7. PRELIMINARY DESIGN

7.1 Design Criteria for Roads

7.1.1 Design Standards

Design standards of the road are shown in Table 7.1.1. The standards generally used for geometric design is “Geometric Design Standards for RHD” (hereinafter called RHD Standards). However, if RHD Standards have no criteria about a certain item, the design for that item is conducted based on AASHTO (American Association of State Highway and Transportation Officials) standards.

For pavement design, although “Pavement Design Guide for RHD” is prioritized, AASHTO standards may need to be referred to.

Table 7.1.1 Design Standards for the Road

Item	Function
Geometric Design	Priority: Geometric Design Standards for RHD (2000) Reference: AASHTO Standard
Pavement Design	Priority: Pavement Design Guide for RHD (2005) Reference: AASHTO Standard

Source: JICA Survey Team

7.1.2 Standard for Roads in Bangladesh

Roads in Bangladesh are regulated by the functional road classifications of RHD. The classifications are described below.

(1) Road Class

Roads in Bangladesh are divided into the following three classifications.

Table 7.1.2 Functional Road Class

Class	Roads	Function
N	National	Roads connecting the national capital with divisional headquarters, old district headquarters, port cities and international highways
R	Regional	Roads connecting different regions with each other, which are not connected by the national highways
Z	Zilla	Roads connecting sub-districts to the arterial network

Source: RMMS Database, RHD

(2) Design Classes

Roads in Bangladesh are divided into the following six design types.

Table 7.1.3 Road Design Types

Design Type	Design Year Traffic Volume [PCU/direction/ peak hr.]	Maximum Design speed (km/h)			Functional Classification		
		Plain	Rolling	Hilly	N	R	Z
1	4500 - 8500	80-100	80	-	√		
2	2100 – 4500	80-100	80	-	√	√	
3	1600 – 2100	80	65	50	√	√	
4	800 – 1600	65	50	40	√	√	√
5	400 – 800	50	40	30		√	√
6	< 400	50	40	30			√

Source: Road geometric design standard by RHD

(3) Geometric Design Criteria for Each Road Class

1) National Roads

Summary of geometric design criteria are shown in Table 7.1.4.

Table 7.1.4 Geometric Design Criteria for National Roads

Item	Unit	Geometric Design of RHD Roads			Remarks
Design Speed	Km/h	100	80	65	
Horizontal Alignment					
Min. Radius (6.2m and 7.3m Carriageway)	m	1,000	500	250	
Min. Radius not Requiring Superelevation	m	4,000	2,000	1,000	
Vertical Alignment					
Max. Gradient *	%	3.0	3.0	3.0	Plain
Min. Vertical Curve K Value	m	70	35	18	
Clearance	m	5.7	5.7	5.7	
Cross Section Elements					
Min. Cross Slope for Road	%	3.0	3.0	3.0	
Min. Cross Slope for Bridge	%	2.0	2.0	2.0	
Sight Distance (Two Lane Roads)					
Stopping Sight Distance (SSD)	m	180	120	90	
Intermediate Sight Distance (ISD)	m	360	250	180	
Overtaking Sight Distance (OSD)	m	720	500	360	

*Maximum gradient (to be taken as a plane) shall be adopted in consideration of terrain conditions.

Source: JICA Survey Team

2) Regional Roads

A summary of geometric design criteria is shown in Table 7.1.5.

Table 7.1.5 Geometric Design Criteria for Regional Road

Item	Unit	Geometric Design of RHD Roads			Remarks
Design Speed	Km/h	80	65	50	
Horizontal Alignment					
Min. Radius (6.2m and 7.3m Carriageway)	m	500	250	120	
Min. Radius not Requiring Superelevation	m	2,000	1,000	500	
Vertical Alignment					
Max. Gradient *	%	3.0	3.0	3.0	Plane
Min. Vertical Curve K Value	m	35	18	9	
Clearance	m	5.7	5.7	5.7	
Cross Section Elements					
Min. Cross Slope for Road	%	3.0	3.0	3.0	
Min. Cross Slope for Bridge	%	2.0	2.0	2.0	
Sight Distance (Two Lane Roads)					
Stopping Sight Distance (SSD)	m	120	90	60	
Intermediate Sight Distance (ISD)	m	250	180	120	
Overtaking Sight Distance (OSD)	m	500	360	250	

*Maximum gradient (to be taken as a plane) shall be adopted in consideration of terrain conditions.

Source: JICA Survey Team

3) Zilla Road

A summary of geometric design criteria is shown in Table 7.1.6.

Table 7.1.6 Geometric Design Criteria for Feeder Roads (Zilla Roads)

Item	Unit	Geometric Design of RHD Roads			Remarks
Design Speed	Km/h	65	50		
Horizontal Alignment					
Min. Radius (6.2m and 7.3m Carriageway)	m	250	120		
Min. Radius not Requiring Superelevation	m	1,000	500		
Vertical Alignment					
Max. Gradient *	%	3.0	3.0		Plain
Min. Vertical Curve K Value	m	18	9		
Cross Section Elements					
Min. Cross Slope for Road	%	3.0	3.0		
Min. Cross Slope for Bridge	%	2.0	2.0		
Clearance	m	5.7	5.7		
Sight Distance (Two Lane Roads)					
Stopping Sight Distance (SSD)	m	90	60		
Intermediate Sight Distance (ISD)	m	180	120		
Overtaking Sight Distance (OSD)	m	360	250		

*Maximum gradient (to be taken as a plane) shall be adopted in consideration of terrain conditions.

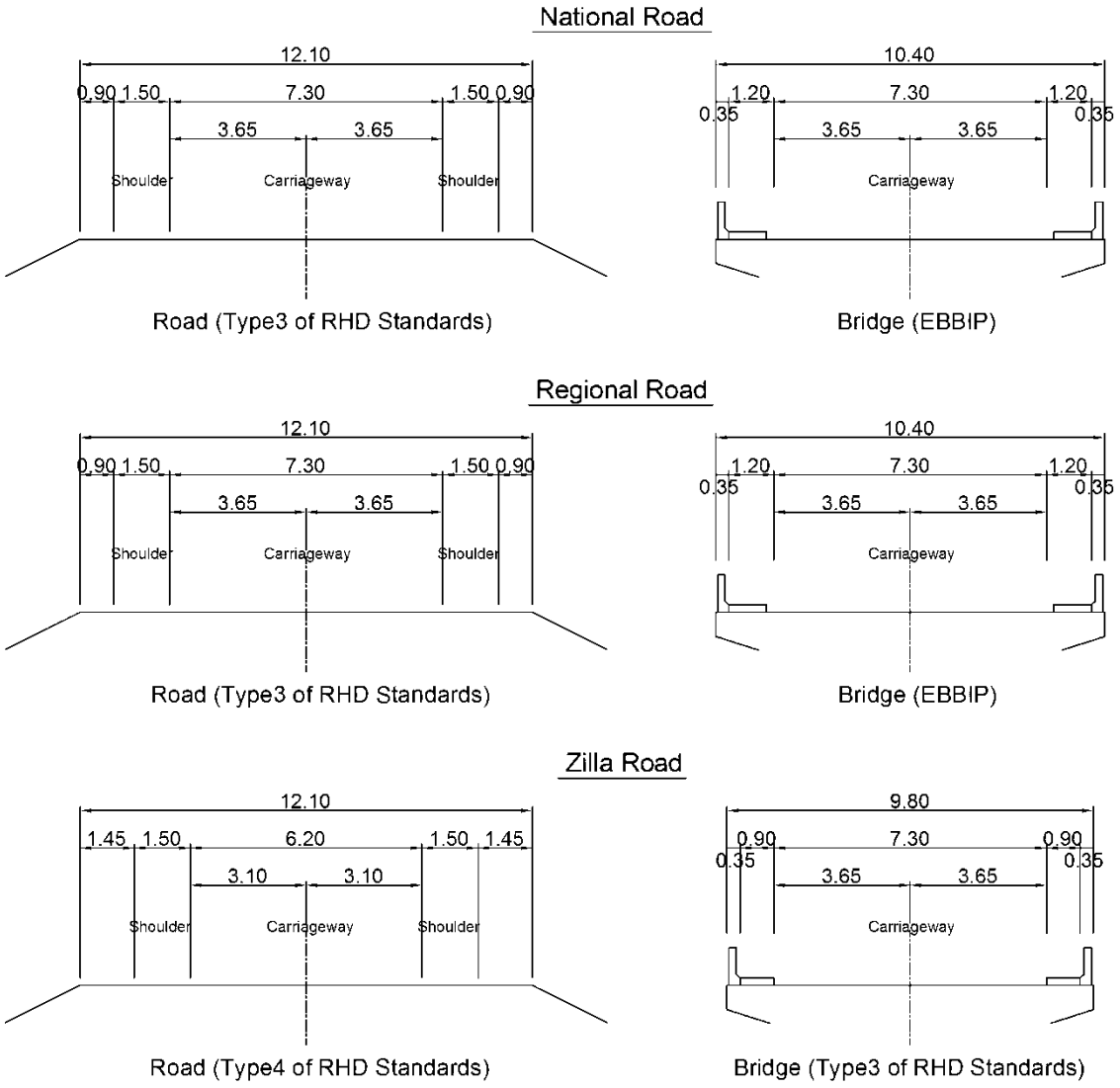
Source: JICA Survey Team

7.1.3 Typical Cross Section

The number of lanes is primarily determined based on the future traffic demand. However, many of the bridges that require more than 2 lanes (according to the demand forecast) will be constructed with only 2 lanes in this Project, in consideration of the following:

- As many bridges as possible should be constructed on a limited budget.
- Even if 4-lane/6-lane bridges are constructed, only 2 lanes will be used since the approach roads (adjacent embankment section) only have 2 lanes.
- Even if 4-lane/6-lane bridges are constructed in anticipation of widening of the approach roads, this widening may not occur soon. Deterioration of the bridge will progress even if all lanes are not used, meaning funds will have been wasted.

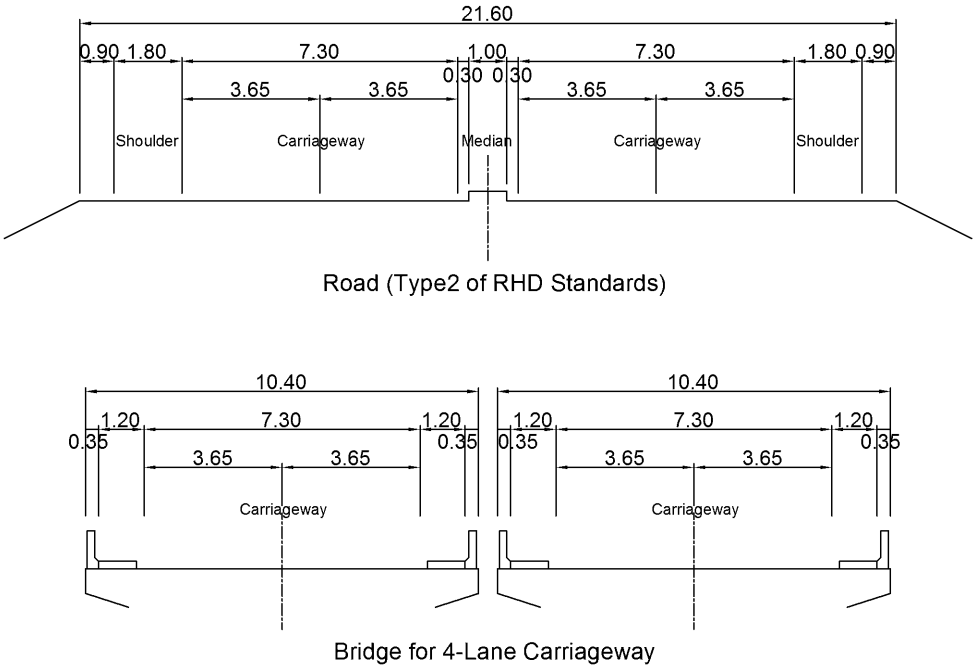
Typical cross sections for National, Regional and Zilla roads are shown in Figure 7.1.1.



Source: JICA Survey Team

Figure 7.1.1 Typical Cross Section for National, Regional and Zilla Roads

A typical cross section of AH1 (Asian Highway No.1) is shown in Figure 7.1.2. Regardless of the road category, the bridges on AH1 are to be constructed with a 4-lane carriageway.



Source: JICA Survey Team

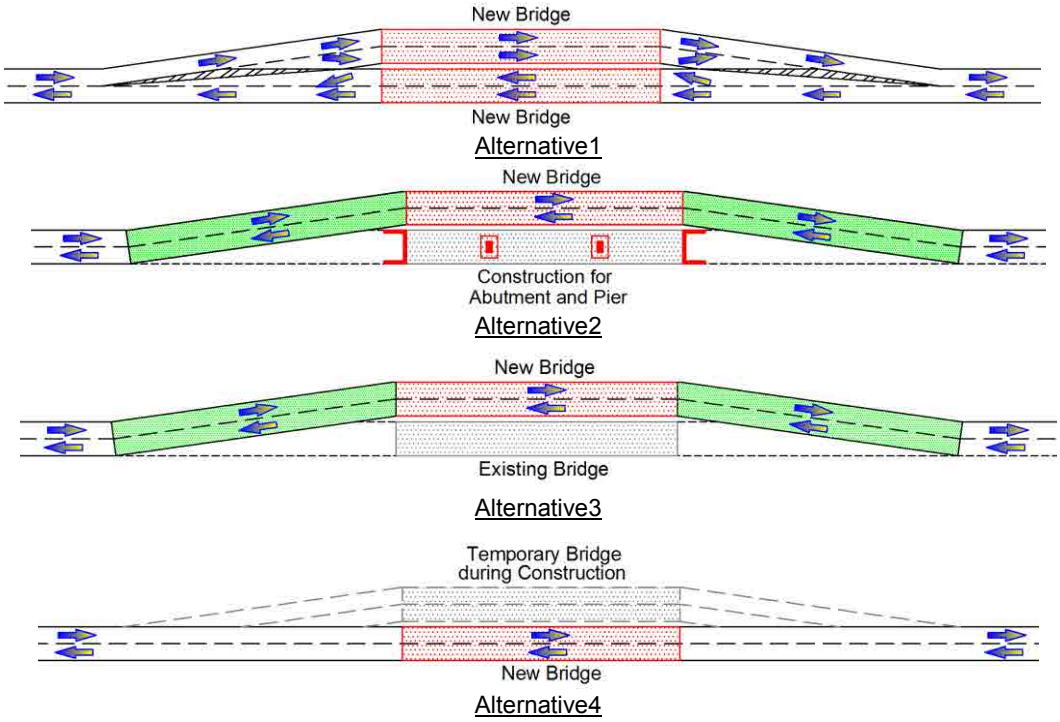
Figure 7.1.2 Typical Cross Section for AH1

7.1.4 Basic Principle for the Location of New Bridge

The location of new bridges shall be determined in consideration of impact to existing residences/shops, cost, etc. However, national roads shall be considered future widening project, additionally.

Table 7.1.7 shows the comparison of several alternatives. For regional roads and zilla roads, Alternative 4 (Replacement Existing Bridge) was selected in consideration initial cost. For national roads, Alternative 3 (New Bridge Construction next to Existing Bridge) was selected in consideration of easy future widening.

Table 7.1.7 The Location of New Bridge

Item	Alternative1	Alternative2	Alternative3	Alternative4
Figure				
Summary	One of new bridge is constructed next to existing bridge and another bridge is constructed at the same position of existing bridge.	New bridge is constructed as 2-lane carriageway next to existing bridge. Additionally, the abutment and the pier are constructed for future widening project.	New bridge is constructed next to existing bridge.	Existing bridge is replaced by new bridge.
Temporary Bridge	Unnecessary Good	Unnecessary Good	Unnecessary Good	Necessary during construction Poor
Economic Efficiency	The initial cost is the most highest among alternatives. Poor	The initial cost is higher than Alternative 3 and 4. Poor	The initial cost is higher than Alternative 4. Good	The initial cost is the cheapest among alternatives. Good
Traffic Capacity	It is improved only in project area. Good	It is same as the existing condition. Fair	It is same as the existing condition. Fair	It is same as the existing condition. Fair
Traffic Safety	It might cause traffic conflict at the diverging point. Poor	It is same as the existing condition. Fair	It is same as the existing condition. Fair	It is same as the existing condition. Fair
Evaluation			**Recommended for National Road** - Easy for future widening.	**Recommended for Regional and Zilla Road** - The cheapest initial cost.

Source: JICA Survey Team

7.2 Design Criteria for Bridges

7.2.1 Design Standards to be followed in Bangladesh

(1) Design Standards

With due consideration for the design standards followed by several bridge projects under the Roads & Highways Department in recent years, the design standards to be used in this present project have been set as follows;

- Bridge Design Standards By Roads & Highways Department (2004)
- Bangladesh National Building Codes (BNBC)-1993 (Gadget 2006)
- Geometric Design Standards for Roads & Highways Department (2001)
- Standard Tender Documents – Section-7: Technical Specifications, RHD, 2011
- AASHTO LRFD Bridge Design Specifications (2010, 5th edition)
- AASHTO Guide Specifications for LRFD Seismic Bridge Design (2011, 2nd edition)
- Standard Specifications and Code of Practice for Road Bridges Section :II (Indian Road Congress (IRC), 2010)
- Specifications for Highway Bridges-Japan Road Association (JRA) (2002)

7.2.2 Navigation Waterway Limitation and Design High Water Level

The navigation waterway limitations are classified as shown in Table 7.2.1 as established by BIWTA (Bangladesh Inland Water Transport Authority), and Project bridges will be required to comply with these limitations. Of the waterways passing under the Project bridges, there is one Class IV navigation channel in Western Bangladesh that includes Atrai River, which passes under Atrai Bridge. The water level required at times when this navigation clearance must be secured is defined as SHWL (Standard High Water Level, Fortnightly Mean Water Levels with 5% exceedance) by BIWTA. For unofficial navigation waterways, a 1.1-year probability high water level will be adopted and values will be checked against those in Table 7.2.2.

The design high water level for Project bridges is taken as a 20-year flood level for Zilla roads and a 50-year flood level for other roads, and the clearance with the underside of the bridge-girders will be ensured to comply with the requirements of Table 7.2.2.

Table 7.2.1 Navigation Waterways Limitation

Classification of Waterways	Minimum Vertical Clearance	Minimum Horizontal Clearance	Remarks
Class- I	18.30m	76.22m	
Class- II	12.20m	76.22m	
Class- III	7.62m	30.48m	
Class- IV	5.00m	20.00m	Atrai Bridge (R548_28B, Atrai River, SHWL=6.37m AMSL)

Source：BIWTA (1991)

Table 7.2.2 Design High Water Level and Bridge Girder Bottom Height

<table>
<tr><td>Classification of Roadway (Bridge)</td><td colspan="2">Zilla Road</td><td colspan="2">High Standard Bridge except Zilla Road</td></tr>
<tr><td>Type of Bridge</td><td>Concrete</td><td>Weathering Steel Bridge</td><td>Concrete Bridge</td><td>Weathering Steel Bridge</td></tr>
<tr><td>Design High Water Level</td><td colspan="2">20 year High Flood Level</td><td colspan="2">50 year High Flood Level</td></tr>
<tr><td rowspan="6">Design Concept for Bridge Girder Bottom Height (Maximum Height of the Right Column)</td><td colspan="2">20 year Flood Level + 0.30m</td><td colspan="2">50 year High Flood Level + 0.30m</td></tr>
<tr><td colspan="2">10 year Flood Level + 0.50m</td><td colspan="2">10 year Flood Level
+ 0.70m (Regional Road)
+ 0.90 m (National Road, AH)</td></tr>
<tr><td colspan="2">Historical High Water Level by Interview + 0.30m</td><td colspan="2">same as on the left</td></tr>
<tr><td colspan="2">Girder Bottom Height of Existing Bridge</td><td colspan="2">same as on the left</td></tr>
<tr><td>1.1 year Flood Level + 1.2m</td><td>1.1 year Flood Level+ 3.0m</td><td>1.1 year Flood Level + 1.2m</td><td>1.1 year Flood Level+ 3.0m</td></tr>
<tr><td colspan="4">If a bridge is at official navigation waterway, it is SHWL + Necessary vertical clearance.</td></tr>
</table>

Source：JICA Survey Team

7.2.3 Design Loads

There are several loads to be considered for the bridge design.

(1) Dead Load

For design dead load, the unit weights prescribed by AASHTO can be used to calculate the dead load of the structure.

Table 7.2.3 Unit Weight of Bridge Materials for Dead Load Calculation

Material	Unit weight (kN/m^3)
Steel	77.0
Plain Concrete	23
Reinforced Concrete	24.5
Prestressed Concrete	24.5
Asphalt mix	22.5

Source: JICA Survey Team

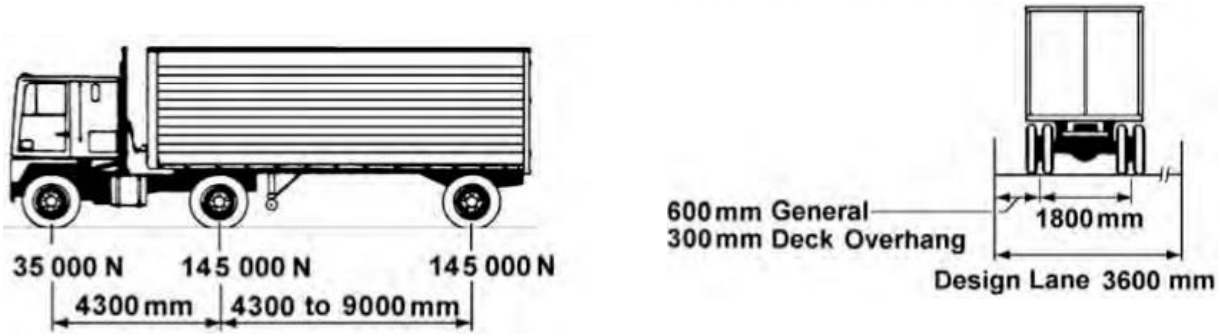
(2) Live Loads

According to AASHTO LRFD, design live loads of the bridges shall consist of the;

- Design truck load
- Design lane load

1) Design Truck Load

The weights and spacing of axles and wheels for the design truck (HS20-44) shall be as per the specification shown in Figure 7.2.1



Source: JICA Survey Team

Figure 7.2.1 Design Truck Load

2) Design Lane Load

The lane load for girder and substructure design is summarized in Table 7.2.4. It consists of a 9.3 kN/m-uniform load that is distributed along the longitudinal direction and spreads over a 3 m-wide lane. The lane load shall not be subjected to dynamic load allowance. Lane load shall not be interrupted to provide space for the design truck or tandem (concentrated load), except where interruption in a patch loading pattern produces an extreme value for certain force effects.

Table 7.2.4 Lane Load Specification for Girder and Substructure Design

Specification	Truck load per lane (concentrated load)	Design load over 3 m lane width (uniformly distributed)	Multiple presence factor for 4-lane bridge	Impact (IM)
AASHTO (HS20-44)	325 kN	9.3 kN/m	65 %	33 % for truck load only

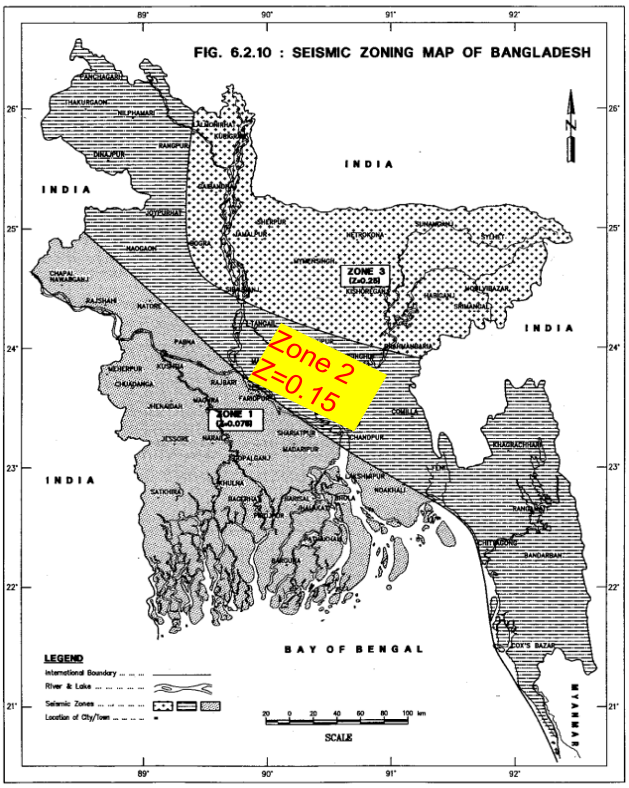
Source: JICA Survey Team

(3) Earthquake Load

To calculate the earthquake load, necessary input parameters include the zone coefficient, site coefficient for soil and design Response Spectrum (RS). In this regard, BNBC (2006) will be used as a supporting document to derive the design RS with respect to Bangladesh.

1) Zone coefficient

In order to compute the earthquake load, the seismic zones are defined in the Bangladesh seismic zoning map (Figure 7.2.2). Based on the severity of the probable intensity of seismic ground motion and damage, Bangladesh is divided into three seismic zones, which are shown with their zone coefficients in Table 7.2.5.



Source: JICA Survey Team

Figure 7.2.2 Seismic Zoning Map of Bangladesh

Table 7.2.5 Zone Coefficient Z (BNBC)

Seismic zone	Zone coefficient
1	0.075
2	0.15
3	0.25

Source: JICA Survey Team

2) Site Coefficient S

The parameter site coefficient shall be determined based on site soil characteristics. According to BNBC, there are four types of soil such as S1, S2, S3 and S4 that are classified based on the depth of the soil, shear wave velocity and soil type. The coefficients are specified in Table 7.2.6 in accordance with geological data surveyed for this project.

Table 7.2.6 Site Coefficient S for Seismic Lateral Forces (BNBC)

Site soil characteristics		Coefficient S
Type	Description	
S1	A soil profile with either: • A rock like material characterized by shear wave velocity greater than 762 m/s or by other suitable means of classification, or • Stiff or dense soil condition where the soil depth is less than 61 m.	1.0
S2	A soil profile with dense or stiff soil conditions, where the soil depth exceeds 61m.	1.2
S3	A soil profile of depth 21 m or greater, containing more than 60 m of soft to medium stiff clay but not more than 12 m of soft clay.	1.5
S4	A soil profile containing more than 12 m of soft clay characterized by shear wave velocity less than 152 m/s.	2.0

Source: JICA Survey Team

3) Design Response Spectrum (RS)

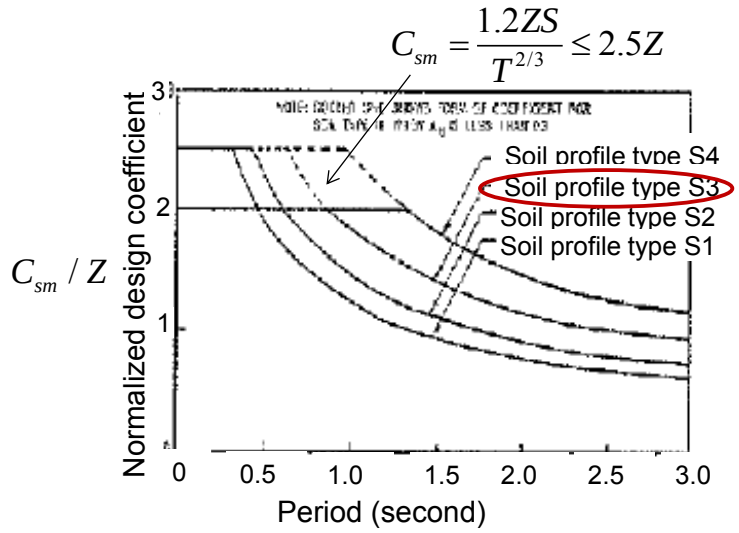
Generally, a design RS shall be developed based on geologic, seismologic and soil characteristics associated with the specific site. In this regard, BNBC has a provision on design RS whose magnitude is almost equal to the magnitude of the response spectra proposed by AASHTO LRFD (2007). The design RS are formulated in Eq. (4.2.1) and schematically shown in Figure 7.2.3.

$$C_{sm} = \frac{1.2ZS}{T_m^{2/3}} \leq 2.5Z \qquad \text{Eq. (4.2.1)}$$

where,

T_m : *Periodic time of* m^{th} *mode vibration*

C_{sm} : *Elastic response coefficient*



Source: JICA Survey Team

Figure 7.2.3 Design Response Spectrum

The RSs shown in Figure 7.2.3 were derived based on a return period of 475 years as specified in AASHTO.

7.2.4 Technical Specifications for Construction Materials

(1) Concrete

In accordance with RHD practice, the values for 28-day-compressive strength of concrete cylinders for various structural components (RC bored piles, abutments, piers) shall be 25 MPa, whereas the concrete strength of prestressed deck slabs shall be 40 MPa as per JIS specifications. The concrete strength values for different bridge components are listed in Table 7.2.7.

Table 7.2.7 Strength Requirements of Concrete for Bridges

Bridge Components	28-days compressive strength of concrete cylinder, σ_{ck} (MPa)
Prestressed concrete girder	40
RCC Piles and abutments and their foundations, piers; Other structural components (RHD)	25

Source: JICA Survey Team

(2) Reinforcing steel bars

Reinforcing steel bars shall be deformed, except that plain bars or plain wire may be used for spirals, hoops, and wire fabric. Two types of reinforcing steel bars: Grade-40 and Grade-60 are available in the Bangladesh market and their strengths are specified by American Society for Testing Materials (ASTM). The ASTM specifications for the said two grades are shown in

Table 7.2.8.

Table 7.2.8 Nominal Stress of Reinforcing Steel Bars for Bridges and ancillary Works

Steel grade	Yield stress σ_y (MPa)	Tensile strength σ_u (MPa)
Grade-40	280	420
Grade-60	420	620

Source: JICA Survey Team

(3) Prestressing Steel

Uncoated low relaxation seven-wire strands and prestressing bars shall be used as prestressing steel in order to achieve continuity in the box girder sections of the existing bridges. Among them, prestressing bars shall be used as external cable. Both forms of prestressing steel shall conform to the JIS specifications shown in Table 7.2.9.

Table 7.2.9 Nominal Stress of Prestressing Steel

Prestressing steel	Grade	Yield stress σ_y (MPa)	Tensile strength σ_u (MPa)
Strand (7-wire)	SWPR7BL	1583	1860
Bar	SBPR930	930	1180

Source: JICA Survey Team

(4) Weathering Steel

As per JIS specifications, the grades SMA400A/SMA400B or SMA490A/SMA490B will be used as weathering steel material. The tensile strength and yield stress of the respective grades are stated in Table 7.2.10.

Table 7.2.10 Nominal Stress of Steel

Steel grade ($16 < t \leq 40$ mm)	Yield stress σ_y (MPa)	Tensile strength σ_u (MPa)
SMA400A/SMA400B	235	400 to 510
SMA490A/SMA490B	315	490 to 610

Source: JICA Survey Team

7.3 Road Design

7.3.1 Design Speed

Design speed is determined based on RHD standards and considering road environment,

terrain condition and so on. Design speed for National, Regional, and Zilla roads is shown in Table 7.3.1, respectively.

Table 7.3.1 Design Speed for National, Regional and Zilla Road

Road Category	Adopted Design Speed
National	V=80 km/h
Regional	V=65 km/h
Zilla	V=50 km/h

Source: JICA Survey Team

7.3.2 Horizontal Alignment

Horizontal alignment including curve radius and transition curves is designed in accordance with RHD standards. However, reduction of design speed must be considered in order to mitigate impact to the surrounding environment when the existing radius of curve does not meet the standard.

Rated values and adopted values are described below, respectively.

(1) Minimum Horizontal Curve Radius

Table 7.3.2 Minimum Horizontal Curve Radius

Design Speed (km/h)	Minimum Horizontal Curve Radius (m)	
	RHD Standards	Adopted Value
50	120	120
65	250	250
80	500	500

*Adopted values are described excluding special standard which meet existing condition in order to avoid impact to surrounding environment.

Source: JICA Survey Team

(2) Minimum Transition Length

Table 7.3.3 Minimum Transition Length

Design Speed (km/h)	Transition Length (m)			Straight Transition Length (m)
	Superelevation			
	7%	5%	3%	
50	45	25	15	15
65	55	35	20	20
80	65	45	25	25

Source: JICA Survey Team

7.3.3 Vertical Alignment

(1) Concepts of Vertical Alignment

Vertical alignment is designed in consideration of the following concepts.

- A minimum gradient of 0.3% is used in order to provide proper surface drainage.
- A maximum gradient of 3.0% is used in accordance with RHD standards.

(2) Vertical Curve, K

The vertical curve denoted by K, which has been specified by RHD standards, shall be taken as the adopted values as shown in Table 7.3.4.

Table 7.3.4 Minimum Vertical Curve, K

Design Speed (km/h)	Minimum K (m/%)	
	RHD Standards	Adopted Value
50	9	24
65	18	35
80	35	35

Source: JICA Survey Team

7.3.4 Crossfall

Crossfall is set in accordance with the RHD standards as shown in Table 7.3.5 Crossfall for Road and Bridge.

Table 7.3.5 Crossfall for Road and Bridge

Road	Bridge
3.0 %	2.0 %

Source: JICA Survey Team

7.3.5 Superelevation

Superelevation is set in accordance with RHD standards as shown in Table 7.3.6.

Table 7.3.6 Superelevation for Radius of Curve

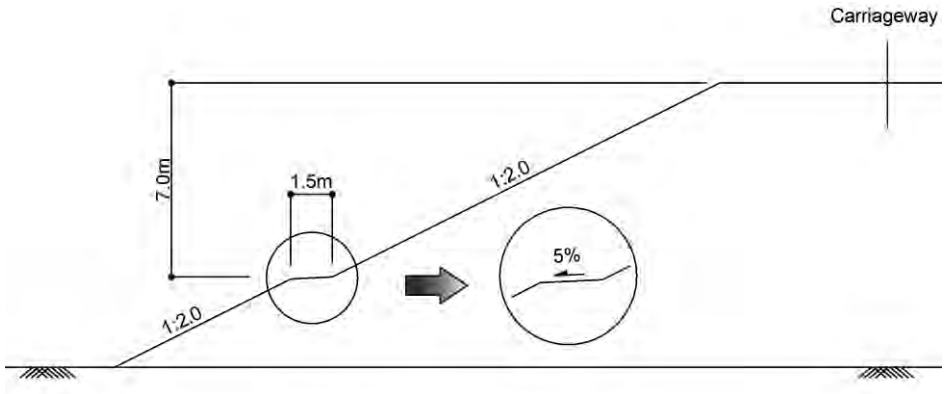
Design Speed (km/h)	Radius of Curve (m)					
	65	120	250	500	1000	2000
50	7 %	5 %	3 %	Nil	Nil	Nil
65	-	7 %	5 %	3 %	Nil	Nil
80	-	-	7 %	5 %	3 %	Nil

Source: JICA Survey Team

7.3.6 Embankment

(1) Height of Embankment

The slope of the embankment should be 1V:2H in accordance with RHD standards. Additionally, for every 7m rise, a step of width 1.5m shall be set in order to prevent erosion by rainwater. The height of the step shall be considered in the detailed design stage.

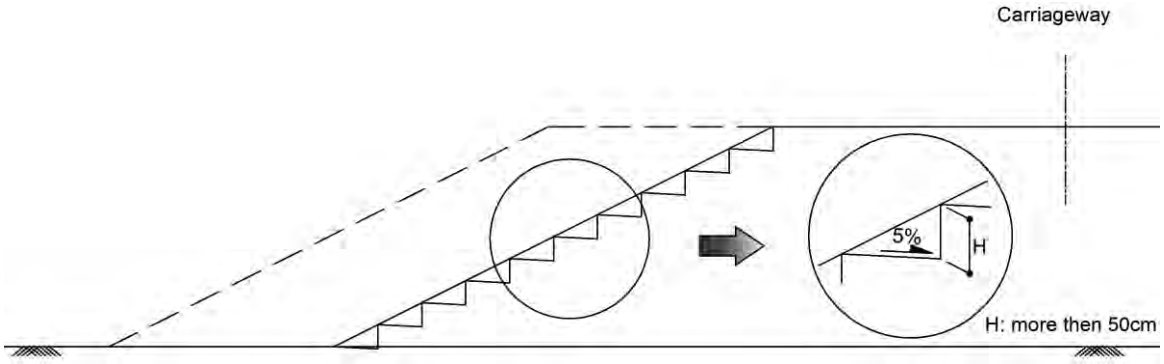


Source: JICA Survey Team

Figure 7.3.1 Embankment

(2) Bench Cut

In order to avoid sliding and sinking of the embankment, bench cuts shall be carried as shown in Figure 7.3.2.



Source: JICA Survey Team

Figure 7.3.2 Detail for Bench Cut

7.3.7 Pavement Design

(1) Introduction

The pavement structure is designed based on the Pavement Design Guide for Roads & Highways Department (April, 2005) and the AASHTO Guide for Design of Pavement Structures (hereinafter called AASHTO Pavement Guide).

In the AASHTO Pavement Guide, the pavement layer thickness is determined so that it provides load-carrying capacity corresponding to the design structural number (SN). The SN is calculated using the following formula.

$$\log_{10}(W_{18}) = Z_R \times S_0 + 9.36 \times \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left(\frac{\Delta PSI}{4.2-1.5}\right)}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 \times \log_{10}(M_R) - 8.07$$

where

W_{18}: *Predicted number of 18-kip equivalent single axle load applications*

Z_R: *Standard normal deviate*

S_0: *Combined standard error of the traffic prediction and performance prediction*

ΔPSI: *Difference between the initial design serviceability index, P_0, and the design terminal serviceability index, P_t*

M_R: *Resilient modulus (psi)*

SN: *Design structural number*

(2) Design Condition

1) Predicted Number of 18-kip Equivalent Single Axle Load Applications (W_{18})

Predicted number of 18-kip equivalent single axle load applications (W_{18}) is calculated based on the traffic volume for 10 years (2021 - 2030) as the design period. Axle load equivalency factor for the Project is shown in Table 7.3.7.

The design period was determined in consideration of the following:

- For the design traffic of each road class such as National, Regional and Zilla, the highest traffic volume in each road class is applied, and thus applying 20 years as the design period is over-investing.
- Future improvement of the pavement such as overlay and re-pavement can be carried out easily without a large impact on the existing traffic, since the project sites are in rural areas.
- Pavement design with long design period provides only limited effects, since it is applied for only bridge approach sections in the Project.

Table 7.3.7 Axle Load Equivalency Factor

Vehicle Type	Total Weight (ton)	Axle-1				Axle-2				Axle-3				Axle Load Equivalency Factor for Vehicle
		Type	Weight (ton)	Weight (kips)	Axle Load Equivalency Factor per a Axle	Type	Weight (ton)	Weight (kips)	Axle Load Equivalency Factor per a Axle	Type	Weight (ton)	Weight (kips)	Axle Load Equivalency Factor per a Axle	
Passenger Car	2.0	Sin	1.0	2.2	0.0004	Sin	1.0	2.2	0.0004					**0.0008**
Truck	9.5	Sin	1.9	4.2	0.0028	Sin	7.6	16.8	0.7738					**0.7766**
Trailer	36.0	Sin	4.4	9.7	0.0529	Tan	15.8	34.8	1.2060	Tan	15.8	34.8	1.2060	**2.4649**
Bus	10.0	Sin	5.0	11.0	0.1385	Sin	5.0	11.0	0.1385					**0.2770**

Source: JICA Survey Team

The predicted number of 18-kip equivalent single-axle load applications (W_{18}) for the Project is shown from Table 7.3.8 to Table 7.3.10 by road classification.

Table 7.3.8 Predicted Number of 18-kip Equivalent Single Axle Load Applications (W_{18}) for National Roads

Vehicle Type	Design Traffic (2021-2030)	ESAL Factor	Design ESAL	18-kip ESAL Traffic in Design Lane
Passenger Car	73,562,465	0.0008	58,850	20,597
Truck	42,093,260	0.7766	32,689,626	11,441,369
Trailer	803,365	2.4649	1,980,214	693,075
Bus	39,456,135	0.2770	10,929,349	3,825,272
Total				**15,980,314**

Source: JICA Survey Team

Table 7.3.9 Predicted Number of 18-kip Equivalent Single Axle Load Applications (W_{18}) for Regional Roads

Vehicle Type	Design Traffic (2021-2030)	ESAL Factor	Design ESAL	18-kip ESAL Traffic in Design Lane
Passenger Car	36,633,590	0.0008	29,307	10,257
Truck	12,877,930	0.7766	10,001,000	3,500,350
Bus	30,766,945	0.2770	8,522,444	2,982,855
Total				**6,493,463**

Source: JICA Survey Team

Table 7.3.10 Predicted Number of 18-kip Equivalent Single Axle Load Applications (W_{18}) for Zilla Roads

Vehicle Type	Design Traffic (2021-2030)	ESAL Factor	Design ESAL	18-kip ESAL Traffic in Design Lane
Passenger Car	58,420,805	0.0008	46,737	16,358
Truck	15,853,775	0.7766	12,312,042	4,309,215
Bus	22,828,560	0.2770	6,323,511	2,213,229
Total				**6,538,801**

Source: JICA Survey Team

2) Standard Normal Deviate (Z_R)

The standard normal deviate (Z_R) is shown in Table 7.3.11.

Table 7.3.11 Standard Normal Deviate (Z_R)

	National Roads	Regional Roads	Zilla Roads
Reliability, R (%)	90	85	85
Deviate, Z_R	-1.282	-1.037	-1.037

Source: AASHTO Pavement Guide

3) Combined Standard Error of the Traffic Prediction and Performance Prediction (S_0)

The combined standard error of the traffic prediction and performance prediction (S_0) for asphalt pavement is “0.45”.

4) Serviceability Index Difference (∆PSI)

The difference (∆PSI) between the initial design serviceability index, P_0, and the design terminal serviceability index, P_t for the Project is shown in Table 7.3.12.

Table 7.3.12 Serviceability Index Difference, P_t (∆PSI)

P_o	4.2
P_t	2.5
∆PSI	**1.7**

Source: AASHTO Pavement Guide

5) Resilient Modulus (psi) (M_R)

Resilient modulus (psi) (M_R) is calculated by the following formula. CBR value of the roadbed soil in the Project is set as “5” based on Pavement Design Guide for RHD.

Resilient Modulus (psi) (MR) = 1500 x CBR = 1500 x 5 = 7500

6) Design Structural Number (SN)

Design structural number (SN) for the Project is calculated based on the SN calculation formula with above stated design conditions. SN is shown in Table 7.3.13.

Table 7.3.13 SN for National, Regional, Zilla Road

Road Category	SN
National Roads	5.3
Regional Roads	4.5
Zilla Roads	4.5

Source: JICA Survey Team

(3) Pavement Layer Thickness

Pavement layer thickness is calculated by the following formula.

$$SN = a_1D_1+a_2D_2m_2+a_3D_3m_3$$

where

a_1, a_2, a_3: *Layer coefficients representative of surface, base, and subbase course, respectively*

D_1, D_2, D_3: *Actual thicknesses of surface, base, and subbase courses, respectively*

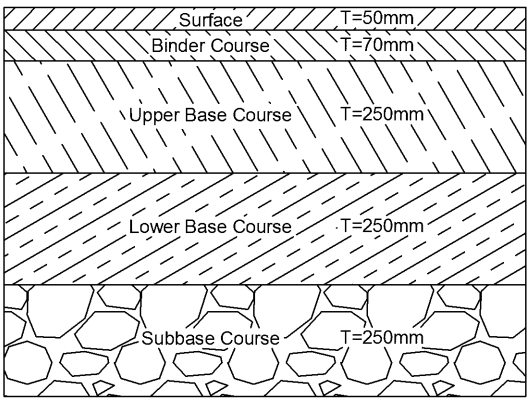
m_2, m_3: *Drainage coefficients for base and subbase layers, respectively*

Pavement layer thickness for National, Regional and Zilla Road are shown below, respectively.

Table 7.3.14 Pavement Layer Thickness for National Roads

Layer	Material	a	m	D		SN		
				cm	inch			
Surface	Bituminous Wearing Course	0.42		5	1.969			
Binder Course	Bituminous Binder Course	0.42		7	2.756			
Base Course	Graded Aggregate Upper Base Course	0.14	1.00	25	9.843	5.5		
Base Course	Aggregate Lower Base Course	0.11	1.00	25	9.843		>	5.3
Subbase Course	Aggregate Sub Base Course	0.11	1.00	25	9.843			**OK**

Source: JICA Survey Team



Source: JICA Survey Team

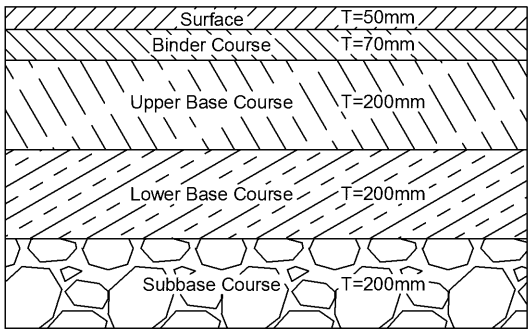
Figure 7.3.3 Pavement Layer Thickness for National Roads

As a result, the pavement layer thickness of national roads used in the Project is the same as the thickness used in EBBIP (East Bangladesh Bridge Improvement Project).

Table 7.3.15 Pavement Layer Thickness for Regional Roads

Layer	Material	a	m	D		SN		
				cm	inch			
Surface	Bituminous Wearing Course	0.42		5	1.969			
Binder Course	Bituminous Binder Course	0.42		7	2.756			
Base Course	Graded Aggregate Upper Base Course	0.14	1.00	20	7.874	4.8		
Base Course	Aggregate Lower Base Course	0.11	1.00	20	7.874		>	4.5
Subbase Course	Aggregate Sub Base Course	0.11	1.00	20	7.874			**OK**

Source: JICA Survey Team



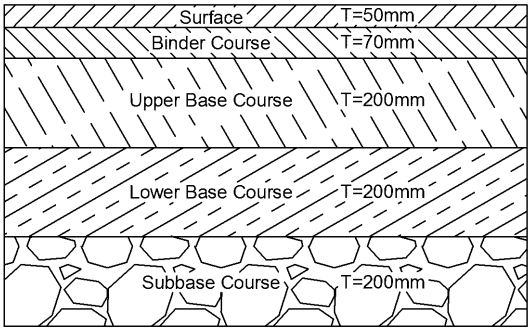
Source: JICA Survey Team

Figure 7.3.4 Pavement Layer Thickness for Regional Roads

Table 7.3.16 Pavement Layer Thickness for Zilla Roads

Layer	Material	a	m	D		SN		
				cm	inch			
Surface	Bituminous Wearing Course	0.42		5	1.969			
Binder Course	Bituminous Binder Course	0.42		7	2.756			
Base Course	Graded Aggregate Upper Base Course	0.14	1.00	20	7.874	4.8		
Base Course	Aggregate Lower Base Course	0.11	1.00	20	7.874		>	4.5
Subbase Course	Aggregate Sub Base Course	0.11	1.00	20	7.874			**OK**

Source: JICA Survey Team



Source: JICA Survey Team

Figure 7.3.5 Pavement Layer Thickness for Zilla Roads

7.4 Bridge Design

7.4.1 Superstructures

(1) Girder Type and Standard Spans

As mentioned in Chapter-6, the bridge type (super structure) is determined as follows.

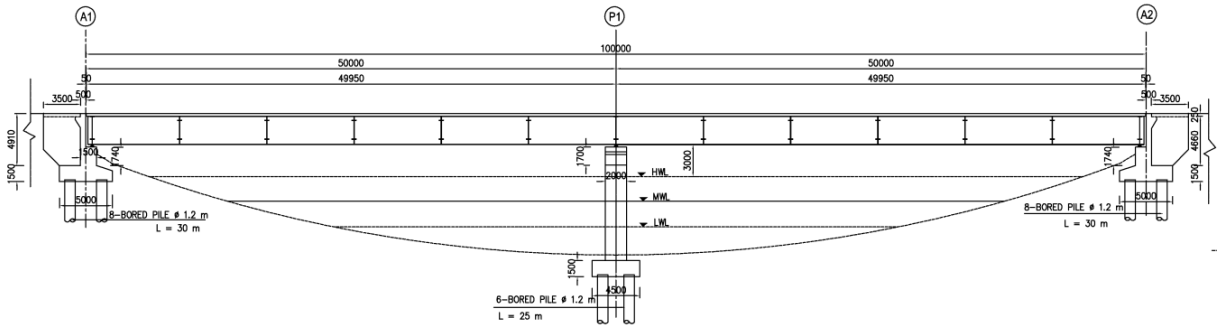
Northern zone (55 bridges):	38 small PC-I girder bridges, and
	17 mid-sized Steel-I (weathering steel) girder bridges
Southern zone (50 bridges):	All small PC-I girder bridges

The bridge span length is standardized with some series of spans to apply easily to all 105 bridge locations, and standard bridge spans are as follows:

PC-I : standard span 25, 30, 35, 40 m

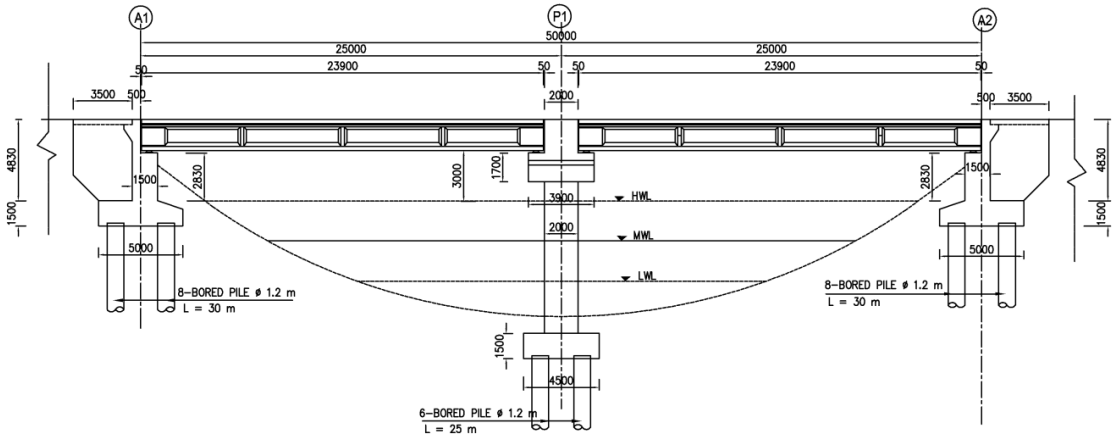
Steel-I : standard span 40, 50, 60 m

Additionally, measures to prevent superstructure collapse are proposed for two types of girders. Continuous girders are proposed for Steel-I girder Bridges as shown in Figure 7.4.1, and “chaired” girders (in which the motion of the pier heads is restricted by the girders) are proposed for PC-I girder bridges as shown in Figure 7.4.2.



Source: JICA Survey Team

Figure 7.4.1 Steel-I Girder (Continuous Girder)

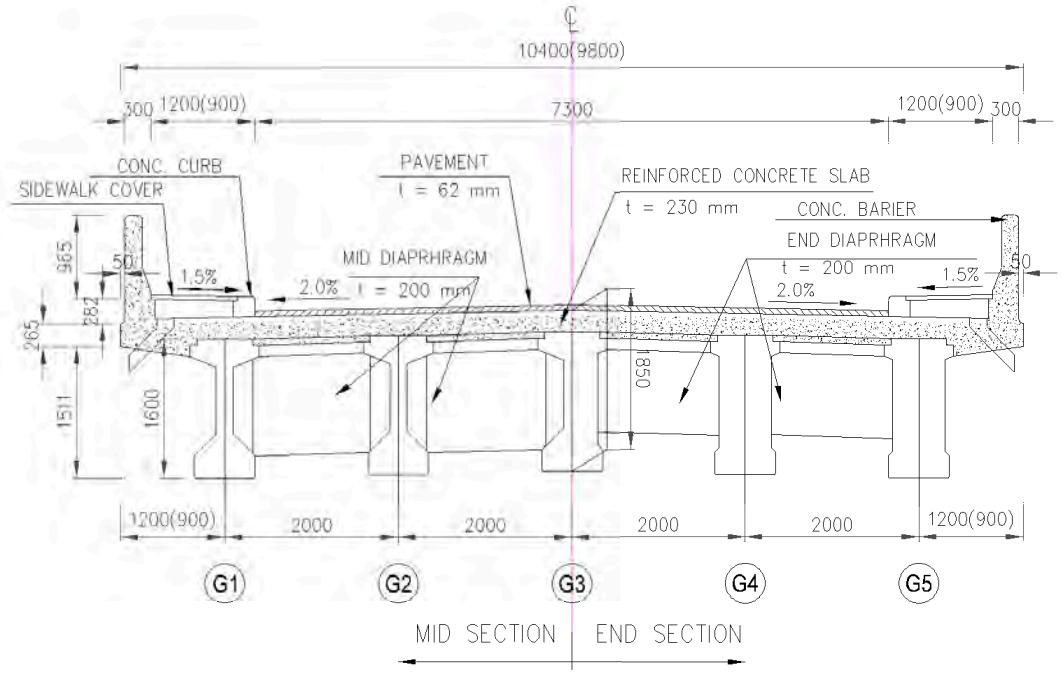


Source: JICA Survey Team

Figure 7.4.2 PC-I Girder (Chaired Single Span Girders)

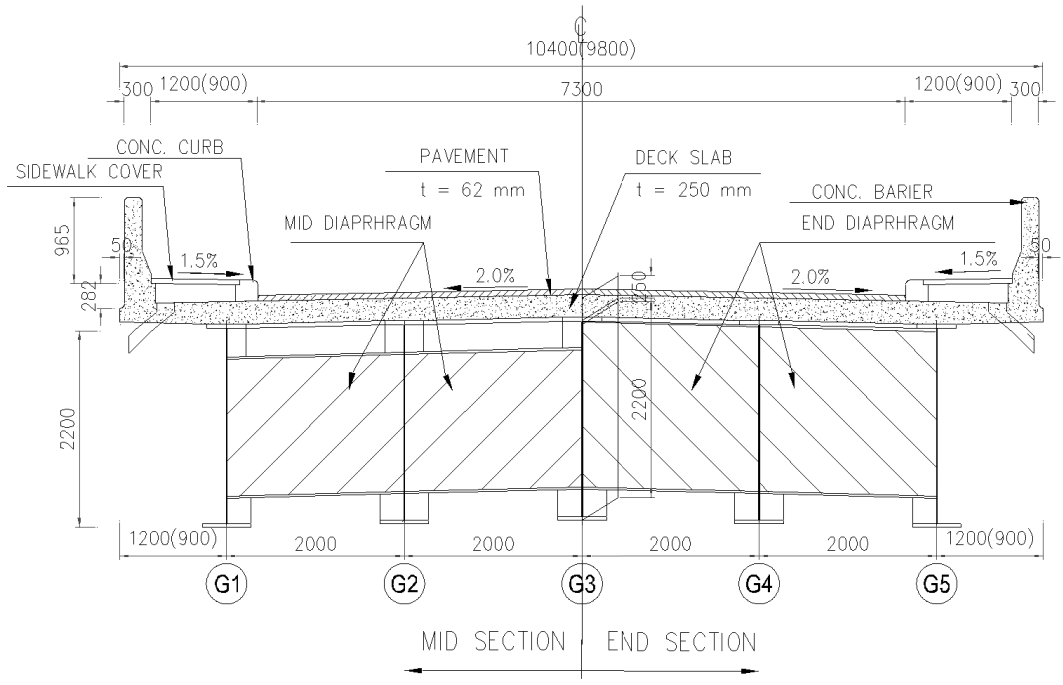
(2) Cross Sections

Cross sections for PC-I girder bridges and Steel-I girder bridges are shown in Figure 7.4.3 and 7.4.4, where number of girders (5) and girder arrangement are same for both types. Slab thickness is designed as 23 cm for PC-I and 25 cm for Steel-I in consideration of deflection of steel girders.



Source: JICA Survey Team

Figure 7.4.3 Cross Section for PC-I Girder



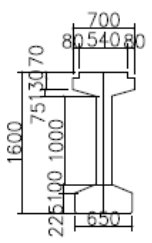
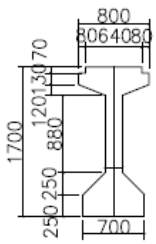
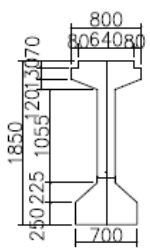
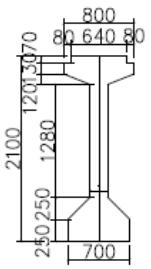
Source: JICA Survey Team

Figure 7.4.4 Cross Section for Steel-I Girder

(3) Result of Preliminary Design

According to the bridge design criteria, superstructures for PC-I and Steel-I girders with series of standard spans were designed. The results are summarized in Table 7.4.1 and 7.4.2.

Table 7.4.1 Summary of Preliminary Design of PC-I

Length	25	30	35	40
Span	25	30	35	40
Width	10.4	10.4	10.4	10.4
Concrete Strength	Class A1 (40 Mpa)	Class A1 (40 Mpa)	Class A1 (40 Mpa)	Class A1 (40 Mpa)
Cross Section				
Sectlon Area (m2)	0.5290	0.6723	0.6960	0.7523
Unlt welght (tm)	1.323	1.661	1.740	1.881

Source: JICA Survey Team

Table 7.4.2 Summary of Preliminary Design of Steel-I

Length		40	50	60	80	100	120	150	180
Span		40	50	60	40+40	50+50	60+60	50+50+50	60+60+60
Width		10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4
Cross Section		440*47 2200*11 550*34	540*49 2700*13 680*34	640*47 3200*16 800*33	440*40 2200*11 550*48	520*39 2600*13 650*50	620*47 3100*15 780*47	500*36 2500*12 630*47	580*40 2900*14 730*47
Material		SMA490W	SMA490W	SMA490W	SMA490W	SMA490W	SMA490W	SMA490W	SMA490W
Weight (ton)	SMA490W/400W	97.5	158.9	262.1	174.1	288.7	467.7	400.9	623.3
	SM400, etc.	4.8	7.1	8.7	8.5	13.6	19.6	18.4	20.8
	HTB	2.2	3.5	8.4	3.9	6.5	10.3	8.9	19.9
	Sum	104.5	169.4	279.2	186.5	308.7	497.6	428.2	664.0
Unit weight (t/m2)		0.251	0.326	0.447	0.224	0.297	0.399	0.274	0.355

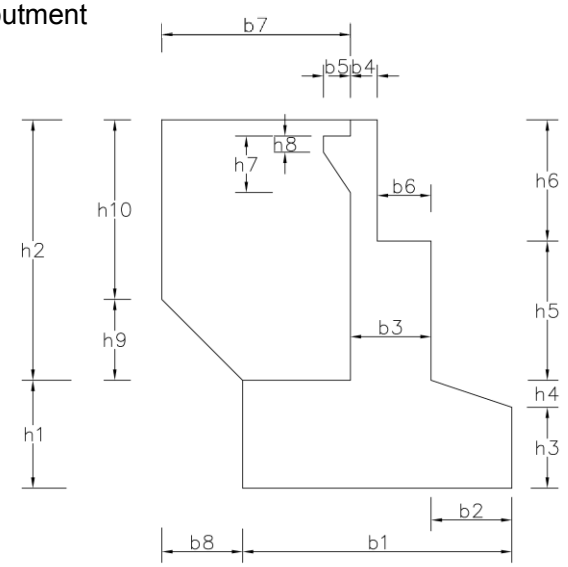
Source: JICA Survey Team

7.4.2 Substructures

(1) Abutments and Piers

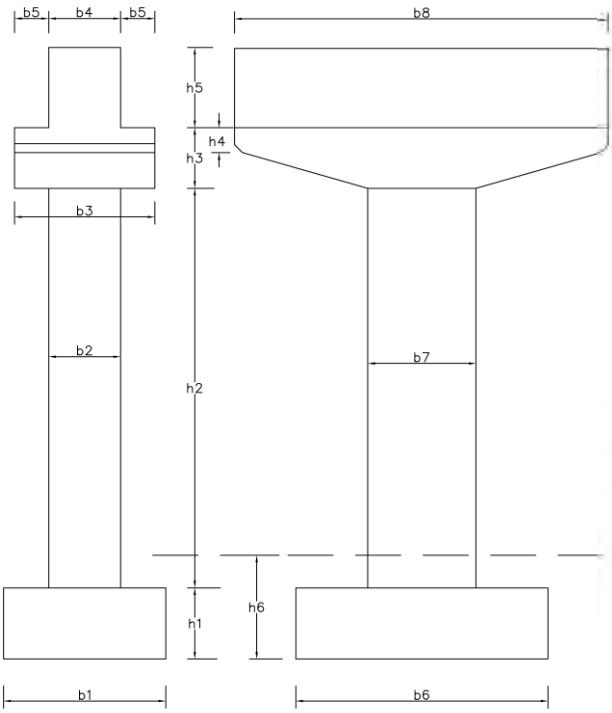
As with superstructures, substructures (i.e. abutments and piers) are also standardized as shown in Figure 7.4.5.

Abutment



h1 =	1.50 m		b1 =	5.00 m
h2 =	5.83 m		b2 =	1.50 m
h3 =	1.00 m		b3 =	1.50 m
h4 =	0.50 m		b4 =	0.50 m
h5 =	3.58 m		b5 =	0.50 m
h6 =	2.25 m		b6 =	1.00 m
h7 =	1.05 m		b7 =	3.50 m
h8 =	0.30 m		b8 =	1.50 m
h9 =	1.50 m			
h10 =	4.33 m			
Excavation Height1	=	4.8 m		
Excavation Height2	=	5.65 m		
Volume Abutment	=	145.16 Cu.m		
Volume Wingwall	=	9.64 Cu.m		
Total	=	154.8 Cu.m		
Reinforced bar	=	28.638 ton		

Pier



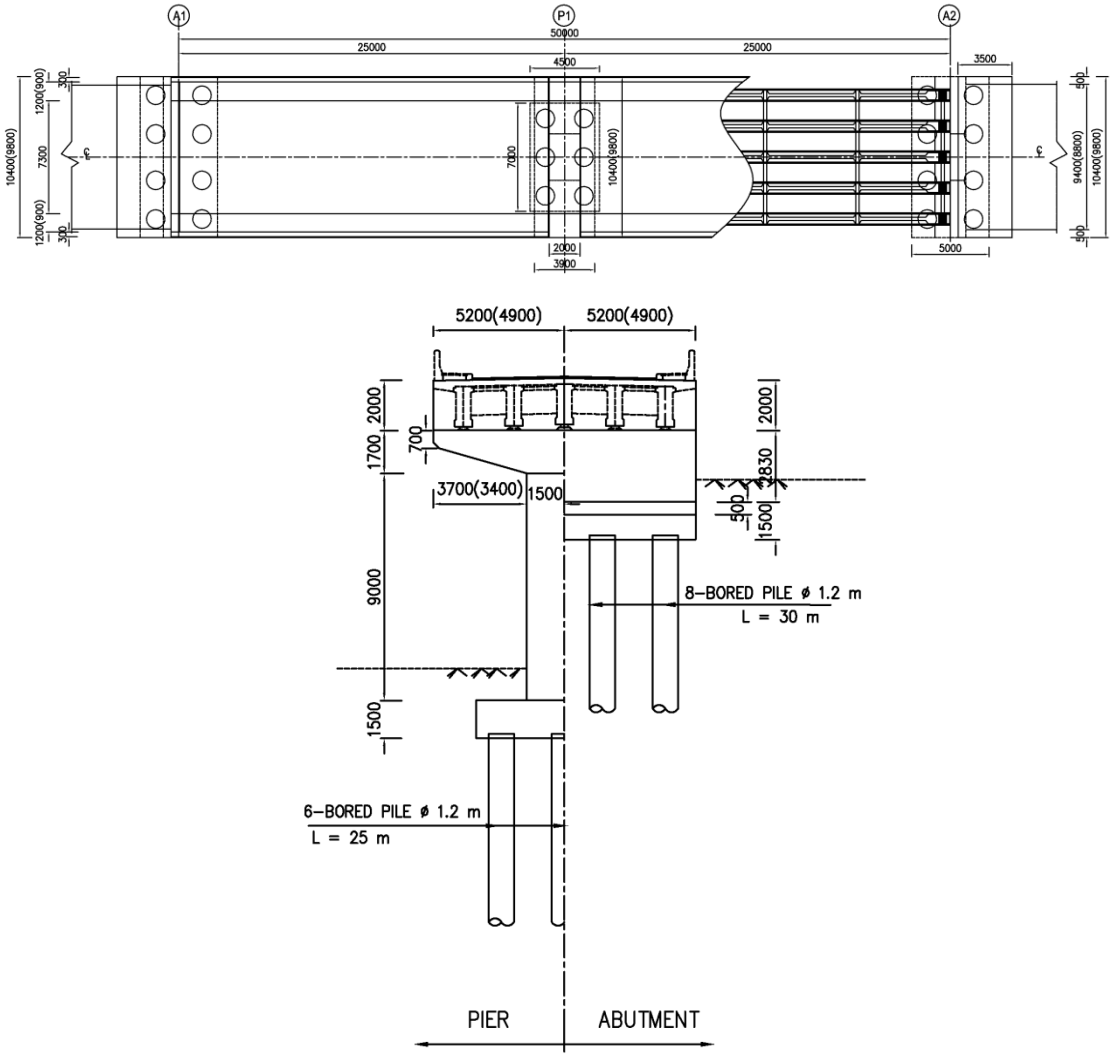
h1 =	2.00 m	b1 =	4.50 m
h2 =	11.21 m	b2 =	2.00 m
h3 =	1.70 m	b3 =	3.90 m
h4 =	0.70 m	b4 =	2.00 m
h5 =	2.25 m	b5 =	0.95 m
h6a =	3.90 m	b6 =	7.00 m
h6b =	3.30 m	b7 =	3.00 m
		b8 =	10.40 m

*All dimensions shown in figure are taken as reference.
Source: JICA Survey Team

Figure 7.4.5 Standard Abutment and Pier

(2) Piles

Cast-in-place concrete piles are selected in consideration of the constructability and easy procurement of material/equipment, which is same type of EBBIP. Based on the preliminary calculations, 8 piles with 1.2 m diameter for abutment and 6 piles with 1.2 m diameter for pier are arranged. Pile length of each bridge location is determined based on the geotechnical survey conducted at each location.



Source: JICA Survey Team

Figure 7.4.6 Pile Arrangement

7.4.3 Summary of Preliminary Design

A summary of preliminary design for 105 bridges is shown in Table 7.4.3. The comparison between existing and new bridges is shown in Table 7.4.4.

Table 7.4.3 Design Summary of 105 Bridges (1)

SN	Zone	Bridge Name	Road Type	Bridge Type	Width (m)	No of Spans	Span Arrangement (m)	Total Length	Bridge Area (m2)	Abutment Pile	Pier Pile Length	Left Approach	Right Approach
1	Barisal	Boalia Bazar Bridge	N	PC-I	10.4	1	40	40	416	44.9	0	7,593	10,247
2	Rangpur	Sharnamoti Bridge	N	PC-I	10.4	2	35+35	70	728	20.6	17.6	10,570	14,939
3	Rajshahi	Chanda Bridge	N	PC-I	10.4	2	35+25	60	624	29.5	24.2	5,518	2,840
4	Rajshahi	Palgari Bridge	N	PC-I	10.4	2	35+25	60	624	33.4	27.1	19,386	13,062
5	Rajshahi	Bhuyagati Bridge	N	PC-I	10.4	3	25+30+25	80	832	26.9	20.8	18,607	8,467
6	Rangpur	Mohosthan Bridge	N	Steel-I	10.4	3	40+40+40	120	1,248	30.0	25.8	6,849	9,983
7	Rajshahi	Chanda Bridge	N	PC-I	10.4	2	35+25	60	624	26.7	21.4	3,411	4,422
8	Rajshahi	Goilhar Bridge	N	PC-I	10.4	2	35+25	60	624	33.8	29.0	12,980	14,262
9	Rajshahi	Purbodalua Bridge	N	PC-I	10.4	3	25+30+25	80	832	25.4	19.1	3,335	9,571
10	Rangpur	Bupinath Bridge	N	PC-I	10.4	2	35+25	60	624	23.8	19.0	6,838	6,266
11	Rangpur	Barati Bridge	N	Steel-I	10.4	4	40+40+40+40	160	1,664	22.9	15.6	4,414	5,635
12	Barisal	Bakerganj Steel Bridge	N	PC-I	10.4	1	35	35	364	37.3	0	6,627	7,893
13	Gopalganj	Jhuldibazar Bridge	N	PC-I	10.4	1	30	30	312	38.0	0	8,722	8,290
14	Gopalganj	Karimpur Bridge	N	PC-I	10.4	2	40+25	65	676	48.9	42.3	9,505	7,450
15	Gopalganj	Porkitpur Bridge	N	PC-I	10.4	1	30	30	312	31.1	0	7,713	7,602
16	Rajshahi	Nukali Bridge	N	Steel-I	10.4	1	50.0	50	520	33.8	0	14,352	12,053
17	Rajshahi	Dattapara Bridge	N	PC-I	10.4	1	40.0	40	416	22.6	0	4,059	3,201
18	Rajshahi	Horisonkorpur Bridge	R	PC-I	10.4	2	25+25	50	520	20.6	16.6	1,406	1,195
19	Rajshahi	Jugnidaha Bridge	N	PC-I	10.4	2	40+25	65	676	24.7	20.8	15,410	8,290
20	Rajshahi	Punduria Bridge	N	Steel-I	10.4	3	40+50+40	130	1,352	22.7	17.6	14,261	11,922
21	Khulna	G.K. Bridge	N	PC-I	10.4	2	30+25	55	572	26.1	23.7	289	1,742
22	Khulna	Gora bridge	N	PC-I	10.4	1	30	30	312	49.2	0	3,614	3,172
23	Gopalganj	Barashia Bridge	N	PC-I	10.4	3	25+40+25	90	936	52.7	44.8	5,142	4,502
24	Rangpur	-	N	PC-I	10.4	1	30.0	30	312	22.8	0	4,724	6,496
25	Khulna	Balai bridge.	N	PC-I	10.4	2	25+35	60	624	53.6	51.1	3,015	3,976
26	Gopalganj	Amgram bridge	N	PC-I	10.4	1	40	40	416	34.8	0	10,140	8,739
27	Rajshahi	Kazir Hat Bridge	N	Steel-I	10.4	4	40+40+40+40	160	1,664	26.3	20.5	6,224	8,197
28	Rajshahi	Atrai Bridge	R	Steel-I	10.4	3	50+50+60	160	1,664	25.0	14.0	18,058	23,488
29	Gopalganj	Kanaipur Bridge	N	PC-I	10.4	1	40	40	416	35.2	0	4,301	1,860
30	Gopalganj	Brahmonkanda Bridge	N	PC-I	10.4	1	30	30	312	33.2	0	9,010	16,707
31	Rangpur	Gaudangi Bridge	N	PC-I	10.4	2	40+25	65	676	24.7	23.7	9,337	9,735
32	Gopalganj	Bimankanda bridge	N	PC-I	10.4	2	35+25	60	624	35.6	29.8	14,034	10,903
33	Rajshahi	Chowkidhoh Bridge	N	PC-I	10.4	2	35+25	60	624	30.6	24.5	9,183	8,661
34	Rajshahi	Notun Dhoh Bridge	N	PC-I	10.4	2	35+25	60	624	35.1	29.7	8,167	11,170
35	Rajshahi	Dhatia Bridge	N	PC-I	10.4	2	40+25	65	676	24.7	21.8	10,971	10,151
36	Rangpur	Ghoga Bridge	N	PC-I	10.4	2	35+25	60	624	19.9	17.2	8,650	9,961
37	Rajshahi	Vitapara Bridge	N	Steel-I	10.4	2	60+40	100	1,040	31.1	24.4	29,320	19,825
38	Rangpur	Khorkhori bridge	N	PC-I	10.4	2	35+25	60	624	24.7	19.5	5,201	6,866
39	Khulna	Buri Bhairab Bridge	N	PC-I	10.4	1	35	35	364	36.6	0	3,898	871
40	Khulna	Gurakhali Bridge	R	PC-I	10.4	2	30+25	55	572	46.3	41	5,997	5,827
41	Khulna	Dhopa Ghata Bridge	N	PC-I	10.4	5	25+30+40+30+25	150	1,560	29.9	25.5	2,971	2,459
42	Barisal	Dawrey Bridge	R	PC-I	10.4	2	30+35	65	676	43.6	41.0	5,720	4,128
43	Khulna	Barda Bridge	N	PC-I	10.4	3	40+40+25	105	1,092	29.9	22.6	973	2,759
44	Khulna	Balipara Bridge	N	PC-I	10.4	1	40	40	416	25.1	0	6,329	4,733
45	Rangpur	Kharua Vanga Bridge	N	Steel-I	10.4	1	40.0	40	416	26.6	0	5,759	6,259
46	Rangpur	Ichamoti Bridge	N	PC-I	10.4	2	40+25	65	676	36.3	33.9	5,038	2,944
47	Rangpur	Chikli Bridge	N	PC-I	10.4	2	35+25	60	624	26.2	22.1	2,426	1,645
48	Rangpur	Kakra Bridge	Z	Steel-I	9.8	3	60+60+50	170	1,666	23.4	17.0	6,204	7,949
49	Rangpur	Gabura Bridge.	Z	PC-I	9.8	3	30+30+30	90	882	21.5	17.2	1,537	634
50	Rangpur	Mathpara Bridge	Z	Steel-I	9.8	2	40+40	80	784	22.8	15.2	4,515	6,475
51	Rangpur	Bombgara Bridge	Z	PC-I	9.8	2	30+30	60	588	24.0	19.4	5,173	4,265
52	Rangpur	Madarganj Bridge	Z	PC-I	9.8	3	25+30+40	95	931	49.4	44.2	5,910	5,735
53	Rangpur	Raktodaho Bridge	Z	PC-I	9.8	3	25+25+25	75	735	16.1	14.8	9,882	8,233

*SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges

Source: JICA Survey Team

Table 7.4.4 Design Summary of 105 Bridges (2)

SN	Zone	Bridge Name	Road Type	Bridge Type	Width (m)	No of Spans	Span Arrangement (m)	Total Length	Bridge Area (m2)	Abutment Pile	Pier Pile Length	Left Approach	Right Approach
54	Rajshahi	Pura Mukto Monch Bridge	N	PC-I	10.4	2	25+25	50	520	16.3	13.7	3,755	3,439
55	Rangpur	Barodia Khali Bridge	Z	Steel-I	9.8	1	60.0	60	588	23.4	0.0	12,763	12,740
56	Barisal	Rahamatpur bridge	N	PC-I	10.4	2	30+30	60	624	38.2	33.4	8,132	5,386
57	Barisal	gounagata bridge	N	PC-I	10.4	1	35	35	364	58.4	0	4,694	7,086
58	Barisal	Gabtala Steel Bridge	Z	PC-I	9.8	1	30	30	294	55.9	0	3,167	2,841
59	Rangpur	Bahagili Bridge	Z	Steel-I	9.8	4	50+50+50+50	200	1,960	20.9	18.5	5,082	6,090
60	Rangpur	Anandababur Pool	Z	PC-I	9.8	1	35.0	35	343	24.1	0	2,157	1,534
61	Rangpur	Duhuli Bridge	Z	PC-I	9.8	1	25+25	50	490	19.0	0	3,117	751
62	Rangpur	Mongle bari kuthibari Bridge	R	Steel-I	10.4	2	40+50	90	936	19.7	15.1	4,288	8,973
63	Khulna	Shakdaha bridge	R	PC-I	10.4	1	25+25	50	520	64.1	0	8,304	8,176
64	Barisal	Souderkhal bridge	N	PC-I	10.4	1	35	35	364	41.2	0	8,197	4,838
65	Barisal	Bottala Bridge	Z	PC-I	9.8	1	35	35	343	33.9	0	3,410	3,050
66	Rangpur	Katakhali Bridge	N	Steel-I	10.4	3	60+60+50	170	1,768	26.5	20.0	14,180	9,144
67	Khulna	Bittipara Bridge	N	PC-I	10.4	1	35	35	364	19.4	0	6,134	5,820
68	Khulna	Bhangura Bridge	R	PC-I	20.8	1	35	35	728	43.7	0	11,933	9,323
69	Barisal	Asokoti bridge	N	PC-I	10.4	1	30	30	312	39.8	0	3,475	5,170
70	Barisal	Banglabazar Bridge	R	PC-I	10.4	1	25+25	50	520	51.5	0	1,571	1,817
71	Barisal	Box-a-ali Bridge	R	PC-I	10.4	1	30	30	312	45.4	0	4,795	4,217
72	Barisal	Borhanuddin Bridge	R	PC-I	10.4	1	40	40	416	45.7	0	5,028	5,305
73	Rajshahi	Mohis Mari Bridge	R	PC-I	10.4	1	25+25	50	520	18.1	0	7,506	8,287
74	Rajshahi	Naiori Bridge	R	PC-I	10.4	2	30+30	60	624	32.1	28.4	5,400	4,169
75	Rajshahi	Chondi Das Bridge	R	Steel-I	10.4	2	40+40	80	832	41.9	34	6,466	6,750
76	Rangpur	Bottoli Bridge	R	Steel-I	10.4	2	40+40	80	832	12.1	6.5	5,700	4,785
77	Gopalganj	Paprail Bailey Bridge	R	PC-I	10.4	1	40	40	416	24.0	0	7,041	5,467
78	Barisal	Afalbarir Khal Bridge	Z	PC-I	9.8	1	40	40	392	32.1	0	3,554	4,368
79	Rangpur	-	N	PC-I	10.4	1	35.0	35	364	17.5	0	2,139	2,457
80	Rangpur	Chawai Bridge	N	PC-I	10.4	2	35+35	70	728	13.8	10.9	5,684	9,654
81	Barisal	Boda Bridge	Z	PC-I	9.8	2	30+30	60	588	34.8	26.4	3,657	3,921
82	Barisal	Raiyer hat bridge	Z	PC-I	9.8	2	25+25	50	490	46.8	41.0	3,419	4,424
83	Gopalganj	Jajihar Bridge	R	PC-I	10.4	2	25+25	50	520	31.6	27	5,172	4,949
84	Gopalganj	Gazipur Bridge	R	PC-I	10.4	4	30+35+35+30	130	1,352	50.7	41.7	21,989	21,301
85	Gopalganj	Balar Bazar Bridge	R	PC-I	10.4	3	30+40+30	100	1,040	38.9	34.6	5,342	3,388
86	Gopalganj	Kumar Bridge	N	PC-I	10.4	3	40+40+40	120	1,248	43.9	33.9	25,352	32,373
87	Rajshahi	Faliarbil Bridge	Z	PC-I	9.8	1	35.0	35	343	19.5	0	5,744	4,911
88	Rangpur	Choto Dhepa bridge.	Z	PC-I	9.8	2	30+25	55	539	18.2	12.9	4,096	5,435
89	Rangpur	Shampur Bridge.	Z	PC-I	9.8	1	35.0	35	343	21.8	0	4,878	4,949
90	Rangpur	Bondorer pool Bridge	Z	PC-I	9.8	2	30+30	60	588	34.6	30.7	4,070	2,401
91	Rangpur	Khottapara Bridge	Z	PC-I	9.8	1	40.0	40	392	24.8	0	3,112	4,642
92	Barisal	Banogram Bridge	Z	PC-I	9.8	2	30+30	60	588	64.5	57.6	6,317	6,050
93	Rangpur	Bhela Bridge	R	PC-I	10.4	1	40.0	40	416	19.1	0	504	646
94	Barisal	Kalijira bridge	Z	PC-I	9.8	3	40+35+40	115	1,127	50.8	45.4	11,463	9,344
95	Barisal	Masrong bridge	Z	PC-I	9.8	1	40	40	392	62.8	0	3,787	2,856
96	Barisal	Padarhat bridge	Z	PC-I	9.8	2	25+25	50	490	34.3	33	1,304	2,139
97	Barisal	Talukdarhat Bailey Bridge	Z	PC-I	9.8	1	40	40	392	36.7	0	4,658	3,387
98	Khulna	Gollamari bridge	R		10.4				-	-	-	-	-
99	Gopalganj	Shajonpur Bailey Bridge	R	PC-I	10.4	1	35	35	364	32.1	0	8,208	9,384
100	Rajshahi	Debokbazar Bridge	Z	Steel-I	9.8	2	40+40	80	784	31.9	24.7	6,909	12,306
Ⅰ	Khulna	Jhikorgacha Bridge	N	PC-I	20.8	3	35+35+35	105	2,184	38.9	34.5	3,977	920
Ⅱ	Rangpur	-	N	PC-I	10.4	1	40	40	416	17.5	0	3,248	3,025
Ⅲ	Khulna	Chandi Pur Bridge	N	PC-I	10.4	1	30	30	312	31.2	0	4,627	3,796
Ⅳ	Gopalganj	Garakola Bridge	N	PC-I	20.8	3	35+40+35	110	2,288	37.8	28.5	9,418	8,510
Ⅴ	Khulna	Tularampur Bridge	R	PC-I	20.8	3	30+35+30	95	1,976	35.5	27.1	1,742	3,138
Ⅵ	Khulna	Hawai khali Bridge	Z	PC-I	20.8	1	30	30	624	40.6	0	13,613	15,006

*SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges

Source: JICA Survey Team

Table 7.4.5 Comparison of Existing and New Bridges

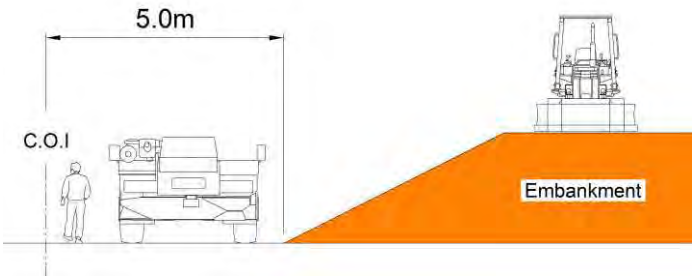
		No. of Bridges	Average Width	Average Length	Total Length
Existing Bridge		105	6.16	54.1	5,682
New Bridge	PC-I	88	10.85	56.88	5,005
	Steel-I	17	10.22	113.53	1,930
	Total	105	10.75	66.05	6,935
Ratio New total/ Existing		-	1.75	1.22	1.22

Source: JICA Survey Team

7.5 Right of Way

The JICA Survey Team conducted a survey in order to clarify the existing Right of Way (ROW) which has been set for each bridge. Based on the result of this survey, where land

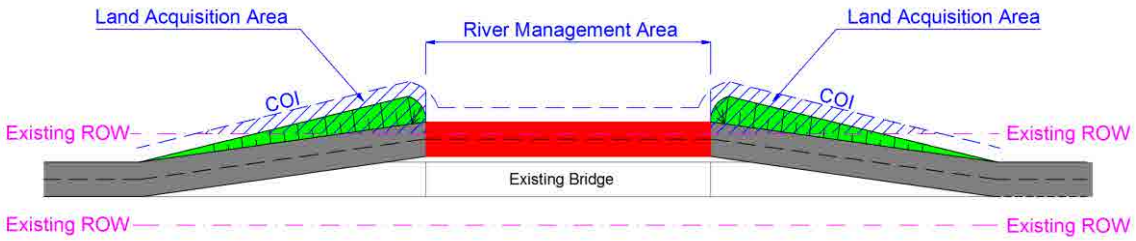
acquisition is required, it is carried out with the Corridor of Impact (COI) set at 5m from the bottom of the embankment as shown in Figure 7.5.1. The COI is set to the minimum required area for construction activities in order to minimize resettlement and compensation.



