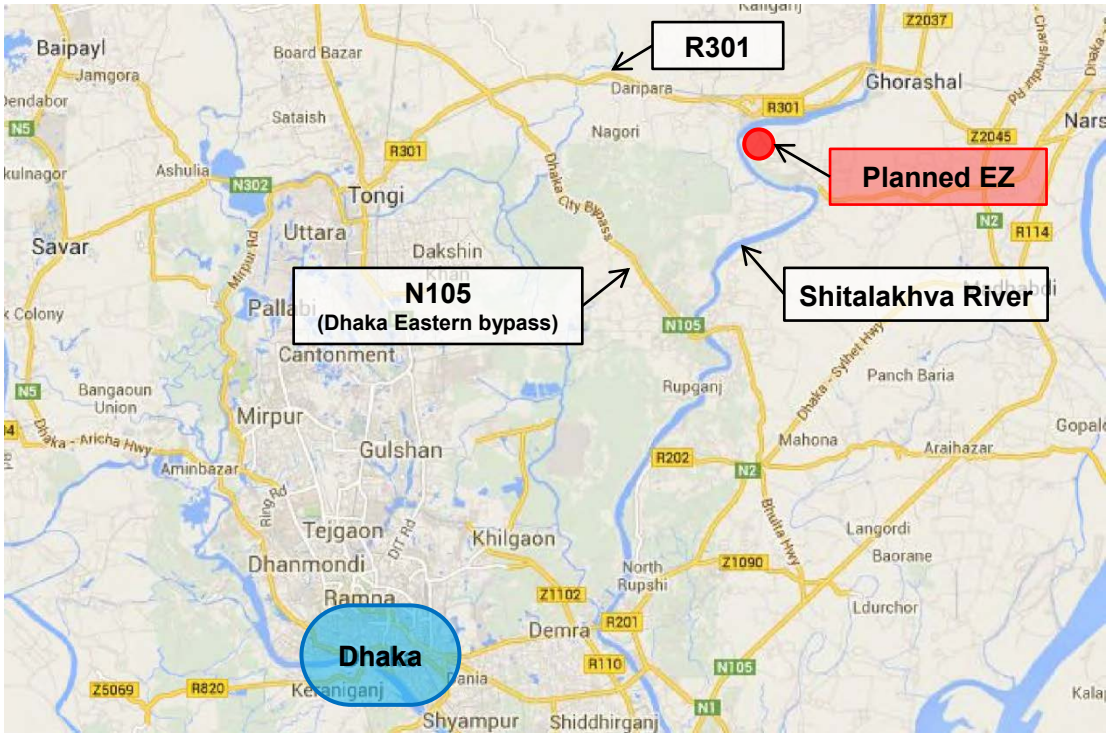
14. THE EZ BRIDGE AND ROAD

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

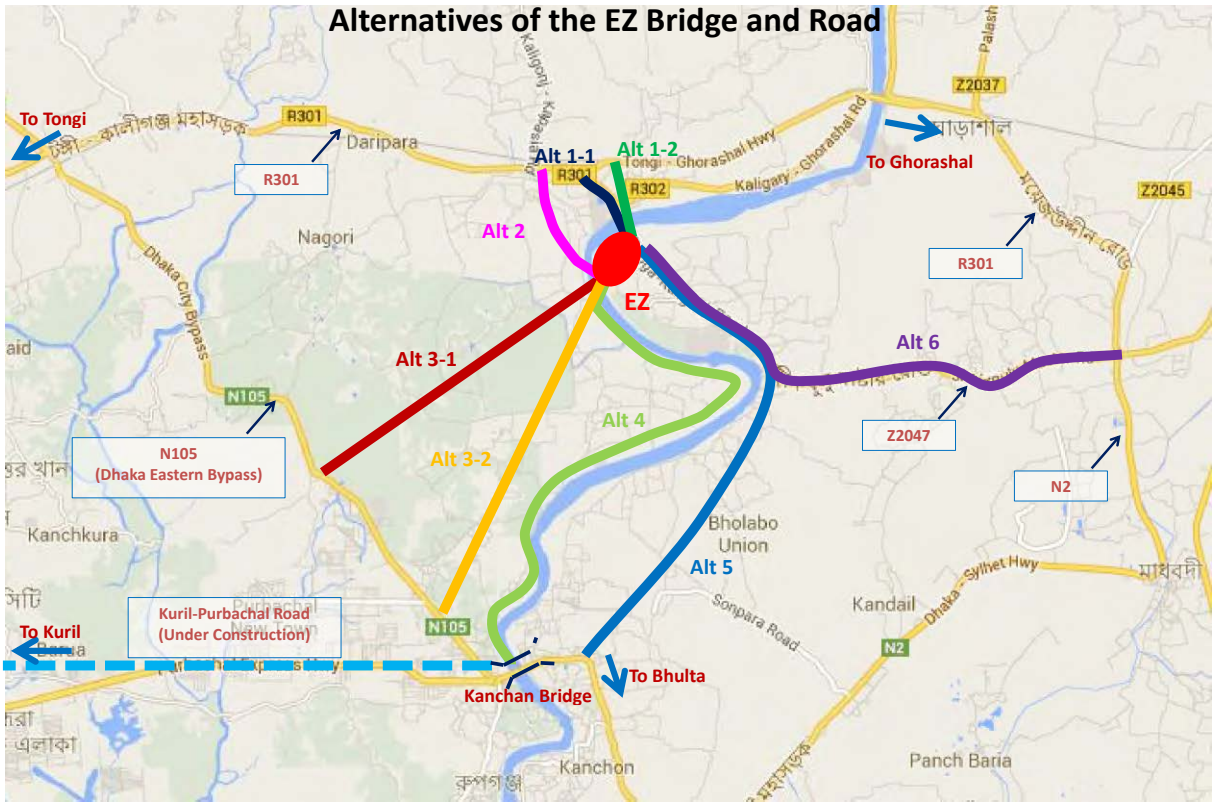
- Construct a new bridge (L=835m) on the south side of planned EZ.
- Construct an access road (L=12,800m) by widening Kaliganji Road.

