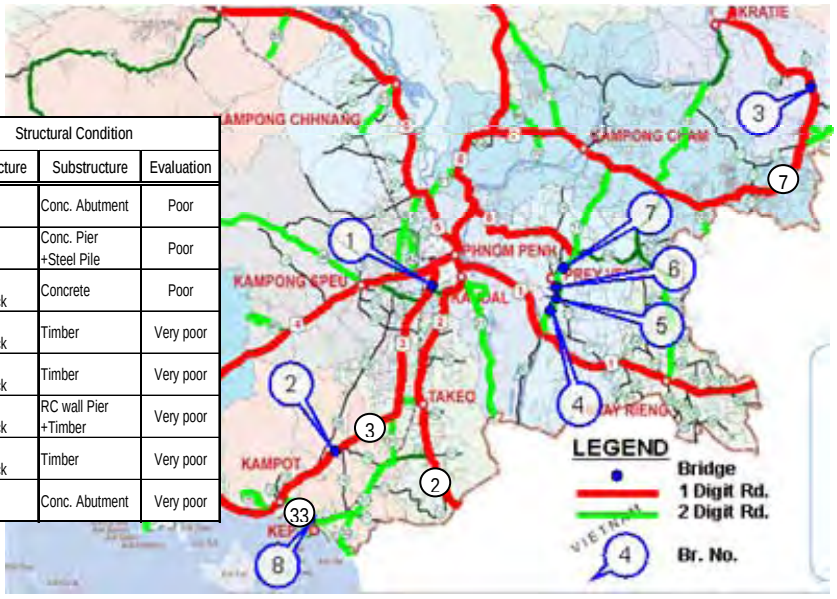


Figure 1.1 Location of Bridges to be Rehabilitated

CHAPTER B-2 GENERAL CONDITION AND ENGINEERING SURVEY

2.1 Natural Condition

2.1.1 Geography and Geology on the Project Site

The bridge sites are in relatively flat geographic areas except for the Bridge No.3 site on NR.7.

Notably, Bridges No.4 to No.7 are located in the Mekong river floodplain area. The site conditons of each bridge are classified as: (1) Flat and Low Elevation and also Flood Area: Bridge No.4, No.5, No.6 and No.7 on NR.11, (2) Flat and Low Elevation Area: Bridge No.1 and No.2 on NR.3, and No.8 on NR.33, and (3) Mountanious Area: Bridge No.3 on NR.7.

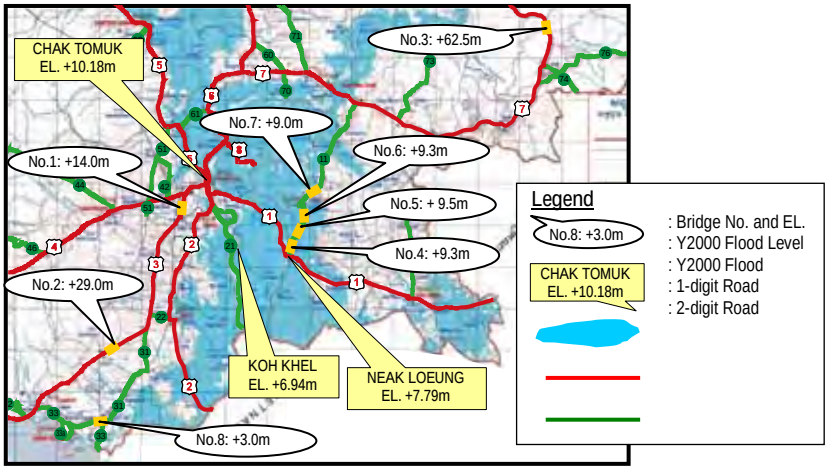


Figure 2.1 Year 2000 Flood in Cambodia with Flood Levels

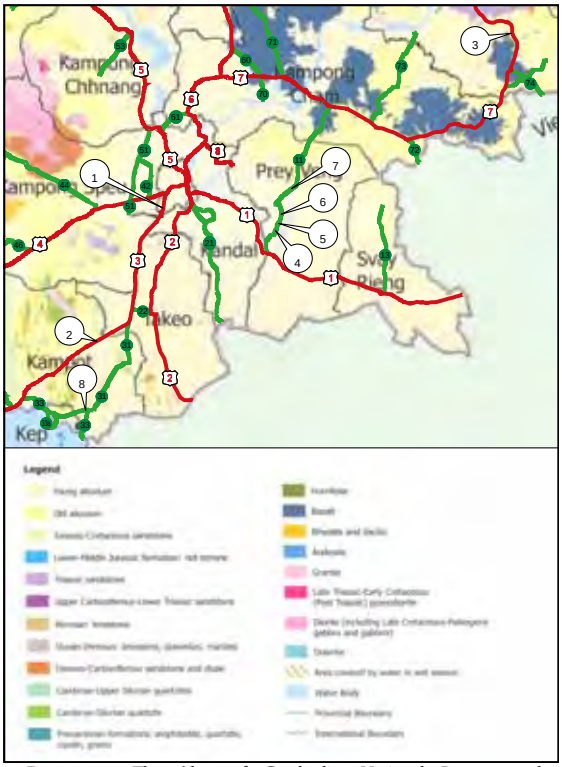
The existing road elevations around each bridge and the Y2000 flood level at MOWRAM stations near the project sites are shown in **Figure 2.1**.

2.1.2 Hydrology and Geology on the Project Site

The general geological conditions in the vicinity of the Project sites are shown in **Figure 2.2**.

The bridge sites except Bridge No.3 on NR.7 are covered by young alluvium deposited by the Mekong River and the Bassac River, and Bridge No.3 site is located in an old alluvium area.

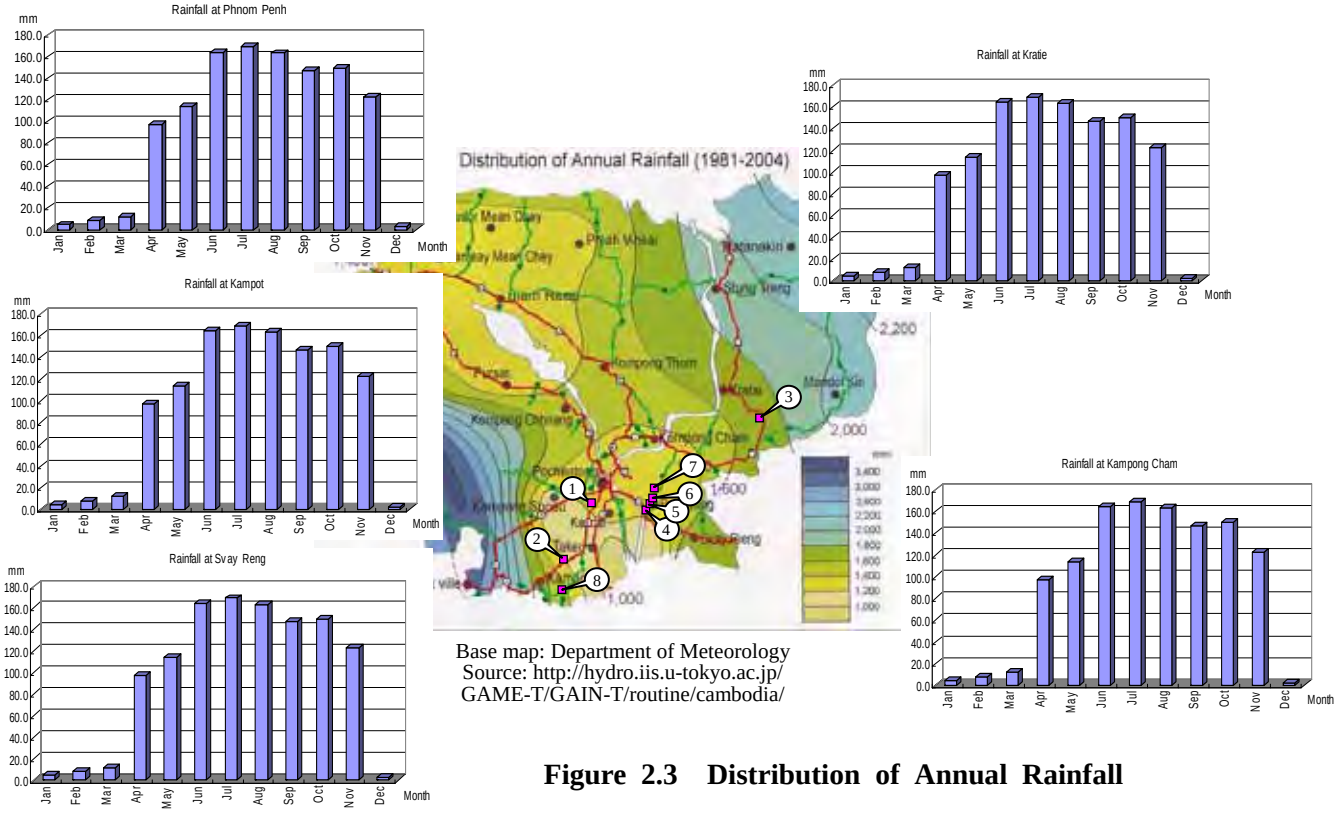
Annual rainfall around the Project sites is shown in **Figure 2.3**. The annual rainfall of the bridge stes are as follows: (a) Bridge No.2 site is approximately 1,200 mm, (b) Bridge No.1, No.3, No.4, No.5, No.6 and No.7 sites are in the range of 1,200-1,400mm and (c) Bridge No.8 site is in the range of 1,400-1,600mm.



Base map: The Altas of Cambodia, National Poverty and Environment Maps, Save Cambodia's Wildlife with Support from Danida

Figure 2.2 Geology of the Project Site

This region has a tropical monsoon climate.



Base map: Department of Meteorology
Source: http://hydro.iis.u-tokyo.ac.jp/GAME-T/GAIN-T/routine/cambodia/

Figure 2.3 Distribution of Annual Rainfall

2.2 Socio-Economic Condition

(1) Population

The population at the direct influence area of each bridge is taken at year 2005 and projected until year 2020, as shown in **Table 2.1**.

Table 2.1 Existing and Future Population in Direct Influence Area, 2005-2020

Province/District			2005	2010	2015	2020	AAGR (%)
Br. No 1	Phnom Penh	Dangkao	127,315	148,704	172,497	198,544	1.030
	Kandal	Kandal Stueng	94,712	104,562	114,286	123,315	1.018
	Pampong Speu	Kong Pisei	116,136	131,234	147,376	164,472	1.023
		Total	338,163	384,500	434,159	486,331	1.025
Br. No 2	Kampot	Chhuk	91,827	100,275	108,999	117,283	1.016
		Dang Tong	53,688	58,627	63,728	68,571	1.016
		Total	145,515	158,902	172,727	185,854	1.016
Br. No 3	Kratie	Chhuk	42,972	48,816	54,820	60,795	1.023
		Total	42,972	48,816	54,820	60,795	1.023
Br. No 4, 5, 6,7	Prey Veang	Peam Ro	64,291	69,049	73,192	76,925	1.012
		Kampong Leav	58,788	63,138	66,926	70,339	1.012
		Prey Veang	101,930	109,473	116,041	121,959	1.012
		Total	225,009	241,660	256,159	269,223	1.012

Table 2.1 Existing and Future Population in Direct Influence Area, 2005-2020

Province/District			2005	2010	2015	2020	AAGR (%)
Br. No 8	Kampot	Kampong Trach	89,965	98,242	106,789	114,905	1.016
		Total	89,965	98,242	106,789	114,905	1.016

Notes: 2005: Estimated on the basis of 2004 village data

2010, 2015, 2020: forecasted based on the growth rate in the Master Plan

(2) Land Use

The land use at each bridge site is summarized in **Table 2.2** below.

Table 2.2 Existing and Future Population in Direct Influence Area, 2005-2020

Bridge No.	Location	Land Use
1	25.927km in NR.3, south of Phnom Penh in Kandal	Land use around Bridge No.1 on NR.3 consists of rich irrigated paddy fields. However, since the site is within the Phnom Penh Metropolitan area, the light industries such as the garment industry and vehicle repair industry, are being developed in the area influenced by this bridge.
2	105.985km in NR.3 in Kampot	Land use around bridge No.2 on NR.3 consists of paddy and, flooded paddy fields as well as marshland. However, since the site is far from the Phnom Penh and Sihanoukville, there is no industrial development or commercial activity found in the area influenced by this bridge.
3	277.200km in NR.7 northeast of Phnom Penh in Kratie	Land use around bridge No.3 in NR.7 consists of dense forest with some grassland.
4, 5, 6, 7	84.900km, 88.094km, 89.060, and 103.475km in NR.11, respectively, in Prey Veng	Land use around bridges 4, 5, 6 and 7 in NR. 11 consists of rich flooded and irrigated paddy fields.
8	36.540km in NR.33 east of Sihanoukville in Kampot	Land use around bridge 8 in NR.33 consists of paddy, flooded paddy fields and marshland. However due to being near the coastal area of the Gulf of Thailand, the tourist industry is being developed in the area influenced by this bridge.

2.3 Engineering Survey

2.3.1 Topographic Survey

The topographic survey for the preliminary design of the urgent bridge rehabilitation program has been carried out based on National Benchmarks established by a geographic survey in 1993-97 and in accordance with the following scope of work: (1) Temporary benchmarks setting at each bridge site using WGS84 MSL and UTM Zone 48N, (2) Road centerline profile survey at 20m interval (100m from each abutment), (3) Topographic survey covering 100m each side of abutment at a 30m width, and (4) River cross-section survey at bridge centerline and 100m upstream and downstream of bridge.

2.3.2 Geotechnical Investigation

A geotechnical investigation was carried out for the preliminary bridge design in accordance with

the following scope of work: (1) Mechanical boring at seven sites with eight boreholes, (2) Standard penetration test at 1.0m interval at each borehole, and (4) Laboratory tests to determine the soil properties of collected sample.

The borehole logs are shown in **Figure 2.4**.