Source: JICA Survey Team

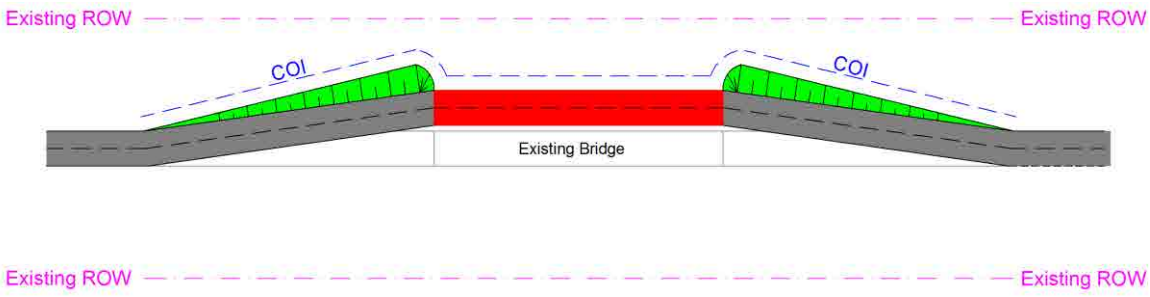
Figure 7.5.1 Corridor of Impact (COI)

As previously mentioned, the ROW already exists for each bridge, and thus the necessity of land acquisition shall differ depending on width of existing ROW as shown in Figure 7.5.2 and Figure 7.5.3.



Source: JICA Survey Team

Figure 7.5.2 Outside of Existing ROW



Source: JICA Survey Team

Figure 7.5.3 Inside of Existing ROW

8. APPLICATION OF MODERN TECHNOLOGIES

8.1 Introduction

Weathering steel is to be adopted for all mid-sized bridges in this Project. Weathering steel girders have the following advantages over PC box girders, (which are generally adopted for mid-sized bridges):

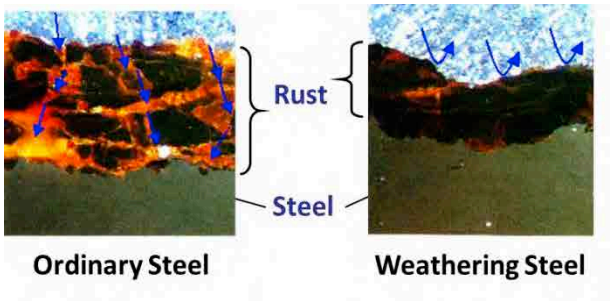
- Constructability: While PC box girder bridges require longer construction periods due to on-site girder construction, weathering steel bridges require shorter periods for construction due to the use of pre-fabricated girders. Thus, the negative impact on regional economy due to construction is less in the case of weathering steel.
- Maintenance: In order to increase the durability of bridges, PC box girders may require surface treatment, which in turn requires periodic retreatment. However, weathering steel does not require such treatment or painting.
- Structural performance: Weathering steel bridges have an advantage in earthquake resistance over PC box girder bridges, which have to be heavier and more costly in order to ensure the earthquake resistance. Note that all Group B bridges are in northern Bangladesh, which is categorized as Seismic Zone II (medium-level seismic activity) and III (high-level seismic activity).
- Technology transfer: While Bangladesh already has experience in PC box girder bridge construction, it does not yet have experience in weathering steel bridge construction. Thus, selection of weathering steel bridges as the bridge type would bring weathering steel technology to Bangladesh through good technological transfer from Japan, which has good experience in this technology. The skills gained will surely prove to be indispensable for future bridge construction in Bangladesh.

In order to confirm whether weathering steel can be applied in Bangladesh, exposure tests and airborne salt tests are carried out in the Survey.

8.2 Weathering Steel

Weathering steel is a high-strength steel that resists corrosion. It resists the corrosive effects of rain, snow, ice, fog, and other meteorological conditions by forming adherent protective

rust over the metal (see Figure 8.2.1 and Figure 8.2.2).



Protective rust is formed on steel surface uniformly and resist corrosion.

Source: JICA Survey Team

Figure 8.2.1 Mechanism of Corrosion Resistance of Weathering Steel

(mass%)

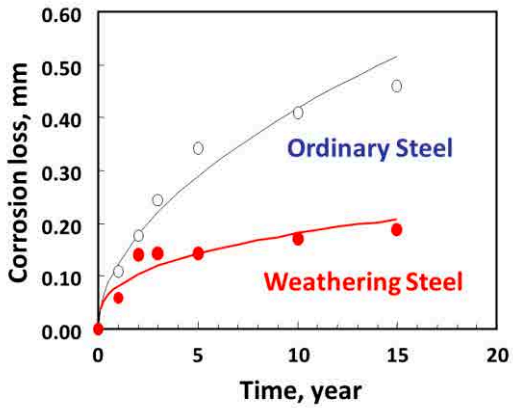
C	Si	Mn	Cu	Ni	Cr
0.12	0.40	0.90	0.35	0.20	0.50

A low alloy steel containing small amounts of corrosion resistant selements such as Cu, Cr and Ni.

Source: JICA Survey Team

Figure 8.2.2 Chemical Composition of Weathering Steel

As can be seen in see Figure 8.2.3, weathering steel has a low corrosion rate, and bridges fabricated from unpainted weathering steel can achieve long design life with only normal maintenance.



The corrosion rate of weathering steel decreased gradually.

Weathering steel could be used without paint.

Source: JICA Survey Team

Figure 8.2.3 Corrosion Rate of Weathering Steel

In simple terms, the steel is allowed to rust and that rust forms a protective coating that slows the rate of future corrosion.

8.3 Tests of Weathering Steel

8.3.1 Test Criteria for Weathering Steel

(1) Applied Test Criteria

In Japan, the test criteria for adopting weathering steel are regulated in the Specifications for Highway Bridges by the Japan Road Association.

The airborne salt test, which ensures that annual average airborne salt is less than 0.05mdd, is the only approved standard for the adoption of weathering steel in Japan, and hence is chiefly used in this Project.

In addition, the exposure test, which ensures that the annual corrosion loss (thickness reduction) is less than 0.03mm, is used as a supplementary test in this Project. This is used as a simplified method, since it requires field and laboratory investigations only once a year (as opposed to 12 times a year in the case of the airborne salt test).

In this Project, the above two tests are conducted in order to obtain various field data from northern and southern zones of Bangladesh.

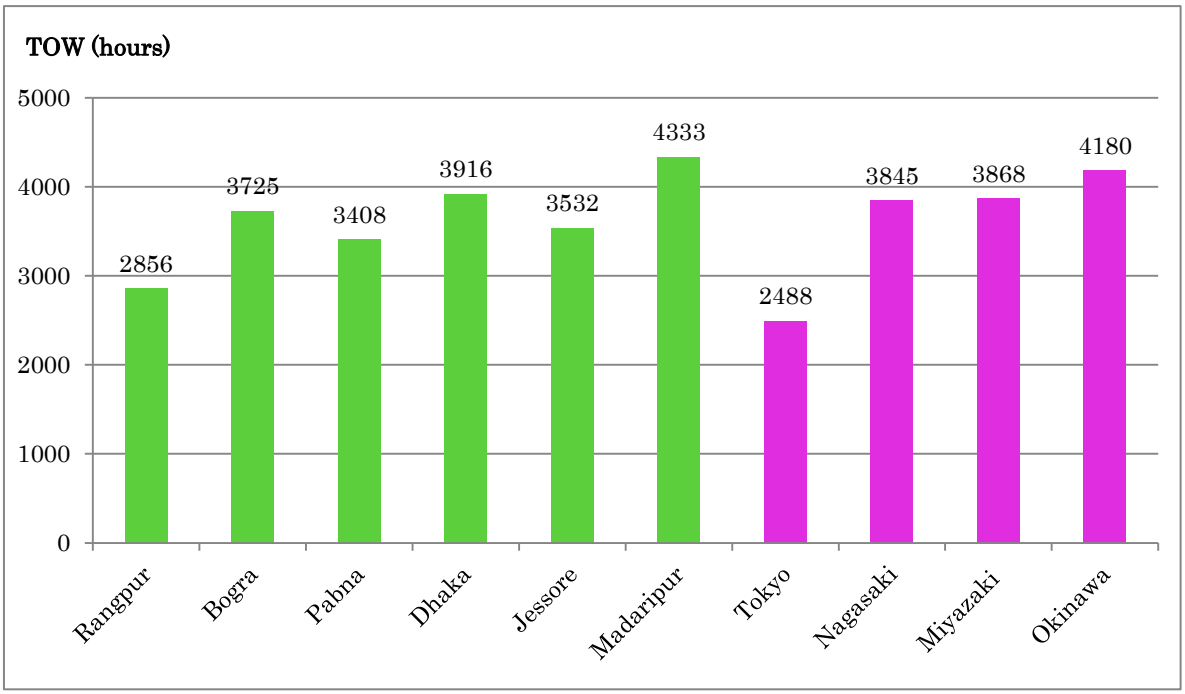
(2) Application of Japanese Criteria in Bangladesh

The major factors that contribute to corrosion on steel plates are airborne salt, temperature and humidity. Yearly temperature and humidity variation can be combined and converted into a value called Time of Wetness (TOW)*.

Figure 8.3.1 shows the TOW at each location in Bangladesh and Japan. The TOW in Bangladesh is higher than that in Tokyo, but almost the same as those in Kyushu area and Okinawa prefectures (Japan).

Weathering steel bridges are being applied in Kyushu area and Okinawa prefecture in case the annual average airborne salt amount is less than 0.05mdd.

It is evaluated that Japanese Criteria can be applied in Bangladesh, since Bangladesh has the same TOW condition as Kyushu area and Okinawa prefecture.



*TOW in Japan is calculated by using estimation method proposed by Japan weathering center

*TOW in Bangladesh is measured in this survey

Source: JICA Survey Team

Figure 8.3.1 TOW in Bangladesh and Japan

* Time of Wetness (TOW)

Time of Wetness (TOW) is the amount of time in which the steel plate surface is wet during a year. TOW is defined in ISO9223 (International Organization for Standardization), and is universally recognized.

8.3.2 Test Locations

Airborne salt tests are carried out on the rooftop of five RHD sub-division offices and one toll office. The purpose of this test is to measure the airborne salt amount in several areas/zones, not at limited locations such as existing bridges. The chosen test locations are the appropriate to measure the airborne salt amount in each area/zone, since there are few buildings or trees to block wind which carries airborne salt from the Bay of Bengal. It was confirmed by the field measurements that rivers are not the source of airborne salt.

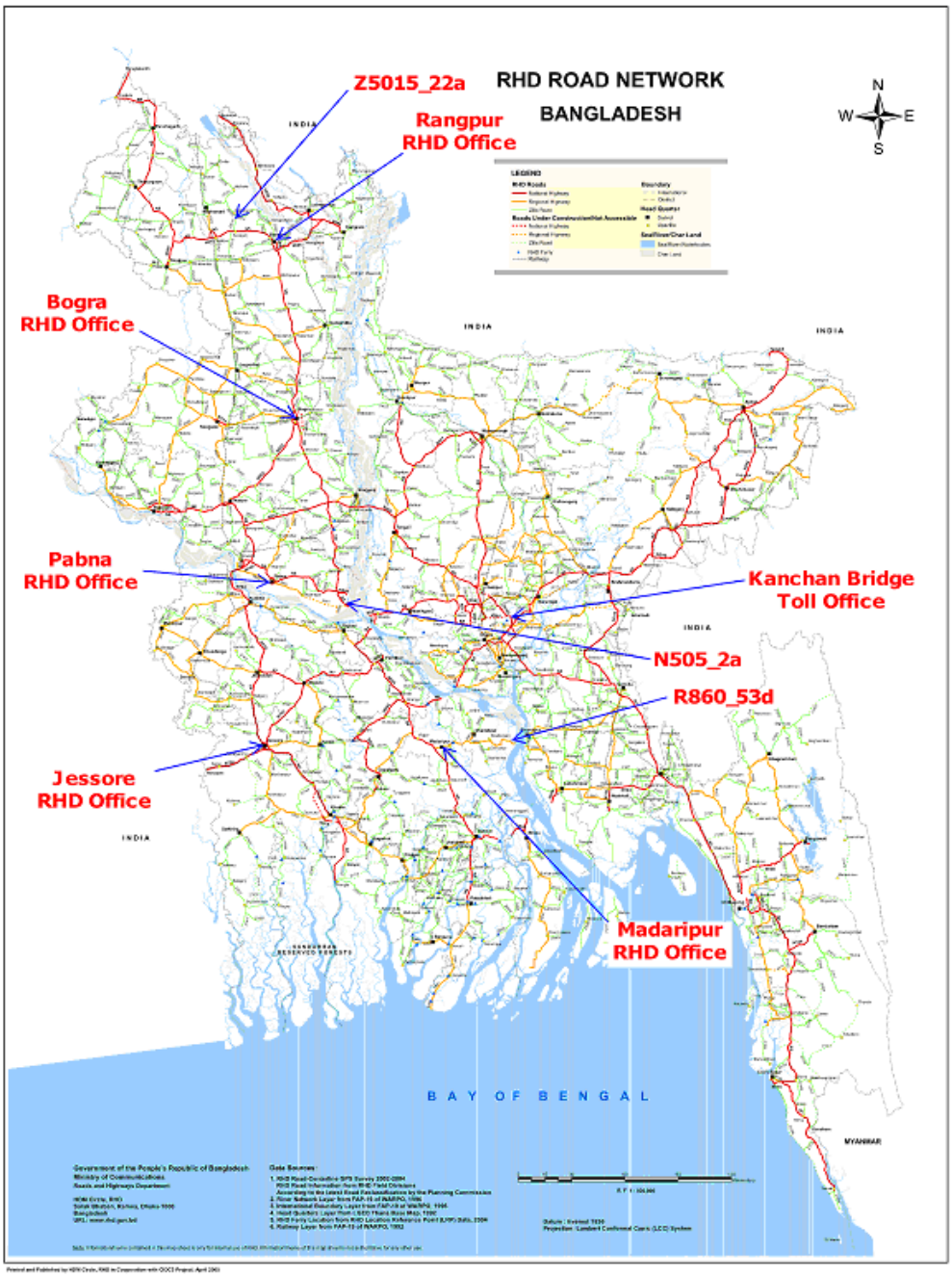
Exposure tests are carried out at the same locations as the airborne salt tests, as well as at existing bridges in order to understand the corrosion conditions at bridges.

The locations for the exposure test and airborne salt test are shown in Table 8.3.1 and Figure 8.3.2.

Table 8.3.1 Locations for Exposure Tests and Airborne Salt Tests

Zone	Location	Exposure Test	Airborne Salt Test
Dhaka	Kanchan Bridge Toll Office	✓	✓
Rangpur	Rangpur RHD Office	✓	✓
Bogra	Bogra RHD Office	✓	✓
Pabna	Pabna RHD Office	✓	✓
Jessore	Jessore RHD Office	✓	✓
Madaripur	Madaripur RHD Office	✓	✓
Rangpur	Z5015_22a (Existing Br.)	✓	
Pabna	ZN505_2a (Existing Br.)	✓	
Madaripur	R860_53d (Existing Br.)	✓	

Source: JICA Survey Team



Source: JICA Survey Team

Figure 8.3.2 Locations for Exposure Tests and Airborne Salt Tests

8.4 Test Method and Schedule

8.4.1 Airborne Salt Test

Airborne salt tests are carried out at 5 RHD sub-division offices and 1 toll office. Gauze frames as shown in Figure 8.4.1 are installed on the rooftops.

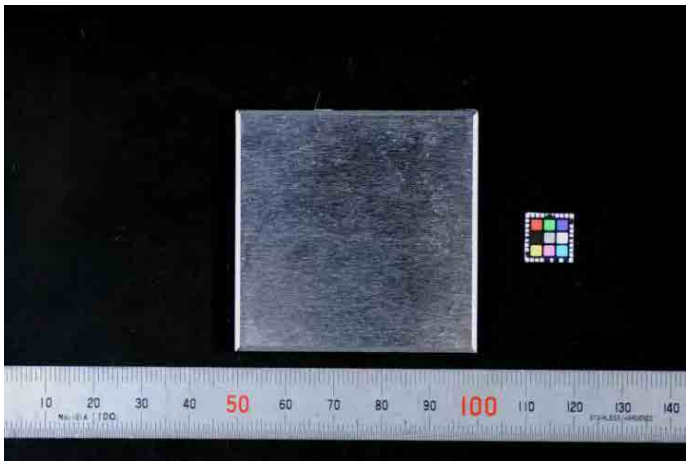
Source: JICA Survey Team

Figure 8.4.1 Gauze Frame for Airborne Salt Test

The total test duration is 12 months. Gauze frames are collected and replaced every month, and those collected are sent to Japan for analysis.

8.4.2 Exposure Test for Weathering Steel

Exposure tests for weathering steel are carried out at 5 RHD sub-division offices, 1 toll office, and 3 existing bridges. Exposure test specimens are made of weathering steel as shown in Figure 8.4.2.



Source: JICA Survey Team

Figure 8.4.2 Exposure Test Specimen

The exposure period of the test specimen is 12 months. 2 sets of specimens are installed at each of the office test locations, and 1 set of specimens is installed at each of the bridge test locations.

1 set of specimens at each of the office test locations are collected 6 months after installation and are sent to Japan for analysis. The remaining set of specimens at each of the office test

locations and each of the bridge test locations are collected 12 months after installation.

8.4.3 Installation of Test Specimens

Test specimens (including gauze frames for the airborne salt tests and exposure test specimens) were installed from January 30th 2014 to February 12th 2014. The specimens are covered by small wooden sheds as shown in Figure 8.4.3.

Source: JICA Survey Team

Figure 8.4.3 Installation of Test Specimens on Office Rooftops

In addition, exposure test specimens were installed at existing bridges as shown in Figure 8.4.4.

Figure 8.4.4 Installation of Exposure Test Specimens at Existing Bridges

8.5 Test Results

8.5.1 Airborne Salt Test Results

Test results of airborne salt test at 6 locations are shown in Table 8.5.1 and Figure 8.5.1. Airborne salt amount at each location is between 0.008 and 0.011. There is not much difference between the airborne salt content at each of the locations. The relationship with distance from coast is not confirmed. This result indicates that wind carries airborne salt from Bay of Bengal without obstruction since all test sites are located in fertile alluvial lowland; these are no mountains.

On other hand, airborne salt amount is different for each month. The amount increases from April to July since high wind speed from south can be observed in this season, as shown in 8.5.2, and this wind carries airborne salt from the Bay of Bengal.

Table 8.5.1 Airborne Salt Test Results

Table. 8. 5. 1 Airborne Salt

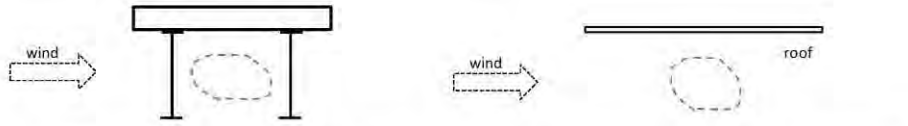
mdd=mg/deci-m2/day

Month	Salt Amount (mdd)	Rangpur S	Rangpur E	Bogra S	Bogra E	Pabna S	Pabna E	Dhaka(Kanchan) S	Dhaka(Kanchan) E	Jessore S	Jessore E	Madaripur S	Madaripur E	Ave of 6 locations
2014 Feb.	Measurement Value (mdd)	0.013	0.019	0.011	0.012	0.0094	0.014	0.016	0.011	0.01	0.011	0.018	0.016	0.008
	Term(days)	36		34		32		37		31		32		
	Max Value M (mdd) *	0.019		0.012		0.014		0.016		0.011		0.018		
	In Girders Value C (mdd) **	0.010		0.006		0.007		0.008		0.006		0.009		
Mar.	Measurement Value (mdd)	0.042	0.046	0.059	0.044	0.019	0.023	0.043	0.028	0.029	0.028	0.042	0.034	0.021
	Term(days)	21		21		21		21		20		19		
	Max Value M (mdd) *	0.046		0.059		0.023		0.043		0.029		0.042		
	In Girders Value C (mdd) **	0.023		0.030		0.012		0.022		0.015		0.021		
Apr.	Measurement Value (mdd)	0.03	0.022	0.038	0.02	0.016	0.012	0.015	0.015	0.052	0.05	0.036	0.038	0.016
	Term(days)	35		35		35		35		35		35		
	Max Value M (mdd) *	0.03		0.038		0.016		0.015		0.052		0.038		
	In Girders Value C (mdd) **	0.015		0.019		0.008		0.008		0.026		0.019		
May.	Measurement Value (mdd)	0.011	0.0068	0.029	0.03	0.032	0.018	0.034	0.051	0.013	0.011	0.012	0.016	0.013
	Term(days)	28		28		28		28		28		28		
	Max Value M (mdd) *	0.011		0.03		0.032		0.051		0.013		0.016		
	In Girders Value C (mdd) **	0.006		0.015		0.016		0.026		0.007		0.008		
Jun.	Measurement Value (mdd)	0.017	0.014	0.0061	0.0077	0.0041	0.0033	0.01	0.008	0.016	0.011	0.023	0.01	0.007
	Term(days)	35		35		35		31		35		35		
	Max Value M (mdd) *	0.017		0.0077		0.0041		0.01		0.016		0.023		
	In Girders Value C (mdd) **	0.009		0.004		0.002		0.005		0.008		0.012		
Jul.	Measurement Value (mdd)	0.016	0.021	0.017	0.017	0.013	0.015	0.016	0.018	0.023	0.031	0.014	0.017	0.010
	Term(days)	33		33		33		37		34		34		
	Max Value M (mdd) *	0.021		0.017		0.015		0.018		0.031		0.017		
	In Girders Value C (mdd) **	0.011		0.009		0.008		0.009		0.016		0.009		
Aug.	Measurement Value (mdd)	0.013	0.013	0.024	0.017	0.0082	0.011	0.0078	0.0052	0.014	0.011	0.0068	0.0073	0.007
	Term(days)	31		31		31		31		30		31		
	Max Value M (mdd) *	0.013		0.024		0.011		0.0078		0.014		0.0073		
	In Girders Value C (mdd) **	0.007		0.012		0.006		0.004		0.007		0.004		
Sep.	Measurement Value (mdd)	0.0069	0.0056	0.012	0.0058	0.0074	0.0069	0.0071	0.0067	0.0067	0.0086	0.019	0.0045	0.005
	Term(days)	35		35		34		35		35		35		
	Max Value M (mdd) *	0.0069		0.012		0.0074		0.0071		0.0086		0.019		
	In Girders Value C (mdd) **	0.003		0.006		0.004		0.004		0.004		0.010		
Oct.	Measurement Value (mdd)	0.011	0.013	0.023	0.021	0.012	0.016	0.01	0.0075	0.009	0.0094	0.014	0.013	0.007
	Term(days)	28		28		29		28		28		28		
	Max Value M (mdd) *	0.013		0.023		0.016		0.01		0.0094		0.014		
	In Girders Value C (mdd) **	0.007		0.012		0.008		0.005		0.005		0.007		
Nov.	Measurement Value (mdd)	0.01	0.0087	0.014	0.0089	0.0056	0.014	0.009	0.0067	0.012	0.012	0.0019	0.0029	0.005
	Term(days)	27		27		27		27		27		26		
	Max Value M (mdd) *	0.01		0.014		0.014		0.009		0.012		0.0029		
	In Girders Value C (mdd) **	0.005		0.007		0.007		0.005		0.006		0.001		
Dec. ***	Measurement Value (mdd)	0.0038	0.0046	0.0120	0.0110	0.0130	0.0160	0.0032	0.0025	0.0089	0.0096	0.0110	0.0094	0.005
	Term(days)	28		95		95		28		88		87		
	Max Value M (mdd) *	0.0046		0.0120		0.0160		0.0032		0.0096		0.0110		
	In Girders Value C (mdd) **	0.002		0.006		0.008		0.002		0.005		0.006		
2015 Jan. ***	Measurement Value (mdd)	0.0190	0.0220	0.0120	0.0110	0.0130	0.0160	0.0100	0.0084	0.0089	0.0096	0.0110	0.0094	0.007
	Term(days)	67		95		95		61		88		87		
	Max Value M (mdd) *	0.0220		0.0120		0.0160		0.0100		0.0096		0.0110		
	In Girders Value C (mdd) **	0.011		0.006		0.008		0.005		0.005		0.006		
Ave. of 12 months (mdd)		0.009		0.011		0.008		0.009		0.009		0.009		0.009

* Max Value M =Maximum (meas.S , meas.E)

** In Girders Value C =Max Value M × K
[Measurement Value] is measured in open environment. [In Girders Value] is measured between bridge girders.
In Japanese standard, [In Girders Value] is used as the criteria.
K is the conversion rate, 0.50

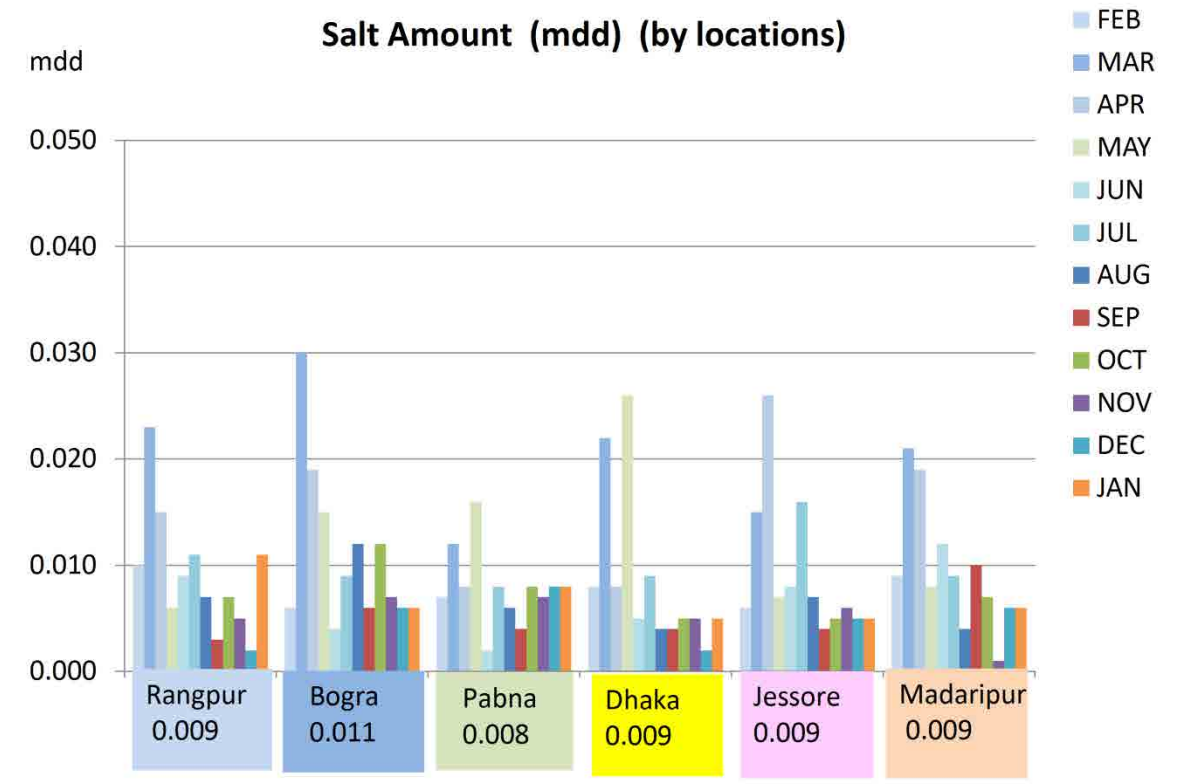
*** 3 months(2014Dec.2015Jan.2015Feb) Average was devoted to Dec. and Jan. equally.

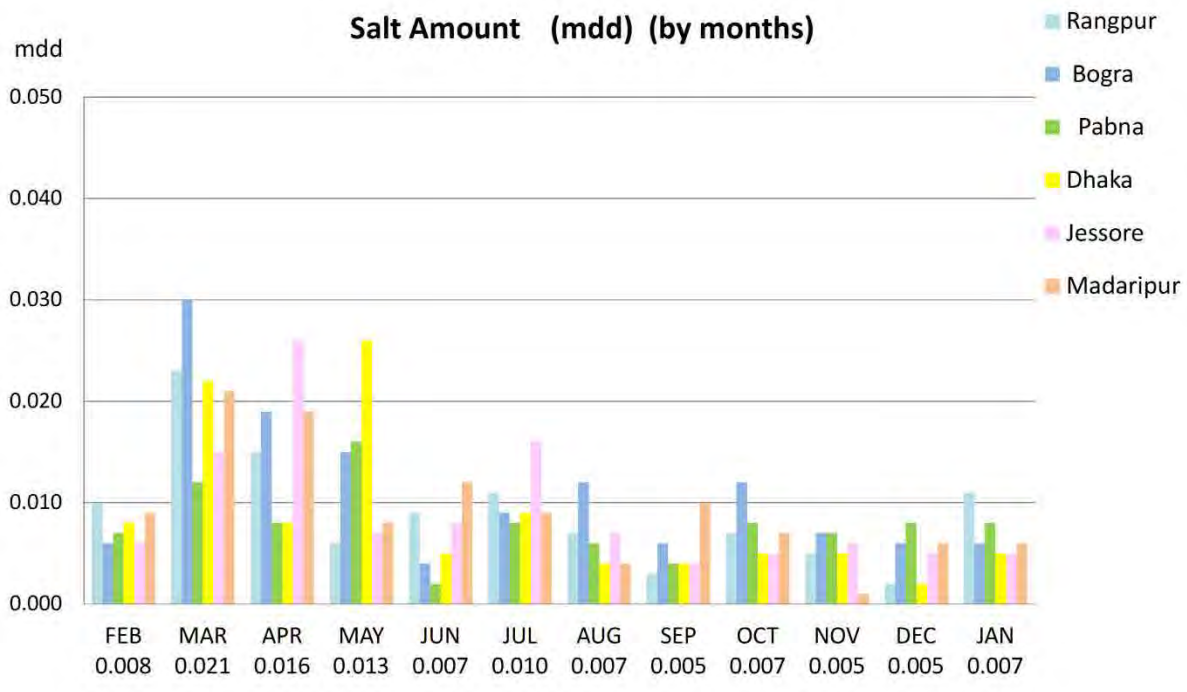


[In Girders Value] is measured between bridge girders.

[Measurement Value] is measured in open environment

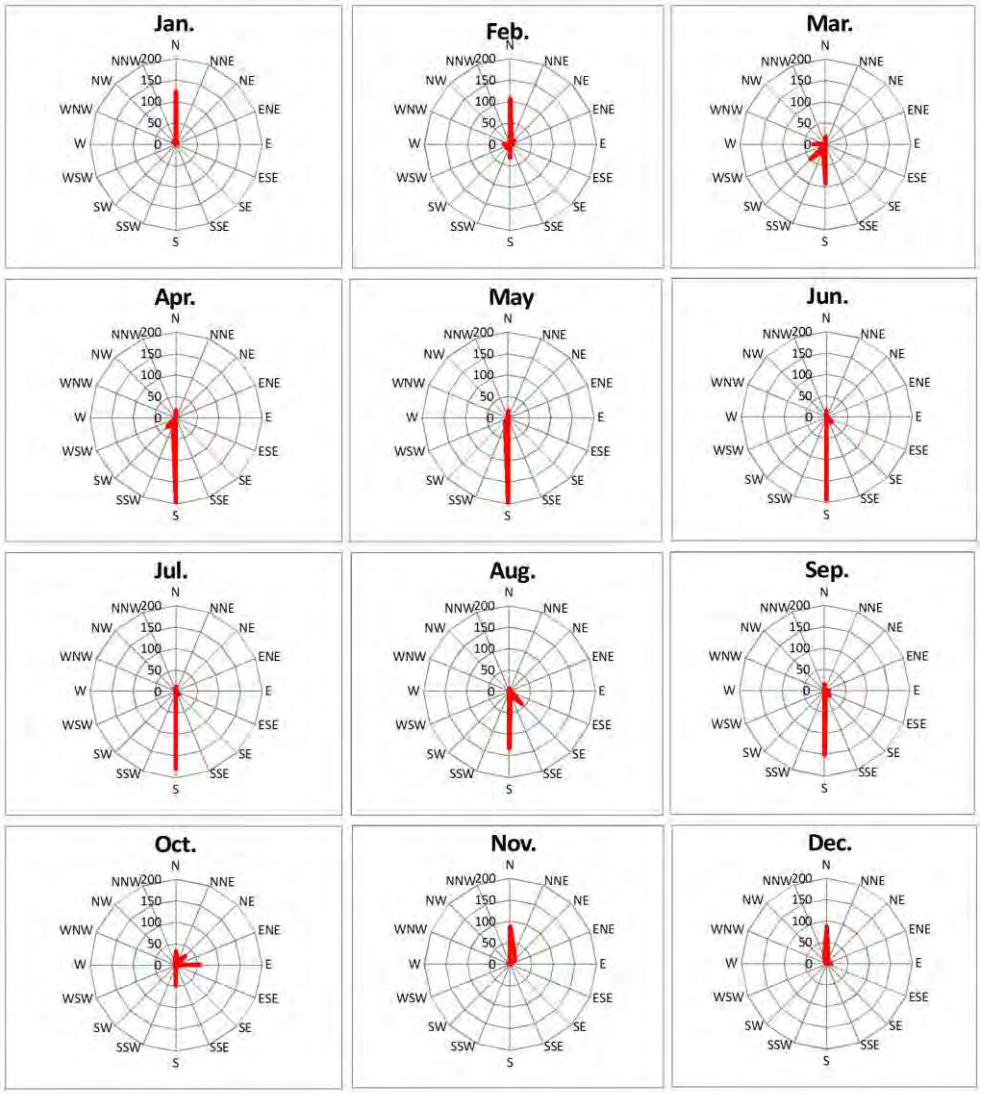
Source: JICA Survey Team





Source: JICA Survey Team

Figure 8.5.1 Airborne Salt Test Results



Source: Bangladesh Meteorological Department Unit: knot (1knot=0.515m/s)

Figure 8.5.2 Wind Directions and 30-year Accumulated Values of Wind Speed in Jessore

8.5.2 Exposure Test Results

Test results of exposure test for after 6 month and one year at RHD office are shown in Table 8.5.2 and Table 8.5.3 and Figure 8.5.3.

According to the exposure test result, corrosion loss (thickness reduction) is between 0.015mm and 0.022mm at each test location. Compared to corrosion loss for the first 6 months (February to July, between 0.014 and 0.019mm), corrosion loss for the last 6 months is low (August to January, between 0.001 and 0.003mm). This is thought to be because rusting rate slows and the airborne salt amount decreases during this period. There is not much difference corrosion losses between each of the locations. The difference is not related

to distance from the coast.

Table 8.5.2 Exposure Test Results after 6 Months

Zone	Test Location	TP weight (g)			loss per m2		thickness reduction (mm)		Evaluation value *	
		initial	6 months	loss	(gm2)	ave	mm	ave		
Rangpur	outside	48.9665	48.3951	0.5738	184.66	182.23	0.0235	0.0232		mm
	upper	49.0566	48.5002	0.5588	179.80		0.0229			
	inside	49.0675	48.6899	0.3800	122.32	127.46	0.0156	0.0162		
	upper	49.0805	48.6708	0.4121	132.60		0.0169		0.014	
	inside	48.9973	48.7335	0.2662	85.62	85.33	0.0109	0.0109		
	lower	49.0454	48.7833	0.2645	85.05		0.0108			
Bogra	outside	48.9764	48.0830	0.8958	288.08	265.08	0.0367	0.0337		mm
	upper	48.9466	48.1961	0.7529	242.08		0.0308			
	inside	48.9688	48.4940	0.4772	153.49	150.49	0.0195	0.0191		
	upper	48.9970	48.5408	0.4586	147.48		0.0188		0.017	
	inside	49.0266	48.6242	0.4048	130.16	123.56	0.0166	0.0157		
	lower	48.9243	48.5626	0.3641	116.97		0.0149			
Pabna	outside	48.8768	48.3799	0.4993	160.46	159.02	0.0204	0.0202		mm
	upper	48.8936	48.4059	0.4901	157.58		0.0200			
	inside	48.7942	48.3727	0.4239	136.35	133.20	0.0173	0.0169		
	upper	48.8744	48.4723	0.4045	130.06		0.0165		0.014	
	inside	48.9160	48.6369	0.2815	90.53	91.16	0.0115	0.0116		
	lower	48.9090	48.6261	0.2853	91.78		0.0117			
Kanchan	outside	49.0510	48.0019	1.0515	338.22	291.12	0.0430	0.0370		mm
	upper	49.0520	48.2956	0.7588	244.02		0.0310			
	inside	48.7227	48.1690	0.5561	178.84	177.61	0.0228	0.0226		
	upper	48.6356	48.0899	0.5481	176.39		0.0224		0.019	
	inside	48.7394	48.3774	0.3644	117.25	115.12	0.0149	0.0146		
	lower	48.8472	48.4986	0.3510	112.98		0.0144			
Jessore	outside	49.0245	48.6061	0.4208	135.33	159.25	0.0172	0.0203		mm
	upper	49.1046	48.5375	0.5695	183.18		0.0233			
	inside	49.2003	48.9001	0.3026	97.31	96.80	0.0124	0.0123		
	upper	49.1572	48.8601	0.2995	96.28		0.0122		0.012	
	inside	49.0081	48.7428	0.2677	86.06	86.33	0.0109	0.0110		
	lower	49.1477	48.8806	0.2695	86.61		0.0110			
Madaripur	outside	49.1101	48.4607	0.6518	209.61	194.31	0.0267	0.0247		mm
	upper	49.0653	48.5109	0.5568	179.00		0.0228			
	inside	49.0159	48.5964	0.4219	135.61	134.18	0.0173	0.0171		
	upper	49.1514	48.7407	0.4131	132.75		0.0169		0.015	
	inside	49.1158	48.7888	0.3294	105.93	104.87	0.0135	0.0133		
	lower	49.2011	48.8807	0.3228	103.81		0.0132			

* Evaluation Value = (inside upper surface loss + inside lower surface loss) / 2

Source: JICA Survey Team

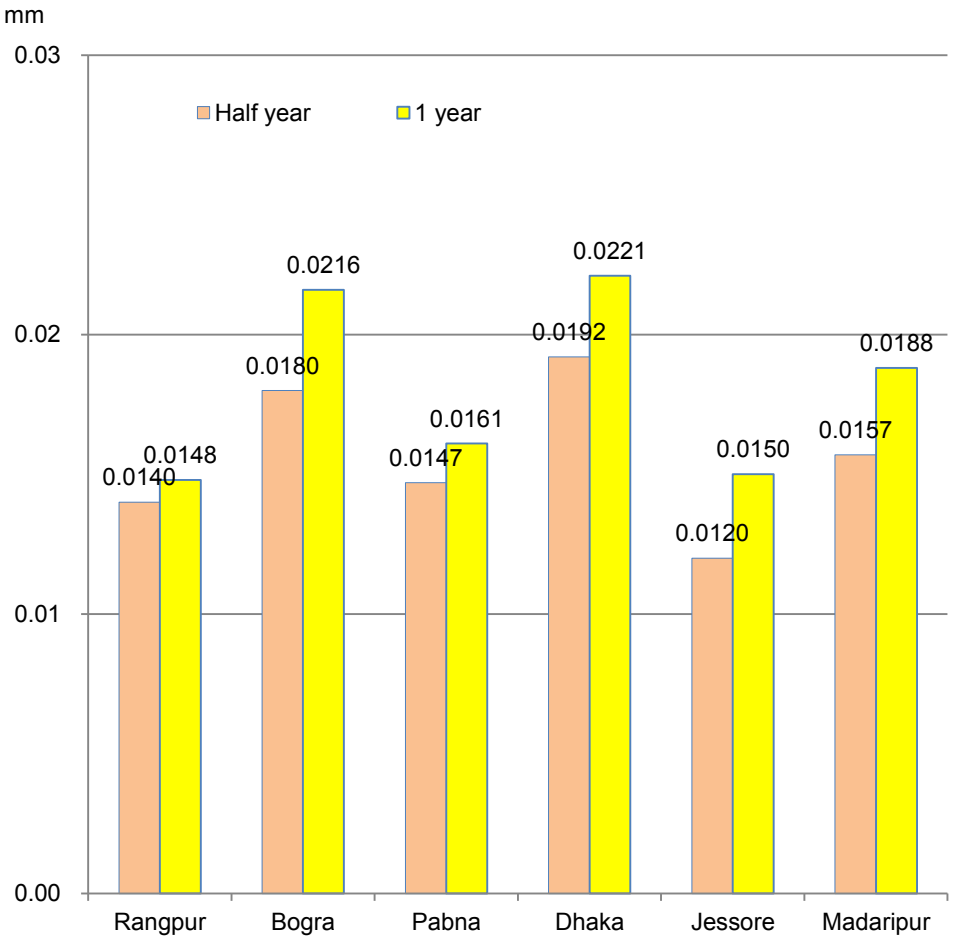
Table 8.5.3 Exposure Test Results after 1 Year

Corrosion Loss and Evaluation Value period: 13 months (Feb 2014-Feb 2015)

Zone	seting surface	exposed period	TP weight (g)			loss per m²		thickness reduction 13 months		evaluation value (inside ave)/12 months
			initial	13 months	loss	(g/m²)	ave	mm	ave	
Rangpur	outside upper	13 months	49.0909	48.2921	0.7992	265.03	253.17	0.0337	0.0322	mm
			49.1066	48.3795	0.7275	241.32		0.0307		
	inside upper		49.0416	48.6012	0.4408	146.39	145.43	0.0186	0.0185	
			49.0594	48.6245	0.4353	144.47		0.0184		
	inside lower		49.1659	48.8261	0.3402	112.82	106.93	0.0144	0.0136	0.0148
			49.1670	48.8628	0.3046	101.04		0.0129		
Bogra	outside upper	13 months	48.9820	47.9581	1.0243	339.80	313.24	0.0432	0.0399	mm
			49.0219	48.1573	0.8650	286.68		0.0365		
	inside upper		48.9562	48.3425	0.6141	203.80	212.56	0.0259	0.0270	
			48.9364	48.2697	0.6671	221.32		0.0282		
	inside lower		49.0298	48.5583	0.4719	156.54	155.79	0.0199	0.0198	0.0216
			49.0468	48.5798	0.4674	155.04		0.0197		
Pabna	outside upper	13 months	48.9474	48.2874	0.6604	219.07	246.89	0.0279	0.0314	mm
			48.9438	48.1159	0.8283	274.70		0.0349		
	inside upper		48.8729	48.3129	0.5604	185.96	168.84	0.0237	0.0215	
			48.8820	48.4250	0.4574	151.72		0.0193		
	inside lower		48.8341	48.5146	0.3199	106.24	105.49	0.0135	0.0134	0.0161
			48.8686	48.5533	0.3157	104.74		0.0133		
Dhaka	outside upper	13 months	48.8492	47.5529	1.2967	430.33	374.40	0.0547	0.0476	mm
			48.8530	47.8939	0.9595	318.47		0.0405		
	inside upper		48.7422	48.1061	0.6365	211.34	209.35	0.0269	0.0266	
			48.8439	48.2193	0.6250	207.35		0.0264		
	inside lower		48.8222	48.3033	0.5193	172.37	166.88	0.0219	0.0212	0.0221
			48.8199	48.3342	0.4861	161.39		0.0205		
Jessore	outside upper	13 months	49.1534	48.5092	0.6446	213.67	246.57	0.0272	0.0314	mm
			49.2179	48.3756	0.8427	279.47		0.0356		
	inside upper		49.1851	48.7759	0.4096	135.78	129.20	0.0173	0.0164	
			49.1104	48.7412	0.3696	122.62		0.0156		
	inside lower		49.0886	48.7105	0.3785	125.48	127.02	0.0160	0.0162	0.0150
			49.0650	48.6776	0.3878	128.56		0.0164		
Madaripur	outside upper	13 months	49.0036	48.1630	0.8410	278.91	259.62	0.0355	0.0330	mm
			49.2238	48.4989	0.7253	240.33		0.0306		
	inside upper		49.2452	48.6428	0.6028	199.79	194.22	0.0254	0.0247	
			49.2395	48.6707	0.5692	188.66		0.0240		
	inside lower		49.2378	48.8624	0.3758	124.58	126.01	0.0158	0.0160	0.0188
			49.1739	48.7899	0.3844	127.43		0.0162		

* Evaluation Value=(inside upper surface loss + inside lower surface loss)/2
* Actually, the result after one year is not one year but one year and one month. JICA survey team could not collect specimens in appropriate time due to general strike.

Source: JICA Survey Team



Source: JICA Survey Team

Figure 8.5.3 Exposure Test Results

Results of exposure tests at each exiting bridge are shown in Table 8.5.4.

Compared with the RHD office, the corrosion losses at existing bridges are high due to some specimens being exposed to water for long periods. Appropriate bridge design which avoids such exposure to water as well as appropriate operation and maintenance are recommended.

Table 8.5.4 Exposure Test Results at Exiting Bridge

Corrosion Loss of Existing Bridges exposed period: 13 months (Feb 2014-Feb 2015)

Zone	Bridge	seting surface	TP weight (g)			loss per m²	thickness reduction 13 months	thickness reduction 12 months		
			initial	13 months	loss	(g/m²)	mm	mm	ave	ave
Rangpur	Z5015-22a	Upper	49.0890	48.2228	0.8666	287.52	0.0366	0.0338	0.0345	0.0316
			49.1434	48.1543	0.9895	328.13	0.0417	0.0385		
			48.9603	48.0969	0.8638	286.52	0.0365	0.0336		
			48.9934	48.1722	0.8216	272.24	0.0346	0.0320		
		Lower	49.0875	48.4990	0.5889	195.15	0.0248	0.0229	0.0288	
			49.0863	48.3794	0.7073	234.59	0.0298	0.0275		
			49.1119	48.0931	1.0192	337.89	0.0430	0.0397		
			49.0441	48.4049	0.6396	212.22	0.0270	0.0249		
Pabna	N505-2a	Upper	49.0635	48.3073	0.7566	250.91	0.0319	0.0295	0.0493	0.0339
			49.0856	48.2722	0.8138	269.97	0.0343	0.0317		
			49.1308	48.1076	1.0236	339.48	0.0432	0.0399		
			49.0771	46.6052	2.4723	819.73	0.1043	0.0963		
		Lower	48.9156	48.2870	0.6290	208.66	0.0265	0.0245	0.0184	
			49.1487	48.7125	0.4366	144.87	0.0184	0.0170		
			49.0536	48.6421	0.4119	136.68	0.0174	0.0161		
			49.1443	48.7317	0.4130	136.92	0.0174	0.0161		
Madaripur	R860-53d	Upper	49.0771	48.4656	0.6119	203.01	0.0258	0.0238	0.0189	0.0223
			49.1394	48.6186	0.5212	172.82	0.0220	0.0203		
			49.1545	48.7135	0.4414	146.35	0.0186	0.0172		
			49.1275	48.7598	0.3681	122.08	0.0155	0.0143		
		Lower	49.1338	48.4442	0.6900	228.87	0.0291	0.0269	0.0256	
			49.1140	48.4162	0.6982	231.54	0.0295	0.0272		
			49.1385	48.4940	0.6449	213.86	0.0272	0.0251		
			49.0878	48.4934	0.5948	197.31	0.0251	0.0232		

8.6 Evaluation and Conclusion

8.6.1 Evaluation

Summary of airborne salt test and exposure test results is shown in Table 8.6.1

Table 8.6.1 Summary of Airborne Salt Test and Exposure Test Results

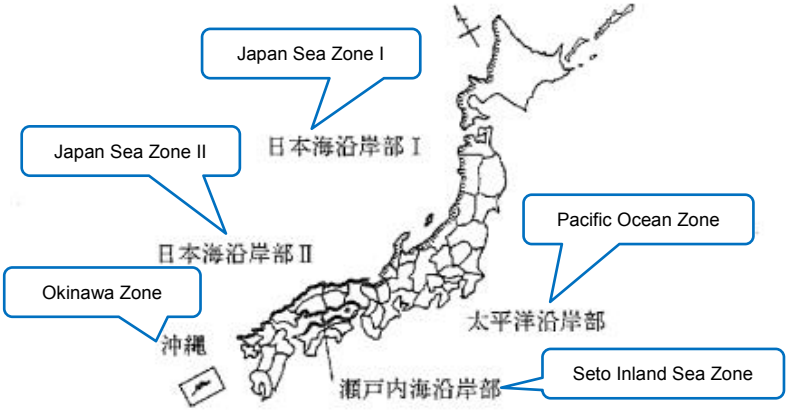
Evaluetion Item		Criteria	Annual Test Results					
			Rangpur	Bogra	Pabna	Dhaka	Jessore	Madaripur
Main Item	Airborne Salt Amount (mdd)	Less than 0.05mdd (annual average)	0.009	0.011	0.008	0.009	0.009	0.009
Sub Item	Corrosion Loss (Thickness Reduction) (mm)	Less than 0.03mm (annual)	0.0148	0.0216	0.0161	0.0221	0.0150	0.0188

*Results of exposure tests at exiting bridge is excluded from evaluation objective due to some specimens being exposed to water
Source: JICA Survey Team

The annual average airborne salt is less than 0.05mdd at all test locations. According to the exposure test result, annual corrosion loss is also less than 0.03mm. These results conclude the weathering steel can be applied.

In addition, these results confirm that weathering steel is permissible for adoption at Jessore and Madaripur in southern zones of Bangladesh (approximately 150km from coast), although no mid-sized bridges are planned for construction in southern zones in WBBIP.

According to the Specifications for Highway Bridges in Japan, weathering steel can be adopted without conducting airborne salt tests depending on the zone and the distance from the coast (Figure 8.6.1). Therefore, it is clear that the distance from the coast is an important factor in deciding on the application of weathering steel.



地域区分		飛来塩分量の測定を省略してよい地域
日本海沿岸部	Ⅰ	海岸線から 20km 超える地域
	Ⅱ	海岸線から 5km を超える地域
太平洋沿岸部		海岸線から 2km を超える地域
瀬戸内海沿岸部		海岸線から 1km を超える地域
沖縄		なし

Zone		Areas not requiring airborne salt tests
Japan Sea	I	>20km from coast
	II	>5km from coast
Pacific Ocean		>2km from coast
Seto Inland Sea		>1km from coast
Okinawa		Test is required everywhere

Source: Specifications for Highway Bridges, Japan Road Association

Figure 8.6.1 Areas where Airborne Salt Test is not Required

WBBIP will be the first bridge construction project in Bangladesh to apply weathering steel (4,100 tons). It is recommended to start from low-risk areas, namely the 2 northernmost zones (areas far from cost), and then expand to other areas.

In Japan, the first weathering steel bridge was constructed in 1967 (Figure 8.6.2), and the

Name: Chita second bridge , Location: Handa city, Aichi Pref.

Figure 8.6.2 First Weathering Steel Bridge in Japan

Figure 8.6.3 Weathering Steel Bridge in Japan

technology has spread all over the nation including severe site conditions near coasts (Figure 8.6.3). In 1999 (the peak year for weathering steel bridges), over 400 bridges with 120,000 tons of weathering steel were constructed. The share of weathering steel bridges as a fraction of all steel bridges in Japan has increased and reached approximately 25 % in 2012 (Figure 8.6.4).

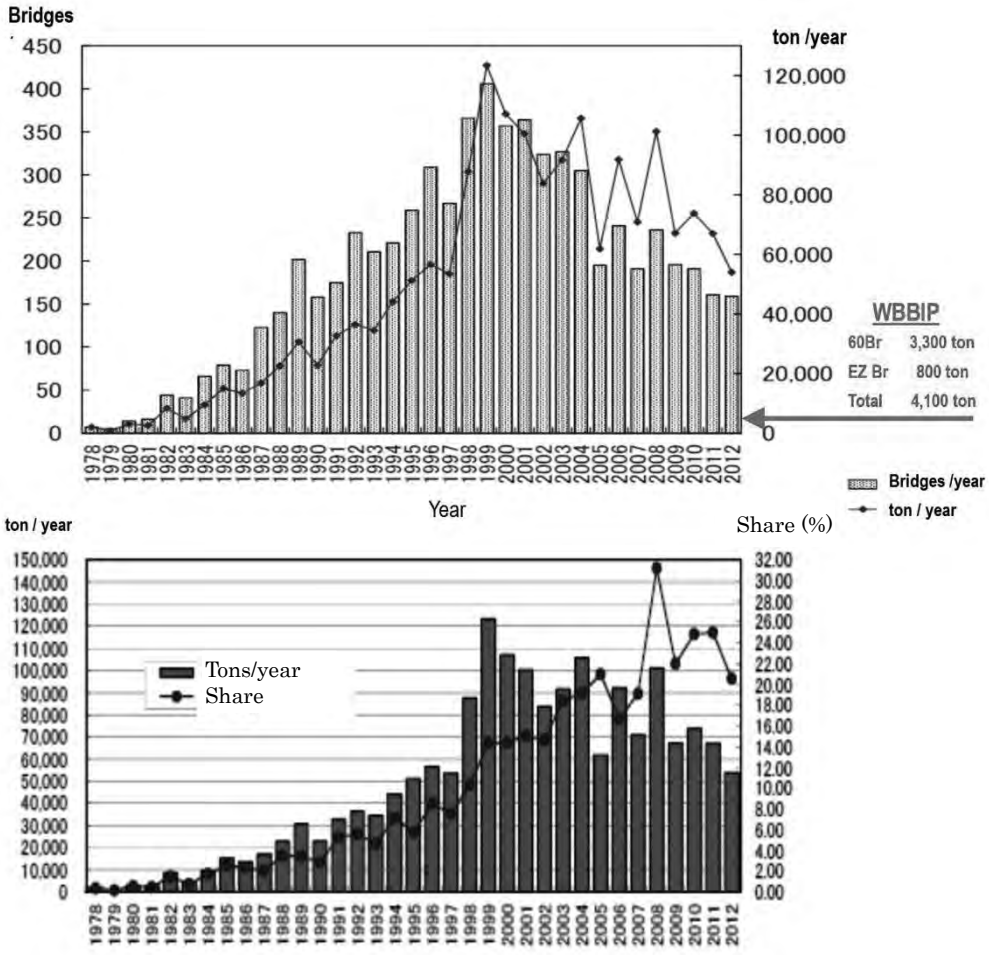


Figure 8.6.4 Share of Weathering Steel Bridge in Japan

8.6.2 Conclusion

As a result of airborne salt tests as well as supplementary exposure tests, it is concluded that weathering steel bridges can be adopted for all mid-sized bridges to be constructed in northern Bangladesh as part of the WBBIP.

9. CONSTRUCTION PLAN

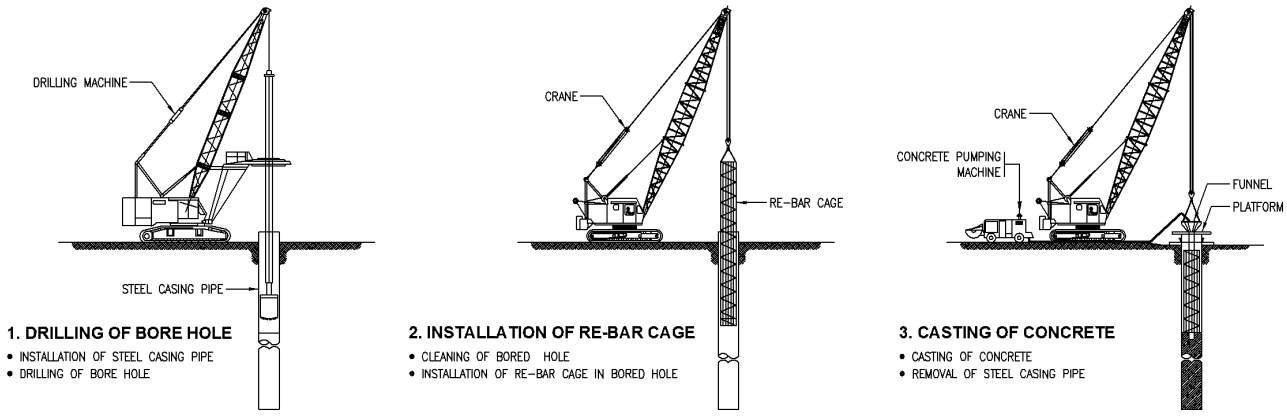
9.1 Introduction

Project bridges will be constructed at the same location as the existing bridges in consideration of impact on existing residences/shops, construction cost, etc. However, project bridges on national roads will be constructed next to the existing bridges in consideration of easy future widening. Therefore, even for busy national roads, traffic control is mostly unnecessary during bridge construction work.

9.2 Bored Pile

Bored Piles will be used for the Project. After installation of temporary steel casing into the ground using a vibrating machine, the soil inside the casing is removed, and bentonite slurry is used to prevent the excavated hole from collapsing.

After installation of the reinforcement cage into the bored hole, concrete is poured into the excavated hole using a tremie pipe. At the end of the casting operation, the temporary steel casing will be removed.



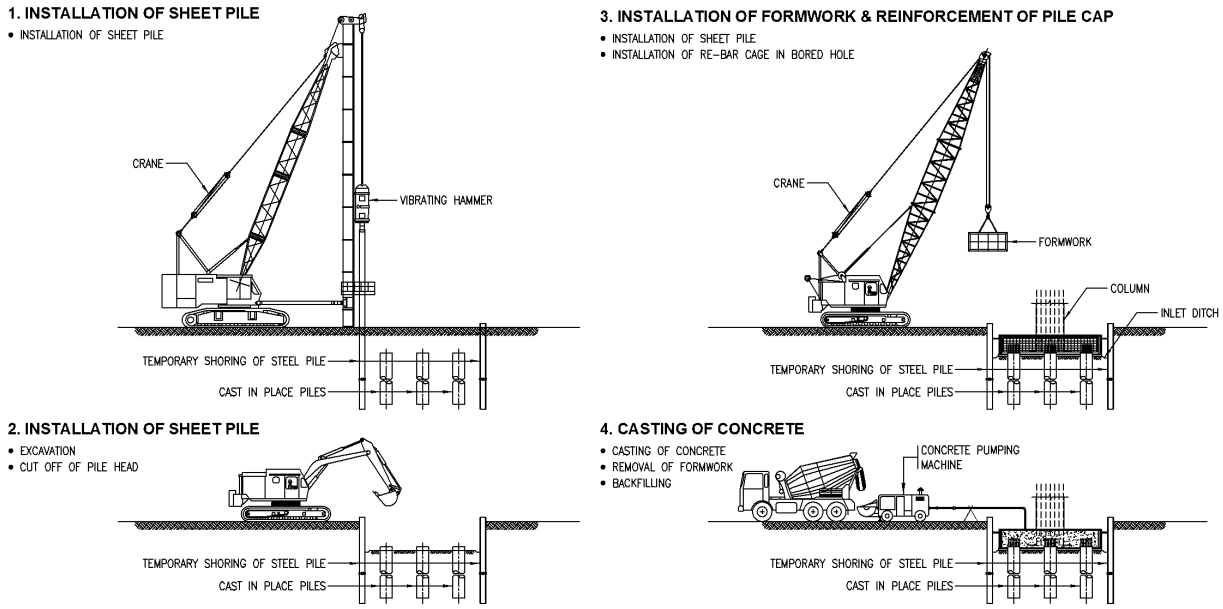
Source: JICA Survey Team

Figure 9.2.1 Construction Method for Bored Piles

9.3 Pile Cap

After installation of sheet piles, excavation is carried out up to the required level. Lean concrete is then cast to provide a plane surface on which the formwork and re-bar can be installed. After casting of the pile cap and removal of the formwork, backfill work will be carried out up to the top surface of the pile cap shortly afterwards.

The use of sheet piles shall be considered during the detailed design stage.



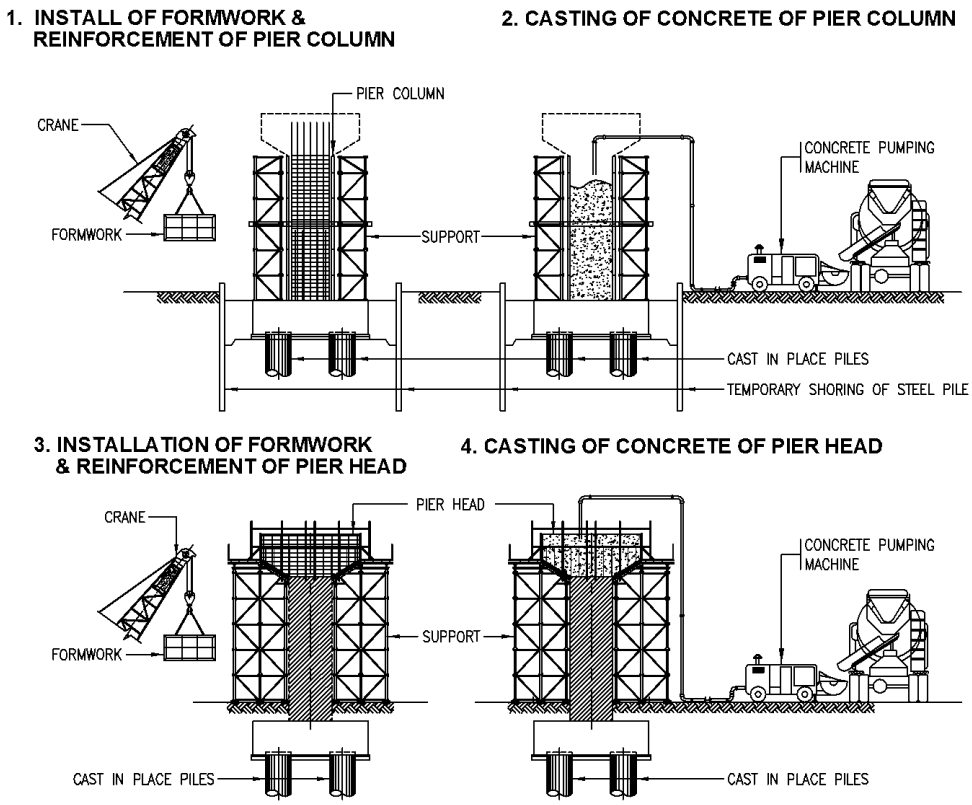
Source: JICA Survey Team

Figure 9.3.1 Construction Method for Pile Caps

9.4 Pier

After installing re-bars overlapping the starter bars of the pile cap, vertical formwork is set up and concrete is cast.

For the pier head, support is assembled from the ground and the formwork is then installed on top of it. After installation of the re-bars, the pier head is cast.



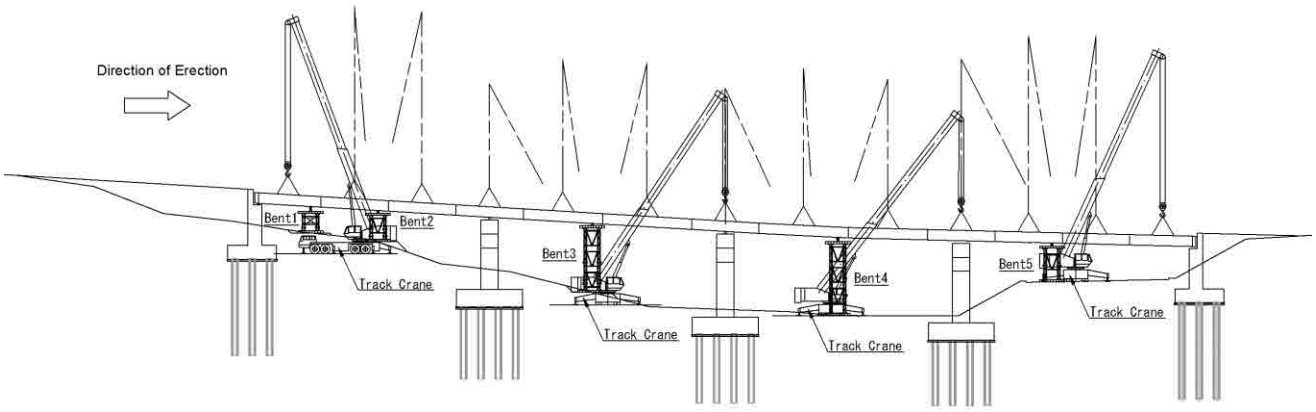
Source: JICA Survey Team

Figure 9.4.1 Construction Method for Piers

9.5 Superstructure (Steel-I Girder)

During the construction of the pile caps and substructures, steel-I girder blocks are prefabricated at a manufacturing factory. When the piers are constructed and bents are installed along the planned alignment, the fabricated blocks are brought on site. The first block is anchored on the pier using a crane. The other blocks are then erected and bolted on the blocks already installed, supported by the bents, until the completion of one span.

As rivers and ponds at the Project sites tend not to have much water during the dry season, truck cranes should be able to approach. Therefore, the “Truck Crane and Bent” method is to be applied as shown in Figure 9.5.1. If there is available land near the site, ground-level assembly of the main girders and reduction of the number of bents shall be considered. If it is difficult that truck crane approach the site during the dry season, the temporary bridge installed for substructure construction shall be utilized, or the direction of the river shall be diverted.

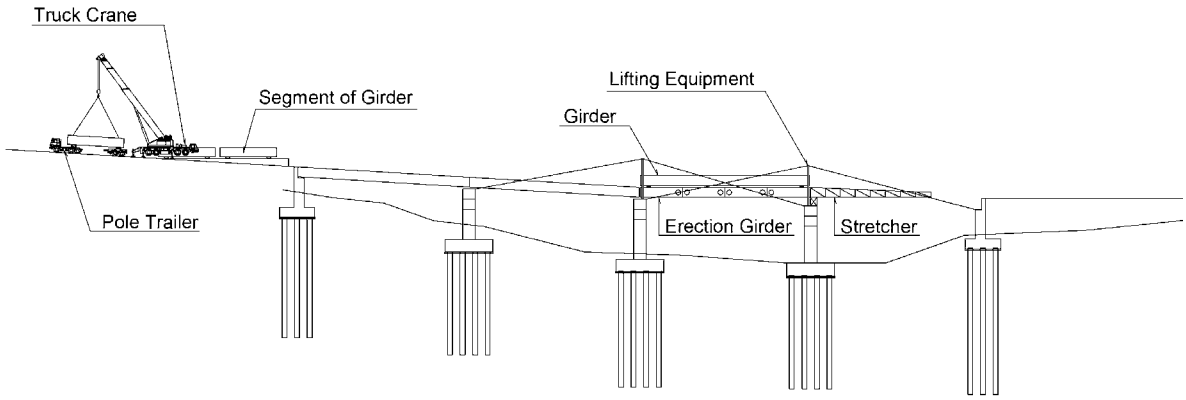


Source: JICA Survey Team

Figure 9.5.1 Construction of Superstructure using "Truck Crane and Bent" Method

In general, if construction using truck cranes is not possible, construction using erection girders is selected. This shall be considered in the detail design stage if the need arises.

As shown in Figure 9.5.2, this method involves casting long sections of the bridge superstructure in a stationary formwork behind one of the abutments, and carrying completed sections forward along the bridge axis using erection girders.



Source: JICA Survey Team

Figure 9.5.2 Construction of Superstructure using Erection Girder Method

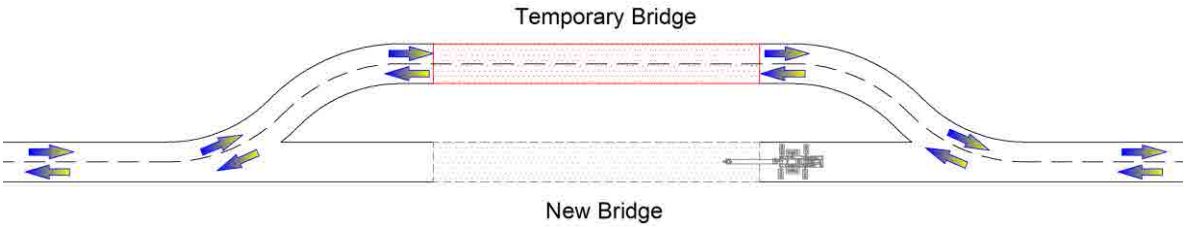
9.6 Superstructure (PC-I girder)

As with Steel-I girders, PC-I girders are mainly erected using truck cranes. During the construction of substructures, PC-I girders are manufactured at fabrication yards near the site. After completion of the piers, PC-I girders are erected using truck cranes.

In the case of difficulty adjusting to erection by track crane, the erection by using erection girder as applicable method shall be studied in detail design stage, in the same way as Steel-I girder.

9.7 Traffic Control during Construction

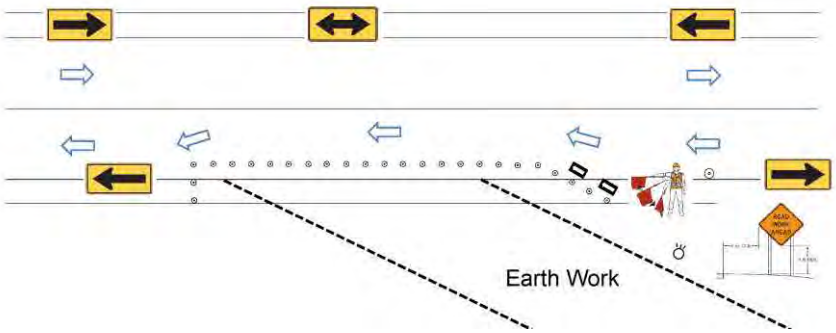
As previously mentioned, project bridges will be constructed in the same position as existing bridges, and thus, temporary bridges are necessary during construction.



Source: JICA Survey Team

Figure 9.7.1 Detour during Construction

Additionally, project bridges on national roads will be constructed next to the existing bridges, and thus, traffic control during construction is basically unnecessary. However, shoulder control is necessary during earthwork and pavement work at connecting areas as shown in Figure 9.7.2.



Source: JICA Survey Team

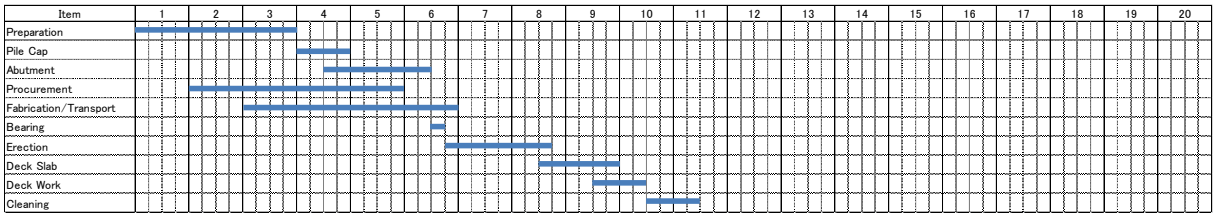
Figure 9.7.2 Traffic Control during Construction

9.8 Construction Schedule

The typical construction schedule for each bridge type is shown in the following tables.