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

Route alternatives		ALT-1-1		ALT-1-2		ALT-2		ALT-3-1	
Route Image									
Route Summary		- New bridge at the north side of planned EZ - Widening of R302 (Kaliganj Bazar) for the access road		- New bridge at the north side of planned EZ - New access road connecting R301		- New bridge at the south side of planned EZ - New access road connecting R301		- New bridge at the south side of planned EZ - New access road connecting N105	
Bridge and Road Length		- Bridge: 1,050m - Access Road: 2,100m		- Bridge: 1,050m - Access Road: 2,100m		- Bridge: 835m - Access Road: 4,195m		- Bridge: 835m - Access Road: 6,900m	
Traffic Condition		- 45km to Dhaka Center - 2 railway crossings and many intersections on R301 which has 2-lane carriageway.	Poor	- 45km to Dhaka Center - 2 railway crossings and many intersections on R301 which has 2-lane carriageway.	Poor	- 45km to Dhaka Center - 2 railway crossings and many intersections on R301 which has 2-lane carriageway. - Another access road can be constructed according to future traffic demand.	Fair	- 39km to Dhaka Center - Adequate capacity on Kuril-Purbachal Road which has 6-lane carriageway (under construction) - Longer travel in N105 which is sometimes congested	Good
Cost	Construction Cost *1	- Bridge: 3.0 bill JPY - Road: 0.5 bill JPY - Total: 3.5 bill JPY (0.71)		- Bridge: 3.0 bill JPY - Road: 0.5 bill JPY - Total: 3.5 bill JPY (0.71)		- Bridge: 2.7 bill JPY - Road: 1.3 bill JPY - Total: 4.0 bill JPY (0.82)		- Bridge: 2.7 bill JPY - Road: 2.2 bill JPY - Total: 4.9 bill JPY (1.00)	
	Cost for ODA Eligible Portion *2	- 5.8 bill JPY (0.71)		- 5.8 bill JPY (0.71)		- 6.6 bill JPY (0.82)		- 8.1 bill JPY (1.00)	
	Land Acquisition and Resettlement Cost	- 1.2 bill JPY (0.32)		- 1.3 bill JPY (0.34)		- 2.3 bill JPY (0.61)		- 3.8 bill JPY (1.00)	
	Project Cost	- 7.0 bill JPY (0.59)	Good	- 7.1 bill JPY (0.60)	Good	- 8.9 bill JPY (0.75)	Good	- 11.9 bill JPY (1.00)	Fair
Construction Period		- 3 year	Fair	- 3 year	Fair	- 3 year	Fair	- 3 year	Fair
Constructability		- Need existing road widening construction keeping existing traffic flow	Poor	- No need existing road widening.	Fair	- No need existing road widening.	Fair	- No need existing road widening.	Fair
Social Impact	Land Acquisition	- Agriculture: 0m2 - Residential: 57,000m2 - Total: 57,000m2	Good	- Agriculture: 0m2 - Residential: 63,000m2 - Total: 63,000m2	Good	- Agriculture: 47,000m2 - Residential: 64,000m2 - Total: 111,000m2	Fair	- Agriculture: 137,000m2 - Residential: 46,000m2 - Total: 183,000m2	Fair
	Resettlement	- House: 28 - Building: 3 - Shop: 107 - Others: 2	Fair	- House: 46 - Building: 5 - Shop: 21 - Others: 0	Poor	- House: 15 - Building: 0 - Shop: 0 - Others: 0	Good	- House: 12 - Building: 0 - Shop: 0 - Others: 0	Good
Environmental Impact		- Negative impact on noise and air quality in populated area.	Fair	- Negative impact on noise and air quality in populated area.	Fair	- Negative impact on noise and air quality in populated area.	Fair	- Negative impact on noise and air quality in populated area.	Fair
Evaluation						**Recommended** - Cheaper construction cost - Cheaper L/A and resettlement cost - Small affected house number - Present accessibility is poor, but it can be improved in the future.			

Route alternatives		ALT-3-2		ALT-4		ALT-5		ALT-6	
Route Image									
Route Summary		- New bridge at the south side of planned EZ - New access road connecting N105		- New bridge at the south side of planned EZ - Widening of Kaliganj Road for the access road		- No new bridge - New access road connecting Kuril-Purbachal Road (under construction)		- No new bridge - Widening of Danga-Kaligonj Road and Z2047.	
Bridge and Road Length		- Bridge: 835m - Access Road: 8,700m		- Bridge: 835m - Access Road: 12,800m		- Bridge: - - Access Road: 12,000m		- Bridge: - - Access Road: 11,500m	
Traffic Condition		- 39km to Dhaka Center - Adequate capacity on Kuril-Purbachal Road which has 6-lane carriageway (under construction) - Shorter travel in N105 which is sometimes congested	Good	- 40km to Dhaka Center - Adequate capacity on Kuril-Purbachal Road which has 6-lane carriageway (under construction)	Good	- 42km to Dhaka Center - Adequate capacity on Kuril-Purbachal Road which has 6-lane carriageway (under construction)	Fair	- 60 km to Dhaka Center - Adequate capacity on Kuril-Purbachal Road which has 6-lane carriageway (under construction)	Poor
Cost	Construction Cost *1	- Bridge: 2.7 bill JPY - Road: 2.8 bill JPY - Total: 5.5 bill JPY (1.12)		- Bridge: 2.7 bill JPY - Road: 3.2 bill JPY - Total: 5.9 bill JPY (1.20)		- Bridge: - - Road: 3.9 bill JPY - Total: 3.9 bill JPY (0.80)		- Bridge: - - Road: 2.7 bill JPY - Total: 2.7 bill JPY (0.55)	
	Cost for ODA Eligible Portion *2	- 9.1 bill JPY (1.12)		- 9.7 bill JPY (1.20)		- 6.4 bill JPY (0.80)		- 4.5 bill JPY (0.55)	
	Land Acquisition and Resettlement Cost	- 5.0 bill JPY (1.32)		- 6.9 bill JPY (1.82)		- 7.4 bill JPY (1.95)		- 7.4 bill JPY (1.95)	
	Project Cost	- 14.1 bill JPY (1.18)	Poor	- 16.6 bill JPY (1.40)	Poor	- 13.8 bill JPY (1.16)	Poor	- 11.9 bill JPY (1.00)	Fair
Construction Period		- 3 year	Fair	- 3 year	Fair	- 3 year	Fair		
Constructability		- No need existing road widening.	Fair	- Need existing road widening construction keeping existing traffic flow	Poor	- No need existing road widening. - No need bridge construction	Good	- Need existing road widening construction keeping existing traffic flow	Poor
Social Impact	Land Acquisition	- Agriculture: 198,000m2 - Residential: 39,000m2 - Total: 237,000m2	Fair	- Agriculture: 0m2 - Residential: 324,000m2 - Total: 324,000m2	Poor	- Agriculture: 108,000m2 - Residential: 240,000m2 - Total: 348,000m2	Poor	- Agriculture: 207,000m2 - Residential: 138,000m2 - Total: 345,000m2	Poor
	Resettlement	- House: 20 - Building: 0 - Shop: 0 - Others: 0	Good	- House: 109 - Building: 4 - Shop: 160 - Others: 10	Poor	- House: 102 - Building: 4 - Shop: 100 - Others: 19	Poor	- House: 123 - Building: 5 - Shop: 373 - Others: 4	Poor
Environmental Impact		- Negative impact on noise and air quality in populated area.	Fair	- Negative impact on noise and air quality in highly-populated area.	Poor	- Negative impact on noise and air quality in highly-populated area.	Poor	- Negative impact on noise and air quality in highly-populated area.	Poor
Evaluation									