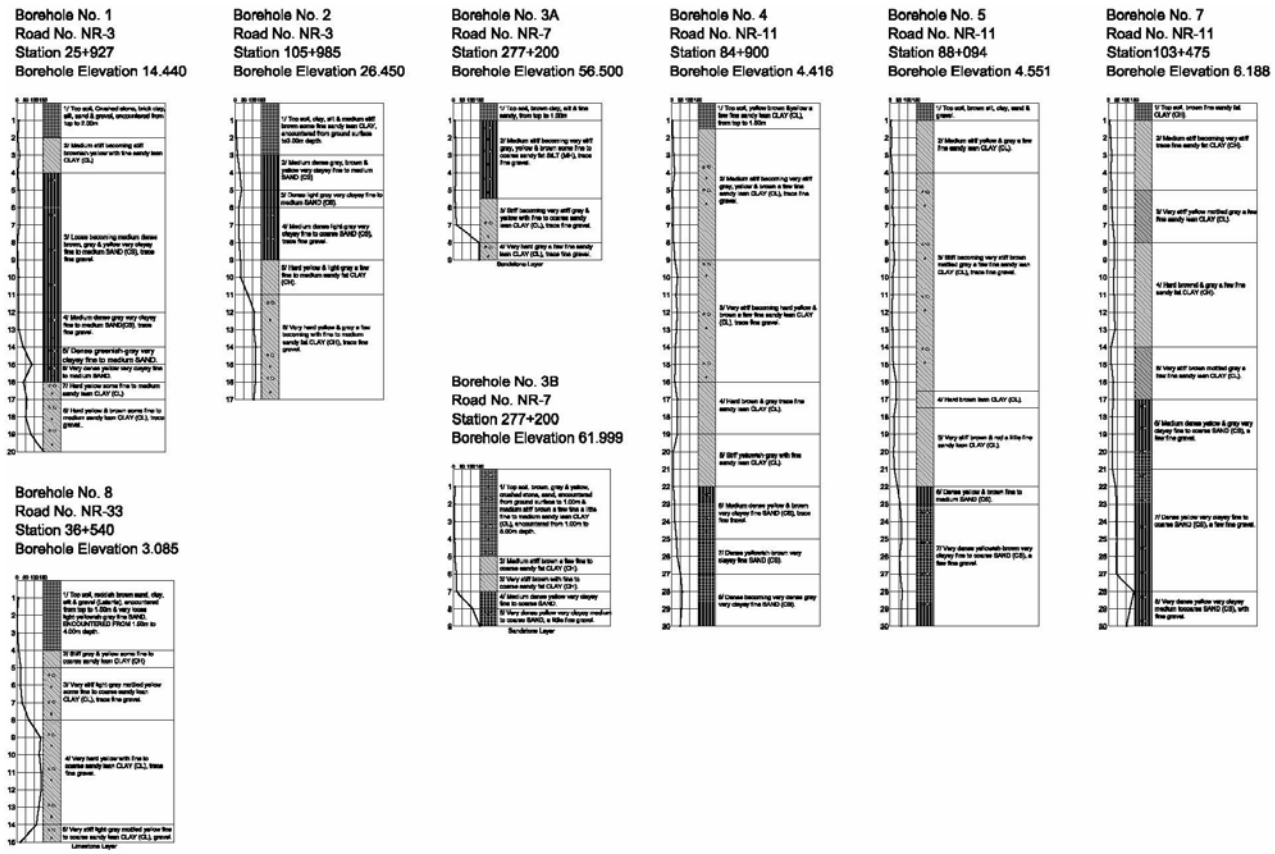


Figure 2.4 Borehole Logs

2.3.3 Hydrologic Survey

Preliminary hydrologic and hydraulic-analyses were also conducted for the Urgent Bridge Rehabilitation to determine the basic hydraulic design data for the bridges.

CHAPTER B-3 PRELIMINARY DESIGN

3.1 Design Concept and Criteria

3.1.1 Design Concept and Criteria for Road

Existing road alignment has been maintained as far as possible to minimize construction cost as well as to minimize negative socio-environmental impacts during construction. Vertical profile of the road is raised basically by additional new pavement layers thicknesses.

The design standard used for road design is basically based on the Cambodia Road Design Standard, Department of Public Works and Transport (MPWT), 2003. When no provision exists in this standard other international standards, such as AASHTO (A Policy on Geometric Design of Highways and Streets, 2001), JRSO (Japan Road Structure Ordinance), AASHTO Guide for Design of Pavement Structures, 1993) etc. have been applied.

The summary of geometric design criteria applied in the design is given in **Table 3.1**.

Table 3.1 Summary of Geometric Design Criteria

Design Elements			Type/Value	Remarks
1	Road Classification		R4/U4	
2	Terrain		Plain	
3	Design Vehicles (L x W x H)		16.7 x 2.6 x 4.1	WB- equivalent
4	Design Speed (km/hr)		80	
5	Cross-Sectional Elements	Formation Width (m)	14.0	
		Carriageway Width (m)	13.0	
		Traffic Lane Width (m)	3.5	
		Paved Shoulder Width (m)	1.5	
		Granular Shoulder Width (m)	1.5	
		Unpaved Verge Width (m)	0.5	
		Crossfall of Roadway (%)	3.0	6% for unpaved shoulder
		Slope of Earthworks		
		Fill	V : H = 1:2.0	1:1.5 for shallow fill
		Cut	Varies	Varies with soil condition
6	Horizontal Alignment	Horizontal Curve		
		Minimum Radius (m)	335 (135)	() for exceptional
		Superelevation		
		Maximum Superelevation (%)	6.0	
		Minimum Radii without Se (m)	1500	
7	Vertical Alignment	Maximum Grade (%)	6	
		Vertical Curve		
		Minimum K-value		
		Crest Curve	30	
		Sag Curve	28	

The typical cross sections used for the design is given in **Figure 3.1**, based on a total formation width of 14m.

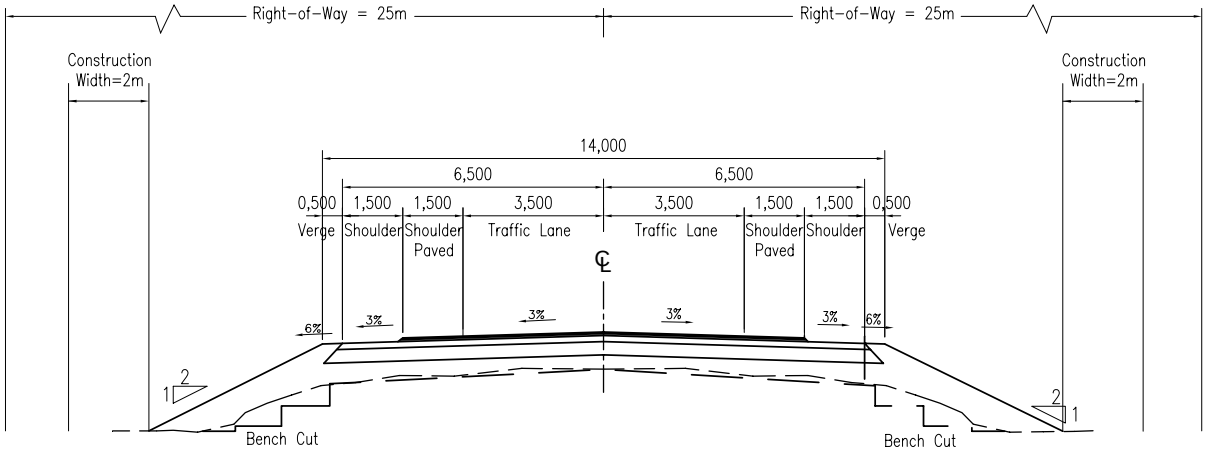


Figure 3.1 Typical Cross Sections

Road Design Standard of Cambodia presents the typed design for pavement structures and does not include detailed procedure. So the AASHTO Guide for Design of Pavement Structure has been applied for the pavement design.

The summary of design criteria, applied in the pavement design based on the AASHTO method, is given in **Table 3.2**.

Table 3.2 Summary of Design Criteria for Pavement Design

Design Input Requirements			Value	Reference
1	Design Variables	Performance Period (years)	10	General
		Analysis Period (years)	10	General
		Traffic		
		Equivalent Single Axle Load (ton)	8.2	AASHTO
		Directional Distribution Factor, D_D	0.6	AASHTO
		Lane Distribution Factor, D_L	1.0	AASHTO
		Reliability (%)	85	AASHTO
		Overall Standard Deviation	0.45	AASHTO
2	Performance Criteria	Initial Serviceability Index, p_0	4.2	AASHTO
		Terminal Serviceability Index, p_t	2.2	AASHTO
		Design Serviceability Loss, ΔPSI	2.0	AASHTO
3	Material Properties	Effective Roadbed Soil Resilient Modulus, M_R (psi)	1500 × CBR	General
		Layer Coefficient for Subbase Course, a_3	from CBR	AASHTO chart
		Layer Coefficient for Base Course, a_2	from CBR	AASHTO chart
		Layer Coefficient for Asphalt Concrete, a_1	Resilient Mod.	AASHTO chart
4	Pavement Characteristics	Drainage Coefficients for Base and Subbase Course, m_2, m_3	1.0	AASHTO

3.1.2 Design Concept and Criteria for Bridge

(1) Design Concept

The following design concepts are adopted to establish the design criteria:

- The bridge shall have the same functional standard as the road,
- The existing bridge alignment/location shall be maintained as much as possible,
- The bridge shall be designed to have minimum adverse social impact,
- Environmental preservation shall be a primary concern,
- The bridge shall incorporate appropriate traffic safety facilities in design and construction.
- The scale and type of bridge shall be determined based on:
  - Bridge Length and Superstructure
  - Substructure and Foundation, and
  - Structure Type

(2) Design Criteria

The following design criteria shall be adopted for NR.57 Bridges:

Table 3.3 Design Criteria for Bridges

Item	Design Criteria
1) Applicable Design Standards	• Australian Bridge Design Code, CAM PW.04.101.99, AUSTROADS, 1996 • Cambodian Bridge Design Standard (CBDS),CAM PW.04.102.99, MPWT, 2003 • Cambodian Road Design Standard, Part 3. Drainage (CRDS), CAM PW.03.103.99, MPWT, 2003 • Standard Specifications for Highway Bridges, AASHTO, 1996 • Specifications for Highway Bridges, Japan Road Association, 1996, 2002 • Specification for River Facilities, Japan River Association, 1998. The basic design requirements will be referred to the Cambodian Bridge Design Standard (CBDS). However, when the said guidelines do not cover other aspects of design or when a safer, more efficient requirement is needed, the design of bridges shall refer to other standards.
2) Bridge Location Consideration	• Stability of river course • Condition of river bank both upstream and down stream
3) Design Flood Frequency and Minimum Freeboard	• Flood Frequency one in fifty years (50 years) • Freeboard ♦ 1.0m for river discharge >500 - 2,000 m^3/s ♦ 0.80m for river discharge >200 - 500 m^3/s, and ♦ 0.60m for river discharge < 200 m^3/s

Table 3.3 Design Criteria for Bridges

<table>
<tr><th colspan="2">Item</th><th>Design Criteria</th></tr>
<tr><td colspan="2">4) Bridge Length</td><td>Total bridge length is decided based on:
the maximum design flood water level (DFL) and discharge
no constriction of river discharge flow, and
existing topographic and natural condition</td></tr>
<tr><td colspan="2">5) Typical Cross-section</td><td>• No. of Lanes – 2
<table><tr><th colspan="5">Bridge Width (m)</th></tr><tr><th>Area</th><th>Traffic Lane</th><th>Shoulder/ Motorbike Lane</th><th>Sidewalk</th><th>Total</th></tr><tr><td>Rural</td><td>2 @ 3.5</td><td>2 @ 1.5</td><td>2 @ 1.0</td><td>12.0</td></tr><tr><td>Urban</td><td>2 @ 3.5</td><td>2 @ 1.5</td><td>2 @ 1.5</td><td>13.0</td></tr></table>See Figure 3.2 for the typical bridge cross-sections.</td></tr>
<tr><td rowspan="4">6) Design Loads</td><td>i. Dead Load</td><td>Shall include weight of permanent members plus superimposed loads</td></tr>
<tr><td>ii. Live Load</td><td>• T44 Truck Loading,
• L44 Lane Loading, and
• Heavy Load Platform Loading (HLP240)</td></tr>
<tr><td>iii. Earthquake Forces</td><td>Uniform acceleration coefficient, a = 0.05</td></tr>
<tr><td>iv. Wind Load</td><td>Quasi-static approach using Cambodian wind map</td></tr>
<tr><td>v. Thermal Effects</td><td>As required in CBDS</td></tr>
<tr><td colspan="2">7) Design Properties of Materials</td><td>• Concrete : f’c = 25, 32, 40, 50 MPa
• Reinforcing Bars : Plain, fy = 250 MPa; Deformed, fy = 400 MPa
• Prestressing Steel : fp = 1750 – 1860 MPa</td></tr>
<tr><td colspan="2">8) Geotechnical Consideration</td><td>Allowable Bearing Capacity
• 0.40m x 0.40m RC Driven Pile : 500kN
• ϕ1.0m RC Cast-in-Place Pile : 2000kN
• Spread Footing on Sandstone : 800 – 1000 kPa</td></tr>
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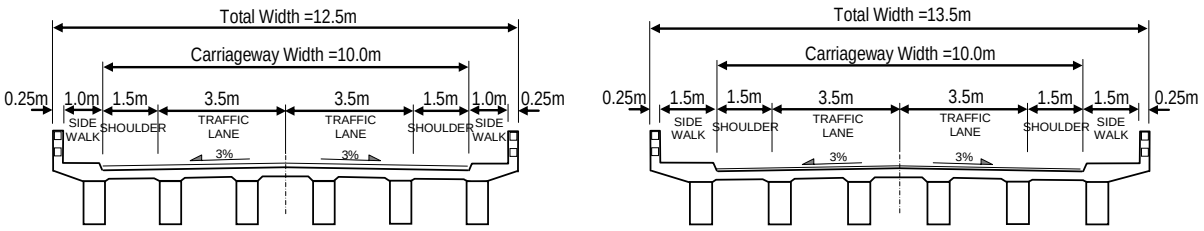


(a) Rural Areas (b) Urban Areas

Figure 3.2 Typical Bridge Cross-Section

3.2 Road Design

3.3.1 Existing Road Conditions

Bridges selected for urgent bridge rehabilitation belong to National Roads NR.3, NR.7, NR.11 and NR.33. The existing surface conditions of these roads are generally Double Bituminous Surface Treatment (DBST). The existing traffic lane width is generally about 7.0m except for BR.No.2 on NR.3 with 6.5m. shoulder widths vary from 1.0m to 1.5m.

3.2.2 Geometric Design

(1) Design of Horizontal Alignment

- As stated in the design concept, the road will generally follow the existing alignment to avoid any adverse socio-environmental effects. As enough space was available for detour during construction, the existing alignments of bridges were retained.
- The alignment design is based on the detailed topographic survey of the area by using total station. Digital Terrain Models (DTM) were prepared for each bridge site from the survey data and were used for the design.
- Generally, the alignments for the approach roads for all the bridges are straight, except for Bridge No.3 on NR.7 where a curve is located near the end.

(2) Design of Vertical Alignment

- Design of profile was based on the profile of existing road created from the prepared Digital Terrain Models.
- Increase in profile grade was done to meet the requirement of free board for the bridge. Vertical curves were designed with the minimum K value of 30 for crest. However, the sag curves at the end of the approach road connecting to the existing road is designed with K value of 15, which corresponds to the design speed of 60 km/hr on existing road.

(3) Design of Cross Sections

- The cross section of approach road has a formation width of 14 m, as required by R5 standard of the Cambodian Road Design Standard. The bridge section has a total paved width of 10m (3.5m lane width plus 1.5m paved shoulder). Since the approach road is for a short section, it is recommended to provide same 10m paved width as the bridge for traffic safety purposes and additional 1.5m shoulder with granular base/subbase, as shown in the typical cross sections.
- The total length of road improvement is taken as 100m on both sides from the abutment of the bridge, which includes 40m of standard cross section and 60m of taper to match to the existing road.

3.2.3 Pavement Design

Traffic survey was conducted at each highway of bridge locations. The performance and analysis periods are taken as 10 years as mentioned in the design criteria. The opening year of improvement is taken as the beginning of year 2011.

The Design ESAL values for each bridge site are shown in **Table 3.4**.

Based on the field survey and laboratory tests at each bridge site, design CBR values of existing subgrade were estimated. Design CBR values of 6% were estimated for the existing subgrade of BR1 to BR3. Similarly design CBR values of 4% were estimated for BR4 to BR8, while existing subgrade is recommended to be replaced in BR4 and BR8 due to the existing CBR of less than equal to 4.