9.8.1 Steel Bridge (Steel-I Girder)

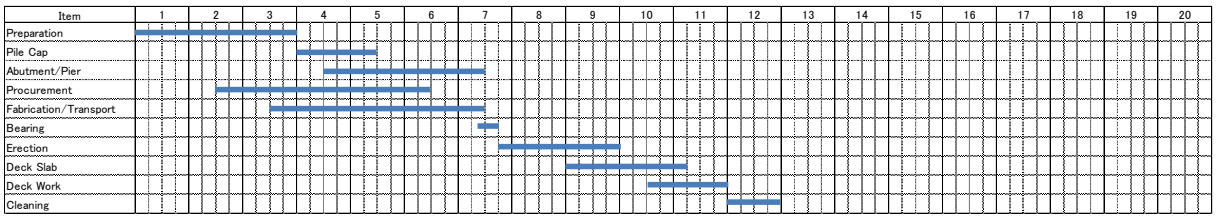
(1) Case-1: Steel-I Girder L=60m



Source: JICA Survey Team

Figure 9.8.1 Construction Schedule for Steel-I Girders of Length 60m

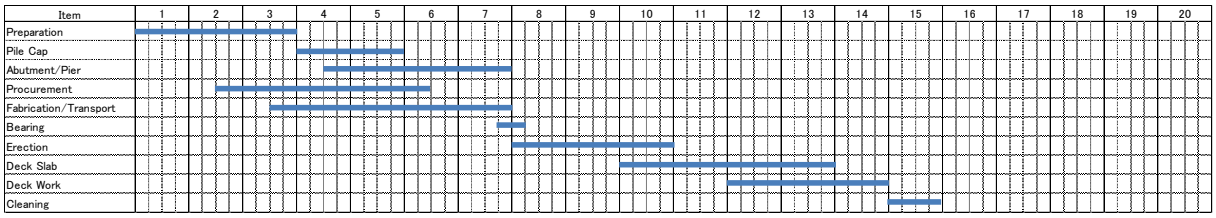
(2) Case-2: Steel-I Girder L=100m (60m + 40m)



Source: JICA Survey Team

Figure 9.8.2 Construction Schedule for Steel-I Girders of Length 100m (60m + 40m)

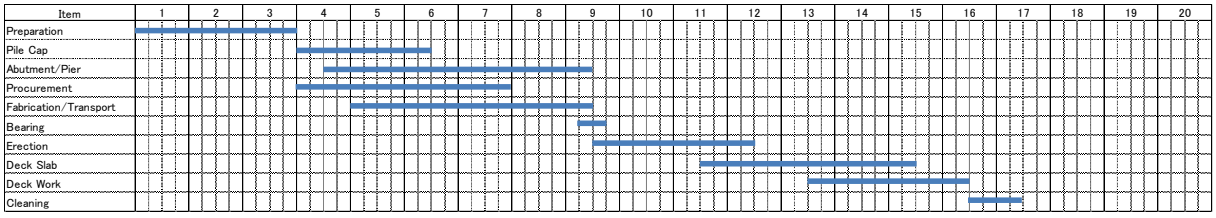
(3) Case-3: Steel-I Girder L=180m (60m x 3)



Source: JICA Survey Team

Figure 9.8.3 Construction Schedule for Steel-I Girders of Length 180m (60m x 3)

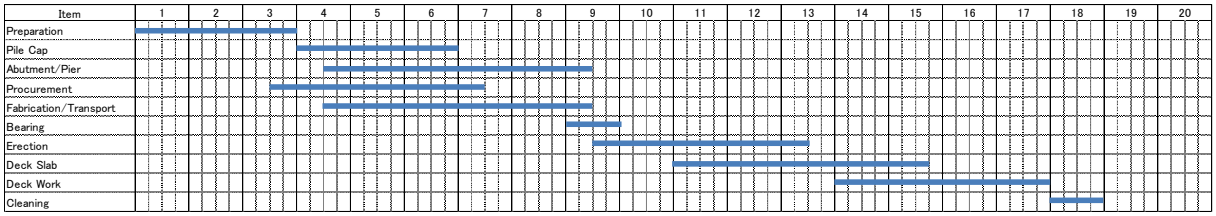
(4) Case-4: Steel-I Girder L=160m (40m x 4)



Source: JICA Survey Team

Figure 9.8.4 Construction Schedule for Steel-I Girders of Length 160m (40m x 4)

(5) Case-5: Steel-I Girder L=200m (40m x 5)

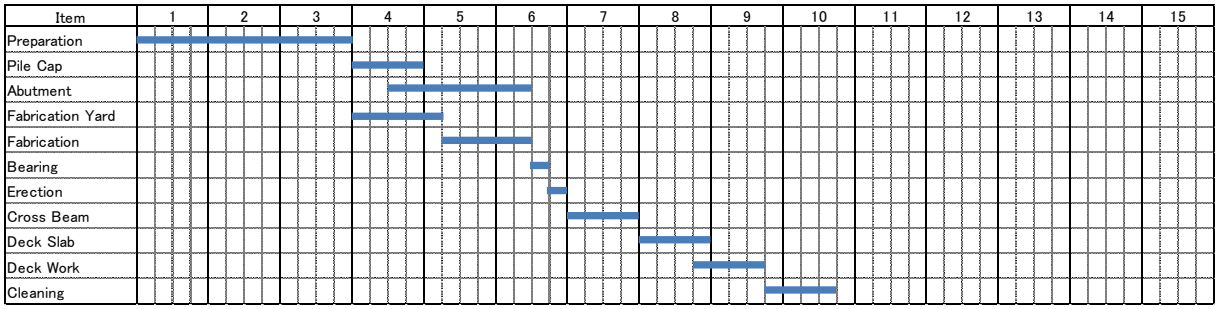


Source: JICA Survey Team

Figure 9.8.5 Construction Schedule for Steel-I Girders of Length 200m (40m x 5)

9.8.2 Concrete Bridge (PC-I Girder)

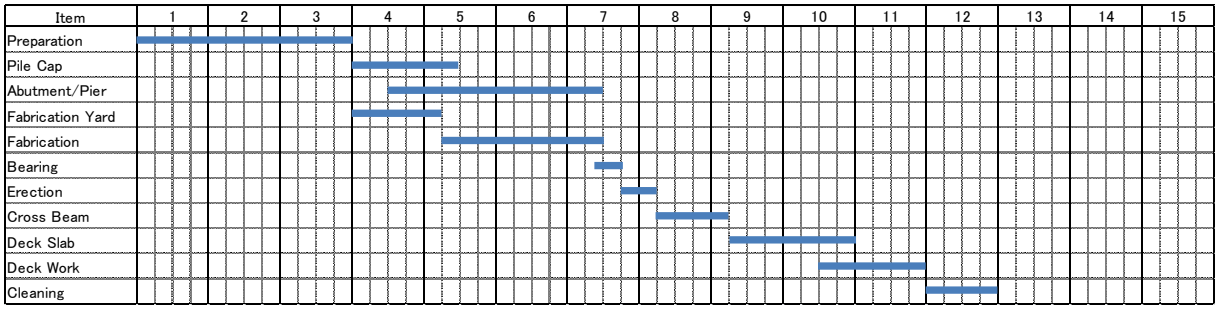
(1) Case-1: PC-I Girder L=40m



Source: JICA Survey Team

Figure 9.8.6 Construction Schedule for PC-I Girders of Length 40m

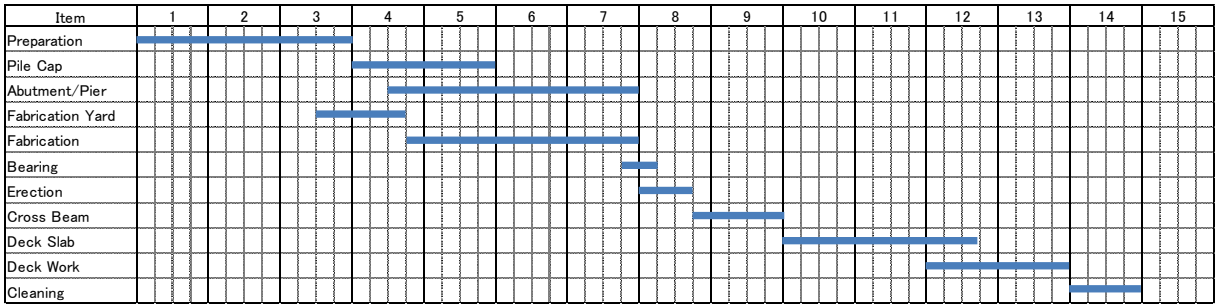
(2) Case-2: PC-I Girder L=80m (40m x 2)



Source: JICA Survey Team

Figure 9.8.7 Construction Schedule for PC-I Girders of Length 80m (40m x 2)

(3) Case-3: PC-I Girder L=120m (40m x 3)



Source: JICA Survey Team

Figure 9.8.8 Construction Schedule for PC-I Girders of Length 120m (40m x 3)

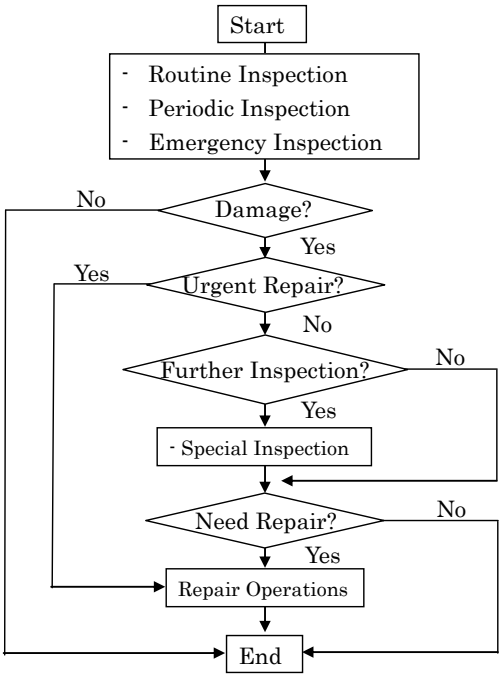
10. OPERATION AND MAINTENANCE PLAN

10.1 Operation and Maintenance Plan for the Project Bridges

10.1.1 General

The Project bridges should be maintained in sound conditions to sustain smooth and safe traffic flow. In general, bridges are administered by road/bridge management system which consists of such major activities as “Preparation of Inventory Data”, “Inspection”, and “Rating and Prioritization based on inspection results for actual Maintenance (Repair) work”, and also documentation of all the records of the activities.

Figure 10.1.1 shows the steps of the maintenance system (from inspection to repair works).



Source :JICA Survey Team

Figure 10.1.1 Maintenance Procedure

10.1.2 Inspection

(1) Purpose of Inspection

- To determine the damage in the road/bridge
- To identify the location of defects and their level of severity, urgency of repair

(2) Type of Inspection

The type of inspection shall be divided as shown in Table 10.1.1

Table 10.1.1 Classification of Inspection Work

Inspection Type	Major objects	Purpose	Methods
Routine (once or twice daily)	Road surface	Road safety	Visual inspection from vehicle-on board
Periodic (yearly)	All components	Damage Repair and Safety	Mainly close visual inspection, using basic equipment (crack measures, hand tape, etc.) if required
Emergency (at time of accident/disaster)	All damaged components	Damage Repair and Safety	Immediate inspection visually and using equipment

Source: JICA Survey Team

1) Routine inspection

In order to find out the current condition of the structures, routine inspections are undertaken visually from road patrol on the shoulder or left-most lane. Accordingly, items for inspection are limited to those which can be observed from moving vehicles. Items include the following:

- Pavement condition
- Water-logging (drainage)
- Embankment/cut slope
- Auxiliary facilities (guard rail, traffic information board, etc.)

2) Periodic inspection

In order to understand the overall status of the structure, visual inspection should be undertaken by equipment, if required. Furthermore, prior to initiating inspection work, several field works such as traffic control, preparation and arrangement of transportation are required.

3) Emergency inspections

Beyond routine or periodic inspections, sometimes additional inspections are necessary if any structural damage is caused at the time of accidents/disasters. The purpose of emergency inspections is to check the soundness of bridges. In the case that serious damage is observed on a major component, further detailed inspection may be necessary.

10.1.3 Maintenance

(1) Maintenance Work

Usually, maintenance works are categorized into routine maintenance, periodic maintenance, and emergency maintenance, as defined as follows.

1) Routine maintenance

Routine maintenance of bridges is conducted regularly, including minor maintenance such as the removal of trash, debris, soil, stone etc. on the bridge and pothole patching.

2) Periodic maintenance

Periodic maintenance takes a relatively long time to implement, and is relatively large in scale, often requiring closure of lane(s). The interval of implementation is influenced by traffic volume, especially that of heavy vehicles.

After completion of the project bridges, anticipated deterioration or damage to project bridges include:

- Wave, rutting, cracking and potholes of the pavement
- Cracking in the slabs, girders, pile-caps of the piers and abutments
- Damage to expansion joints
- Damage to girder bearings

Those maintenance (repair) works should be planned and conducted based on rating and prioritization of inspection results.

3) Emergency maintenance

Emergency maintenance mainly refers to the urgent repair of structures damaged by natural disasters or large-scale accidents. There are various forms of such damage and it is very difficult to anticipate its extent.

To minimize traffic disturbance, repair work of defects is often implemented in two stages: urgent temporary repair to secure traffic flow, and full-scale repair including strengthening to prevent future recurrence.

10.1.4 Special Maintenance for Weathering Steel Bridge

As described in “8. Application of Modern Technologies”, weathering-steel bridges require almost no special maintenance budget (such as repainting of surfaces). However, it is necessary to take care of chlorides and humidity that can adversely affect the stability of the protective rust and cause excessive corrosion. Surface contamination can be caused by

accumulation of dirt, dust and bird droppings that absorb moisture (e.g. due to rain), and hence surfaces should be periodically cleaned using low-pressure water washing, taking care not to disrupt the protective rust. Furthermore, overhanging vegetation causing continuous dampness should be removed, and drainage systems should be regularly cleared. Any leakage should be traced to its source, and any damage in drainage systems or joints should be repaired. In addition to routine and periodic maintenance, it is desirable to conduct to following:

(1) Visual Inspection (at least every two years)

Visual inspections should be carried out to check the condition of rust. Adhered fine-grained rust indicates that corrosion is progressing at an acceptable rate, whereas coarse laminated rust layers and flaking suggests unacceptable performance.

(2) Monitoring by equipment (every six years)

The corrosion rate of weathering steel bridges should be monitored, by measuring the remaining steel thickness at clearly identified critical points on the structure. These points should be defined on the as-built drawings or in the bridge maintenance manual. The original (reference) thickness measurements taken at the end of the construction period should also be recorded.

The survey steps for weathering steel bridges are shown in Figure 10.1.2.

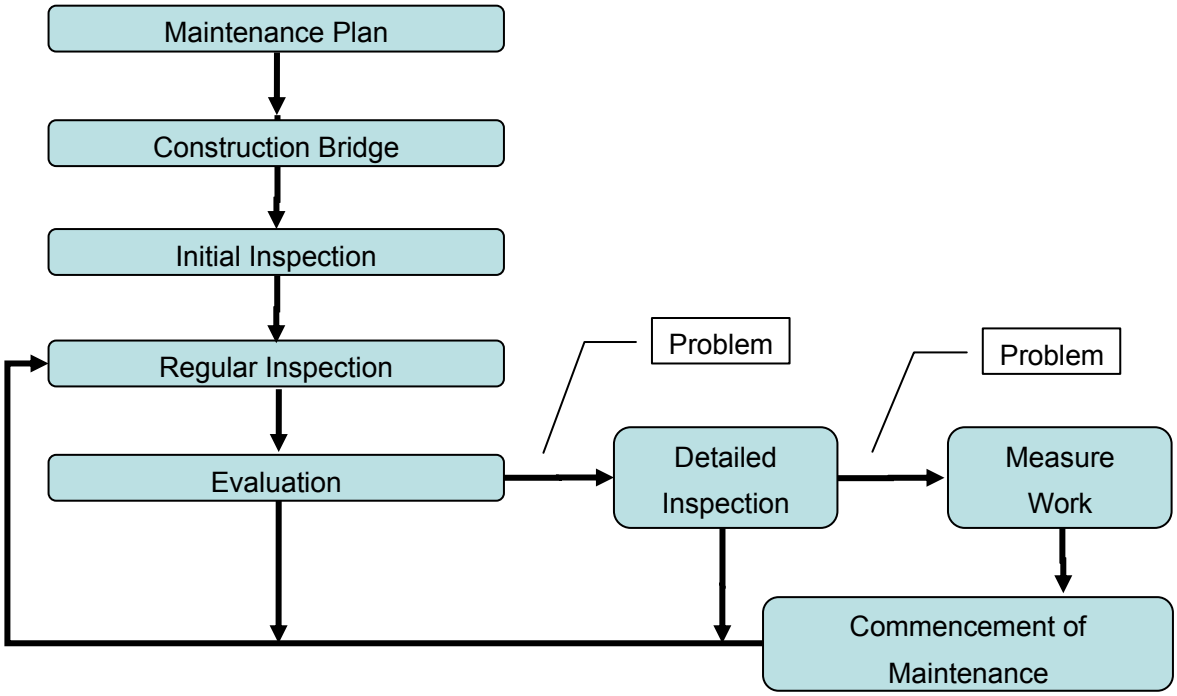


Figure 10.1.2 Weathering Steel Bridge Survey

10.2 Organization

10.2.1 Ministry of Road Transportation and Bridges

(1) Ministry of Road Transport and Bridges

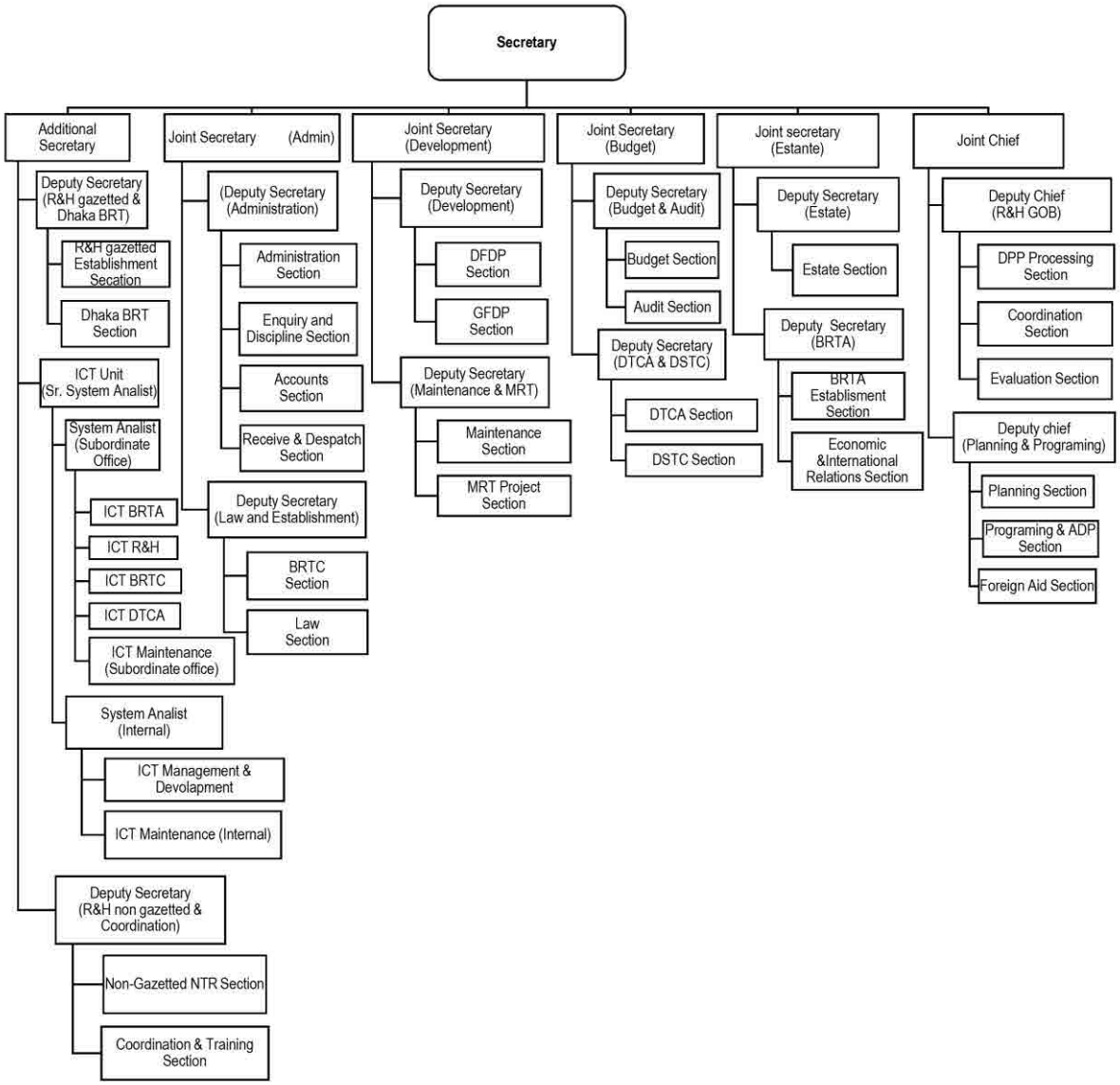
The Ministry of Road Transport and Bridges (MORTB) is comprised of two divisions, namely the Road Transport and Highways Division (RTHD) and the Bridges Division (BD). RTHD deals with major road networks in Bangladesh, whereas BD deals with all matters relating to bridges longer than 1500m. MORTB plays a vital role in the socio-economic development of Bangladesh through governing the departments/organizations which are playing very important roles in infrastructure development. The departments/organizations governed by MORTB are followings.

- Roads & Highways Department (RHD)
- Bangladesh Road Transport Authority (BRTA)
- Bangladesh Road Transport Corporation (BRTC)
- Dhaka Transport Co-ordination Board (DTCB)
- Bangladesh Bridge Authority (BBA)

The primary objective of RTHD of MORTB is to ensure the improvement of socioeconomic conditions of the nation through formulating policies regarding roads and road transport, in addition to the construction, development, expansion and maintenance of environmentally-friendly and user-friendly integrated road transportation.

(2) Organization Chart of MORTB (Road Transport and Highways Division)

The organizational structure of MORTB (RTHD) is illustrated below. As of 2014, the total number of RTHD officers is 191.



Source: MORTB Official Website accessed 2014 (http://www.rthd.gov.bd/)

Figure 10.2.1 Organization Chart of Road Transport and Highways Division, MORTB

Table 10.2.1 MORTB's Officers Class and Number (Road transport and Highways Division)

Name of Position	Number
Secretary	1
Additional Secretary	1
Joint Secretary /Joint Chief	5
Deputy Secretary/Deputy Chief	12
Senior System Analyst	1
Sr. Asst. Secretary/Asst. Secretary	19
Sr. Asst. Chief/ Asst. Chief	6
Private Secretary of Secretary	1
Asst. Programmer/Asst. Maint. Engineer	12
Accounting Officer	1
Total of Class Ⅰ	59
Total of Class Ⅱ	39
Total of Class Ⅲ	47
Total of Class Ⅳ	46
Total(All classes)	191

Source: MORTB Official Website accessed 2014
(http://www.rthd.gov.bd/)

10.2.2 Roads and Highways Department (RHD)

(1) Introduction

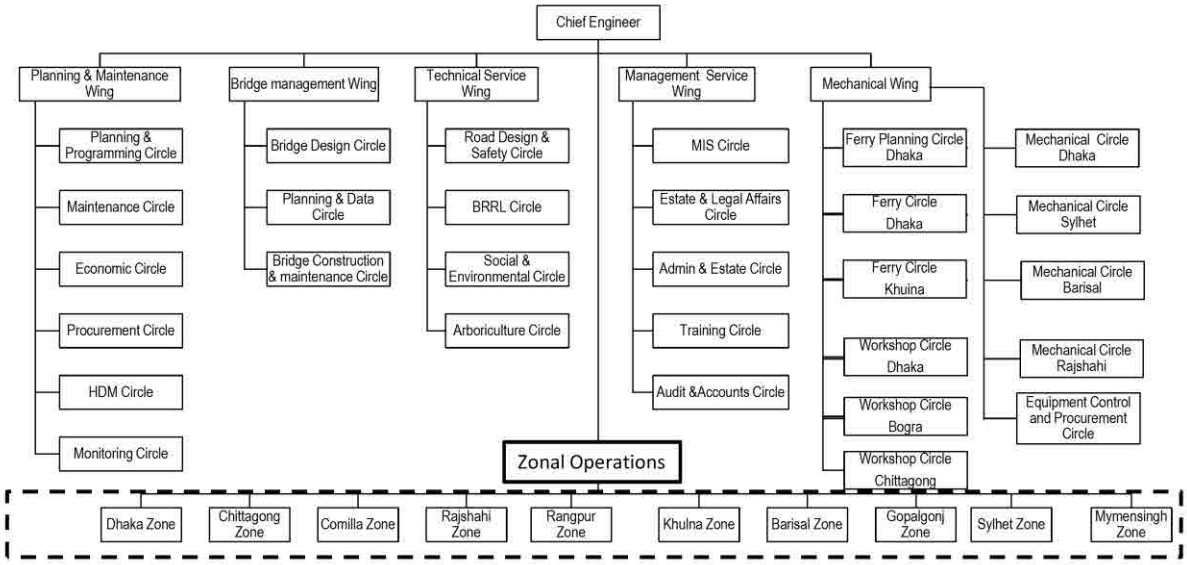
The Roads and Highways Department (RHD) was founded in 1962 under the former road division of MORTB. The department is responsible for the construction and maintenance of the major road network of Bangladesh.

It is officially defined as follows: "The Roads and Highways Department has a sustainable capacity to plan, manage and deliver its full range of responsibilities in respect of the main road and bridge network and to be accountable for these duties".

The Assets of RHD have been conservatively estimated at BDT 460 billion of which the largest proportion by far is the value of the 21,590 km of road and the 16,985 bridges. These assets are probably the greatest of any organization in Bangladesh and maintaining their value is vital to the country's economy

(2) Organization Chart of RHD

The department is headed by a chief engineer who is supported by a number of additional chief engineers (ACEs). The recent structure for RHD consists of 5 headquarter wings and 10 field zones, each headed by an additional chief engineer who reports directly to the chief engineer. In addition, 8 ACEs are assigned to manage foreign-aided projects.



Source: RHD Web site

Figure 10.2.2 Organization Chart of RHD

The number of current employed staff of the department is 2,143 in total, comprising 445 class I, 521 class II, 788 class III and 389 class IV. In addition to this total figure, there are currently about 7,233 vacant posts. Total number of sanctioned post is 9,376.

Table 10.2.2 Summary of Staff of RHD

Name of Post	Number
Chief Engineer	1
Additional Chief Engineer	15
Additional Chief Engineer(Reserved)	1
Superintending Engineer	43
Chief Transport Economist	1
Chief Arboriculturist	1
Director(Audit & Accounts)	1
Executive Engineer	102
Executive Transport Economist	1
Executive Arboriculturist	1
Computer System Analyst	1
Deputy Director	1
Reserved - Executive Engineer	9
Sub Division Engineer	120
Sub Division Engineer (Reserved)	10
Sub-Divisional Arboriculturist	1
Assistant Director(Security)	1
Assistant Engineer	125
Account Officer	2
Assistant Arboriculturist	2
Assistant Programmer	1
Statistician	1
Assistant Engineer(Reserved)	4
Total of Class Ⅰ	445
Total of Class Ⅱ	521
Total of Class Ⅲ	788
Total of Class Ⅳ	389
Total(All classes)	2,143

Source: RHD (As of Oct 21, 2014)

10.2.3 Department Relevant to Bridge Management

(1) Bridge Management Wing

The Bridge management wing is responsible for all aspects of data collection, surveys, planning, construction and maintenance of bridges on RHD roads. The bridge management wing maintains a close liaison with all other RHD wings to ensure that all bridge works are well-managed from conception through to physical completion and are then appropriately maintained to optimize the use of funds.

The bridge management wing consists of three circles, each headed by a superintending engineer. The intended total staffing for the wing is 277 persons.

The main activities of the wing are as follows.

- Establishing bridge design, construction and maintenance standards to be applied to all bridge works within the RHD.
- Collecting, collating, reviewing and monitoring data on the entire RHD bridge stock to be included in the RMMS.
- Developing a systematic approach to bridge management.
- Procuring or undertaking surveys for the planning, design, maintenance and construction of bridge works.
- Procuring (from RHD or otherwise) necessary economic studies of new and replacement bridges
- Preparing recommendations for any proposed bridge replacement, major repairs and provision of new bridges including commissioning reviews of environmental, ecological, hydrological and social impacts of the proposals.
- Liaising with other wings, circles and field zones in relation to road safety, environmental and social issues related to bridges
- Procuring consultants for the design and supervision. Check and review designs to ensure they meet all the specified requirements.
- Developing annual & multi-year programs for maintenance & development of the bridge stock (including foreign aided projects) in consultation with the planning authorities in the MORTB and the Planning Commission.
- Preparing draft PCPs, PPs and TAPPs for all proposed bridge projects.
- Developing annual budgets for the maintenance, replacement and new construction of bridges.

- Procuring contractors for execution of bridge maintenance and construction works.
- Establishing adequate funds for the operation of the wing to meet the objectives stated above by securing budgets based on actual operational needs.
- Establishing increased funding for bridge maintenance on a long term basis.
- Preparing monthly and annual reports on all bridge related activities

(2) Planning and Maintenance Wing

The planning and maintenance wing is responsible for all aspects of planning, programming, procurement, maintenance and monitoring of road and bridge projects.

The wing is currently using road/bridge management systems for the establishment of annual maintenance programs designed to ensure that the value of the RHD's road and bridge assets are maintained and enhanced in a cost-effective manner.

This wing consists of six circles, each headed by a superintending engineer. The total intended staffing for the wing is 344 persons.

The main activities of planning and maintenance wing are as follows.

- Collecting, collating, reviewing and monitoring data on the entire network included in the RMMS.
- Undertaking additional surveys that may be necessary to carry out economic or other analyses in the planning process.
- Applying HDM-4 for the analysis of maintenance, improvement and development programs in order to optimize the use of available financial and other resources.
- Developing annual & multi-year programs of maintenance & development works (including foreign aided projects) in consultation with the planning authorities in the MORTB and the Planning Commission.
- Providing guidance on future investment alternatives to the MORTB, the MOF and the Planning Commission based on economic optimization analyses.
- Preparing recommendations for any proposed future expansion of the network including commissioning reviews of environmental, ecological, hydrological and social impacts of the proposed construction or acquisition.
- Preparing PCPs, PPs and TAPPs using data available from the RMMS and HDM-4 analyses.
- Maintaining monitoring systems for revenue and ADP projects including those funded from external resources.

- Carrying out the packaging of annual periodic maintenance programs, procuring contractors and consultants for undertaking large scale periodic maintenance works, and monitoring the execution of these works.
- Providing procurement assistance to other circles and field divisions for works and services contracts including: Studies, Surveys, Supervision and Construction for Routine and Periodic Maintenance, Improvement Works and New Construction.
- Undertaking mid-year reviews of progress and if appropriate preparing re-allocation of funds to ensure efficient utilization of resources.
- Developing a coordinated approach to program development involving all circles within the Wing whilst ensuring the highest possible service to customers.
- Establishing adequate funds for the operation of the Wing to meet the objectives stated above by securing budgets based on actual operational needs.
- Establishing increased funding for road & bridge maintenance on a long-term basis.

(3) Zonal Offices

Road and bridge construction and maintenance activities in RHD are carried out though the 10 zonal offices which manage and execute operational works at the field level. Zonal offices are responsible for ensuring that administration and management of the zonal operations are carried out efficiently.

The main activities of zonal offices are as follows.

- Compiling analyses and summaries of field activity reports from all the circles within the Zone into a consolidated progress report for the Zone.
- Carrying out all routine and periodic maintenance works through the dedicated teams.
- Carrying out all normal development works through dedicated teams.
- Implementing foreign-aided projects attached to the Zone.
- Assisting the Head Office HDM and Bridges Circles in carrying out surveys on the condition of roads and bridges.
- Coordinating the operation of plant, equipment and ferries in the field through the Zonal plant pools and in cooperation with the Mechanical SEs.
- Conducting flood damage and other emergency surveys and carrying out emergency works as required.
- Maintaining all accounts and preparing annual budgets.

10.3 Budgetary Situation of Road and Bridge Development and Maintenance

10.3.1 National Revenue and Expenditure

National revenue and expenditure over the last several years is shown in Table 10.3.1.

Table 10.3.1 Consolidated Receipts and Expenditures of the Government of Bangladesh

Heads	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Revenue and Receipts	**448,680**	**494,720**	**605,390**	**691,800**	**794,840**	**951,877**	**1,183,850**
(a) Tax	361,750	392,470	480,120	555,256	639,560	790,524	957,850
(b) Non-tax	86,930	102,250	125,270	136,544	155,280	161,353	226,000
Development Receipts	**222,320**	**212,290**	**373,350**	**293,420**	**355,590**	**399,610**	**508,310**
(a)Project	74,750	85,290	94,990	111,900	124,800	134,300	207,200
(b)Food and Commodities	39,570	26,690	79,130	39,540	57,540	17,140	29,030
(c)Internal Resources	108,000	100,310	199,230	141,980	173,250	248,170	272,080
Total Receipts	**671,000**	**707,010**	**978,740**	**985,220**	**1,150,430**	**1,351,487**	**1,692,160**
Revenue Expenditure(gross)	**351,544**	**413,551**	**521,923**	**626,760**	**687,110**	**771,030**	**1,029,030**
(a)Wage and Salaries	109,965	141,186	155,330	151,060	170,470	204,790	225,350
(b)Commodities and Services	51,525	54,183	82,400	91,640	96,930	169,430	122,220
(c)Transfer	174,369	201,190	265,686	258,890	279,320	322,600	346,420
(d)Other Services	15,685	16,992	18,507	125,170	140,390	134,210	335,040
Development Expenditure	**194,720**	**179,280**	**185,060**	**197,000**	**259,170**	**328,550**	**348,500**
(a)Agriculture, Flood Control, Water Resource and Rural institutions	40,981	38,022	39,245	53,174	63,424	77,221	75,336
(b)Industry	5,004	4,579	4,725	4,125	4,428	3,518	4,471
(c)Transport and communication	43,157	39,687	40,963	21,811	39,073	41,089	60,096
(d)Other Service	105,578	96,992	100,127	117,890	152,245	206,722	208,597
Total Expenditure	**546,264**	**592,831**	**706,983**	**823,760**	**946,280**	**1,099,580**	**1,377,530**
Real Public Expenditure	374,058	380,147	416,719	455,827	491,788	531,429	-
Population of Mid Financial Year	138.80	140.60	142.40	144.20	146.20	149.70	-
Per capita Expenditure							
(a)Constant Prices(deflated)	**2,695**	**2,704**	**2,926**	**3,161**	**3,364**	**3,593**	**-**
(b)Current Prices	3,936	4,216	4,965	5,713	6,473	7,435	-
Total Public Expenditure as % GDP **at current market price**	13.14	12.55	12.95	13.40	13.63	13.80	-

Source:Statistical YearBook of Bangladesh 2012 Unit:Million BDT

For the 7 years since 2005, the national total revenue has been increasing every year at an average growth ratio of 17.7% with the rate of Developments Receipts to the Total Receipts accounting for around 1/3 of the amount.

10.3.2 Development and Maintenance Allocation for RHD Roads and Bridges

The budget allocation for development and maintenance of RHD roads and bridges over the past several years is shown in Table 3.2. It is observed that the maintenance budget for 2013-14 has accounted for 26% of the total.

Table 10.3.2 Development and Maintenance Allocation for RHD Roads and Bridges

Confidential

Source: RHD

Table 10.3.3 shows both the requested budget and the allocated budget for maintenance. There are consistently significant discrepancies between the two values.

Table 10.3.3 Requested and Allocated Maintenance Budget

Confidential

Source: RHD

10.4 Current Issues faced in Bridge Operation and Maintenance

10.4.1 Lack of Budget

As mentioned in “3.2 Development and Maintenance Allocation for RHD Roads and Bridges), there still remain significant discrepancies between requested and actual allocated budgets. In order to maintain the best bridge conditions possible, strategies for raising funds and efficient budget use should be considered.

10.4.2 Inappropriate Operation and Maintenance Work

There are many bridges with severe deck slab damage (refer to Section 2.5.2, Analysis of Bridge Conditions). The progression of the damage could be controlled by conducting only simple and basic maintenance/rehabilitation methods at an appropriate time. According to

interviews with RHD staff, the most of the budget for bridge maintenance is being used for pavement maintenance rather than structural defects. It is common knowledge that as structural defects progress, repair costs increases, and bridge life decreases. Thus, immediate treatment is important in consideration of the limited budget

It is important to establish efficient management plan and train RHD staff.

10.4.3 Ineffective Utilization of BMMS

Bridge maintenance works are carried out under funding from the national budget. In general, the budget for bridge maintenance is limited in developing countries. Thus, implementation of bridge repair works is constrained due to insufficient budget provisions as well as insufficient human resources. It is necessary to prioritize bridge repair works for efficient budget expenditure. BMMS will be instrumental in establishing an efficient bridge maintenance plan.

However BMMS has not been utilized efficiently as yet.

10.4.4 Overloaded Vehicle

One of the major causes of damage on bridges (especially deck slabs) is overloaded vehicles. Overloaded vehicles inflict significant damage on roads and bridges. In order to prevent damage, overloaded vehicle should be properly regulated. The necessity for regulating overloaded vehicles is also described in the Road Master Plan (2009).

10.5 Recommendations for Operation and Maintenance

10.5.1 Stable Financing for Roads and Bridges Maintenance

As mentioned above, the national budget allocation is insufficient for road and bridge maintenance. Therefore, it is necessary to create a stable financing source in accordance with the Road Fund described in the Road Master Plan (2009):

> 17.4.1. Road Fund
>
> Funding for road and bridge maintenance should come from the Road Fund. Draft legislation for the Road Fund also provides powers for the fund to pay for road safety measures. Full funding for road and bridge maintenance should be provided by the Government of Bangladesh until the matter of the Road fund establishment is finalized

The Road Fund was established in July 2013 (Act No. 28). However, it has not been implemented as yet.

10.5.2 Establishment of Efficient Maintenance Plan

Through the capacity building component to be supplied as part of the EBBIP, the following results are anticipated:

- Provision of a bridge maintenance manual
- Update of the bridge condition inventory
- Education and training of RHD personnel

Through this project, it is expected that staff's knowledge of maintenance and management will be broadened, and that their skills in "inspection", "damage evaluation" and "planning for maintenance" will be improved. Skills in maintenance and management methodology should be further improved through technical assistance such as overseas training and technical cooperation projects.

10.5.3 Prohibition and Control of Overloaded Vehicles

In order to avoid unexpected deterioration by overloaded vehicles, the following actions are highly recommended.

- A ban on the import of 2-axle trucks with gross weight over 6 tons
- Placing the Highway Police under RHD
- Periodical inspection by axle load measuring equipment
- Issuing penalty tickets for overloading

10.6 Proposal of Future Japanese Support

10.6.1 Technical Cooperation Project Regarding Bridge Operation & Maintenance

It is proposed that a technical cooperation project regarding bridge operation & maintenance will be conducted.

Summary of the technical cooperation project is as follows.

(1) Objectives of the Project

- Improvement of RHD's capacity for bridge operation and maintenance

(2) Project Outcomes

- (Outcome 1) Development of RHD bridge operation and maintenance organization

- (Outcome 2) Creating bridge inspection manual and bridge repair/improvement manual
- (Outcome 3) Establishment of new bridge management system (BMS)
- (Outcome 4) Development of RHD staffs' knowledge required for bridge operation and maintenance

(3) Project Activities

1) (Outcome 1) Development of RHD bridge operation and maintenance organization

- To understand current bridge operation and maintenance activities
- To clarify the issues of current bridge operation and maintenance activities
- To study the bridge operation and maintenance organization
- To develop appropriate bridge operation and maintenance activities and organizational structure

2) (Outcome 2) Creating bridge inspection manual and bridge repair/improvement manual

- To review existing bridge operation and maintenance manuals, and to clarify issues
- To create draft bridge inspection manual
- To create draft bridge repair/improvement manual
- To share the created manuals with RHD staffs

3) (Outcome 3) Establishment of new bridge management system (BMS)

- To review the existing BMMS
- To study the method for utilization of new BMS with RHD
- To establish new BMS
- To move the data from existing BMMS to new BMS
- To create draft BMS manuals (for administrator and users)
- To share the created manuals with RHD staffs

4) (Outcome 4) Development of RHD staffs' knowledge required for bridge operation and maintenance

- To carry out on-the-job training (OJT) in a model area focusing on bridge inspection by utilizing bridge inspection manual
- To carry out on-the-job training (OJT) in a model area focusing on prioritized bridge

selection for repair/improvement.

- To carry out on-the-job training (OJT) in a model area regarding selection of repair/improvement method and its cost estimates.
- To support the supervision for bridge repair/improvement implemented by RHD

(4) Japanese Expert

Japanese experts will be dispatched in the Project to perform the following tasks:

- Team Leading / Bridge Operation and Maintenance Planning
- Bridge Inspection
- Bridge Soundness Assessment
- Bridge Repair / Improvement
- Bridge Management System
- Cost Estimates
- Project Assistance

(5) Project Period

- 30 months

10.6.2 Overseas Training on Weathering Steel

In addition to the technical cooperation project, the overseas training on weathering steel will be carried out during the detailed design stage and the construction stage of the WBBIP. A draft program of the overseas training is shown in Table 10.6.1.

Table 10.6.1 Overseas Training Program on Weathering Steel (Draft)

Day		Program	Stay
Day 1	Sun	Fly from Dhaka to Tokyo	Tokyo
Day 2	Mon	Introduction and explanatory session by Consultant	Tokyo
Day 3	Tue	Technical visit to Tokyo Aqua Line, Tokyo Rainbow Bridge, Tokyo Gate Bridge and Tokyo road network	Tokyo
Day 4	Wed	Lecture on weathering steel bridges by Consultant	Tokyo
Day 5	Thu	(AM) Move to Nagasaki prefecture (PM) Technical visit of weathering steel bridge located in Nagasaki prefecture	Nagasaki
Day 6	Fri	Meeting with operation & maintenance authorities to discuss design, construction and operation & maintenance of weathering steel	Nagasaki
Day 7	Sat	Free	Nagasaki
Day 8	Sun	(AM) Move to Hyogo prefecture by Shinkansen (Express Train) (PM) Technical visit of Akashi Bridge	Hyogo
Day 9	Mon	(AM) Meeting with Honshu-Shikoku Bridge Expressway Company Ltd. to discuss on design, construction and operation & maintenance of long bridge (PM) Move to Tokyo by Shinkansen (Express Train)	Tokyo
Day 10	Tue	Meeting with Ministry of Land, Infrastructure, Transport and Tourism to discuss on design, construction and operation & maintenance of bridge	Tokyo
Day 11	Wed	(AM) Wrap-up at JICA headquarters (PM) Free	Tokyo
Day 12	Thu	Fly from Tokyo to Dhaka	-

Source: JICA Survey Team

10.7 Operation and Maintenance Cost

Operation and maintenance costs are comprised of inspection, routine/periodic maintenance (every 1 year), pavement resurfacing (every 10 years) and concrete surface treatment (every 40 years). Operation and maintenance costs for the bridges and the approach roads to be constructed under the Project are estimated at around BDT 154 million per year. Details are shown in Table 10.7.1 and 10.7.2.

Table 10.7.1 Operation and Maintenance Costs (1)

Bridge Data					O&M Cost		
SN	Bridge ID	Zone	Bridge Name	New Bridge Type	Routine/Periodic mantenance (Per Year/TAKA)	Resurface of Pavement (Every 10years/TAKA)	Concrete Surface Treatment (Every 40years/TAKA)
1	N8_178a	Barisal	Boalia Bazar Bridge	PC-I	1,819,767	6,008,267	4,852,711
2	N509_19a	Rangpur	Sharnamoti Bridge	PC-I	1,223,733	5,393,896	3,263,288
3	N5_119a	Rajshahi	Chanda Bridge	PC-I	1,282,381	8,980,462	3,419,682
4	N5_127a	Rajshahi	Palgari Bridge	PC-I	2,031,720	7,158,819	5,417,920
5	N5_176a	Rajshahi	Bhuyagati Bridge	PC-I	1,604,339	6,667,814	4,278,236
6	N5_235a	Rangpur	Mohosthan Bridge	Steel-I	4,788,497	5,725,054	-
7	N5_120a	Rajshahi	Chanda Bridge	PC-I	1,535,273	3,794,898	4,094,061
8	N5_128a	Rajshahi	Goilhar Bridge	PC-I	1,357,796	7,159,435	3,620,788
9	N5_158a	Rajshahi	Purbodalua Bridge	PC-I	1,570,003	6,491,576	4,186,674
10	N5_265a	Rangpur	Bupinath Bridge	PC-I	1,187,790	5,188,643	3,167,439
11	N5_350b	Rangpur	Barati Bridge	Steel-I	6,043,652	6,020,581	-
12	N8_182a	Barisal	Bakerganj Steel Bridge	PC-I	952,055	5,170,173	2,538,812
13	N7_025a	Gopalganj	Jhuldibazar Bridge	PC-I	919,362	5,419,523	2,451,633
14	N7_039a	Gopalganj	Karimpur Bridge	PC-I	2,645,239	4,870,029	7,053,971
15	N7_049a	Gopalganj	Porkitpur Bridge	PC-I	1,038,449	5,464,160	2,769,198
16	N5_134a	Rajshahi	Nukali Bridge	Steel-I	2,193,765	4,973,925	-
17	N6_97a	Rajshahi	Dattapara Bridge	PC-I	810,802	4,925,440	2,162,137
18	R681_10a	Rajshahi	Horisonkorpur Bridge	PC-I	1,403,340	1,252,396	3,742,240
19	N5_140a	Rajshahi	Jugnidaha Bridge	PC-I	1,247,353	6,661,658	3,326,274
20	N5_118a	Rajshahi	Punduria Bridge	Steel-I	5,761,439	5,768,152	-
21	N704_43a	Khulna	G.K. Bridge	PC-I	1,196,629	6,532,365	3,191,012
22	N7_248c	Khulna	Gora bridge	PC-I	1,057,845	6,608,555	2,820,920
23	N7_054a	Gopalganj	Barashia Bridge	PC-I	2,529,473	6,768,632	6,745,262
24	N5_356a	Rangpur	-	PC-I	731,667	6,226,834	1,951,113
25	N7_246a	Khulna	Balai bridge.	PC-I	1,705,931	7,094,173	4,549,148
26	N8_095a	Gopalganj	Amgram bridge	PC-I	1,220,760	6,275,318	3,255,361
27	N505_2a	Rajshahi	Kazir Hat Bridge	Steel-I	6,151,397	6,302,254	-
28	R548_28b	Rajshahi	Atrai Bridge	Steel-I	7,020,618	2,322,140	-
29	N7_036c	Gopalganj	Kanaipur Bridge	PC-I	1,837,216	6,273,779	4,899,242
30	N7_048a	Gopalganj	Brahmonkanda Bridge	PC-I	1,212,945	7,138,040	3,234,521
31	N5_378a	Rangpur	Gaudangi Bridge	PC-I	1,260,922	5,884,362	3,362,460
32	N7_047a	Gopalganj	Bimankanda bridge	PC-I	3,353,747	11,219,998	8,943,325
33	N5_156a	Rajshahi	Chowkidhoh Bridge	PC-I	1,296,868	6,492,346	3,458,315
34	N5_172a	Rajshahi	Notun Dhoh Bridge	PC-I	1,786,281	5,611,154	4,763,416
35	N5_179a	Rajshahi	Dhatia Bridge	PC-I	1,953,554	5,577,291	5,209,477
36	N5_188a	Rangpur	Ghoga Bridge	PC-I	1,346,313	6,231,451	3,590,167
37	N5_126a	Rajshahi	Vitapara Bridge	Steel-I	3,956,776	6,598,550	-
38	N518_4a	Rangpur	Khorkhori bridge	PC-I	1,201,687	5,078,590	3,204,498
39	N7_141b	Khulna	Buri Bhairab Bridge	PC-I	942,631	6,418,464	2,513,682
40	R720_44a	Khulna	Gurakhali Bridge	PC-I	1,908,299	1,193,393	5,088,797
41	N703_Sd	Khulna	Dhopa Ghata Bridge	PC-I	2,716,264	6,661,658	7,243,372
42	R890_45a	Barisal	Dawrey Bridge	PC-I	2,028,806	1,404,777	5,410,150
43	N704_14a	Khulna	Barda Bridge	PC-I	1,863,547	5,696,579	4,969,459
44	N704_33b	Khulna	Balipara Bridge	PC-I	841,062	5,083,208	2,242,831
45	N5_344c	Rangpur	Kharua Vanga Bridge	Steel-I	2,128,858	5,124,766	-
46	N5_382a	Rangpur	Ichamoti Bridge	PC-I	1,452,968	5,688,114	3,874,582
47	N5_360a	Rangpur	Chikli Bridge	PC-I	1,231,886	5,348,720	3,285,029
48	Z5025_55a	Rangpur	Kakra Bridge	Steel-I	7,104,563	2,184,061	-
49	Z5025_64a	Rangpur	Gabura Bridge.	PC-I	2,171,000	1,045,255	5,789,334
50	Z5401_45a	Rangpur	Mathpara Bridge	Steel-I	3,580,421	1,315,855	-

*SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges

Source: JICA Survey Team

Table 10.7.2 Operation and Maintenance Costs (2)

Bridge Data					O&M Cost		
SN	Bridge ID	Zone	Bridge Name	New Bridge Type	Routine/Periodic mantenance (Per Year/TAKA)	Resurface of Pavement (Every 10years/TAKA)	Concrete Surface Treatment (Every 40years/TAKA)
51	Z5072_14a	Rangpur	Bombgara Bridge	PC-I	1,581,142	1,400,361	4,216,380
52	Z5025_60a	Rangpur	Madarganj Bridge	PC-I	2,840,610	1,377,525	7,574,960
53	Z5472_6a	Rangpur	Raktodaho Bridge	PC-I	1,861,403	1,570,300	4,963,741
54	N5xx_Sa	Rajshahi	Pura Mukto Monch Bridge	PC-I	1,236,551	4,671,472	3,297,471
55	Z5552_10a	Rangpur	Barodia Khali Bridge	Steel-I	2,695,981	1,098,449	-
56	N8_152c	Barisal	Rahamatpur bridge	PC-I	1,432,676	5,681,957	3,820,470
57	N8_127b	Barisal	gounagata bridge	PC-I	1,212,973	4,873,107	3,234,595
58	Z8052_009d	Barisal	Gabtala Steel Bridge	PC-I	1,335,994	1,011,937	3,562,652
59	Z5015_22a	Rangpur	Bahagili Bridge	Steel-I	8,368,083	2,242,802	-
60	Z5701_1a	Rangpur	Anandababur Pool	PC-I	1,015,672	933,816	2,708,458
61	Z5701_9a	Rangpur	Duhuli Bridge	PC-I	1,173,331	971,832	3,128,882
62	R545_115c	Rangpur	Mongle bari kuthibari Bridge	Steel-I	4,083,107	1,583,837	-
63	R760_049c	Khulna	Shakdaha bridge	PC-I	1,754,843	1,689,272	4,679,582
64	N8_123a	Barisal	Souderkhal bridge	PC-I	999,976	4,731,501	2,666,602
65	Z8701_3d	Barisal	Bottala Bridge	PC-I	1,137,004	1,065,077	3,032,011
66	N5_260b	Rangpur	Katakhali Bridge	Steel-I	6,299,360	6,109,854	-
67	N704_27b	Khulna	Bittipara Bridge	PC-I	917,072	6,433,856	2,445,526
68	R750_22c	Khulna	Bhangura Bridge	PC-I	1,933,230	538,720	5,155,281
69	N8_129a	Barisal	Asokoti bridge	PC-I	1,660,726	4,335,157	4,428,603
70	R890_16a	Barisal	Banglabazar Bridge	PC-I	1,598,916	1,096,680	4,263,777
71	R890_21a	Barisal	Box-a-ali Bridge	PC-I	1,220,177	1,160,748	3,253,805
72	R890_28a	Barisal	Borhanuddin Bridge	PC-I	1,374,905	1,119,703	3,666,413
73	R548_40a	Rajshahi	Mohis Mari Bridge	PC-I	1,184,982	1,358,485	3,159,952
74	R451_1a	Rajshahi	Naiori Bridge	PC-I	1,752,092	1,525,347	4,672,244
75	R451_7a	Rajshahi	Chondi Das Bridge	Steel-I	4,046,820	1,602,307	-
76	R550_28b	Rangpur	Bottoli Bridge	Steel-I	3,560,256	1,294,269	-
77	R860_31a	Gopalganj	Paprail Bailey Bridge	PC-I	1,106,709	1,077,440	2,951,225
78	Z8708_1c	Barisal	Afalbarir Khal Bridge	PC-I	1,188,143	936,475	3,168,382
79	N5_458a	Rangpur	-	PC-I	706,562	4,392,107	1,884,166
80	N5_488a	Rangpur	Chawai Bridge	PC-I	1,107,950	5,381,043	2,954,533
81	Z8708_12b	Barisal	Boda Bridge	PC-I	1,747,867	1,287,955	4,660,980
82	Z8033_017a	Barisal	Raiyer hat bridge	PC-I	1,817,411	1,005,852	4,846,428
83	R860_34a	Gopalganj	Jajihar Bridge	PC-I	1,587,496	1,195,431	4,233,322
84	R860_44c	Gopalganj	Gazipur Bridge	PC-I	3,712,042	1,624,626	9,898,779
85	R860_53d	Gopalganj	Balar Bazar Bridge	PC-I	2,741,954	1,720,313	7,311,878
86	N8_69a	Gopalganj	Kumar Bridge	PC-I	2,701,180	7,124,957	7,203,146
87	Z6010_12b	Rajshahi	Faliarbil Bridge	PC-I	958,657	1,009,173	2,556,418
88	Z5008_1a	Rangpur	Choto Dhepa bridge.	PC-I	1,406,197	1,191,020	3,749,859
89	Z5024_5c	Rangpur	Shampur Bridge.	PC-I	987,144	920,762	2,632,384
90	Z5025_46a	Rangpur	Bondorer pool Bridge	PC-I	1,765,398	1,064,994	4,707,727
91	Z5040_4a	Rangpur	Khottapara Bridge	PC-I	1,097,748	869,305	2,927,329
92	Z8810_13a	Barisal	Banogram Bridge	PC-I	2,260,519	1,080,306	6,028,050
93	R585_80a	Rangpur	Bhela Bridge	PC-I	1,046,119	1,153,476	2,789,650
94	Z8033_008a	Barisal	Kalijira bridge	PC-I	3,162,779	1,404,712	8,434,079
95	Z8033_019a	Barisal	Masrong bridge	PC-I	1,568,311	885,227	4,182,164
96	Z8034_011a	Barisal	Padarhat bridge	PC-I	1,624,430	864,197	4,331,813
97	Z8044_004a	Barisal	Talukdarhat Bailey Bridge	PC-I	1,245,055	871,207	3,320,145
99	R860_35a	Gopalganj	Shajonpur Bailey Bridge	PC-I	1,130,973	1,077,440	3,015,927
100	Z5041_2a	Rajshahi	Debokbazar Bridge	Steel-I	3,734,209	1,294,240	-
I	N706_14b	Khulna	Jhikorgacha Bridge	PC-I	3,677,161	28,385,926	9,805,761
II	N5_435a	Rangpur	-	PC-I	747,507	10,551,216	1,993,352
III	N704_12c	Khulna	Chandi Pur Bridge	PC-I	835,223	10,612,784	2,227,262
IV	N805_24a	Gopalganj	Garakola Bridge	PC-I	3,724,477	28,502,906	9,931,938
V	R750_25a	Khulna	Tularampur Bridge	PC-I	3,332,813	2,924,480	8,887,501
VI	Z7503_5a	Khulna	Hawai khali Bridge	PC-I	1,406,285	923,520	3,750,093

*SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges

Source: JICA Survey Team

11. COST ESTIMATES

11.1 Introduction

In this chapter, project cost is estimated for the 105 bridges for which preliminary design was conducted[3].

The general conditions of cost estimates, project cost components for GOJ/GOB portions and cost calculation method are summarized in the following sections.

11.2 General Condition of Cost Estimates

(1) Term of Cost Estimates

The unit rates of material, equipment, labor and other costs adopted for this cost estimates are based on rates valid as of December 2014.

(2) Exchange rate

The exchange rates adopted for these cost estimates are as follows:

US$ 1 = Yen 119

US$ 1 = BDT 77.5

BDT 1 = Yen 1.54

(3) Eligible Portion by GOJ

1) Civil Work Cost

The civil work cost is estimated on the basis of quantities of each bridge component multiplied with its unit price derived from basic unit rates. The quantities of each bridge component are determined in accordance with the preliminary design (carried out at each bridge location) in most cases, and in accordance with structural design calculations of standard bridges in the remaining cases.

[3] 106 bridges were selected as the candidate bridges in Chapter 3. However the preliminary design was conducted for 105 bridges since it was confirmed that 1 bridge is under construction in another project.

2) Consulting Services

The cost of the consulting services is determined on the basis of man-months required (national and international level) as specified in the TOR for consulting services. The man-months are determined based on expected manpower required for each stage of the project implementation (D/D, tendering assistance and C/S).

3) Physical Contingency

The physical contingencies are set at 10.0 % for the civil work, and 5.0 % for the consulting service cost.

4) Price Escalation Rate

The price escalation rates shall follow JICA guidelines for loan calculation, and are set at 4.9 % for the local currency and 2.0 % for foreign currencies in accordance with other ODA-loan projects in Bangladesh.

5) Interest During Construction

The interest incurred during construction as calculated by JICA guidelines shall be covered by the GOJ portion.

(4) Non-eligible Portion Covered by GOB

1) Land Acquisitions and Resettlement Cost

The following costs are required to be covered by GOB in the preconstruction stage.

- Resettlement of houses and public/private structures
- Relocation of utilities
- Land acquisitions cost

2) Administration Cost

The administration cost incurred for establishment of the organization under RHD is set at 10% of the sum of construction cost and consultant service costs.

3) VAT (Value Added Tax)

In accordance with VAT law, regulation, order and SRO booklet (2011), VAT 15.0 % is applied for purchasing any product from the local market, therefore VAT is added to the total civil works cost and consulting services costs respectively.

4) Custom Duty

Import tax is charged at a rate from 3% to 25% depending on the item. The rate for major

construction materials procured from international markets is shown in Table 11.2.1.

Table 11.2.1 Rate of Import Tax

Item	Procured country (generally)	Rate of import tax
Weathering steel girders	Japan	12%
Weathering H.T. bolts	Japan	12%
Elastomeric bearing for STGs	Japan	12%
Elastomeric bearing for PCGs	China/India	12%

5) Income Taxes (IT)

All contractors and consulting firms will be charged an IT of 10.0%.

11.3 Civil Work Cost

11.3.1 Unit Rate of Major Pay Items

In order to derive the unit rate of major pay items for WBBIP, unit rate analysis is carried out in reference to EBBIP which is a similar project. The labor, material, equipment rental and other costs to formulate the unit rate of major items are mostly set at 1.10 times of unit rates used in the EBBIP. The increase is because the EBBIP tender was conducted mostly in 2012 and a price escalation of 5.0 % per year is assumed with reference of consumer price index shown in Table 11.3.1.

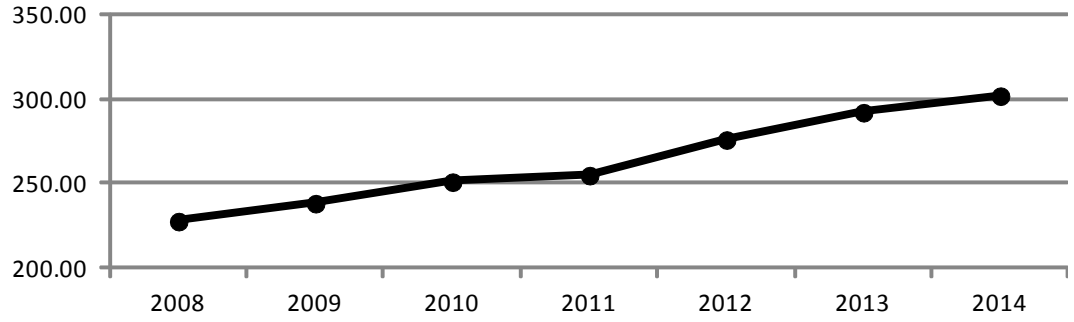
Some of the unit rates derived from EBBIP are adjusted for the current market prices in Bangladesh, and new unit rates for steel bridges are calculated by the JICA Survey Team based on market price research.

The unit rates of each item are broken down into foreign currency (USD) and local currency (BDT), and the foreign portion of the equivalent total amount is calculated. The calculated unit rate of major pay items are listed in Table 11.3.2.

Table 11.3.1 Consumer Price Index (CPI)

Year	2008	2009	2010	2011	2012	2013	2014
CPI	228.18	238.73	251.43	255.33	276.34	292.45	302.24
increase		4.6%	5.3%	1.6%	8.2%	5.8%	3.3%
note					from 2012 to 2014		9.4%

1 CPI of "Transport & Communication of National" from statistic book Bangladesh
2 Base CPI of 1996 as 100
3 CPI of 2014 is derived from CPI of the past years



Source: JICA Survey Team

Table 11.3.2 Unit Rate of Major Pay Items for Civil Works

Unit: USD 1.0=BDT 77.5

Confidential

11.3.2 Cost Calculation for Standard Bridges (18 types)

Cost calculation for standard bridges (18 types) is conducted to set unit prices for each bridge component as shown in Table 11.3.3. The major bridge components are set as 7 components to formulate total civil works cost, as listed below.

I. Superstructure
II. Abutment
III. Pier
IV. Pile
V. Approach road
VI. Temporary bridge and demolish bridges
VII. Soft soil treatment

Table 11.3.3 Standard Bridges to be Calculated

PC-I Girder		
No	Length/Span(m)	Width(m)
1	30	9.8
2	35	9.8
3	40	9.8
4	25+25=50	9.8
5	30+30=60	9.8
6	25+25+25=75	9.8
7	30+30+30=90	9.8
8	35+35+35=105	9.8

Steel-I Girder		
No	Length/Span(m)	Width(m)
1	40	9.8
2	50	9.8
3	60	9.8
4	40+40=80	9.8
5	50+50=100	9.8
6	60+60-120	9.8
7	50+50+50=150	9.8
8	60+60+60=180	9.8

Source: JICA Survey Team

11.3.3 Unit Prices for Bridge Component

In the cost calculations for standard bridges (18 types), unit prices of each bridge component are set by local currency (BDT) and foreign currency (USD) for each bridge type (PC-I and Steel-I). Civil work costs are calculated by adding the overhead cost of the contractor to the sum of costs for each bridge component. A summary of unit prices for each bridge component is shown in Table 11.3.4.

Table 11.3.4 Unit Prices for Bridge Component

Confidential

Source: JICA Survey Team

11.3.4 Civil Work Cost of 105 Bridges

Based on the unit prices for the 7 major bridge components as well as the preliminary design (at each bridge location), the civil work cost for all 105 project bridges are calculated. Summary of civil work cost by bridge component and by bridge type are shown in Table 11.3.5 and Table 11.3.6, respectively, and detailed civil work cost for 105 bridges are shown in Table 11.3.7 and Table11.3.8.

Table 11.3.5 Summary of Civil Work Costs by Bridge Component

Confidential

Source: JICA Survey Team

Table 11.3.6 Summary of Civil Works Cost by Bridge Type

Confidential

Source: JICA Survey Team

Table 11.3.7 Civil Work Cost for 105 Bridges (1)

Confidential

*SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges

Source: JICA Survey Team

Table 11.3.8 Civil Work Cost for 105 Bridges (2)

Confidential

*SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges
Source: JICA Survey Team

12. PROJECT EFFECT

12.1 Operation and Effect Indicators

JICA has been utilizing a system of Operation and Effect Indicators in order to quantitatively inspect and evaluate project performance since 2000.

- Operation Indicator: A quantitative indicator to measure the operational status of a project.
- Effect Indicator: A quantitative indicator to measure the effects generated by a project

These indicators used for JICA loans correspond with the outcome indicators used for World Bank projects. In this chapter, operation and effect indicators are summarized to evaluate the project performance.

12.1.1 Selection of Operation and Effect Indicators

Operation and effect indicators are selected based on data availability, validity and reliability in both the current year (taken as the baseline) and 2 years after project completion. Selected operation and effect indicators are summarized at Table 12.1.1.

Decrease in traffic accidents after bridge completion is desirable as an effect indicator, but this figure cannot be determined as the past traffic accident data on the bridge is not available. Improvement of travel speed was also not taken as an indicator as the target bridge and approach roads already have same numbers of lanes in most cases, so the travel speed will not be significantly changed.

Table 12.1.1Selection of Operation and Effect Indicators

Indicator		Baseline	2 years after project completion
Operation Indicators	Freight Traffic Volume (pcu/day)	2014	2023
	Passenger Vehicle Traffic Volume (pcu/day)		
Effect Indicators	Travel Cost from Detour when Bridge Collapsed (1000 taka/year)		
	Reduction of Detour Days during Flooding (days)		
	Unserviceability rate		

Source: JICA Study team

(1) Freight and Passenger Vehicle Traffic Volume by Vehicle Type

The freight and passenger traffic volume of the baseline and 2 years after the project completion were selected as operational indicators. Baseline traffic volume in both directions was obtained from the result of a traffic count survey conducted for this preparatory survey, and traffic volume in both directions after 2 year of project completion was calculated in Chapter 5 based on the growth rate by road types.

(2) Travel Cost from Detour when Bridge Collapsed

The target bridges were selected from high possibility of collapse or impassable due to bridge degradation and damage due to overloaded vehicle passing. When the bridge is collapsed or impassable, vehicles have to take detours which generates loss of time and value (cost of movement for people and materials). Therefore, the “travel cost from detour when bridge collapsed” was selected as the first effect indicator.

The travel costs of both the normal route and the detour route were calculated from the intersection before the bridge to the intersection after crossing the bridge, taking the detour route as the route that would be taken if the current bridge had collapsed or had become impassable. The difference between these two costs was then calculated. The detour route was selected using roads of municipal level or higher to ensure a practical route.

(3) Reduction of Detour during Flooding (All year accessible Bridge)

Bangladesh is a mostly flat land. Approximately 90% by area of Bangladesh is less than 10 meters above of sea level, and soil is poorly drained. In addition, present bridges sometimes become flooded (especially in the rainy season) and vehicles have to take detours, which causes losses in productivity. Therefore, the reduction of detour days when bridge is flooded was selected as the second effect indicator. Taking calculated HWL in this Project(refer to the 4.3) as the standard, a baseline detour period of 60 days was assumed for existing low bridges.

(4) Unserviceability rate

Several bridges within the set of project bridges are severely damaged, and are judged to have a high probability of traffic hindrance (e.g. due to collapse), which would lead them to a stoppage of service. With this in mind, "unserviceability rate" is selected as third effect indicator. The unserviceability rates are the probability of occurrence of traffic hindrance, estimated based on the bridge age.

12.1.2 Proposed Operation and Effect Indicators

The calculated operation and effect indicators for each bridge are shown in Table 12.1.2 and Table 12.1.3.

Table 12.1.2 Proposed Operation and Effect Indicator 1

SN	Zone	Bridge ID	Road No	Name of Bridge	Road Class	Operation Indicator (Traffic Volume) unit: pcu/day				Travel cost from detour when bridge collapsed ('000 taka/year)		Detour days when bridge is flooded (day)		Unserviceability rate (%)	
						2014	2023	2014	2023						
						Freight Vehicle	Passenger Vehicle	Freight Vehicle	Passenger Vehicle	2014	2023	2014	2023	2014	2023
2	Rangpur	N509_19a	N509	Shamamoti Bridge	National Road	693	2,720	1,059	4,158	N/A	0	60.0	0	59%	0
6		N5_235a	N5	Mohosthan Bridge		14,400	20,162	22,017	30,825	81,976	0	0.0	0	66%	0
10		N5_265a	N5	Bupinath Bridge		7,884	11,328	12,054	17,319	60,352	0	60.0	0	59%	0
11		N5_350b	N5	Barati Bridge		2,673	5,334	4,086	8,157	47,334	0	0.0	0	5%	0
24		N5_356a	N5	Nanjchere (Tetujari) Bridge		2,673	5,334	4,086	8,157	121,459	0	0.0	0	5%	0
31		N5_378a	N5	Gaudangi Bridge		2,481	4,472	3,792	6,834	74,191	0	60.0	0	20%	0
36		N5_188a	N5	Ghogar Bridge		18,549	23,658	28,359	36,173	349,629	0	60.0	0	8%	0
38		N518_4a	N518	Khorkhori bridge		2,481	4,472	3,792	6,834	13,721	0	60.0	0	10%	0
45		N5_344c	N5	Kharobaj Bridge		2,673	5,334	4,086	8,157	47,334	0	0.0	0	5%	0
46		N5_382a	N5	Ichamoti Bridge		2,481	4,472	3,792	6,834	74,191	0	0.0	0	13%	0
47		N5_360a	N5	Chikli Bridge		2,673	5,334	4,086	8,157	121,459	0	60.0	0	5%	0
66		N5_260b	N5	Katakhali Bridge		7,884	11,328	12,054	17,319	60,352	0	0.0	0	32%	0
79		N5_458a	N5	Pathoraj Bridge		1,869	5,947	2,856	9,092	100,668	0	60.0	0	43%	0
80		N5_488a	N5	Chawai Bridge		4,350	5,549	6,651	8,483	0	0	0.0	0	4%	0
102		N5_435a	N5	Sattapir Bridge		3,219	6,636	4,923	10,145	97,177	0	0.0	0	10%	0
62		R545_115c	R545	Mongla bari kuthibari Bridge	Regional Road	2,250	7,353	3,300	10,780	114,428	0	0.0	0	59%	0
76		R550_28b	R550	Bottoli Bridge		2,931	5,405	4,296	7,924	8,374	0	0.0	0	14%	0
93		R585_80a	R585	Bhela Bridge		4,116	5,559	6,036	8,152	83,128	0	60.0	0	8%	0
48		Z5025_55a	Z5025	Kakra Bridge	Zilal Road	1,317	3,480	1,872	4,947	36,428	0	60.0	0	5%	0
49		Z5025_64a	Z5025	Gabura Bridge.		1,317	3,480	1,872	4,947	36,428	0	0.0	0	7%	0
50		Z5401_45a	Z5401	Matpara Bridge		2,643	6,637	3,756	9,431	130,987	0	60.0	0	5%	0
51		Z5072_14a	Z5072	Bombgara Bridge		1,119	1,830	1,590	2,598	N/A	0	60.0	0	2%	0
52		Z5025_60a	Z5025	Madarganj Bridge		1,317	3,480	1,872	4,947	36,428	0	60.0	0	6%	0
53		Z5472_6a	Z5472	Rakhta Dha Bridge		0	184	0	262	N/A	0	60.0	0	1%	0
55		Z5552_10a	Z5552	Barodia Khali Bridge		672	3,597	954	5,112	13,579	0	60.0	0	0%	0
59		Z5015_22a	Z5015	Bahagili Bridge		231	1,191	327	1,694	9,955	0	0.0	0	6%	0
60	Rangpur	Z5701_1a	Z5701	Anandababur Pool	Zilla Road	561	3,157	798	4,485	60,520	0	0.0	0	5%	0
61		Z5701_9a	Z5701	Duhuli Bridge		288	2,227	408	3,166	49,854	0	60.0	0	6%	0
88		Z5008_1a	Z5008	Choto Dhepa bridge		642	3,813	912	5,419	66,346	0	60.0	0	68%	0
89		Z5024_5c	Z5024	Shampur Bridge.		672	943	954	1,339	N/A	0	0.0	0	20%	0
90		Z5025_46a	Z5025	Bondorer pool Bridge		1,374	3,056	1,953	4,342	66,869	0	60.0	0	38%	0
91		Z5040_4a	Z5040	Khottapara Bridge		1,338	2,267	1,902	3,224	17,120	0	0.0	0	41%	0
3	Rajshahi	N5_119a	N5	Chanda Bridge	National Road	3,996	7,780	6,108	11,895	85,318	0	0.0	0	52%	0
4		N5_127a	N5	Palgari Bridge		3,996	7,780	6,108	11,895	400,388	0	60.0	0	41%	0
5		N5_176a	N5	Bhuyagati Bridge		15,087	17,169	23,067	26,249	295,513	0	0.0	0	26%	0
7		N5_120a	N5	Chanda Bridge		3,996	7,780	6,108	11,895	85,318	0	0.0	0	52%	0
8		N5_128a	N5	Goilhar Bridge		4,374	6,193	6,687	9,468	359,750	0	60.0	0	41%	0
9		N5_158a	N5	Purbodalua Bridge		6,234	9,267	9,531	14,170	123,589	0	0.0	0	48%	0
16		N5_134a	N5	Nukali Bridge		4,374	6,193	6,687	9,468	207,666	0	60.0	0	50%	0
17		N6_97a	N6	Dattapara Bridge		10,221	9,697	15,627	14,827	98,334	0	0.0	0	41%	0
19		N5_140a	N5	Jugnidaha Bridge		4,374	6,193	6,687	9,468	161,773	0	0.0	0	26%	0
20		N5_118a	N5	Punduria Bridge		3,996	7,780	6,108	11,895	85,318	0	60.0	0	52%	0
27		N505_2a	N505	Kazir Hat Bridge		243	797	372	1,221	N/A	0	0.0	0	0%	0
33		N5_156a	N5	Chowkidihoh Bridge		6,234	9,267	9,531	14,170	123,589	0	60.0	0	50%	0
34		N5_172a	N5	Notun Dhoh Bridge		15,087	17,169	23,067	26,249	295,513	0	0.0	0	32%	0
35		N5_179a	N5	Dhatia Bridge		18,549	23,658	28,359	36,173	349,629	0	60.0	0	26%	0
37		N5_126a	N5	Vitapara Bridge		3,996	7,780	6,108	11,895	400,388	0	0.0	0	48%	0
54		N5xx_Sa	N5xx	Pure Mukto Monoh Bridge		6,234	9,267	9,531	14,170	0	0	0.0	0	57%	0
18		R681_10a	R681	Horisonkorpur Bridge	Regional Road	501	953	735	1,398	0	0	0.0	0	NA	0
28		R548_28b	R548	Atrai Bridge		657	2,414	963	3,537	17,517	0	0.0	0	4%	0
73		R548_40a	R548	Mohis Mari Bridge		570	2,735	837	4,007	41,162	0	60.0	0	1%	0
74		R451_1a	R451	Naiori Bridge		4,530	12,061	6,642	17,686	60,741	0	60.0	0	17%	0
75		R451_7a	R451	Chondi Das Bridge		4,530	12,061	6,642	17,686	60,741	0	60.0	0	10%	0

Note: 1) Detour travel cost (when bridge collapsed/impassable) was set as 0 when there is no detour and it was set as NA when detour distance is too long to be realistic.

2) Unserviceability rate was set as NA when bridge age was not identified.