*1: "Construction cost" does not include other costs such as price escalation, contingency, consulting service, tax, etc.

*2: "Cost for ODA Eligible Portion" includes other costs such as price escalation, contingency, consulting service, tax, etc. but not include land acquisition and resettlement cost.

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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.

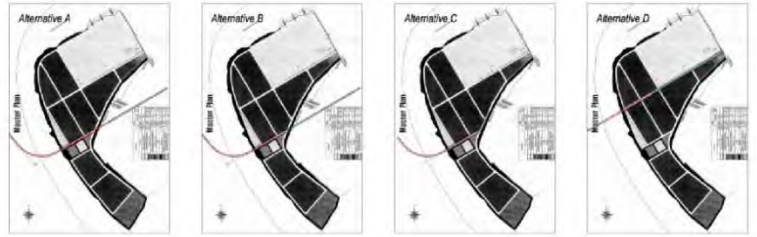
Alternative D

- 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

Table 14.4.1 Alignment Evaluation of the EZ Bridge and Road

Alignment Alternatives		Alternative A		Alternative B		Alternative C		Alternative D	
Alignment Image									
Summary		- The Road connects to existing roads at beginning and end points.		- The Road connects to existing roads at beginning and end points.		- The Road connects to existing road at beginning point and connects to EZ at end point.		- The Road connects to existing road at beginning point and connects to EZ at end point.	
Bridge and Road Length		- Bridge: 1,015m - Road: 4,015m - Total: 5,030m		- Bridge: 835m - Road: 4,195m - Total: 5,030m		- Bridge: 835m - Road: 3,645m - Total: 4,480m		- Bridge: 835m - Road: 3,885m - Total: 4,720m	
Bridge Utilization		- All Traffic including local traffic and EZ related traffic can use the Bridge.	Good	- All Traffic including local traffic and EZ related traffic can use the Bridge.	Good	- Local traffic cannot use the Bridge, since the Bridge is connected to EZ directly.	Poor	- All Traffic including local traffic and EZ related traffic can use the Bridge.	Good
Cost	Construction Cost *1	- 4.4 billion JPY		- 4.0 billion JPY		- 3.9 billion JPY		- 4.0 billion JPY	
	Cost for ODA Eligible Portion *2	- 7.1 billion JPY		- 6.6 billion JPY		- 6.4 billion JPY		- 6.5 billion JPY	
	Land Acquisition and Resettlement Cost	- 2.3 billion JPY		- 2.3 billion JPY		- 2.0 billion JPY		- 2.0 billion JPY	
	Project Cost	- 9.4 billion JPY	Poor	- 8.9 billion JPY	Good	- 8.4 billion JPY	Good	- 8.5 billion JPY	Good
Constructability		- Main bridge (Steel box girder bridge) is constructed in curve section.	Fair	- Main bridge (Steel box girder bridge) is constructed in curve section.	Fair	- Main bridge (Steel box girder bridge) is constructed in curve section.	Fair	- Main bridge (Steel box girder bridge) can be constructed in straight section.	Good
The Number of Affected Houses		- 26	Fair	- 26	Fair	- 16	Fair	- 20	Fair
Impact to EZ		- The Bridge passes over the EZ. - Enough vertical clearance is provided under the bridge.	Good	- EZ is divided into north and south by the bridge and road. - Enough vertical clearance is partially provided under the bridge.	Fair	- EZ is divided into north and south by the bridge and road. - Enough vertical clearance is partially provided under the bridge.	Fair	- EZ is divided into north and south by the bridge and road just behind container terminal. - Smooth traffic between container terminal and other areas cannot be secured	Poor
Evaluation				**Recommended** - Good or Fair for all evaluation items - Alt A: the highest project cost - Alt C: Poor bridge utilization - Alt D: Big negative impact to EZ					

*1: "Construction cost" does not include other costs such as price escalation, contingency, consulting service, tax, etc.
*2: "Cost for ODA Eligible Portion" includes other costs such as price escalation, contingency, consulting service, tax, etc. but not include land acquisition and resettlement cost.

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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.”