The required Structural Numbers (SN) and the designed pavement thicknesses for the respective bridge sites are then calculated and are as given in **Table 3.4**.

Table 3.4 Designed Pavement Thicknesses for Each Bridge Site

Bridge	Design ESAL (million)	Design CBR (%)	SN	Asphalt Concrete		Base	Subbase
				Surface	Binder		
1	5.2	6	3.91	4 cm	5 cm	25 cm	30 cm
2	3.5	6	3.69	4 cm	5 cm	20 cm	30 cm
3	0.9	6	2.99	4 cm	5 cm	15 cm	20 cm
4	5.8	4	4.56	4 cm	5 cm	30 cm	40 cm
5	5.8	4	4.56	4 cm	5 cm	30 cm	40 cm
6	5.8	4	4.56	4 cm	5 cm	30 cm	40 cm
7	5.7	4	4.55	4 cm	5 cm	30 cm	40 cm
8	0.2	4	2.73	4 cm	5 cm	15 cm	15 cm

3.3 Bridge Design

3.3.1 Existing Bridge Conditions

The candidate bridges for Urgent Bridge Rehabilitation in the southeast block region are shown in **Figure 3.3**. The existing conditions of these bridges are summarized as:

- Bailey bridges supported by old piers and abutments of collapsed bridges – the integrity and structural capacity of these substructures are questionable,
- Steel I-Girder bridges are supported by timber post/pile bent piers – these piers are in very poor condition whose structural integrity is also questionable,
- Timber decks of I-Girder bridges are badly damaged and deteriorated,
- Steel decks of bailey bridges are deformed and needs proper fixing,
- Steel I-Girders are all corroded, and
- Seven bridges are posted with 15 tons load limit while one bridge is posted with 5 tons load limit – these bridges are not capable of supporting the live loading stipulated in the Cambodian Bridge Design Standard.

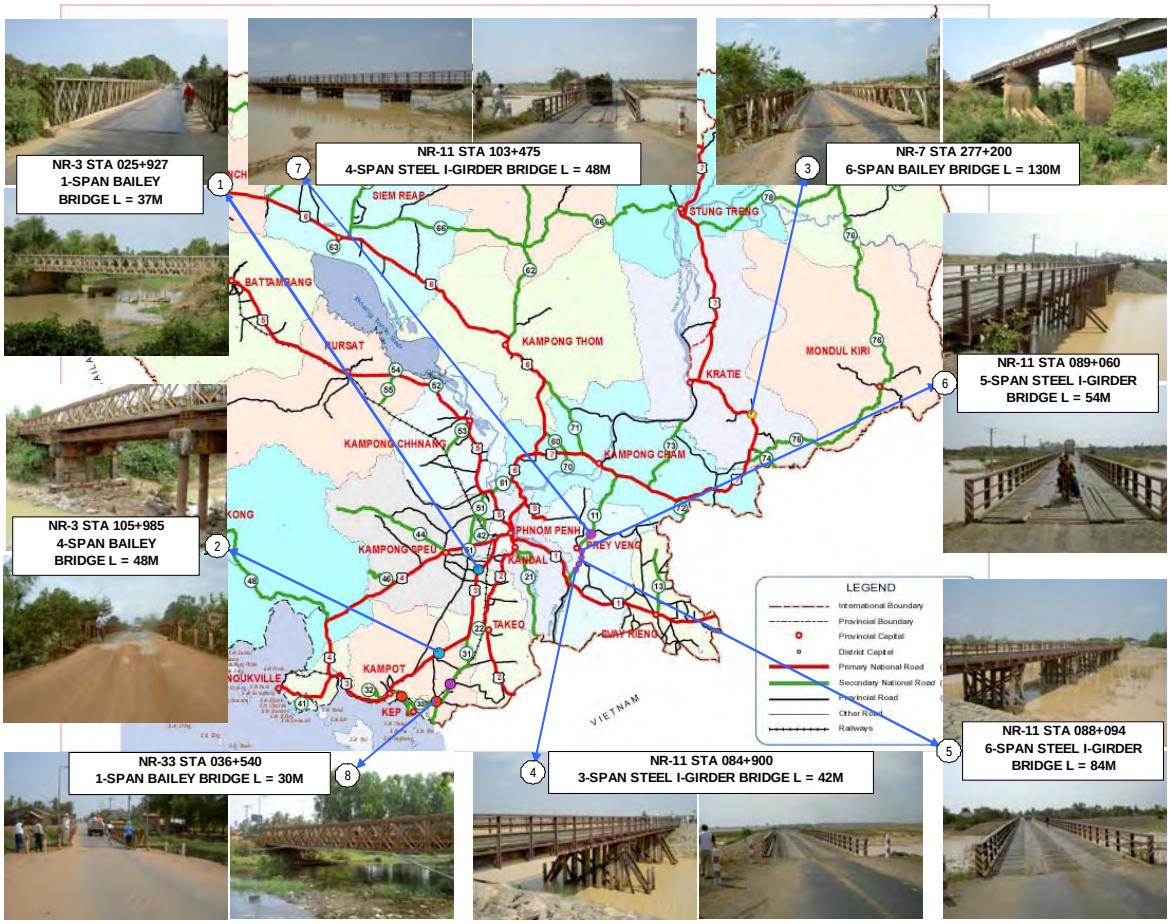


Figure 3.3 Candidate Bridges for Urgent Bridge Rehabilitation

3.3.2 Hydrologic Analysis and River Hydraulic

Basic hydrological analysis was conducted mainly to derive design flood discharge at each bridge's site. The design flood discharge for the eight (8) bridges varies from 62 cu.m./sec (at Bridge No.8) to 1,775 cu.m./sec (at Bridnge No.3). The approaching velocity of flood is also calculated and the waterway opening recommended to determine the bridge length.

3.3.3 Policy on Selection of Bridge Type

In this study, the most appropriate bridge type is selected by evaluating the various factors in bridge planning including economy, durability, vertical alignment, environmental impacts, constructability and maintainability. The choices of structure types are summarized in **Table 3.5.**

Table 3.5 Selection of Bridge Structure Type

Choice of Foundation	Choice of Superstructure	Choice of Material
• Spread Foundation – for foundation on sandstone layer (depth < 5m), • RC Driven Pile – for soft upper soil layers until 20m deep • RC Cast-in-Place Pile – for soft upper layers deeper than 20m	• For bridge spans 12m or less, cast-in-place reinforced concrete slab bridge is preferred since: o it requires less structure depth and advantageous in bridge sites where the existing road vertical profile has less room for adjustment, o this type has the least cost at this span range, and • For bridge spans greater than 12m until 20m, cast-in-place reinforced concrete girder bridge is preferred since this is most cost-effective at this range. • For bridge spans greater than 20m, prestressed concrete I-girder is preferred since: o this is cost competitive at this span range, and o construction period is shorter using precast girders	Concrete is preferred over steel bridges since: • concrete bridges requires minimal maintenance compared to steel bridges, • steel bridges generally cost more than concrete bridges (see **Table 3.3.3**), and • past experience in bridge construction in Cambodia is directed more to concrete bridges.

A comparison of foundation types is presented in **Table 3.6** while comparison between concrete and steel bridge is given in **Table 3.7**.

Table 3.6 Comparison of Foundation Types

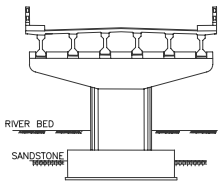
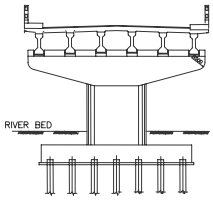
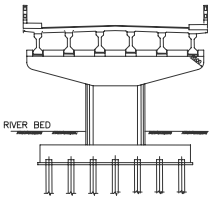
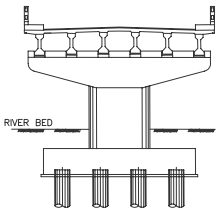
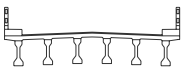
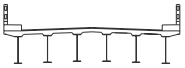
Items	Pier on Spread Footing	Pier on RC Driven Piles	Pier on Steel H-Piles	Pier on RC Cast-in-Place Piles
Section		 RC Driven Piles	 Steel H Driven Piles	
Applicability	• Applicable to bearing layer less than 5m deep • Used for bearing type not susceptible to scour action	• Used for soft upper layer • Applicable to deep bearing layer • Most common type used in Cambodia • Stable to scour action	• Used for soft upper layer • Applicable to deeper bearing layer than RC driven piles • Stable to scour action	• Used for soft upper layer • Applicable to deeper bearing layer than driven piles • Becoming popular type used in Cambodia • Stable to scour action
Constructability	• Easiest construction • Need to embed footing to sandstone layer for stability	• Need crane for handling piles and for pile driving • Difficult to drive on hard intermediate layer • Difficult to handle long piles (>20m) – transportation and driving	• Need crane for handling piles and for pile driving; handling is easier than RC piles • Applicable to hard intermediate layer • Difficult to handle long piles (>20m) – transportation and driving	• Need facilities for drilling and rebar fabrication • Careful quality control required • Applicable for longer pile lengths (>20m) since piles are drilled and cast-in-place
Construction Period	• Shortest construction period	• Construction period is 90% of RC cast-in-place pile period	• Construction period is 90% of RC cast-in-place pile period	• Construction period is longer than other types
Cost	• Cheapest construction cost	• Construction cost is 70% of RC cast-in-place pile cost	• Construction cost is 120% of RC cast-in-place pile cost	• Construction cost is more expensive than other types
Environmental Impact	• Minimal environmental impact; care should be taken during excavation	• Noise and vibration produced during driving • Not recommended on urban areas	• Noise and vibration produced during driving • Not recommended on urban areas	• Requires proper measure for prevention of water pollution and disposal of waste materials
Evaluation	RECOMMENDED FOR SHALLOW HARD BEARING LAYER	RECOMMENDED FOR PILE LENGTHS LESS THAN 20M	NOT RECOMMENDED DUE TO HIGH COST	RECOMMENDED FOR PILE LENGTH GREATER THAN 20M

Table 3.7 Comparison Between Concrete Bridge and Steel Bridge

Superstructure Type	Cost Ratio*			Construction Aspect	Maintenance	Evaluation
	Items	24m	34m			
Prestressed Concrete Girder (PCDG) 	Superstructure Substructure Erection Other works Total	0.49 1.00 2.98 1.06 **0.81**	0.55 0.80 3.95 1.06 **0.85**	• Construction period is similar to steel plate girder • Construction requires heavy lifting if girders are precast • Superstructure can be cast on site by all staging method and post-tensioned; requires only medium-sized crane • Falsework should be planned carefully during rainy season	• Concrete bridge structures require minimum maintenance	• Advantageous in terms of total cost and requires minimal maintenance RECOMMENDED
Steel Plate Girder 	Superstructure Substructure Erection Other works Total	1.00 1.00 1.00 1.00 **1.00**	1.20 0.80 1.00 1.00 **1.08**	• Construction period is similar to PCDG • Construction is easier using medium-sized crane • Deck slab to be cast using suspended falsework • Requires prefabrication of steel girders and transportation to site • Area for storage of steel girders necessary and may affect traffic condition	• Steel girder requires regular inspection and maintenance • Use of atmospheric corrosion resistant steel minimizes steel maintenance but is more expensive	• More expensive than concrete bridge and requires maintenance NOT RECOMMENDED

Note: *Based on "The Project for Rehabilitation of Bridges Along the Main Trunk Roads in Cambodia" (JICA, on-going construction)

3.3.4 Bridge Planning

(1) Existing Bridge Location and River Condition

Bridge Nos. 1, 2, 3 and 8 are crossing rivers while bridges along NR.11 (Nos. 4 to 7) are openings on Mekong river flood plains. River section openings are sufficient at the bridge locations except for Bridge No. 1 which tends to constrict the river. Bailey bridges at Nos. 1, 2 and 3 are replacement of collapsed bridges where the collapsed structures are left in the river constricting flood flow at the bridge location. Span lengths are proposed to be increased to improve flood flow except for bridge No.8 where the span is reduced due to small river discharge.

(2) Bridge Length and Span Lengths

The bridge length is decided based on the existing topography at bridge site, existing bridge lengths and condition, river design flood discharge, maximum flood water level and the condition of the river and banks. On the other hand, the span length is decided based on existing span lengths, river hydraulic and expected debris flow, depth of superstructure to minimize approach road profile adjustment and depth of existing water to minimize construction of piers on river. The proposed bridge lengths and spans are presented in **Table 3.8**.

(3) Deck Elevation

Since the bridges are improvement of existing bridges, it is desired to keep the existing deck elevation as much as possible. However, the minimum freeboard or vertical clearance from the design flood level (DFL) to the bottom of the major structural element (girders or slab) shall be secured as discussed in the design criteria. It is seen that almost all bridge elevations have to be adjusted except for Bridge No.3 at NR.7 which has sufficient clearance from the design flood based on the site topography.

3.3.5 Bridge Design

Table 3.8 presents the proposed bridge type and bridge lengths for the eight bridges while **Figure 3.4** illustrates the basic bridge cross-sections for RC Slab, RCDG and PCDG bridges.

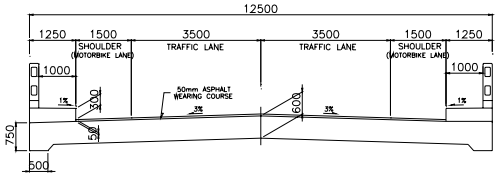
River Protection

In order to protect the bridge foundations and abutments against high flood flow velocities and possible scour, wet masonry protection is provided in front of and around the abutments with gabion box cut-off perimeter at the toes of the wet masonry. Moreover, the top of pier footings and pile caps are located at a minimum depth of 1.0m below the river bed with 0.5m thick gabion mattress provided at the river beds.