3)SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges

Table 12.1.3 Proposed Operation and Effect Indicator 2

SN	Zone	Bridge ID	Road No	Name of Bridge	Road Class	Operation Indicator (Traffic Volume) unit: pcu/day				Travel cost from detour when bridge collapsed ('000 taka/year)		Detour days when bridge is flooded (day)		Unservicability rate (%)	
						2014	2023	2014	2023						
						Freight Vehicle	Passenger Vehicle	Freight Vehicle	Passenger Vehicle	2014	2023	2014	2023	2014	2023
87	Rajshahi	Z6010_12b	Z6010	Faliarbil Bridge	Zilla Road	555	988	789	1,405	9,846	0	60.0	0	10%	0
100		Z5041_2a	Z5041	Debokbazar Bridge		1,086	2,301	1,542	3,269	24,374	0	60.0	0	10%	0
1	Barisal	N8_178a	N8	Boalia Bazar Bridge	National Road	4,668	14,486	7,137	22,146	243,013	0	0.0	0	6%	0
12		N8_182a	N8	Bakerganj Steel Bridge		4,668	14,486	7,137	22,146	N/A	0	0.0	0	6%	0
26		N8_095a	N8	Amgram bridge		2,895	6,915	4,425	10,571	199,008	0	0.0	0	32%	0
56		N8_152c	N8	Rahamatpur bridge		3,102	9,257	4,743	14,153	77,838	0	0.0	0	5%	0
57		N8_127b	N8	gounagata bridge		2,388	7,554	3,651	11,551	32,414	0	0.0	0	3%	0
64		N8_123a	N8	Souderkhal bridge		2,388	7,554	3,651	11,551	32,414	0	60.0	0	5%	0
69		N8_129a	N8	Asokoti bridge		2,388	7,554	3,651	11,551	25,328	0	0.0	0	12%	0
86		N8_69a	N8	Kumar Bridge		5,049	13,224	7,719	20,216	164,918	0	0.0	0	6%	0
104		N805_24a	N805	Garakola Bridge		7,005	12,596	16,113	49,498	489,556	0	0.0	0	1%	0
42		R890_45a	R890	Dowry Bridge	Regional Road	4,788	11,765	7,020	17,251	76,159	0	0.0	0	6%	0
70		R890_16a	R890	Bangla Bazar Bridge		1,485	3,342	2,178	4,902	17,625	0	0.0	0	7%	0
71		R890_21a	R890	Boksheali Bridge		1,485	3,342	2,178	4,902	4,637	0	60.0	0	8%	0
72		R890_28a	R890	Sheyali Bailey Bridge		1,485	3,342	2,178	4,902	N/A	0	60.0	0	3%	0
77		R860_31a	R860	Paprali Bailey Bridge		1,494	2,758	2,190	4,044	17,094	0	0.0	0	5%	0
83		R860_34a	R860	Jajihar Bridge		1,494	2,758	2,190	4,044	17,094	0	60.0	0	6%	0
84		R860_44c	R860	Gazipur Bridge		1,494	2,758	2,190	4,044	N/A	0	0.0	0	1%	0
85		R860_53d	R860	Balar Bazar Bridge		1,494	2,758	2,190	4,044	N/A	0	0.0	0	7%	0
99		R860_35a	R860	Shajonpur Bailey Bridge		1,494	2,758	2,190	4,044	17,094	0	0.0	0	7%	0
58		Z8052_009d	Z8052	Gabtala Steel Bridge	Zilla Road	465	3,407	660	4,843	N/A	0	60.0	0	9%	0
65		Z8701_3d	Z8701	Bottala Bridge		690	2,870	981	4,081	17,194	0	60.0	0	10%	0
78		Z8708_1c	Z8708	Algy Bridge		9	1,131	12	1,607	11,065	0	0.0	0	6%	0
81		Z8708_12b	Z8708	Satani Bridge		705	2,347	1,002	3,335	26,704	0	0.0	0	3%	0
82		Z8033_017a	Z8033	Raiyer hat bridge		507	5,203	720	7,392	10,572	0	0.0	0	15%	0
92		Z8810_13a	Z8810	Madhabkhali bridge		465	3,407	660	4,843	17,711	0	0.0	0	2%	0
94	Barisal	Z8033_008a	Z8033	Kalijira bridge	Zilla Road	336	3,157	477	4,484	44,056	0	0.0	0	2%	0
95		Z8033_019a	Z8033	Masrong bridge		1,053	6,438	1,497	9,150	58,381	0	0.0	0	3%	0
96		Z8034_011a	Z8034	Padarhat bridge		135	2,740	192	3,892	N/A	0	0.0	0	3%	0
97		Z8044_004a	Z8044	Talukdarhat Bailey Bridge		951	4,175	1,350	5,933	N/A	0	0.0	0	8%	0
13	Khulna	N7_025a	N7	Jhuldibazar Bridge	National Road	8,397	7,623	12,837	11,654	85,444	0	0.0	0	6%	0
14		N7_039a	N7	Karimpur Bridge		5,826	7,248	8,907	11,082	248,136	0	0.0	0	20%	0
15		N7_049a	N7	Porkitpur Bridge		5,952	7,148	9,099	10,929	59,049	0	60.0	0	17%	0
21		N704_43a	N704	Khune-Kumte-Churesh Bridge		19,731	21,347	30,168	32,636	418,980	0	0.0	0	8%	0
22		N7_248c	N7	Gora bridge		3,966	3,400	6,063	5,197	N/A	0	0.0	0	13%	0
23		N7_054a	N7	Barashia Bridge		5,952	7,148	9,099	10,929	21,387	0	0.0	0	14%	0
25		N7_246a	N7	Balai bridge.		3,966	3,400	6,063	5,197	N/A	0	0.0	0	NA	0
29		N7_036c	N7	Kanaipur Bridge		5,826	7,248	8,907	11,082	248,136	0	0.0	0	14%	0
30		N7_048a	N7	Brahmonkanda Bridge		5,952	7,148	9,099	10,929	59,049	0	60.0	0	14%	0
32		N7_047a	N7	Bimankanda bridge		5,952	7,148	9,099	10,929	59,049	0	0.0	0	10%	0
39		N7_141b	N7	Buri Bhairab Bridge		8,391	5,482	12,828	8,384	130,487	0	0.0	0	24%	0
41		N703_Sd	N703	Dhopa Ghata Bridge		4,118	15,002	6,294	22,937	8,196	0	60.0	0	20%	0
43		N704_14a	N704	Barda Bridge		13,029	12,815	19,920	19,596	90,670	0	60.0	0	20%	0
44		N704_33b	N704	Balipara Bridge		11,283	8,614	17,250	13,169	256,449	0	60.0	0	20%	0
67		N704_27b	N704	Bittipara Bridge		11,283	8,614	17,250	13,169	376,885	0	60.0	0	20%	0
101		N706_14b	N706	Jhikorgacha Bridge		12,960	16,324	25,218	55,199	511,050	0	60.0	0	41%	0
103		N704_12c	N704	Chandi Pur Bridge		13,029	12,815	19,920	19,596	208,814	0	0.0	0	5%	0
40		R720_44a	R720	Gurakhali Bridge	Regional Road	432	1,539	660	2,352	8,104	0	60.0	0	4%	0
63		R760_049c	R760	Shakdaha bridge		3,438	5,037	5,040	7,388	178,223	0	60.0	0	41%	0
68		R750_22c	R750	Bhangura Bridge		1,980	4,556	8,430	37,206	126,894	0	60.0	0	41%	0
105		R750_25a	R750	Tularampur Bridge		1,980	4,556	8,430	37,206	126,894	0	0.0	0	50%	0
106		Z7503_5a	Z7503	Hawai khali Bridge	Zilla Road	3,102	7,575	10,146	41,822	N/A	0	0.0	0	24%	0

Note:1) Detour travel cost (when bridge collapsed/impassable) was set as 0 when there is no detour and it was set as NA when detour distance is too long to be realistic.

2) Unserviceability rate was set as NA when bridge age was not identified.

3) SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges

12.2 Economic Evaluation

12.2.1 General

In this section, the economic feasibility of reconstruction of the selected bridges is evaluated in terms of the national economy. In Chapter 3, 106 bridges in western Bangladesh were selected as the results of screening of 200 bridges from view of technical points. Since it was confirmed that 1 of these bridges is under construction as part of another project, 105 bridges are taken for economic evaluation.

The economic analysis of the project is performed through comparison of the economic cost of the project with the economic benefit derived from the bridge construction.

The traffic demand forecast of each bridge was made in Chapter 5, the preliminary design study was carried out in Chapter 7, and the cost estimate of each bridge was made in Chapter 11. Based on these studies, the economic evaluation of each bridge project shall be carried out in this section.

In order to determine a procedure for economic analysis, the corresponding procedure developed for the “Eastern Bangladesh Bridge Improvement Project”[4] was reviewed. Due to the similar nature of the project, it was decided that the same procedure would be adopted

12.2.2 Basic Assumptions and Conditions

(1) Basic Concept of Benefit

In Chapter 3, 105 bridges in need of reconstruction were selected based on several technical criteria. In this section, necessity is reevaluated from an economic standpoint.

A substantial portion of the benefits derived from construction of new bridges is the reduction of Vehicle Operation Cost (VOC) and Travel Time Cost (TTC) of passing vehicles, by reducing the probability of bridge collapse. As shown in the following Figure, in the case of collapse, vehicles crossing the bridge will be forced to take another bridge located along a detour route that normally requires a longer travel distance with worse surface conditions.

Probability of bridge collapse depends on the type and conditions of bridges. Temporary bridges have higher probability than permanent bridges, and damaged permanent bridges have higher probability than new ones. The difference between VOC/TTC in regular routes and detour routes will be considered a benefit.

[4] JBIC Special Assistance for the Project Formulation (SAPROF) for Eastern Bangladesh Bridge Improvement Project” Dec. 2007

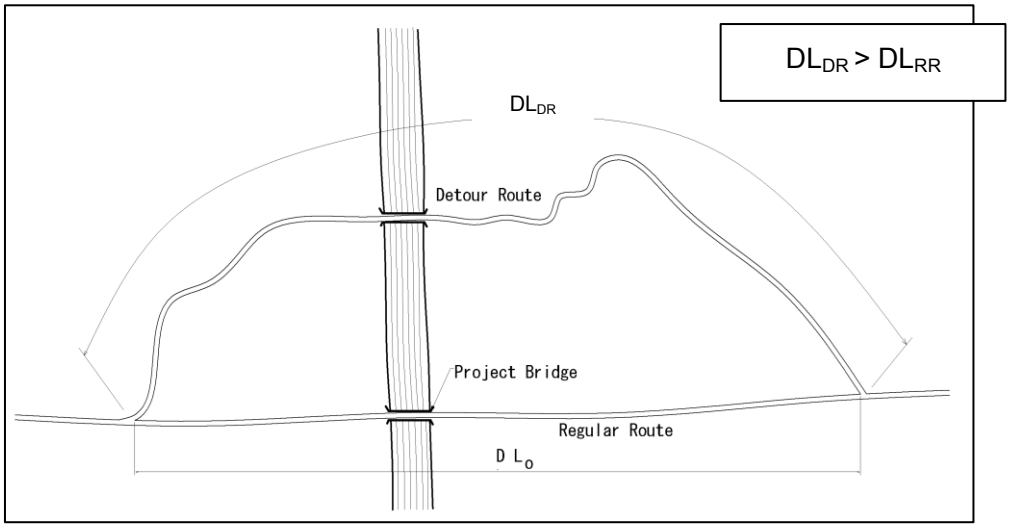


Figure 12.2.1 Travel Distance of Regular Route vs Detour Route

Widening of bridges width will increase travel speed of vehicles crossing the bridges. If traffic volume is high with respect to the carriageway width, a marked reduction of travel speed will occur. Reduction of VOC/TTC by increasing travel speed derived from bridge widening is considered a benefit.

(2) Implementation Schedule

As described in Chapter 14, the project is proposed to be implemented with the following schedule:

- 2015 - 2016 Detailed design
- 2017 Procurement of contractors
- 2018 - 2020 Construction of bridges
- 2021 Opening to traffic

(3) Project Life

The economic life of the project is assumed to be 25 years (2021 - 2045), although the physical life of the bridge is much longer. Economic viability of the bridge construction shall be verified using a period of 25 years.

(4) Discount Rate

The rate of opportunity cost of capital is estimated at 12 %. This rate is generally used as the discount rate for the evaluation of infrastructure projects in Bangladesh.

12.2.3 Economic Cost Estimate

The economic cost is calculated from financial cost (construction cost) taking account the following factors:

- Escalation factor: Price inflation was not taken into account for either construction cost or operation/maintenance cost.
- Administrative cost, VAT and import duty: Imposition of value added tax and import duty was excluded.
- Standard conversion factor: A standard conversion factor (0.80) is applied to the price of non-tradable goods and services.
- Land acquisition cost and compensation cost: Resettlement cost estimated in the Abbreviated Resettlement Plan is used in the economic analysis.
- Construction and operation/maintenance costs: These costs are set up for each bridge based on the Project implementation schedule.

Table 12.2.1 Economic Cost Estimate

Confidential

Source: JICA Study team

Figure in million BDT

12.2.4 Benefit Measurement

(1) Type of Benefits

Benefits derived from the bridge projects are considered the followings:

- Reduction of vehicle operating cost (VOC)
- Reduction of travel time cost (TTC)
- Reduction of incremental VOC and TTC
- Saving in bridge maintenance cost

Benefits are classified by bridge type into the following three groups:

- Permanent bridges
- Temporary bridges
- New bridges (See Chapter 15)

(2) Unit Road Users Cost

1) Vehicle Operating Cost (VOC)

Benefits derived from road and bridge projects are mainly accrued from savings in Vehicle Operating Cost (VOC), which includes operating and maintenance costs for each vehicle category. The VOC used in this study was taken from the RHD Road user Cost Annual report with some modifications made by considering the consumer price index (CPI) between 2004 and 2014. The VOC by road roughness (IRI) in 2014 is presented in Table 12.2.2.

Table 12.2.2 Vehicle Operating Cost by Road Roughness (as of 2014 Prices)

	Good	Fair	Bad	V. Bad
IRI	4	6	8	10
Car	19.57	20.75	21.92	23.33
Utility	19.45	21.10	23.48	26.80
Microbus	23.86	25.77	28.03	31.00
Minibus	23.94	25.20	26.42	27.82
Large Bus	28.81	31.33	34.08	37.90
Small Truck	22.66	24.82	27.01	29.40
Medium Truck	27.09	29.36	31.77	34.40
Heavy Truck	29.88	32.38	37.17	40.25
Auto Rickshaw	4.87	5.12	5.42	5.75
Motor Cycle	2.73	2.81	2.86	2.88

Note: Estimated based on “RHD Road User Cost Annual Report by FY 2004/05” and CPI between 2004 and 2014

The value of IRI corresponds to surface type and road conditions, and is assumed as follows:

Table 12.2.3 IRR by Road Condition

Condition	IRI
Good	4
Fair	6
Bad	8
Very bad	10

Source: JICA Study Team

Table 12.2.4 CPI Index and Growth Index

	2004/05	2014/15	Growth Index 2014/2004
CPI	93.423	196.187	2.10

Source: IMF World Economic Outlook, 2014

2) Travel Time Cost (TTC)

Travel Time Cost (TTC) is an important component of road user cost (RUC). The concept of travel time cost is based on the premise that time spent on travelling could be used for an alternate activity which also produces or may produce some significant cost benefit. If the alternate activity can have a monetary value assigned to it, this can be used as part of road user cost in economic appraisal of projects (particularly in transport projects). Table 12.2.5 shows TTC by vehicle type.

Table 12.2.5 Travel Time Cost (TTC) by Vehicle Type (as of 2014 Prices)

Vehicle Category	TTC per passenger (BDT/hr)	Average Occupancy (Person / Veh)	TTC per Vehicle (BDT/hr)
Car	64.9	3.2	207.1
Utility	64.9	3.2	207.1
Microbus	22.9	10.1	231.2
Mini Bus	37.0	32.0	1,182.7
Large Buses	37.0	44.0	1,626.2
Light Truck	-	-	200.0
Medium Truck	-	-	220.2
Heavy Truck	-	-	220.2
Auto Rickshaw	34.4	3.7	128.5
Motor Cycle	48.1	1.1	50.6

Note: Estimated based on “RHD Road User Cost Annual Report by FY 2004/05” and CPI between 2004 and 2014

(3) Benefit Measurement Model for Reconstruction of Bridge

In order to qualify the benefit of reducing the unserviceability duration of bridges, a probability model is introduced based on “Statistical Analysis Model on Bridge Life”[6].

1) Bridge Life

It is usually said that a newly constructed bridge has a 40 to 80-year life span. A 50-year life span is commonly used for a purpose of asset management. This life span is mainly fitted for calculating depreciation and does not reflect the real bridge life span.

2) Probability Model for Bridges to be Unusable

In Japan, a reliability function for bridges, R(t), has been obtained through statistical analysis on bridge life, as shown in Figure 12.2.2(b). An unreliability function, F(t), can be expressed in terms of R(t) as

$$F(t) = 1 - R(t)$$

Therefore, “Unserviceability Probability Density” of bridges, f(t), can be defined as follows:

$$f(t) = dF(t)/dt = 1 - dR(t)/dt$$

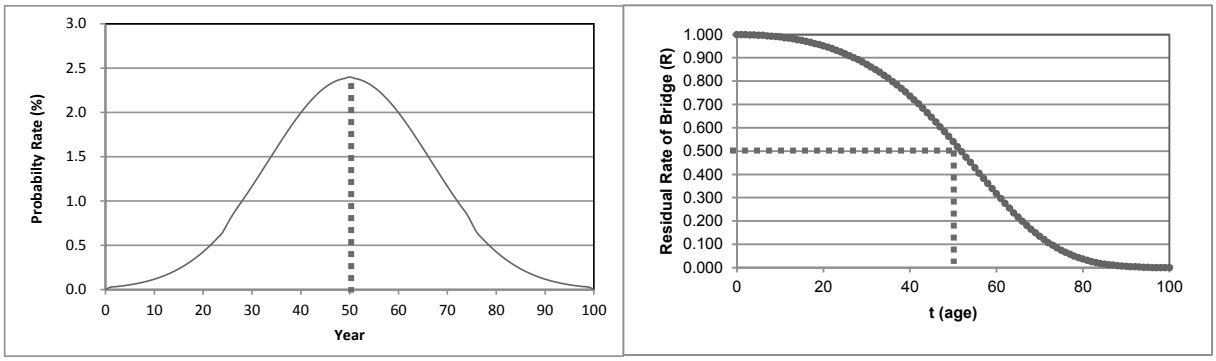
The reliability function R(t) can be expressed as shown in Figure 12.2.2(a) while the “Residuals Rate of Unserviceability” f(t)can be expressed as shown in Figure 12.2.2(b).It can be seen that the function follows a normal distribution. With a mean of 50 years and a standard deviation of 16.7 years, the function can also be defined as follows.

$$f(t) = \frac{1}{\sqrt{2\pi\delta}} e^{-(t-m)2/2\delta} = IN\ 【m, \delta^2】 = IN\ 【50\ 16.7^2】$$

Hence, the cumulative probability rate that a newly constructed bridge becomes unserviceable by the year t is expressed as follows:

$$F(t) = \int f(t)dt$$

[6] This model was used for “the Study on the Maintenance and Rehabilitation of Bridges in Malaysia” Dec.1992, JICA and “Eastern Bangladesh Bridge Improvement Project” Dec. 2007, JICA (JBIC). Original model was developed and presented in “.Statistical Analysis on Project Life” in 1988 by H. Iizuka.

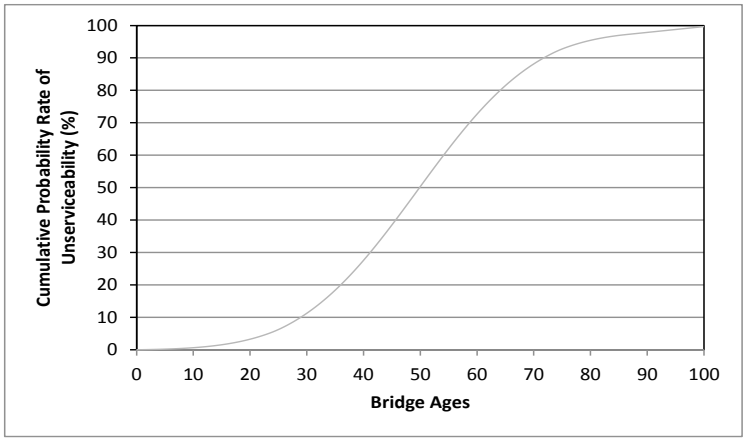


(a)Probability Rate of Unserviceability of Existing Bridge

(b) Residuals Rate of Unserviceability

Source: "Eastern Bangladesh Bridge Improvement Project" Dec. 2007, JICA (JBIC)

Figure 12.2.2 Relation between Probability and its Cumulative of Unserviceability and Timing of New Bridge Construction by Bridge Age



Source: Eastern Bangladesh Bridge Improvement Project" Dec. 2007, JICA (JBIC)

Figure 12.2.3 Relation between Cumulative Probability Rate of Unserviceability and Bridge Age

As seen in Figure 12.2.3, the probability of unserviceability of existing bridges drastically increases so that probability of unserviceability for a bridge of age 50 years and a newly-constructed bridge is calculated as shown in Table 12.2.6, in comparison with original probability densities.

Table 12.2.6 Probability Rate of Unserviceability by Bridge Types

Year	Probability Rate of Existing Bridge[1] (%)	New Bridge (with project)[2] (%)	Bridge age 50 yrs. old (without project)[3] (%)
51	2.3846	0.0270	4.8862
52	2.3718	0.0323	4.8599
53	2.3506	0.0384	4.8166
54	2.3213	0.0455	4.7565
55	2.2842	0.0538	4.6804
56	2.2396	0.0633	4.5890
57	2.1880	0.0743	4.4833
58	2.1299	0.0868	4.3643
59	2.0660	0.1011	4.2333
60	1.9968	0.1173	4.0915
61	1.9230	0.1356	3.9403
62	1.8453	0.1563	3.7812
63	1.7644	0.1794	3.6154
64	1.6811	0.2052	3.4446
65	1.5959	0.2339	3.2701
66	1.5096	0.2657	3.0933
67	1.4229	0.3007	2.9156
68	1.3364	0.3391	2.7383
69	1.2506	0.3810	2.5625
70	1.1661	0.4265	2.3895
71	1.0835	0.4758	2.2201
72	1.0031	0.5289	2.0554
73	0.9254	0.5858	1.8961
74	0.8506	0.6465	1.7429
75	0.7790	0.7110	1.5962
Total	42.4697	6.2112	87.0225

Notes:
1) Values of probability rate of unserviceability under 'Original Probability Density' are obtained from bridge age 50 in Figure 12.2.2(a)
2) Values of probability rate of unserviceability under 'New Bridge' are obtained from bridge age 0 in Figure 12.2.2(a)
3) Values of probability rate of unserviceability of 'Bridge Age 50' are obtained from bridge age 50 in Figure 12.2.2(b)

Source: Eastern Bangladesh Bridge Improvement Project" Dec. 2007, JICA (JBIC)

3) Probability Model for Bridges to be Unusable after Reconstruction

In order to estimate the unserviceability duration of bridges, numbers of months required for bridge construction was assumed as a function of bridge length as follows:

$$Log(M) = 0.5721 \log (L) + 0.043$$

Where

M : *Standard number of Months required for bridge construction*

L : *Bridge length (m)*

Using "M", the number of days of bridge unserviceability is derived with the following formula:

$$d = f \times M \times (365/12)$$

Where

f : *probability for a bridge to be unusable*

d : *number of days for a bridge to be unusable*

All bridges in the study are assumed to be reconstructed within two (2) years, hence, maximum value M is set as 24.

4) Benefit Calculation

VOC and TTC savings resulting from the replacement of permanent bridges is calculated with the following formulae:

$$B_{xc} = \sum_i [f_0(x) - f_w(x)] \times d \times AADT \times (DL_0 \times VOC_{oi} - DL_w \times VOC_{wi}$$

$$B_{xt} = \sum [f_0(x) - f_w(x)] \times d \times AADT_{xi} \times (\frac{OL_0}{V_{0i}} - DL_w - \frac{DL_w}{V_{wi}}) \times TTC_i$$

where:

B_{xc} *:VOC savings at year x*

B_{xt} *:TTC savings at year x*

$f_o(x)$ *:Probability of bridge unusable in year x for without project case*

$f_w(x)$ *:Probability of bridge unusable in year x for with project case*

d *:Number of days required for bridge reconstruction*

$AADT_{xi}$ *:Average Annual Daily Traffic of vehicle type i in year x*

DL_o *:Length of detour route (km)*

DL_w *:Length of regular route (km)*

VOC_{0i} *:Vehicle operating cost of vehicle type i along detour route (Taka/km)*

VOC_{wi} *:Vehicle operating cost of vehicle type i along regular route (Taka/km)*

TTC_i *:Travel time cost of vehicle type i (Taka/h)*

C *:Bridge reconstruction cost*

V_{0i} *:Vehicle operating speed of vehicle type i along detour route (km/h)*

V_{wi} *:Vehicle operating speed of vehicle type i along regular route (km/h)*

(4) VOC/TTC Reduction from Reconstruction of Temporary Bridge

For temporary bridges, more linear behavior on the probability of bridge collapse is used considering that the life of these bridges is very short as compared with permanent ones. Physical life of temporary bridges is assumed to be 7 years:

The short physical life of temporary bridges is attributed not only rapid dilapidation of bridge components, but also high risk of bridge wash out during the rainy season. The annual probability of bridge unserviceability is assumed to be distributed uniformly over its physical life period.

1) Probability Density for Temporary Bridges

It would be unreasonable to assume that all existing temporary bridges are new, so with absence of reliable data, the average physical bridge age is assumed to be 3 years.

The probability density of temporary bridges is shown in Table 12.2.7 together with the probability of newly constructed bridges.

Table 12.2.7 Probability Density of Bridge Unserviceability for Temporary Bridges

Year	New Permanent Bridges (with project) (%)	Temporary Bridges (without project) (%)
1	0.0270	25.0000
2	0.0323	25.0000
3	0.0384	25.0000
4	0.0455	25.0000
5	0.0538	14.2857
6	0.0633	14.2857
7	0.0743	14.2857
8	0.0868	14.2857
9	0.1011	14.2857
10	0.1173	14.2857
11	0.1356	14.2857
12	0.1563	14.2857
13	0.1794	14.2857
14	0.2052	14.2857
15	0.2339	14.2857
16	0.2657	14.2857
17	0.3007	14.2857
18	0.3391	14.2857
19	0.3810	14.2857
20	0.4265	14.2857
21	0.4758	14.2857
22	0.5289	14.2857
23	0.5858	14.2857
24	0.6465	14.2857
25	0.7110	14.2857
Total	**6.2113**	**399.9997**

Source: Eastern Bangladesh Bridge Improvement Project" Dec. 2007, JICA (JBIC)

The period required for restoration of collapsed/washed-out temporary bridges is estimated as follows:

Table 12.2.8 Period Required for Temporary Restoration

Bridge Length (m)	Period of Restoration (days)
5 - 20	10
20 - 30	20
30 - 50	30
50 - 100	40
100 - 150	50
150 - 200	60
200 - 250	65
250 - 300	70
300 - 350	75
350 -	80

Source: "Eastern Bangladesh Bridge Improvement Project" Dec. 2007, JICA (JBIC)

2) Benefit Measurement for Temporary Bridges

VOC and TTC savings from replacement of temporary bridge are calculated from the following equation:

$$B_{xc} = \sum [f_0(x) - f_w(w)] \times d \times AADT_{xi} \times (DL_0 \times VOC_{oi} - DL_w \times VOC_{wo})$$

$$B_{xt} = \sum [f_0(x) - f_w(x)] \times d \times AADT_{xi} \times (DL_0/V_{0i} - DL_w/V_{wi}) \times TTC_i$$

Where:

B_{xc} *:VOC savings at year x*

B_{xt} *:TTC savings at year x*

$f_0(x)$ *:Probability of bridge unusable in year x for without project case*

$f_w(x)$ *:Probability of bridge unusable in year x for with project case*

d *:Number of days required for bridge reconstruction*

$AADT_{xi}$ *:Average Annual Daily Traffic of vehicle type i in year x*

DL_0 *:Length of detour route (km)*

DL_w *:Length of regular route (km)*

VOC_{0i} *:Vehicle operating cost of vehicle type i along detour route (Taka/km)*

VOC_{wi} *:Vehicle operating cost of vehicle type i along regular route (Taka/km)*

TTC_i :*Travel time cost of vehicle type i (Taka/h)*

V_{0i} :*Vehicle operating speed of vehicle type i along detour route (km/h)*

V_{wi} :*Vehicle operating speed of vehicle type i along regular route (km/h)*

C :*Bridge reconstruction cost*

Traffic volume of heavy vehicles is excluded for temporary bridges, since these vehicles are not allowed to cross this type of bridge.

3) Incremental Benefit Measurement from Widening Bridge

When two or more vehicles travelling in different directions arrive at a single-lane bridge at the same time, a slowing or stopping in one or both directions occurs. The total incremental traffic costs are calculated on the basis of the basic traffic costs and the unit penalties in the form of dl-values and deceleration, acceleration, crossing time and waiting time.

The equations shown below are the formulae used for the calculation of incremental traffic costs on an annual basis.

Incremental VOC:

$$VOC = 6.14^{1)} \times 365(2AB+C(D-2B)+EF)$$

Incremental TTC:

$$TTC = 0.0002778^{2)} \times 365(DG+2BH+I(D-2B)+2BJ)$$

Where:

VOC :*Incremental VOC*

TTC :*Incremental TTC*

A :*dl Encounter*

B :*No. of encounters per day*

C :*dl none encounter*

D :*AADT*

E :*dl waiting*

F :*No. of waiting vehicles per day*

1) Basic representative VOC (Taka/km)

2) Basic representative TTC (Taka/sec)

G :Crossing time in seconds

H :Deceleration + acceleration encounters in seconds

I :Deceleration + acceleration non-encounters in seconds

J :Waiting time in seconds

4) Maintenance Cost Saving

Maintenance costs for bridges include routine and periodic maintenance costs. Reduction in these maintenance costs through the construction of new bridges is considered a benefit.

a) Routine Maintenance Cost Savings

Routine maintenance includes sweeping and cleaning of decks, painting of railings and repairs of deck plates of temporary bridges.

Unit cost of routine maintenance is estimated as follows:[7]

Table 12.2.9 Maintenance Cost Required for Temporary Bridge

Type of Bridge	Maintenance Cost (2007)	Maintenance Cost (2014)
1. Bailey	7,269	15,265
2. Concrete	727	1,527
3. Steel	2,544	5,342

Source: "Eastern Bangladesh Bridge Improvement Project" Dec. 2007, JICA (JBIC)

b) Routine Maintenance Cost Savings

Periodic replacement for bailey bridges including replacement of abutments, piers, panels and decks is considered to be part of maintenance costs. Periodic maintenance costs for concrete and steel bridges are almost negligible since all abutments and piers are assumed to be concrete. Maintenance costs for each type of bridge element are presented by bridge length in Table 12.2.10.

Table 12.2.10 Maintenance Costs for Temporary Bridges

(Units: 1,000 Taka)

Bridge Elements	Replacement Frequency (Years)	Bridge Length (m)							
		30	40	50	80	100	150	200	250
Abutments	15	600	600	600	600	600	600	600	600
Piers	10,20	190	380	570	953	1144	1716	2282	3035
Deck	5,10,15,20,25	1730	2271	2953	4697	5729	8651	11593	14144

Source: "Eastern Bangladesh Bridge Improvement Project" Dec. 2007, JICA (JBIC)

[7] Consultant's estimate (references: "Study of Maintenance of Roads and Bridges Constructed with Japanese Assistance for Road Networks under RHD and LGED of Bangladesh", JICA, 2003; RHD Schedule of Rates for Road and Bridge Works, July 2003.)

12.2.5 Results of Economic Evaluation

Results of economic evaluation by the 105 bridge projects are shown in Table 12.2.12 to 12.2.14. Table 12.2.11 summarizes the Project's northern and southern packages. According to the results, it can be said that all bridge project and its packages are economically feasible. The Government shall be implemented following by the schedule as recommended.

Table 12.2.11 Results of Economic Evaluation by Region

Region	No. of Bridges	EIRR (%)	BCR	NPV (Million BDT)
Northern Package	55	26.54%	3.23	302.97
Southern Package	50	26.81%	3.19	288.90
Average	105	26.67%	3.22	298.09

Source: JICA Survey Team

Table 12.2.12 Summary of Economic Evaluation by Bridge (1)

SN	Bri_ID	Zone	Existing Bridge data				AADT in 2021	New Bridge data			EIRR	BCR	NPV
			Structure Name	Bridge Type	Total length (m)	Width (m)		Bridge type	Total length (m)	Width (m)			
1	N8_178a	Barisal	Boalia Bazar Bridge	Bailey with Steel Deck,	39.7	4	43,628	Steel-I	120	10.4	24.4%	2.4	176.4
2	N509_19a	Rangpur	Shamamoti Bridge	RCC Girder Bridge, Bailey with Steel Deck	56.2	6	8,418	Steel-I	50	10.4	27.9%	3.0	229.0
3	N5_119a	Rajshahi	Chanda Bridge	RCC Girder	43.3	7.1	26,223	Steel-I	160	10.4	35.0%	3.99	268.0
4	N5_127a	Rajshahi	Palgari Bridge	RCC Girder	43.2	6.9	26,223	Steel-I	90	10.4	50.4%	7.8	1,138.9
5	N5_176a	Rajshahi	Bhuyagati Bridge	RCC Girder	72.8	7.2	59,956	PC-I	70	10.4	50.9%	7.96	965.6
6	N5_235a	Rangpur	Mokosthan Bridge	RCC Girder	77.3	7.2	65,103	PC-I	80	10.4	18.8%	1.7	206.4
7	N5_120a	Rajshahi	Chanda Bridge	RCC Girder	41.4	7.1	26,223	PC-I	60	10.4	31.7%	3.46	243.1
8	N5_128a	Rajshahi	Goilhar Bridge	RCC Girder	43.7	7	27,019	PC-I	65	10.4	54.0%	8.9	998.1
9	N5_158a	Rajshahi	Purbodalua Bridge	RCC Girder	70	7	33,864	PC-I	40	10.4	37.5%	4.6	474.0
10	N5_265a	Rangpur	Bupinath Bridge	RCC Girder	42.2	7.1	36,623	PC-I	65	10.4	18.6%	1.6	59.9
11	N5_350b	Rangpur	Barati Bridge	RCC Girder	135.4	7.2	16,319	PC-I	30	10.4	13.2%	1.1	39.0
12	N8_182a	Barisal	Bakerganj Steel Bridge	Bailey with Steel Deck,	33.6	4	43,628	PC-I	65	10.4	13.7%	1.2	17.0
13	N7_025a	Gopalganj	Jhuldibazar Bridge	RCC Girder	27.4	7.2	28,937	PC-I	35	10.4	36.3%	4.37	283.4
14	N7_039a	Gopalganj	Karimpur Bridge	RCC Girder	51.65	7	23,956	Steel-I	130	10.4	55.0%	9.14	1,367.9
15	N7_049a	Gopalganj	Porkitpur Bridge	RCC Girder	24.7	7	24,398	Steel-I	100	10.4	36.5%	4.06	256.6
16	N5_134a	Rajshahi	Nukali Bridge	RCC Girder	44.8	7.3	27,019	Steel-I	40	10.4	39.5%	5.07	688.8
17	N6_97a	Rajshahi	Dattapara Bridge	RCC Girder	30	6.9	39,380	Steel-I	170	10.4	37.4%	4.65	375.1
18	R681_10a	Rajshahi	Horisonkorpur Bridge	Bailey with Steel Deck,	39.3	3.4	6,360	Steel-I	160	10.4	17.5%	1.65	67.6
19	N5_140a	Rajshahi	Jugnidaha Bridge	RCC Girder	53	8.6	27,019	Steel-I	80	10.4	55.6%	9.5	987.1
20	N5_118a	Rajshahi	Punduria Bridge	RCC Girder	82	7	26,223	Steel-I	80	10.4	22.2%	2.07	401.4
21	N704_43a	Khulna	-	RCC Girder	31.5	7.15	87,639	PC-I	60	10.4	31.6%	3.6	293.3
22	N7_248c	Khulna	Gora bridge	RCC Girder	25.7	9.4	16,875	PC-I	30	10.4	41.2%	4.83	272.2
23	N7_054a	Gopalganj	Barashia Bridge	RCC Girder	82.6	7.8	24,398	PC-I	40	10.4	40.8%	4.76	282.3
24	N5_356a	Rangpur	-	RCC Girder	20.7	7.2	16,319	PC-I	150	10.4	23.1%	2.2	75.5
25	N7_246a	Khulna	Balai bridge.	RCC Girder	56	9.54	16,875	PC-I	40	10.4	30.5%	3.06	231.3
26	N8_095a	Gopalganj	Amgram bridge	RCC Girder	37	7	20,924	PC-I	60	10.4	42.7%	5.7	493.7
27	N505_2a	Rajshahi	Kazir Hat Bridge	Truss with Steel Deck,	135.2	4.3	6,552	PC-I	80	10.4	12.5%	1.05	18.7
28	R548_28b	Rajshahi	Atrai Bridge	Truss with Steel Deck,	140.08	4	13,712	PC-I	90	10.4	12.5%	1.06	29.2
29	N7_036c	Gopalganj	Kanaipur Bridge	RCC Girder	27.5	7.1	23,956	PC-I	105	10.4	39.7%	4.72	401.5
30	N7_048a	Gopalganj	Brahmonkanda Bridge	RCC Girder	24.9	7	24,398	PC-I	40	10.4	23.6%	2.17	131.6
31	N5_378a	Rangpur	Gaudangi Bridge	RCC Girder	53.9	7.2	15,777	PC-I	30	10.4	21.8%	2.0	106.9
32	N7_047a	Gopalganj	Bimankanda bridge	RCC Girder	50	7	24,398	PC-I	55	10.4	24.7%	2.37	299.0
33	N5_156a	Rajshahi	Chowkidhoh Bridge	RCC Girder	43	7.5	33,864	PC-I	60	10.4	50.3%	7.7	730.3
34	N5_172a	Rajshahi	Notun Dhoh Bridge	RCC Girder	43.3	7.6	59,956	PC-I	60	10.4	51.7%	8.2	936.5
35	N5_179a	Rajshahi	Dhatia Bridge	RCC Girder	54.1	7.5	75,808	PC-I	55	9.8	47.6%	7.0	852.2
36	N5_188a	Rangpur	-	RCC Girder	52	7	75,808	PC-I	60	9.8	52.0%	8.23	779.8
37	N5_126a	Rajshahi	Vitapara Bridge	RCC Girder	59.1	7.1	26,223	PC-I	40	9.8	40.5%	5.3	1,350.5
38	N518_4a	Rangpur	Khorkhon bridge	RCC Girder	49.5	5.2	15,777	PC-I	65	10.4	15.7%	1.3	36.2
39	N7_141b	Khulna	Buri Bhairab Bridge	RCC Girder	30.9	8.7	27,408	PC-I	50	10.4	56.1%	8.52	516.3
40	R720_44a	Khulna	Gurakhali Bridge	RCC Girder	33	4.8	6,296	PC-I	55	10.4	29.5%	3.82	414.6
41	N703_9d	Khulna	Dhopa Ghata Bridge	RCC Girder	134.5	6.1	48,166	PC-I	60	10.4	13.4%	1.1	18.8
42	R890_45a	Barisal	-	Bailey with Steel Deck,	62.3	5.03	35,725	PC-I	35	10.4	30.2%	3.78	345.4
43	N704_14a	Khulna	Barda Bridge	RCC Girder	97.9	7.2	51,144	PC-I	35	10.4	32.5%	3.6	290.0
44	N704_33b	Khulna	Balipara Bridge	RCC Girder	26	7.2	38,806	PC-I	30	10.4	51.4%	8.1	480.3
45	N5_344c	Rangpur	-	RCC Girder	26.2	7.1	16,319	PC-I	30	10.4	15.1%	1.3	41.1
46	N5_382a	Rangpur	Ichamoti Bridge	RCC Girder	55	7.8	15,777	PC-I	60	10.4	23.9%	2.27	119.5
47	N5_360a	Rangpur	Chikli Bridge	RCC Girder	49.2	7.1	16,319	PC-I	60	10.4	26.0%	2.60	175.8
48	Z5025_55a	Rangpur	Kakra Bridge	Bailey with Steel Deck,	153.9	4.3	12,147	PC-I	65	10.4	13.6%	1.17	72.7
49	Z5025_64a	Rangpur	Gabura Bridge.	Bailey with Steel Deck,	73.6	4.2	12,147	PC-I	60	10.4	16.7%	1.46	59.9
50	Z5401_45a	Rangpur	-	Bailey with Steel Deck,	61.8	4.3	26,517	PC-I	35	10.4	18.6%	1.69	170.3
51	Z5072_14a	Rangpur	Bombgara Bridge	Bailey with Steel Deck,	57.8	5	8,022	PC-I	35	10.4	19.1%	1.83	87.0
52	Z5025_60a	Rangpur	Madarganj Bridge	Truss with Steel Deck, Bailey with Steel Deck,	87	4.2	12,147	PC-I	30	10.4	59.3%	10.14	1,553.4
53	Z5472_6a	Rangpur	-	Bailey with Steel Deck,	60.9	4.9	536	PC-I	70	10.4	12.3%	1.03	4.3

*SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges

Source: JICA Survey Team

Table 12.2.13 Summary of Economic Evaluation by Bridge (2)

SN	Bri_ID	Zone	Existing Bridge data				AADT in 2021	New Bridge data			EIRR	BCR	NPV
			Structure Name	Bridge Type	Total length (m)	Width (m)		Bridge type	Total length (m)	Width (m)			
54	N5xx_Sa	Rajshahi	Pura Mukto Monch Bridge	Steel Beam & RCC Slab,	39.1	5.6	33,864	PC-I	35	9.8	15.1%	1.28	27.0
55	Z5552_10a	Rangpur	Barodia Khali Bridge	Bailey with Steel Deck,	52.5	4	11,071	PC-I	50	9.8	14.6%	1.28	53.6
56	N8_152c	Barisal	Rahamatpur bridge	PC Girder	56.9	7.1	26,885	PC-I	35	9.8	29.7%	3.1	235.9
57	N8_127b	Barisal	gounagata bridge	RCC Girder	33.7	7.2	21,898	PC-I	35	9.8	14.0%	1.2	20.1
58	Z8052_009d	Barisal	Gabtala Steel Bridge	Bailey with Steel Deck,	22.8	3.9	13,148	PC-I	90	9.8	22.3%	2.33	122.1
59	Z5015_22a	Rangpur	-	Bailey with Steel Deck,	189	5.3	5,079	PC-I	95	9.8	13.4%	1.14	70.1
60	Z5701_1a	Rangpur	Anandababur Pool	Bailey with Steel Deck,	24.39	4.04	9,398	PC-I	40	9.8	18.5%	1.78	104.4
61	Z5701_9a	Rangpur	Duhuli Bridge	Bailey with Steel Deck,	37.37	4.52	6,468	PC-I	35	9.8	25.7%	2.88	160.3
62	R545_115c	Rangpur	Mongle bari kuthibari Bridge	RCC Girder	78.8	7.1	25,859	PC-I	60	9.8	21.2%	2.17	291.3
63	R760_049c	Khulna	Shakdaha bridge	RCC Girder	36.1	7.1	19,857	PC-I	75	9.8	39.8%	6.16	629.0
64	N8_123a	Barisal	Souderkhal bridge	RCC Girder	30.8	8.6	21,898	PC-I	50	10.4	13.6%	1.1	11.3
65	Z8701_3d	Barisal	Bottala Bridge	Bailey with Steel Deck,	22	4.01	8,871	PC-I	50	10.4	26.5%	2.10	156.3
66	N5_260b	Rangpur	Katakhali Bridge	RCC Girder	158.6	7.3	36,623	PC-I	60	10.4	13.5%	1.1	52.8
67	N704_27b	Khulna	Bittipara Bridge	RCC Girder	33.5	7.3	38,806	PC-I	40	10.4	22.9%	2.2	86.8
68	R750_22c	Khulna	Bhangura Bridge	RCC Girder	31.2	4.3	11,344	PC-I	130	10.4	53.3%	10.74	1,345.6
69	N8_129a	Barisal	Asokoti bridge	RCC Girder	27.4	7.2	21,898	PC-I	40	10.4	12.6%	1.1	6.3
70	R890_16a	Barisal	-	Bailey with Steel Deck,	37.7	4.1	10,557	PC-I	60	10.4	14.3%	1.23	22.3
71	R890_21a	Barisal	-	Bailey with Steel Deck,	24.55	4.15	10,557	PC-I	40	10.4	16.9%	1.56	50.4
72	R890_28a	Barisal	-	Bailey with Steel Deck,	30.85	4.22	10,557	PC-I	50	10.4	14.4%	1.25	22.3
73	R548_40a	Rajshahi	Mohis Mari Bridge	Bailey with Steel Deck,	33	4.1	9,118	PC-I	35	10.4	25.7%	2.92	178.2
74	R451_1a	Rajshahi	Naion Bridge	Bailey with Steel Deck,	50	8.2	33,811	PC-I	30	9.8	25.5%	2.87	206.2
75	R451_7a	Rajshahi	Chondi Das Bridge	Bailey with Steel Deck,	50.2	8.3	33,811	PC-I	50	9.8	17.3%	1.62	152.7
76	R550_28b	Rangpur	Bottoli Bridge	RCC Girder	65.4	6.9	18,585	PC-I	40	9.8	15.9%	1.44	97.9
77	R860_31a	Gopalganj	Paprail Bailey Bridge	Bailey with Steel Deck,	28.89	4.8	9,924	PC-I	50	10.4	12.4%	1.04	3.7
78	Z8708_1c	Barisal	-	Bailey with Steel Deck,	26	4	3,381	PC-I	35	20.8	15.3%	1.35	33.0
79	N5_458a	Rangpur	-	Steel Beam & RCC Slab,	28.5	7.1	18,700	PC-I	40	10.4	13.5%	1.1	15.9
80	N5_488a	Rangpur	Chawai Bridge	RCC Girder	49.3	7.1	21,549	PC-I	65	10.4	21.4%	2.0	86.2
81	Z8708_12b	Barisal	-	Bailey with Steel Deck,	51	3.8	9,423	PC-I	30	10.4	13.4%	1.15	24.4
82	Z8033_017a	Barisal	Raiyer hat bridge	RCC Girder	42.4	4.3	14,378	PC-I	50	10.4	12.4%	1.04	6.0
83	R860_34a	Gopalganj	Jajihar Bridge	Bailey with Steel Deck,	33.5	4.8	9,924	PC-I	100	10.4	13.8%	1.17	18.6
84	R860_44c	Gopalganj	Gazipur Bridge	Bailey with Steel Deck,	111.2	5	9,924	PC-I	35	10.4	17.1%	1.52	138.1
85	R860_53d	Gopalganj	Balar Bazar Bridge	Bailey with Steel Deck,	93	4	9,924	PC-I	60	10.4	18.0%	1.62	111.7
86	N8_69a	Gopalganj	Kumar Bridge	RCC Girder	110	8.9	38,602	PC-I	120	10.4	33.4%	3.83	698.6
87	Z6010_12b	Rajshahi	Faliarbil Bridge	RCC Girder	21.7	4.7	4,739	PC-I	60	9.8	18.1%	1.66	54.9
88	Z5008_1a	Rangpur	Choto Dhepa bridge.	Steel Beam & RCC Slab,	42.2	4.05	14,589	PC-I	60	9.8	21.6%	2.0	93.3
89	Z5024_5c	Rangpur	Shampur Bridge.	RCC Girder	22.3	4	4,255	PC-I	115	9.8	21.1%	1.98	70.1
90	Z5025_46a	Rangpur	Bondorer pool Bridge	RCC Girder	45.7	3.7	10,980	PC-I	50	9.8	24.0%	2.58	165.2
91	Z5040_4a	Rangpur	-	RCC Girder	26.9	4.8	8,563	PC-I	40	9.8	15.6%	1.35	32.1
92	Z8810_13a	Barisal	Madhabkhali bridge	Bailey with Steel Deck,	50	4.25	13,148	Steel-I	160	10.4	14.6%	1.27	42.1
93	R585_80a	Rangpur	Bhela Bridge	Bailey with Steel Deck,	24.9	8.4	21,016	PC-I	60	10.4	42.9%	6.90	339.2
94	Z8033_008a	Barisal	Kalijira bridge	Bailey with Steel Deck,	105.4	5	9,558	PC-I	60	10.4	14.2%	1.21	48.1
95	Z8033_019a	Barisal	Masrong bridge	Bailey with Steel Deck,	31.3	3.9	15,790	Steel-I	80	9.8	13.9%	1.18	17.5
96	Z8034_011a	Barisal	Padarhat bridge	Bailey with Steel Deck,	33.7	4.5	12,683	Steel-I	80	9.8	14.9%	1.29	31.2
97	Z8044_004a	Barisal	Talukdarhat Bailey Bridge	Bailey with Steel Deck,	30.7	4.1	13,755	Steel-I	170	9.8	19.0%	1.75	66.7
99	R860_35a	Gopalganj	Shajonpur Bailey Bridge	Bailey with Steel Deck,	30.6	5.1	9,924	Steel-I	60	9.8	12.2%	1.02	3.4
100	Z5041_2a	Rajshahi	Debokbazar Bridge	Bailey with Steel Deck,	60	4.2	9,425	Steel-I	200	9.8	12.3%	1.03	6.8
I	N706_14b	Khulna	Jhikorgacha Bridge	RCC Girder	118.67	7.3	50,364	PC-I	105	20.8	32.4%	3.65	1,083.3
II	N5_435a	Rangpur	-	RCC Girder	38.3	7.8	22,216	PC-I	40	10.4	20.0%	1.78	63.5
III	N704_12c	Khulna	Chandi Pur Bridge	RCC Girder	24.2	7.5	51,144	PC-I	30	10.4	45.3%	5.73	372.3
IV	N805_24a	Gopalganj	Garakola Bridge	PC Girder	105.05	10	33,111	PC-I	110	20.8	45.7%	6.37	1,289.0
V	R750_25a	Khulna	Tularampur Bridge	RCC Girder	91.5	8.23	11,344	PC-I	95	20.8	42.1%	6.74	1,120.4
VI	Z7503_5a	Khulna	Hawai khali Bridge	RCC Girder	26.1	7.9	19,184	PC-I	30	20.8	16.7%	1.46	57.2

*SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges

Source: JICA Survey Team

13. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

13.1 Environmental and Social Considerations

13.1.1 Project Components which may cause Impacts

A total of 105 bridges[8] in 5 zones (Rangpur, Rajshahi, Gopalganj, Khulna and Barisal) in western Bangladesh have been selected as candidates for improvement, of which almost all are unsafe for road users because of major structural damage. Many of the bridges are baily bridges and not suitable for road bridges due to lack of capability and safely function and some of them have already collapsed. To improve road safety and remove traffic jams at the bridge sites, the bridges will be improved.

13.1.2 Present Natural and Social Condition

(1) Climate and Temperature

Bangladesh has virtually a homogeneous climate with only slight local variation. The northeast region has the most rainfall while the northwest region has the least. Temperature also shows little local variation from northeast to southwest. Occasion nocturnal rain with thunder showers observed in the southeast region is due to vicinity to the sea.

The maximum temperature of 31-34°C occurs during the May-October period, and the minimum temperature of 11-16°C occurs during the November-February period. The winter climate (November-January) is cold and dry, the spring climate (February-March) is pleasant, and the summer climate (March-May) is hot and dry, while the monsoon season (June-September) is wet. The temperature and rainfall during the monsoon season are high. The peak temperature during April-May may reach up to 40°C locally. The average climatic data recorded at stations in Khulna, Rajshahi and Barisal are shown in Table 13.1.1.

[8] 106 bridges were selected as the candidate bridges in Chapter 3. However the EIA and ARP study were conducted for 105 bridges since it was confirmed that 1 bridge is under construction in another project.

Table 13.1.1 Monthly Rainfall and Temperature for Khulna, Rajshahi, Barisal Divisions

Month	Khulna		Rajshahi		Barisal	
	Temp. (°C)	Rainfall (mm)	Temp. (°C)	Rainfall (mm)	Temp. (°C)	Rainfall (mm)
January	25.7	12	24.5	11	25.6	8
February	28.4	40	27.7	17	28.2	27
March	33.1	57	33.3	24	32.2	56
April	34.7	85	36.3	63	33.3	128
May	34.2	192	35.0	137	33.0	230
June	32.8	335	33.5	257	31.7	409
July	31.8	349	32.1	327	30.9	408
August	31.7	336	32.3	268	30.9	370
September	32.0	269	32.2	297	31.5	268
October	32.0	136	31.7	113	31.5	162
November	29.9	33	29.3	17	29.6	53
December	26.6	5	25.8	12	26.6	15
Annual average	31.2	1,849	31.2	1,543	30.4	2,134

Source: Bangladesh Bureau of Statistics (BBS) 2012: Average of 2006 and 2007

(2) Topography and Geology

Topography of western Bangladesh in the Meghna, Tista, Jamuna and Ganges floodplains is almost level with convex ridges and concave basin sites. Parts of the north region Bogra and the northwest regions Rajshahi, Rangpur and Dinajpur are occupied by level and/or undulated terrace lands.

The undulated terrace lands of Rangpur, Dinajpur and Rajshahi districts were previously covered with dense deciduous “sal forests” managed by private ownership and subsequently by the Bangladesh Forest Department (BFD). Presently the sal forests particularly in level lands are heavily depleted and used for rain-fed or irrigated paddy production. Patches of the sal forest still remain on undulated terrace lands of the Barind in Rangpur, Dinajpur and Rajshahi districts.

(3) Air Quality

The air quality of different locations (105 points of bridges in the Western Bangladesh) was assessed, and the major components of air pollution were found to be respirable suspended particulate matter, as well as gaseous pollutants such as: CO, CO_2, NOx and SO_2.

The maximum allowable limit of pollutant concentration is given in Table 13.1.2.

Table 13.1.2 National Air Quality Standards for Bangladesh

No.	Area Category	Suspended Particulate maters, PM_{10} (µg/ m3)	Sulphur dioxide		Carbon Monoxide		Oxides of Nitrogen	
			µg/ m^3	ppm	µg/ m^3	ppm	µg/ m^3	ppm
1	Industrial and mixed	500	120	0.045	5,000	4.36	100	0.053
2	Commercial and mixed	400	100	0.038	5,000	4.36	100	0.053
3	Residential and Rural	200	80	0.030	2,000	1.75	80	0.043
4	Sensitive	100	30	0.011	1,000	0.87	30	0.016

Source: Environment Conservation Rules, 1997

The PM_{10} concentration standard is 500µg/m^3 for industrial and mixed zones, and is 100µg/m^3 for sensitive zones. In this study, it has been observed that the PM_{10} concentration of 48 sampling points (45.3% of sampling sites) is below the standard limit (<100 µg/m^3), while only for 7 locations, PM_{10} concentration exceeds the limit 500µg/m^3. The highest PM_{10} concentrations were found in Dattapara Bridge (Rank 17) and Harishankarpur Bridge (Rank 18) where the value exceeds 1,000µg/m^3. These two points were located at very busy roads and the sampling was performed on a sunny day (average temperature ~37 ^{0}C). The minimum PM_{10} concentration was observed in sampling point named Rayerhat Bridge (Rank 82); and it was mainly because rain started in the middle of sampling. Due to monsoons, there are several points where sampling was performed in the middle of raining or after raining, and therefore lower pollutant concentration was observed. The average ratio of total suspended particulate matters (SPM) and PM_{10} is about 3.5.

The gaseous pollutant standard limit is 0.045ppm for SO_2, 4.36ppm for CO and 0.053ppm for NOx. For most of the selected sites, the gaseous pollutant concentration was below the standard limit. Only for three sites carbon monoxide concentration was found higher than the standard limit. The average carbon dioxide concentration was about 480µg/m^3. There are few sites (about 5%) where carbon dioxide concentration was found comparatively higher. The higher gaseous concentrations were observed in the sampling points which were located either in busy areas or near industrial areas or brick fields. The concentrations of NOx and SO_2 were found either in trace amounts or below the detection range.

(4) Water Quality

National Standard for inland surface water according to Environment Conservation Rules, 1997 is shown in Table 13.1.3. There are six different types of surface water standards based on the application sectors mentioned in the ECR, 97. Table 13.1.4 shows the relevant parameters of the drinking water standards according to ECR, 97. Since there is no specific standard for groundwater, Table 13.1.4 has been considered for groundwater comparison

during this study.

Table 13.1.3 National Standards for Island Surface Water

Best Practice based classification	Parameter			
	pH	BOD_5 (mg/L)	DO (mg/L)	Total Coliform (number/100ml)
a. Source of drinking water for supply only after disinfecting:	6.5-8.5	≤2	≥6	≤50
b. Water usable for recreational activity	6.5-8.5	≤3	≥5	≤200
c. Source of drinking water for supply after conventional treatment :	6.5-8.5	≤6	≥6	≤5000
d. Water usable by fisheries	6.5-8.5	≤6	≥5	-
e. Water usable by various process and cooling industries	6.5-8.5	≤10	≥5	≤5000
f. Water usable for irrigation	6.5-8.5	≤10	≥5	≤1000

Source: Environment Conservation Rules, 1997

Table 13.1.4 National Standards for Drinking Water

Parameter	Unit	Standard
BOD5 at 20°C	mg/L	0.2
DO	mg/L	6
pH	-	6.5-8.5
Suspended particulate matters	mg/L	10
Total dissolved solid (TDS)	mg/L	1000
Temperature	°C	20-30
Turbidity	NTU	10

Source: Environment Conservation Rules, 1997

Surface and ground water samples near 105 points of bridges in Western Bangladesh were collected and tested for different parameters according to the methods described earlier. Apart from few exceptions, most of the water parameters were found to be consistent and within the limit imposed by Environment Conservation Rules, (ECR), 1997 of the Government of Bangladesh. Surface water pH values were mostly between 6.5 to 8.5, the range allowed by ECR. Only 3.8% samples had pH value higher than 9 with only one sample higher than 10. All of the ground water pH readings were found to be within the range suggested by ECR. Most of the surface water samples had temperature within the range of 20-30^{o}C; however, a significant number of samples also had higher temperature mainly because of the high ambient temperature in summer. Groundwater samples were relatively cooler than the surface water of the same location and were rarely found to be higher than 30^{0}C.

Dissolved oxygen is to be higher than 5 mg/L according to ECR and other international standards. Though around 38.6% of surface water samples had DO less than 5 mg/L, only 5.6% of samples had extremely low DO (less than 3.5 mg/L). These water sources might have been contaminated with inorganic or other pollutants. Moreover, samples were

collected during the months of summer when the ambient temperature was very high on most of the days, causing a low level for dissolve oxygen in water. Ground water samples had lower DO, as expected, and few of them were found to be as low as ~1 mg/L.

The surface water turbidity values were found to be very scattered ranging from 3 to 750 FTU. This is because of different types and extent of sedimentation and insoluble contamination from run-off and nearby populations. The turbidity values in the southern regions (especially Barisal and Patuakhali) tend to be relatively high, which might be explained by the presence of salt in water. Turbidity is not a major concern for ground water and thus was not considered in this study. Conductivity is an important parameter for ground water, and 87% samples exhibited conductivity lower than 1 mS/cm. For the remaining 13% of ground water samples, slightly higher conductivity was found, which might be related to the presence of higher metal ions (such as: iron).

As surface water is exposed to the atmosphere, it might retain significant amount of suspended solids. Our analysis found varying amounts of total suspended solids (TSS) in surface water samples, where most of the samples (85%) had TSS lower than 0.2g/L and only few (4.7%) had TSS as high as 0.4g/L. This may be due to rainy and windy weather, populated neighborhood, and many more influenced factors. Since there is no standard set for this parameter in Bangladesh (ECR, 97), it is not possible to compare the experimental values with the national standard.

Biochemical oxygen demand (BOD), a very critical parameter of water quality, was analyzed for both surface and ground water samples. ECR suggested the maximum value for BOD5 is 6mg/L for surface water and 0.2mg/L for drinking water if supplied after disinfecting. Most of the surface water samples (76.5%) were found to be good according to ECR, 97 and the remaining 23.5% of water samples had BOD5 higher than 6mg/L. Those water sources could have been contaminated with different types of organic pollutants such as municipal, domestic and agricultural wastes. Only very few (1.8%) samples had relatively higher BOD5 (higher than 9mg/L) and that indicates an overall good quality of surface water in that region. Ground water is supposed to be less contaminated and our analysis result also suggested the same. 46% of ground water samples had BOD5 higher than 3mg/L indicating presence of organic contamination to some extent. It is not uncommon for the tube wells to go under water during flood and that can introduce organic contamination in ground water. In many areas, ground water could also be contaminated with microorganisms causing a slightly higher BOD5 value. This can only be confirmed with a coliform test (of any type). Since BOD5 values of the above ground water samples exceed the standard value of drinking water BOD5 (0.2mg/L, ECR, 97), the ground water samples do not comply with ECR, 97. It is to be noted that there is no ground water standard set by the Government of Bangladesh.

The ground water in Bangladesh is polluted largely due to seepage from non-sanitary latrines and leakage of agro-chemicals (WARPO 2000). Ground water at bridges sites may be

polluted due to seepage from cement concrete mixing and working sites. This can however be reversed after the project activities are completed and work camps are dismantled if sites are cleared properly.

(5) Noise and Vibration

National standards for noise are set by category of area, as given in Table 13.1.5. Areas within a radius of 100m around hospitals, educational institutions or special institutions/establishments are designated by the government as silent zones.

Table 13.1.5 National Standards for Sound for Different Areas

No.	Categories of Area	Standard for Day Time (6 AM to 9PM) (dB)	Standard for Night Time (9 PM to 6 AM) (dB)
1	Silent zone	45	40
2	Residential	50	40
3	Mixed area, includes both for Residential and commercial	60	50
4	Commercial	70	60
5	Industrial	75	70

Source: Environment Conservation Rules, 1997

(6) Ground Subsidence

Bangladesh is situated in the earthquake prone region. The country has experienced over 200 quakes in the past two years. No major case of ground subsidence occurred either in floodplains or elsewhere due to earthquakes. The most devastating earthquakes, those in the Chakhar (1869), Bengal (1885), Assam(1897), Srimangal (1918), and Dibrugarh (1930), had tremor intensities over 7.0 (Richter). The epicenters of all the earthquakes were outside the borders of Bangladesh. The Assam earthquake caused large-scale damage in Assam, but did not cause any large-scale ground subsidence (Bangladesh Building Code 1993).

(7) Bottom Sediment

Bangladesh is formed from deposition of sediments transported by major rivers that had been deposited under meander, tidal and/or estuarine conditions. The floodplain sediments are therefore vertically well sorted. The sediments in bottom layers settled down earlier are therefore coarser and coarseness of sediments increases with the depth of the layer. The coarse textured sediments occur below 100 m depth in floodplains and level terrace regions. This is evident from the borehole records of deep tube wells and from the available sporadic geotechnical study data from different borehole sites.

(8) Fauna and Flora

The major habitats for floral and faunal diversities in Bangladesh are the hill forests, inland upland forest, homesteads, wetlands, coastal mangrove forest, agriculture lands, etc. All of these ecosystems have been disturbed since the past decades due to poor management, demographic pressure, natural calamities and deteriorated law and order situation. Consequently, diversity and population of flora and fauna declined in Bangladesh. Many wildlife species as a result are under stress and 50 are endangered already. 10 % of mammal species, 3.0% of avifauna species and 4.0% of reptile species in Bangladesh are extinct (IUCN 2000). The status of the resident inland vertebrates in Bangladesh as indicated in the IUCN Red Book (2000) is shown in Table 13.1.6.

Table 13.1.6 Status of the Resident Inland Vertebrate Species in Bangladesh

Groups	Total living	Extinct	Threatened			Not threatened
			Critically endangered	Endangered	Vulnerable	
Fishes	266	0	12	28	14	146
Amphibians	22	0	0	3	5	7
Reptiles	109	1	12	24	22	12
Avifauna	388	2	19	18	4	189
Mammals	110	10	21	13	6	17

Source: IUCN Red Book (2000)

(9) Water Use

Open water bodies (rivers and channels) throughout Bangladesh are used extensively for navigation, capture fisheries, agriculture and industry. People settled on river ridges usually depend on water for domestic uses that include washing, bathing, cattle washing, and collection of drinking water (though at present most rural people collect drinking water from shallow and deep tube wells sunk either on homesteads or at agriculture land). Fishermen and boatmen communities (specializing in fishing and boat plying) live along river banks, and presently such industries make industrial use of river water. Unfortunately, wastes and effluents from these industries as well as solid wastes generated in industries and urban/rural residences are discharged untreated in open water bodies, pollute the river water.

(10) Protected Areas

There exist 34 protected areas in Bangladesh that have been declared by MoEF under the Bangladesh Wildlife (Preservation) Order (23 of 1973) and subsequent Amendments). Moreover, the National Parks at Kuakata, Nawabganj, Kadigarh, Singra and Tengragiri Wildlife Sanctuary at Barguna were declared Protected Areas in 2010-2011. Bhawal National Park, Baldha Garden and Madhabkunda Eco-park have also been declared Protected Areas.

(11) Soil and Land-use

Soils of the Barind tract are weakly structured, acidic clays in the subsoil overlying an unaltered clayey substratum at variable depths. The landscape was probably initially colonized by pioneer vegetation species (grasses and/or sedges) several thousand years ago. The early settlers cleared the pioneer vegetation to adapt the land for agricultural use. (They disliked the well-drained upland for sedentary agriculture because unsufficient water.) Conversely, many indigenous tribes (Santhal, Kool and others) preferred to settle on undulated uplands and initially practiced shifting cultivation.

The lands on floodplains were also initially covered by reeds, rushes, and other sorts of grass varieties. The floodplain soils were either cleared for agriculture by early settlers or were brought directly under agricultural uses.

(12) Cultural Assets

Cultural assets deserving special mention include relics of the structures constructed during the rule of different political dynasties over two the past thousand years. The oldest cultural relics date back to the Buddhist period, followed by the Hindu period, which then transitioned into the Muslim and Mughal periods. Structures from the English colonial period such as the University of Dhaka and other universities, the high court, district courts, post offices, and railway tracks can be seen as nuclei of modern development.

(13) Indigenous or ethnic Minority

The size of the ethnic population in Bangladesh is nearly 1 million; 0.7 million live in eastern and southeastern hilly regions and 0.3 million live in other districts. Ethnic tribes living in Bangladesh are the Chakma, Khami, Kuki, Boum, Banjogi, Khiang, Lushai, Marma, Moorang, Mroo, Pankhoo, Rakhain, Tanchunga, Tipra, Khiang and Chak in Chittagong and Chittagong Hill Tract; the Khasia, Monipuri, Khami, Khiang in Sylhet; and the Habiganj, Moulvibazar, Garo, Hajong, Santhal, Kool and Kotch in the Madhupur and Barind Tract regions (BBS 2007,2012). The Santhal, Sakh, Hajong, Orao, Koch, Kool tribes live in Rajshahi, the Harijan and Rajbangsi tribes live in wetlands and 30,000 Rakhain tribe people live in Patuakhali district. Many ethnic minorities, particularly those in Patuakhali and Rajshahi districts have virtually merged with the mainstream culture. The trend of indigenous tribes merging with mainstream population accelerated in the past several decades due to improvement of internal communication that advanced labor movement.

(14) Health Care Facilities

Heath care services in Bangladesh are provided by GOB, NGOs, private clinics and individual practitioners. In addition, service from the Homeopaths and Ayurvedic practitioners are available at low cost both at rural and urban areas. The health care facilities available in Bangladesh are shown in Table 13.1.7.

Table 13.1.7 National Health Services Facilities Available in Bangladesh.

Health care facilities (Total in Bangladesh)	Survey years			
	2003	2004	2005	2006
Hospitals (total)	1,384	1,676	1,676	1,683
Government Hospitals	672	672	672	678
Government Dispensaries	1,297	1,397	1,397	1,397
Hospital beds (total)	46,125	50,655	50,827	51,044
Registered Nurses (total)	19,500	20,000	20,097	20,129
Registered Midwives (total)	17,622	18,037	18,937	19,911
Registered Doctors (total)	36,576	40,210	41,933	44,632
Govt. Medical College (total)	13	13	13	13

Source: BBS 2007

(15) Educational Institutions

The present national literacy rate in Bangladesh is 45.3% (49.6 % male, 40.8% female). This rate varies by district and by region. The districts with the lowest recorded literacy rates are Sherpur and Jamalpur (31.0%). The district with the highest rate is Dhaka (64.3%), whereas the rate in Gazipur is 56.4 percent. The number of academic institutions in Bangladesh (government and non-government) is shown in Table 13.1.8.

Table 13.1.8 Total Number and Types of Academic Institutions in Bangladesh

Types of Institutions	Survey years			
	2001	2002	2003	2004
Primary schools	63,255	63,545	86,373	-
Secondary Schools	15,837	15,806	17,386	-
Colleges	2,551	2,870	2,577	-
Madrasas	7,277	7,373	7,920	-
Govt Universities	17	17	22	-
Non-govt Universities	24	41	53	-

Source: BBS 2012

(16) HIV/AIDS

Spread of HIV/AIDS in Bangladesh (particularly rural areas) is minimal according to the results of studies conducted so far. AIDS patients have rarely and sporadically been observed amongst the sex workers who live in the port cities Mongla and Chittagong. Generally speaking, HIV/AIDS is not a major issue in Bangladesh. The cautionary measures to avoid the spread of STDs and information about how to deal with patients are given widespread publicity by GOB in electronic and printed media.

(17) Gender

Gender equality is required to be maintained in accordance with GOB rules and donor requirements for the recruitment of staff, payment and other items. Camps for female workers should be situated apart from camps for male workers. Separate toilets and washing facilities should be provided for privacy.

(18) Children's Rights

Bangladesh imposes restrictions on child labor. Of note, children may not be appointed in jobs that might pose health hazards. Education is free, and it is mandatory for children between 6 and 10 to attend school. However, rights of education are not respected in all cases, as child laborers, handicapped children, native children, etc. only rarely have access to education.

(19) Climate Change

Coastal region of Bangladesh including roads crossing southern regions have seen a rise of sea level of 18cm in the past 40 years, and that is predicted to accelerate in next 40 years. This could gravely impact coastal plains of Bangladesh. Bangladesh however can do little to combat this global issue, because of its shortage of resources. Therefore, Bangladesh has no option but to leave this issue on a technical level, and appeal to the conscience of the global community, informing them that the country is facing great danger due to climate change and consequent sea level rise, a problem which Bangladesh has had essentially no contribution to.

(20) Fishermen Community

Fisherman communities in Bangladesh (engaged in marine and/or fresh water fishing as full-time or part-time occupations) are struggling for survival because of abrupt reduction of fresh water fish catch, increased cost of living, shrinking of wetland areas, as well as conflicts with the businesses that have recently acquired development rights. The pollution of open water bodies due to disposal of industrial and urban wastes has affected both population and diversity of fresh water species.

(21) Landscape

Bangladesh has a total land area of 147,470 km^2 of which 79.1% is floodplain, 12.6% (mainly in the north, northeast, south, and southeast) is occupied by Mio-Pliocene hills, and 8.3% (in north central and in northwest regions) is Plio-Pleistocene terrace land.

(22) Road Accident

Several issues (such as narrow widths of existing bridges, structural weaknesses, ill-maintained and undeveloped pavements, lack of pedestrians' awareness regarding traffic rules, and poor law and order) pose serious threats to road safety, causing accidents that lead to death and grievous injuries to pedestrians and passengers. Bangladesh at present faces an extremely high number of road accident every year (10 accidents/1,000 registered vehicles/year). This costs Bangladesh $0.35 million annually for import of spare parts to repair accident-damaged vehicles.

13.1.3 EIA System in Bangladesh

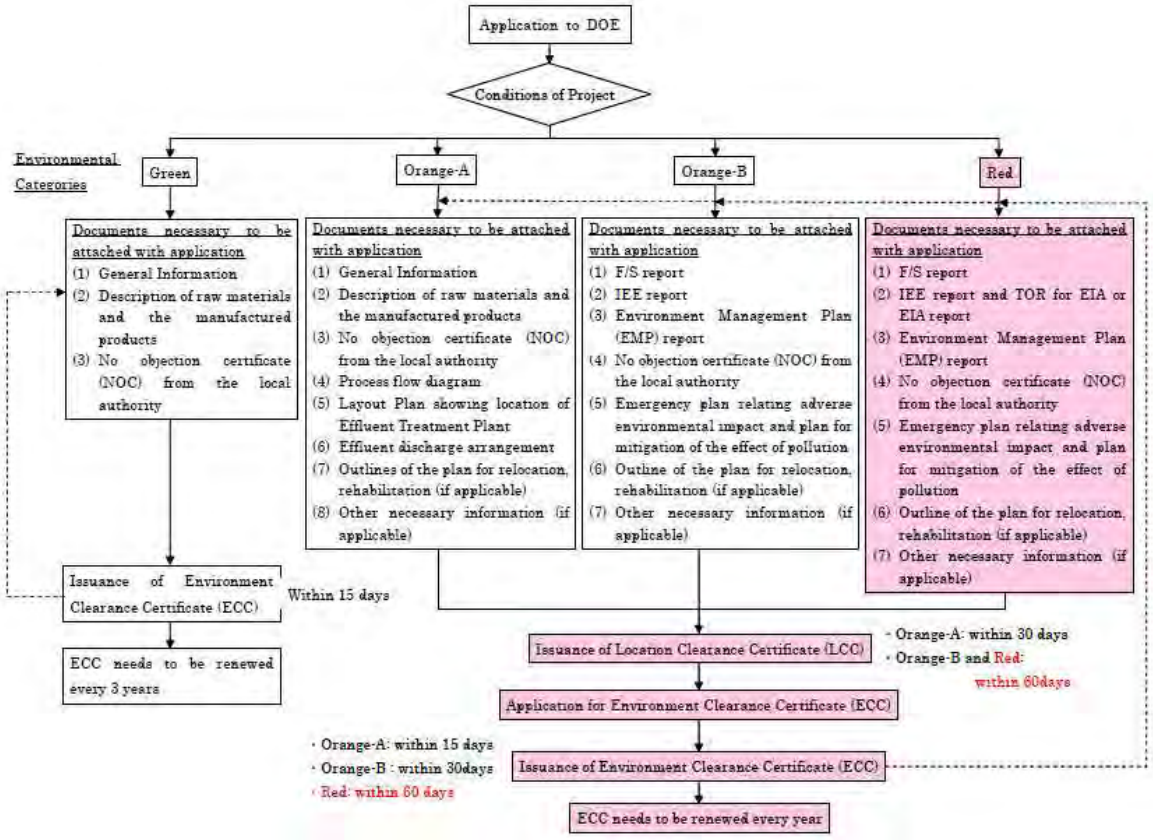
The legislative basis for environmental assessment in Bangladesh is the Environment Conservation Act (1995). The Act was enacted to conserve and improve environmental quality as well as to control pollution. Subsequently, the Environment Conservation Rules was enacted in 1997 to evaluate, review the Environmental Impact Assessment (EIA) of various projects and activities.

The Department of Environment (DoE) under the Ministry of Environment and Forest is the regulatory body which is responsible for enforcing the act and rules. Although the proponent is responsible for conducting an environmental impact assessment of the development proposal, the responsibility for reviewing EIA for the issuance of Environmental Clearance Certificate (ECC) rests with DoE.

In accordance with the Schedule-1 of Environmental Conservation Rules, the following provisions classify the environmental category of WBBIP bridges as "Orange B Category" and "Red Category":

Construction, re-construction and extension of bridges (length < 100m) fall under "Orange B Category", whereas construction, reconstruction and expansion of bridges (length ≥ 100m) fall under "Red Category"

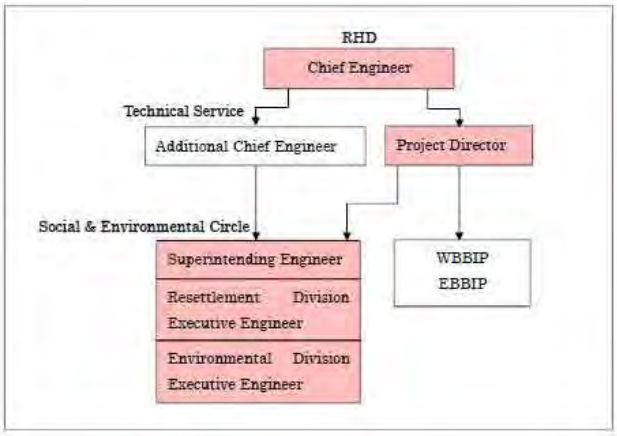
A discussion was made between DoE and JICA Survey Team with the presence of Social & Environment Circle of RHD in November, 2013 in terms of environmental categorization on WBBIP and it was concluded that the "Red Category" procedure will be applied .To obtain Environmental Clearance Certificate (ECC), RHD shall first obtain Location Clearance Certificate (LCC). The necessary documents including EIA report and required time to obtain ECC from DoE is presented in Figure 13.1.1.



Source: JICA Survey Team

Figure 13.1.1 Procedure to obtain ECC

ECC was issued on 1st January, 2015. And the ECC should be renewed once in every year. Following Figure 13.1.2 presents the Organogram on Environmental and Social Considerations at RHD.



Source: JICA Survey Team

Figure 13.1.2 Organogram of RHD on Environmental and Social Considerations

13.1.4 Alternatives

(1) Alternative Alignment

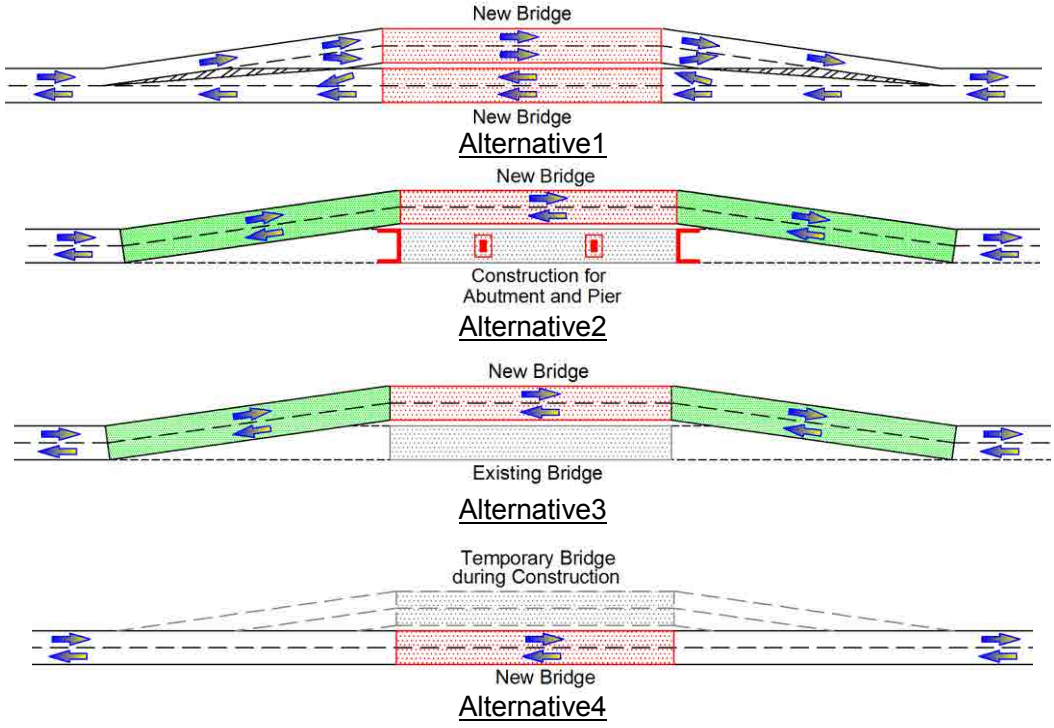
The location of new bridges shall be determined in consideration of impact to existing residences/shops, cost and so on. However, National roads shall also be considered in respect to future widening projects.