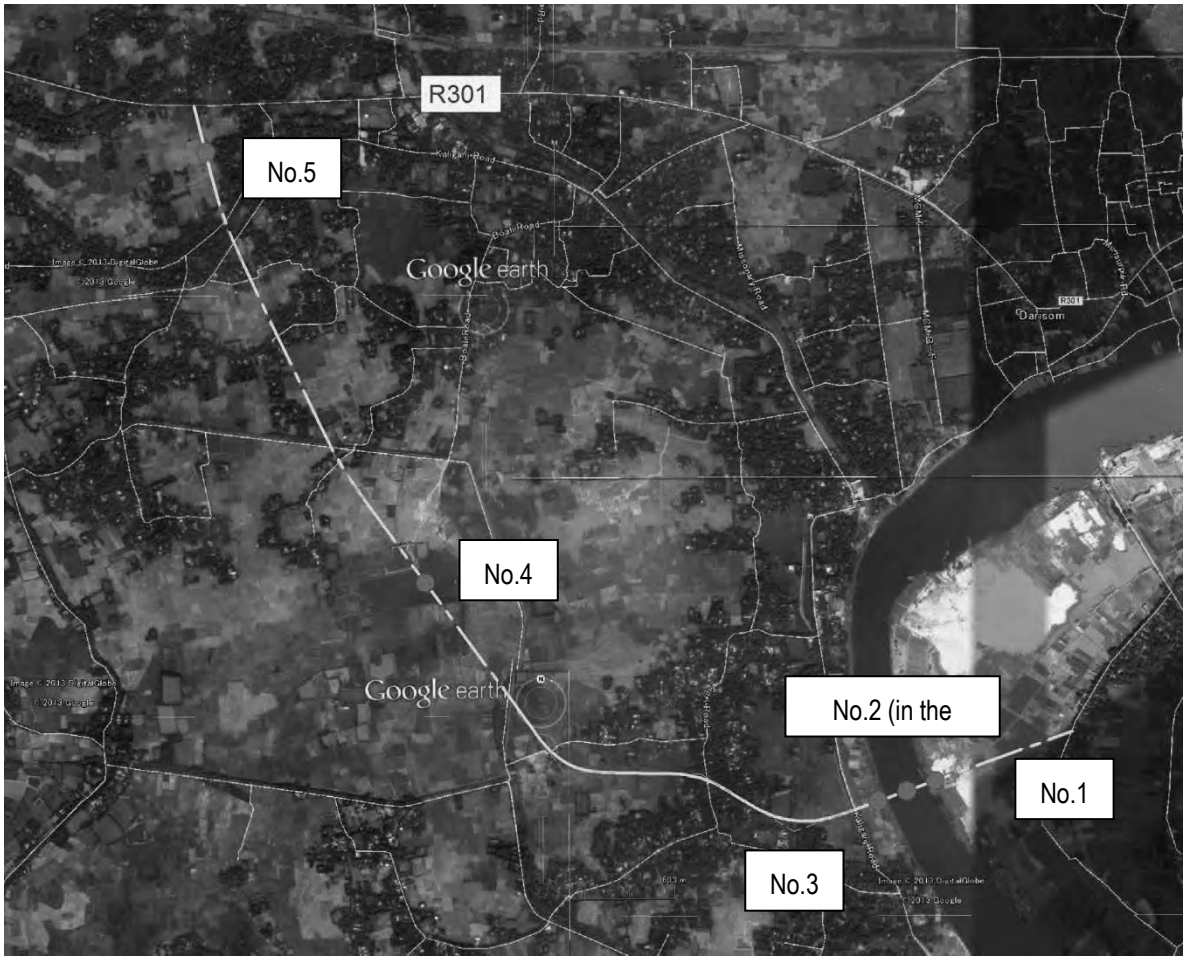
The bridge will cross the Shitalakshya River, a distributary of Brahmaputra at the south of the current bridge of Tongi-Ghorashal Highway crossing Shitalakshya.

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.