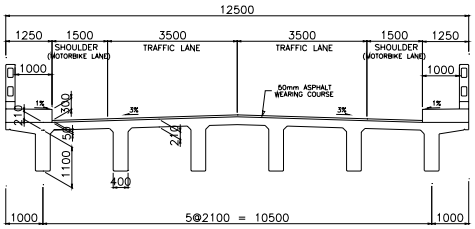
Table 3.8 Proposed Bridges for Urgent Bridge Rehabilitation

Bridge No.	Road No.	Station	Deck Elev. (m)	Total Length (m)	Superstructure			Substructure	
					Type	Spans (m)	Deck Width (m)	Pier	Abutment
1	NR-3	025+900.000	15.40	60.6	PCDG (AASHTO Type IV)	3 @ 20		Column Pier on RC Driven Pile (0.4x0.40m)	Seat Type Cantilever on RC Driven Pile (0.4x0.40m)
2	NR-3	105+958.442	30.00	54.6	RCDG (D=1100)	3 @ 18		Column Pier on RC Driven Pile (0.4x0.40m)	Seat Type Cantilever on RC Driven Pile (0.4x0.40m)
3	NR-7	277+129.970	63.25	140.8	PCDG (AASHTO Type VI)	4 @ 35	Sidewalk : 2@1.00	Column Pier on Spread Footing	Seat Type Cantilever on RC CIP Pile (ϕ1.0m)
4	NR-11	084+878.359	10.14	42.6	PCDG (AASHTO Type IV)	2 @ 21	Shoulder : 2@1.50	Column Pier on RC CIP Piles(ϕ1.0m)	Seat Type Cantilever on RC CIP Pile (ϕ1.0m)
5	NR-11	088+047.591	11.60	92.6	PCDG (AASHTO Type IV)	4 @ 23	Traffic Lane : 2@3.50	Column Pier on RC CIP Piles(ϕ1.0m)	Seat Type Cantilever on RC CIP Pile (ϕ1.0m)
6	NR-11	089+025.372	10.80	69.6	PCDG (AASHTO Type IV)	3 @ 23	Total : 12.00	Column Pier on RC CIP Piles(ϕ1.0m)	Seat Type Cantilever on RC CIP Pile (ϕ1.0m)
7	NR-11	103+448.058	10.84	54.6	PCDG (AASHTO Type IV)	3 @ 18		Column Pier on RC CIP Piles(ϕ1.0m)	Seat Type Cantilever on RC CIP Pile (ϕ1.0m)
8	NR-33	036+524.167	3.60	30.6	RC Slab (D=600)	3 @ 10		Wall Pier on RC Driven Pile (0.4x0.40m)	Seat Type Cantilever on RC Driven Pile (0.4x0.40m)

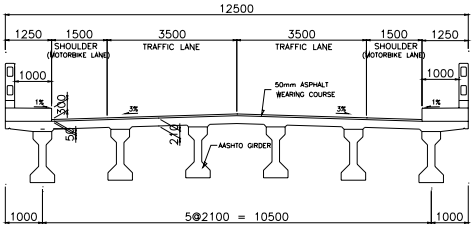
NOTES : 1. PCDG is Prestressed Concrete Deck Girder Bridge
2. RCDG is Reinforced Concrete Deck Girder Bridge
3. RC Slab is Reinforced Concrete Cast-in-Place Slab Bridge
4. RC CIP Pile is Reinforced Concrete Cast-in-Place Pile



a. RC Slab Bridge



b. RCDG Bridge

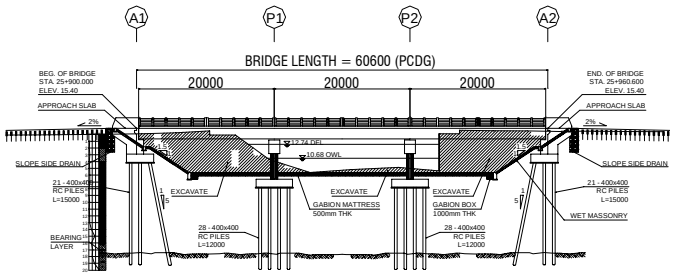


AASHTO GIRDER TYPE	DEPTH (mm)	BRIDGE NO.
IV	1371	1,4,5,6,7
VI	1829	3

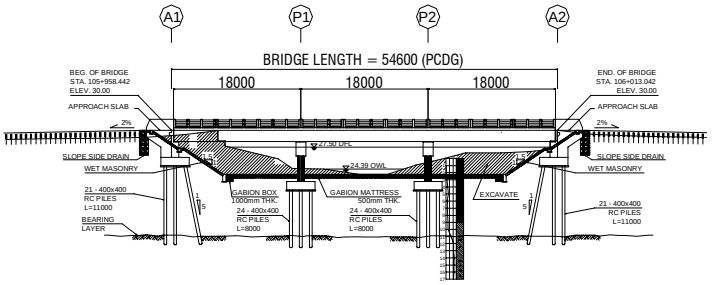
c. PCDG Bridge

Figure 3.4 Basic Bridge Cross-Sections

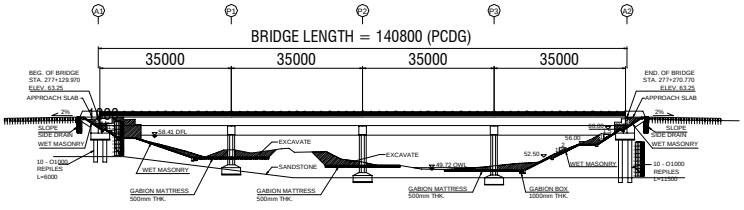
The proposed bridges for Urgent Bridge Rehabilitation are shown in **Figure 3.5**.



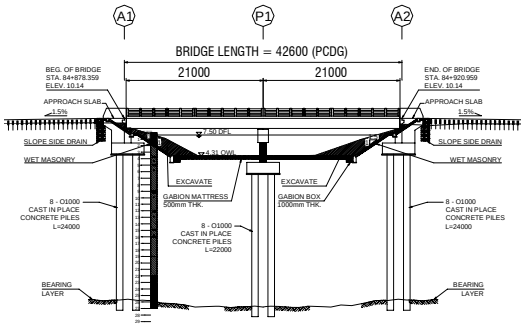
BRIDGE NO.1 PRESTRESSED CONCRETE DECK GIRDER BRIDGE
NR.3 (STA.25+900) BRIDGE LENGTH=60.60m



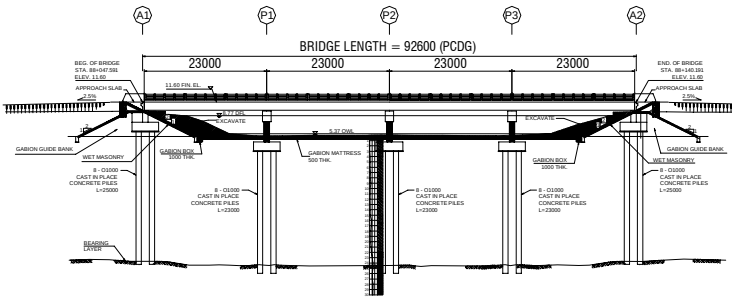
BRIDGE NO.2 REINFORCED CONCRETE DECK GIRDER BRIDGE
NR.3 (STA.105+958.442) BRIDGE LENGTH=54.60m



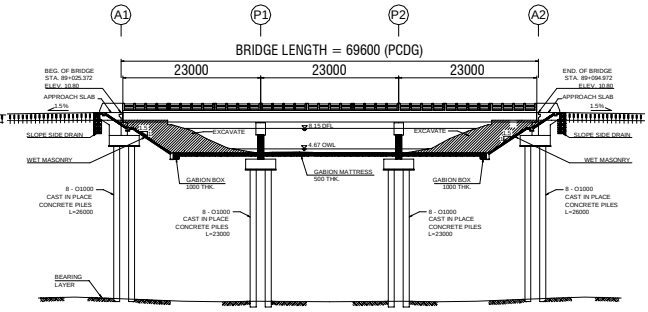
BRIDGE NO.3 PRESTRESSED CONCRETE DECK GIRDER BRIDGE
NR.7 (STA.277+129.970) BRIDGE LENGTH=140.80m



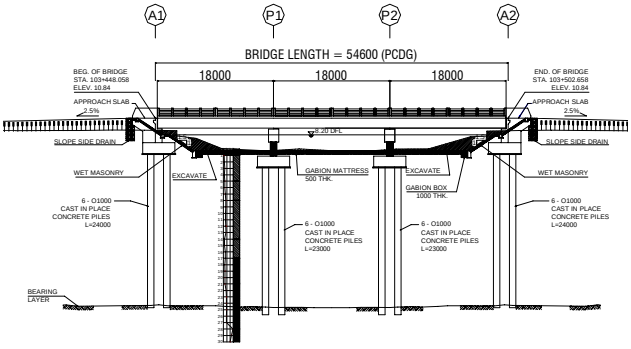
BRIDGE NO.4 PRESTRESSED CONCRETE DECK GIRDER BRIDGE
NR.11 (STA.84+878.359) BRIDGE LENGTH=42.60m



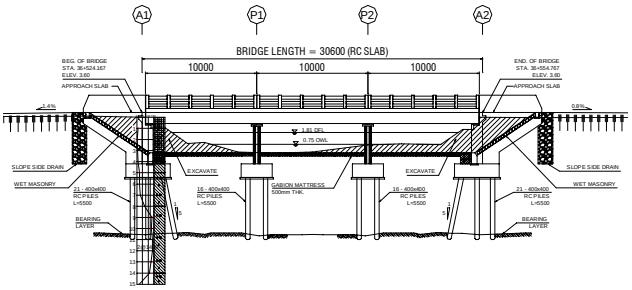
BRIDGE NO.5 PRESTRESSED CONCRETE DECK GIRDER BRIDGE
NR.11 (STA.88+047.591) BRIDGE LENGTH=92.60m



BRIDGE NO.6 PRESTRESSED CONCRETE DECK GIRDER BRIDGE
NR.11 (STA.89+025.372) BRIDGE LENGTH=69.60m



BRIDGE NO.7 PRESTRESSED CONCRETE DECK GIRDER BRIDGE
NR.11 (STA.103.448.058) BRIDGE LENGTH=54.60m



BRIDGE NO.8 REINFORCED CONCRETE SLAB BRIDGE
NR.33 (STA.36+524.167) BRIDGE LENGTH=30.60m

Figure 3.5 Proposed Bridges

CHAPTER B-4 CONSTRUCTION PLAN, COST ESTIMATE AND IMPLEMENTATION PROGRAM

4.1 Construction Plan

4.1.1 Construction Policy

The construction plan has been prepared based on the following policies:

(1) Proper consideration shall be given to local regulations required in Cambodia for construction work to proceed,

(2) The construction method and schedule shall be agreeable with local conditions and local practice.

(3) Local construction equipment and materials shall be utilized as much as possible. When necessary these can be imported from Thailand or other countries, based on the most economical within the range of specified quality.

4.1.2 Considerations on Construction Planning

The following are considered in planning the construction schedule, taking into account the local conditions:

(1) The project has been divided in two stages based upon the accessibility and similarity of major components of the bridge construction works. Stage-1 includes Bridges No.1, No.2, No.3 and No.8. Stage-2 includes Bridges No.4, No.5, No.6 and No.7, which are on National Road No.11 and near to each other.

(2) Commencement of the construction work is scheduled for November, in order to avoid interference by high water levels during the rainy season, which in Cambodia starts in May and ends in October.

(3) To ensure on-going traffic is not disrupted during construction work a detour, adjacent to the existing bridge, is provided for each bridge site.

(4) The project sites are not listed under the landmine and UXOs contaminated area but a survey and clearing of landmine and UXOs needs to be carried out before the commencement of construction work, especially at the planned locations of piers in the flume or river.

4.1.3 Major Project Components

The major project components include eight bridges and 200 m of access roads for each bridge. The list of bridges is given in **Table 4.1**.

Table 4.1 Major Project Components

	Bridge No.	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8
Super Structure	Type of Girder	PCDG	RCDG	PCDG	PCDG	PCDG	PCDG	PCDG	RCS
	No. of Span	3	3	4	2	4	3	3	3
	Span Length (m)	20	18	35	21	23	23	18	10
	Bridge Length (m)	60.6	54.6	140.8	42.6	92.6	69.6	54.6	30.6
	Weight of a Girder (ton)	25.4	–	61.3	24.5	29.2	29.2	22.9	–
Substructure	Foundation	RC Pile	RC Pile	Spread & Bore Piles	Cast in place Concrete	Cast in place Concrete	Cast in place Concrete	Cast in place Concrete	RC Pile
	Pile Size (mm)	400 x 400	400 x 400	ϕ.1,000	ϕ.1,000	ϕ.1,000	ϕ.1,000	ϕ.1,000	400 x 400
	No. of Piles	98	90	20	24	40	32	24	74
	Pipe Length (m)	1302	846	175	560	952	784	564	407

Ref. *RC Pile: Pre-cast Reinforced Concrete Pile*
Spread : Spread Footing
PCDG: Pre-Cast Prestressed Deck Girder
RCDG: Reinforced Concrete Deck Girder
RCS : Reinforced Concrete Slab

4.1.4 Plan for Procurement and Transportation

Local material sources for roads and bridge structures for each bridge site are listed in **Table 4.2**.

Table 4.2 Location of Quarry and Borrow Pits

Road No.	NR.3	NR.7	NR.11	NR.33
Bridge No.	1,2	3	4,5,6,7	8
Pavement structure materials	**Material Sources**			
Sub-Grade	Trank Khang	Borrow Pit along NR.7	Peam Ro	Borrow Pit along NR.3/33
Base Course	Trank Khang	Dambae	Ba Ohnum / Ou Ream Ov	Kampot
Bitumen	Phnom Penh	Phnom Penh	Phnom Penh	Phnom Penh
Embankment material	Borrow Pit along NR.3	Borrow Pit along NR.7	Borrow Pit along NR.1/11	Borrow Pit along NR.3/33

Judging from the construction volume of bitumen and distances to the sites, it is not economical to put in a plant for bitumen. With proper transportation arrangements and care it is considered that bituminous material can be transported from Phnom Penh.

In Stage-1, a concrete mixing plant should be installed at the site of Bridge No.2, which is located between Bridge No.1 and No.8 so it can also be used to supply ready mixed concrete to these bridge sites as well. The Bridge No.3 site will need a separate one. For Stage-2, it is considered that, due to their close proximity, one concrete mixing plant be installed for all bridge construction sites.

Due to the low quantity of demand and accessibility bituminous material can be supplied from Phnom Penh for all the bridges.

.

4.2 Preliminary Cost Estimate

4.2.1 Construction Cost

Construction Cost

The construction cost consists of direct and indirect costs, and temporary and permanent facilities. The costs of direct and permanent facilities are estimated by using the unit prices, whereas indirect costs and temporary works are estimated on the basis of percentages obtained from past projects in Cambodia.

(1) Conditions of Cost Estimation

For the purpose of cost estimates, the costs of temporary and indirect works have been estimated based on similar projects in Cambodia and are given in **Table 4.3**.

Table 4.3 Share of Temporary and Indirect Works

Construction Works		
Direct Cost	A	(a+b)
Direct Construction Work	a	
Site Temporary Work	b	a*15%
Temporary Works in Common	B	a*12%
Site Management	C	a*24%
General Management	D	(A+B*C)*8%
Detailed Design and Supervision		
Detailed Design and Construction Supervision		10%

(2) Cost Estimation

The quantities and cost estimation have been carried out based mainly upon the drawings and the conditions mentioned above. The summary of construction costs, which is to be born by the external resources, is as follows:

Construction Costs	**(x 1,000 US$)**
No.1	1,195.4
No.2	1,031.3
No.3	2,693.3
No.4	898.2
No.5	1,836.7
No.6	1,355.3
No.7	1,112,5
No.8	587.2
Total of Civil Works	**10,709.9**
Detailed Engineering & Construction Supervision	**1,071.0**
Total Construction Cost	**11,780.9**

1) Staged cost of the external resources

Components	Preliminary Cost Estimate（x 1,000 US$）	
	Stage-1 (4 Bridges)	Stage-2 (4 Bridges)
Bridge Construction	5,507.30	5,202.60
Detailed Design, Construction Supervision	550.70	520.30
Sub-Total	6,058.00	5,723.90
Total	**11,780.90**	

2) The following are the costs to be born by the Government of Cambodia:

Items	Cost (in x 1,000 US$)
Land Acquisition	Nil
Compensation to the Residents	US$ 15.0
Relocation of Public Utilities	US$ 16.6
Gross Total	**US$ 31.6**

(3) Total Project Cost

Based on the above estimation, the total project cost is estimated at US$. 11,812,500.

(Unit : x 1,000 US$)

Items	External Resources	Cambodia Government
Construction Cost	10,709.9	
Detailed Design & Construction Supervision	1,071.0	
Compensation to the Residents		15.0
Relocation of Public Utilities		16.6
Total	11,780.9	31.6
Gross Total	**11,812.5**	

4.2.2 Conditions

Cost estimation has been made on the conditions mentioned below:

1 Time of Cost Estimation: June 2006

2 Exchange Rate:

1.0 US Dollar = 4,113.5 Riels

3 Construction Period:

The project consists of two stages as mentioned in the implementation schedule.