As a result of comparison (see Table 13.1.9 Comparison of Alternatives), Alternative 4 (replacement of existing bridge) was selected for Regional and Zilla roads from an initial cost perspective. Regarding National roads, Alternative 3 (New Bridge Construction next to Existing Bridge) was selected in consideration of future widening.

(2) No Action Alternative

All the 105 bridges under WBBIP are to be constructed or reconstructed to replace the existing bridges on different national, regional and zilla roads. With this in mind, the ‘no action alternative’ is considered not practicable.

Table 13.1.9 Comparison of Alternatives

Item	Alternative1	Alternative2	Alternative3	Alternative4
Figure				
Summary	One of new bridge is constructed next to existing bridge and another bridge is constructed at the same position of existing bridge.	New bridge is constructed as 2-lane carriageway next to existing bridge. Additionally, the abutment and the pier are constructed for future widening project.	New bridge is constructed next to existing bridge.	Existing bridge is replaced by new bridge.
Temporary Bridge	Unnecessary Good	Unnecessary Good	Unnecessary Good	Necessary during construction Poor
Economic Efficiency	The initial cost is the most highest among alternatives. Poor	The initial cost is higher than Alternative 3 and 4. Poor	The initial cost is higher than Alternative 4. Good	The initial cost is the cheapest among alternatives. Good
Traffic Capacity	It is improved only in project area. Good	It is same as the existing condition. Fair	It is same as the existing condition. Fair	It is same as the existing condition. Fair
Traffic Safety	It might cause traffic conflict at the diverging point. Poor	It is same as the existing condition. Fair	It is same as the existing condition. Fair	It is same as the existing condition. Fair
Evaluation			**Recommended for National Road** - Easy for future widening.	**Recommended for Regional and Zilla Road** - The cheapest initial cost.

Source: JICA Survey Team

13.1.5 Scoping and ToR on EIA

A reconnaissance survey was carried out, taking natural environment and social conditions in the Project area into account. A “predicted scoping matrix”, expressing environmental impacts in the context of pollution, the natural and social environment and several other points of view is shown in Table 13.1.10. The ToR (Terms of Reference) on EIA is shown in Table 13.1.11.

Table 13.1.10 Predicted Scoping Matrix

No.	Items of Impact	Predicted Impact		Assessed Impact		Reason of Assessment
		Before/ During Construction Stage	Operation Stage	Before/ During Construction Stage	Operation Stage	
Anti-Pollution Measures						
1	Air pollution	B-	D	B-	D	Air pollution will be caused during construction stage due to vehicular emissions and dust blowing.
2	Water pollution	B-	D	B-	D	Water pollution during construction stage likely due to construction activities.
3	Soil pollution	B-	D	B-	D	Soil pollution during construction stage may be caused due to spilling of oil and lubricants.
4	Waste	B-	D	B-	D	Camp sites and construction wastes may pollute soil.
5	Noise and vibration	B-	D	B-	B-	Noise level may increase during construction and operation stage.
6	Ground subsidence	D	D	D	D	No ground subsidence likely during implementation stages.
7	Offensive odors	D	D	D	D	No offensive odor likely at any stage of project implementation.
8	Global warming/Climate change	D	D	D	D	No impact anticipated due to global warming.
Natural Environment						
9	Topography and geology	D	D	D	D	No impact anticipated due to implementation of the project.
10	Bottom sediment	D	D	D	D	No impact anticipated
11	Biota and ecosystem	C	C	D	D	No precious species is found at project sites. Impact might be very small.
12	Hydrology	B-	C	D	D	No impact on hydrology due to the project is apprehended.

13	Water use	C	C	D	D	Impact on present water use due to project implementation is apprehended almost nil.
14	Protected area	D	D	D	D	No protected site will be affected.
Social Environment						
15	Involuntary resettlement	A-	D	B-	D	Displacement is required in pre-construction stage.
16	Local economies, such as employment, livelihood, etc.	B-/B+	C	B-	D	At several bridges sites livelihoods may be affected due to removal of shops and acquisition lands.
17	Land use and utilization of local resources	D	D	D	D	Impact on land use may not be serious due to acquisition of agriculture lands at several bridge sites.
18	Social institutions and local decision-making institutions and social service facilities	C	B+	B-	D	Some utilities might be affected due to the new bridge construction.
19	Poor	A-	A-	B-	D	Poor people living on RHD land may be affected.
20	Indigenous or ethnic minority people	C	C	D	D	No indigenous tribal people likely to be affected due to WBBIP implementation.
21	Misdistribution of benefits and damages	D	D	D	D	No impact might be anticipated.
22	Local conflicts of interest	D	D	D	D	No impact might be anticipated.
23	Gender	A-	A-	D	D	No negative impact on gender issues apprehended.
24	Children's right	C	C	D	D	No legal rights of children are anticipated.
25	Cultural heritage	C	C	D	D	No cultural and/or historical relics occurs at bridges sites hence will not be affected.
26	Infectious diseases such as HIV/AIDS	B-	D	B-	D	Influx of worker may cause the possibility of infectious diseases.
27	Landscape	D	D	D	D	No impact might be anticipated.
28	Working conditions	B-	D	B-	D	Insufficient safety management will cause the accidents in construction stage.
29	Social consensus	A-	D	B-	D	The physical construction activities might be hampered without appropriate local consensus.

Others						
30	Accident	B-	D	B-	B-	In-appropriate traffic control and increase of traffic may induce accidents.

Source: JICA Survey Team

Note: A+/-: Remarkable Positive/Serious Negative Impact is predicted.
B+/-: Positive/Negative Impact is expected to some extent.
C: Extent of Impact is unknown. (A further examination is needed and the impact could be defined as study progresses)
D: Impact is very small or nil and further survey is not required

Table 13.1.11 ToR on EIA

Items of Impacts	Items to be Studied	Practice of Study
Air pollution	• Confirm the environmental standards in Bangladesh • Confirm the present level of pollution • Check on the location of neighbor residence, school, hospital located project site • Review the impacts while in construction stage	• From the existing data • Sampling, testing and analysis through EIA activity • From the plan drawing prepared based on the topographic survey • Assessment in accordance with site survey results
Water pollution	• Confirm the environmental standards in Bangladesh • Confirm the present water quality level • Review the impacts while in construction stage	• From the latest standards • Sampling, testing and analysis through EIA activity • Assessment in accordance with site survey results
Soil pollution	• Review the counter measures against fuel/oil leakage	• Content of work activity, working method, time frame, kind of construction equipment, way of movement and storage
Waste	• Review the waste treatment method occur in construction stage	• From the similar and neighbor construction activity
Noise	• Confirm the environmental standards in Bangladesh • Confirm the distance from noise source to residential area, hospital, school • Review the impacts while in construction stage	• From the latest standards • From the plan drawing prepared based on the topographic survey
Biota and ecosystem	• Confirm the species existing in/around the project bridge	• In accordance with site survey results
Hydrology	• Confirm the present situation of water-flow/riverbed	• In accordance with site survey results
Water use	• Confirm the present situation of water use	• In accordance with site survey results
Protected area	• Confirm the location of protected area and distance to the project bridge	• From the existing data • In accordance with site survey results
Involuntary resettlement	• Confirm the number of displaced persons/affected households at	• From related ordinance in Bangladesh

Items of Impacts	Items to be Studied	Practice of Study
	each bridge • Prepare RAP or ARP	• From census and socio-economic survey • RAP and ARP in accordance with JICA's guidelines
Local economy such as employment and livelihood	• Confirm the way economic status and way of livelihood accompany with PAPs	• From socio-economic survey
Existing social infrastructures and services	• Survey the existing utilities and confirm if impacts arisen due to the project bridge • Review the impacts due to the detour provided in construction stage	• In accordance with site survey results
Poor	• Confirm the income of affected persons	• From socio-economic survey
Indigenous or ethnic minority people	• Confirm if the project bridge locates in tribal village • Confirm the distance to project bridge from tribal village	• In accordance with site survey results
Gender	• Confirm woman headed household must be involved in SES, if any • Confirm the participation of women group to the stakeholder meeting	• From local SHM results • From socio-economic survey
Children's right	• Confirm the present distance to the school from project bridge • Review the method of detour provided in construction stage	• From the plan drawing prepared based on the topographic survey • From working method statement
Cultural heritage	• Confirm the location of designated cultural heritage • Confirm the distance to the heritage from project bridge	• From the existing data • From hearing survey results
Working conditions	• Confirm the measures to provide worker's safety while in construction stage	• From working method statement
Accident	• Review the necessity of safety equipment/tool to prevent an accident while in construction stage	• From working method statement

Source: JICA Survey Team

13.1.6 Result of EIA Survey

The result of EIA survey on item of impact in accordance with the scoping is presented in following Table 13.1.12.

Table 13.1.12 Result of EIA Survey

No.	Item of Impact	Outline of the Survey Result
Anti-Pollution Measures		
1	Air pollution	The air quality of different locations (105 points of bridges in the Western Bangladesh) had been assessed. it has been observed that the PM10 concentration of 48 sampling points (45.3% of sampling sites) is below the Bangladesh environmental standards lower limit (<100 µg/m3) while only for 7 locations, PM10 concentration exceeds Bangladesh environmental standards upper limit 500µg/m3. The gaseous pollutant standard limit is 0.045ppm for SO2, 4.36ppm for CO and 0.053ppm for NOx. For most of the selected sites, the gaseous pollutant concentration was below the standard limit. The impact might be very small except some extent of impact in a construction stage.
2	Water pollution	Most of the surface water samples (76.5%) were found to be good according to ECR, 97: Water usable by fisheries, however remaining 23.5% water samples had BOD5 higher than 6mg/L. Those water sources could have been contaminated with different types of organic pollutants such as: municipal, domestic and agricultural wastes. The impact might be very small except some extent of impact in a construction stage.
3	Soil pollution	It might be occurred due to the spillage of refueling to equipment in the construction stage. Impact is not assumed in operation stage.
4	Waste	Wastes from working site, garbage from site office and workers' camp will contain potential impact. Impact is not assumed in operation stage.
5	Noise and vibration	The noise level was monitored for each selected sites. In most of the sites, the average noise level was below (~80 dB). There were few locations located near the bazar (market) areas or busy road where noise level exceeded the 80dB which over the daytime upper limit applied for industrial areas in Bangladesh standards. Some extent of impact in assumed both in construction and operation stage.
6	Ground subsidence	Bangladesh because of location is situated in the earthquake prone region. This country jolted by over 200 quakes since past two years. No major case of ground subsidence occurred either in floodplains or elsewhere due to earth quake. Impact is not assumed in any stages.
7	Offensive odors	The possibility to induce offensive odor will be almost nil.
8	Global warming/Climate change	The coastal region of Bangladesh including part of the south cross road may be the victim of apprehended sea level rise of 0.18 m/ 40 years that is apprehended to accelerate in next 40 years. If the rise of sea level accelerates the assumed impact coastal plains of Bangladesh may be serious. Bangladesh however can do little to combat this global issue, because of its shortage of resources. Impact will be very small in each stage.
Natural Environment		

9	Topography and geology	Topography of western Bangladesh that is covered by the Meghna, Tista, Jamuna and Ganges floodplains is almost level with convex ridges and concave basin sites. Part of the North Central region in Bogra and North West region Rajshahi, Rangpur and Dinajpur is occupied by level and/or undulated terrace lands. Impact is not assumed in any stages.
10	Bottom sediment	Bangladesh was formed due to deposition of sediments transported by major rivers that had been deposited under meander, tidal and/or estuarine conditions. The floodplain sediments are therefore vertically well sorted. The sediments in bottom layers settled down earlier are therefore coarser and coarseness of sediments increases with the depth of the layer. The coarse textured sediments occur below 100 m depth in floodplains and level terrace regions. Impact is not assumed in any stages.
11	Biota and ecosystem	The major habitats for floral and faunal diversities in Bangladesh are the hill forests, inland upland forest, homesteads, wetlands, coastal mangrove forest, agriculture lands, etc. All the ecosystems have been disturbed since the past decades due to poor management, demographic pressure, natural calamities and deteriorated law and order situation. Consequently, diversity and population of flora and fauna declined in Bangladesh. Common flora species are rain tree, mango etc.,, and the fauna species are rodent, fog, toad etc., and the bird species are spotted dove and rock pigeon etc.. No precious specie is found at project sites. Impact is not assumed in any stages.
12	Hydrology	The potential impact against hydrology will be almost nil.
13	Water use	Water of open water bodies (rivers and channels) throughout Bangladesh used extensively for navigation, capture fisheries, agriculture and for industrial uses. The people settled on river ridges usually depend on water for domestic uses that include potable water collection, bathing and washing and cattle washing. Though at present most of the rural people collect drinking water from shallow and deep tube wells sunk either on homesteads or at agriculture land. Presently many industries that are on adjacent to river banks make industrial use of river water. Unfortunately wastes and effluents from many of these industries are discharged in the rivers. Part of the solid wastes generated in industries and in urban/rural residences are also discharged untreated in open water bodies that pollute the river water. Impact is not assumed in any stages.
14	Protected area	There exist 34 Protected areas in Bangladesh that have been declared by MoEF under the Bangladesh Wildlife (Preservation) Order (23 of 1973)and subsequent Amendments). Moreover, the National Parks at Kuakata, Nawabganj, Kadigarh, Singra and Tengragiri Wildlife Sanctuary at Barguna have been declared as Protected Areas in 2010-2011. Bhawal National Park, Baldha Garden and Madhabkunda Eco-park have also been declared as Protected Areas. Impact is not assumed in any stages because the project bridges are not located in the protected area.
Social Environment		
15	Involuntary resettlement*	A total of 20.99 ha of land will need to be acquired of which 10.51 ha in Rangpur zone, 6.40 ha in Rajshahi zone, 0.90 ha in Gopalganj zone, 1.67 ha in Khulna zone, 1.50 ha in Barisal zone. As a result, 346 households and 1,628 people must be displaced.

16	Local economies, such as employment, livelihood, etc.	In total 3,002 people are going to lose their income as wage earners in the business and commercial enterprises affected by the project. Highest numbers are from Rangpur zone followed by Khulna and Gopalganj zones. Lowest number is found in Rajshahi zone. Thirteen category or type businesses have been identified to be affected by this project. In total 2,513 businesses are going to be affected by this project. Some extent of impact is assumed, however it is not assumed in operation stage.
17	Land use and utilization of local resources	Soils of the Barind tract are weakly structured, acidic clays in the subsoil overlying an unaltered clayey substratum at variable depths. The landscape was probably colonized by pioneer vegetation species (grasses and/or sedges) initially several thousand years back. The early settlers cleared the pioneer vegetation to bring the land under present agricultural uses. The early settlers disliked the well-drained upland for sedentary agriculture because of shortage of water. The indigenous tribes (Santal, Kool and others) on the contrary preferred to settle on undulated uplands and practiced shifting cultivation initially. Impact is not assumed in any stages.
18	Social institutions and local decision-making institutions and social service facilities	There are 98 common property resources in five zones of the project and are getting affected. Out of these 43 in Rangpur zone, 7 in Rajshahi zone, 8 in Gopalganj zone, 19 in Khulna zone and 21 in Barisal zone. The common properties are mostly government and private offices, School and colleges, mosques, club or community societies, pedestrian shed etc. built beside the bridge where people usually gather. Some extent of impact is assumed in construction stage, however it is not assumed in operation stage.
19	Poor	Poverty in Bangladesh is measured through per capita income or through Direct Calorie Intake (DCI) where persons having DCI of less than 2,122 kcal are considered to be living in poverty while a person having DCI of less than 1,805 kcal is considered to be 'hard core poverty'. As per Statistical Year Book of Bangladesh 2010 average household size is 4.50 and 40.94% households earn maximum BDT 60,000 per year. Based on the census socioeconomic survey (April - June 2014) indicating yearly income and expenditure of the project affected households it is found that about 6.27% households earn less than Tk 60,000 per year. Some extent of impact is assumed due to the project, however impact is not assumed in operation stage.
20	Indigenous or ethnic minority people	In all nineteen ethnic tribes living in Bangladesh are the Chakma, Khami, Kuki, Boum, Banjogi, Khiang, Lushai, Marma, Moorang, Mroo, Pankhoo, Rakhain, Tanchunga, Tipra, Khiang and Chak in Chittagong and Chittagong Hill Tract; Khasia, Monipuri, Khami, Khiang in Sylhet, Habiganj, Moulvibazar, and Garo, Hajong, Santhal, Kool and Kotch in the Madhupur and Barind Tract regions. No ethnic is confirmed at the project sites, therefore, Impact is not assumed in any stages.
21	Misdistribution of benefits and damages	In accordance with the result of local stakeholder meeting, the potential items which will cause the negative impact will be almost nil.
22	Local conflicts of interest	In accordance with the result of local stakeholder meeting, the potential items which will cause the negative impact will be almost nil.
23	Gender	Gender equity is required to be maintained as per the GOB rules and of donor requirements in case of recruitment of staff, payment and other facilities. Camp for the workers should be situated apart from the male workers camps. Separate toilet and washing facilities should be provided for with due privacy. impact will be very small in each stage.

24	Children's right	There is restriction on child labor particularly the child's pay not be appointed in jobs that might pose health hazard. In Bangladesh, education is free, and it is mandatory for children between 6 and 10 to attend school. The project will not cause commuting distance to school, therefore, Impact is not assumed in any stages.
25	Cultural heritage	The mentionable cultural heritages include relics of the structures constructed during the rule of different political dynasties since over two thousand years. Oldest cultural relics are of Buddhist period then by structures of Hindu period. Muslim and Mughal periods followed the Hindu period. There is no cultural heritage nearby, therefore, Impact is not assumed in any stages.
26	Infectious diseases such as HIV/AIDS	Spread of HIV/AID in Bangladesh particularly rural areas is minimal as per results of studies conducted so far. AIDS bearing patients have rarely and sporadically been observed amongst the sex workers who live in port cities Mongla and Chittagong. Some extent of impact is assumed due to the influx of workers in construction stage, however it is not assumed in operation stage.
27	Landscape	Bangladesh has the total land area of 147,470 km2 of which 79.1 percent is floodplain, 12.6 percent in north, northeast and south southeast is occupied by Mio-Pliocene hills and 8.3 percent in north central and in northwest regions is Plio-Pleistocene terrace land. The project will not hamper the present landscape, therefore, Impact is not assumed in any stages.
28	Working conditions	It is necessary to secure the safety of workers, pedestrians and vehicular traffics in construction stage.
29	Social consensus	Stakeholders meetings were conducted in two stages or phases. At the initial stage, in every bridge location the consultants disclosed about the goal, objective, different component of the project as a whole and narrated the tentative design of the proposed bridge of that particular location, where stakeholders meetings were conducted. Consultants also narrated the potential land acquisition status in that specific area. Feedback of the consultation meetings were incorporated and considered to finalize the project and bridge locations. After finalization of the bridge locations second phase of consultation took place in selected bridge locations. The Consultants disclosed the entitlements of the affected households and other stakeholders as designed in the ARP. Impact is not assumed in operation stage.
Others		
30	Accident	Narrow width of existing bridges, the structural weakness, and ill maintained road transports, lack of pedestrians' awareness regarding traffic rules and poor law and order situation all combined pose serious threat to road accidents causing death and grievous injuries to the pedestrian and passengers. Bangladesh at present faces highest number of road accident every year (10 accidents/1,000 registered vehicles/year). Some extent of impact is assumed both in construction and operation stages due to the increasing traffics.

*The number is not for 105 project candidate bridges but for 61 project bridges which are selected in Cap 15.

Source: JICA Survey Team

13.1.7 Assessment of Impacts

Various impacts of bridge construction during pre-construction, construction and operation stages are indicted in Table 13.1.13. These are for general consideration and may not apply to each individual bridge.

Table 13.1.13 Comparison of Scoping before/after EIA Study

No.	Items of Impact	Predicted Impact		Assessed Impact		Reason of Assessment
		Before/ During Construction Stage	Operation Stage	Before/ During Construction Stage	Operation Stage	
Anti-Pollution Measures						
1	Air pollution	B-	D	B-	D	Air pollution will be caused during construction stage due to vehicular emissions and dust blowing.
2	Water pollution	B-	D	B-	D	Water pollution during construction stage likely due to construction activities.
3	Soil pollution	B-	D	B-	D	Soil pollution during construction stage may be caused due to spilling of oil and lubricants.
4	Waste	B-	D	B-	D	Camp sites and construction wastes may pollute soil.
5	Noise and vibration	B-	D	B-	B-	Noise level may increase during construction and operation stage.
6	Ground subsidence	D	D	D	D	No ground subsidence likely during implementation stages.
7	Offensive odors	D	D	D	D	No offensive odor likely at any stage of project implementation.
8	Global warming/Climate change	D	D	D	D	No impact anticipated due to global warming.
Natural Environment						
9	Topography and geology	D	D	D	D	No impact anticipated due to implementation of the project.
10	Bottom sediment	D	D	D	D	No impact anticipated
11	Biota and ecosystem	C	C	D	D	No precious species is found at project sites. Impact might be very small.
12	Hydrology	B-	C	D	D	No impact on hydrology due to the project is apprehended.
13	Water use	C	C	D	D	Impact on present water use due to project implementation is apprehended almost nil.

14	Protected area	D	D	D	D	No protected site will be affected.
Social Environment						
15	Involuntary resettlement	A-	D	B-	D	Displacement is required in pre-construction stage.
16	Local economies, such as employment, livelihood, etc.	B-/B+	C	B-	D	At several bridges sites livelihoods may be affected due to removal of shops and acquisition lands.
17	Land use and utilization of local resources	D	D	D	D	Impact on land use may not be serious due to acquisition of agriculture lands at several bridge sites.
18	Social institutions and local decision-making institutions and social service facilities	C	B+	B-	D	Some utilities might be affected due to the new bridge construction.
19	Poor	A-	A-	B-	D	Poor people living on RHD land may be affected.
20	Indigenous or ethnic minority people	C	C	D	D	No indigenous tribal people likely to be affected due to WBBIP implementation.
21	Misdistribution of benefits and damages	D	D	D	D	No impact might be anticipated.
22	Local conflicts of interest	D	D	D	D	No impact might be anticipated.
23	Gender	A-	A-	D	D	No negative impact on gender issues apprehended.
24	Children's right	C	C	D	D	No legal rights of children are anticipated.
25	Cultural heritage	C	C	D	D	No cultural and/or historical relics occurs at bridges sites hence will not be affected.
26	Infectious diseases such as HIV/AIDS	B-	D	B-	D	Influx of worker may cause the possibility of infectious diseases.
27	Landscape	D	D	D	D	No impact might be anticipated.
28	Working conditions	B-	D	B-	D	Insufficient safety management will cause the accidents in construction stage.
29	Social consensus	A-	D	B-	D	The physical construction activities might be hampered without appropriate local consensus.
Others						

30	Accident	B-	D	B-	B-	In-appropriate traffic control and increase of traffic may induce accidents.

Note: A: Remarkable Negative Impact is predicted.

B: Negative Impact is expected to some extent.

C: Extent of Impact is unknown. (A further examination is needed and the impact could be defined as study progresses)

D: Impact is very small or nil and further survey is not required

Source: JICA Survey Team

13.1.8 Mitigation Measures and its Cost

Surrounding environmental condition and nature of the WBBIP are very similar. Thus, Table 13.1.14 presents the combined mitigation measures on anticipated adverse impacts in pre-construction/construction stage, and Table 13.1.15 presents in operation stage, respectively.

Table 13.1.14 Mitigation Measures during Pre-construction/Construction Stage

Item of Impact	Mitigation Measures	Implementing Organization	Responsible organization
Air pollution	- Contractors are required to conduct daily routine equipment and machinery check-ups to ensure that these are in the optimum working conditions. - Regular preventive maintenance service of construction equipment and machineries will strictly comply with. - To reduce the dust, periodical water spray should be taken.	Contractor	Project Implementation Unit (PIU)
Water pollution	- Temporary coffer dam must be provided to accelerate sedimentation of turbid water and prevent a straight water flow into the present water way. - Temporary sanitation facilities such as portable toilets and garbage bins will be provided by the contractors to ensure that the domestic wastes to be generated by the construction personals are properly handled and not thrown into the drainage to prevent further pollution.	Contractor	PIU
Soil pollution	- The operator of heavy equipment should pay attention to prevent fuel leakage when he feeds. - The contractor and consultant of supervision should monitor the manner of fuel feed.	Contractor	PIU
Waste	- Contractors are required to facilitate proper disposal plan and manage the construction waste. - The consultant of supervision should monitor the waste disposal.	Contractor	PIU
Noise and vibration	- Noise suppressors such as mufflers will be installed whenever deemed necessary to maintain the noise the noise generated by the various heavy equipment and other construction machinery within permissible limits. - Contractors are required to use low-noise equipped machinery whenever it is necessary.	Contractor	PIU

Item of Impact	Mitigation Measures	Implementing Organization	Responsible organization
Involuntary resettlement	- Conduct census survey and local stakeholder meeting. - Prepare ARP involving the following measures. • PAPs must be acknowledged as an eligible for compensation. • Identify the eligibility of non-titled people at the census survey intended to PAPs and ensure the compensation and support. • Refer the previous/on-going projects by other donors, determine the requirement for social vulnerability and compensate to them. • Resettlement site must be prepared when PAPs need it. - Confirm if resettlement activities conform to ARP or not by internal monitoring etc.. • Establish Grievance Redress Committee - Establish external monitoring committee consists of the third party.	PIU	RHD
Local economies, such as employment, livelihood etc.	- Prepare ARP involving the following measure. • Measure to restore PAPs' livelihood must be secured.	PIU	RHD
Social institutions, such as social infrastructure and local decision making institutions. Existing social infrastructure and services	- Social utilities; such as power supply, drinking water, drainage and communication line are to be diverted before starting the construction activity.	PIU	RHD
Poor people	- To minimize impact on present agricultural activities, the construction schedule should be disclosed to the PAPs at the earliest possible stage. - The proper compensation should be given to the PAPs.	PIU	RHD
Infectious diseases such as HIV/AIDS	- Contactor will be required to conduct a periodical health education to his personnel.	Contractor	PIU
Working conditions	- Construction personnel provides with the necessary safety gears such as protective hard hat and safety belt as necessary. - Contractor must provide temporary scaffolding, temporary landslide protection wall etc. to protect workers.	Contractor	PIU
Social consensus	- RHD must hold local stakeholder meetings periodically, and release project information to neighbor villagers.	PIU	RHD
Accident	- A sound traffic management and detour plans duly approved by the local RHD must bel strictly implemented. - Traffic enforcers and flagmen will be designated when heavy equipment/vehicle will be operated adjacent to public road.	Contractor	PIU

Source: JICA Survey Team

Table 13.1.15 Mitigation Measures in Operation Stage

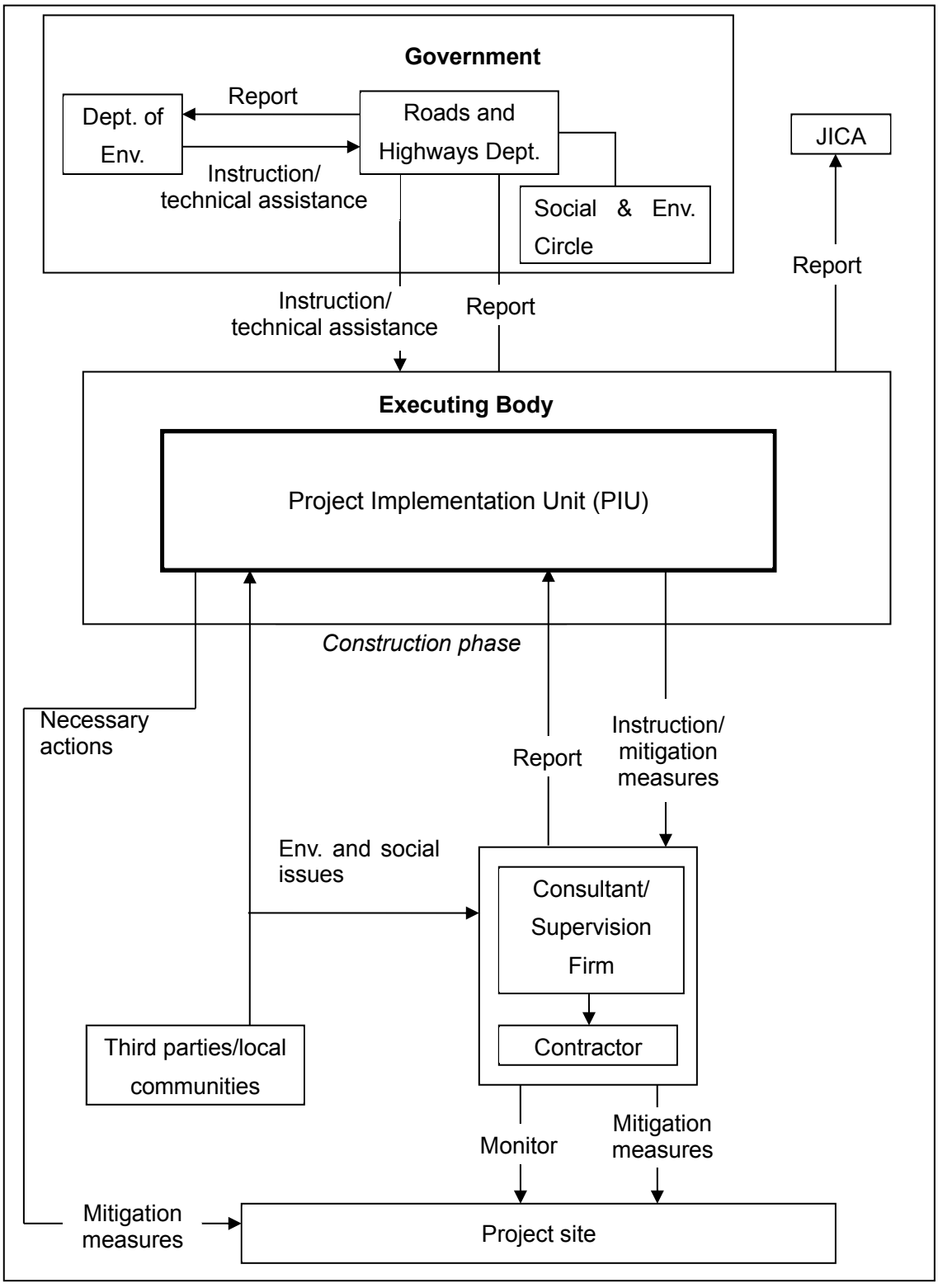
Item of Impact	Mitigation Measures	Implementing Organization	Responsible organization
Noise	- Monitoring and review the result by RHD. - Where noise level exceed the environmental standards, provide hump/planting strip.	Local RHD	RHD
Accident	- Provide hump where school/hospital/market exist.	Local RHD	RHD

Source: JICA Survey Team

13.1.9 Environmental Management Plan (EMP)

(1) Institutional Framework

The institutional framework for environmental management and monitoring is presented in Figure 13.1.3.



Source: JICA Survey Team

Figure 13.1.3 Institutional Framework for Environmental Management and Monitoring

Environmental monitoring is required to be performed periodically during the project implementation stages. Two approaches are followed usually during monitoring of

environmental impacts. These are (i) compliance monitoring during pre-construction and construction stages and (ii) monitoring of impacts on environmental components during construction and operation stages. The following table has been prepared for monitoring the operation & maintenance phase activities of the sub-project, and its monitoring form is attached in Appendix 2.5 Form of Monitoring.

Table 13.1.16 Environmental Monitoring Plan in Construction Stage

No.	Environmental Indicator	Parameters /Units	Means of Monitoring	Frequency	Implementing Organization	Responsible Organization
01	Air Quality	Exhausted gas from construction equipment	Visual inspection	Dairy	Contractor	PIU: Consultant of supervision
02	Water Quality	Turbidity, oil film	Visual inspection	Dairy	Contractor	PIU: Consultant of supervision
03	Soil	Odor at refueling site	Inspection	Dairy	Contractor	PIU: Consultant of supervision
04	Dust Control	Working condition of water sprinkle vehicle	Visual inspection	Daily	Contractor	PIU: Consultant of supervision
05	Waste Management	Garbage, toilet at contractor's office and work camp	Visual inspection	Daily	Contractor	PIU: Consultant of supervision
06	Noise Level	Monitor the (dB) caused construction activity	Monitoring by tool	Daily	Contractor	PIU: Consultant of supervision
07	Working conditions and Accident	Monitor tools, equipment and temporary facilities	Visual inspection	Daily	Contractor	PIU: Consultant of supervision

Source: JICA Survey Team

Table 13.1.17 Environmental Monitoring Plan in Operation Stage

No.	Environmental Indicator	Parameters/ Units	Means of Monitoring	Frequency	Implementing Organization	Responsible Organization
01	Noise Level	Monitor the (dB) caused traffics	Monitoring by tool	Once in a year	Local RHD	RHD
02	Accident	Number of accident on way of transportation basis	Data collection from traffic police	Monthly	Local RHD	RHD

Source: JICA Survey Team

Environmental management costs cover the mitigation of impact during implementation stages including environmental enhancement activities e.g. turf on roadsides, air/water/soil control, etc. Estimates for these costs are shown in Table 13.1.18 and Table 13.1.19.

Table 13.1.18 Estimates for Environmental Monitoring Costs Borne by Contractor

Confidential

Note: Costs above mentioned shall be borne by the Project implementation Contractor(s)

Table 13.1.19 Estimates for Environmental Monitoring Costs Borne by RHD

Confidential

Note: Costs for I + II related to land acquisition and resettlement

13.2 Land Acquisition and Resettlement

13.2.1 Necessity of Land Acquisition and Resettlement

All bridges will be replaced with new bridges in adjacent locations downstream or upstream of existing bridges with new approach roads to connect these bridges.

It is observed that only a small number of people (less than 200) are to be affected at each bridge site due to the project activities. By following OP 4.12 of WB ("when impacts on the entire displaced population are minor, or when fewer than 200 people are displaced at each bridge site"), an Abbreviated Resettlement Plan (ARP) for the project was prepared.

13.2.2 Legal Framework of Land Acquisition and Resettlement

The current legislations governing land acquisition for Bangladesh is the Acquisition and Requisition of Immovable Property Ordinance 1982 and subsequent amendments during 1993 - 1994. The Ordinance requires that compensation be paid for (i) land and assets permanently acquired (including standing crops, fisheries, trees, houses); and (ii) any other damages caused by such acquisition. The Deputy Commissioner (DC) determines the

market price of assets based on the approved procedure and in addition to that pays an additional 50 percent (as premium) on the assessed value as the market price established by Land Acquisition Officer (LAO) which remains much below the replacement value. The 1994 amendment made provisions for payment of crop compensation to tenant cultivators. The Ordinance, however, does not cover project-affected persons without titles or ownership record, such as informal settler/squatters, occupiers, and informal tenants and lease-holders (without document) and does not ensure replacement value of the property acquired. The act has no provision of resettlement assistance and transitional allowances for restoration of livelihoods of the non-titled affected persons. The Acquisition and Requisition of Immovable Property Ordinance (ARIPO, 1982) including its necessary amendments will be utilized for this project.

The DC processes land acquisition under the Ordinance and pays compensation to the legal owners of the acquired land. The Ministry of Lands (MOL) is authorized to deal with land acquisition through the DCs. Khas (government owned) lands should be acquired first when a project acquires both khas and private land. If a project acquires only khas, the land will be transferred through an inter-ministerial meeting following the preparation of acquisition proposal submitted to DC/MOL.

The land owner has to establish ownership by producing a record-of-rights in order to be eligible for compensation under the law. The record of rights prepared under Section 143 or 144 of the State Acquisition and Tenancy Act 1950 (revised 1994) are not always updated and as a result legal land owners have to face difficulties in trying to “prove” ownership. The APs must also produce rent receipt or receipt of land development tax, but this does not assist in some situations as a person is exempted from payment of rent if the area of land is less than 25 bighas (3.37 ha).

The Government of Bangladesh has prepared a draft national policy on involuntary resettlement funded by ADB but yet to be enacted, which is consistent with the general policy of the Government that the rights of those displaced by development project shall be fully respected, and persons being displaced shall be treated with dignity and assisted in such a way that safeguards their welfare and livelihoods irrespective of title, gender, and ethnicity.

The draft Policy was submitted to the Government in November 2007. It has been approved by the Ministry of Land on 1 January 2008 and is placed before the Cabinet later in February 2008. After cabinet approval, the Government will be abided to undertake further work towards legislative changes to safeguard resettlement rights by law.

13.2.3 Gap between JICA’s Guidelines and related Ordinance in Bangladesh

A comparison between JICA’s Guidelines and related Ordinance in Bangladesh is provided in the table below to illustrate the gaps and to provide relevant recommendations and

measures to cover to the gaps.

Table 13.2.1 Gap and Gap Filling Measure

No.	JICA's Guidelines (2010)	GOB's Acquisition and Requisition of Immovable Property Ordinance (ARIPO) of 1982	Gaps Between JICA's Guidelines and ARIPO	Proposed Gap Filling Measures
1	Involuntary resettlement should be avoided wherever possible.	Not specified	The 1982 ordinance legislated nothing, while the JICA Guidelines require to avoid/minimize resettlement/loss of livelihood	Like other donor funded projects in Bangladesh the approach of avoiding involuntary resettlement has already been taken care during preparing this project. This will be further practiced during design and implementation stages.
2	When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken.	Not specified for non-titled people	There is no provisions for compensation to the non-titled residents in Bangladesh ordinance, while JICA's Guidelines acknowledge all affected persons whether legally residing or not, eligible for compensation.	Compensations are proposed even if non-titled affected people providing: - Compensation for structures, trees - Structure transfer assistance - Structure reconstruction assistance - Moving assistance for residential house owner - Tenant moving allowance
3	People who must be settled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre0project levels.	Not specific for keeping living standard of affected people same or above pre-project levels.	There is no provisions for maintaining living standard of affected people at same or above pre-project levels in Bangladesh ordinance, while JICA's Guidelines require that no one is worse off as a result of resettlement and would maintain their living level at least original levels	Assistances were proposed in the form of: - Grant for business loss - Compensation for loss of plant and fish-stock - Grant for loss of wage employment - Rental fee loss for displaced rented house owner - One time moving assistance for tenant business owner - Introduction of micro-credit - Provision of job training - Provision of priority employment etc.
4	Compensation must be based on the full replacement cost as much as possible	Compensation is made based on the pre-determined government prices as are usually quite cheaper than market price	There are no provisions in Bangladesh ordinance, while JICA's Guidelines require that the replacement cost in accordance with market price for compensation.	The resettlement plan addresses all these issues and spells out a mechanism to fix the replacement cost by having an independent evaluator (committee) who will be responsible for deciding the replacement costs. Compensation based on full replacement cost shall be agreed with RHD.

No.	JICA's Guidelines (2010)	GOB's Acquisition and Requisition of Immovable Property Ordinance (ARIPO) of 1982	Gaps Between JICA's Guidelines and ARIPO	Proposed Gap Filling Measures
5	Compensation and other kinds of assistance must be provided prior to displacement	Payment is made on predetermined time, regardless before or after the construction starts	Compensations and other assistances are made regardless before or after construction, while JICA Guidelines requires to make it prior to relocation	The resettlement plan addresses all these issues and spells out a mechanism for all the compensation will be paid prior to possession of the acquired land / prior to displacement
6	For projects that entails large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public.	There is no provision for the formulation of RAP and public hearing. Deputy Commissioner contacts to land owner through land Acquisition Officer (LO), and if landowner has no objection, confirm operation for compensation amount etc. will be proceeded.	There is no provision for preparation of resettlement action plan that describes all features of resettlement requirements and ready to disclose to public.	The Abbreviated Resettlement Plan (ARP) prepared for this project with all features of resettlement requirements and mechanism of disclosure to the public is integral part of ARP. This will be further practiced during design and implementation stages.
7	In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance.	The 1982 Ordinance have provisions to notify only the owners of property to be acquired	There is no provision in the law for consulting the stakeholders but the land allocation committees at district, division and central government level.	The ARP/resettlement plan for the project has been prepared following a consultation process which involves all stakeholders (affected persons, government department/line agencies, local community, NGORP, etc.), and the consultation will be a continuous process at all stages of the project development such as project formulation, feasibility study, design, implementation, and post-implementation, including the monitoring phase.
8	When consultation held, explanation must be given in a form, manner, and language that are understandable to the affected people	There is no provisions	Requirements of JICA Guidelines are not specifically mentioned in the Bangladesh laws and rules	The resettlement plan for the project has been prepared following a consultation process with all stakeholders in local language and by following participatory process with question and explanation on the components of the ARP through participation of all the stakeholders representing different groups and the consultation will be a continuous process at all stages of the project development such as project formulation, feasibility study, design, implementation, and post-implementation, including the monitoring phase.

No.	JICA's Guidelines (2010)	GOB's Acquisition and Requisition of Immovable Property Ordinance (ARIPO) of 1982	Gaps Between JICA's Guidelines and ARIPO	Proposed Gap Filling Measures
9	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans	There is no provision for the monitoring related activities with the participation of affected people	There is no provisions in Bangladesh ordinances, while JICA Guidelines recommend a participation of affected people in planning, implementation and monitoring of RAP	The resettlement plan for the project has been prepared following a consultation process with all stakeholders and the consultation will be a continuous process at all stages of the project development such as project formulation, feasibility study, design, implementation, and post-implementation, including the monitoring phase.
10	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities	Increase AP have objection to compensation amount, the AP should protest and entrust the matter to the Arbitrator. If AP has to appeal against Arbitrator's decision, then AP should file a law suit to the court and wait for the sentence.	The laws of Bangladesh states appeal to Arbitrator and court case, while JICA's Guidelines recommend establishing appropriate grievance redress mechanism for amicable settlement to minimize legal confrontation.	The resettlement plan prepared for this project has made a provision of setting up of grievance redress mechanism accessible for all the affected people including non-titled affected people.
11	Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socio-economic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advantage of such benefit.	No such an activity required	There is no provision in Bangladesh ordinances, while JICA Guidelines recommend identification of affected people there in least possible time preferably at the project identification stage.	This ARP has been prepared based on the data collected through conducting a census, socioeconomic survey for the displaced persons and making inventory of losses. Video filming has also been done for the affected properties.
12	Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under la), the PAPs who do not have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying	There is no provision.	Requirements of JICA's Guidelines are not specifically mentioned in the Bangladesh laws and rules.	The resettlement plan ensures the compensation and assistance to all affected persons, whether physically displaced or economically displaced, irrespective of their legal status. The end of the census survey will be considered as the cut-off date, and affected persons listed before the cut-off date will be eligible for assistance.

No.	JICA's Guidelines (2010)	GOB's Acquisition and Requisition of Immovable Property Ordinance (ARIPO) of 1982	Gaps Between JICA's Guidelines and ARIPO	Proposed Gap Filling Measures
13	Preference should be given to land –based resettlement strategies for displaced persons whose livelihoods are land-based.	There is no provision.	Requirements of JICA Guidelines are not specifically mentioned in the Bangladesh laws and rules.	Though this option may be a difficult proposition given the lack of government lands and the difficulties associated with the acquisition of private lands, the resettlement plan proposes land-for-land compensation as its priority, if feasible. Attempt will be made to find alternate land for the loss of land, in case it is available and if it is feasible, looking at the concurrence of host community and land value.
14	Provide support for the transition period (between displacement and livelihood restoration)	There is no provision for support for the transition period.	There is no provision in Bangladesh ordinances, while JICA Guidelines require providing support for the transition period.	Following are provided in the ARP: - Moving assistance for residential house owners - Tenant moving allowance
15	Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc.	There is no provision for either acknowledgment of or compensation to vulnerable groups	There is no provision in Bangladesh ordinances, while JICA Guidelines require providing special attention to vulnerable people and groups.	Vulnerable allowances were proposed to widowed, old, disabled and poor house head families such as : - Special Assistance for Vulnerable households
16	For project that entails land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared	There is no provision	Requirements of JICA Guidelines are not specifically mentioned in the Bangladesh laws and rules	ARP has been prepared since the displaced people are estimated fewer than 200 at each project bridge.

Source: JICA Survey Team

13.2.4 Census and Socio-economic Survey

(1) Methodology

Relevant information for preparation of the Abbreviated Resettlement Plan (ARP) for 105 bridges of the project is collected from all affected households who stay in COI. Various methods (census/socio-economic survey (SES), stakeholders consultation meetings (SHM), and valuation surveys) were utilized to assess the market price of affected land, structures, trees and other properties. This information is used to prepare a database for design of the ARP. Information to be collected is primarily focused on the direct and indirect impact of the project on the people and their properties as well as other infrastructure in the proposed project area. The database provides a detailed picture of the social and economic impact and is used for resettlement management and implementation in this project.

(2) Project Area

The selected 105 bridges are located in five zones: Rangpur, Rajshahi, Gopalganj, Khulna and Barisal. A total of 32 bridges are located in Rangpur zone (Bogra, Dinajpur, Gaibandha, Joypurhat, Lalmonirhat, Nilphamari, Panchagarh, Rangpur and Thakurgaon districts), 23 bridges are in Rajshahi zone (Naogaon, Natore, Pabna, Rajshahi, and Sirajganj districts), 15 bridges are in Gopalganj zone (Faridpur, Gopalganj, Madaripur, and Shariatpur districts), 15 bridges are in Khulna zone (Bagerhat, Jessore, Jhenaidah, Kushtia, Narail and Satkhira districts), and 20 bridges are in Barisal zone (Barisal, Bhola, Jhalokati Patuakhali and Pirojpur districts). The distribution of bridges in each zone and project-affected units are shown in Table 13.2.2, and the number of households to be displaced due to required demolition of residential structures for each bridge is shown in Table 13.2.3, respectively.

Table 13.2.2 Zone-wise Number of Bridges and Project affected Units

Zone	Districts	Number of bridges	Project Affected Units (PAUs)			
			No. of HHs*1	No. of CBE*2	No. of CPRs	Total
Rangpur	Bogra	06	30	16	02	48
	Dinajpur	08	68	228	15	311
	Gaibandha	03	12	80	00	92
	Joypurhat	02	17	73	01	91
	Lalmonirhat	01	10	00	00	10
	Nilphamari	04	34	115	10	159
	Panchagarh	02	12	93	05	110
	Rangpur	05	23	114	07	144
	Thakurgaon	01	01	46	03	50
	Sub-total	**32**	**207**	**765**	**43**	**1,015**
Rajshahi	Naogaon	01	10	94	01	105
	Natore	02	26	26	02	54
	Pabna	06	44	41	00	85
	Rajshahi	02	33	07	01	41
	Sirajganj	12	77	150	03	230
	Sub-total	**23**	**190**	**318**	**07**	**515**
Gopalganj	Faridpur	07	29	85	01	115
	Gopalganj	01	06	00	00	06
	Madaripur	02	06	111	03	120
	Shariatpur	05	13	68	04	85
	Sub-total	**15**	**54**	**264**	**08**	**326**
Khulna	Bagerhat	02	22	45	00	67
	Jessore	02	43	208	10	261
	Jhenaidah	03	38	70	02	110
	Kushtia	03	35	62	03	100
	Narail	04	33	85	04	122
	Satkhira	01	00	00	00	01
	Sub-total	**15**	**171**	**470**	**19**	**660**
Barisal	Barisal	12	116	462	15	593
	Bhola,	04	18	44	04	66
	Jhalokati	02	14	39	01	54
	Patuakhali	01	09	04	01	14
	Pirojpur	01	09	01	00	10
	Sub-total	**20**	**166**	**550**	**21**	**737**
Total		**105**	**788**	**2,367**	**98**	**3,253**

*1: Households (HHs) are defined as land with residential structures & trees, residential structures, rented residential structures, private trees, and other various items (ponds, fish, gate etc.)

*2: Commerce, Businesses and Enterprises (CBEs) are defined as land with business structures & trees, business structures, or rented business structures

Source: Census & Socioeconomic survey, June 2014

Table 13.2.3 Displaced Number of Households by Bridge

Serial No.	Bridge ID	Number of Residence lose Households	Number of Residence lose People	Serial No.	Bridge ID	Number of Residence lose Households	Number of Residence lose People
Zone: Rangpur				Zone: Rajshahi			
2	N509_19a	4	12	3	N5_119a	0	0
6	N5_235a	1	5	4	N5_127a	8	32
10	N5_265a	1	4	5	N5_176a	3	19
11	N5_350b	1	6	7	N5_120a	0	0
24	N5_356a	1	3	8	N5_128a	0	0
31	N5_378a	0	0	9	N5_158a	6	32
36	N5_188a	2	9	16	N5_134a	2	11
38	N518_4a	2	9	17	N6_97a	26	101
45	N5_344c	2	9	18	R681_10a	31	152
46	N5_382a	19	92	19	N5_140a	8	43
47	N5_360a	9	52	20	N5_118a	21	87
48	Z5025_55a	14	53	27	N505_2a	4	15
49	Z5025_64a	2	8	28	R548_28b	9	40
50	Z5401_45a	5	26	33	N5_156a	4	11
51	Z5072_14a	0	0	34	N5_172a	3	11
52	Z5025_60a	1	2	35	N5_179a	2	7
53	Z5472_6a	0	0	37	N5_126a	4	22
55	Z5552_10a	5	28	54	N5xx_Sa	1	6
59	Z5015_22a	0	0	73	R548_40a	0	0
60	Z5701_1a	12	60	74	R451_1a	1	4
61	Z5701_9a	11	59	75	R451_7a	0	0
62	R545_115c	15	76	87	Z6010_12b	0	0
66	N5_260b	5	17	100	Z5041_2a	3	10
76	R550_28b	0	0	Zone: Khulna			
79	N5_458a	9	51	21	N704_43a	14	63
80	N5_488a	0	0	22	N7_248c	5	19
88	Z5008_1a	9	44	25	N7_246a	13	56
89	Z5024_5c	1	2	39	N7_141b	7	37
90	Z5025_46a	3	16	40	R720_44a	16	86
91	Z5040_4a	7	37	41	N703_Sd	15	58
93	R585_80a	2	10	43	N704_14a	3	12
II	N5_435a	1	7	44	N704_33b	1	5
Zone: Gopalganj				63	R760_049c	0	0
13	N7_025a	1	5	67	N704_27b	2	9
14	N7_039a	3	15	68	R750_22c	0	0
15	N7_049a	1	7	98	R760_003a	-	-
23	N7_054a	12	51	I	N706_14b	28	147
26	N8_095a	1	6	III	N704_12c	3	10
29	N7_036c	3	30	V	R750_25a	5	14
30	N7_048a	0	0	VI	Z7503_5a	0	0
32	N7_047a	0	0	Zone: Barisal			
77	R860_31a	1	7	1	N8_178a	9	51
83	R860_34a	1	6	12	N8_182a	5	45
84	R860_44c	0	0	42	R890_45a	1	9
85	R860_53d	2	8	56	N8_152c	4	15
86	N8_69a	3	11	57	N8_127b	12	54
99	R860_35a	3	21	58	Z8052_009d	5	22
IV	N805_24a	6	36	64	N8_123a	6	32
				65	Z8701_3d	1	4
				69	N8_129a	6	40
				70	R890_16a	5	17
				71	R890_21a	0	0
				72	R890_28a	0	0
				78	Z8708_1c	4	19
				81	Z8708_12b	6	37

Serial No.	Bridge ID	Number of Residence lose Households	Number of Residence lose People	Serial No.	Bridge ID	Number of Residence lose Households	Number of Residence lose People
				82	Z8033_017a	15	77
				92	Z8810_13a	8	40
				94	Z8033_008a	4	31
				95	Z8033_019a	3	18
				96	Z8034_011a	5	15
				97	Z8044_004a	1	5
				71	R890_21a	0	0

*SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges

Source: JICA Survey Team

Out of the total 3,253 affected units, 2,367 commercial enterprises, 788 residential households and 98 community properties were identified on the Corridor of Impact (CoI). Out of 788 households, 529 households are going to lose their housing structure, 190 households are going to lose their trees and 74 households are going to lose other properties like ponds, gates and other minor infrastructures. Most of the affected units are located on private land and some are on RHD land. Community properties are mainly located on RHD land. A total of 109,538 m^2 of different categories of structures are affected by the interventions. Impacts for each zone are shown in the Table 13.2.4.

Table 13.2.4 Distribution of Impacts by Zone

No	Loss type	Zones					Total
		Rangpur	Rajshahi	Gopalganj	Khulna	Barisal	
1	Total number of bridges	32	23	15	15	20	105
2	Total quantity of land (ha) affected	18.50	8.41	5.51	2.70	4.85	39.97
2a	Residential/Commercial land (ha) affected	3.87	2.43	1.49	1.12	2.13	11.05
2b	Agriculture/Others land (ha) affected	14.63	5.97	4.02	1.58	2.72	28.92
3	Total Project Affected Units (PAUs)	1,015	515	326	660	737	3,253
4	Total Households (HHs) affected*1	207	190	54	171	166	788
5	Total commerce and business enterprises (CBEs) affected*2	765	318	264	470	550	2,367
6	Total community property (CPR) affected	43	07	08	21	19	98
7	Total number of structures affected	1,030	494	349	724	766	3,363
7a	Total quantity of all structure (sqm) affected	37,445	12,931	13,589	21,687	23,886	109,538
7.b	Total quantity of residential structure (sqm) affected	10,778	5,902	2,437	7,674	6,417	33,208
7.c	Total quantity of commercial structure (sqm) affected	24,161	6,796	10,270	12,954	15,423	69,604
7d	Total quantity of CPR structures (sqm) affected	2,506	233	882	1,059	2,046	6,726
8	Total no. of toilets affected	14	40	14	05	38	111
9	Total no. of tube wells affected	38	41	12	20	31	142
10	Total no. of trees on private land affected	15,825	8,692	3,830	7,081	9,350	44,778
11	No of trees on government land affected	2,500	2,502	1,852	818	1,776	9,448

*1: Households (HHs) are defined as land with residential structures & trees, residential structures, rented residential structures, private trees, and other various items (ponds, fish, gate etc.)

*2: Commerce, Businesses and Enterprises (CBEs) are defined as land with business structures & trees, business structures, or rented business structures

Source: Census & Socioeconomic survey, June 2014

(3) Profile of Affected Households

Out of the total affected population, 8,378 (52.68%) are male and 7,525 (47.32%) are female. In the project area, 336 people were found to be old or sick and 47 people were found to be physically handicapped.

Table 13.2.5 Number of Male and Female Population by Zone

Zone	Total HH	Population				Total population
		Male	Percentage (%)	Female	Percentage (%)	
Rangpur	972	2,591	53.07	2,291	46.93	4,882
Rajshahi	508	1,324	52.69	1,189	47.31	2,513
Gopalganj	318	833	54.09	707	45.91	1,540
Khulna	641	1,738	51.77	1,619	48.27	3,357
Barisal	716	1,892	52.40	1,719	47.60	3,611
Total	3,155	8,378	52.68	7,525	47.32	15,903

Source: Census & Socioeconomic survey, June 2014

Among affected households, 3,074 are male-headed, and 81 (less than 3%) are female-headed (Table 13.2.6).

Table 13.2.6 Affected Household Heads by Zone and Gender

SEX	Affected Household Heads by zone						Percentage
	Rangpur	Rajshahi	Gopalganj	Khulna	Barisal	Total	
Male	941(96.8%)	490(96.5%)	313(98.4%)	625(97.5)	705(98.5%)	3,074	97.43
Female	31(3.2%)	18(3.5%)	05(1.6%)	16(2.5)	11(1.5%)	81	2.57
Total	972(100%)	508(100%)	318(100%)	641	716	3,155	100

Source: Census & Socioeconomic survey, June 2014

Poverty in Bangladesh is measured through per capita income or through Direct Calorie Intake (DCI) where persons having DCI of less than 2,122 kcal are considered to be living in poverty, while a person having DCI of less than 1,805 kcal is considered to be living in “extreme poverty”. Based on the socioeconomic survey indicating yearly income and expenditure of the project affected households, it was found that about 6.27% households earn less than Tk 60,000/year.

Table 13.2.7 Poverty Level and Annual income of head of the households by Zone

Zone	Rangpur		Rajshahi		Gopalganj		Khulna		Barisal		Total	
Income (Tk)	No.	%	No.	%	No	%	No.	%	No.	%	No.	%
<15000	04	0.41	02	0.39	01	0.31	00	0.00	01	0.14	08	0.25
15001-30,000	07	0.72	06	1.18	01	0.31	01	0.16	03	0.42	18	0.57
30,001-45,000	21	2.16	04	0.79	03	0.94	06	0.94	04	0.56	38	1.20
45,001-60,000	62	6.38	28	5.51	12	3.77	16	2.50	16	2.23	134	4.25
60,001-80,000	59	6.07	21	4.13	04	1.26	17	2.65	22	3.07	123	3.90
80,001-100,000	100	10.29	45	8.86	13	4.09	41	6.40	45	6.28	244	7.73
100,001-120,000	196	20.16	116	22.83	57	17.92	111	17.32	152	21.23	632	20.03
120.001-135,000	16	1.65	03	0.59	01	0.31	07	1.09	02	0.28	29	0.92
135,001-150,000	67	6.89	23	4.53	13	4.09	46	7.18	45	6.28	194	6.15
150.001-165.000	13	1.34	06	1.18	03	0.94	06	0.94	04	0.56	32	1.01
165,001-180,000	129	13.27	62	12.20	49	15.41	85	13.26	122	17.04	447	14.17
>=180.001	298	30.66	192	37.80	161	50.63	305	47.58	300	41.90	1,256	39.81
Total	972	100.00	508	100.00	318	100.00	641	100.00	716	100.00	3,155	100.00

Source: Census & Socioeconomic survey June 2014

13.2.5 Eligibility Policy and Entitlement Matrix

All APs will be entitled to compensation and resettlement assistance based on severity (significance) of impacts. Nevertheless, eligibility to receive compensation and other assistance will be limited by the cut-off date. For those identified on the project right of way land proposed for acquisition, the cut-off date for compensation under law (Ordinance II of 1982 and its 1994 amendments) is considered at the time of serving notice under Section 3 or at the time of joint verification by DC (whichever is earlier). The cut-off date of eligibility for resettlement assistance under this ARP is the commencement date of the disclose of entitlements and consultation meeting with the stakeholders which is the 5th August 2014 for Rangpur and Rajshahi zones and 20th August 2014 for Gopalganj, Khulna and Barisal zones for the APs staying on public lands. The absence of legal title will not bar APs from compensation and assistance, as specified in the Entitlement Matrix (Table 13.2.8).

An Entitlement Matrix has been prepared based on results of the census and socioeconomic survey (SES) conducted from 11th April 2014 to 30th June 2014. It identifies the categories of impact based on the census & SES and shows the entitlements for each type of loss. The matrix describes the units of entitlements for compensating the lost assets, and various resettlement benefits. Cash compensation under law (CCL) for lost assets (land, tree, structure & other physical establishments) will be accorded to the owners through the DCs as per market value assessed through legal procedures. The resettlement benefits for indirect losses and difference between replacement value and the CCL will be paid by RHD through ARP Implementing Agency.

The framework of the ARP was distributed at the 2nd round local stakeholder meeting, and approval was received from project-affected people (PAPs). The prepared ARP has been submitted to the RHD, and approved by the Ministry of Road Transport and Bridges on 29th December, 2014.

Table 13.2.8 Compensation and Entitlement Matrix

Item No.	Type of loss	Entitled Persons (Beneficiaries)	Entitlement (Compensation Package)	Implementation issues/Guidelines
1	Loss of homestead, commercial, Agriculture land, pond, ditches and orchards etc.	Legal owner(s) of land	i. Replacement value (RV) of land (Cash Compensation under Law (CCL) and additional grant to cover the current market price of land and stamp duty & registration cost @ 10.5% of CMP for land) to be determined by PVAT. ii. Dislocation allowance @ BDT 100 per decimal for agricultural, fish pond, ditch, etc. and @ BDT 200/decimal for homestead, orchard and commercial lands. iii. Compensation for standing crops to actual owners/ cultivators as determined by PVAT.	a. Assessment of quantity and quality of land by Joint Verification Survey b. Assessment of Market Value by Land Market Survey (LMS) c. Assessment of Cash Compensation under Law (CCL) d. Updating of title of the affected persons e. Payment of Cash Compensation under Law (CCL) f. APs will be fully informed of the entitlements and procedures regarding payments g. Additional cash grant to be paid to cover the replacement value of land compensation based on DC's CCL . h. Stamp duty and registration fees will be added with current market price (CMP) for land @ 10.5% of CMP to facilitate the APs in purchasing alternative lands.
2	Loss of access to cultivable land by owner cultivator/ tenant/ sharecropper	Tenants/ sharecropper/ Legal owner/ grower/ socially recognized owner/ lessee/ unauthorized occupant of land	i. Compensation for standing crops to owner cultivator/ sharecroppers or lessees as determined by PVAT. ii. Owner/grower to take away the crop	a. All the individuals identified by the JVS as tenants or sharecroppers of land b. Compensation to be paid after taking possession of land and the legal /socially recognized owner is paid cash compensation for crop and on certification of receipt by legal/socially recognized owner c. Additional cash grant to cover current market value of crop compensation as prescribed by PVAT in case of private owner himself cultivating crop d. Crop compensation and the crop will be shared between owner and sharecropper as per terms of sharecropping in case of privately owned

Item No.	Type of loss	Entitled Persons (Beneficiaries)	Entitlement (Compensation Package)	Implementation issues/Guidelines
				land/socially recognized owner e. In case of dispute over verbal agreement on sharecropping, certification from the elected representative will be considered as legal document
3	Loss of Trees/ Perennials / fish stocks	1. Person with Legal Ownership of the land 2. Socially recognized owner/ Unauthorized occupant of the trees/ fishes	i. Cash compensation at market rates for replacement of trees/ perennials/ fish stocks value ii. For fruit bearing trees- compensation for fruits @ 30% of timber value X 1 year iii. Compensation for fish stocks as determined by PVAT. iv. 5 saplings will be distributed free of cost among each affected household losing trees v. Owners will be allowed to fell and take away their trees, perennial crops/ fishes etc. free of cost without delaying the project works.	a. Assessment of loss and market value of affected trees b. Payment of CCL for trees c. Adequate compensation will be paid and the owner will be allowed to fell and take the tree free of cost d. Compensation for fruit will paid for small, medium and large categories of trees. e. 5 saplings (2 fruit tree, 2 timber types and 1 medicinal tree) free of cost will be distributed among the tree losing households.
4	Loss of residential /commercial structure by owner(s)/ squatters	Legal Owners or squatters	i. Replacement value of structure at market price determined by PVAT. ii. Transfer grant @ Tk.12.50% of the replacement value of main structure iii. Reconstruction grant @ Tk.12.50% of the replacement value of main structure. iv. Owners to take away all salvage materials free of cost	a. Payment of CCL for the losses b. Verification of Joint Verification Survey (JVS) and other records c. APs will be fully informed about their entitlements and assisted to obtaining it.
5	Loss of access to Residential houses/ commercial structures (rented or leased)	Tenants of rented/ leased properties	i. One time cash grant for facilitating alternative housing/CBEs Tk. 3000.00 per household or entity ii. Shifting allowance per household based on family members @ Tk. 500/- per member with minimum Tk. 2000	a. Verification of JVS and records b. Shifting allowance will be paid on relocation from project site

Item No.	Type of loss	Entitled Persons (Beneficiaries)	Entitlement (Compensation Package)	Implementation issues/Guidelines
6	Loss of business by CBEs due to dislocation	Owner/operator of the business as recorded by JVS	i. Business restoration grant @ Tk. 10,000 for each business unit.	a. All persons recorded by the JVS b. Cash grant to be paid while taking possession of land
7	Loss of Income and work days due to displacement	Employees identified by the Joint Verification Team (JVT)	i. Cash grant to the affected employees/wage earners equivalent to 30 days wage @ Tk. 300/per day ii. Preferential employment in the project construction work, if available.	a. All persons recorded by the JVS b. Cash grant to be paid while taking possession c. Involvement of the incumbents in project civil works d. Training on income generating activities such as psiculture, livestock and poultry, horticulture, welding, mechanics, plant cultivation, social forestry, etc.
8	Poor and vulnerable households	Poor and vulnerable households as identified by JVT	i. Additional cash grant of Tk. 3000for affected poor women headed households and other vulnerable households ii. Training on IGA for AP/ nominated by AP.	a. Identification of Vulnerable households b. Income restoration schemes for vulnerable households c. Arrange training on income generating activities
9	Loss of Common Property Resources	Affected Common Property Resources (Mosque, school, community infrastructure etc.)	i. Grant for each affected CPR for reconstruction Or Reconstruction of CPR through the project	a. Identification of the management committee of the CPRs b. Cash grant to the Management committee of CPR c. Or Reconstruction of the CPR by the project
10	Temporary impact during construction	Community / Individual	i. The contractor shall bear the cost of any impact on structure or land due to movement of machinery and in connection with collection and transportation of borrow materials. ii. All temporary use of lands outside proposed CoI to be through written approval of the landowner and contractor. iii. Land will be returned to owner rehabilitated to original preferably better standard.	a. Community people should be consulted before starting of construction regarding air pollution, noise pollution and other environmental impact b. The laborers in the camp would be trained about safety measures during construction, aware of health safety, STDs, safe sex etc. The contractor shall ensure first aid box and other safety measures like condoms at construction site.

Source: ARP, September 2014

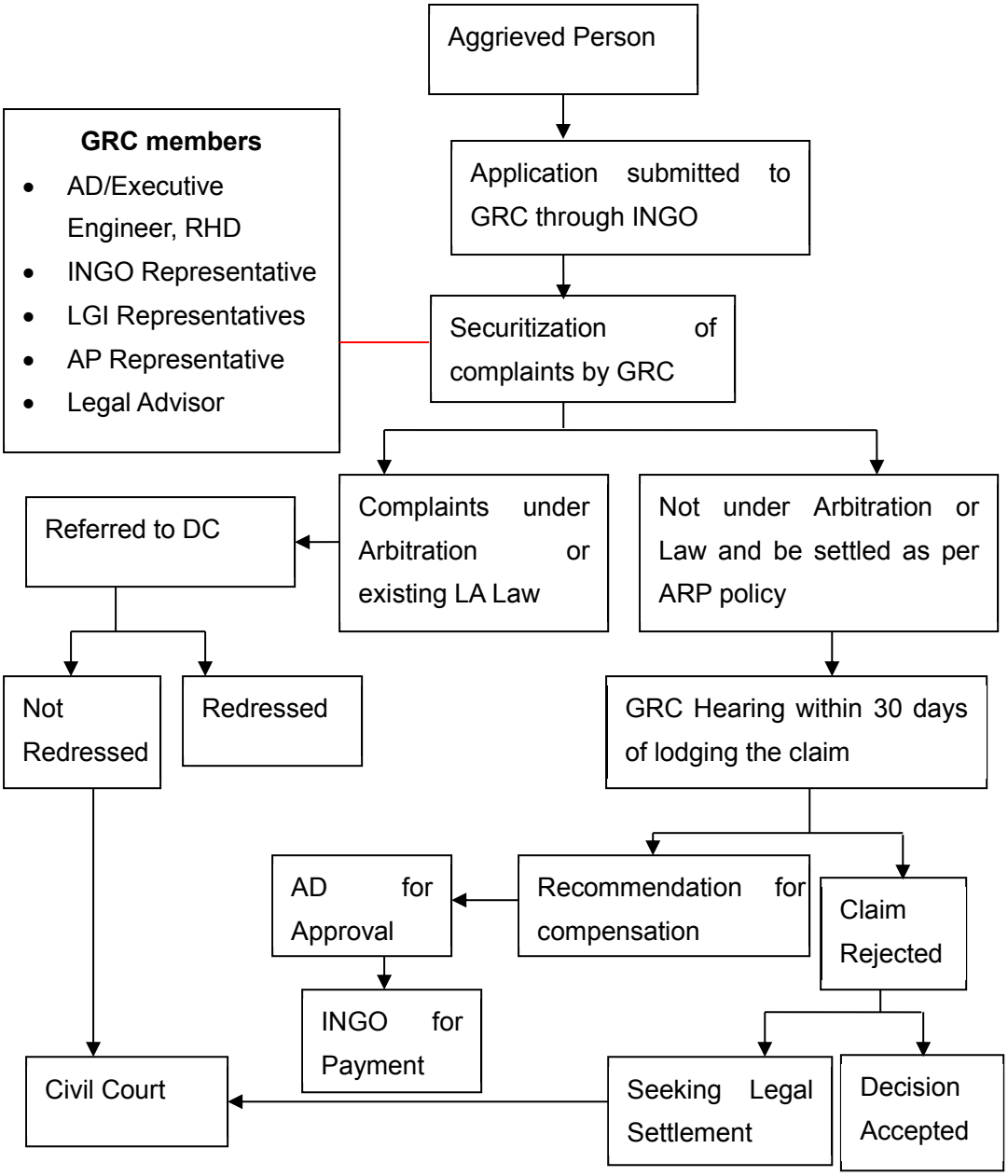
13.2.6 Grievance Redress Committee

The complex land record system in Bangladesh leaves considerable room for conflicts over titles to land and properties involving land, structures, trees, ponds etc. Grievances may also aired about the road alignment and/or the valuation of land and/or other properties in determining compensation. There are established procedures in the LA Ordinance of 1982 regarding compensation for some of these grievances. But recourse of law is always a complicated process, which usually discriminates against the poor due to their lack of knowledge and resources for litigation and is always time consuming. There are grievances, which can be easily resolved out of court if the law is properly explained and fair play made clear. It is with these objectives that Grievance Redress Committee (GRC) will be set-up in each union where land acquisition will be taking place.

GRCs will be formed at Union level for any grievances involving resettlement benefits, relocation, and other assistance. A gazette notification on the formation and scope of the GRCs will be required from the MORTB. The GRC for each union will be composed of the following members:

- Assistant Director (AD) of RU Executive Engineer, RHD - Convener
- Area Manager, INGO - Member secretary
- Union Parishad -The lowest tier of local administration, the Chairman and members of which are elected by member of the people of the union.
- One representative of APs - Member
- One UP member (female) - Member

The grievance redress mechanism is elaborated in Figure 13.2.1.



Source: JICA Survey Team

Figure 13.2.1 Grievance Redress Mechanism

13.2.7 Implementation Organization

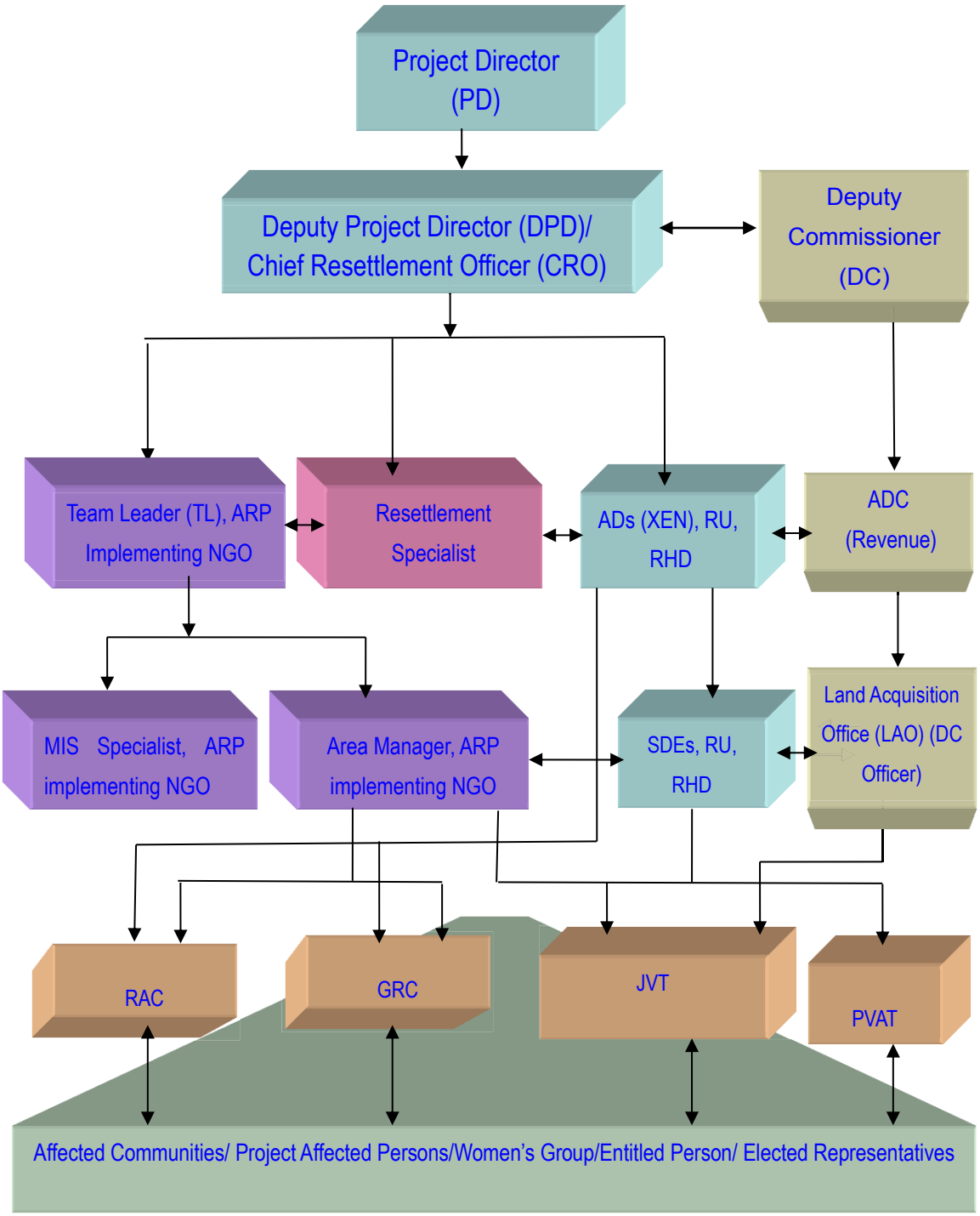
(1) Implementation Organization

The Roads and Highways Department (RHD), a designated agency of the Government of Bangladesh (GOB), is responsible for the resettlement of the people affected by the project. At the time of implementation RHD will establish a Project Implementation Unit (PIU) headed by a Project Director (PD), at the project office that will be responsible for the overall execution of the Project. The PIU will consist of three units: Engineering Service Unit (ESU),

Environmental Management Unit (EMU) and Resettlement Unit (RU) for total implementation of the project. The PD will work on deputation from RHD at the level of Superintending Engineer or Additional Chief Engineer. The project will be overseen by the PD, RHD. The RU will be responsible for the overall implementation, management and monitoring of the ARP of the project. ARP Implementing Agency (IA) plays important role in the field level in coordination with the DC, RHD and consultants. Their main activities are;

- To create ID numbers for each affected person as identified during Joint Verification survey by JVT for both title and non-title holder.
- To assist the APs in preparing record of rights to the property and receiving compensation under law (CCL) from DC office.
- To form focus groups with the affected people based on homogeneity and/or proximity and hold meetings on a regular basis to let them know their rights and entitlements as prescribed in the ARP.
- To form unions based resettlement advisory committee (RAC) to involve the local communities and APs in the implementation process.
- To prepare payment debit vouchers & other documents and disburse account payee cheque to the APs.

The implementation organizations and hierarchy involved in the implementation process is shown in Figure 13.2.2.



Source: JICA Survey Team

Figure 13.2.2 ARP implementation organogram

(2) Women Groups in Resettlement Process

The ARP implementation will ensure a gender sensitive approach in planning, management and operations of land acquisition and resettlement. Separate groups of female APs will be formed and operated by the INGO. Feedback from the female APs and female headed AHs

will be obtained through these female focused groups for relocation and resettlement planning. The female members of the households will be given special consideration in getting employment in civil construction.

The female staff engaged by implementing NGO will identify needs of female APs for income restoration approaches and implementation of the income restoration component of the ARP. Thus, women were consulted during the whole process of Resettlement.

(3) Appointment of Implementing Non-Government Organization (INGO)

RHD will appoint an experienced NGO through standard procurement system. This NGO will be appointed for implementation of the ARP in the field level in coordination with DC, RHD and National Resettlement Consultant (NRS) in accordance with TOR attached in Appendix 2.6 TOR for IA for ARP Implementation of this document for the executing agency.

13.2.8 Implementation Schedule

The implementation schedule will be finalized considering possible changes of events during the project implementation period of the project. The APs will be paid their resettlement cash payments independent of legal compensation before their relocation and payments related to award of compensation by DC.