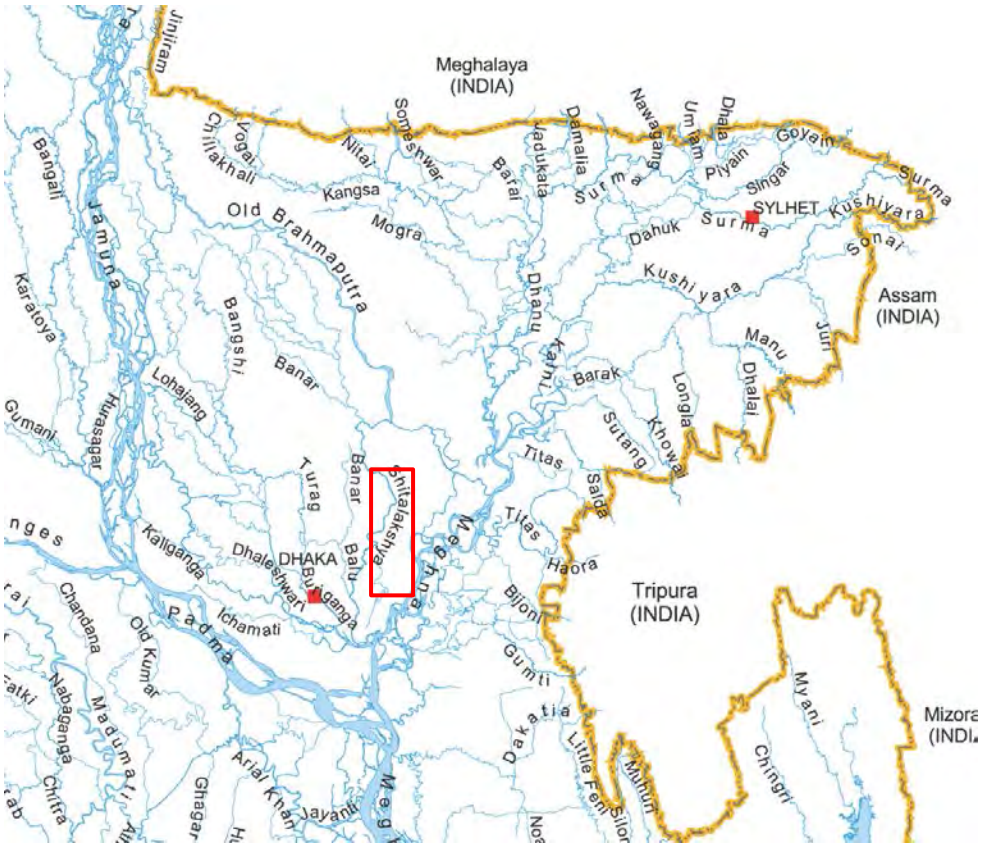


Figure 14.5.2 Lakhya River and Meghna Riverine System

Source: JICA Survey Team

Figure 14.5.3 Location of Proposed Bridge and Gauging Stations

2) River Characteristics of Lakhya River

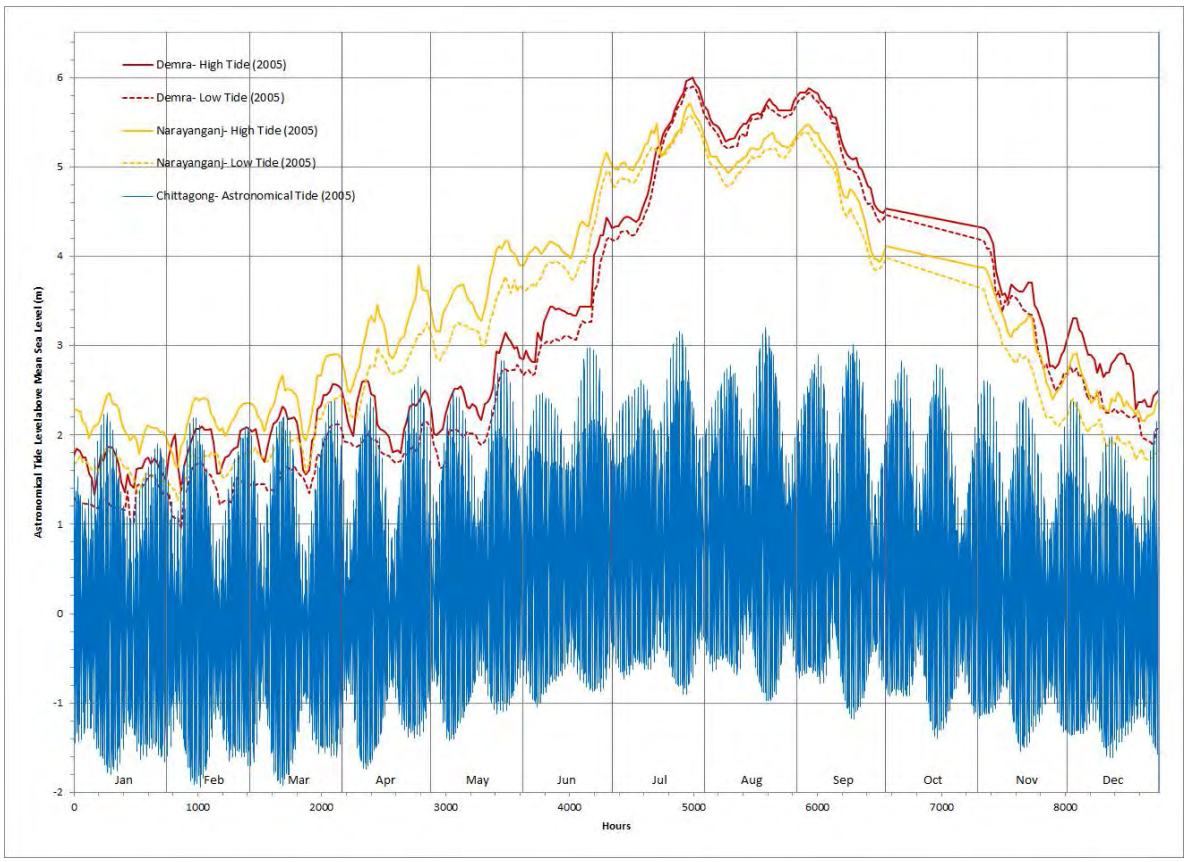
In order to verify the river characteristics, hydrological records and documents were collected from BWDB and BIWTA. Collected items and its period of records are shown in Table 14.5.2.

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.