4 Others:

The project is to be implemented with finance from external resources based on international bidding.

4.3 Maintenance Plan

4.3.1 Bridge Maintenance System

The necessity of bridge preventive maintenance to keep these bridges in an "as-built" condition and/or protect it from inevitable deterioration due to the influence of traffic, environment and natural forces is discussed in this section.

(1) Concept of Preventive Bridge Maintenance

Preventive maintenance of bridge facilities as opposed to reactive maintenance is necessary in order to:

- Keep the basic function of a roadway to provide a safe and efficient transportation system on a day-to-day basis,
- Keep the bridge in its current as-built condition and protect it from further deterioration due to its environment, traffic vibrations and other forces, and
- Preserve the intended structural carrying capacity of the bridge and safeguard the safety of the public using it.

The concept of preventive maintenance for bridges is concisely illustrated in **Figure 4.1**.

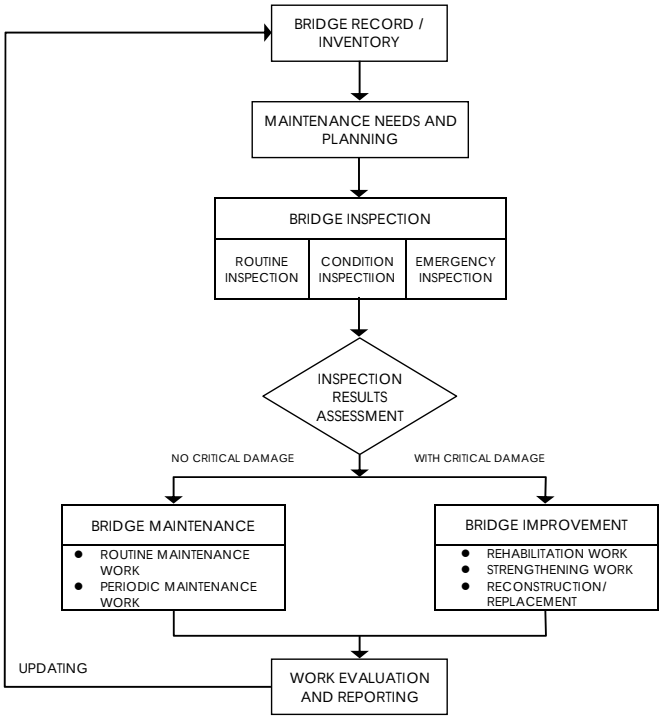


Figure 4.1 Bridge Maintenance Concept

The maintenance system starts with the bridge historical record and inventory followed by proper bridge inspection. The basic inspections include routine inspection (for routine maintenance), condition inspection (to determine periodic maintenance need or improvement work intervention) and emergency inspection (following accidents or natural catastrophes).

If the inspection results indicate no critical damage in the bridge, ordinary maintenance work is done (such as routine and periodic maintenance). However, when critical damage is found in the bridge a more detailed inspection follows which will determine the necessary bridge improvement work to be done. Updating of the bridge historical record should be done after every inspection and maintenance work.

(2) Routine Maintenance Works

Routine maintenance works for bridges are small scale activities normally performed as a regular preventive maintenance activity on a monthly, quarterly or annual basis. The objectives of routine maintenance shall be:

- To maintain the bridge in its current state or operating condition, and
- To prevent early deterioration of bridge members/elements by keeping it safe and clean.

Typical routine maintenance activities includes cleaning (bridge decks, scuppers, drain pipes, expansion joints, etc.), sealing minor cracks and asphalt wearing course, repair/sealing expansion joints, and minor repairs. Planning for these activities is either done as a part of a regular maintenance routine or as a result of a routine/maintenance inspection.

(3) Periodic Maintenance Works

Periodic maintenance works for bridges are maintenance activities performed after a certain number of years requiring additional resources for implementation to restore the condition of some bridge elements due to wear and deterioration. The scope of the work is normally larger than routine maintenance. The objectives of periodic maintenance are:

- To maintain the original function of the bridge and its elements, and
- To prevent further deterioration of bridge members/elements.

Typical periodic maintenance activities include replacement of wearing course and expansion joints, repair and sealing of structural cracks, replacement of bridge drainage facilities, repair of slope and pier protection and other works short of bridge rehabilitation. Planning for these activities is done as a result of periodic inspection.

(4) Major Bridge Improvement Works

Repair works, as part of the routine and periodic maintenance activities, will refer to remedial work activities to restore the bridge elements to their original condition. The "scope" and "cost" is much smaller than for rehabilitation. Major improvement works on bridges include:

1) Rehabilitation

Rehabilitation is repair work of significant nature that consists of restoring the bridge to the service level it once had and has now lost. Rehabilitation is intended to extend the service life of an existing bridge and may include deck repair or replacement, procedures for correcting settlement problems, strengthening or replacing critical members, replacing bridge bearings, bridge widening, and correcting bridge deck alignments.

2) Strengthening

Strengthening aims to increase the load-carrying capacity of an existing structure by providing the structure with a service level higher than the structure originally had or was initially planned for

structure. Such improvement may include geometric changes to the bridge, such as widening or raising the deck to improve its road traffic capacity and navigational capacity.

3) Reconstruction

Reconstruction of the whole bridge is resorted to when the cost and extent of rehabilitation and strengthening is beyond the acceptable economic or technical limit.

(5) Maintenance Plan for Urgent Bridge Rehabilitation

The maintenance plan and responsibilities for "Urgent Bridge Rehabilitation" bridges follows the system shown in **Figure 4.2**.

- The bridge construction record shall be the baseline of maintenance planning. The MPWT is responsible for maintaining bridge inventory and records while the DPWT inputs data update.
- Ordinary routine maintenance works shall be carried-out by the DPWT for these bridges on a regular basis, depending on the available resources.
- Regular inspection shall be carried-out by the MPWT with assistance from the DPWT to assess the bridge condition and determine additional maintenance requirements. Decisions for maintenance or improvement works shall be made after inspection results are assessed. Periodic maintenance and improvement works shall be the responsibility of the MPWT.
- All maintenance and inspections done for the bridge shall be recorded and kept in each bridge's file or folder and maintained by the MPWT.

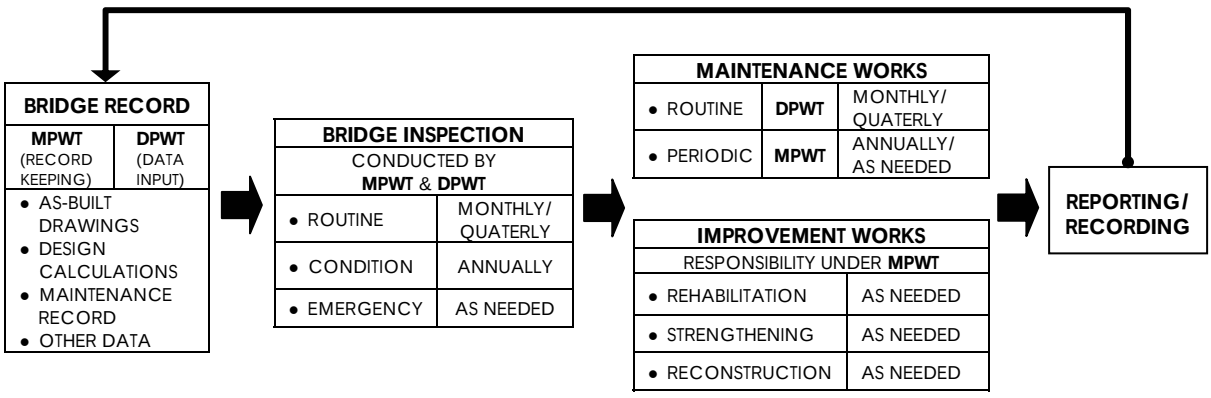


Figure 4.2 Urgent Bridge Maintenance Plan

4.4 Implementation Plan

4.4.1 Project Components

The Urgent Bridge Rehabilitation involves the bridges given in **Table 4.4**, which are to be replaced on the same horizontal alignment and raised vertically to secure adequate free board:

Table 4.4 Urgent Bridges

Bridge. No.	Road No.	PK	Bridge Type	Length (m)
No.1	NR.3	25+927	PCDG	60.6
No.2	NR.3	105+985	RCDG	54.6
No.3	NR.7	277+200	PCDG	140.8
No.4	NR.11	84+900	PCDG	42.6
No.5	NR.11	88+094	PCDG	92.6
No.6	NR.11	89+060	PCDG	69.6
No.7	NR.11	103+475	PCDG	54.6
No.8	No.33	36+540	RCS	30.6

4.4.2 Implementation Schedule

The following schedule has been prepared on the assumption that the consultant will carry out the detailed design, preparation of the tender document and evaluation, and also the construction supervision.

(1) Detailed Design

The overall detailed design shall be carried out at the beginning of Stage-1, including the Stage-2 detailed design. The period required for the detailed design is estimated to be 6 months, including the preparation of tender documents.

(2) Tendering

- Preparation of tender documents
- The following process will be undertaken at the start of Stage-2.
- Public announcement
- Pre-Qualification of bidders
- Tendering
- Tender evaluation
- Promotion of contract establishment

(3) Construction Supervising

- Collation and approval of survey data and construction planning
- Quality control
- Schedule control
- Progress quantity check
- Safety management
- Handover

Required period for construction is estimated at 17 months for each stage.

(4) Construction Equipment

All construction equipment that is not already available will have to be imported, as there is no local leasing company. For some equipment such as backhoe, bulldozer and tire roller, large size crane, reverse circulation drill and vibration-hammer, it is believed that there is enough in Cambodia at present to cope with the demand. It has been observed that there are two sets of reverse circulation drilling machines and ancillary equipment being used in on-going bridge projects, but if required, equipment can be arranged from other countries.

(5) Implementation Schedule

The target bridges are scattered; two on NR.3, one on NR.33, four on NR.11 one on NR.7 and only four bridges on NR.11 are grouped. Under such conditions, the project has been divided into two stages, based upon accessibility and importance, similarity of work components etc. Stage-1 includes Bridge No.1, No.2 and No.3 on 1-Digit roads, and Bridge No.8 which should be included in with nearby NR.2, though it is located on a 2-Digit road. Stage-2 comprises Bridge No.4, No.5, No.6 and No.7 located nearby each other. The types of foundation and girder are also the same for these bridges as the soil and topographical conditions are similar.

The commencement of the project is planned for November, just after the rainy season is over, with the idea that foundation work be completed as much as possible during the dry season in order to avoid interference by high water and poor accessibility.

The Project Implementation Schedule is given in **Figure 4.3**.

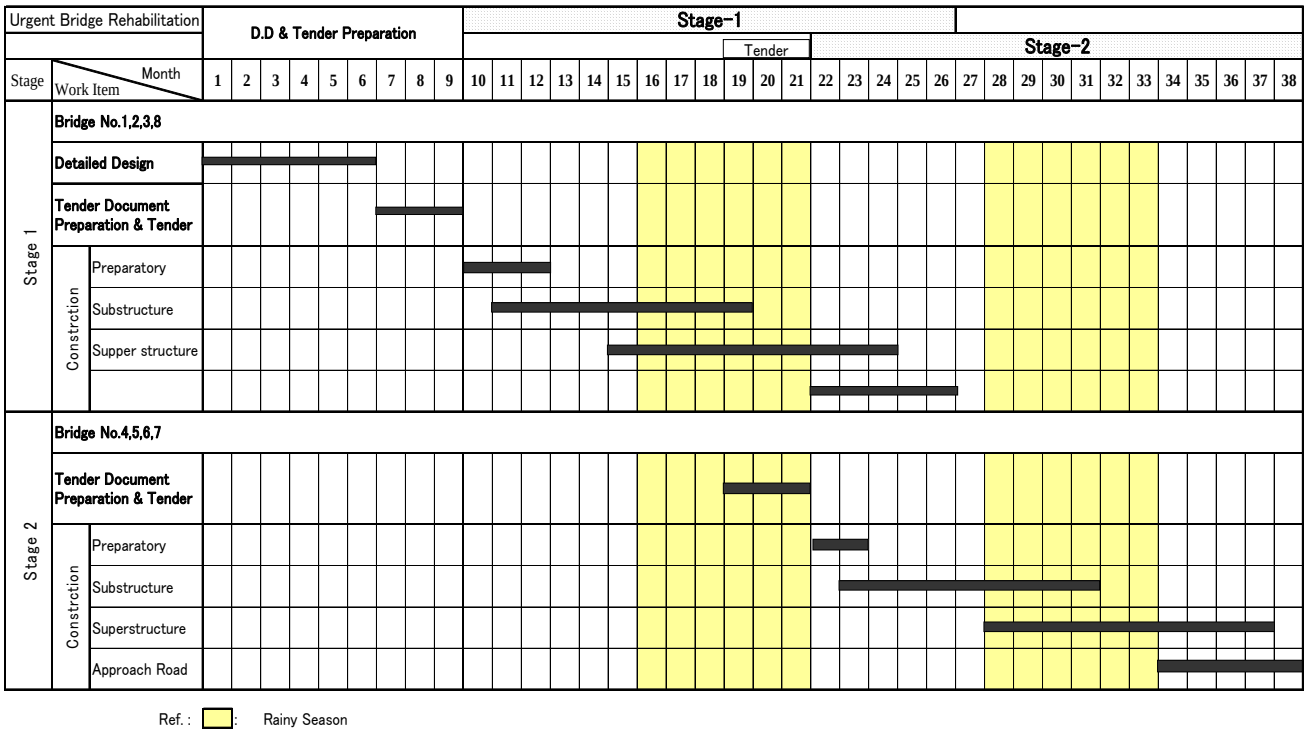


Figure 4.3 Implementation Schedule

CHAPTER B-5 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

5.1 Introduction

5.1.1 Background

This chapter has been prepared to provide reference material for the IEIA for the urgent bridge rehabilitation program, which should be finalized and submitted to MOE for the approval of the project once the government has decided to proceed with the project. Because the project implementation has not yet been decided; and there is a constraint that an interview survey for the residents could not be conducted due to the insufficient capabilities of the government officers in law enforcement for land management especially in ROW. This IEIA follows the laws and regulations in Cambodia as well as the "Guidelines for Environmental and Social Considerations, April 2004, JICA".

5.1.2 Objectives

The objectives of this chapter are to:

- Prepare the draft IEIA as a basis for the final IEIA that is required for the submission;
- Prepare the basic data to enable decision making in relation to the project implementation;
- Predict social and environmental impacts that may be caused by the project; and
- Consider the necessary improvement measures and an environmental management plan.

This program for urgent bridge rehabilitation is composed of 8 bridges, which are temporary bridges with structurally poor conditions, and to be constructed. The section length of each bridges are 100 m for both access roads (200m in total) plus bridge section length. The components of the projects are substructure, superstructure, foundation works, and construction of access road with earthworks including AC pavement.

5.2 Social and Environmental Impact

5.2.1 General

The project impacts can be divided into two (2) types. The first impacts are those occurring during the project implementation, including the design and construction period, and the second impacts are those occurring after the project has been completed. The impacts during the project implementation are mainly caused by land acquisitions and construction works, such as earthworks, construction machines and equipment. The impact after the completion is mainly caused by air pollution, noise and vibration with increased traffic volume, and safety with over speed vehicles.