Confidential

Confidential

Source: JICA Survey Team

Figure 13.2.3 ARP 13.2.7 Implementation Schedule

13.2.9 Resettlement and Compensation Costs & Budget

Eventually, from the 105 bridge candidates, 60 bridges were selected as project objective in Chapter 15. The selected bridges involve 346 project-affected households (PAHs) and 1,628 project-affect people (PAPs).

The ARP budgets for compensation for land, structures, other assets, crops and trees, and special assistance will be calculated using the market rates reflecting replacement cost at the time of dispossession. The costs for relocation and special assistance will be consistent with the resettlement policy. Other costs involving project disclosure, public consultations and focus group discussions have been included in the ARP budget under 'Operation cost for IA' head. Training on IGA will be organized under the Livelihood and Income Restoration Program (LIRP). Budget has been allocated for the purpose, as well as a budget allocation for 5% as contingency.

The budget also includes operational cost of the Implementing Agency (IA) and capacity building training cost of the Executing Agency (EA). The total estimated cost for implementation of the ARP of selected 60 Bridges is BDT Confidential including CCL amount to be determined by the DC for land and other physical assets. These estimates and the budget must be regarded as provisional, given the need for updating the ARP (if required) during implementation. Final rates per unit for land, structures, trees and other affected properties will be determined by the PVAT. Based on the rate and ARP policy, a final resettlement budget shall be prepared and approved by the EA. All resettlement funds will be provided by the EA (RHD) based on the financing plan agreed by the GOB.

13.2.10 Monitoring and Evaluation

ARP implementation monitoring will be done both internally and externally to provide feedback to RU (RHD) and to assess the effectiveness. Evaluation of the resettlement activities will be performed during and after implementation of the ARP to assess whether the resettlement objectives were appropriate and whether they were met, specifically, whether livelihoods and living standards have been restored or enhanced. The evaluation will also assess resettlement efficiency, effectiveness, impact and sustainability, drawing lessons as a guide to future resettlement planning.

(1) Internal Monitoring

Internal monitoring will be undertaken by the RU through SDE with assistance from the NRS and IA. The IA will gather information on ARP implementation covering relevant activities as per schedule. Internal monitoring reports on ARP implementation will be included in the quarterly Project Progress Report (PPR) to be prepared by RU, RHD. The report of RU will contain: (i) accomplishment to-date, (ii) objectives attained and not attained during the period, (iii) challenges encountered, and (iv) targets for the next quarter. Furthermore,

internal monitoring would be carried out every half year in operation stage for at least two years. Table 13.2.9 shows the potential monitoring indicators that will be reported. , and Table 13.2.10 shows the format for ARP implementation monitoring which will be filled by RU quarterly.

Table 13.2.9 Format for ARP Implementation Monitoring

Component	Total (unit)	Completed (unit)	Cumulative Achievement Total (unit)	Progress During Reporting Month (%)		Status & Remarks
				Target (%)	Achievement (%)	
Resettlement Preparation						
Distribution of Brochures						
Identification of AHs/CBEs						
Issuance of ID cards						
Consultation Meetings						
Formation of PVAT/RAC/GRC						
Payment of Compensation						
Compensation for land						
Compensation for tree/crop/fish						
Res/Commercial structure						
Payment for rent/leaseholder						
Shifting/relocation costs						
Social Development Activities						
Grant for loss of wages						
Loss of business grant						
Business restoration grant						
Payment for indirect impact						
LIRP activities						

Source: ARP September, 2014

Table 13.2.10 Potential Monitoring Indicators

Monitoring Issues	Monitoring Indicators
Budget and Timeframe	• Have all land acquisition and resettlement staff been appointed and mobilized for field and office work on schedule?

Monitoring Issues	Monitoring Indicators
	• Have capacity building and training activities been completed on schedule? • Are resettlement implementation activities being achieved against agreed implementation plan? • Are funds for resettlement being allocated to resettlement agencies on time? • Have resettlement offices received the scheduled funds? • Have funds been disbursed according to ARP? • Has all land been acquired and occupied in time for project implementation?
Delivery of AP Entitlements	• Have all APs received entitlements according to numbers and categories of loss set out in the entitlement matrix? • How many affected households have received land titles? • How many affected households relocated and built their new structure at new location? • Are income and livelihood restoration activities being implemented as planned? • Have affected businesses received entitlements? • Have the APs losing their eroded land received proper compensation? • Have the squatters, encroachers of RHD or government land, displaced due to the project, been compensated? • Have the community structures are compensated and rebuilt at new site?
Consultation, Grievances and Special Issues	• Have resettlement information brochures/leaflets been prepared and distributed? • Have consultations taken place as scheduled including meetings, groups, community activities? • Have any APs used the grievance redress procedures? What were the outcomes? • Have conflicts been resolved?
Benefit Monitoring	• What changes have occurred in patterns of occupation compared to the pre-project situation? • What changes have occurred in income and expenditure patterns compared to pre-project situation? • Have APs income kept pace with these changes? • What changes have occurred for vulnerable groups?

Source: ARP September, 2014

(2) External Monitoring

The RHD will engage individuals/firms to conduct a one-time social impact evaluation, at least six months following the completion of resettlement. It will use appropriate investigative and analytical techniques in assessing the post-project socio-economic conditions of the APs in relation to the baseline socio-economic data generated before undertaking of the resettlement implementation.

The evaluation will describe any outstanding future issues that are required to bring the resettlement into compliance with JICA's Guidelines for Environmental and Social Considerations and Government policies, and further mitigation measures needed to meet the needs of any APs or families perceiving themselves to be worse off as the result of resettlement. It will include lessons learned from the evaluation that may be useful in developing future policies on involuntary resettlement of APs in Bangladesh.

The Resettlement Specialist (within the project consultants) will conduct periodic reviews and supervision during the implementation stage. In addition to regular supervision, RHD will undertake a comprehensive mid-term review of the ARP implementation. A post-evaluation of ARP activities will be carried out by RHD to assess the resettlement impact in terms of adequacy and deficiency in planning and R&R operations following the social impact evaluation.

TOR for External Monitoring is presented in Appendix 2.7 TOR for External Monitoring Consultant.

13.2.11 Local Stakeholder Meeting (SHM)

Stakeholders meetings were conducted in two stages or phases. At the initial stage, in every bridge location the consultants disclosed about the goal, objective, different component of the project as a whole and narrated the tentative design of the proposed bridge of that particular location, where stakeholders meetings were conducted. Consultants also narrated the potential land acquisition status in that specific area. Feedback of the consultation meetings were incorporated and considered to finalize the project and bridge locations. After finalization of the bridge locations second phase of consultation took place in selected bridge locations. The Consultants disclosed the entitlements of the affected households and other stakeholders as designed in the ARP based on GOB policy and JICA's Guidelines. The consultants also declared the cut-off date as the commencement date of second phase SCMs for eligibility of receiving resettlement benefits for the non-titled affected peoples.

(1) Meeting Phase I

In the initial stage of the project in April 2014 the local potential APs of each bridge location along with local community leaders and other stakeholders like RHD representatives, local

government representatives were consulted through consultation meetings and personal contract. Stakeholders were informed about the meeting time and location ahead of time through personal contact and over telephone. Other local people were invited privately, as well as a notification via loudspeaker.

A summary of meetings with APs and other stakeholders is shown in Table 13.2.11.

Table 13.2.11 Stakeholders Consultation Phase I

No.	Dates of holding meetings	Type of Participants & Methodology	Issues Discussed	Outcome of the discussion
1	During conducting survey from the 12to 22 April2014 in Rangpur and Rajshahi zone and - 7 to 27 May 2014 in Barisal, Khulna and Gopalganj zone.	A total of 105 stakeholders meetings were held in 105 bridge locations. People attended the meeting including farmer, homestead owner, service holder, shop owner, community leader, RHD representative, Local government representatives (Chairman, member) etc. *People were consulted through Consultation meetings.*	Issue based discussion was held on community people's perception, attitude, needs and aspiration from the project. Following issues were discussed along with their raised issues: - Knowledge of people about the project - Attitude of the people towards the project - Major problems relating to the project, - Proposed suggestion to minimize the problem - Identification of alternate location/alignment of the proposed bridge - Potential benefit of the project for the locality, - Need of the project, specifically the proposed bridge for that area - Relocation of houses and other establishments - JICA's Guidelines for Environmental and Social Considerations - Gender issues, especially the local practice/attitude about women working in construction site.	a. The bridges need to be replaced by wider bridges and with good material to reduce very frequent accidents; b. Well-constructed bridges are required for better communication and transportation of the commodities; c. Proper compensation for land, crops, business enterprises, etc. to be paid; d. Land used for existing bridge need to be utilized for the proposed one instead of totally a new one. This way land acquisition can be reduced; e. Local people should be employed during construction of the new bridge irrespective of gender; f. Construction of new bridge on one side should not be done. Existing bridge should be widened on both side; g. Proposed Bridge location should be on the other side; h. Try to build the bridge on RHD land rather than on private land f. Facilities for using river water will be kept undisturbed for the community

Source: ARP September, 2014

Some photographs of consultation meetings

			
Naori bridge, 74 Sirajganj	**Anandobabur Pul, 60 Nilphamari**	**Kanaipur bridge, 29 Faridpur**	**Dhopaghata bridge,41 Jhenaidah**
			
Ichamoti bridge, 46 Dinajpur	**Mohishmari bridge, 73 Natore**	**Garakola bridge, 1 Gopalganj**	**Bakerganj steel bridge, 12 Barisal**

(2) Meeting Phase II

After selection of the bridge locations and completion of the detailed design, community level stakeholders consultations were held in all bridge sites. A total of 105 stakeholders consultation meetings (Barisal zone 20, Khulna zone 15, Gopalganj zone 15, Rangpur zone 32and Rajshahi zone 23) were held in the period from August 5 2014 to August 30 2014 covering affected communities in all bridge locations.

Local consultant had introduced the frame of entitlement and local participants accepted it with satisfaction. However, at some sites, local stakeholders proposed to change the bridge location, insisting that otherwise they would not agree with the project
In response to the proposal, the survey team consulted with JICA and RHD and the measures to change the initial location of the prioritized bridges and hold 3rd round meeting were taken.

A summary of the consultation meetings with APs and other stakeholders is given in Table 13.2.12.

Table 13.2.12 Stakeholders Consultation Phase II

Sl. No.	Dates of holding meetings	Type of Participants & Methodology	Issues Discussed	Outcome of the discussion
1	During conducting survey from the 5 to16 August 2014 in Rangpur and Rajshahi	A total of 105 stakeholders meetings were held in 105 bridge locations. People attended the meeting including farmer, homestead	Issue based discussion was held on community people's perception, attitude, needs and aspiration from the project. Following issues were discussed along with their raised issues: - Impact (positive and	a. Entitlements of the affected people and cut-off-date for listing of the lost properties are known to the people b. Land price should be fixed on open market rate and compensation

Sl. No.	Dates of holding meetings	Type of Participants & Methodology	Issues Discussed	Outcome of the discussion
	zone and 20 to30 August 2014 in Barisal, Khulna and Gopalganj zone.	owner, service holder, shop owner, community leader, RHD representative, Local government representative Chairman/Member etc. *People were consulted through Consultation, Group Discussion and personal contact.*	negative) of the project & mitigation measures against negative impact, - Policy of compensation and resettlement grants for land, crops, houses and shops on private and public lands, - Discloser of the compensation packages for different kinds of losses. Additional assistance for the vulnerable and others were also discussed, - People's preference on mode of compensation payment - Relocation of houses and other establishments - JICA's Guidelines for Environmental and Social Considerations - Cut-off date for listing affected properties i.e. commencement date of 2nd phase stakeholders consultation meeting (5th August 2014 for Rangpur and Rajshahi Zone and 20th August 2014 for Barisal, Khulna and Gopalganj zone) for indirect APs and notice under section 3 is for land owners. - Training and cash grant for vulnerable households, etc. - Gender issues, especially the scope of work for women in project civil work.	should be paid at their door step before displacement; c. Proper compensation for land, crops, business enterprises, etc. to be paid d. People will be encouraged for self-relocation for living within the kin groups with mutual support. e. Vulnerable APs will be preferentially employed in the civil construction of the project on the basis of their qualification end eligibility irrespective of gender. f. Facilities for using river water will be kept undisturbed for the community g. Training on some income generating activities should be provided to the poor. h. People know their right and responsibilities at the initial stage of the project by FGD, consultation, information campaign, etc.

Source: ARP September, 2014

(3) Meeting Phase III

Further meetings were conducted from 23rd to 25th September,2014 concerning eight bridges for which PAPs had proposed to change a bridge location during Meeting Phase II, and PAPs agreed with the changed bridge location. Thus, the consensus to construct new bridge was reached with the PAPs.

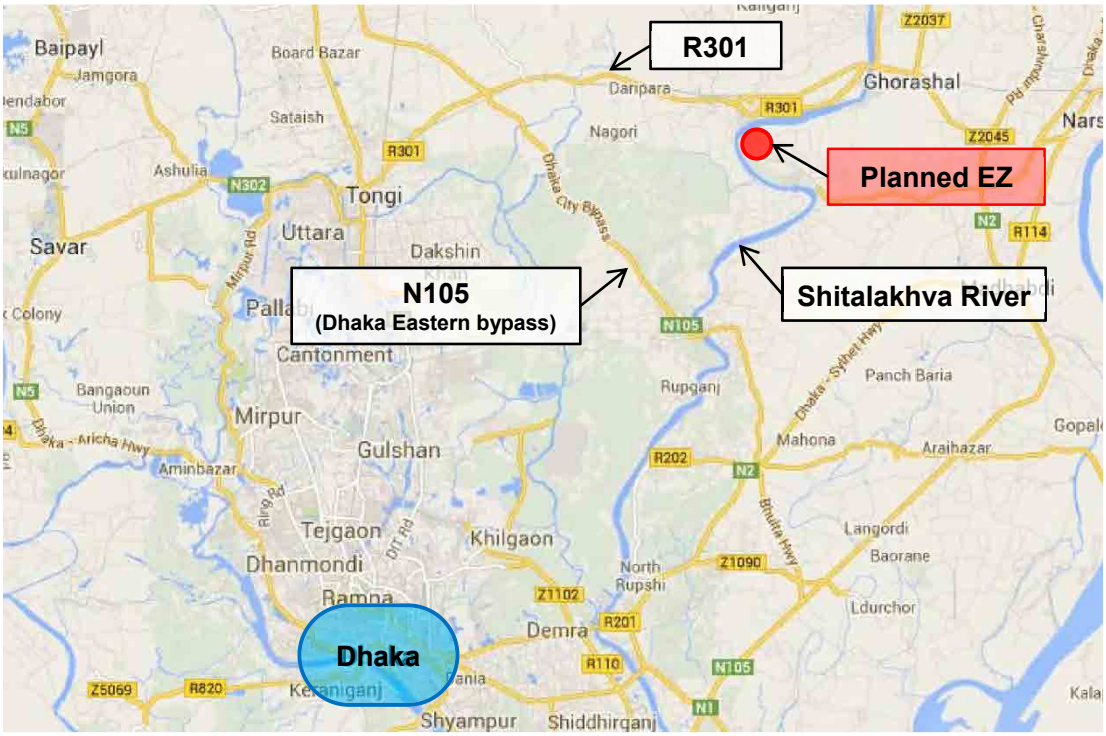
14. THE EZ BRIDGE AND ROAD

14.1 Introduction

Due to the capacity saturation of existing economic zones (EZ) in Bangladesh, it is an urgent requirement to swiftly launch new economic zones to meet the rising industrial demand, as well as to further enhance foreign direct investment in Bangladesh. For a smooth launch and efficient use of an economic zone, It is essential to develop appropriate road and bridge infrastructures to access the site in a timely manner.

Some EZs have been planned in and around Dhaka, the capital city of Bangladesh. The Survey studied the development of bridge and road access to the EZ planned in Narsingdi (hereinafter referred to as the EZ Bridge and Road) as one of the important EZs in Bangladesh.

The location of the planned EZ in Narsingdi is shown in Figure 14.1.1.



Source: JICA Survey Team

Figure 14.1.1 Location Map of Planned EZ in Narsingdi

14.2 Route Alternatives

The following eight route alternatives for the EZ Bridge and Road were planned. The alignment location for each of the alternatives is shown in Figure 14.2.1.

Alt 1-1

- Construct a new bridge (L=1,050m) on the north side of planned EZ.
- Construct an access road (L=2,100m) by widening R302 (Kaliganj Bazar).

Alt 1-2

- Construct a new bridge (L=1,050m) on the north side of planned EZ.
- Construct a new access road (L=2,100m) connected to R301.

Alt 2

- Construct a new bridge (L=835m) on the south side of planned EZ.
- Construct a new access road (L=4,195m) connected to R301.

Alt 3-1

- Construct a new bridge (L=835m) on the south side of planned EZ.
- Construct a new access road (L=6,900m) connected to N105.

Alt 3-2

- Construct a new bridge (L=835m) on the south side of planned EZ.
- Construct a new access road (L=8,700m) connected to N105.

Alt 4

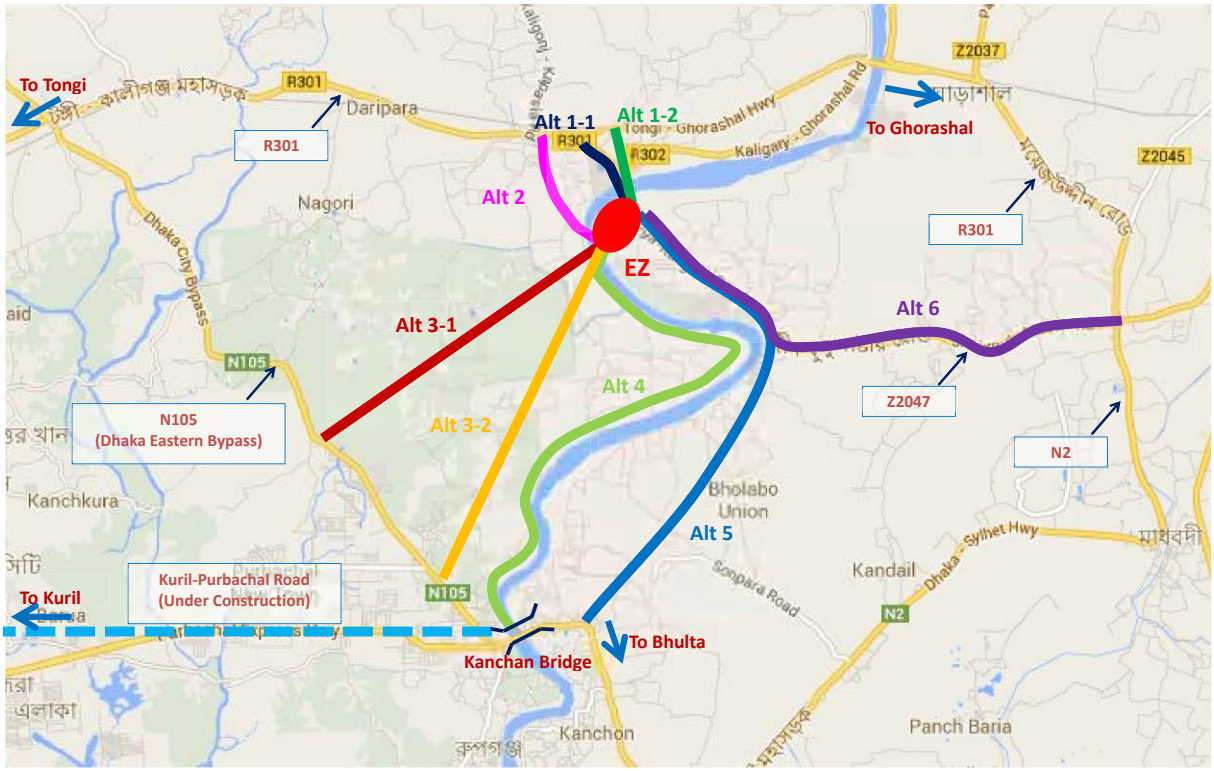
- Construct a new bridge (L=835m) on the south side of planned EZ.
- Construct an access road (L=12,800m) by widening Kaliganji Road.

Alt 5

- No bridge is constructed.
- Construct a new access road (L=12,000m) connected to Kuril-Purbachal Road (under construction).

Alt 6

- No bridge is constructed.
- Construct an access road (L=11,500m) by widening Danga-Kaligonj Road.



Source: JICA Survey Team

Figure 14.2.1 Alternatives of the EZ Bridge and Road

14.3 Route Evaluation

The eight route alternatives were evaluated as shown in Table 14.3.1. Upon comparing results, “Alt 2” was selected as the most appropriate route for the EZ Bridge and Road on the basis of the following points:

- Lower construction cost
- Lower land acquisition and resettlement cost
- Smaller number of affected houses (No affected buildings, shops, or others)
- Present accessibility is poor, but it can be connected to national highway in the future

Table 14.3.1 Route Evaluation of the EZ Bridge and Road

Confidential

Confidential

JICA Survey Team

14.4 Alignment Alternatives and Evaluation

Upon the selection of “Alt-2”, this alignment was studied in further detail. Four detailed alignment alternatives based on the selected alignment are as follows.

Alternative A

- The Road connects to existing roads at beginning and end points.
- The Bridge passes over the EZ.
- Enough vertical clearance is provided under the bridge in the EZ.

Alternative B

- The Road connects to existing roads at beginning and end points.
- EZ is divided into north and south by the bridge and road.
- Enough vertical clearance is partially provided under the bridge in the EZ.

Alternative C

- The Road connects to an existing road at the beginning point and connects to the EZ at the end point.
- The EZ is divided into north and south by the bridge and road.
- Enough vertical clearance is partially provided under the bridge in the EZ.

Alternative D

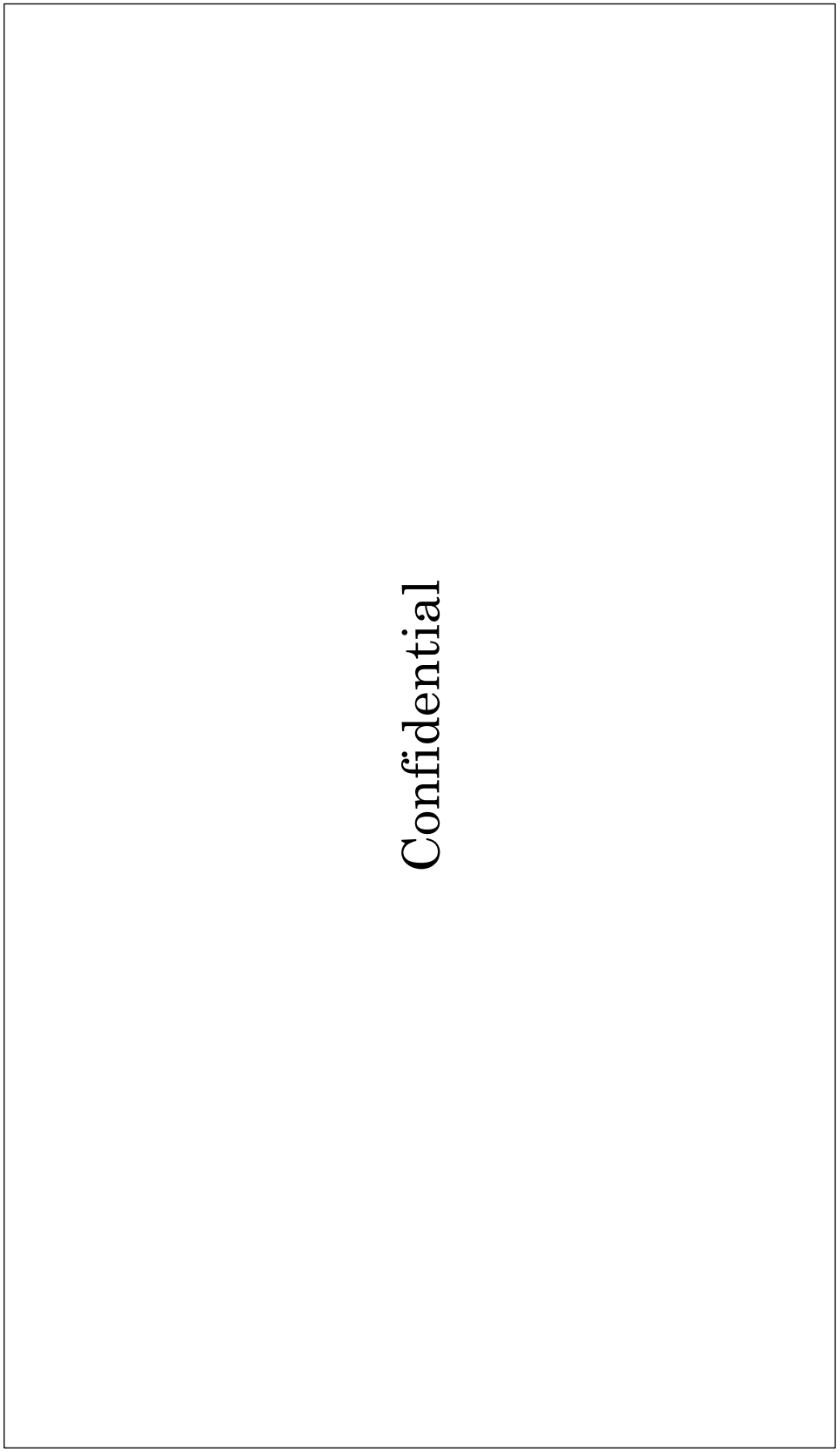
- The Road connects to the existing road at the beginning point and connects to the EZ at the end point.
- EZ is divided into north and south by the bridge and road, just behind the container terminal.
- Enough vertical clearance is partially provided under the bridge in the EZ.

The four detailed alignment alternatives were evaluated as shown in Table 14.4.1. As a result, “Alternative B” was selected as the most appropriate alignment for the EZ Bridge and Road on the basis of the following points:

- Alternative B scored either “good” or “fair” for all evaluation items.
- Alternative A would incur the highest project cost of all alternatives.
- Alternative C would prevent local traffic from using the bridge.
- Alternative D would negatively impact the EZ, preventing smooth traffic flow between the

container terminal and other areas.

Table 14.4.1 Alignment Evaluation of the EZ Bridge and Road



JICA Survey Team

14.5 Natural Conditions

14.5.1 Physiography

According to Figure 4.1.1 Physiographic Division of Bangladesh, the candidate site of the bridge corresponds to a “Flood Plain.”

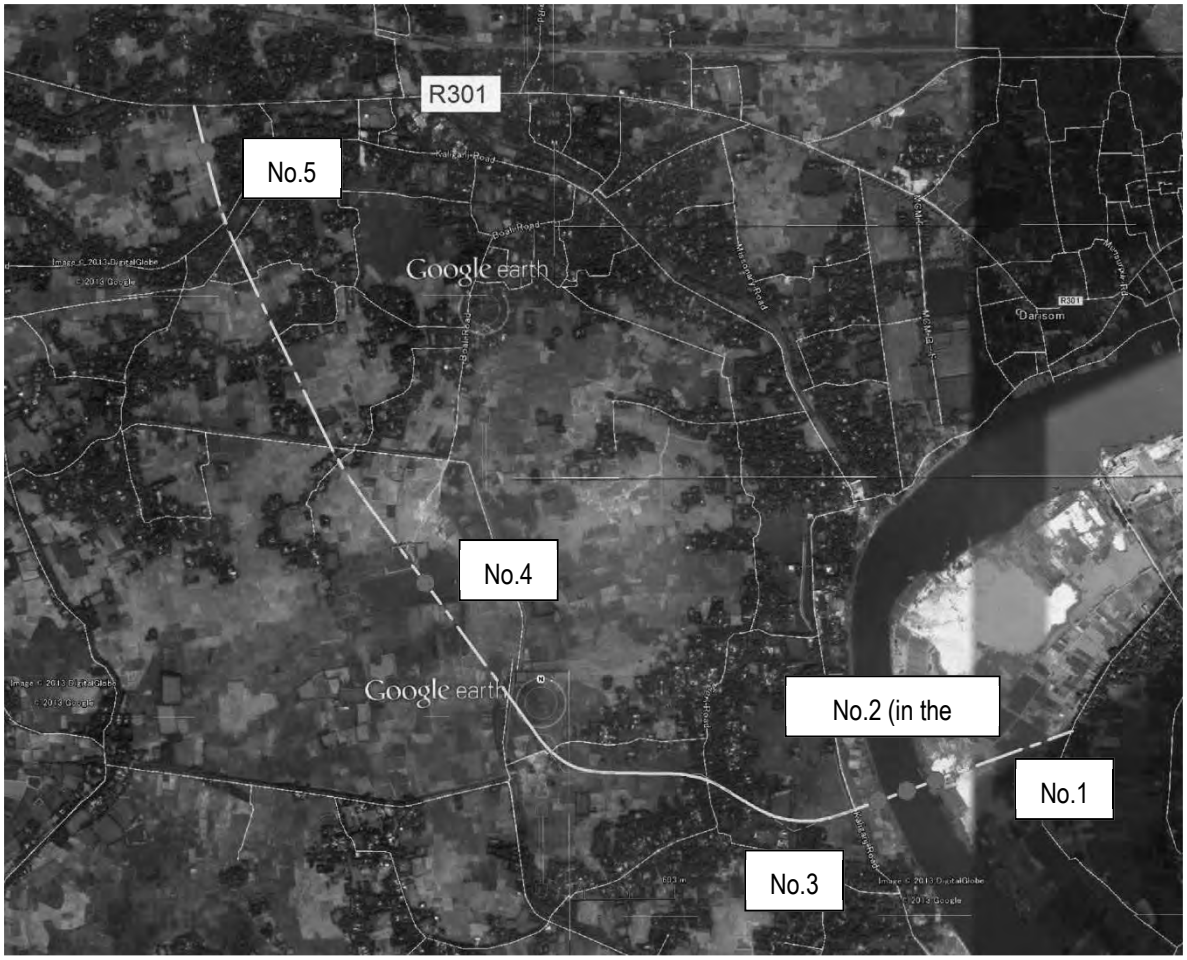
The bridge will cross the Shitalakshya River, a distributary of Brahmaputra at the south of the current bridge of Tongi-Ghorashal Highway crossing Shitalakshya.

Before the diversion of Brahmaputra in the 19th century, the width of the Shitalakshya River was said to be much wider than it is presently and thus the water flow of the river at that time was likely to be more abundant than it is. This suggests that thick distribution of soft alluvium sediment along the Shitalakshya River was possibly provided by the abundant water flow by old Brahmaputra.

14.5.2 Geology

According to the geological framework of Bangladesh (as shown in Figure 4.2.1), the geological condition at the candidate site is alluvial silt.

Borehole investigations were executed at 5 of the bridge candidate sites as well as on the planned alignment of the approach road. Figure 14.5.1 displays the location of the bore sites.



Source: JICA Survey Team

Figure 14.5.1 Location of Borings in Dhaka Zone (Narsingdi)

Table 14.5.1 summarizes the results of the borehole investigation. The borehole logs and results of lab tests are attached to Appendix 1.4.

At 3 boreholes on both sides of and in the middle of the river, the appropriate bearing layer was not confirmed up to 70 meters deep from the ground. As mentioned in the previous chapter, before its diversion in the 19th century, the abundant flow of the old Brahmaputra was likely to distribute these very thick strata of soft alluvial deposit along the Shitalakshya River.

Table 14.5.1 Summary of Boring Investigation at Narsingdi

Bridge Data				Bearing Layer			
Boring	Zone	Division	Sub-Division	Depth (GL-m)	Soil Type	SPT N Value	Remarks
No.1	Dhaka	Nasingdhi		***No***			***No appropriate bearing layer was found.***
No.2	Dhaka	Nasingdhi		***No***			***No appropriate bearing layer was found.***
No.3	Dhaka	Nasingdhi		***No***			***No appropriate bearing layer was found.***
No.4	Dhaka	Nasingdhi		39	Clayey Sand , SC	50 <	
No.5	Dhaka	Nasingdhi		41	Fine Sand, SM	50 <	

Source: JICA Survey Team

In the following Detail Design, the boring investigation of more than 70 meters deep shall be executed at the sites to confirm a possible bearing layer for the foundation of the bridge. Thus, necessary arrangements to execute drillings of much deeper depth from the ground, such as 100 meters or 150 meters deep, shall be prepared as well.

14.5.3 Hydrological Conditions

(1) River and Characteristics of River Flow

1) Summary of Lakhya River

The river Lakhya, also known as Shitalakshya River, originates from Old Brahmaputra River and it is a part of the Old Brahmmapura-Lakhya-Meghna river system. The Lakhya River flows south and joins the lower Dhaleshwari near Munshiganj; the combined flow meets with Meghna River near Gazaria.

The Lakhya River is a well-defined channel and passes through the erosion resistance soils of the Madhupur Tract without a river-morphology of the meandering and braiding river. The length of the river from its riverhead up to the confluence with the Dhaleshwari is about 112 km. The peak discharge of the river during a high-flood ranges from 660 to 2740 m^3/sec at Demra station. The highest recorded water level at Demra was 7.11 m PWD during the 1998 flood which is about 1.0 m higher than the natural ground level. The maximum depth of river around the proposed bridge locations ranges from 15 to 20 m from the existing bank level. The existing river course of the Lakhya River and proposed bridge location are shown below in Figure 14.5.2 and Figure 14.5.3.

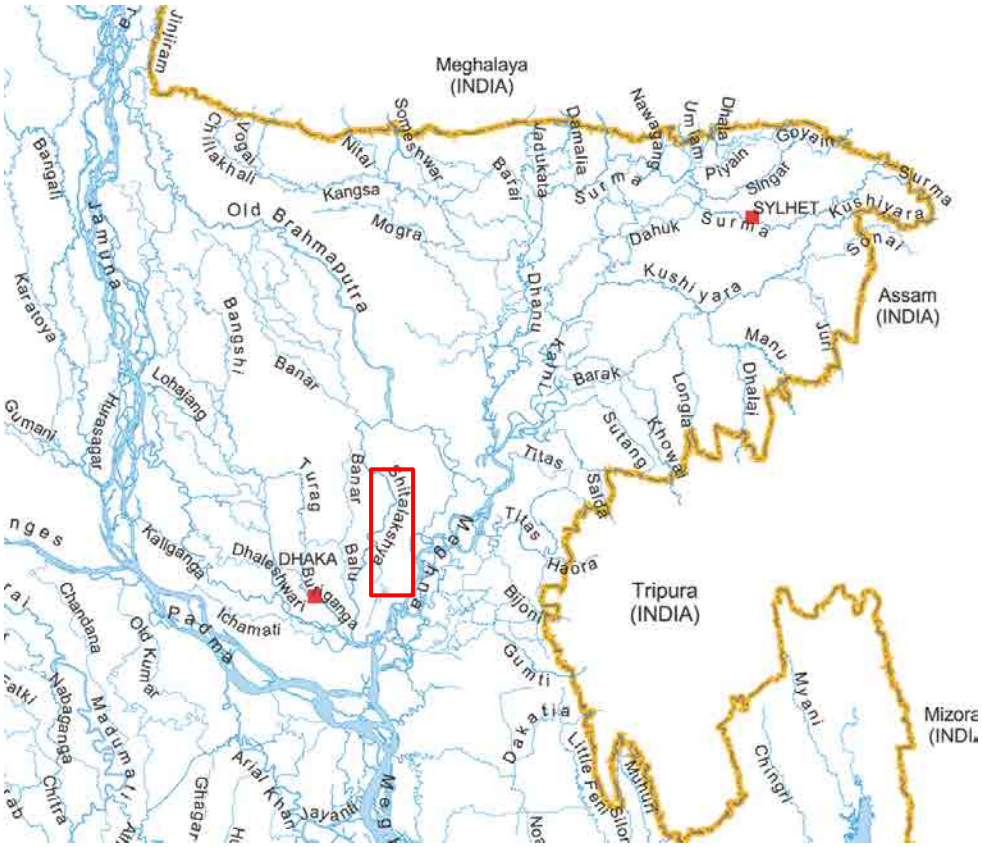


Figure 14.5.2 Lakhya River and Meghna Riverine System

Source: JICA Survey Team

Figure 14.5.3 Location of Proposed Bridge and Gauging Stations

2) River Characteristics of Lakhya River

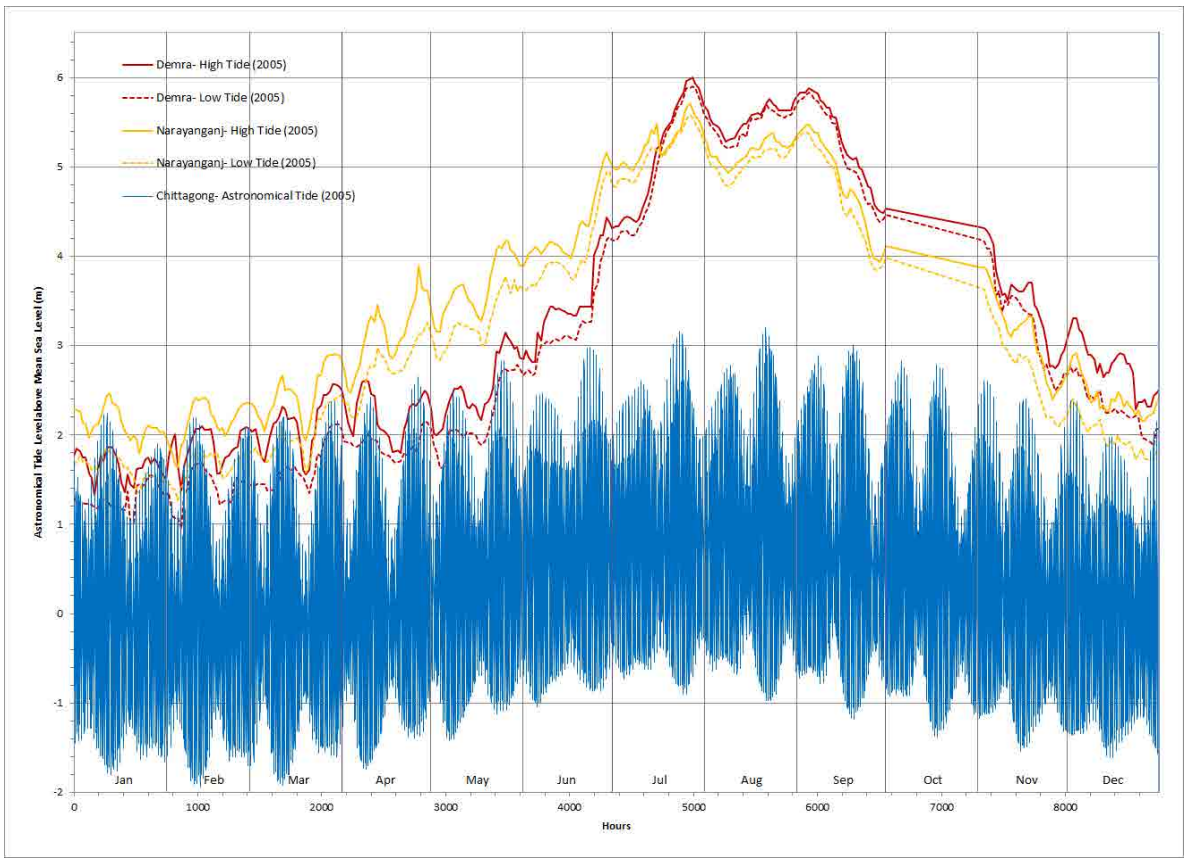
In order to verify the river characteristics, hydrological records and documents were collected from BWDB and BIWTA. Collected items and its period of records are shown in Table 14.5.2.

Table 14.5.2 Collected Hydrological Data at Related Gauging Stations in Lakhya River

No.	Name	Station ID (WMO)	Latitude	Longitude	Distance from Proposed Bridge	Collected Item / Period of Record				SHWL SLWL (statistic)	Bathymetric Survey Drawings	Remarks
						Daily High/Low Tide	Annual Maximum Water Level	Daily Mean Discharge	Annual Maximum Discharge			
1	Narayanganj	SW180	90.5240	23.6602	28km to downstream	1971.4-2012.9	1981-2012	-	-			
2	Demra (Lahkya)	SW179	90.5101	23.7217	28km to downstream	1971.4-2012.9	1968-2012	(1997.6-2006.6)	1966-2012			Daily mean discharge has many missing data.
3	Demra (Balu)	SW7.5	90.5018	23.7232	28km to downstream	-	-	-	1994-2012	○	○	
4	Ghorasal	SW178	90.6199	23.9384	8.1km to upstream	-	-	-	-			
5	Lakhpur	SW177	90.6534	24.0397	37.2km to upstream	-	1983-2012	-	-		-	

Source: BWDB, BIWTA

The gauging stations of BWDB are classified into the non-tidal and tidal water level stations. The gauging stations listed in Table 14.5.2, are entirely the tidal station, and the river-zone up to the proposed bridge over Lakhya River is affected by the tide. However, as shown in Figure 14.5.4 , the fluctuation range of the tide is very small compared with them of the outer sea, and its lower limit of low tide at Demra is nearly high tide of outer sea. Also, the tidal influence is limited just to dry season, the water level of the river is affected by storm water from upstream during most of the rainy season.

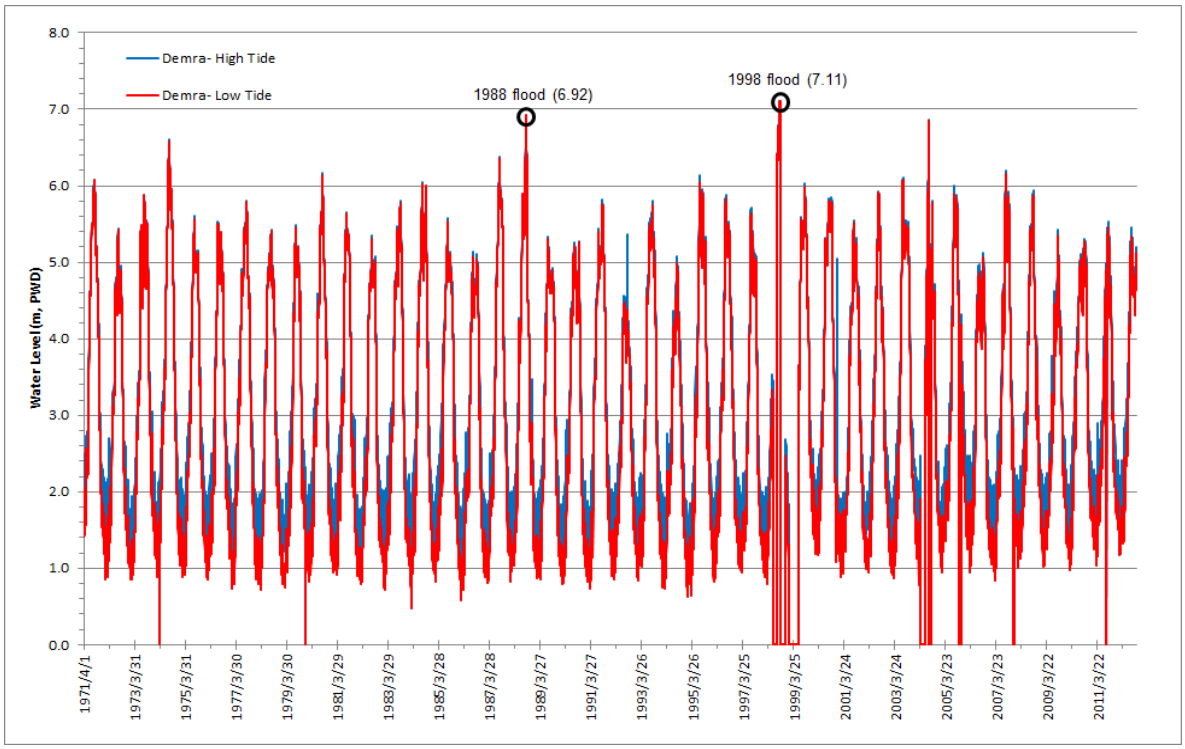


Source: BWDB, Earthquake Research Institute (the University of Tokyo, JAPAN)

Figure 14.5.4 Relationship between "astronomical tide of outer sea (Chittagong)" and "daily high / low tide of related stations (Demra, Narayanganj)" at 2005

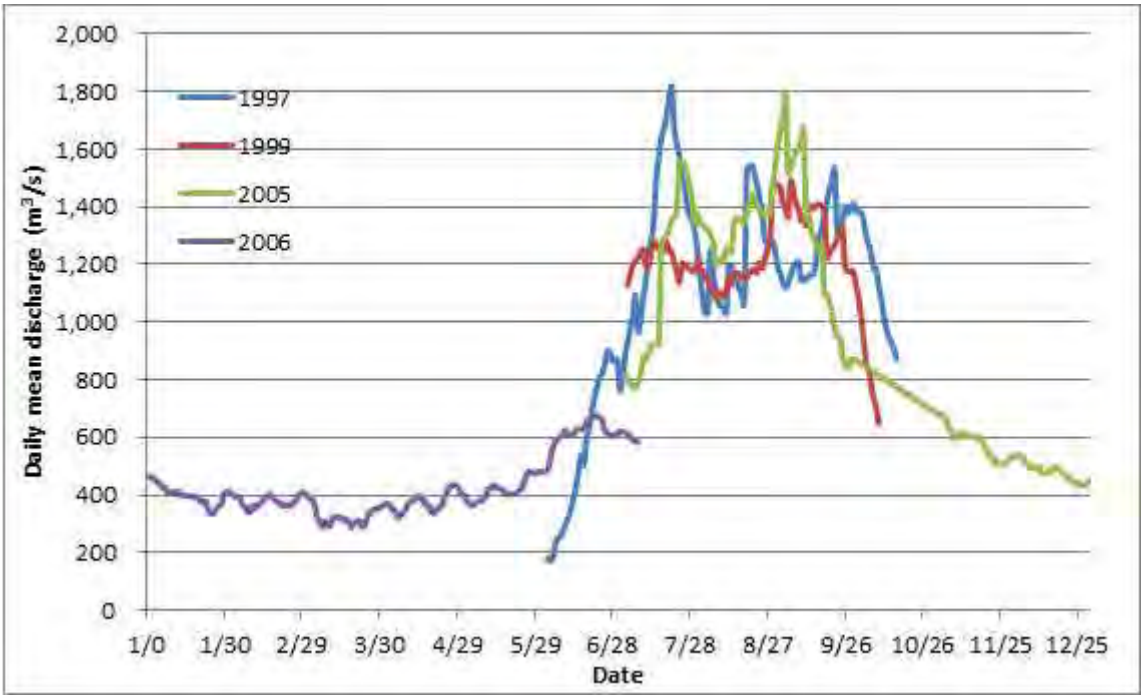
Past annual high water levels have occurred during the rainy season, the highest recorded water level at Demra was 7.11 m PWD during the 1998 flood (as shown in Figure 14.5.5). Although the flood magnitude and damage in 1998 was higher at the national level, the flood level in 1998 has been recorded as a higher level within the study area.

Similarly, the annual maximum discharge has also recorded at Demra in 1998. Regarding seasonal fluctuation of the discharge, most of the daily discharge data were still unfiled data; nevertheless, some collected data are shown in Figure 14.5.6. Daily mean discharge trends during the rainy season are affected by rainfall runoff. Although the discharge during the dry season is affected by the tides, seasonal discharge does not show the tendency for extreme decreases that seasonal rainfall does. This is presumed to be the effect of semi-diurnal tidal fluctuation, especially the falling-tide.



Source: BWDB

Figure 14.5.5 Daily Water Level (High/Low Tide) at Demra Station (1971.4-2012.9)



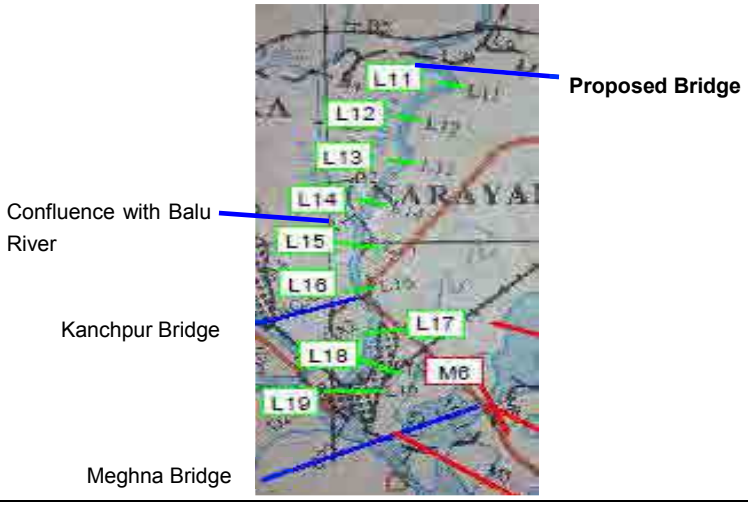
Source: BWDB

Figure 14.5.6 Seasonal (Daily) Flow Pattern at Demra Station

3) Aggradations and Degradations of Rivers

Bathymetric survey data that are collected are listed in Table 14.5.3. From these data, cross-sectional data of related river is prepared by JICA survey team. These cross section data are useful to check and understand the change of cross-sectional / longitudinal profile, such as aggradations and degradations of rivers.

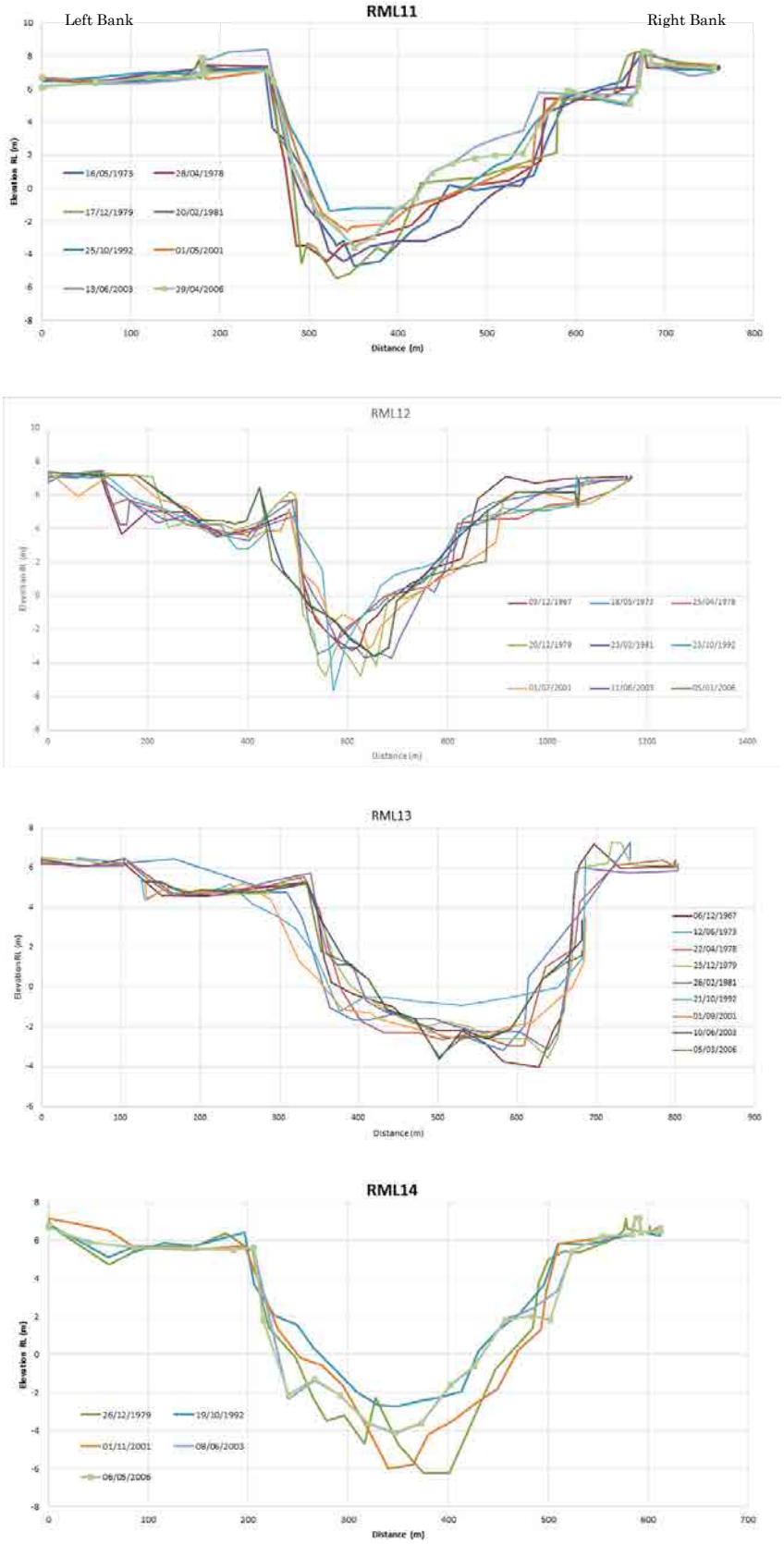
Table 14.5.3 Bathymetric Survey Data List

Organization / Contents	Reach	Survey Year	Remarks
BIWTA / Bathymetry survey plan drawings	Lakhya River mouth – Ghorashal station	2009-2014	
BWDB / Bathymetry cross-sectional data	RML11 – RML19 (5km downstream of proposed bridge - Lakhya River mouth)	1967-2006	
			

Source: BWDB, BIWTA

The river fluctuations of the cross-sectional shape of Lakhya River from RML11 (5km downstream of proposed bridge) to RML14 (confluence with Balu tributary) during recent decades by BWDB are shown in Figure 14.5.7.

There is almost no change in the river channel course, the river course is relatively stable. However, the riverbed fluctuation ranges from 2m to 4m at each cross-section. Its trend is not steady, and it is indicated that aggradation and degradation of the riverbed has been repeated. According to some reference documents, the riverbed material of Lakhya River is very fine sand of 0.1-0.2mm, and it is approached the wash-load with having both characteristics between suspended sand and bed load sediment. Hence, it is presumed the riverbed fluctuation of Lakhya will continue in the future.



Source: JICA study team based on the data from BWDB (Elevation is PWD datum.)

Figure 14.5.7 Change of Cross-sectional Data at RML11-14 points of Lakhya River

(2) Estimation of Probable Floods and Water Levels

1) Probable Floods

Past annual maximum discharges (extremal values) of 2 stations (Demra at Lakhya and Balu River) for the design discharges are collected as shown in Table 14.5.4. In this study, the design maximum discharge (probable flood) of proposed EZ bridge is directly applied a probability value of the Demra of Lakhya River. (The probability value of Demra of Balu River is used for calculating the discharge downstream of the Demra station in Lakhya River.)

The magnitude of design discharge adopted for the proposed bridge a 50 year flood.

Table 14.5.4 Collection Data List for Annual Maximum Discharge

Station Name	River Name	Period of Record	Collected Data No.	Remarks
Demra	Lakhya	1966-2012	40	missing 7 years of observation
Demra	Balu	1994-2012	16	missing 2 years of observation

Source: BWDB

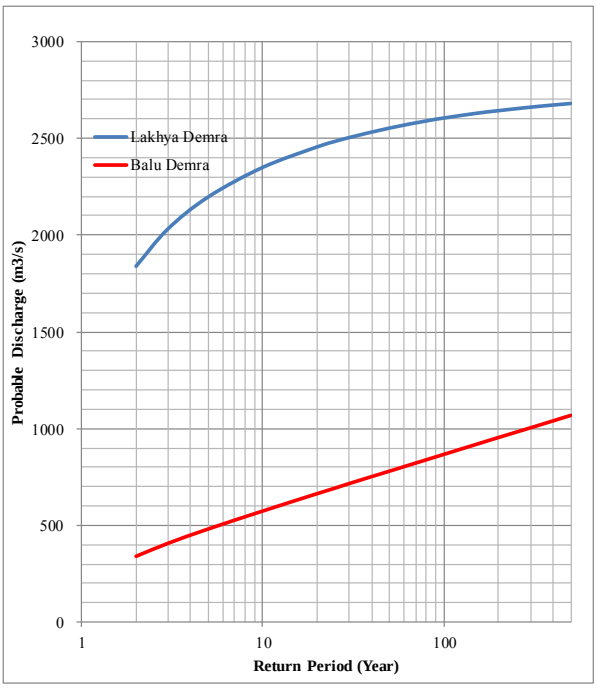
The probable discharges are calculated according to the following;

- To select the appropriate model for probability distribution from several methods; Demra of Lakhya River is applied to the Log-Pearson type III distribution, and Demra of Balu River is the Gumbel distribution, by adopting the distribution formula of minimum SLSC (Standard Least Squares Criterion).
- Calculation return periods are for 2, 3, 5, 10, 20, 25, 30, 50, 80, 100, 150, 200, 300, 400 and 500 years.

The results of probable discharge at 2 discharge-gauge stations (Demra of Lakhya and Balu Rivers) are shown in Table 14.5.5.

Table 14.5.5 Probable Flood Calculation at 2 Demra Stations

Bridge Name		EZ Bridge	-		Remarks
River Name		Lakhya	Balu	Lahkya	
Station Name		Demra	Demra	(Down-stream of Demra)	
Station ID		SW179	SW7.5	-	
Returen Period					
2	50%	1839	340	2179	
3	33.3%	2032	407	2439	
5	20%	2197	481	2678	
10	10%	2350	574	2924	
20	5%	2456	664	3120	
25	4%	2484	692	3176	
30	3.33%	2504	716	3220	
50	2%	2553	780	3333	Design Q
80	1.25%	2590	839	3429	
100	1.00%	2605	867	3472	
150	0.667%	2629	918	3547	
200	0.50%	2643	954	3597	
300	0.333%	2661	1004	3665	
400	0.25%	2672	1040	3712	
500	0.20%	2680	1068	3748	
Applicable distribution		LogP3	Gumbel	-	
SLSC(99%)		0.032	0.036	-	
SLSC(50%)		0.094	0.048	-	
Applicable distribution Method		Log Pearson type III distribution (Logarithmic space method)	Gumbel distribution	-	



Source: JICA study team based on the data from BWDB

2) Probable High Flood Level

Past annual maximum High Flood Levels (extremal values) of Demra and Lakhpur stations were collected to aid in calculating HFL. From these values, probable High Flood Levels at the proposed bridge is calculated as shown in Table 14.5.6.

Table 14.5.6 Probable High Flood Level

River Name		Lakhya			Remarks
Station Name		Lakhpur	(EZ bridge location)	Demra	
Station ID		SW177	-	SW179	
Distance from Bridge		37km upstream	0km	28km downstream	
Returen Period		m, MSL			
1.1	90.91%	5.34	5.04	4.80	
5	20%	6.52	6.06	5.71	
10	10%	6.89	6.38	6.00	
20	5%	7.25	6.70	6.28	
25	4%	7.36	6.79	6.37	Design Scale
50	2%	7.71	7.10	6.64	
100	1%	8.06	7.40	6.90	

Source: JICA study team based on the data from BWDB

3) Hydraulic Calculation

In the tidal river, the hydraulic phenomena (rising tide, falling tide, etc., in addition to the river's own flood) at the tidal compartment of the river are needed to simulate all of the tidal reaches. However, as presented above, the tidal range at the proposed bridge during flooding is small. Hence, the effect of the tidal component of the river is ignored on the hydraulic calculation in this study.

a) Analysis Software

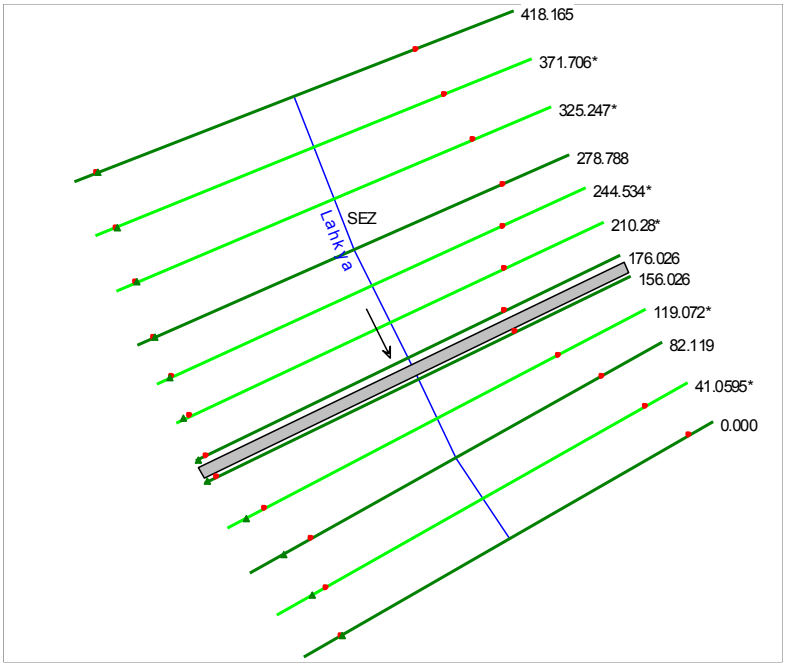
Hydraulic analysis was carried out to simulate the hydraulic phenomena using HEC-RAS (Hydrologic Engineering Center - River Analysis System) developed by the US Army Corps of Engineers.

HEC-RAS has the capability to compute one-dimensional water surface profiles for both steady and unsteady flow. Sub-critical, super-critical and mix flow regime profiles can be calculated.

Water surface profiles are computed from one cross section to the next by solving the energy equation using the standard-step method. Energy losses are evaluated by friction (Manning's equation) and contraction/expansion coefficients. HEC-RAS requires inputs for boundary conditions of upstream discharge and either the downstream water level or the known energy gradient.

b) Hydraulic calculation model

The hydraulic calculation model at the proposed bridge is shown in Figure 14.5.8. The cross-sections for hydraulic calculation are given by using the bathymetry survey results.



Source: JICA study team

Figure 14.5.8 Hydraulic Calculation Model at Proposed Bridge

c) Hydraulic Analysis and the Result

Hydraulic analysis is performed under the following conditions and its result is shown in Table 14.5.7 and Figure 14.5.9.

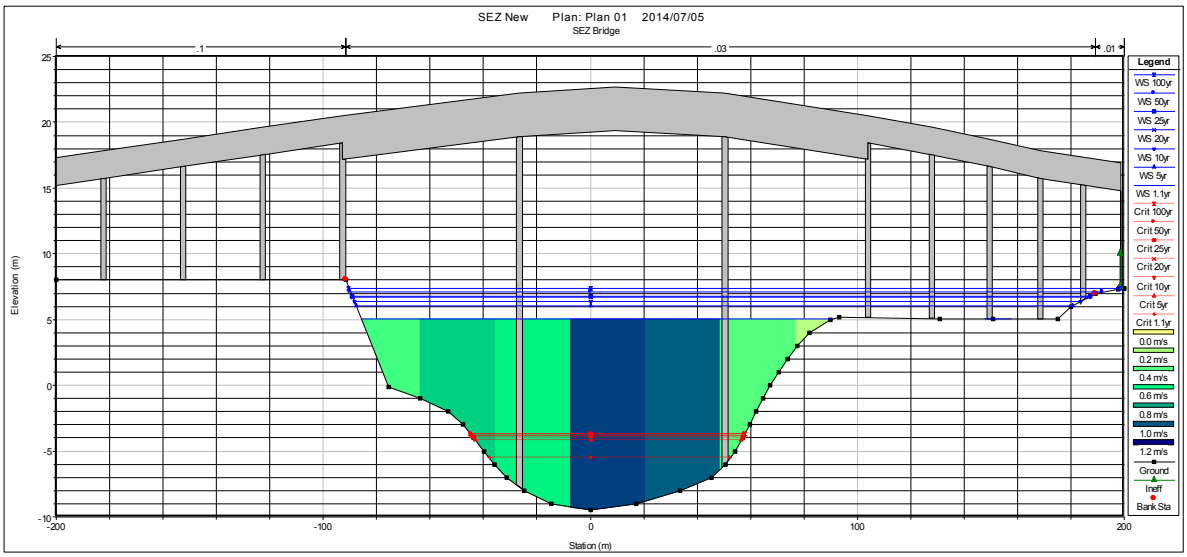
- Discharge - 1.1, 5, 10, 20, 25, 50 (design scale) and 100 years
- Water Level at downstream end of calculation - above calculated probable high flood level

Table 14.5.7 Results of Hydraulic Analysis

Plan: Plan 01 Lankya SEZ RS: 166.026 Profile: 50yr

E.G. US. (m)	7.17	Element	Inside BR US	Inside BR DS
W.S. US. (m)	7.1	E.G. Elev (m)	7.17	7.17
Q Total (m3/s)	2553	W.S. Elev (m)	7.1	7.09
Q Bridge (m3/s)	2553	Crit W.S. (m)	-3.73	-3.73
Q Weir (m3/s)		Max Chl Dpth (m)	16.6	16.59
Weir Sta Lft (m)		Vel Total (m/s)	1.2	1.21
Weir Sta Rgt (m)		Flow Area (m2)	2118.76	2118.44
Weir Submerg		Froude # Chl	0.14	0.14
Weir Max Depth (m)		Specif Force (m3)	13362.17	13359.65
Min El Weir Flow (m)	10	Hydr Depth (m)	7.95	7.95
Min El Prs (m)	19.35	W.P. Total (m)	343.99	343.94
Delta EG (m)	0	Conv. Total (m3/s)	238464.4	238413.5
Delta WS (m)	0	Top Width (m)	266.62	266.59
BR Open Area (m2)	5961.69	Frctn Loss (m)	0	0
BR Open Vel (m/s)	1.21	C & E Loss (m)	0	0
Coef of Q		Shear Total (N/m2)	6.92	6.93
Br Sel Method	Energy only	Power Total (N/m s)	-9575.58	-9575.58

Source: JICA Study Team



Source: JICA Study Team

Figure 14.5.9 Hydraulic Cross-sectional profile of Proposed Bridge

(3) Hydrological Assessment of proposed bridge sites

1) Hydraulic Design Criteria of Bridge

In order to design the opening of the bridge waterway, the following design criteria for hydraulics are required:

- The backwater does not significantly increase the flood damage to properties upstream of the bridge.
- The velocity through the bridge does not damage the road facility or increase the damage to downstream properties.
- The existing flow distribution is maintained to the extent practicable.

- The pier and abutment are designed to minimize the flow disruption.
- Potential local scour is within acceptable limits.
- Clearance at the structure is adequately designed to pass safely any anticipated debris. (The elevation of bottom of the bridge girder is higher than "Highest high water level + Navigation channel height.")

The design return period, the clearance from the bridge girder to high water level shall be compliant with authorized standards by the organizations concerned. (See Chapter 4.3.4.)

In this study, the design return period is adopted as a **50-year return period**. Also, the design standard is based on the HEC series of FHWA[9] as well-used international standards.

2) Assessment of Scouring

a) Basic concept

Scour at bridge causes due to the erosive action of flowing water, excavating and carrying away materials from the riverbed and its banks. Scour process is cyclic in nature, which complicates determining the magnitude of scour. Scour can be deepest near the peak of a flood; however, it is hardly visible since scour holes refill with sediment during the receding stage of a flood. In general, several floods may be needed to attain maximum scour under typical flow conditions at bridge crossings.

b) Methodology of scour computation

In designing the bridge sub structure, it is very important to evaluate the scour potential at piers and abutments, carefully studying site-specific subsurface information. Total scour at a bridge crossing is comprised of three components.

I Contraction scour

II Local scour

III Long-term aggradation or degradation

c) Aggradation and Degradation

Aggradation and degradation are changes of streambed elevation in the long-term due to natural or man-induced causes that can affect the streambed. Aggradation involves the deposition of material eroded from the stream or watershed upstream of the bridge and degradation involves the lowering of the streambed due to the lack of sediment supply from upstream. Basically, it is to be evaluated independently of the hydraulic model. Generally, streams are considered to be stable and balance sediment transport if the configuration is

[9] Hydraulic Engineering Circular, Federal Highway Administration, USA

not changed in the long-term. (In this study, the riverbed/course-fluctuation analysis is not conducted. At the stage of detailed design, it shall be conducted, and their results will be studied after surveying current and past topographic data of rivers.)

d) Contraction Scour

Contraction scour at a bridge crossing, involves the removal of material from the streambed and banks across the channel width, as a result of a contraction of the flow area and an increase in discharge at the bridge.

In the case of new bridge construction, common causes for the contraction of flows are constriction (encroachment) of road embankment onto the floodplain and/or into the main channel or piers blocking a portion of flow. As a result, flow area decreases, causing an increase in velocity and bed shear stress. Hence, more bed material is removed from the contracted reach than transported into the reach. As bed elevation is lowered, the flow area increases, velocity decreases, and a situation of relative equilibrium is reached.

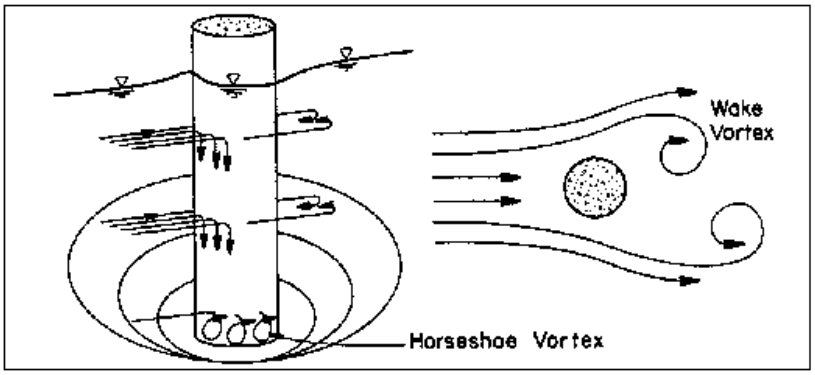
e) Local scour

Local scour at piers or abutments is due to the removal of bed material as a result of formation of vortices known as the horseshoe vortex and wake vortex at their base. The horseshoe vortex results from the pileup of water on the upstream surface of the obstruction and subsequent acceleration of the flow around the nose of the pier or abutment. The action of the vortex removes bed material around the base of the obstruction. In addition to the horseshoe vortex around the base of a pier, there are vertical vortices downstream of the pier called the wake vortex. Both the horseshoe and wake vortices remove material from the pier base region. The intensity of wake vortices diminishes rapidly as the distance downstream of the pier increases. As a result, immediately downstream of a long pier there is often deposition of material.

Factors which affect the magnitude of local scour depth at piers and abutments are:

- Velocity of the approach flow,
- Depth of flow,
- Width of the pier,
- Discharge intercepted by the abutment and returned to the main channel at the abutment,
- Length of the pier if skewed to flow,
- Size and gradation of bed material,
- Angle of attack of the approach flow to a pier or abutment,

- Shape of a pier or abutment,
- Bed configuration, and
- Ice formation or jams and debris.



Source: Evaluating Scour at Bridges (2012 Fifth edition), Hydraulic Engineering Circular No. 18 (HEC 18), FHWA, USA

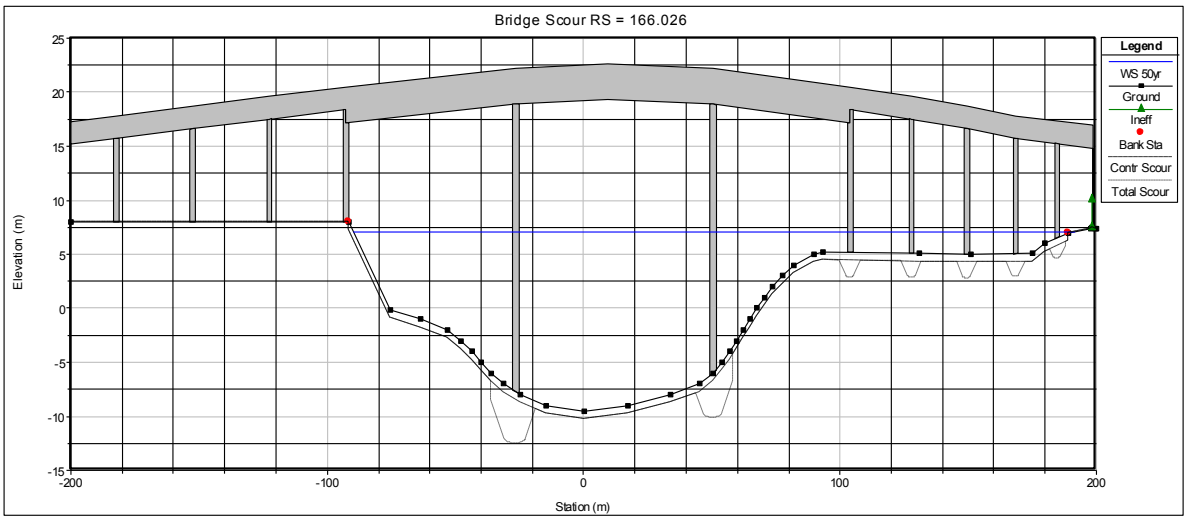
Figure 14.5.10 Simple schematic representation of scour at a cylindrical pier

f) Scour Estimation

All major streams intercepted by the proposed bridge alignment were modeled by the HEC-RAS model developed by the Hydraulic Engineering Center, USA. The model reach covered a sufficient length from upstream to downstream of the bridge location. These models were simulated for 50-year return period discharges under existing conditions (without the bridge) and incorporating bridge. In Geometric Data, all bridge data, including deck/roadway and piers, are given and a schematic diagram of the bridge is shown in Figure 14.5.11.

Scour estimation by steady flow analysis of HEC-RAS is conducted, based on Hydraulic Engineering Circular No. 18 (HEC 18) of Federal Highway Administration (FHWA), USA by using the value of probable maximum discharge and probable high water level.

The results of scour estimation are as shown in Table 14.5.8.



Source: JICA Study Team

Figure 14.5.11 Scouring Computation Result at Proposed Bridge

Table 14.5.8 Results of Scouring Computation

Pier No.	Calculated Scour Depth (m)		
	Local Scour	Contraction Scour	Total Scour
Pier 19	-	-	-
Pier 18	-	-	-
Pier 17	-	-	-
Pier 16	-	-	-
Pier 15	4.8	0.76	4.05
Pier 14	4.13	0.76	3.37
Pier 13	2.33	0.76	1.58
Pier 12	2.25	0.76	1.49
Pier 11	2.27	0.76	1.52
Pier 10	2.13	0.76	1.38
Pier 9	1.92	0.76	1.17

Source: JICA Study Team

3) Hydrological Recommendation

From the above scouring and hydraulic computations, the scouring depths at each pier were estimated. As for hydraulic issues of the proposed bridge, the following aspects are left as future challenges:

- The contraction scour occurs 0.76m over a cross section of the bridge. This means that the river section flow area is small. (However, the value of the contraction scour is not so big, and it might be no problem.)
- As the computation results in the local scouring, it occurs in pier 9 to pier 15. The riverbed around the pier is not protected by the bed protection work. Therefore, the study of appropriate bed protection and revetment works shall be conducted at detailed design

stage. In addition, estimation of scouring is necessary to study further other prediction formulas including the HEC formula.

- In order to secure the accuracy of the elevation, checking the difference between "PWD datum of BWDB stations" and "topographic survey datum" shall be performed in the detailed design stage.

14.6 Traffic Demand Forecast

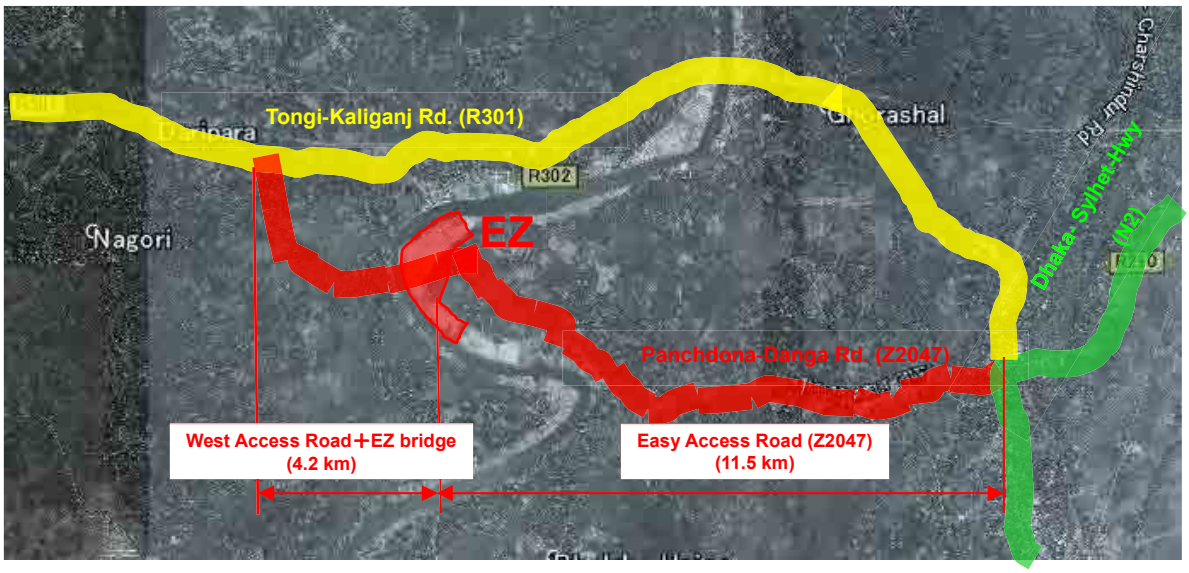
The new Economic Zone (EZ) is planned to operate from 2016 as a response to increasing domestic demand in the future due to recent remarkable economic growth and shortage of capacity in the current EPZ of the Dhaka district. At present, to start the operation, various infrastructure developments are being constructed and one of the development plans is the access road to the EZ. One of the plans of the access road to the EZ is to construct a new road and bridge in the west side across the river Shitalakshya. The other plan is to improve the current road on the east side. However improving of the current road on the east side will be costly as it requires improvement of the long distance road and also land acquisition cost. For this reason, constructing a new road and bridge on the west side is recommended. In this chapter, a study of the number of lanes for the west access road of the EZ and the EZ Bridge was carried out based on the route selection and future traffic demand.