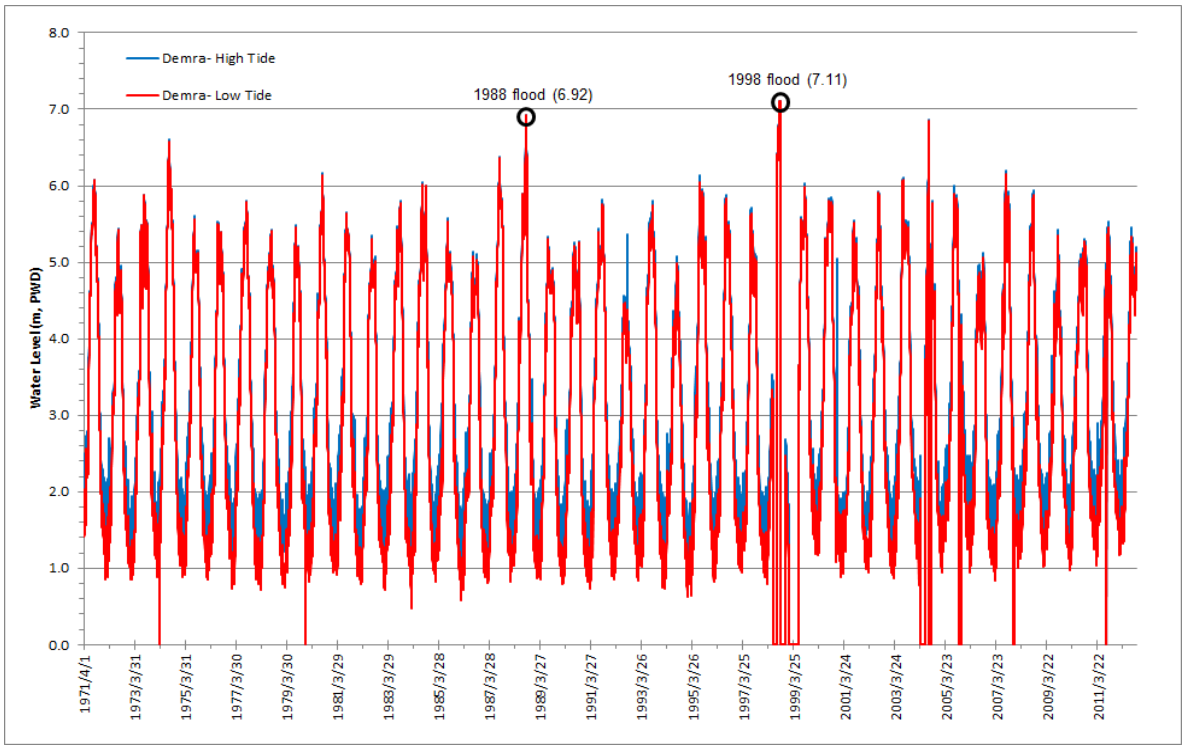


Source: BWDB, Earthquake Research Institute (the University of Tokyo, JAPAN)

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

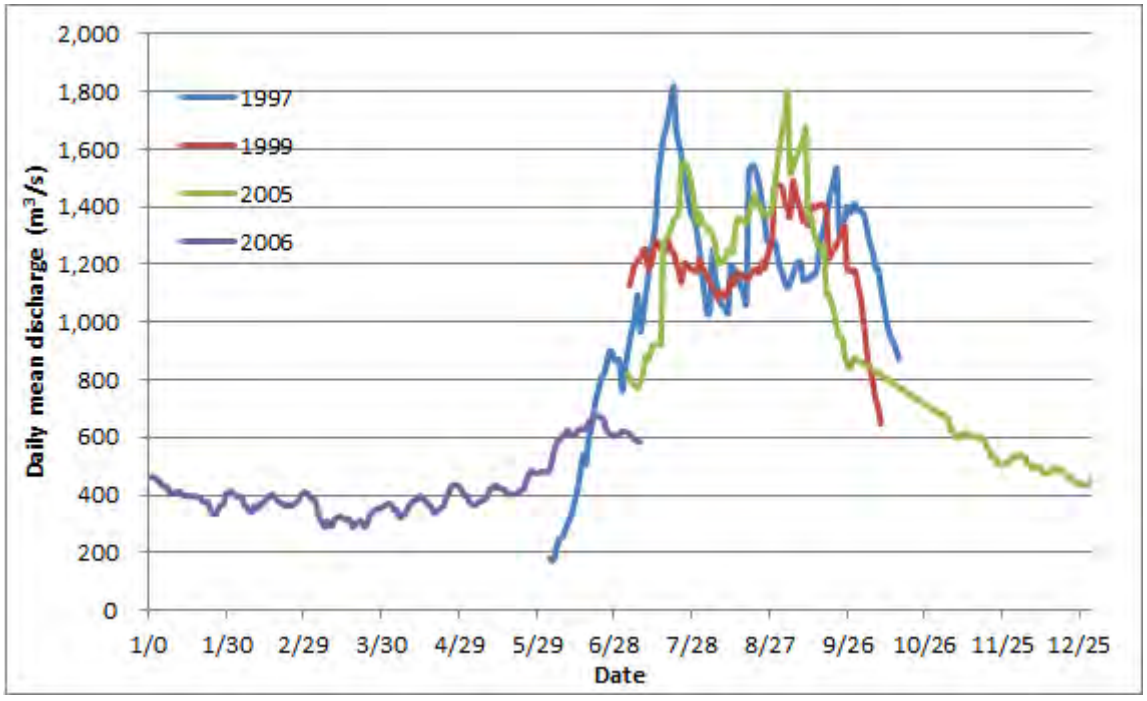
Past annual high water levels have occurred during the rainy season, the highest recorded water level at Demra was 7.11 m PWD during the 1998 flood (as shown in Figure 14.5.5). Although the flood magnitude and damage in 1998 was higher at the national level, the flood level in 1998 has been recorded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



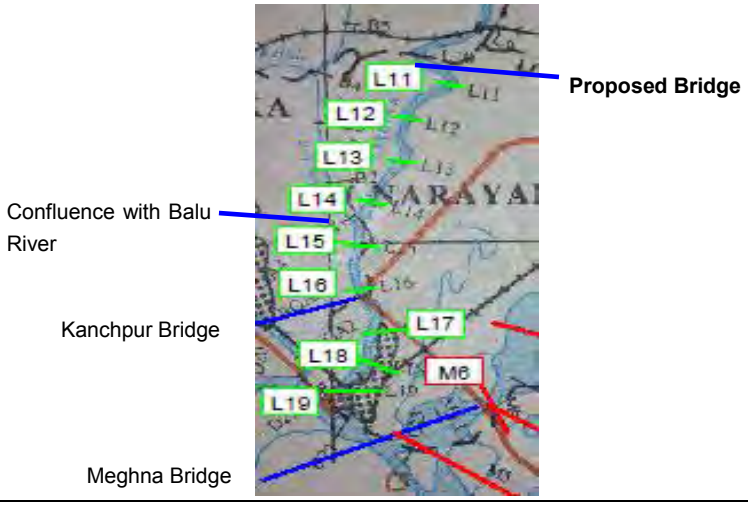
Source: BWDB

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.