5.2.2 Scoping

The following table is a checklist for scoping based on the JICA guideline.

Table 5.3 Checklist for Scoping

No	Impacts	Bridge No.								Total	Description
		1	2	3	4	5	6	7	8		
Social Environment: *Regarding the impacts on "Gender" and "Children's Right", might be related to all criteria of Social Environment.											
1	Involuntary Resettlement	B	B	B	no	B	no	B	B	B	Several involuntary resettlements will be caused by land acquisition.
	Affected Property in ROW	25	5	1	0	15	0	2	23	71	
	Affected Property in PRW	6	1	1	0	14	0	2	5	29	
	Affected Property to be compensated in PRW	3	1	0	0	6	0	0	4	14	
2	Local economy such as employment and livelihood, etc.	B	B	no	no	no	no	B	B	B	Several shops/restaurants will be relocated caused by land acquisition.
3	Land use and utilization of local resources	no	no	no	no	no	no	B	no	B	Some part of cultivate land in PRW will be affected by land acquisition.
4	Social institutions such as social infrastructure and local decision-making institutions	no	no	no	no	no	no	no	no	no	
5	Existing social infrastructures and services	B	B	no	no	no	no	B	no	B	There are some pagodas.
6	The poor, indigenous and ethnic people	C	C	C	C	C	C	C	C	C	Social survey must be conducted before the finalization of IEIA.
7	Misdistribution of benefit and damage	no	no	no	no	no	no	no	no	no	
8	Cultural heritage	B	B	no	no	no	no	B	no	B	There are some pagodas.
9	Local conflict of interests	C	C	C	C	C	C	C	C	C	Social survey must be conducted before the finalization of IEIA.
10	Water Usage or Water Rights and Rights of Common	B	B	B	B	B	B	B	B	B	Usage of river water might be affected during construction period.
11	Sanitation	no	no	no	no	no	no	no	no	no	
12	Hazards (Risk) Infectious diseases such as HIV/AIDS	B	B	B	B	B	B	B	B	B	Infection diseases might be increased by construction workers during construction period.
Natural Environment											
13	Topography and Geographical features	no	no	no	no	no	no	no	no	no	
14	Soil Erosion	no	no	no	no	no	no	no	no	no	
15	Groundwater	no	no	no	no	no	no	no	no	no	
16	Hydrological Situation	B	B	B	B	B	B	B	B	B	Difficulty of water flow of river during construction period
17	Coastal Zone	no	no	no	no	no	no	no	no	no	
18	Flora, Fauna and Biodiversity	B	B	B	B	B	B	B	B	B	Wildlife, birds, fish and other aquatic animal might be disturbed during construction period.
19	Meteorology	no	no	no	no	no	no	no	no	no	
20	Landscape	no	no	no	no	no	no	no	no	no	
21	Global Warming	no	no	no	no	no	no	no	no	no	

Table 5.3 Checklist for Scoping

No	Impacts	Bridge No.								Total	Description
		1	2	3	4	5	6	7	8		
Pollution											
22	Air Pollution	B	B	B	B	B	B	B	B	B	- Dust during construction period - Air pollution after construction with increase of future traffic volume
23	Water Pollution	B	B	B	B	B	B	B	B	B	Risk of water pollution during construction
24	Soil Contamination	no	no	no	no	no	no	no	no	no	
25	Waste	B	B	B	B	B	B	B	B	B	- Construction and demolition waste of existing bridge - Wastes from construction yard
26	Noise and Vibration	B	B	B	B	B	B	B	B	B	- Noise and vibration during construction period - Noise and vibration after construction with increase of future traffic volume
27	Ground Subsidence	no	no	no	no	no	no	no	no	no	
28	Offensive Odor	no	no	no	no	no	no	no	no	no	
29	Bottom sediment	B	B	B	B	B	B	B	B	B	Benthos might be disturbed during construction period.
30	Accidents	B	B	B	B	B	B	B	B	B	- Traffic accidents might occur by over speed vehicles after construction. - Traffic accidents during the construction period might occur due to the detour road.
31	Others	B	B	B	B	B	B	B	B	B	- UXOs - Landmines

Rating:
A: Serious impact is expected.
B: Some impact is expected.
C: Extent of impact is unknown (Examination is needed. Impacts may become clear as study progresses.)
No Mark: No impact is expected. IEE/EIA is not necessary.

The above items are categorized as B, C and no mark in terms of the total program for all of the eight (8) bridges. As a result, the overall program is considered to be category B in accordance with the JICA guidelines. Therefore, the program does not require a full scale environmental impact assessment (EIA).

5.2.3 Social Impact

Based on the above table, the details of the situation and impacts are described in the following sections.

(1) Involuntary Resettlement

ROW

The ROW area for NR.3, 7, 11 and 33 is stipulated as being 25 m from the centerline. Several properties were confirmed to be located within the ROW area for six (6) of the bridges, excluding Bridge No. 4 and 6.

PRW

The Provisional Road Width (PRW) has been set at 2 m from the edge of the embankment to provide adequate construction space and safety. This 2 m width is necessary for the construction activities such as construction machines and trucks.

Therefore, the properties located within the PRW will need to be removed for the construction works to be undertaken. In total 29 properties were confirmed to be located within the PRW at six (6) bridge sites, excluding Bridge No. 4 and 6.

Compensation

Basically, the affected property owners will be paid compensation. However, if the property, such as a cottage, can be easily moved, compensation will not be paid. As a result, compensation will be required for a total of 14 properties at four (4) bridge sites. These are located at Bridge No. 1, 2, 5 and 8.

PAPs

The number of Project Affected Persons (PAPs) for this program is not clear at the moment because a household survey has not yet been conducted.

Table 5.3.5 Affected Properties

Bridge No.	(a) Affected Property in ROW	(b) Affected Property in PRW	(c) Affected Property to be compensated in PRW
1	25	6	3
2	5	1	1
3	1	1	0
4	0	0	0
5	15	14	6
6	0	0	0
7	2	2	0
8	23	5	4
Total	71	29	14

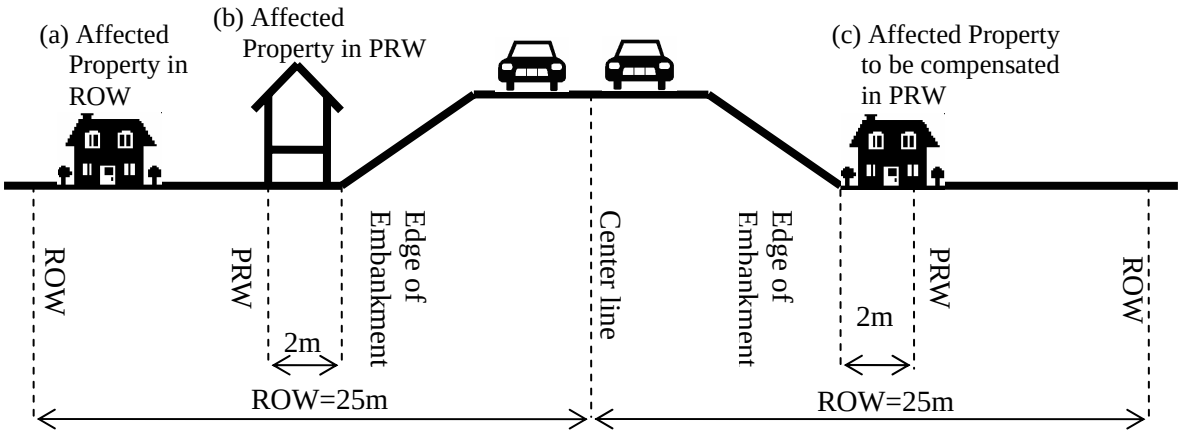


Figure 5.3.1 Affected Property

Involuntary resettlements are one of the most serious problems caused by the project. Even though a large number of resettlements will not occur, the necessary actions relating to the resettlements need to be undertaken in an effective and careful manner.

The necessary actions relating to the resettlements need to be considered and formulated in a Resettlement Action Plan (RAP), which will include the number of PAPs, compensation, a detailed measurement survey (DMS), support for compensation, resettlement and livelihood recovery, grievance procedures, relocation sites if required and monitoring.

(2) Local Economy, Land Use and Local Resources

Some shops/restaurants and some areas of cultivated land will be affected by the project. The necessary compensation should be paid for these properties.

(3) Social Infrastructure and Cultural Heritage

There are pagodas within the areas of Bridge No. 1, 2 and 7. The gates of the pagodas in the areas of Bridge No. 1 and 7 are within the PRW and will be affected by the construction works. The wall of the pagoda in the area of Bridge No. 2 is in the PRW and will be affected as well. However, it will be possible to mitigate the affects by constructing a retaining wall. It will be necessary to discuss the necessary measures with the monks and community people before implementation.

Consultation with monks and village people will be necessary before construction. The construction works required to avoid these gates and the wall could be considerable, such as the construction of a retaining wall.

(4) Water Usage

Water usage of the rivers for daily life, such as laundry and bathing, might be affected by the construction works. The construction method adopted should minimize changes to the water flow and usage. The substructure and foundation works for the bridges should be constructed during the dry season.

(5) Infectious Diseases

The number of cases of infectious diseases, such as HIV/AIDS, might increase in the construction workers during the construction period. Many construction workers will travel to the project sites from outside of the project areas.

Educational training on HIV/AIDS and other infectious diseases should be conducted for the construction workers. For this purpose, the NGOs who are involved in these activities should be considered for conducting the training.

5.2.4 Natural Impacts

(1) Hydrological Situation

The hydrological conditions may be affected during the construction of the substructure and foundation works. The hydrological situation itself will be unchanged after construction as riverbed protection works will be carried out and the new bridges will be longer than the existing temporary bridges. Basically, the substructure and foundation works should be constructed during the dry season, and construction methods which may significantly affect the river flows should be avoided.

(2) Flora, Fauna and Biodiversity

Wildlife, birds, fish and other aquatic animals might be disturbed during the construction of the substructure and foundation works. Basically, the substructure and foundation works should be constructed during the dry season, and treatments for polluted water, to minimize the affects on the river, should be undertaken during the construction period.

(3) Air Pollution

Dust will be caused during the construction period due to the earthworks and detour roads. Periodic sprinkling and covering the detour roads with gravel will be necessary, especially in the areas of Bridge No. 1, 2, 5 and 8, where there are many houses. Air pollution may occur after the construction period due to the increase in the future traffic volumes. This is, however, considered to be an indirect impact as the reconstruction of the existing bridges does not contribute directly to the increase in traffic volumes. The bridge widening may contribute towards smoothing the traffic flows as vehicles will not need to stop and wait for the vehicles traveling from the opposite direction to pass. This smoothing of traffic flows may contribute towards a decrease in emissions.

(4) Water Pollution

Water pollution might occur during the construction period if waste water is discharged to the river directly during the mixing and laying of concrete. The construction waste water should be treated before it is discharged. Therefore monitoring of water quality is necessary, including a baseline survey before construction. The necessary measures will need to be undertaken when the results of the monitoring exceed the standard level.

(5) Waste

There will be several types of waste as a result of the construction works: general construction waste, such as surplus soil; existing pavements and concrete; and waste produced by the construction workers. The MPWT, which maintain the bridges, should collect the superstructure of the existing bridges as they are recyclable. The general construction waste and waste from the construction workers should be disposed of to the designated sites.

(6) Noise and Vibrations

During the construction period noise and vibrations will occur mainly as a result of the machines and earthworks. They may also occur due to the increased traffic volumes after the completion of the construction works. There are many houses around Bridge No.'s 1, 2, 5 and 8. For these areas, special considerations are required. During construction, low-noise construction equipment and low-vibration machines should be used. After the completion of construction, the vibration levels may vary due to the future traffic volumes, however, these will not be directly caused by the project. The noise levels after completion of the project will be reduced from the current level of noise that is caused by the steal deck plates.

Monitoring during the construction period is necessary, including a baseline survey before construction. The necessary mitigation measures should be undertaken when the results of the monitoring exceed the standard level.

(7) Bottom Sediment

A part of bottom sediment will be changed by the construction works due to the riverbed protection works. The ecological system, however, will not be affected (even though benthos might be disturbed during the construction period) because the affected area is only the area of the riverbed protection works and this is only a small area.

(8) Accidents

The number of traffic accidents might increase during and after the construction works. Therefore, during the construction period, traffic safety measures should be undertaken such as using flag men and traffic sign boards. After the completion of the construction works, traffic safety sign boards and directional arrows will be necessary, to avoid traffic accidents occurring due to speeding vehicles and increased traffic volumes.

(9) Other Issues

There may be UXOs and landmines around the construction areas. To avoid accidents occurring due to the UXOs and landmines, these should be cleared in cooperation with the Cambodian Mine Action Centre (CMAC).

5.3 Environmental Management Plan

An Environmental Management Plan (EMP) is required for the monitoring before, during and after the construction works and the necessary measures. The items that must be included in the EMP, which the contractor will need to implement, should be included in the tender documents. A baseline survey will be necessary during the basic design (B/D) stage to allow for comparisons against the situation before construction. The items that need to be monitored include air pollution, water pollution, noise, vibrations, accidents and the resettlement process, which includes the negotiation process and assessing livelihood recovery after the resettlement.

5.4 Necessary Actions to be taken

When the government approves the project, the following actions should be promptly undertaken.

5.4.1 Public Consultation

Public consultation should be conducted with the people around the project sites for the purpose of disclosing the project information so that they can understand both the positive and negative impacts of the project.

Public consultation is required to explain the procedure of the project, the legal framework and grievance mechanisms as most of the people will not know the aspects relating to land acquisition and resettlement.

Public consultation should be conducted several times as necessary, such as before the public awareness survey and the DMS.

5.4.2 Public Awareness Survey

A public awareness survey is necessary for the people around the project sites for the purpose of confirming their basic agreement to the project. If many people oppose the project, the project should be reconsidered. In addition to their basic agreement to the project, their needs and social situations should be clarified through the survey. The survey should be conducted at the same date as the cut-off date.

5.4.3 Cut-off Date

The cut-off date must be declared when the project implementation is decided so as to protect the ROW against illegal squatters aiming to get compensation.