The area of the factory site and the number of planned employees in the EZ is described in Table 14.6.1.

Table 14.6.1 Area of the EZ and Employee Number (Plan)

(1)	Area of EZ (m2)	850,000 m^2	-
(2)	Area of the Container Terminal (m^2)	242,800 m^2	-
(3)	Area of the Factory Site (m^2)	388,970 m^2	-
(4)	Road, Park and Other Facilities (m^2)	218,230 m^2	(1)-(2)-(3)
(5)	Number of Employees (person)	16,605 persons	-

Source：Feasibility Study Report, the project of A.K.KHAN Container Terminal, 2013



Source: JICA Study Team

Figure 14.6.1 Planned construction site of EZ and Access Road (Plan)

14.6.1 Traffic Demand Forecast Methodology

The Panchdona-Danga Road (Z2047) of the east access road is only approximately 5 meters wide and identified as an alternative to the one-way road for cars or freight vehicles. The road condition of a certain section (approximately 11.5 km length) of national highway Dhaka-Sylhet (N2) is unsatisfactory. In addition, there is no realistic plan for road development; it is costly due to requiring improvement over a long distance and also acquiring land acquisition. Therefore, after the construction of the EZ bridge and west access road, “Freight trip”, “Commuting trip” and “Business trip” will be converted from the east access road. The traffic demand of through traffic is not considered due to the comparison of travel times.

Therefore, it is expected that all trips which relate to the EZ will use the EZ bridge and west access road, and through traffic will not exist after construction of the EZ bridge and west access road. The target years of the traffic demand forecast are set for 3 specific years: 2021 (opening year of EZ bridge), 2023 (evaluation year of operation and effect indicator) and 2031 (10 years after EZ construction).

(1) Freight trips of EZ:

1) Daily Freight Demand

According to the “Feasibility Study Report, the project of A.K.KHAN Container Terminal, 2013,” full operation of the EZ is expected starting in 2021 with 494,231 TEU/year of freight

demand[10].

However, the full operation year is different between completion of EZ construction and full operation years, and it will take time from EZ construction to reach full operation. In addition, the EZ expect a Japanese company (foreign company) to be the target company of the EZ; therefore, it will take additional time due to preparations such as employee relocation, when compared with a Bangladeshi company. For this reason, the full operation year is set as 2031 with 494,231 TEU/year of freight demand and gradually increasing. As a result, the freight demand and freight growth rate of the EZ are set in Table 14.6.2[11].

Table 14.6.2 Freight Demand of EZ

Year	Freight Demand (TEU)	
	TEU/year	TEU/day
2021 (2021 – 2022)	349,936	1,215
2023 (2023 – 2024)	374,935	1,302
2031 (2031 – 2032)	494,231	1,716
Growth Rate	3.51 %/year	

Source: Feasibility Study Report, the project of A.K.KHAN Container Terminal, 2013

2) Freight Vehicle Volume

Freight vehicle volume was estimated based on future freight demands. In this EZ project, raw materials are planned to be transported by water transport through the Shitalakshya River and manufactured products will be sent to other areas of Bangladesh by land transport. Therefore, it was assumed that empty freight vehicles will come to the EZ, and after loading manufactured products, it will be dispatched towards different areas of Bangladesh. Share by freight vehicle type on N302 which closes Dhaka EPZ is assumed as a general share by freight vehicle type in Bangladesh and its adapted estimation of Freight vehicle volume on the EZ bridge.

The calculated daily freight volume is provided in Table 14.6.3.

[10] A low scenario of freight demand was selected to avoid over-evaluation.

[11] Using assumed values on number of employees and factory site area in EZ based on “MENTARIES FOR PORT AND HARBOUR FACILITIES IN JAPAN” , this is confirmed to be within the acceptable range.

Table 14.6.3 Freight Vehicle Volume

		2021	2023	2031
Freight demand (TEU/day)		1,215	1,302	1,716
Share by Freight Vehicles (%)	Heavy Truck (20ft Container)	28%		
	Medium Truck	38%		
	Small Truck	34%		
Traffic Volume (vehicles/one dir./day)	Heavy Truck (20ft Container)	761	816	1,075
	Medium Truck	1,034	1,108	1,461
	Small Truck	938	1,006	1,325
	Total	2,733	2,930	3,861
PCU Factor		3.00		
Traffic Volume (pcu/one dir./day)		8,199	8,790	11,583
Traffic Volume (pcu/both dir./day)		16,398	17,580	23,166

Note 1: Share of freight vehicles on N302 based on traffic survey conducted in 2011 by RHD, which is located close from Dhaka EPZ.
Note 2: 1 TEU is set as 10.61 ton based on actual value of Chittagong port in 2010 (Source: Chittagong Port Authority)
Note 3: Loading ratios of medium and small trucks are set as 80%
Note 4: PCU factor is adapted based on Geometric Design of RHD Roads Ver.4
Source: JICA Study Team

(2) Commuting Trips of EZ

1) Numbers of Commuting Trips

Number of commuting trips per day using EZ Bridge and the west access road of the EZ is forecast considering various factors such as residence of the employees, operating days of the factory at the EZ, and the annual attendance rate. As for the EZ operation plan, operating companies and so on are not yet finalized; these were assumed based on the interview results of the EZ developers which was held in April 2014. For assuming the annual factory operating days, currently operational similar EPZs are taken into consideration. Considering all factors, the forecasted number of commuting trips is below.

Table 14.6.4 Number of Commuting Trips (Full Operation: 2031)

Operating days of the EZ	288 days 52 weeks * 6 working days = 312 days 312 days – 24 annual government holidays = 288 days
Annual days of paid leave[1]	17 days
Average attendance rate (%)[2]	94% (288 days – 17 Annual Paid Leave) / 288 days = 94%
Total number of employees	16,605 persons
Number of employees commuting to work per day	15,609 persons 16,605 persons * 94 (%) = 15,609 persons (rounded up)
Total commuting trips (both directions) per day	31,218 Trips 15,609 Persons * 2 (round trip) = 31,218

[1] : Doing Business 2014, World Bank, 2014

[2] : Assuming 100% of paid leave is taken

The numbers of employees in 2021 and 2023 was estimated by subtracting from the number of employees in 2031 based on the assumption that the number of employees will increase with the same increasing rate of freight demand (3.51% / year). As a result, the number of employees is 2,185 persons in 2021 and 4,309 persons in 2023, and the number of commuting trips is 4,370 trips in 2021 and 8,618 in 2023.

2) Traffic Volume by Transport Mode

Based on the number of commuting trips, the transport mode share was calculated by a linear interpolation method based on the share of transport modes in 2009 and 2025, obtained from Dhaka Urban Transport Network Development Study, JICA, 2010. In addition, the share of commuting by rickshaw was distributed accordingly among other modes of transport since commuting by rickshaw is planned to be prohibited due to restrictions in parking capacity in the EZ.

The calculated daily traffic volume by transport mode of commuting trips is provided in Table 14.6.5.

Table 14.6.5 Traffic Volume by Transport Mode of Commuting Trips

		Walking, Cycle	Rickshaw	Auto-Rickshaw	Passenger car	Bus	Total
Share of Transport Mode of Commuting Trips	2009*	19.7%	38.8%	6.5%	4.9%	30.1%	100%
	2021	16.4%	33.4%	9.4%	9.5%	31.5%	100%
	2023	15.9%	32.5%	9.8%	10.2%	31.7%	100%
	2025*	15.3%	31.6%	10.3%	11.0%	31.9%	100%
	2031	13.7%	28.9%	11.7%	13.3%	32.6%	100%
Share of Transport Mode of Commuting Trips (adjusted)	2021	24.6%	-	14.1%	14.2%	47.2%	100%
	2023	23.5%		14.5%	15.1%	46.9%	100%
	2031	19.2%		16.4%	18.7%	45.7%	100%
Number of Commuting Trips by Transport Mode	2021	1,073	-	615	621	2,061	4,370
	2023	2,027		1,249	1,300	4,041	8,617
	2031	5,998		5,123	5,823	14,274	31,218
Average Number of Passenger[1]		-		1.42	1.71	37.23	-
Traffic Volume by Vehicle Type	2021	-		433	363	55	-
	2023			880	760	109	
	2031			3,608	3,405	383	
PCU Factor[2]		-		0.75	1.00	3.00	-
Traffic Volume by Type (pcu /day)	2021	-		325	363	165	853
	2023			660	760	327	1,747
	2031			2,706	3,405	1,149	7,260

[1] : Dhaka Urban Transport Network Development Study, JICA, 2010

[2] : Geometric Design of RHD Roads Ver.4

Source: JICA Study Team

(3) Business trip of EZ

The number of business trips was calculated based on non-home based business trips* to and from the Dhaka urban area and the number of workers per day at the EZ as shown below. Transport mode of business trips was assumed to be passenger car.

Table 14.6.6 Traffic Volume of Business Trip

Items		2021	2023	2031	Note
(1)	Number of workers per day	2,185	4,309	15,609	
(2)	Trip rate*	0.25			
(3)	Number of trips per day	1,093	2,155	7,805	(1)*(2)*2
-	Average number of passengers[1]	1.71			
-	Traffic volume (vehicles/day)	639	1,260	4,564	
-	PCU factor[2]	1.00			
-	Traffic volume (pcu/day)	639	1,260	4,564	

[1] Dhaka Urban Transport Network Development Study, JICA, 2010
[2] Geometric Design of RHD Roads Ver.4

14.6.2 Result of Traffic Demand Forecast and Number of Lanes

The forecasted peak hour traffic volumes are 1,318 in 2021, 1,694 in 2023 and 3,834 in 2031 as shown in Table 14.6.7. As shown in "5.5 Traffic Capacity" of the RHD standard, the required number of lanes was 2, thus the number of lanes was determined as 2 lanes (both directions).

Table 14.6.7 Future Traffic Volume of Western Access Road of EZ and EZ Bridge

	Daily Traffic Volume (pcu /day)			Peak Ratio (%)	Traffic Volume of Peak Hour (pcu /day)		
	2021	2023	2031		2021	2023	2031
Commuting Trips	853	1,747	7,260	25.0%[1]	213	437	1,815
Business Trip	639	1,260	4,564	12.5%[2]	80	158	571
Cargo Trip	16,398	17,580	23,166	6.3%[3]	1,025	1,099	1,448
Total	17,890	20,587	34,990	-	1,318	1,694	3,834

[1] Based on interview results of the developer of EZ; employees will work in 2 shifts for 16 hours daily
[2] Commuting trips are evenly distributed from 9AM to 5PM for each day
[3] Freight trips are evenly distributed during operational hours
Source: JICA Study Team

14.7 Preliminary Design

14.7.1 Design Criteria for Road

(1) Design Standards

For Design Standards of the road, refer to 7.1.1.

(2) Standard for Roads in Bangladesh

1) Road Class

The Approach Road is classified into the Regional Road in consideration of the road environment and the road characteristic features.

For details, refer to 7.1.2.

2) Design Classes

Design Type applies type-4, and Design Speed applies V=65km/h.

For details, refer to Table 7.1.3.

3) Geometric Design Criteria

For Geometric Design Criteria, refer to Table 7.1.5.

(3) Typical Cross Section

For Typical Cross Section, refer to Figure 7.1.2.

14.7.2 Design Criteria for Bridge

(1) Design Standards

The design standards to be used for design of EZ Bridge have been selected as follows;

- Bridge Design Standards By Roads & Highways Department (2004)
- Bangladesh National Building Codes (BNBC)-1993 (Gadget 2006)
- Geometric Design Standards for Roads & Highways Department (2001)
- AASHTO LRFD Bridge Design Specifications (2010, 5th edition)
- AASHTO Guide Specifications for LRFD Seismic Bridge Design (2011, 2nd edition)
- Specifications for Highway Bridges--Japan Road Association (JRA) (2002)

(2) Design Loads

1) Dead Load

Dead load shall include the weight of all components of the structure, pavement wearing surface, and future overlays. In absence of precise information, the unit weights prescribed by AASHTO can be used to calculate the dead load of the structure.

Table 14.7.1 Unit Weight of Bridge Materials

Material	Unit weight (kN/m^3)
Steel	77.0
Plain Concrete	23
Reinforced Concrete	24.5
Prestressed Concrete	24.5
Asphalt mix	22.5

Source: AASHTO

2) Live load

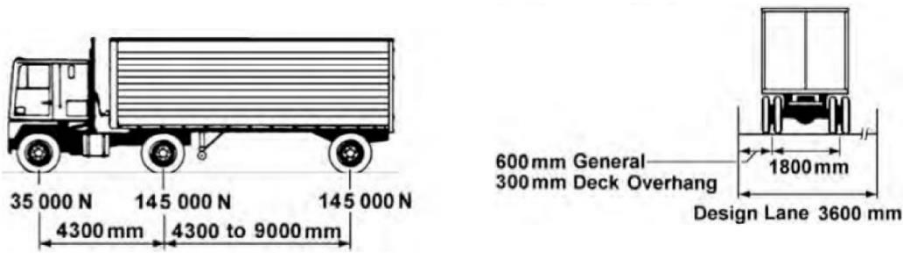
According to AASHTO LRFD, live loads on the roadways of the bridges shall consist of the;

a) Design truck or design tandem, and

b) Design lane load

c) Design truck

The weights and spacing of axles and wheels for the design truck shall be as per the specification shown in Figure 14.7.1.



Source: ASSHTO

Figure 14.7.1 Characteristics of Design Truck (HS20-44)

d) Design Lane Load

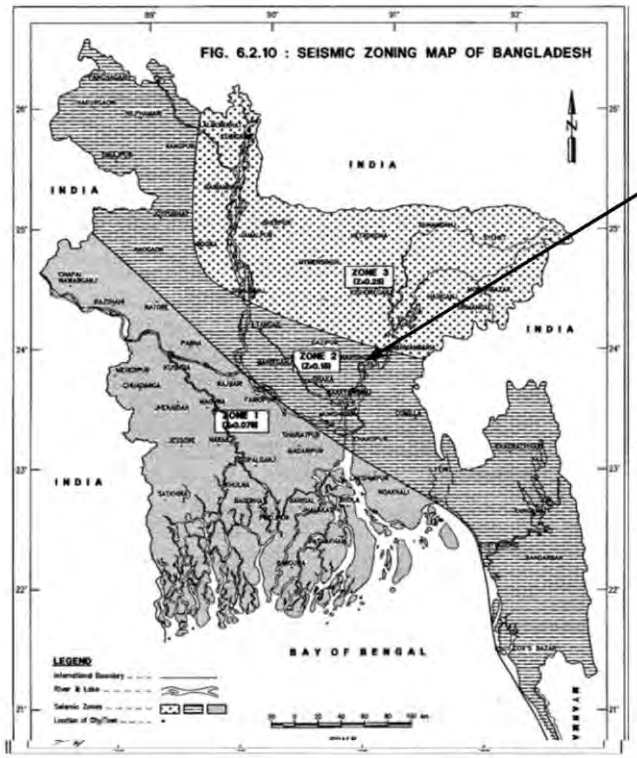
The design lane load consists of a uniform load of 9.3 kN/m.

3) Seismic Design

To calculate the earthquake load, necessary input parameters include the zone coefficient, site coefficient for soil, and design Response Spectrum (RS). In this regard, BNBC (2006) will be used as a supporting document to derive the design RS with respect to Bangladesh.

a) Zone Coefficient

The seismic zones are defined in the Bangladesh seismic zoning map. Based on the severity of the probable intensity of seismic ground motion and damage, Bangladesh is divided into three seismic zones. The EZ bridge is located in zone 2 and accordingly, the zone coefficient Z is in accordance with zone 2, determined as 0.15



Seismic Zone	Zone Coefficient
1	0.075
2	0.15
3	0.25

Source: BNBC

Figure 14.7.2 Seismic Zone Map

b) Site Coefficient S

According to BNBC, there are four types of soil that are classified based on the depth of the soil, shear wave velocity, and soil type. The coefficients are specified in the following table. In accordance with geological data surveyed for this project, the soil profile can be classified as soil type S3 (S = 1.5).

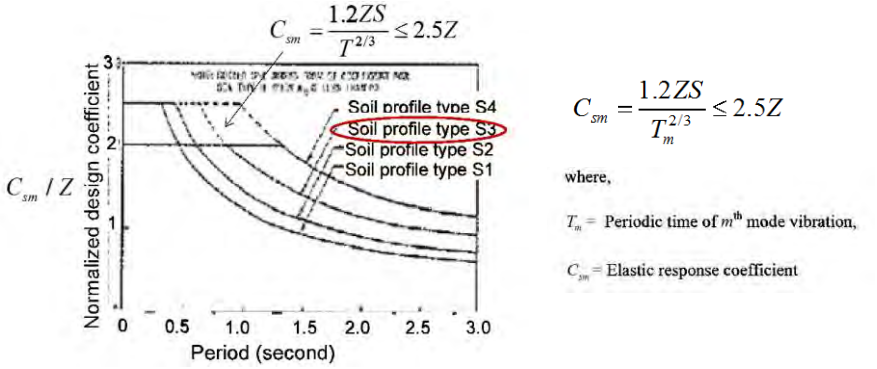
Table 14.7.2 Site Coefficient (BNBC)

Site Soil Characteristics		Coefficient S
Type	Description	
S1	A soil profile with either: A rock-like material characterized by shear wave velocity greater than 762 m/s or by other suitable means of classification, or a stiff or dense soil condition where the soil depth is less than 61 m.	1.0
S2	A soil profile with dense or stiff soil conditions, where the soil depth exceeds 61 m.	1.2
S3	A soil profile 21 m or more in depth containing more than 60 m of soft to medium stiff clay but not more than 12 m of soft clay.	1.5
S4	A soil profile containing more than 12 m of soft clay characterized by shear wave velocity less than 152 m/s.	2.0

Source: BNBC

c) Design Response Spectrum (RS)

Generally, a design Response Spectrum shall be developed based on geologic, seismologic, and soil characteristics associated with the specific site. In this regard, BNBC has a provision on design RS whose magnitude is almost equal to the magnitude of the response spectra proposed by AASHTO LRFD (2007). The design RS are formulated in the schema below.



Source: ASSHTO

Figure 14.7.3 Design Response Spectra

The design of the EZ Bridge shall be conducted in accordance with the Response Spectrum (RS) corresponding to soil type S3. The RS corresponding to S3 shall be used to carry out multimodal dynamic analysis.

4) Wind Load

The project bridge site is in a cyclone prone area. Therefore, the calculation of wind load acting on the bridge superstructure and substructure will be necessary. It can be judged that design wind load in BNBC (2006) only gives for building structures. Therefore, JRA code shall be applied to this study.

The design wind pressures shall be given based on JRA code as follows. The effects of Cd, G, and so on have been considered in the formula. For simplicity only a case without live loadings shall be considered.

The design wind pressure on the superstructure shall be;

for 1 ≦B/D < 8, *p = [4.0 - 0.2 (B/D)] D ≧ 6.0 in kN/m*

for 8 ≦ B/D, *p = 2.4D ≧ 6.0 in kN/m*

where

p: *the design wind pressure to be applied horizontally on the superstructure in kN per longitudinal linear meter of the bridge structure,*

B: *the overall bridge width.*

D: *the overall bridge girder height including the overall height of the solid parapet or the overall height of the open parapet minus 40 cm.*

The design wind pressure on the substructure shall be;

for circular or elliptical sections, *q = 1.5 kN/m2*

for rectangular sections, *q = 3.0 kN/m2*

where

q: *The design wind pressure to be applied horizontally on the substructure in kN per projected square meter area of the substructure.*

5) Thermal Load

The average temperature is verified by temperature data at Dhaka station, which is shown in the table below.

Table 14.7.3 Ambient Temperature at Dhaka

Location	Avg. Temp. (ºC)	Max. Temp. (ºC)	Min. Temp. (ºC)
Dhaka	26.2	36.1	12.0

Source: Data from Bangladesh Meteorological Department edited by JST

The thermal gradient is determined in accordance with the JRA code, which shall be stated as follows;

- Thermal gradient between concrete slab-to-concrete girder: 5 ºC
- Thermal gradient between concrete slab-to-steel girder: 15 ºC

6) Load Combinations

Several load combinations such as permanent load, transient load, live load, wind load, earthquake load, and stream pressure are needed for bridge design. These load combinations and load factors are followed by AASHTO LRFD.

(3) Technical Specifications for Construction Materials

1) Concrete

The concrete strength values according to bridge components are listed in the following table.

Table 14.7.4 Strength Requirements of Concrete for Bridges

Bridge Components	28-days compressive strength of concrete cylinder, σ_{ck} (MPa)
RCC Piles and abutments and their foundations, piers; Other structural components (RHD)	25

Source: JST based on RHD practice

2) Reinforcing Steel Bar

Reinforcing steel bars shall be deformed, except that plain bars or plain wire may be used for spirals, hoops, and wire fabric. Two types of reinforcing steel bars: Grade-40 and Grade-60 are available in the Bangladesh market and their strengths are specified by the American Society for Testing Materials (ASTM). The ASTM specifications for the two said grades are shown in the following table.

Table 14.7.5 Nominal Stress of Reinforcing Steel Bars

Steel grade	Yield stress σ_y (MPa)	Tensile strength σ_u (MPa)
Grade-40	280	420
Grade-60	420	620

Source: ASTM

3) Prestressing Steel

Uncoated low relaxation seven-wire strands and prestressing bar shall be used as prestressing steel. Forms of prestressing steel shall conform to the JIS specifications shown in the following table.

Table 14.7.6 Nominal Stress of Prestressing Steel

Prestressing steel	Grade	Yield stress σ_y (MPa)	Tensile strength σ_u (MPa)
Strand (7-wire)	SWPR7BL	1583	1860
Bar	SBPR930	930	1180

Source: JIS

4) Steel Box Girder

As per JIS specification, the grades SMA400W or SMA490W will be used as weathering steel material for steel box girders. The tensile strength and yield stress of the respective grades are stated in the following table.

Table 14.7.7 Nominal Stress of Weathering Steel

Steel grade	Yield stress σ_y (MPa)	Tensile strength σ_u (MPa)
SMA400W	235	400-540
SMA490W	355	490-610

Source: JIS

(4) Navigation Clearance

1) Design Vessels

According to the FS Report of the Project of A.K.KHAN Container Terminal, Oct 2013, design vessel is 110 TEU (1,000 DWT alas)

2) Existing Bridges on Waterway

The overall navigation route of waterways from Chittagong Port to the EZ will be 320km. On waterways to EZ, there are three existing Bridges (Kanchan Bridge, Demra Bridge, and Kanchpur Bridge).

Table 14.7.8 Navigation Height of Existing Bridges

Water Level	**Kanchan Bridge** 14km downstream of EZ, Span: 55.77m	**Demra Bridge** 30km downstream of EZ, Span: 90.00m	**Kanchpur Bridge** 33km downstream of EZ, Span: 73.2m
Vertical Clearance from Standard High Water Level (SHWL)	Unknown (Approx. 10-12m)	Unknown (Approx. 10-12m)	12.20m (Class 2)

Source: JICA Study Team

3) Required Navigation Clearance

The waterways where the EZ Bridge is located are classified as Class 2 by the classification of Bangladesh Inland Water Transport Authority (BIWTA). In addition, according to the BIWTA specification, the necessary navigation clearance of the waterway of Class 2 is as follows.

Table 14.7.9 Required Navigation Clearance of Class 2 Waterway

Horizontal Width	76.22m
Vertical Height	12.2m

Source: BIWTA

According to the FS Report of the Project of A.K.KHAN Container Terminal, Oct 2013, the minimum width of navigation route of approximately 1L (= approx. 80m) shall be secured in

consideration of narrow waterways there from Demra. And the vertical clearance (approximately 10-12m) of Kanchan Bridge keeps sufficient clearance for vessels to pass below the bridge without any interruption.

In addition, a vertical clearance of 12.2m must be achieved for Kanchpur Bridge in detailed design in accordance with BIWTA specifications.

Accordingly, the required navigation height of the EZ Bridge is set as follows.

Table 14.7.10 Navigation Clearance of EZ Bridge

Horizontal Width	76.62m
Vertical Height	12.2m

Source: JICA Study Team

14.7.3 Road Design

(1) Design Speed

As previously mentioned, Design Speed applies 65km/h.

(2) Horizontal Alignment

For Horizontal Alignment, refer to 7.3.2.

(3) Minimum Radius of Curve

Table 14.7.11 Minimum Radius of Curve

Design Speed (km/h)	RHD Standards (m)	Adopted Value (m)
65	250	250

Source: JICA Survey Team

(4) Minimum Transition Length

For Minimum Transition Length, refer to Table 7.3.3.

(5) Vertical Alignment

1) Concepts of Vertical Alignment

For Concepts of Vertical Alignment, refer to 7.3.3 (1).

2) Vertical Curve, K

Vertical curve, K, which is determined by RHD standards, shall be ensured the numerical value as shown in Table14.7.12.

Table 14.7.12 Minimum Vertical Curve, K

Design Speed (km/h)	RHD Standards	Adopted Value
65	18	18

Source: JICA Survey Team

(6) Crossfall

For Crossfall, refer to 7.3.4.

(7) Superelevation

For Superelevation, refer to 7.3.5.

(8) Embankment

For Embankment, refer to 7.3.6.

(9) Pavement Design

1) Introduction

For Introduction, refer to 7.3.7 (1).

2) Design Condition

a) Predicted Number of 18-kip Equivalent Single Axle Load Applications (W18)

The predicted number of 18-kip equivalent single axle load applications (W18) is calculated based on the traffic volume for 10 years (2021 - 2030) as the design period.

Axle load equivalency factor for the Project is shown in below table.

Table 14.7.13 Axle Load Equivalency Factor

Vehicle Type	Total Weight (ton)	Axle-1				Axle-2				Axle-3				**Axle Load Equivalency Factor for Vehicle**
		Type	Weight (ton)	Weight (kips)	Axle Load Equivalency Factor per a Axle	Type	Weight (ton)	Weight (kips)	Axle Load Equivalency Factor per a Axle	Type	Weight (ton)	Weight (kips)	Axle Load Equivalency Factor per a Axle	
Passenger Car	2.0	Sin	1.0	2.2	0.0004	Sin	1.0	2.2	0.0004					**0.0008**
Truck	9.5	Sin	1.9	4.2	0.0028	Sin	7.6	16.8	0.7738					**0.7766**
Trailer	36.0	Sin	4.4	9.7	0.0529	Tan	15.8	34.8	1.2060	Tan	15.8	34.8	1.2060	**2.4649**
Bus	10.0	Sin	5.0	11.0	0.1385	Sin	5.0	11.0	0.1385					**0.2770**

Source: JICA Survey Team

Predicted number of 18-kip equivalent single axle load applications (W18) for the Project is shown in Table 14.7.14.

Table 14.7.14 Predicted Number of 18-kip Equivalent Single Axle Load Applications (W18) for Approach Road

Vehicle Type	Design Traffic (2021-2030)	ESAL Factor	Design ESAL	**18-kip ESAL Traffic in Design Lane**
Passenger Car	16,958,630	0.0008	13,567	4,748
Truck	17,588,620	0.7766	13,659,322	4,780,763
Trailer	6,787,905	2.4649	16,731,507	5,856,027
Bus	838,405	0.2770	232,238	81,283
Total				**10,722,822**

Source: JICA Survey Team

b) Standard Normal Deviate (Z_R)

Standard normal deviation (Z_R) for the Project is shown in below table.

Table 14.7.15 Standard Normal Deviate (Z_R)

Reliability, R (%)	85
Deviate, Z_R	-1.037

Source: AASHTO Pavement Guide

c) The combined Standard Error of Traffic Prediction and Performance Prediction (S_0)

For the coefficient, refer to 7.3.7 (1) 3).

d) The difference between the Initial Design Serviceability Index, P0, and the Design Terminal Serviceability Index, Pt (ΔPSI)

For the coefficient, refer to 7.3.7 (1) 4).

e) Resilient Modulus (psi) (MR)

For the coefficient, refer to 7.3.7 (1) 5).

f) Design Structural Number (SN)

The design Structural Number (SN) for the Project is calculated based on the SN calculation formula with above stated design conditions.

As a result of calculation, SN is 4.1.

3) Pavement Layer Thickness

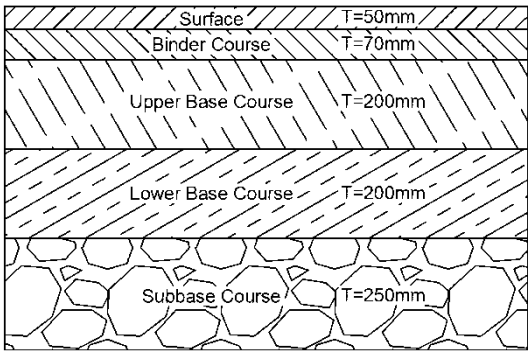
For calculating the formula regarding pavement layer thickness, refer to 7.3.7 (5).

Pavement layer thickness for Approach Road is shown below.

Table 14.7.16 Pavement Layer Thickness

Layer	Material	a	m	D		SN		
				cm	inch			
Surface	Bituminous Wearing Course	0.42		5	1.969			
Binder Course	Bituminous Binder Course	0.42		7	2.756			
Base Course	Graded Aggregate Upper Base Course	0.14	1.00	20	7.874	5.0		
Base Course	Aggregate Lower Base Course	0.11	1.00	20	7.874		>	4.8
Subbase Course	Aggregate Sub Base Course	0.11	1.00	25	9.843			**OK**

Source: JICA Survey Team



Source: JICA Survey Team

Figure 14.7.4 Pavement Layer Thickness

Pavement Design was studied as asphalt pavement in consideration of general pavement structure.

In the Detail Design, Pavement Design shall be studied such as concrete pavement and semi-flexible pavement considering rutting due to heavy track.

(10) Intersection Design

1) Location of Intersections

The location of intersections is shown in below table.

Table 14.7.17 Location of Intersections

KM	Name	Leg	Note
0+00 (Beginning Point)	No.1 Intersection	Three-leg	Connected with R301.
5+28 (End Point)	No.2 Intersection	Three-leg	Connected with existing road.

Source: JICA Survey Team

2) Geometric Design

a) Design Vehicle

It is expected that a large number of trailers will travel on the project road because the project road connects with the Economic Zone.

Dimension of trailers is shown in below table.

Table 14.7.18 Dimension of Trailer (Unit: m)

Vehicle Type	Overall Length	Overall Width	Height	Front Overhang	Rear Overhang	Wheel Base
Trailer	16.50	2.50	4.00	1.30	2.20	4.00 / 9.00

Source: JICA Survey Team

b) Shift Lane

Length of shift lane is set based on the following formula.

$$Lane\ shift\ (m) = V \times \Delta W / 2$$

Where,

V: *Design speed (km/h)*

ΔW: *Shift width (m)*

c) Tapered Lane

Length of tapered lane is set based on the following formula.

$$Lane\ shift\ (m) = V \times \Delta W / 6$$

Where,

V: *Design speed (km/h)*

ΔW: *Shift width (m)*

d) Storage Lane

The storage lane should be sufficiently long to store the number of vehicles likely to accumulate during a critical period. Although the storage length should be determined based on intersection traffic analysis, it is set as 30m to accommodate one track and one trailer in F/S. In the detail design, storage length shall be determined in consideration of intersection traffic analysis.

3) No.1 Intersection

a) Lane Arrangement

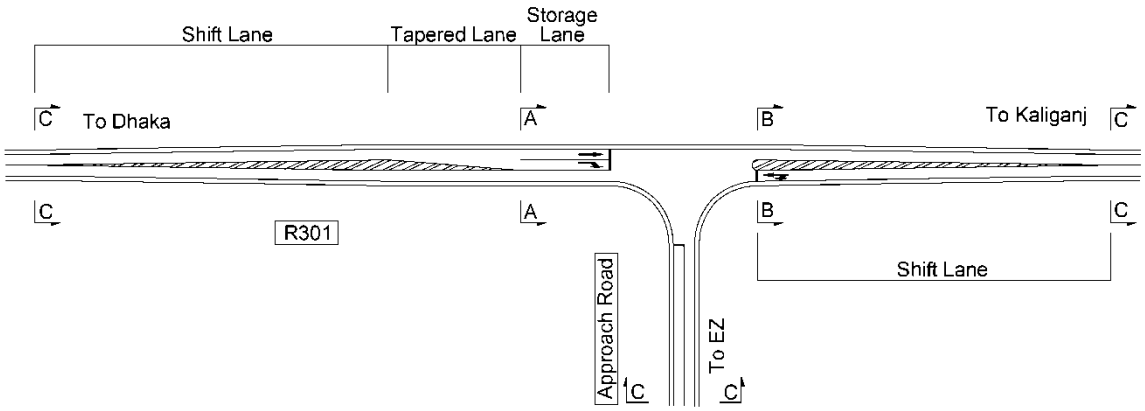
It is expected that a large number of trailers will come and go between Dhaka and Economic Zone and pass through this intersection. Therefore, a storage lane (i.e., right turn lane) is set in order to avoid traffic congestion as shown in below figure.

Design Speed: *Approach Road V = 65 km/h*
R301 V = 65 km/h

Shift Lane Length *= V x ΔW / 2*
= 65 x 3.65 / 2
= 118.6
≈ 120 (m)

Tapered Lane Length *= V x ΔW / 6*
= 65 x 3.65 / 6
= 39.5
≈ 40 (m)

Storage Lane Length *= 30 (m)*



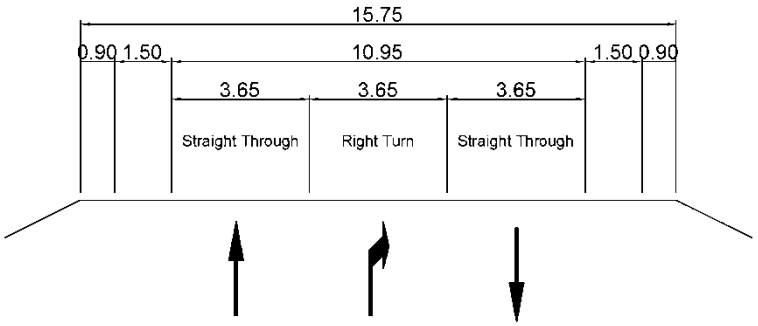
Source: JICA Survey Team

Figure 14.7.5 Plan for No. 1 Intersection

A parallel lane is not set out in this study in order to minimize the affected land. It shall be studied during detail design.

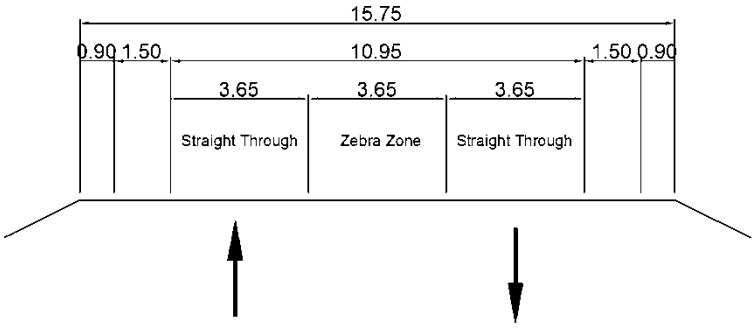
b) Cross Section for Intersection

The cross sections of section A-A, B-B and C-C are shown in Figure 14.7.6 to 14.7.8.



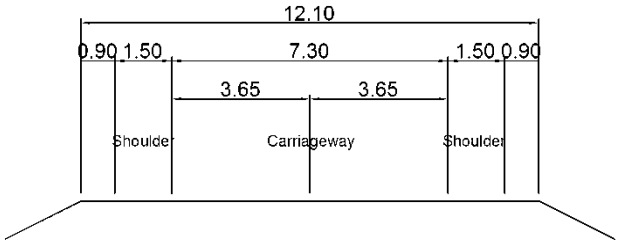
Source: JICA Survey Team

Figure 14.7.6 Section A-A



Source: JICA Survey Team

Figure 14.7.7 Section B-B

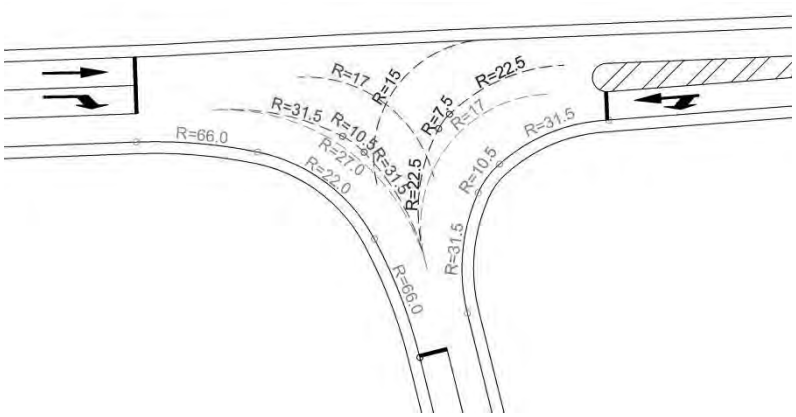


Source: JICA Survey Team

Figure 14.7.8 Section C-C

c) Turning Path Design

Although the turning path design shall be designed considering a smooth transit, a wide turning path can disrupt the traffic stream. Thus, the turning path shall be consolidated in order to allow regular transit.



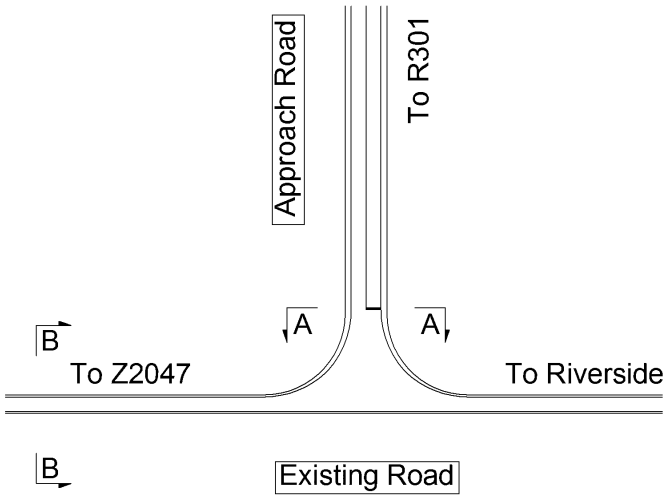
Source: JICA Survey Team

Figure 14.7.9 Turning Path at No.1 Intersection

4) No. 2 Intersection

a) Lane Arrangement

The approach road connects with the existing road at the end point. After completion of approach road and EZ, it is expected that few transit vehicles from the EZ pass through the intersection. Although most vehicles pass through the No.1 Intersection to Dhaka and vice versa, the No.2 Intersection shall be designed in consideration of passing the trailer, the same as Intersection No.1. However, it is unnecessary to install the storage lane because much traffic is not anticipated. In addition, the improvement of the existing road is outside the scope of this project.

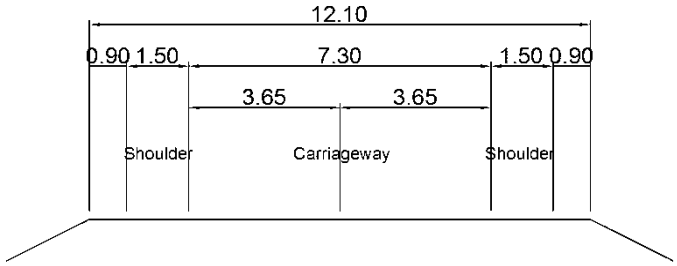


Source: JICA Survey Team

Figure 14.7.10 No.2 Intersection

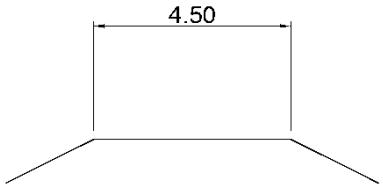
b) Cross Section

The cross sections of section A-A and B-B are shown in Figure 14.7.11 to 14.7.12.



Source: JICA Survey Team

Figure 14.7.11 Section A-A

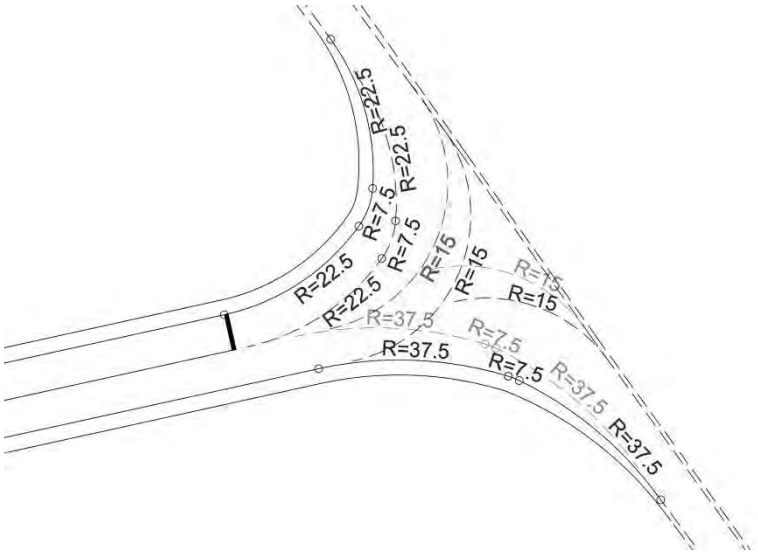


Source: JICA Survey Team

Figure 14.7.12 Section B-B

c) Turning Path Design

As mentioned above, the improvement of the existing road is outside the scope of this project. Thus, the turning path was designed for the existing road, and the design policy is the same as the No.1 intersection.



Source: JICA Survey Team

Figure 14.7.13 Turning Path at No. 2 Intersection

Besides, it is expected to increase heavy vehicle which passes through between port and approach road. However, heavy vehicle cannot pass each other on the existing road. Thus,

the following alternative plan is proposed considering future widening of existing road. The widening width of existing road is the same as approach road.

- Alternative-1: Widening of port side
- Alternative-2: Widening and improvement of intersection

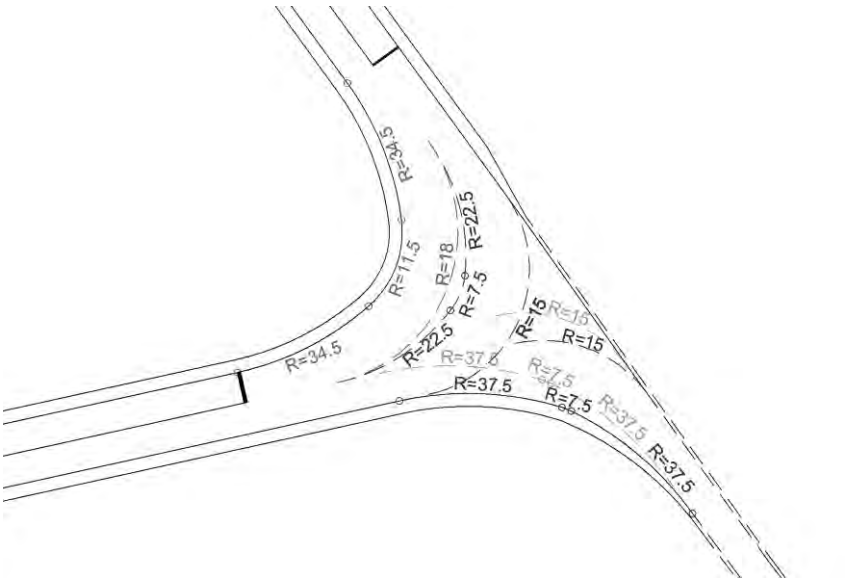


Figure 14.7.14 Turning Path at No.2 Intersection (Alternative-1)

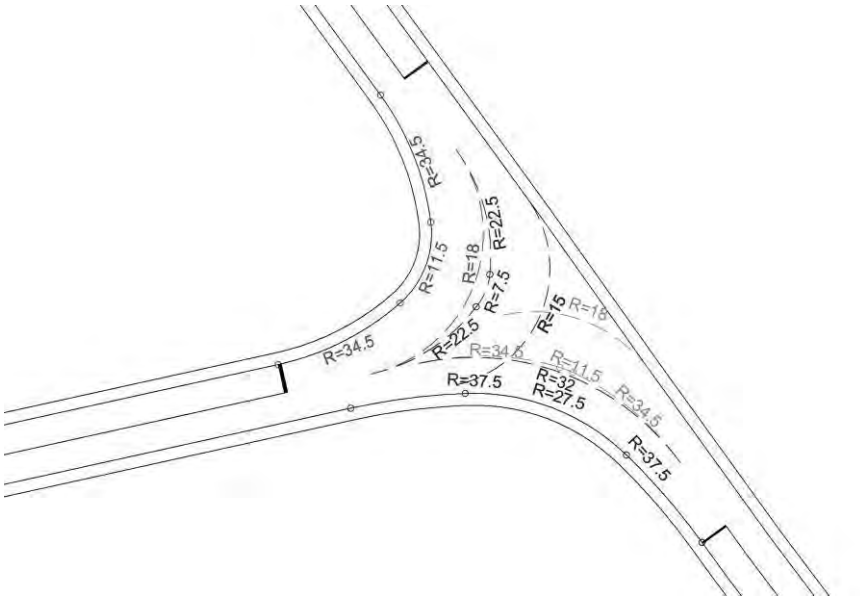


Figure 14.7.15 Turning Path at No.2 Intersection (Alternative-2)

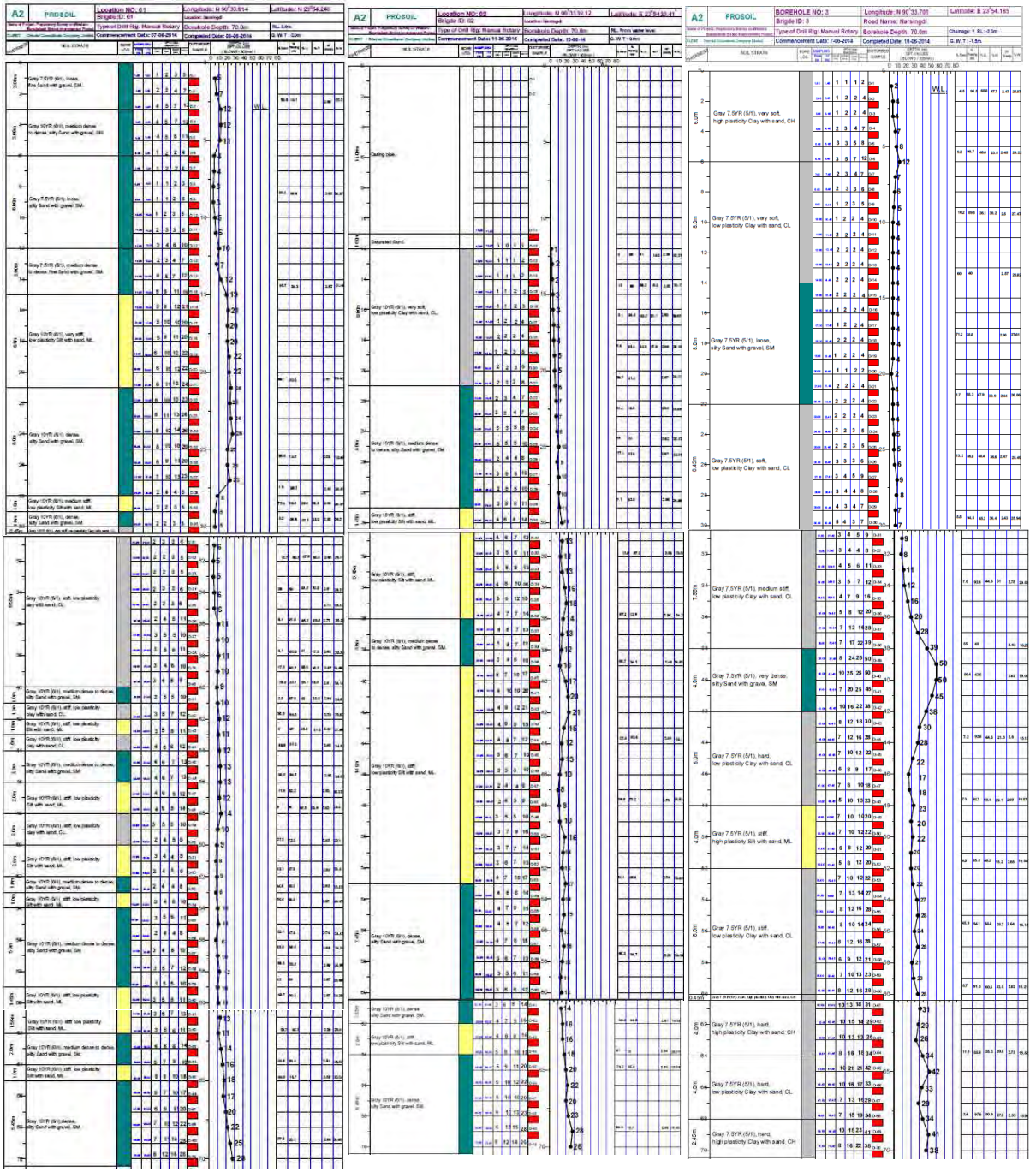
14.7.4 Bridge Design

The EZ Bridge is designed through the comparison of several alternatives for major design

components including the foundation type, superstructure type, the substructure type, the span arrangement, and the cross section.

(1) Selection of Foundation Type

The geological investigation was conducted along the original proposed alignment of EZ Bridge. Figure 14.7.16 Bore Log of EZ Bridge shows the result of the bore log.



Source: JICA Survey Team

Figure 14.7.16 Bore Log of EZ Bridge

The stratum is mainly comprised of the sand layer. Although the borehole drilling was

conducted to a maximum depth of 70m that the soil investigation company in Bangladesh could carry out, a layer with N ≥ 50 was not observed. Sand layers with N ≥ 30 are considered supporting layers in accordance with Japanese Bridge Standards. Additionally, it assumed that the bearing layer N ≥ 50 exists at more than GL-70m depth in this study. However, soil investigations at the exact locations of piers and careful study of the supporting layers (pile length) are proposed for the detailed design stage.

The study of the foundation type is carried out in two patterns, one is for inside the River, and the other on land, since the general condition is greatly different.

1) Foundations inside River

Regarding the selection of foundation type inside the river, the following conditions shall be studied specifically:

- The water depth for proposed bridge sites
- Possibility of scouring (sufficient attention must be paid to scouring)
- Supporting load of foundation
- Depth of the supporting layer

The following table shows the selection of foundation types.

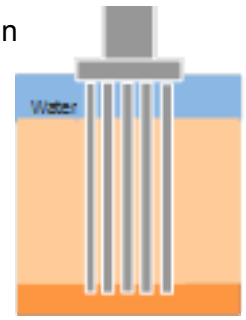
Table 14.7.19 Applicability Criteria of Foundation Types (inside River)

Applicable Condition \ Foundation Type			Cast- in-place Concrete Pile	PHC/SC PIle	Steel Pipe Pile	Diaphragm wall	Steel pipe sheet pile	Caisson
Condition of Construction	Temporary Jetty	Depth < 5 m	△	○	○	×	○	△
		Depth > 5 m	△	△	○	×	○	△
	Environment	Vibration Noise	○	×	×	○	△	○
		Impact on Adjacent Structure	○	×	△	○	△	△
	Loading	Normal	○	○	○	○	○	○
		Large	○	×	○	○	○	○
Ground Condition	Depth of Supporting Layer from Ground Level	< 5 m	△	×	×	×	×	×
		5 ~ 15 m	○	○	○	△	△	○
		15 ~ 25 m	○	○	○	○	○	○
		25 ~ 40 m	○	○	○	○	○	○
		40 ~ 60 m	○	△	○	○	○	○
		≥ 60 m	△	×	△	△	△	△
	Soil Condition	Clay (20 ≤ N)	○	○	○	○	○	○
		Sand/Gravel (30 ≤ N)	○	○	○	○	○	○

Note : ○: Suitable, △: Possible, ×: Impossible
Source: JRA

According to the above Table, four foundation types (Cast-in-Place Concrete Pile, Steel Pipe Pile, Steel Pipe Sheet Pile (SPSP) and Caisson) can be considered. However, when we look at Steel Pipe Pile, a temporary cofferdam will be required so that it can be determined that Steel Pipe Sheet Pile (SPSP) will be more reasonable than Steel Pipe Pile. And as for the concrete caisson foundation, it requires a large the construction facility, and the construction cost is not economical.

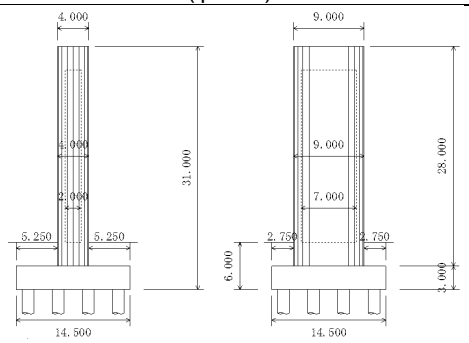
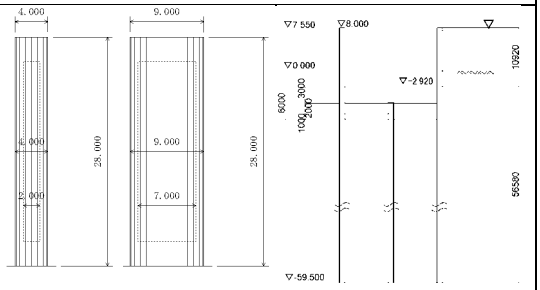
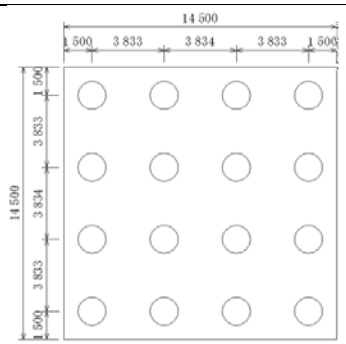
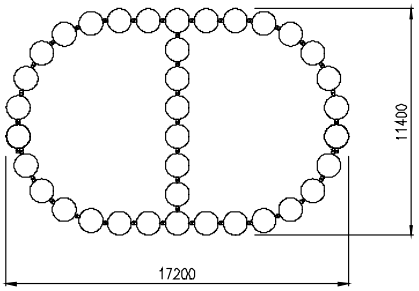
As for the cast-in-place concrete pile, pile-bent type is very common in Bangladesh. However, this type frequently leads to a whirlpool during a flood, and is easy to catch wood flowing down the river. In addition, it is unfavorable due to a lack of stability in the pier. Therefore, this foundation type is forbidden in Japan.



Pile-bent Type

Finally, two foundation types (Cast-in-Place Concrete Pile and Steel Pipe Sheet Pile) are compared for P15. The evaluation is shown in Table 14.7.20. In this Preparatory Survey, Cast-in-Place Concrete Pile (φ1500, L=54m, n=16) is recommended for the piers in the river (P14, P15). However, the foundation type shall be ultimately determined by confirming the supporting layer at each pier position based on the geotechnical investigations during the detailed design stage.

Table 14.7.20 Comparison of Foundation Types (P15)

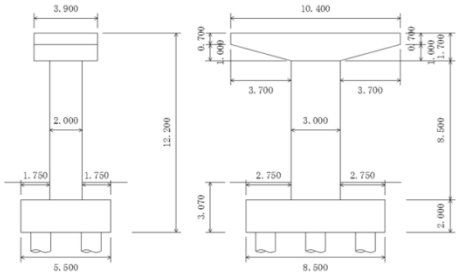
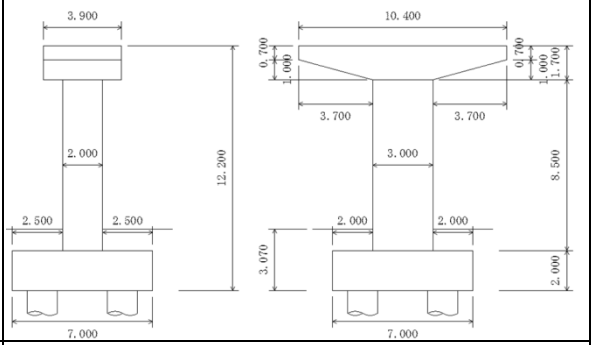
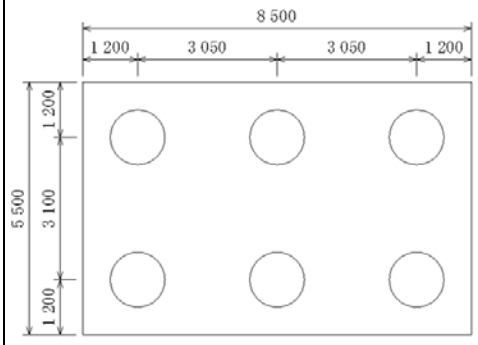
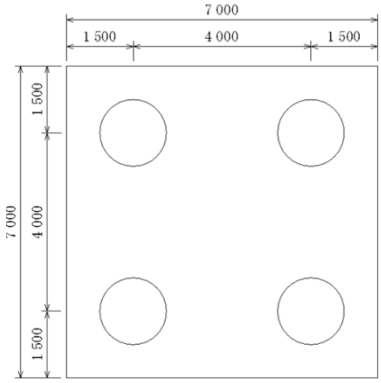
	Option 1: Cast-in-place Concrete Pile (φ1500)	Option 2: Steel Pipe Sheet Pile
Pier and Foundation Shape		
Plan View	 φ1500-16、L=54.0m	 φ1200-36, L=67.5m
Work Period	**Suitable** -Work period for the foundation takes slightly more time than Option 2 since a temporary cofferdam is required. However, it does not become a critical pass. (9/10)	**More suitable** -Work period of foundation is slightly faster than Option 1 since a temporary cofferdam is not required. However, it does not become a critical pass. (10/10)
Protection against Ship Collision	**Suitable** -Temporary intervention for navigation clearance during construction is larger than Option 2. -It will be safer by installing a buffer device for ship collisions. (4/5)	**More suitable** -Temporary intervention for navigation clearance during construction is smaller than Option 2. -It will be safer by installing buffer device for ship collisions. (5/5)
Against Scoring	**Same** -Structure is not affected by the river scouring since its depth is quite small and the cover soil thickness of the pile cap is secure enough. (5/5)	
Workability	**Suitable** -Temporary cofferdam is required separately. -Quality control during construction is required more than Option 2. (8/10)	**More suitable** -Temporary cofferdam is not required separately. (10/10)
Cost	**1.00** (15/15)	**2.32** (7/15)
Technology Transfer	-Many experience and no new technology in Bangladesh. (3/5)	-New Technology and Technology Transfer can be done. (5/5)
Evaluation	Although Work Period, Safety of Works and Protection against Ship Collision are slightly inferior, cost is much cheaper than Option 2. **Recommended** (44/50)	Although Work Period, Safety of Works and Protection against Ship Collision are slightly superior, cost is much higher than Option 1. (42/50)

Source: JICA Survey Team

(2) Foundations on Land

As for the foundation type on land, piers and abutments are constructed on existing ground surfaces. A Cast-in-place Concrete Pile Foundation will be selected for its ease of constructability and procurement of materials/equipment as well as previous experience in Bangladesh.

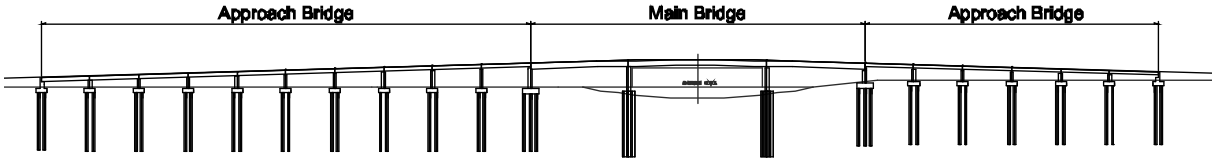
Table 14.7.21 Comparison of Diameter of Cast-in-place Concrete Pile (P17)

	Cast-in-place Concrete Pile (ø1200)	Cast-in-place Concrete Pile (ø1500)
Pier and Foundation Shape		
Plan View	 φ1200-6、L=72.5m	 φ1500-4, L=73.0m
Cost	**1.02**	**1.00**
Evaluation	Not Recommended	Cost is lower. **Recommended**

Source: JICA Survey Team

(3) Selection of Superstructure Type

The EZ Bridge is composed of a main bridge and approach bridge on both sides as shown in the following figure. The main bridge maintains the navigational requirement and the approach bridge connects to the main bridge from the highway. The type of the main bridge is determined based on engineering criteria such as span length, navigation requirement, structural stability, constructability, construction cost, maintenance, and aesthetic point.



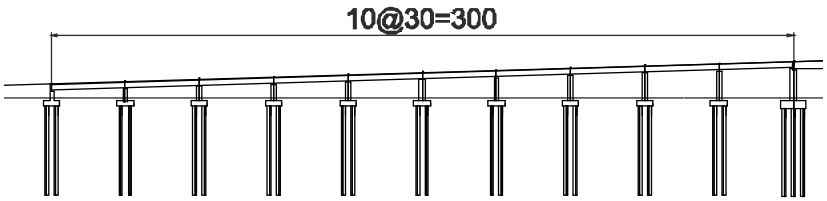
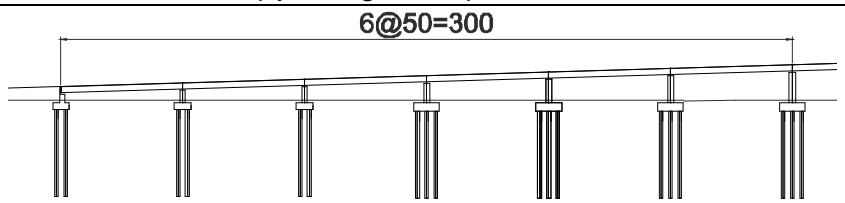
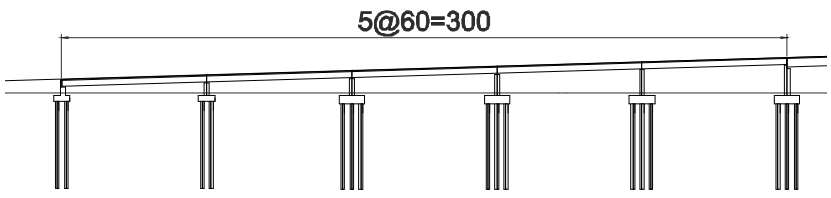
Source: JICA Survey Team

Figure 14.7.17 Bridge Composition

1) Approach Bridge

The span length of the approach bridge applies to 30m - 60m in consideration with girder depth restriction and economical point. The following table shows the alternatives for the Approach Bridge.

Table 14.7.22 Alternatives for Approach Bridge Type

Alternative 1 : PC-I girder (span length =30m)

Alternative 2 : PC Box Girder (span length =50m)

Alternative 3 : Steel Narrow Box Girder (span length =60m)


Note: Comparison of alternatives shown in bridge with 300m length.

Source: JICA Survey Team

2) Main Bridge

As mentioned above, required navigation width is 76.62m. Therefore, the span length of the EZ Bridge shall be set as 85m in consideration of substructure width.

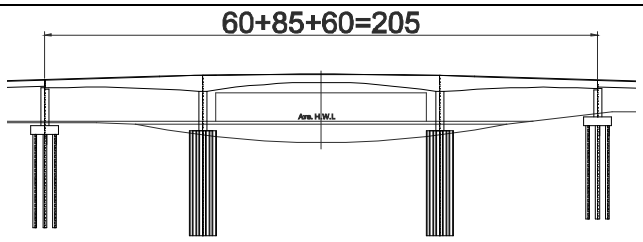
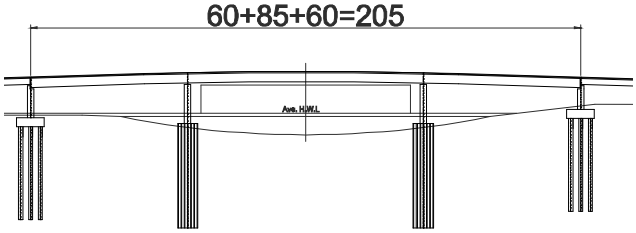
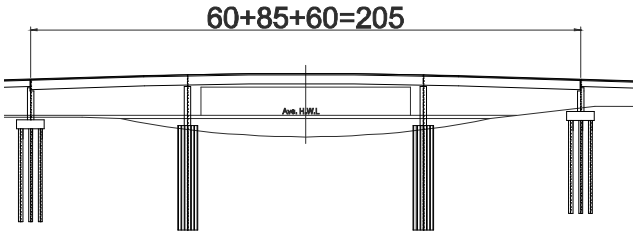
Bridge types are related to the bridge span, and applicable/economical bridge span for major bridge types are shown in Table 14.7.23. As for the Steel Box Girder, weathering the steel bridge is extracted as one alternative in consideration of the bridge life cycle cost (LCC). The alternatives for the Main Bridge are shown in Table 14.7.24.

Table 14.7.23 Applicable Span Length on Bridge Type

Bridge Type	Applicable Span Length
PC Box Girder	45-100m
Steel Box Girder	50-120

Source: JICA Survey Team

Table 14.7.24 Alternatives for Main Bridge Type

Alternative 1 : PC Box Girder

Alternative 2 : Steel Box Girder (by traditional steel)

Alternative 3 : Steel Box Girder (by weathering steel)


Source: JICA Survey Team

(4) Comprehensive Evaluation of Bridge Type

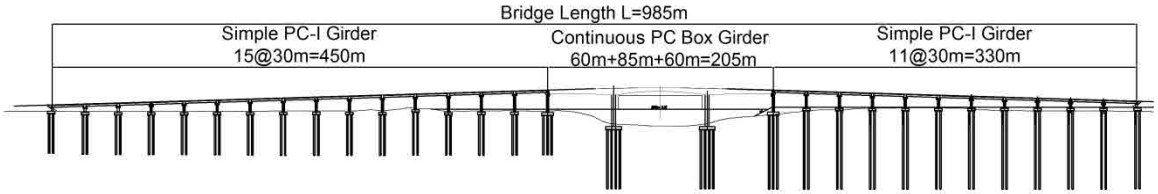
1) Approach Bridge

The comprehensive evaluation of the Approach Bridge is carried out based on various evaluation items such as Structural Performance, Constructability, Cost, Maintenance, Aesthetic View, and Environmental Impact, and each major item consists of several sub-items. The evaluation result for the three alternatives of the Approach Bridge is shown in Table 14.7.25. Although Alternative 3 (Steel Box Girder) is superior to other alternatives in some items, the life cycle cost of Alternative 3 is more than 10% higher than Alternative 1 and the difference of the cost cannot be ignored. Therefore, “PC-I Girder” is recommended as the most appropriate bridge type for the Approach Bridge.

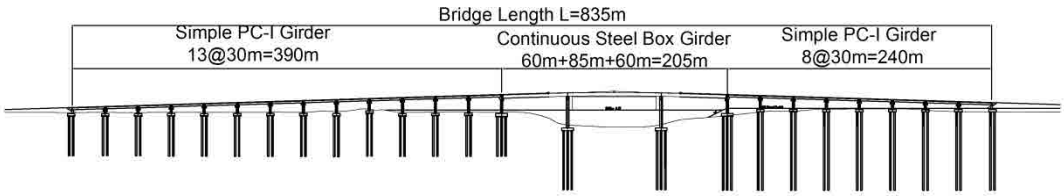
2) Main Bridge

The comprehensive evaluation of the Main Bridge is carried out for the whole bridge length (including the Approach Bridge) as shown in the following figure. The lengths of the Approach Bridge of Alternative 2 and 3 (Steel Box Girder) can be shorter than Alternative 1 (PC Box girder) since the girder depth of Steel Box girder is lower than PC Box girder.

Alternative 1: PC Box Girder + PC-I Girder (15@30+60+85+60+11@30=985m)



Alternative 2 &3: Steel Box Girder + PC-I Girder (13@30+60+85+60+8@30=835m)

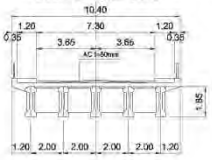
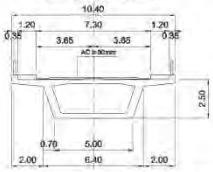
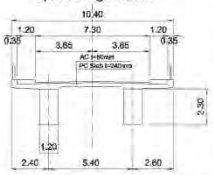


Note: The type of Approach Bridge adopts PC-I Girder in all Alternatives.
Source: JICA Survey Team

Figure 14.7.18 Alternatives for EZ Bridge

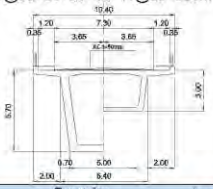
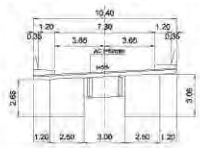
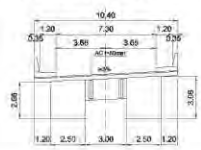
The comprehensive evaluation result for the three alternatives of the Main Bridge is shown in Table 14.7.26. Alternative 3 has some vital factors such as shortest construction period, advantageous earthquake resistance, Life Cycle Cost, and aesthetic view. Specifically, the lengths of Approach Bridge of Alternative 2 and 3 (steel girder) can be shorter (approximately 150m) than Alternative 1 (PC Box girder) since the girder depth of the steel girder is much lower than PC Box girder. The short Approach Bridge length will bring significant advantages to the EZ since it can minimize the area division of the EZ. Due to the above reasons, “Steel Box Girder Bridge with Weathering Steel” is recommended as the most appropriate bridge type for the Main Bridge.

Table 14.7.25 Comparison Table of Bridge Types for Approach Bridge

Alternatives			Alternative 1 PC-I Girder		Alternative 2 PC Box Girder		Alternative 3 Steel Box Girder (by Weathering Steel)	
Span Length and Cross Section of Approach Bridge			Span Length : 30m 		Span Length: 50m 		Span Length: 60m 	
Structural performance	Durability	Durability of floor slab	Superior (PC slab)	◎	Superior (PC slab)	◎	Superior (PC slab)	◎
	Earthquake Resistance	Weight of superstructure	Moderate	○	Moderate	○	Superior	◎
Constructability	Difficulty level of construction		No difficulty	◎	No difficulty	◎	No difficulty	◎
	Construction Period		Longer than Alt.3	○	Longer than Alt.3	○	Shortest	◎
Cost	Initial Cost		1.00	◎	1.12	○	1.14	○
	Life Cycle Cost (50 years)		1.00	◎	1.09	○	1.12	○
Maintenance	Repainting	Necessity of painting	No need repainting	◎	No need repainting	◎	No need repainting (weathering steel)	◎
	EXP joint and Bearing Shoe	Necessity of Replacement	1 time per 20-30 years	○	1 time per 20-30 years	○	1 time per 20-30 years	○
Aesthetic view			Moderate	○	Moderate	○	Moderate	○
Consistency with Main Bridge (steel box girder)			Moderate	○	Moderate	○	Superior	◎
Environmental Impact	River Hydrology (Scouring)	Nos. of piers inside river	Nil.	○	Nil.	○	Nil.	○
Evaluation			Although it is a little lacking in consistency with Main Bridge, LCC is the cheapest. **Recommendable**					

Legend: ◎ Excellent, ○ Good, △ Poor

Table 14.7.26 Comparison Table of Bridge Types for Main Bridge

Alternatives			Alternative 1 **PC Box Girder** + PC-I Girder (Rigid Frame)		Alternative 2 **Steel Box Girder** + PC-I Girder (by Traditional Steel)		Alternative 3 **Steel Box Girder** + PC-I Girder (by Weathering Steel)	
Span Arrangement / Bridge Length and Cross Section of Main Bridge			Bridge Length : 15@30+60+85+60+11@30=985m 		Bridge Length: 13@30+60+85+60+8@30=835m 		Bridge Length: 13@30+60+85+60+8@30=835m 	
Structural performance	Durability	Durability of floor slab	Superior (PC slab)	◎	Moderate (RC slab)	○	Moderate (RC slab)	○
	Earthquake Resistance	Weight of superstructure	Moderate	○	Superior	◎	Superior	◎
Constructability	Difficulty level of construction		No difficulty	◎	No difficulty	◎	No difficulty	◎
	Construction Period (including Approach Road)		3.5 years	○	3.0 years	◎	3.0 years	◎
Cost (for whole bridge length)	Initial Cost		1.20	◎	1.00	◎	1.02	○
	Life Cycle Cost (50 years)		1.13	◎	1.02	○	1.00	◎
Maintenance	Repainting	Necessity of painting	No need repainting	◎	Need repainting for Main Bridge	△	No need repainting (weathering steel)	◎
	EXP joint and Bearing Shoe	Necessity of Replacement	1 time per 20-30 years	○	1 time per 20-30 years	○	1 time per 20-30 years	○
Aesthetic view			Inferior (High girder depth)	△	Moderate (Low girder depth)	○	Moderate (Low girder depth)	○
Environmental Impact	River Hydrology (Scouring)	Nos. of piers inside river	2	○	2	○	2	○
	Noise / vibration	Nos. of EXP joint	2 for Main Bridge	○	2 for Main Bridge	○	2 for Main Bridge	○
	During maintenance painting		No need repainting	◎	Volatile organic compounds are released into the air.	△	No need repainting	◎
Evaluation							- Shortest Construction Period - Advantageous to earthquake resistance - Lowest Life Cycle Cost **Recommendable**	

Legend: ◎ Excellent, ○ Good, △ Poor
Note: Comparison of main bridge is carried out for whole bridge length.

Source: JICA Survey Team

(5) Design of Superstructures

The preliminary design of the superstructure is carried out for the recommended bridge alternative. The purpose of the preliminary design is to define the structural element sizes so that better estimates of cost and constructability can be obtained. The refinement of the alternative study also allows the preliminary design to have a more efficient structure and to more accurately show the sizes that are reflected in the drawing. Structural analysis are initially carried out for each of the recommended types of the superstructure in order to assess the vertical reaction loads from the superstructure for the design of the substructure and foundation and the structural stability considering site specific loadings such as temperature, stream flow, wind, and seismic loads.

General View of the EZ Bridge is shown in figure 14.7.19. Cross section of Steel Box Girder for the main bridge and PC-I Girder for the approach bridge are shown in Figure14.7.20 and Figure14.7.21, respectively.