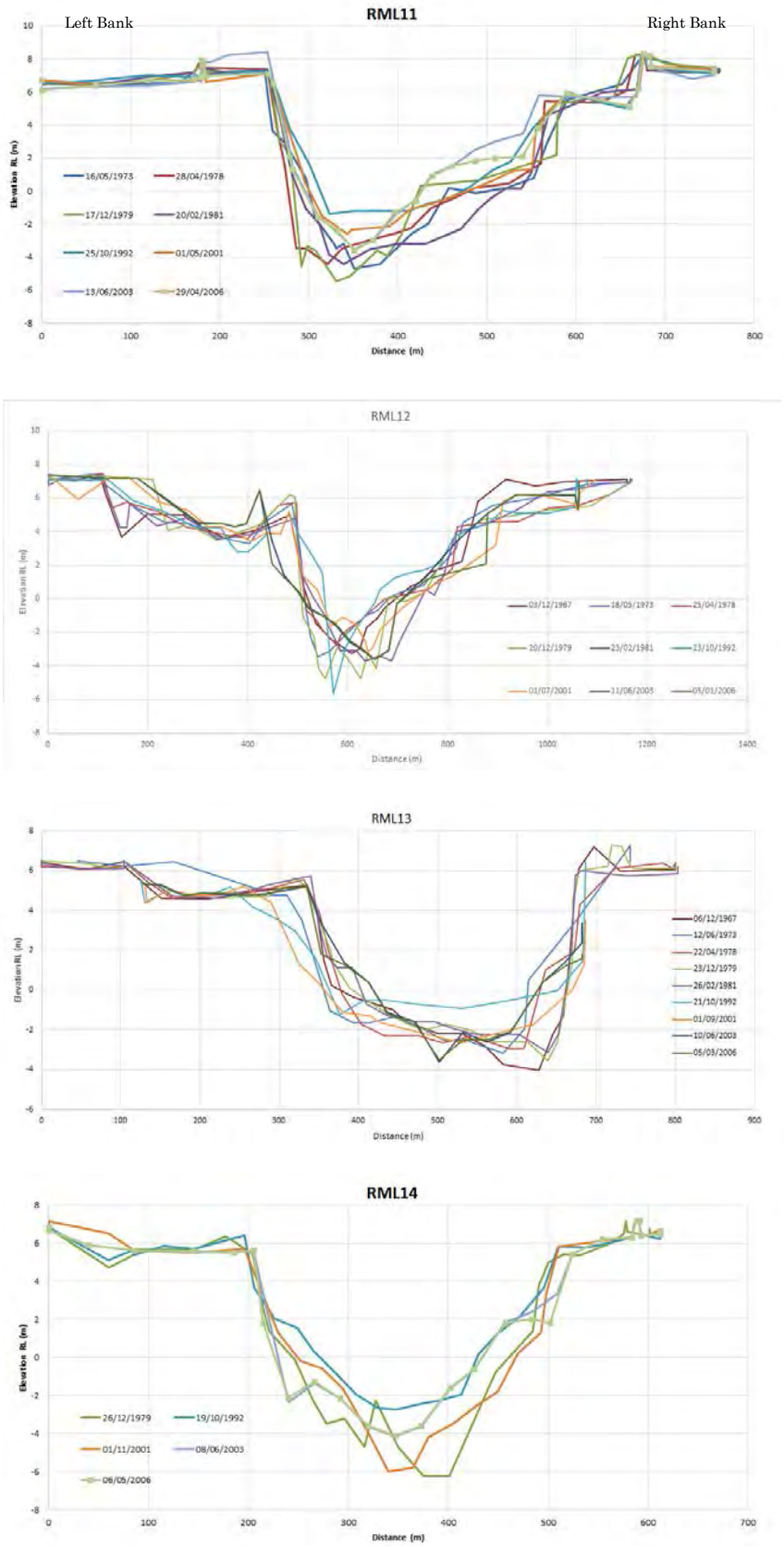
Table 14.5.3 Bathymetric Survey Data List

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

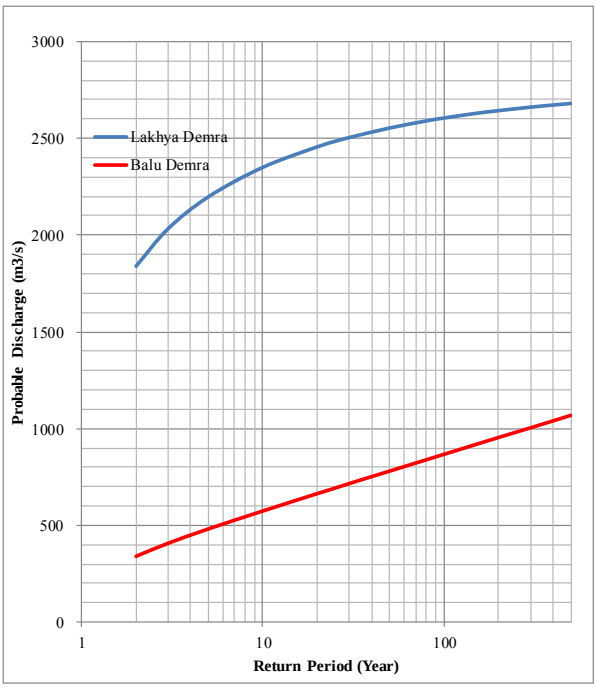
The probable discharges are calculated according to the following;

- 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

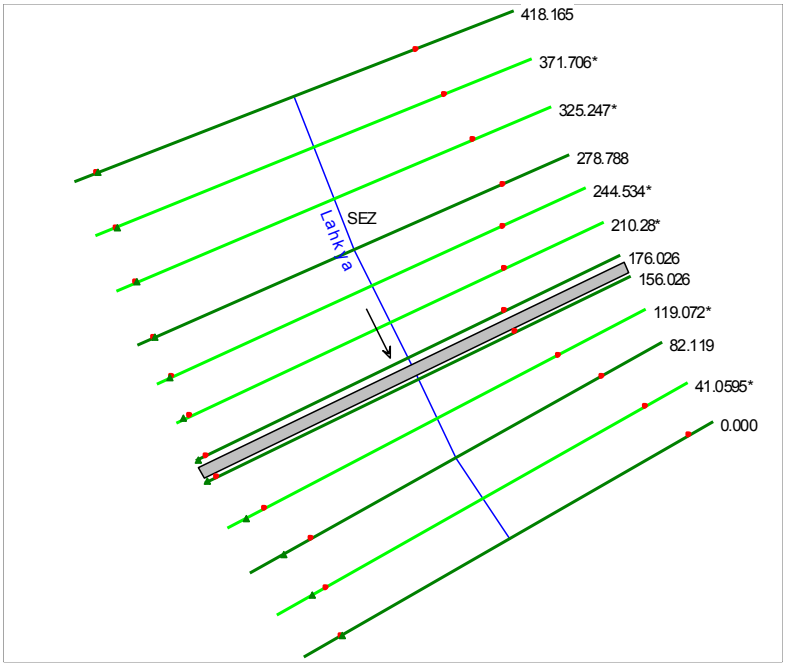
Hydraulic analysis was carried out to simulate the hydraulic phenomena using HEC-RAS (Hydrologic Engineering Center - River Analysis System) developed by the US Army Corps of Engineers.