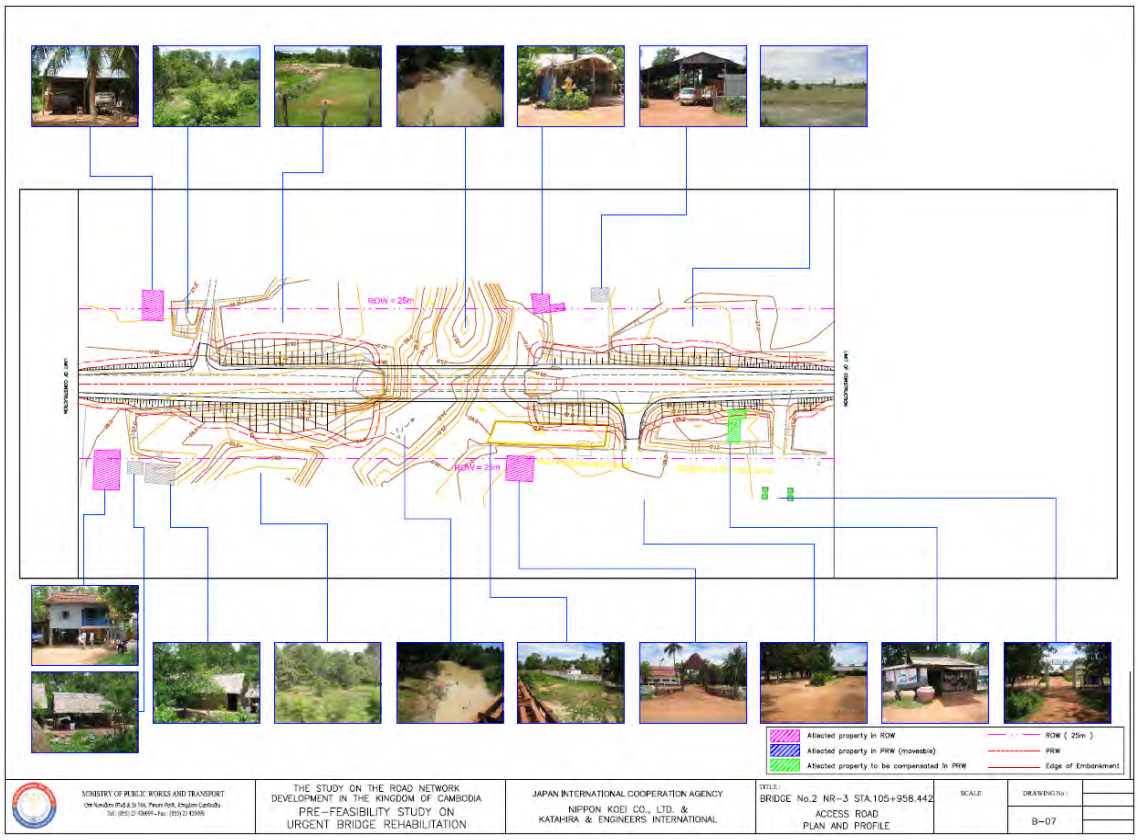
5.4.4 Formulation of the Resettlement Action Plan (RAP)

The formulation of a Resettlement Action Plan (RAP) is crucial after the project implementation date has been decided. The purpose of the RAP is to protect the livelihood of the PAPs and to maintain the same standard of living as before the project. In this sense, the necessary measures should be planned in the RAP and the monitoring plan (for after the resettlement) should be formulated in RAP.

5.4.5 Finalization and Submission of IEIA

The MPWT, as the project owner, has to finalize the IEIA and submit it to MOE for the project approval. The necessary additional surveys, such as the household survey (forming part of the public awareness survey), should be conducted in an effective and prompt manner.

The properties within the ROW for every construction site are shown in the figures starting from the next page.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ROW (25m)
PRW
Edge of Embankment
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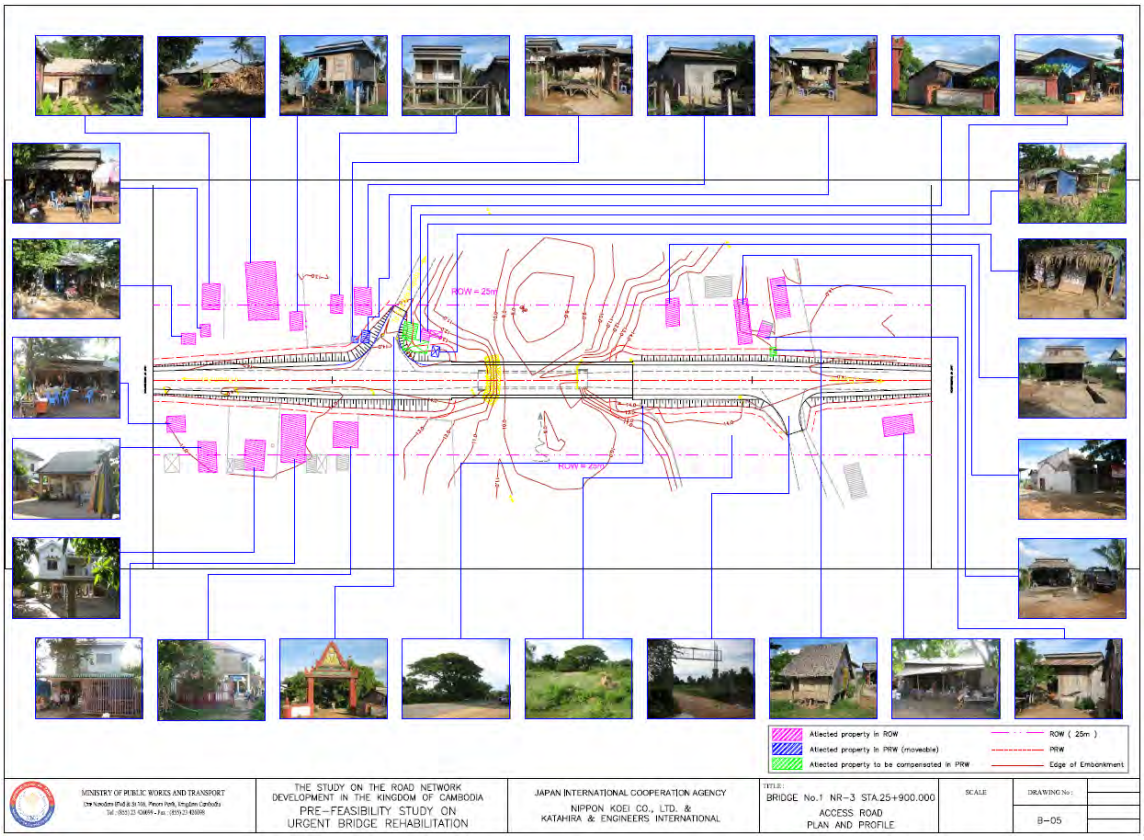
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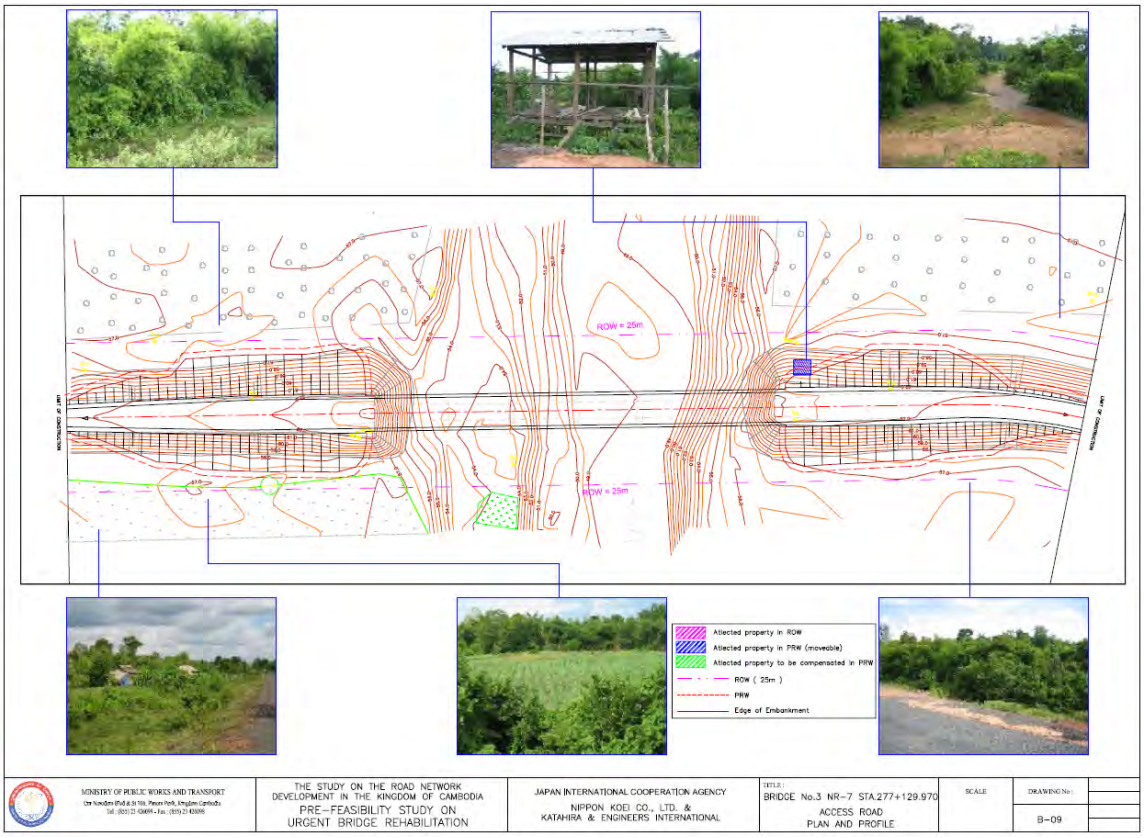
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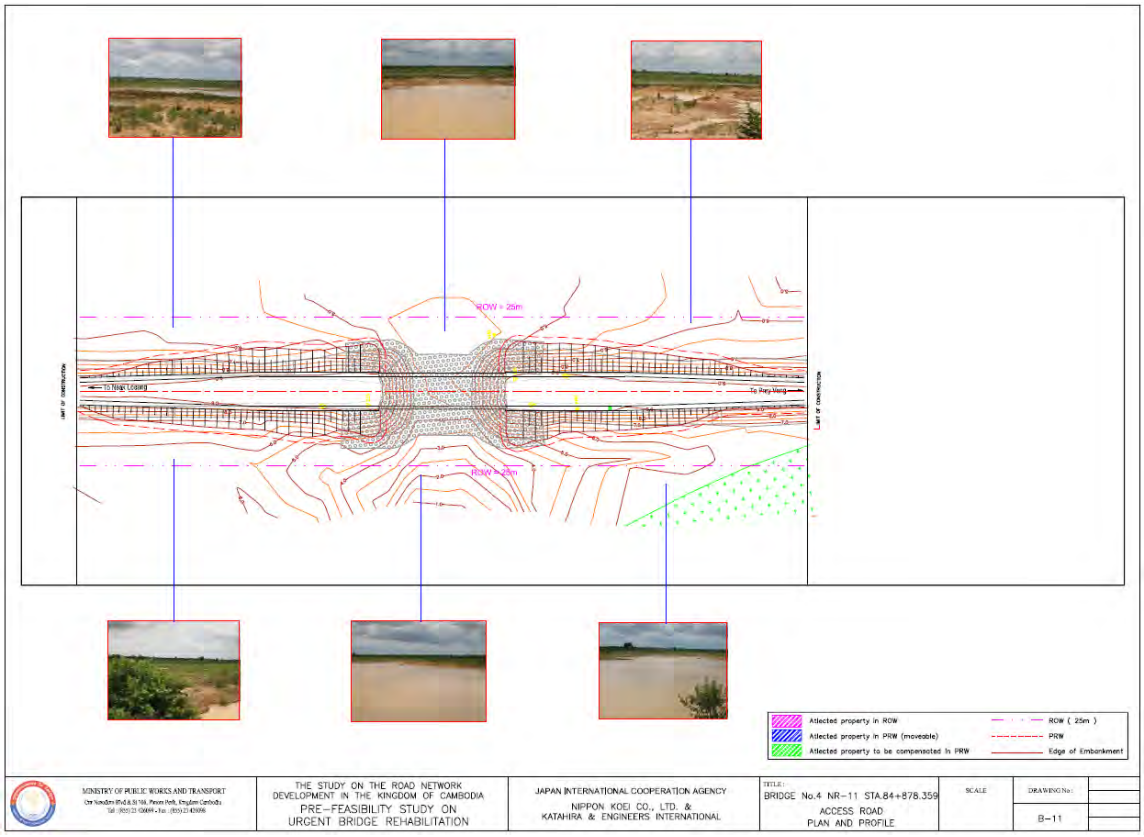
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PRW
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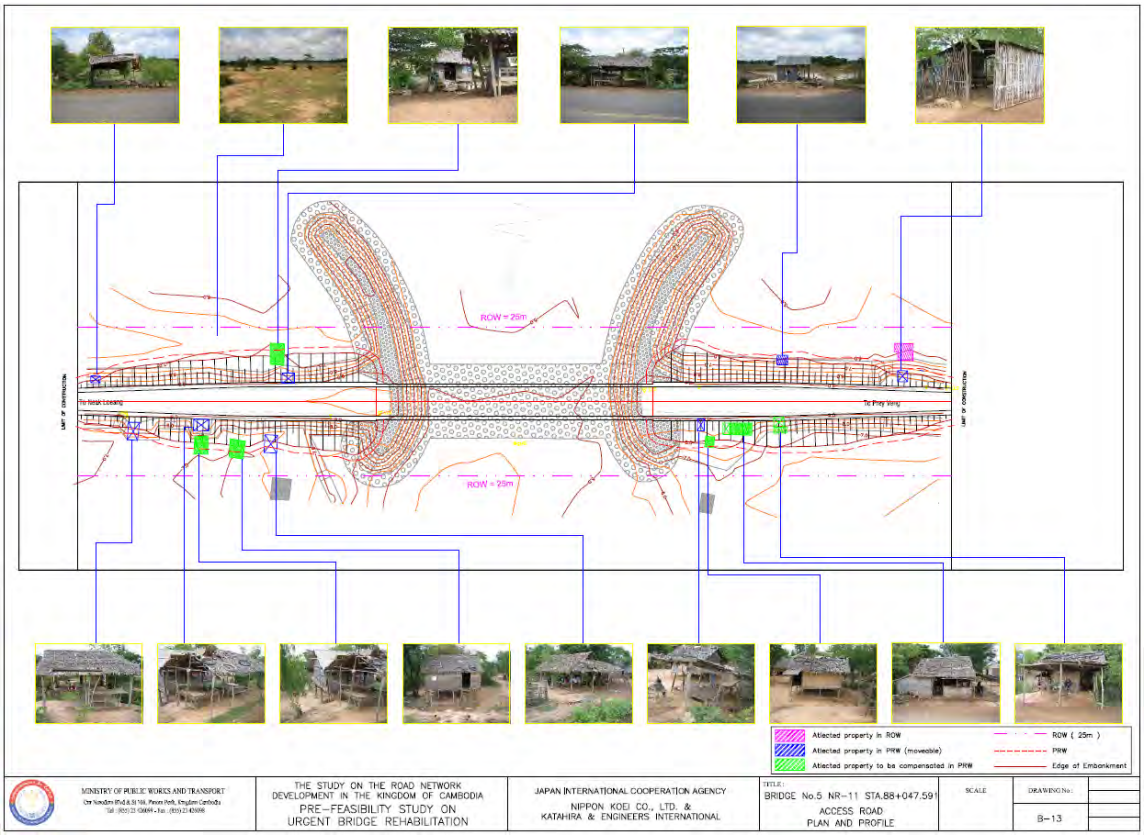
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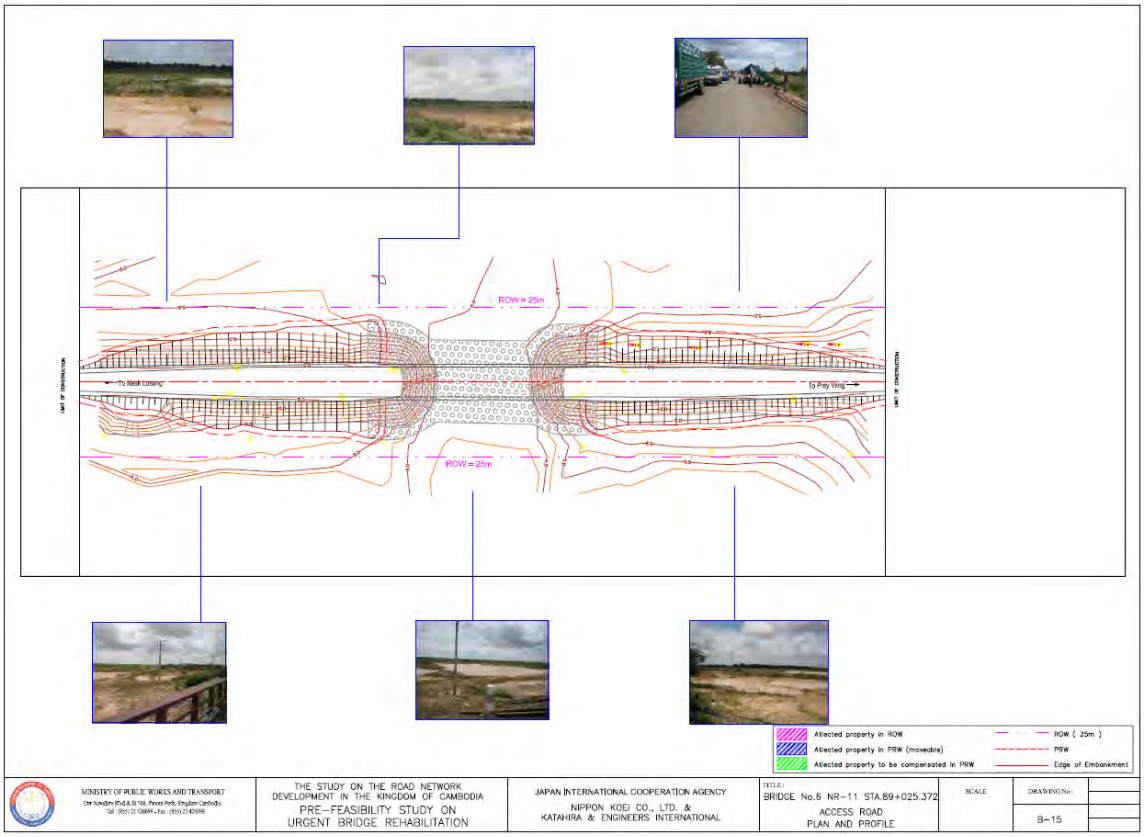
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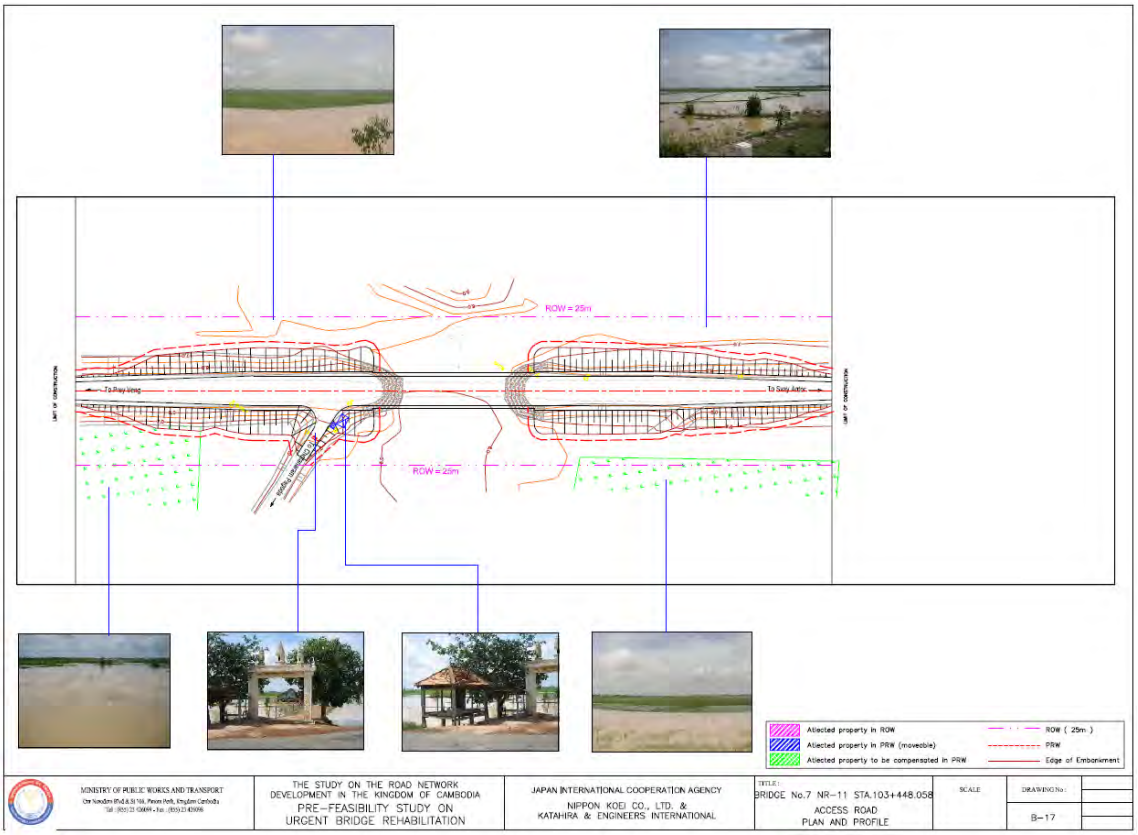
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Affected property to be compensated in PRW
ROW (25m)
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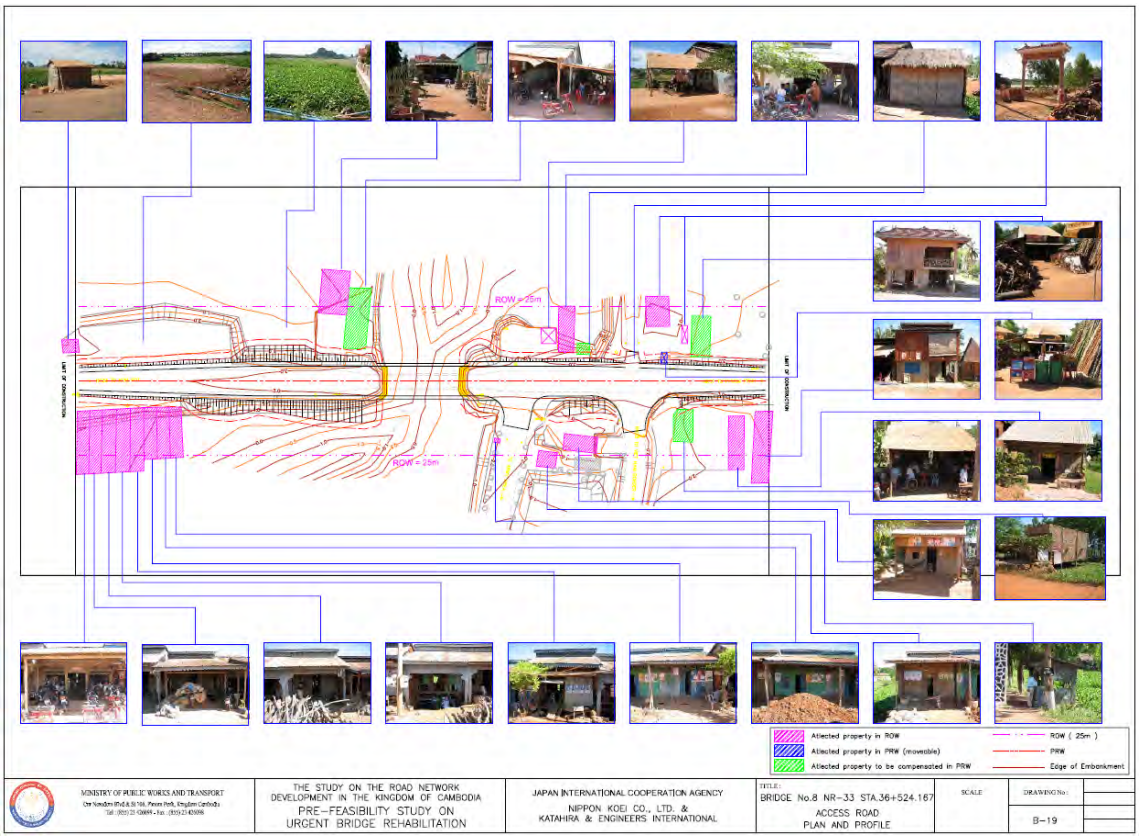
JAPAN INTERNATIONAL COOPERATION AGENCY
NIPPON KOEI CO., LTD. & KATAHIRA & ENGINEERS INTERNATIONAL
TITLE:
BRIDGE No.7 NR-11 STA.103+448.058
ACCESS ROAD
PLAN AND PROFILE
SCALE
DRAWING No.:
B-17