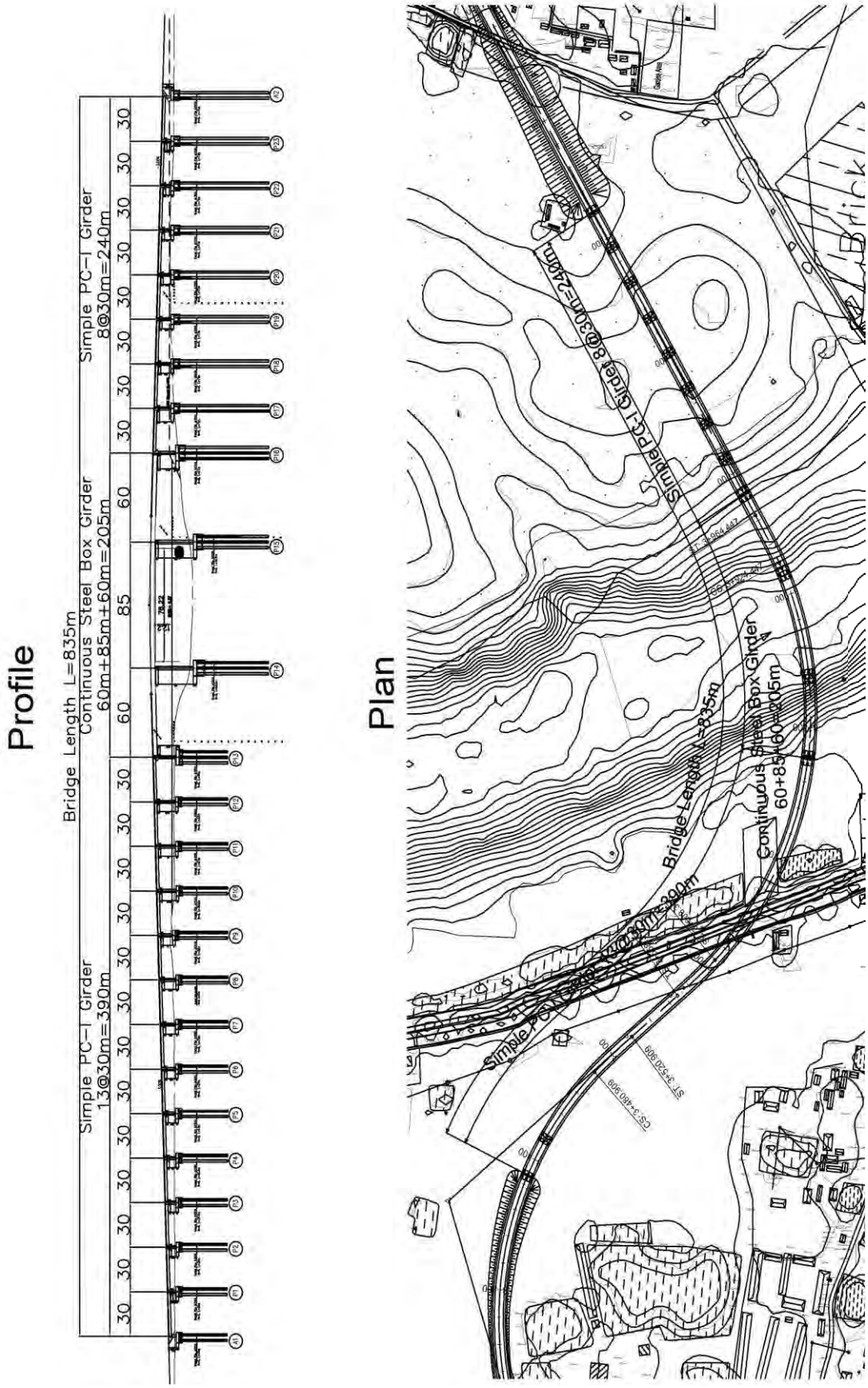
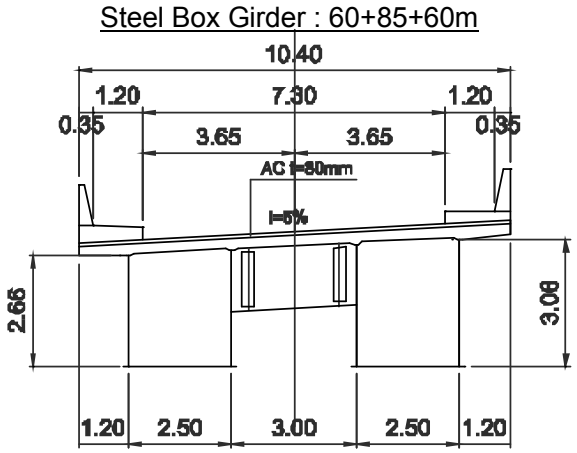


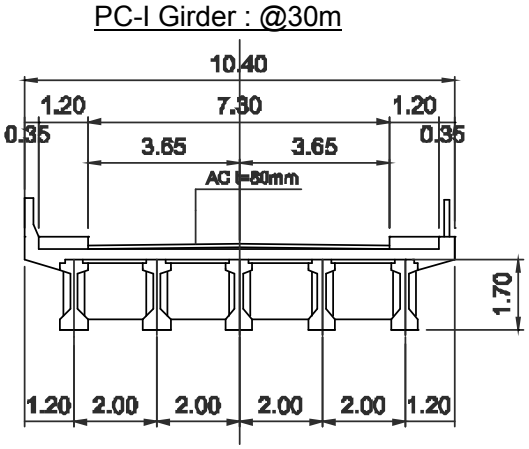
Figure 14.7.19 General View of the EZ Bridge

Source: JICA Survey Team



Source: JICA Survey Team

Figure 14.7.20 Cross-section of Steel Box Girder for Main Bridge



Source: JICA Survey Team

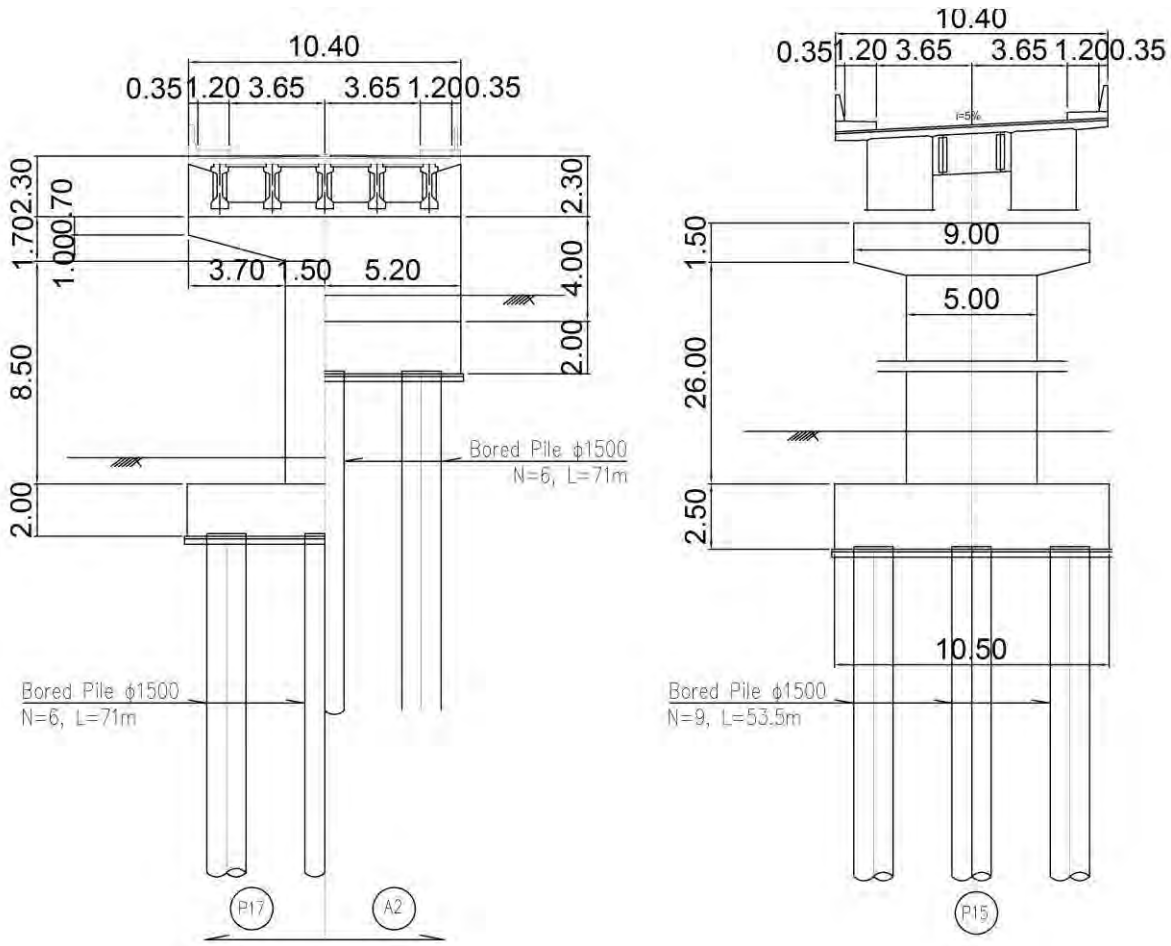
Figure 14.7.21 Cross-section of PC-I Girder for Approach Bridge

(6) Design of Substructure and Foundations

As described in Selection of Foundation Type, a Cast-in-place concrete pile is used for foundations in consideration of the economical aspect.

As for the shape of the substructure, an oval or round shape can be applied. This bridge has a relatively wide width with four lanes, and in consideration of smooth river flow, oval-shaped piers shall be used.

The shapes of the substructure and foundation based on the preliminary design are shown in Figure14.7.22.



Source: JICA Survey Team

Figure 14.7.22 Substructure and Foundation Shapes for EZ

14.7.5 Right of Way

For Right of Way, refer to 7.5.

Existing ROW does not exist because the approach road is planned in the agricultural and residential lands.

14.8 Construction Plan

(1) Bored Pile

For Bored Pile, refer to 9.2.

(2) Pile Cap

For Pile Cap, refer to 9.3.

(3) Pier

For Pier, refer to 9.4.

(4) Superstructure (Steel-Box Girder)

For Steel-Box Girder, refer to 9.5.

(5) Superstructure (PC-I Girder)

For PC-I Girder, refer to 9.6.

(6) Approach Road

The construction of the approach road is carried out based on the following steps.

1) Site Cleaning

The root of the tree is removed by a bulldozer and a backhoe before embankment work.

2) Embankment Work

The material of the embankment is carried by dump truck from the borrow pit and compacted by a pneumatic tire roller.

3) Slope Protection Work

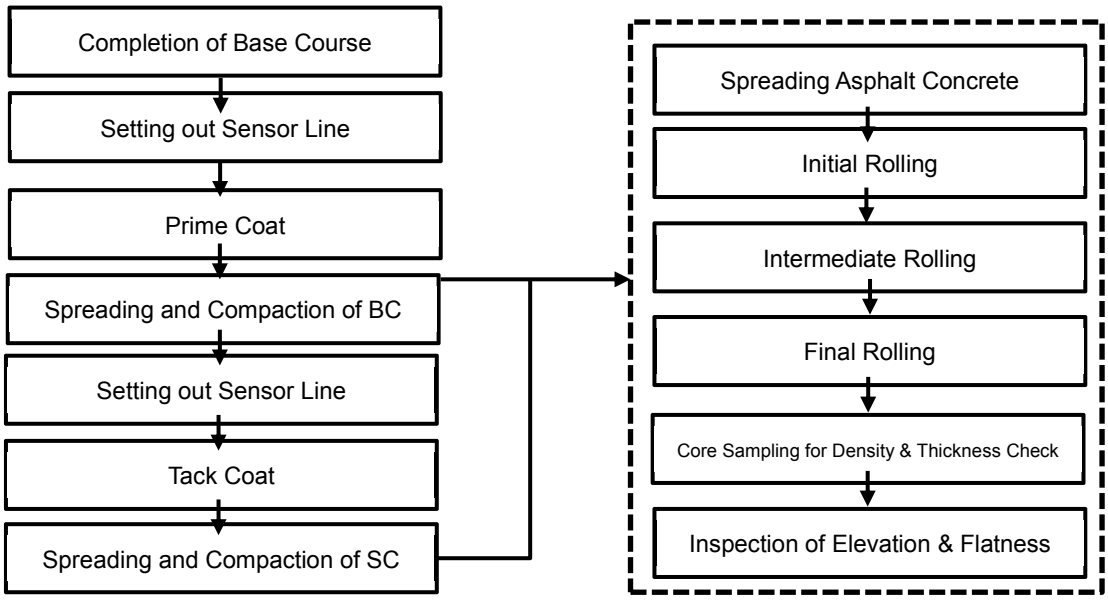
The slope of the embankment is formed by a back hoe after it is compacted by a bulldozer. And then slope protection work, such as planting, is carried out.

4) Pavement Work

A Base Course and Sub-base Course are leveled by a motorized grader, and it is compacted by a road roller and a pneumatic tire roller.

For Surface Course (SC) and Binder Course (BC), the asphalt mixture is leveled by an asphalt finisher, and then it is compacted by a pneumatic tire roller.

Work Flow is shown in Figure14.8.1.

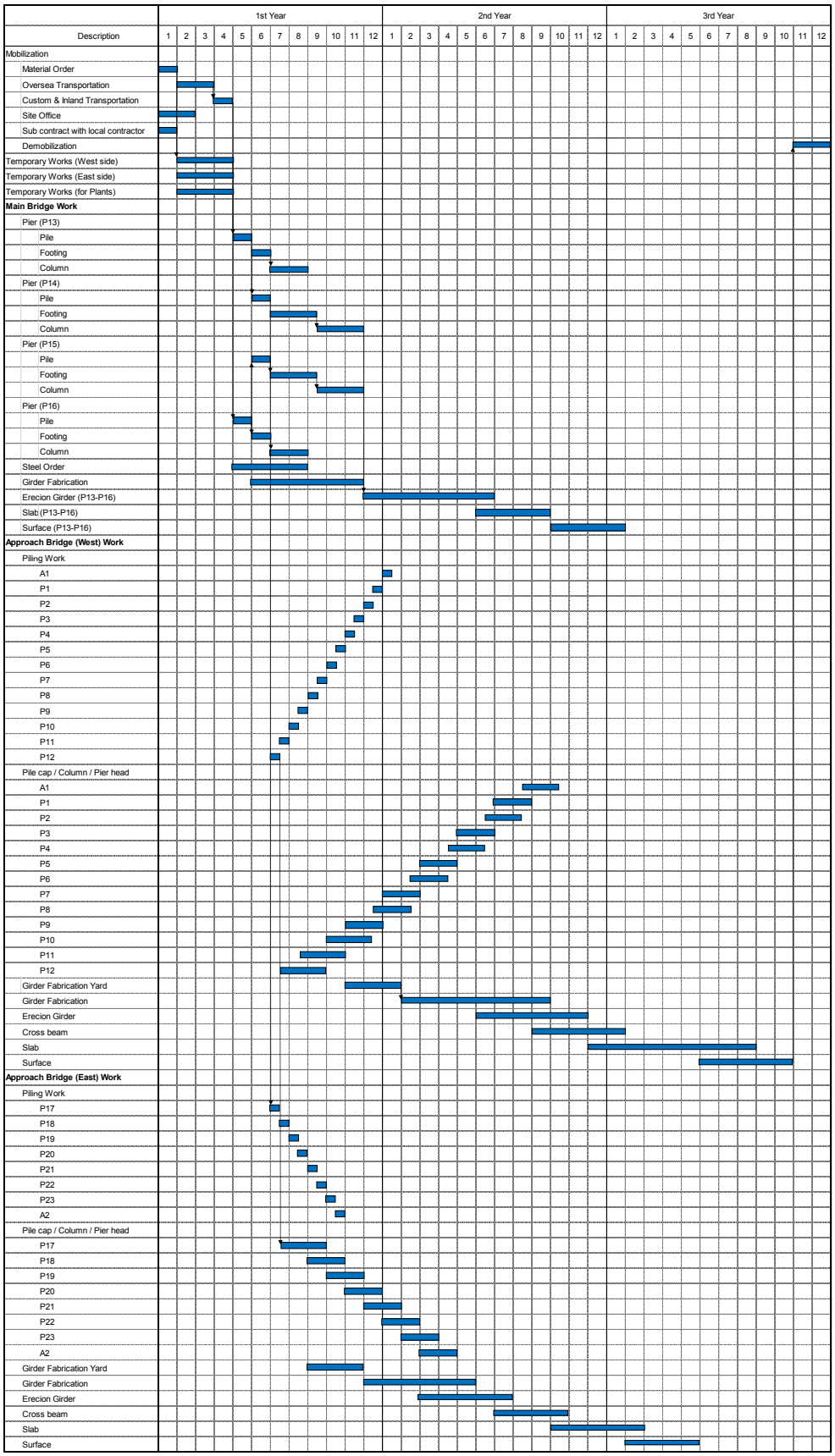


Source: JICA Survey Team

Figure 14.8.1 Work Flow of Pavement Work

(7) Construction Schedule

The construction period for the EZ is 36 months as shown in Figure 14.8.2.



Source: JICA Survey Team

Figure 14.8.2 Construction Schedule

14.9 Operation and Maintenance Plan

14.9.1 Operation and Maintenance Plan for EZ Bridge

The EZ Bridge is weathering steel box girder. The operation and maintenance plan for this bridge is the same as a steel I-girder bridge constructed in Western Bangladesh. Refer to "10.1 Operation and Maintenance Plan for the Project Bridge."

14.9.2 Operation and Maintenance Cost

Maintenance costs for the EZ bridge including the approach roads are summarized in Table14.9.1.

Table 14.9.1 Operation and Meintenance Cost for EZ bridge

Routine/Periodic maintenance (Per Year/TAKA)	32,101,889
Carbonation (Every 40years/TAKA)	617,876
Resurface (Every 10years/TAKA)	38,695,488

Source: JICA Study Team

14.10 Cost Estimates

In this chapter, project cost is estimated for the EZ Bridge and Road. The general conditions of cost estimates, project cost components for GOJ/GOB portions, and the cost calculation method are the same as the cost estimate of small- and middle size bridges in Western Bangladesh (105 bridges).

(1) Term of Cost Estimates

The unit rates of material, equipment, labor, and other costs adopted for this cost estimate is based at the time of December 2014.

(2) Exchange Rate

The exchange rate adopted for this cost estimates is as follows:

- US$ 1 = Yen 119
- US$ 1 = BDT 77.5
- BDT 1 = Yen 1.54

(3) Eligible Portion by GOJ

The eligible portions by GOJ for the EZ Bridge and Road are as follows.

I. Civil Work Cost

II. Consulting Services

III. Physical Contingency

IV. Price Escalation

V. Interest During Construction

(4) Non-eligible portion covered by GOB

The non-eligible portion by GOJ for the EZ Bridge and Road are as follows.

I. Land Acquisitions and Resettlement Cost

II. Administration Cost

III. VAT (Value Added tax)

IV. Custom Duty

V. Income Taxes (IT)

(5) Civil work Cost

Civil work cost for the EZ Bridge and Road are calculated by unit price and quantities, as shown in Table 14.10.1 and Table 14.10.2.

Table 14.10.1 Summary of Civil Works Cost by Bridge/Road Component

Confidential

Source: JICA Survey Team

Table 14.10.2 Civil Works Cost of the EZ Bridge and Road

Confidential

14.11 Project Effect

14.11.1 Operation and Effect Indicator

(1) Selection of Operation and Effect Indicators

Operation and effect indicators are selected based on data availability, validity, and reliability in the current year (baseline) and 2 years after project completion. Selected operation and effect indicators are summarized in Table 14.11.1.

Table 14.11.1 Selection of Operation and Effect Indicator

Indicator		Baseline	2 years after project completion
Operation Indicator	Freight Traffic Volume (pcu/ day)	2014	2023
	Passenger Vehicle Traffic Volume (pcu/ day)		
Effect Indicator	Reduction of Travel Cost (Million taka/year)		

Source: JICA Study Team

Decreasing the number of traffic accidents after completion of the bridge could have been considered as one of the effect indicators. However, as the past traffic accident data on the bridge is not available, this was not included as an effect indicator.

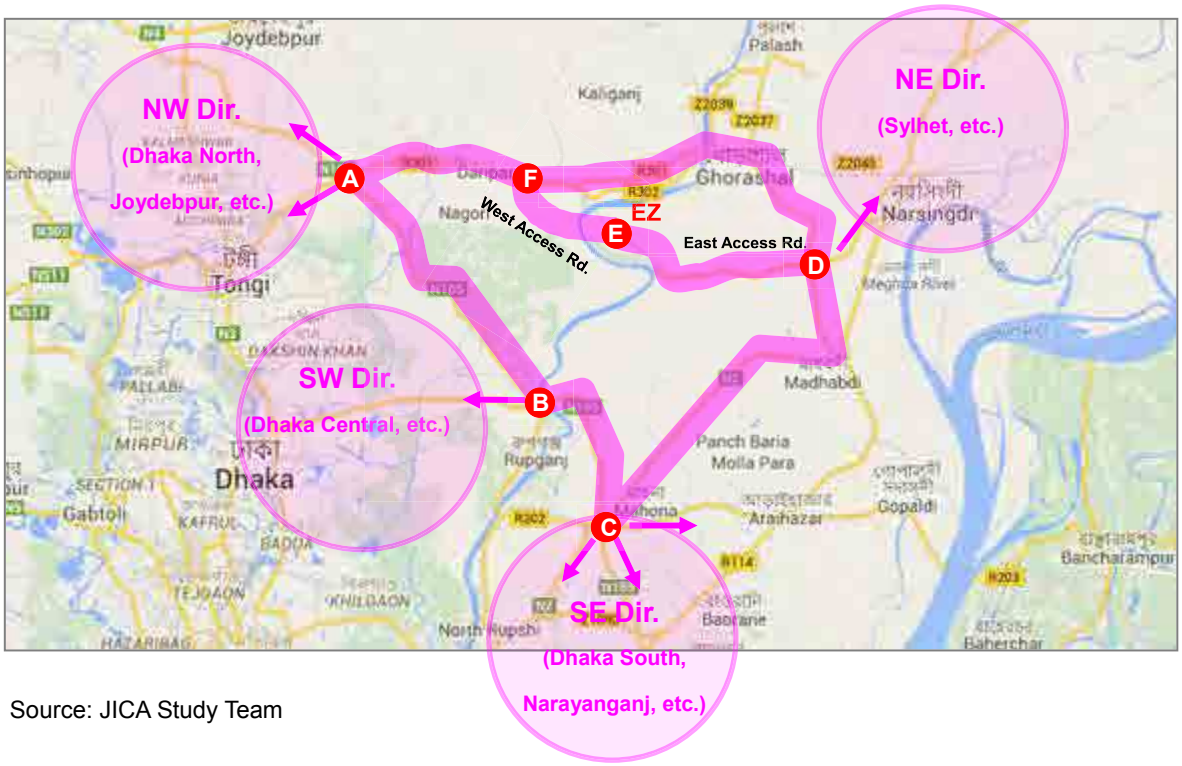
(2) Setting of Operation Indicator

The freight and passenger traffic volume of the baseline and 2 years after the project completion were selected as an operational indicator. However, traffic volume of the baseline does not exist since construction of the EZ bridge is in progress.

(3) Setting of Effect Indicator

The reduction of travel cost (movement for people and materials) was selected as an effect indicator. Specifically, traffic volume of “14.6 traffic demand forecast” was distributed as 4 directions based on population distribution in the GDA in 2011. Traffic demand in 2023 is shown in Table 14.11.2 and traffic demand by direction is shown in Table 14.11.3.

The with and without routes of the EZ bridge were set based on future traffic congestion and road improvements as shown in Figure 14.11.2. The calculation method of travel cost is summarized in “14.11.2 Economic Analysis”.



Source: JICA Study Team

Figure 14.11.1 Setting of Trips of EZ by Directions

Table 14.11.2 Traffic Demand in 2023 (vehicles/day)

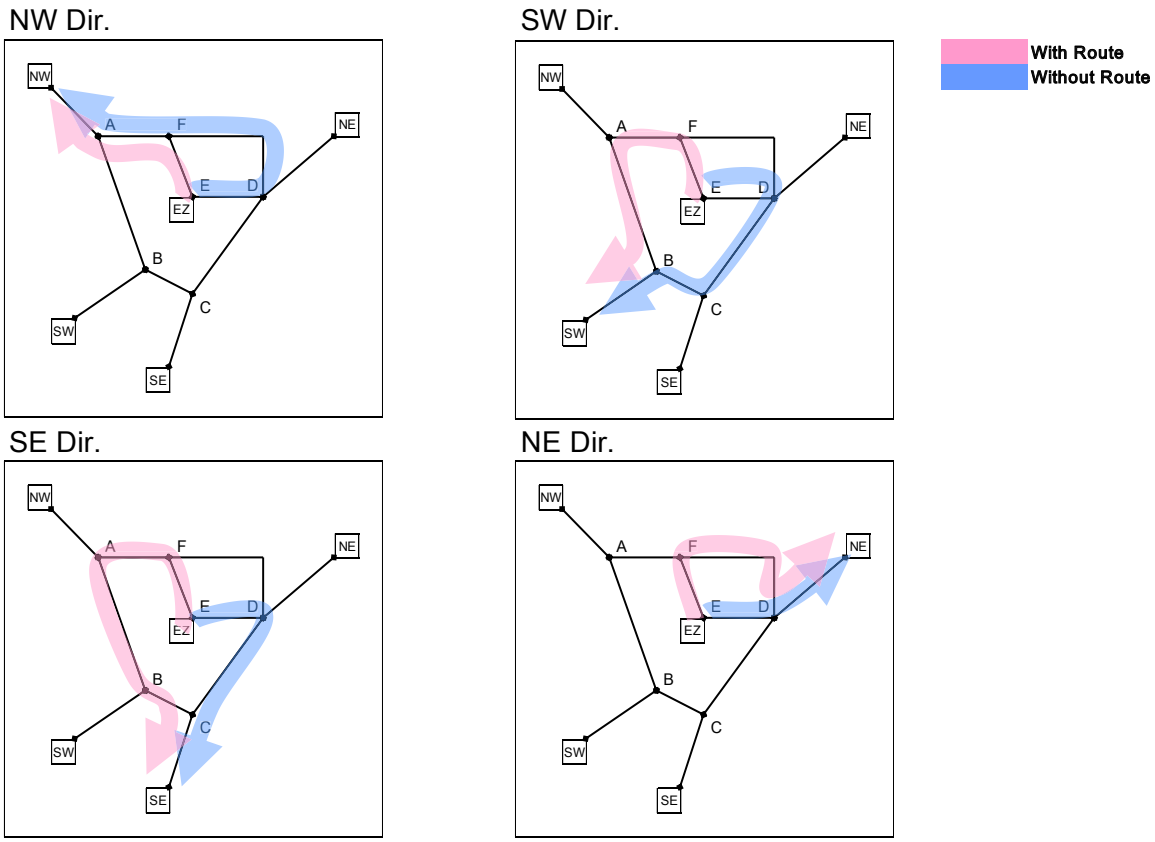
Auto rickshaw	Car	Bus	20ft Container	Medium Truck	Small Truck	Total
880	2,020	109	1,632	2,216	2,012	8,869

Source: JICA Study Team

Table 14.11.3 Traffic Demand by Direction in 2023 (vehicles/day)

Direction	Population Share	Number of Vehicles (vehicles/day)						
		Auto rickshaw	Cars	Busses	20ft Containers	Medium Trucks	Small Trucks	Total
SE	46%	405	929	50	751	1,019	925	4,079
NE	9%	79	182	10	147	200	181	799
SW	15%	132	303	16	245	332	302	1,330
NW	30%	264	606	33	489	665	604	2,661
Total	100%	880	2,020	109	1,632	2,216	2,012	8,869

Source: JICA Study Team



Note: AC section is assumed as 4 lanes
Source: JICA Study Team

Figure 14.11.2 Setting of With-Without Route

(4) Proposed Operation and Effect Indicators

The calculated operation and effect indicators of the baseline and 2 years after the project completion are shown in table below.

Table 14.11.4 Proposed Operation and Effect Indicators

Indicator		Target	Baseline	2 years after project completion
Operation Indicator	Freight traffic volume (pcu/day)	EZ bridge	NA	17,580
	Passenger vehicle traffic volume (pcu/day)		NA	3,007
Effect Indicator	Reduction of travel cost (million taka/year)	Total	0	2,810

14.11.2 Economic Analysis

(1) General

The economic analysis of the EZ Bridge and approach road construction is carried out by comparing the economic cost of the project with economic benefits, which will be generated by the bridge construction.

- Economic Internal Rate of Return (EIRR)
- Benefit/Cost Ratio (BCR)
- Net Present Value (PNV)

As for the implementation schedule, the project is proposed to be implemented according to the following schedule:

- 2016 - 2017 Detailed design
- 2018 Procurement of contractors
- 2019 - 2022 Construction of the EZ bridge and approach road
- 2023 Open to traffic

Project life is assumed to be 25 years from 2023-2047 and an opportunity cost of capital is assumed at 12% per annum.

(2) Traffic Demand on EZ

The traffic demand for the EZ bridge and related roads was already projected in the previous section. The projected traffic demand is shown in Table 14.11.2.

Table 14.11.5 Traffic Demand Forecast in EZ

	Heavy Truck	Medium Truck	Light Truck	Bus	Car	Auto Rickshaw	Total
2021	1,522	2,068	1,876	55	1,002	433	6,956
2026	1.351	1,809	2,458	145	2,826	1,250	8,489
2031	2,150	2,922	2,650	383	7,969	3,608	19,682
2036	2,346	3,188	2,891	541	11,537	4,807	25,309
2041	2,559	3,479	3,154	763	16,703	6,403	33,061
2046	2,792	3,795	3,441	1,078	24,181	8,530	43,817

(3) Economic Cost Estimate

The economic cost is calculated from the financial cost, taking into account the following factors:

- Escalation is not taken into account
- Administrative cost, VAT, and import duty are excluded

- Standard Conversion Factor (SFC) of 0.80 is adopted for tradable goods and services
- Land acquisition and compensation cost are included in the economic cost.

Table 14.11.6 Financial Cost and Economic Cost

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Source: JICA Survey Team Unit: million BDT

(4) Benefit Calculation

VOC and TTC savings from the new bridge construction is calculated from the following formulae:

$$B_{xc} = \sum_i AADT_{xi} \times (DL_0 \times VOC_{woi} - DL_w \times VOC_{wi})$$

$$B_{xt} = \sum_i AADT_{xi} \times (\frac{DL_o}{V_{woi}} - \frac{DL_w}{V_{wi}}) \times TTC_i$$

where:

B_{xc} = *VOC savings at year x*
B_{xt} = *TTC savings at year x*
$AADT_{xi}$ = *Average Annual Daily Traffic of vehicle type i in year x*
DL_{wo} = *Length in case of without project (km)*
DL_w = *Length in case of with project (km)*
VOC_{woi} = *Vehicle operating cost of vehicle type i in case of without project*
VOC_{wi} = *Vehicle operating cost of vehicle type i in case of with project*
TTC_i = *Travel time cost of vehicle type i (Taka/h)*
V_{woi} = *Vehicle operating speed of vehicle type i in case without project*

V_{wi} = *Vehicle operating speed of vehicle type i in case with project*

(5) Road User Cost (RUC)

The road user's cost was already estimated in Chapter 12. In this section, the same travel time cost and vehicle operating cost shown in Tables 14.11.4 and Table 14.11.6 are used for this analysis.

Table 14.11.7 Travel Time Cost (TTC) by Vehicle Type (as of 2014 Prices)

Vehicle Category	TTC per passenger	Average Occupancy	TTC per Vehicle
	(BDT/hr)	(Person / Veh)	(BDT/hr)
Car	64.9	3.2	207.1
Utility	64.9	3.2	207.1
Microbus	22.9	10.1	231.2
Mini Bus	37.0	32.0	1,182.7
Large Buses	37.0	44.0	1,626.2
Light Truck	-	-	200.0
Medium Truck	-	-	220.2
Heavy Truck	-	-	220.2
Auto Rickshaw	34.4	3.7	128.5
Motor Cycle	48.1	1.1	50.6

Note: Estimated based on "RHD Road User Cost Annual Report by FY 2004/05" and CPI between 2004 and 2014

Table 14.11.8 Vehicle Operating Cost by Road Roughness (prices as of 2014)

	Good	Fair	Bad	V. Bad
IRI	4	6	8	10
Car	19.57	20.75	21.92	23.33
Utility	19.45	21.10	23.48	26.80
Microbus	23.86	25.77	28.03	31.00
Minibus	23.94	25.20	26.42	27.82
Large Bus	28.81	31.33	34.08	37.90
Small Truck	22.66	24.82	27.01	29.40
Medium Truck	27.09	29.36	31.77	34.40
Heavy Truck	29.88	32.38	37.17	40.25
Auto Rickshaw	4.87	5.12	5.42	5.75
Motor Cycle	2.73	2.81	2.86	2.88

Note: Estimated based on "RHD Road User Cost Annual Report by FY 2004/05" and CPI between 2004 and 2014

Table 14.11.9 Vehicle Operating Cost by Road Roughness (prices as of 2014)

Vehicle type	IRI	Travel Speed (km/h)
Good	4	60
Fair	6	40
Bad	8	30
V. Bad	10	20

(6) Benefit Calculation

Using the above mentioned input data and formula, the economic benefits in terms of vehicle operating costs and travel time costs are estimated as shown in Table 14.11.7.

Table 14.11.10 Estimation of Economic Benefits by Construction of the EZ Bridge and Road

Unit: BDT Million

Year	VOC					TTC					Total
	Truck	Large Bus	Car	Baby-Taxi/ CNG	Total	Truck	Large Bus	Car	Baby-Taxi/ CNG	Total	
2021	692	124	1,357	144	2,318	230	75	203	54	561	2,880
2025	880	122	1,418	154	2,575	292	74	212	58	636	3,210
2030	1,188	120	1,498	168	2,974	394	72	224	63	753	3,727
2035	1,603	119	1,599	185	3,506	532	71	237	69	908	4,414
2040	2,164	117	1,671	198	4,149	717	70	250	74	1,112	5,261

Source: JICA Study Team

(7) Economic Analysis

Using the economic cost and economic benefits, the economic cash flow analysis is made and the result is shown in Table 14.11.8. Judging from the economic indicators, the construction of the EZ Bridge and road is economically feasible.

Table 14.11.11 Result of Economic Analysis

Economic Indicator	
EIRR (%)	28.20%
BCR	4.61
NPV(BDT million)	14,922.25

Table 14.11.12 Discounted Cost and Benefit Flow

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Source: JICA Study Team

(8) Sensitivity Analysis

The sensitivity analysis of the economic analysis is conducted for

- Project costs fluctuation (±10%),
- Benefit fluctuation (±10%),

The results of the sensitivity analysis by project cost and benefits are shown in Table 14.12.10.

Even if the project cost is increased by 10% of the original construction cost and O/M cost, the EZ Bridge and Road Project is economically feasible.

Table 14.11.13 Sensitivity Analysis

Factor	Economic Indicator	EIRR (%)
Project cost	Base Case	28.2%
	10% increase in every year	26.9%
	10% decrease in every year	29.6%
Benefit	Base Case	28.2%
	10% increase in every year	29.5%
	10% decrease in every year	26.8%

Source: JICA Study Team

14.12 Environmental and Social Considerations

14.12.1 Environmental and Social Considerations

(1) Project Components which may cause impacts

For Project Components that may cause impacts, refer to 14.1.

(2) Present Natural and Social Condition

1) Climate and Temperature

For Climate and Temperature, refer to 4.3.2

2) Topography and Geology

For Topography and Geology, refer to 4.2

3) Air Quality

The PM_{10} concentration standard is 500μg/m^3 for industrial and a mixed zone and is 100μg/m^3 for a sensitive zone. In this study, it has been observed that the PM_{10} concentration at the EZ Bridge sites is much below the standard limit of industrial & mixed or commercial & mixed and also lower than residential & rural standard. But this only exceeds the limit of the national standard category of sensitive areas. The national gaseous pollutant standard limit is 0.045ppm for SO_2, 4.36ppm for CO and 0.053ppm for NOx. For the EZ bridge sites, the gaseous pollutant concentration was below the standard limit. The average carbon dioxide concentration was about 480ppm. But the bridge site was found to be 530ppm, which is a bit higher due to the brickfield near the vicinity of the bridge site. The higher gaseous concentration was observed in the sampling points, which were located either in busy areas or near the industrial area or brickfields. The concentrations of NOx and SO_2 were found either in trace amounts or below the detection range.

Table 14.12.1 Air Pollution Data at EZ Bridge Site

Date of Sampling	Location	Air Pollution Parameter	
25-08-14	Kaliganj	Avg. Temperature (C^0)	32.3
		PM_{10}(Micro gm/m^3) at STP	122
		SPM(Micro gm/m^3) at STP	230
		NO_X (ppm)	0.020
		SO_2 (ppm)	0.066
		CO_2 (ppm	530
		CO (ppm)	1.000

Source: BUET 2014

4) Water Quality

Surface and ground water samples near points of the proposed EZ bridge have been collected and tested for different parameters according to the methods described earlier. Apart from a few exceptions, most of the water parameters were found to be consistent and within the limit proposed by the Environment Conservation Rules, (ECR), 1997 of the Government of Bangladesh.

Table 14.12.2 Water Pollution Status at EZ Bridge Site

Date of Sampling	Parameters	Surface Water	Ground Water	Remarks
25-08-14	Temperature (C^0)	32.3	31.1	N/A not applicable
	DO(mg/L	3.60	2.47	
	BOD_5 (mg/L)	2.70	0.92	
	SS (mg/L)	0.194	N/A	
	Turbidity (FAU)	173	NA	
	pH	7.2	6.8	
	Conductivity(mS/cm	N/A	1.094	

Source : BUET 2014

5) Noise and Vibration

The noise level was monitored for each selected site. All of them show that the average noise level was below the standard limit (~80 dB).

Table 14.12.3 Noise Level at EZ Bridge Site

Date of Sampling	Time	Average Noise Level count (dB)	Total Vehicles for 10 minutes
25-08-14	9.00 AM	63	7
	10.00 AM	62	9
	11.00 AM	62	6
	12.00 PM	62	10
	1.00 PM	63	9
	2.00 PM	64	14
	3.00 PM	66	12
	4.00 PM	66	9

Source: BUET 2014

6) Ground Subsidence

For Ground Subsidence, refer to 13.1.2

7) Bottom Sediment

For Bottom Sediment, refer to 13.1.2

8) Fauna and Flora

For Fauna and Flora, refer to 13.1.2

9) Water Use

Water available in the Shitalakshya River is used for household utilities, navigation, capture fisheries, agriculture, and industries. People on riverbanks use river water for domestic uses, bathing, washing, and for cleaning domestic animals. The Shitalakshya River according to IWTA is a classified navigation route: many industries grew on the banks, and many fishermen depend on Shitalakshya to earn a livelihood. Additionally, water is used for agriculture practice.

10) Protected Area

For Protected Area, refer to 13.1.2

11) Soil and Land Use

For Soil and Land Use, refer to 13.1.2

12) Cultural Heritage

For Cultural Heritage, refer to 13.1.2

13) Indigenous and Ethnic Minority

Presently no indigenous people live at the EZ Bridge site.

14) Health Care Facilities

For Health Care Facilities, refer to 13.1.2

15) Educational Institutions

For Educational Institutions, refer to 13.1.2

16) HIV/AIDS

For HIV/AIDS, refer 13.1.2

17) Gender

For Gender, refer to 13.1.2

18) Children's Rights

For Children's Rights, refer to 13.1.2

19) Climate Change

For Climate Change, to refer 4.4

20) Fisherman Communities

For Fisherman Communities, refer to 13.1.2

21) Landscape

For Landscape, refer to 13.1.2

(3) EIA System in Bangladesh

For EIA System in Bangladesh, refer to 13.1.3.

(4) Alternatives

For Alternatives, refer to 14.2.

(5) Assessments of Impact

For Assessments of Impact, refer to 13.1.5.

(6) Mitigation Measures and Its Cost

For Mitigation Measures and Its Cost, refer to 13.1.6 and below tables.

Table 14.12.4 Estimates for Environmental Monitoring Costs borne by Contractor

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Note: Costs mentioned above shall be borne by the Project implementation Contractor(s)

Table 14.12.5 Estimates for Environmental Monitoring Costs borne by RHD

Confidential

Note: Costs for I + II related to land acquisition and resettlement

(7) Environmental Monitoring Plan (EMP)

For EMP, refer to 13.2.9

14.12.2 Land Acquisition and Resettlement

(1) Necessity of Land Acquisition and Resettlement

The project is to provide a new bridge, which will connect the existing R301 and the EZ, including an access road. It is observed that only a small number of people (less than 200 or maybe even fewer) are to be affected due to the relevant activities. By following OP 4.12 of WB when impacts on the entire displaced population are minor, or if fewer than 200 people are displaced at a site, an Abbreviated Resettlement Plan (ARP) needs to be prepared for the project.

(2) Legal Framework of Land Acquisition and Resettlement

For the legal framework of land acquisition and resettlement, refer to 13.2.2

(3) Gap between JICA's Guidelines and related Ordinance in Bangladesh

For the gap between JICA's Guidelines and related ordinances in Bangladesh, refer to 13.2.3

(4) Census and Socio-economic Survey

Number of project-affected households for each Upazila is shown in the Table 14.12.6.

Table 14.12.6 Project Affected Households for Each Upazila

Project	District	Upazila	No of HHs (Land with structure and trees)	No of residence loose people
EZ Bridge	Gazipur	Kaliganj	20	104
	Narsingdi	Palash	19	86
	total	Sub-total	39	190

Source: Census & Socioeconomic survey, July 2014

Out of the total, 39 units are affected in other residential households wards identified on the Corridor of Impact (CoI). All the affected households are losing land, structures, and trees. A total of 3,709 square meters in different categories of structures will be affected by the interventions. The impact of this project is shown in Table 14.12.7.

Table 14.12.7 Distribution of Impacts of the Project

Sl No	**Loss type**	**No/Total**
1	Total quantity of land (hectares) affected	12.49
2	Total number of households (land with structures) affected	39
3	Total number of structures affected	81
4	Total quantity of structures (Sqm) affected	3,709
5	Total no. of toilets affected	36
6	Total no. of tube wells affected	34
7	Total no. of trees on private land affected	12,259

Source: Census & Socioeconomic survey, July 2014

(5) Eligibility Policy and Entitlement Matrix

For Eligibility and Entitlement Matrix, refer to 13.2.5

(6) Implementation Organization

For Implementation Organization, refer to 13.2.6

(7) Implementation Schedule

For Implementation Schedule, refer to 13.2.7

(8) Resettlement and Compensation Costs & Budget

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(9) Monitoring and Evaluation

For Monitoring and Evaluation, refer to 13.2.9

(10) Local Stakeholder Meeting

For Local Stakeholder Meeting, refer to 13.2.10 and;.

1) Meetings Phase I

In the initial stage of the project in July 2014, the local potentially affected persons of the project area along with local community leaders and other stakeholders like RHD representatives and local government representatives were consulted through consultation meetings and personal contact. Summary of consultation meetings with affected people and other stakeholders are described in Table 14.12.9.

Table 14.12.8 Stakeholders Consultation Phase I

Sl. No. Dates of holding meetings	Type of Participants & Methodology	Issues Discussed	Outcome of the discussion
9 July 2014,	A total of three stakeholders meetings were held in the project area. People attended the meeting including farmer, homestead owner, service holder, community leader, RHD representative, Local government representatives (Chairman, member) etc.	Issue based discussion was held on community people's perception, attitude, needs and aspiration from the project. Following issues were discussed along with their raised issues: - Knowledge of people about the project - Attitude of the people towards the project - Major problems relating to the project, - Proposed suggestion to minimize the problem - Identification of alternate location/alignment of the proposed bridge - Potential benefit of the project for the locality, - Need of the project, specifically the proposed bridge for that area - Relocation of houses and other establishments - JICA's Guidelines for Environmental and Social Considerations - Gender issues, especially the local practice/attitude about women working in construction site.	a. The bridge location should be downstream than that of the present location, near Kanchan bridge or Kanchan bridge can be used for the purpose instead of building new one; b. Wide and four lane bridge is required for better communication and transportation of the commodities; c. New bridge at proposed location can be constructed but existing road network through widening can be used instead of proposed new access road. This way land acquisition can be reduced. d. Proper compensation for land, crops, fishes etc. to be paid; e. Local people should be employed during construction of the new bridge irrespective of gender; f. Try to build the bridge and road on government khas land rather than on private land g. Facilities for using river water will be kept undisturbed for the community

Source: ARP September, 2014

2) Meetings Phase II

After finalizing the project location and completion of the detailed design, community-level stakeholder consultations were held at the project site. A total of three stakeholders consultation meetings (Teury, Alua Bazar (Hannan Market) and Chowari Khola) were held on 19 August 2014. However, local people did not agree with the landaquisition required for the access road which must cross their private land, and proposed the alternative access roads. In response to the proposal, the survey team consulted with JICA and RHD and planned to hold 3rd round meeting. Summary of consultation meetings with affected people and other stakeholders are described in Table 14.12.10.

Table 14.12.9 Stakeholders Meeting Phase II

Dates of holding meetings	Type of Participants & Methodology	Issues Discussed	Outcome of the discussion
19 August 2014	A total of three stakeholders meetings were held in three locations in the project area. People attended the meeting including farmer, homestead owner, service holder, community leader, RHD representative, Local government representative Chairman/Member etc.	Issue based discussion was held on community people's perception, attitude, needs and aspiration from the project. Following issues were discussed along with their raised issues: - Impact (positive and negative) of the project & mitigation measures against negative impact, - Policy of compensation and resettlement grants for land, crops, houses on private, -Discloser of the compensation packages for different kinds of losses. Additional assistance for the vulnerable and others were also discussed, - People's preference on mode of compensation payment - Relocation of houses and other establishments - JICA's Guidelines for Environmental and Social Considerations - Cut-off date for listing	a. Entitlements of the affected people and cut-off-date for listing of the lost properties are known to the people b. Land price should be fixed on open market rate and compensation should be paid at their door step before displacement; c. Proper compensation for land, crops, trees etc. to be paid d. People will be encouraged for self-relocation for living within the kin groups with mutual support. e. Access road could follow the existing road by widening it instead of acquiring private land f. Access road can be constructed by following the flood protection embankment along the river on government land rather than private

Dates of holding meetings	Type of Participants & Methodology	Issues Discussed	Outcome of the discussion
		affected properties i.e. date of 2nd phase stakeholders consultation meeting (19 August 2014) for indirect EPs and notice under section 3 is for land owners. - Training and cash grant for vulnerable households, etc. - Gender issues, especially the scope of work for women in project civil work.	land g. One very old graveyard is going to be affected, they do not want that h. The affected household wants alternate land rather compensation money, it would be difficult to get alternate land in the locality and cost would be too high and beyond their buying capacity i. Vulnerable APs will be preferentially employed in the civil construction of the project on the basis of their qualification end eligibility irrespective of gender. j. Facilities for using river water will be kept undisturbed for the community k. Training on some income generating activities should be provided to the poor. l. People know their right and responsibilities at the initial stage of the project by FGD, consultation, information campaign, etc.

Source: ARP September, 2014

3) Meetings Phase III

Their demand was same as of 2nd round meeting; (a) they want the bridge, (b) the existing embankment road should be widened to build the approach/access road, (c) they will not allow road to be built by acquiring new lands inflicting damage to the lands and properties of the people and (d) if the authorities decide against their proposal they will oppose

vehemently and organize agitations. Summary of consultation meetings with affected people and other stakeholders is described in Table 14.12.11.

Table 14.12.10 Stakeholders Meeting Phase III

Dates of holding meetings	Type of Participants & Methodology	Issues Discussed	Outcome of the discussion
24 November 2014	A total of three stakeholders meetings were held in three locations in the project area. People attended the meeting including farmer, homestead owner, service holder, community leader, RHD representative, Local government representative Chairman/Member etc.	- Impact (positive and negative) of the project & mitigation measures against negative impact, - Policy of compensation and resettlement grants for land, crops, houses on private, - Discloser of the compensation packages for different kinds of losses. Additional assistance for the vulnerable and others were also discussed.	a. Local people want the bridge b. They proposed that the existing embankment road should be widened to build the approach/access road c. They will not allow road to be built by acquiring new lands inflicting damage to the lands and properties of the people and; d. If the authorities decide against their proposal they will oppose vehemently and organize agitations.

Source: ARP February, 2015

4) Meetings Phase IV

The 4th round SHM was held at the request of the RHD in order to assess if there had been any change in the observations and demands of the stakeholders since the last SHMs held on 24 Nov 2014.

The State Minister for Women and Children Affairs of the GoB, Ms. Meher Afroze Chumki had agreed to attend and chair the meeting.

As a result, both Government of Bangladesh and APs/stakeholders agreed that (a) Compensation is a replacement cost based on a market price, (b) Payment will be made to avoid Middlemen/Agency, (c) Compensation package should be circulated before acquisition, (d) Suitable land area to build house for displaced people will be considered.

With adequate and proper handling of the acquisition/resettlement process the APs/stakeholders unanimously consented in favour of the project and the road alignment. Summary of consultation meetings with affected people and other stakeholders is described in Table 14.12.12.

Table 14.12.11 Stakeholders Meeting Phase IV

Dates of holding meetings	Type of Participants & Methodology	Issues Discussed	Outcome of the discussion
06 February 2015	Meeting was held in the Tumulia Union where locates in the project area. People attended the meeting including farmer, homestead owner, service holder, community leader, State Minister, RHD representative, Local government representative Chairman, Member of Tumulia Union etc.	- Alternative routes for bridge and access - Discloser of the compensation packages for different kinds of losses. - Methods of restoration the livelihoods - Methods of land acquisition and resettlement monitoring	a. Compensation is a replacement cost based on a market price b. Payment will be made to avoid Middlemen/Agency c. Compensation package should be circulated before acquisition d. Suitable land area to build house for displaced people will be considered

Source: ARP February, 2015

15. IMPLEMENTATION PLAN

15.1 Introduction

106 bridges were selected as the candidate bridges of the Project in "3. Selection of Project Bridges." It was confirmed that the construction of 105 bridges[12] respectively is economically feasible based on the preliminary design, cost estimates, economic analysis, etc. of the 105 bridges.

In this chapter, the bridges to be implemented in this Project are selected in the 106 candidate bridges. In addition, the implementation organization, the implementation schedule, and the contract package are proposed in order to implement the Project effectively and successfully.

15.2 Selection of Project Bridges

15.2.1 Project Bridges Selection Criteria

The Project bridges are selected from the 106 candidate bridges by the following evaluation items of selection criteria.

1. Damage Level & Construction Year

The oldest and most damaged bridges should be improved preferentially in the limited budget. Higher priority is given to bridges with Damage Level D that are more than 30 years old.

2. Middle-sized Bridges

Middle-sized bridges requiring higher technology for design and construction, which would involve a technology transfer through the Project implementation, are given higher priority.

3. Road Type

Future widening will be implemented according to the traffic demand and traffic capacity of

[12] 106 bridges were selected as the candidate bridges in Chapter 3. However the preliminary design was conducted for 105 bridges since it was confirmed that 1 bridge is under construction in another project.

each road. Higher priority is given to those bridges that would have to cope with high traffic demand.

4. Expectation by Stakeholders

Higher priority is given to the bridges that are expected by the stakeholders.

5. Constructability

Less priority is given to the bridges requiring special soft soil treatment (cement mix, piled slab, etc.) in the approach road, since special soft soil treatment has a high cost and faces difficulties in the construction.

6. Economically Not Viable

The bridges with EIRR less than 12 % are dropped from the list.

7. Inclusion in Other Projects

The bridges already included or to be included in other projects are dropped from the list to avoid overlapping.

8. Construction Difficulties

The bridges that are expected to face significant construction difficulties are dropped from the list. These difficulties include construction of large scale retaining walls, steel girder transportation in narrow Zilla Roads, etc.

Weight and point of each evaluation item is shown in Table 15.2.1

Table 15.2.1 Project Bridges Selection Criteria

Item	Weight	Point	Criteria
1. Damage Level & Construction Year	7	4	Level D, and more than 30 years after construction
		2	Level D, but within 30 years after construction
		0	Other Levels
2. Middle Sized Bridge	7	4	Middle sized bridge
		0	Small sized bridge
3. Road Type	5	4	National highway
		2	Regional highway
		0	Zilla road
4. Expectation by Stakeholders	3	4	Expected by stakeholders in the stakeholder meetings
		0	Not expected by stakeholders in the stakeholder meetings
5. Constructability	3	4	Not requiring special soft soil treatment (cement mix, piled slab, etc.) in approach road
		0	Requiring special soft soil treatment (cement mix, piled slab, etc.) in approach road
6. Economically Not Viable	Drop		EIRR Less than 12 %
7. Inclusion in Other Projects	Drop		Already included or to be included in other projects
8. Difficulties for Construction	Drop		Significant difficulties for Construction
	Total score=100		

Source: JICA Survey Team

15.2.2 Project Bridges Selection

As a result of evaluation by the project bridge selection criteria, the top 60 bridges were initially selected as the project target bridges. However, 2 bridges shown in Table 15.2.2 were dropped from the list.

Table 15.2.2 2 Bridges Dropped from the List

Rank	SN	Zone	Bridge Name	Road Type	Bridge Type	Reason to add in the list
2	16	Rajshahi	Nukali Bridge	N	Steel-I	New bridge is not required since the existing canal has not already been used.
38	46	Rangpur	Ichamoti Bridge	N	PC-I	Agreement from PAPs for the bridge construction has not been obtained.

*SN (Serial Number) is equivalent to rank in selection of 106 project candidate bridges

Source: JICA Survey Team

In place of the above 2 bridges, another 2 bridges shown in Table 15.2.3 were added to the list.

Table 15.2.3 2 Bridges Added to the List

Rank	SN	Zone	Bridge Name	Road Type	Bridge Type	Reason to add in the list
66	74	Rajshahi	Naiori Bridge	R	PC-I	- On regional road - Expected by SHs - No difficulties in construction - In Rajshahi
73	79	Rangpur	-	N	PC-I	- On national highway - Expected by SHs - No difficulties in construction - In Rangpur

*SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges

Source: JICA Survey Team

Finally, 61 bridges including 60 bridges in Western Bangladesh and the EZ Bridge were selected as the project target bridges. The final 61 bridges are shown in Table 15.2.4 and Figure 15.2.1.

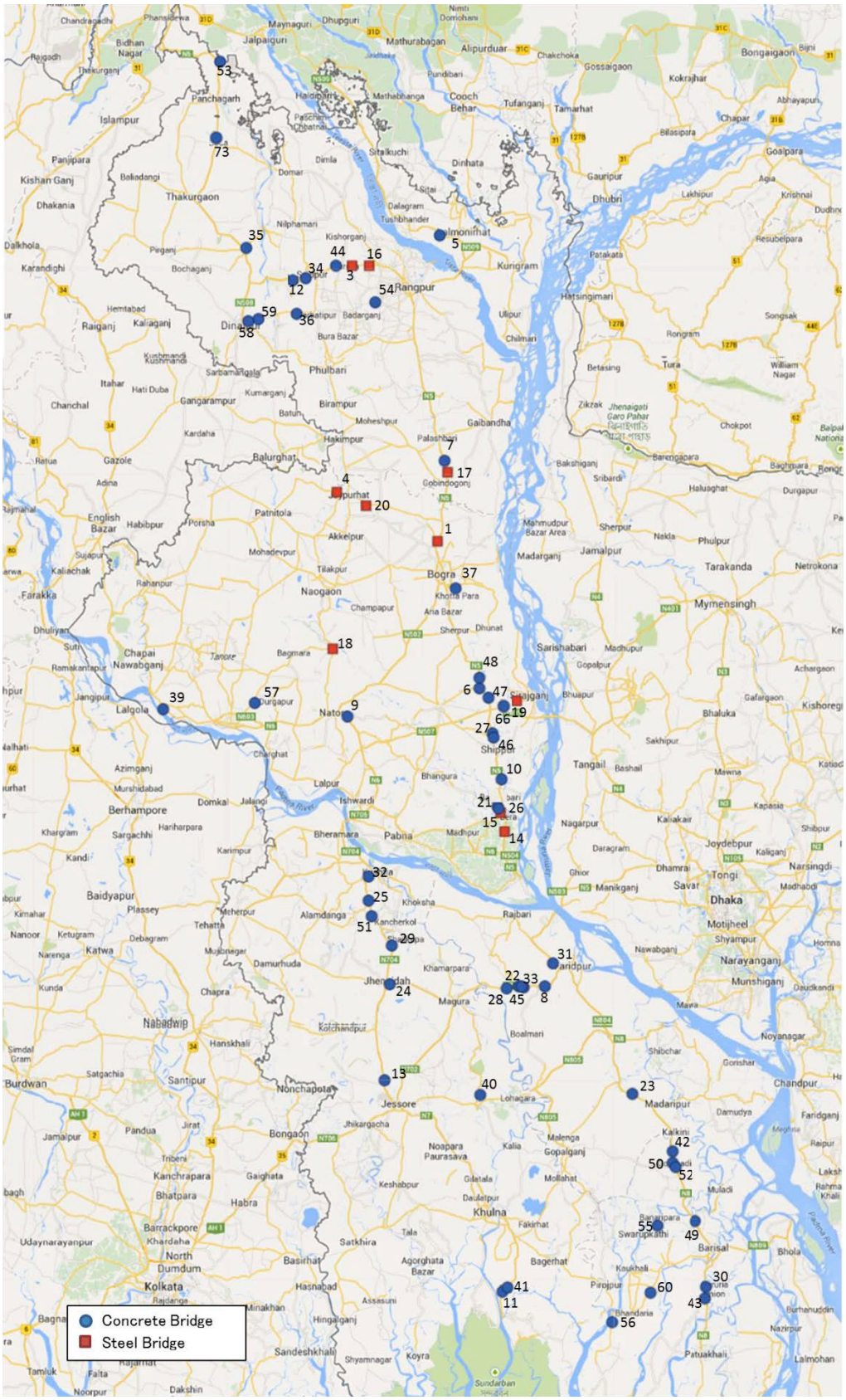
Table 15.2.4 2 List of Final Project Bridges

Rank	SN	Zone	District	Bridge Name	Road Type	Bridge Type	Span Arrangement (m)
1	6	Rangpur	Bogra	Mohosthan Bridge	N	Steel-I	40+40+40
3	11	Rangpur	Rangpur	Barati Bridge	N	Steel-I	40+40+40+40
4	62	Rangpur	Joypurhat	Mongle bari kuthibari Bridge	R	Steel-I	40+50
5	2	Rangpur	Lalmonirhat	Sharnamoti Bridge	N	PC-I	35+35
6	5	Rajshahi	Sirajganj	Bhuyagati Bridge	N	PC-I	25+30+25
7	10	Rangpur	Gaibandha	Bupinath Bridge	N	PC-I	35+25
8	14	Gopalganj	Faridpur	Karimpur Bridge	N	PC-I	40+25
9	17	Rajshahi	Natore	Dattapara Bridge	N	PC-I	40.0
10	19	Rajshahi	Sirajganj	Jugnidaha Bridge	N	PC-I	40+25
11	22	Khulna	Bagerhat	Gora bridge	N	PC-I	30
12	31	Rangpur	Dinajpur	Gaudangi Bridge	N	PC-I	40+25
13	39	Khulna	Jessore	Buri Bhairab Bridge	N	PC-I	35
14	20	Rajshahi	Pabna	Punduria Bridge	N	Steel-I	40+50+40
15	37	Rajshahi	Pabna	Vitapara Bridge	N	Steel-I	60+40
16	45	Rangpur	Rangpur	Kharua Vanga Bridge	N	Steel-I	40.0
17	66	Rangpur	Gaibandha	Katakhali Bridge	N	Steel-I	60+60+50
18	28	Rajshahi	Naogaon	Atrai Bridge	R	Steel-I	50+50+60
19	75	Rajshahi	Sirajganj	Chondi Das Bridge	R	Steel-I	40+40
20	76	Rangpur	Joypurhat	Bottoli Bridge	R	Steel-I	40+40
21	8	Rajshahi	Pabna	Goilhar Bridge	N	PC-I	35+25
22	15	Gopalganj	Faridpur	Porkitpur Bridge	N	PC-I	30
23	26	Gopalganj	Madaripur	Amgram bridge	N	PC-I	40
24	41	Khulna	Jhenaidah	Dhopa Ghata Bridge	N	PC-I	25+30+40+30+25
25	44	Khulna	Kushtia	Balipara Bridge	N	PC-I	40
26	4	Rajshahi	Pabna	Palgari Bridge	N	PC-I	35+25
27	9	Rajshahi	Sirajganj	Purbodalua Bridge	N	PC-I	25+30+25
28	23	Gopalganj	Faridpur	Barashia Bridge	N	PC-I	25+40+25
29	43	Khulna	Jhenaidah	Barda Bridge	N	PC-I	40+40+25
30	1	Barisal	Barisal	Boalia Bazar Bridge	N	PC-I	40
31	13	Gopalganj	Faridpur	Jhuldibazar Bridge	N	PC-I	30
32	21	Khulna	Kushtia	G.K. Bridge	N	PC-I	30+25
33	32	Gopalganj	Faridpur	Bimankanda bridge	N	PC-I	35+25
34	38	Rangpur	Nilphamari	Khorkhori bridge	N	PC-I	35+25
35	88	Rangpur	Dinajpur	Choto Dhepa bridge.	Z	PC-I	30+25
36	90	Rangpur	Dinajpur	Bondorer pool Bridge	Z	PC-I	30+30

Rank	SN	Zone	District	Bridge Name	Road Type	Bridge Type	Span Arrangement (m)
37	91	Rangpur	Bogra	Khottapara Bridge	Z	PC-I	40.0
39	18	Rajshahi	Rajshahi	Horisonkorpur Bridge	R	PC-I	25+25
40	40	Khulna	Narail	Gurakhali Bridge	R	PC-I	30+25
41	25	Khulna	Bagerhat	Balai bridge.	N	PC-I	25+35
42	64	Barisal	Barisal	Souderkhal bridge	N	PC-I	35
43	12	Barisal	Barisal	Bakerganj Steel Bridge	N	PC-I	35
44	24	Rangpur	Rangpur	-	N	PC-I	30.0
45	30	Gopalganj	Faridpur	Brahmonkanda Bridge	N	PC-I	30
46	33	Rajshahi	Sirajganj	Chowkidhoh Bridge	N	PC-I	35+25
47	34	Rajshahi	Sirajganj	Notun Dhoh Bridge	N	PC-I	35+25
48	35	Rajshahi	Sirajganj	Dhatia Bridge	N	PC-I	40+25
49	56	Barisal	Barisal	Rahamatpur bridge	N	PC-I	30+30
50	57	Barisal	Barisal	Gounagata bridge	N	PC-I	35
51	67	Khulna	Kushtia	Bittipara Bridge	N	PC-I	35
52	69	Barisal	Barisal	Asokoti bridge	N	PC-I	30
53	80	Rangpur	Panchagarh	Chawai Bridge	N	PC-I	35+35
54	89	Rangpur	Rangpur	Shampur Bridge.	Z	PC-I	35.0
55	82	Barisal	Barisal	Raiyer hat bridge	Z	PC-I	25+25
56	65	Barisal	Pirojpur	Bottala Bridge	Z	PC-I	35
57	87	Rajshahi	Rajshahi	Faliarbil Bridge	Z	PC-I	35.0
58	49	Rangpur	Dinajpur	Gabura Bridge.	Z	PC-I	30+30+30
59	52	Rangpur	Dinajpur	Madarganj Bridge	Z	PC-I	25+30+40
60	78	Barisal	Jhalokati	Afalbarir Khal Bridge	Z	PC-I	40
66	74	Rajshahi	Sirajganj	Naiori Bridge	R	PC-I	30+30
73	79	Rangpur	Panchagarh	-	N	PC-I	35
EZ	-	Dhaka	District	EZ Bridge	-	Steel-Box, PC-I	13@30+60+85+60+8 @30

*SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges

Source: JICA Survey Team



Note: The number in the Figure indicates the rank in selection of 60 project bridges.
Source: JICA Survey Team

Figure 15.2.1 Map of Final Project Bridges

15.3 Contract Package for 61 Bridges

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15.4 Cost Estimates for 61 Bridges

15.4.1 Civil Work Cost for 61 Bridges

(1) Civil Work Cost for 60 bridges in Western Bangladesh

The civil work cost for 60 bridges in Western Bangladesh is shown in Table 15.4.1.

(2) Civil Work Cost for the EZ Bridge and Road

Refer to 15.10.

Table 15.4.1 Civil Work Cost for 60 bridges in Western Bangladesh

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*SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges

15.4.2 Project Cost for 61 Bridges

The project cost for 61 bridges is shown in Table 15.4.2.

Table 15.4.2 Project for 61 Bridges

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Unit: (JPY million)

Notes: 1. Exchange Rate: US$ 1= Tk 77.5 = JPY119
2. Price Escalation: 2.0% per annum (Foreign Currency Portion), 4.9% per annum (Local Currency Portion)
3. Physical Contingency: 5% for consulting services, 10% for civil works
4. Base Year for Cost Estimation: January 2015

15.5 Project Effect for 61 Bridges

Economic analyses for 105 bridges in Western Bangladesh and the EZ Bridge and Road were carried out in “12.2.5 Results of Economic Evaluation” and “14.11.2 Economic Analysis,” respectively.

The result of the economic analysis for 61 bridges is shown in Table 15.5.1.

Table 15.5.1 Result of Economic Analysis for 61 Bridges

EIRR (%)	25.48%
BCR	2.72
NPV (BDT million)	161.03

Source: JICA Survey Team

15.6 Land Acquisition and Resettlement for 61 Bridges

(1) Land Acquisition and Resettlement for 60 Bridges in Western Bangladesh

The Land acquisition and resettlement for 60 bridges in Western Bangladesh is summarized in following tables. The number of AHs and APs are 346 and 1,628 respectively.

Table 15.6.1 Distribution of Impacts by Zone

No	Loss type	Zones					Total
		Rangpur	Rajshahi	Gopalganj	Khulna	Barisal	
1	Total number of bridges	19	16	7	9	9	60
2	Total quantity of land (ha) affected	10.51	6.41	0.90	1.67	1.50	20.99
2.a	Total quantity of Residential/Commercial land (ha) affected	1.16	1.82	0.19	0.42	0.84	4.43
2.b	Total quantity of Agriculture/Others land (ha) affected	9.62	4.32	0.72	1.25	0.66	16.56
3	Total of displaced households	64	126	76	62	18	346
4	Total of displaced people	301	561	345	337	84	1,628
5	Total Project Affected Units (PAUs)	426	349	45	285	459	1,564
6	Total Households affected*1	100	167	25	121	88	501
7	Total commerce and business enterprises (CBEs) affected*1	304	176	20	156	362	1,018
8	Total community property (CPR) affected	22	6	0	8	9	45
9	Total number of structures affected	10.7876	6.1337	0.9034	1.6661	1.4999	21
9.a	Total quantity of all structure (sqm) affected	1	2	0	0	1	4
9.b	Total quantity of residential structure (sqm) affected	10	4	1	1	1	17
9.c	Total quantity of commercial structure (sqm) affected	426	349	45	285	459	1,564
9.d	Total quantity of CPR structures (sqm) affected	100	167	25	121	88	501
10	Total no. of toilets affected	304	176	20	156	362	1018
11	Total no. of tube wells affected	22	6	0	8	9	45
12	No. of trees on private land affected	13,171	8,413	2,156	6,935	3,689	34,364
13	No of trees on government land affected	1,970	1,374	1,408	1,153	334	6,239

*1: Households (HHs) are defined as land with residential structures & trees, residential structures, rented residential structures, private trees, and other various items (ponds, fish, gate etc.)

*2: Commerce, Businesses and Enterprises (CBEs) are defined as land with business structures & trees, business structures, or rented business structures

Source: JICA Survey Team

Table 15.6.2 Displaced Number of Households by Bridge

Rank	Serial No.	Bri. ID	Number of Residence lose Households	Number of Residence lose People	Rank	Serial No.	Number of Residence lose Households	Number of Residence lose People	Number of Residence lose People
Zone: Rangpur					Zone: Rajshahi				
1	6	N5_235a	1	5	6	5	N5_176a	3	19
3	11	N5_350b	1	6	9	17	N6_97a	26	101
4	62	R545_115c	15	76	10	19	N5_140a	8	43
5	2	N509_19a	4	12	14	20	N5_118a	21	87
7	10	N5_265a	1	4	15	37	N5_126a	4	22
12	31	N5_378a	0	0	18	28	R548_28b	9	40
16	45	N5_344c	2	9	19	75	R451_7a	0	0
17	66	N5_260b	5	17	21	8	N5_128a	0	0
20	76	R550_28b	0	0	26	4	N5_127a	8	32
34	38	N518_4a	2	9	27	9	N5_158a	6	32
35	88	Z5008_1a	9	44	39	18	R681_10a	31	152
36	90	Z5025_46a	3	16	46	33	N5_156a	4	11
37	91	Z5040_4a	7	37	47	34	N5_172a	3	11
44	24	N5_356a	1	3	48	35	N5_179a	2	7
53	80	N5_488a	0	0	57	87	Z6010_12b	0	0
54	89	Z5024_5c	1	2	66	74	R451_1a	1	4
58	49	Z5025_64a	2	8	Zone: Khulna				
59	52	Z5025_60a	1	2	11	22	N7_248c	5	19
73	79	N5_458a	9	51	13	39	N7_141b	7	37
Zone: Gopalganj					24	41	N703_Sd	15	58
8	14	N7_039a	3	15	25	44	N704_33b	1	5
22	15	N7_049a	1	7	29	43	N704_14a	3	12
23	26	N8_095a	1	6	32	21	N704_43a	14	63
28	23	N7_054a	12	51	40	40	R720_44a	16	86
31	13	N7_025a	1	5	41	25	N7_246a	13	56
33	32	N7_047a	0	0	51	67	N704_27b	2	9
45	30	N7_048a	0	0	Zone: Barisal				
					30	1	N8_178a	9	51
					42	64	N8_123a	6	32
					43	12	N8_182a	5	45
					49	56	N8_152c	4	15
					50	57	N8_127b	12	54
					52	69	N8_129a	6	40
					55	82	Z8033_017a	15	77
					56	65	Z8701_3d	1	4
					60	78	Z8708_1c	4	19

Table 15.6.3 Zone-wise Number of Bridges and Project affected Units

Zone	Districts	Number of bridges	Project Affected Units (PAUs)			
			No. of HHs*1	No. of CBE*2	No. of CPRs	Total
Rangpur	Bogra	2	15	13	1	31
	Dinajpur	5	24	84	2	115
	Gaibandha	2	7	1	0	10
	Joypurhat	2	17	73	1	93
	Lalmonirhat	1	10	0	0	11
	Nilphamari	1	5	26	7	39
	Panchagarh	2	12	93	5	112
	Rangpur	4	10	14	6	34
	Sub-total	19	100	304	22	426
Rajshahi	Naogaon	1	10	94	1	106
	Natore	1	26	26	2	55
	Pabna	3	39	16	0	58
	Rajshahi	2	33	7	1	43
	Serajganj	9	59	33	2	103
	Sub-total	16	167	176	6	349
Gopalganj	Faridpur	6	23	14	0	43
	Madaripur	1	2	6	0	9
	Sub-total	7	25	20	0	45
Khulna	Bagerhat	2	22	45	0	69
	Jessore	1	12	0	4	17
	Jhenaidah	2	29	23	1	55
	Kustia	3	35	62	3	103
	Narail	1	23	26	0	50
	Sub-total	9	121	156	8	285
Barisal	Barisal	7	75	361	9	452
	Jhalokati	1	4	0	0	5
	Pirojpur	1	9	1	0	11
	Sub-total	9	88	362	9	459
Total		**60**	**501**	**1018**	**45**	**1564**

1: Households (HHs) are defined as land with residential structures & trees, residential structures, rented residential structures, private trees, and other various items (ponds, fish, gate etc.)

*2: Commerce, Businesses and Enterprises (CBEs) are defined as land with business structures & trees, business structures, or rented business structures

Source: JICA Survey Team

(2) Land Acquisition and Resettlement for 60 Bridges in Western Bangladesh

The Land acquisition and resettlement for EZ bridge are summarized in following tables.

Table 15.6.4 Project Affected Households for Each Upazila

Project	District	Upazila	No of HHs (Land with structure and trees)	Total
EZ Bridge	Gazipur	Kaliganj	20	20
	Narsingdi	Palash	19	19
	Sub-total	Sub-total	39	39

Source: Census & Socioeconomic survey, July 2014

Table 15.6.5 Distribution of Impacts of the Project

Sl No	**Loss type**	**No/Total**
1	Total quantity of land (hectares) affected	12.49
2	Total number of households (land with structures) affected	39
3	Total of displaced households	39
4	Total of displaced people	190
5	Total number of structures affected	81
6	Total quantity of structures (Sqm) affected	3,709
7	Total no. of toilets affected	36
8	Total no. of tube wells affected	34
9	Total no. of trees on private land affected	12,259

Source: Census & Socioeconomic survey, July 2014.

15.7 Implementation Organization

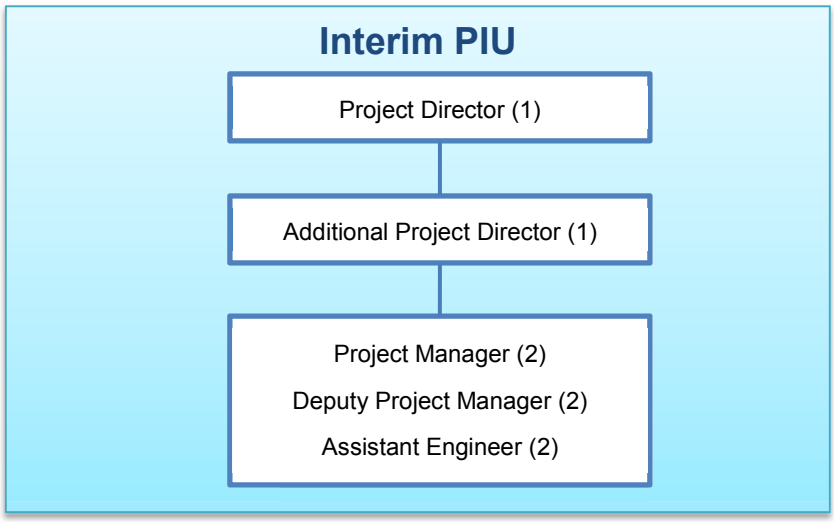
The project organization will be organized so that the GOB can implement the Project smoothly and effectively as well as coordinate with project stakeholders.

It is recommended that the Project Implementation Unit (PIU) for the Project will be organized under the Chief Engineer (CE) of RHD. PIU is divided into the following two stages.

- Interim PIU,
- PIU

(1) Interim PIU

Interim PIU was established for conducting formulation of the project, preparation of DPP(Development Project Proposal) and the consultant selection activity as JICA's counterpart in November 2014. The organization diagram of the interim PIU is shown in Figure 15.6.1.



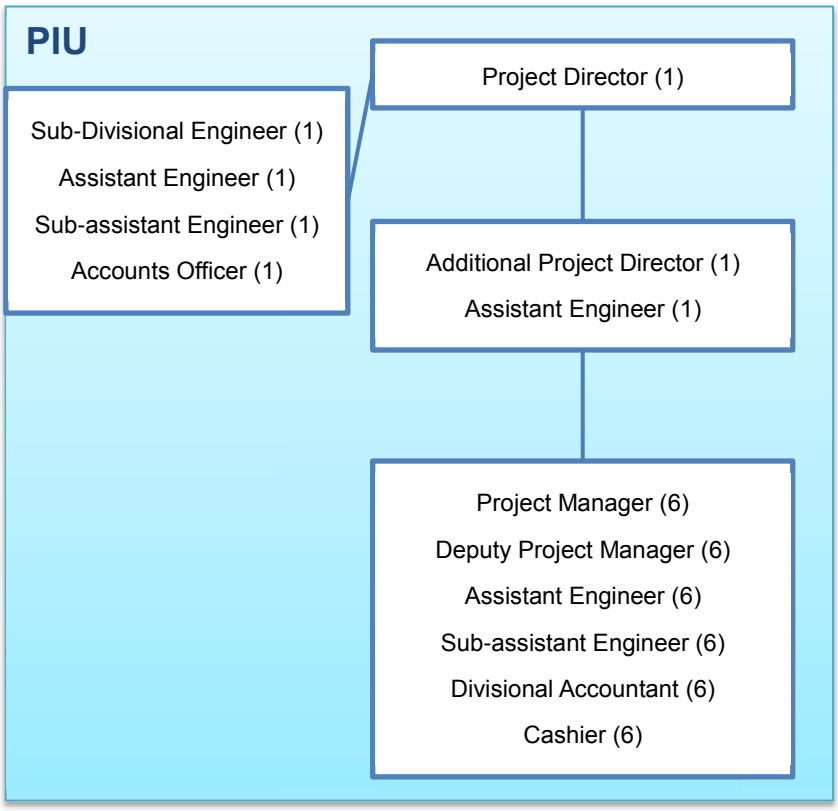
Note: ( ): No. of Post

Source: JICA Survey Team

Figure 15.7.1 Organization Diagram of Interim PIU

(2) PIU

PIU is organized after DPP is officially approved. The organization diagram of the PIU is shown in Figure 15.6.2.



Note: ( ): No. of Post

Source: JICA Survey Team

Figure 15.7.2 Organization Diagram of PIU

15.8 Implementation Schedule

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Source: JICA Survey Team

Figure 15.8.1 Implementation Schedule

16. CONCLUSION AND RECOMMENDATIONS

16.1 Conclusion

The conclusion of the Preparatory Survey is as follows:

- The Project is technically and economically feasible and environmentally sound.
- Hence, it is justified to implement the Project for national and people's benefits.
- The Project is comprised of 60 small- and middle-size bridges in Western Bangladesh and the EZ Bridge and Road.
- Confidential
- Three types of bridges are constructed in the Project, namely, PC-I girder bridge, steel-I girder bridge, and steel-box girder bridge.
- Weathering steel is applied for steel bridges.

A summary of the Project is shown in Table 16.1.1 and Figure 16.1.1

Table 16.1.1 Summary of the Project

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Source: JICA Survey Team

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16.2 Recommendations

Recommendations for further studies and tasks are as follows:

- Asphalt pavement was selected as a general pavement type in the preliminary design. Adoption of other pavement types such as concrete pavement or stone mastic asphalt (SMA) shall be considered, especially for some sections of the EZ approach road in the detailed design, since a number of heavy vehicles will utilize the EZ Bridge and Road.
- The EZ Bridge and Road will be connected to the existing regional road (R301). The improvement of R301 shall be considered during detailed design stage, since R301 is very narrow and damaged in some sections. R301 may not provide required capacity for increased traffic volume by the construction of the EZ Bridge and Road.
- In this Preparatory Survey, the recommendation for EZ Bridge‘s foundation type in the river is Cast-in-Place Concrete Pile (φ1500, L=54m, n=16). However, it shall be finally determined by confirming the supporting layer at each pier position based on the geotechnical investigations during the detailed design stage.
- 60 bridges are planned to be constructed at 60 river/water crossings in Western Bangladesh. Construction of box culverts shall be considered for some locations, such as pond crossings not having water flow, as a cost reduction measure in the detailed design.
- Safety measures such as providing road marking, road hump, guardrails, etc. shall be considered in the detailed design. Specifically, the countermeasure for ship collisions to piers of the EZ Bridge shall be important.
- Detailed surveys for public utilities such as waterworks, telephone lines, power lines, etc. shall be conducted in the detailed design. The bridge and road design shall be conducted in consideration of that information.
- RHD shall undertake the tasks for the EIA and ARP during the entire project period in order to implement the Project successfully.