ROW = 25m
ROW = 25m
Affected property in ROW
Affected property in PRW (moveable)
Affected property to be compensated in PRW
ROW (25m)
PRW
Edge of Embankment
MINISTRY OF PUBLIC WORKS AND TRANSPORT
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NIPPON KOEI CO., LTD. & KATAHIRA & ENGINEERS INTERNATIONAL
TITLE:
BRIDGE No.8 NR-33 STA.36+524.167
ACCESS ROAD
PLAN AND PROFILE
SCALE
DRAWING No.:
B-19

CHAPTER B-6 PROJECT EVALUATION

The evaluation of the proposed Urgent Bridge Rehabilitation Project considers traffic, economic, financial and regional development factors.

6.1 Economic Analysis

(1) Economic Benefits

Economic benefits are assumed to be three (3): a) saving in vehicle operating cost (SVOC), b) saving in travel time cost (STTC) and c) saving in detour cost (SDC) which will be born by the collapsing bridges caused by flooding and /or over loaded trucks. These benefits are derived from difference between the "With the Project" and "Without the Project" scenarios. However, detouring benefits are assumed to be born every five (5) years based on the past historical experiences. **Table 6.1** shows estimation of the economic benefits.

Table 6.1 Estimation of Economic Benefits by Bridges in 2020

(Unit: US$ '000 / year)

Bridge No.	Route	SVOC	STTC	S-Total	SDC	Total
Bridge 1	NR.3	46.4	563.3	609.7	87.9	697.7
Bridge 2	NR.3	21.7	188.0	209.6	28.6	238.3
Bridge 3	NR.7	7.6	137.3	144.9	76.4	221.3
Bridge 4	NR.11	43.0	521.5	564.4	77.7	642.2
Bridge 5	NR.11	55.7	675.5	731.1	77.7	808.9
Bridge 6	NR.11	43.9	532.5	576.3	77.7	654.1
Bridge 7	NR.11	43.1	523.1	566.3	74.9	641.2
Bridge 8	NR.33	5.9	52.1	58.0	20.9	78.9

(2) Economic Costs

The economic costs, converted from the financial costs deducted transfer elements and applying standard conversion factor (SCF) for non-trade goods, are estimated as shown in **Table 6.2**.

Table 6.2 Economic Cost Estimates

(Unit: US$ '000)

Bridge No.	Route	Financial Cost	Economic Cost
Bridge 1	NR.3	1,332	1,204
Bridge 2	NR.3	1,166	1,052
Bridge 3	NR.7	2,980	2,697
Bridge 4	NR.11	1,005	908
Bridge 5	NR.11	2,037	1,843
Bridge 6	NR.11	1,508	1,363
Bridge 7	NR.11	1,241	1,121
Bridge 8	NR.33	663	598
Total		11,932	10,786

(3) Cost Benefit Analysis

The results of the cost benefit analysis are summarized as shown in **Table 6.3**. The cost benefit analysis shows that urgent rehabilitation projects of Bridges 1, 2, 4, 5, 6 and 7 are economically feasible while those of Bridges 3 and 8 are scarcely economically feasible.

Table 6.3 Economic Indications of Cost Benefit Analysis

Bridge No.	Road No.	NPV (US $'000)	BCR	EIRR
Bridge 1	NR.3	2,505.9	3.40	22.54
Bridge 2	NR.3	313.9	1.34	14.19
Bridge 3	NR.7	-1,005.9	0.57	7.60
Bridge 4	NR.11	2,769.2	4.50	24.34
Bridge 5	NR.11	2,576.9	2.62	24.34
Bridge 6	NR.11	2,386.1	3.02	20.46
Bridge 7	NR.11	2,641.7	3.72	22.07
Bridge 8	NR.33	-156.8	0.70	9.35

Notes: 1) Project life is assumed to be 25 years
2) Discount rate is 12 %

6.2 Financial Analysis

In the Master Plan Study, the overall financial analysis of the implementation program for the improvement and rehabilitation projects proposed has been examined. As a result, the implementation program as shown in **Table 6.4** of the Master Plan Study was recommended. This project is principally in accordance with the recommended implementation program and there are no foreseen problems for the implementation of the Urgent Bridge Rehabilitation project from a financial viewpoint.

Table 6.4 Financial Capability of the Project

(Unit: US $ Million)

Description	Short Term (2006-2010)
A.. Fund to be Procured	
(1) International fund	428
(2) Domestic fund	135
Total	563
B. Proposed Implementation Program in M/P	
(1) Improvement / Rehabilitation	403
(2) Maintenance	113
(3) Urgent Bridge Rehabilitation Program	(20)
Total	516
C. Amount of Balance	47

6.3 Other Effects

(1) Securing Traffic Throughout the Year

As mentioned in the engineering investigations of the urgent bridges, these bridges have suffered damage and collapsed due to heavy flooding and over-loaded trucks. When one of the bridges is damaged, it has to be closed to vehicles for several months forcing, if possible, detours to other routes. This badly affects industry and the activity of people along the route served by the bridge.

The bridge rehabilitation project can prevent damage such as the collapse of these bridges, so that traffic will be able to use these bridges throughout the year. As a result, it will encourage more agricultural, industrial and commercial activities and the activity of people along the roads with these bridges

(2) Traffic Safety Provision on Bridges,

Presently, the urgent bridges to be rehabilitated are one-lane temporary bridges allowing only one-way traffic. As a result, traffic accidents sometimes occur at these sections of bridges.

The bridge rehabilitation project can reduce traffic accidents and improve traffic safety on these bridges.

(3) Promotion of Regional Development

The project will provide an efficient transport facility around the area influenced by of the "urgent" bridges. Since economic activities within area influenced by the urgent bridges will be stimulated, the project will contribute to the economic growth around the urgent bridge sites and the regional development.

CHAPTER B-7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

This Pre-Feasibility Study proved that this program is technically feasible but Bridge No.3 on NR.7 and Bridge No.8 on NR.33 have low economic viability with an economic internal rate of return less than 12% as shown in Chapter FS-B-6.

Although the rehabilitation of the two (2) bridges, Bridge No.3 and No.8 do not yield high economic internal rate of return, these bridges should also be rehabilitated in terms of safety and road importance. These bridges are bailey bridges with very low load carrying capacity. On the other hand, NR.7 (Bridge No.3) is part of the Asian Highway AH11, NR.33 (Bridge No.8) is part of the Asian Highway AH123, and NR.3 (Bridge No.2) is a major trunk highway in the southwest block of Cambodia. This program should be implemented as early as possible due to its importance as indicated in the implementation schedule proposed in Chapter FS-B-4.

7.2 Recommendations

In order for the project successfully materialize, the following actions by the Royal Government of Cambodia is recommended;.

(1) Allocation of Budget for Project Preparation

(2) Operation and Maintenance

(3) Recycle of the existing temporary superstructure

(4) Education for Traffic Safety, Rules and User Behavior