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.

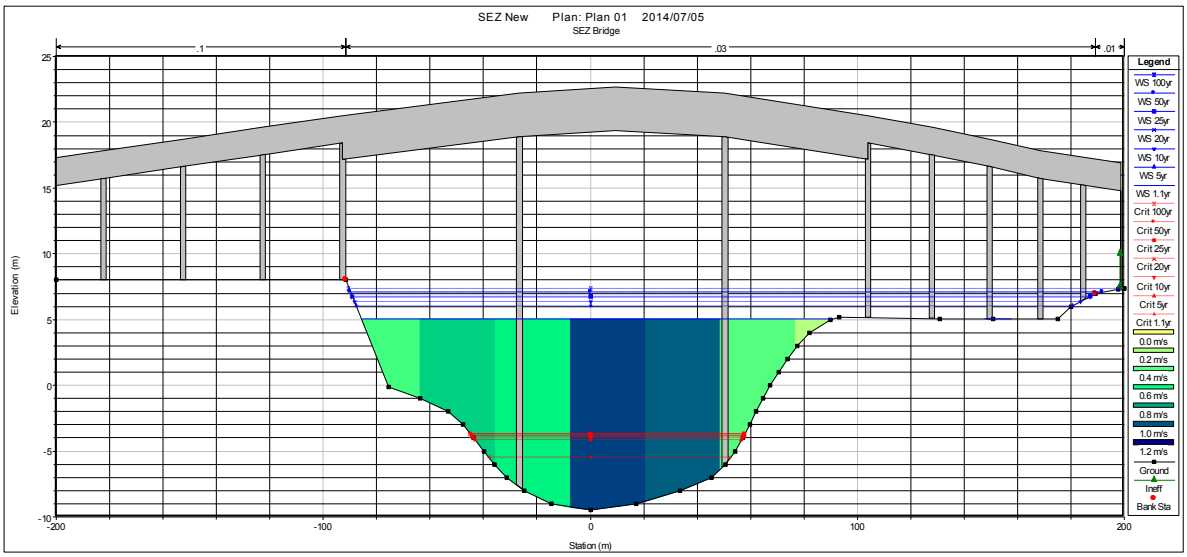
- Discharge - 1.1, 5, 10, 20, 25, 50 (design scale) and 100 years
- Water Level at downstream end of calculation - above calculated probable high flood level

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.

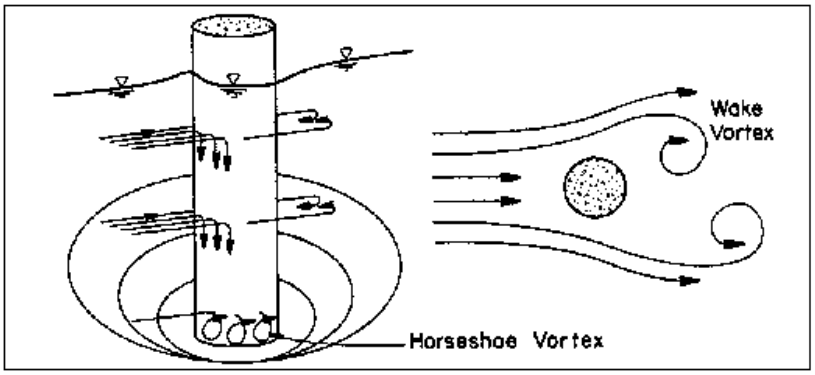
e) Local scour

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

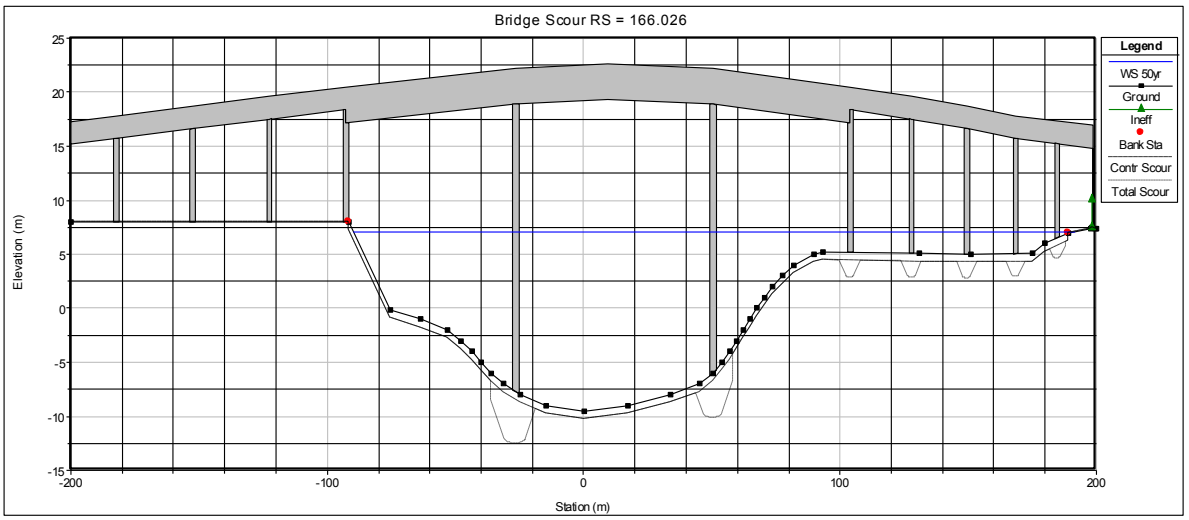
Figure 14.5.10 Simple schematic representation of scour at a cylindrical pier

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

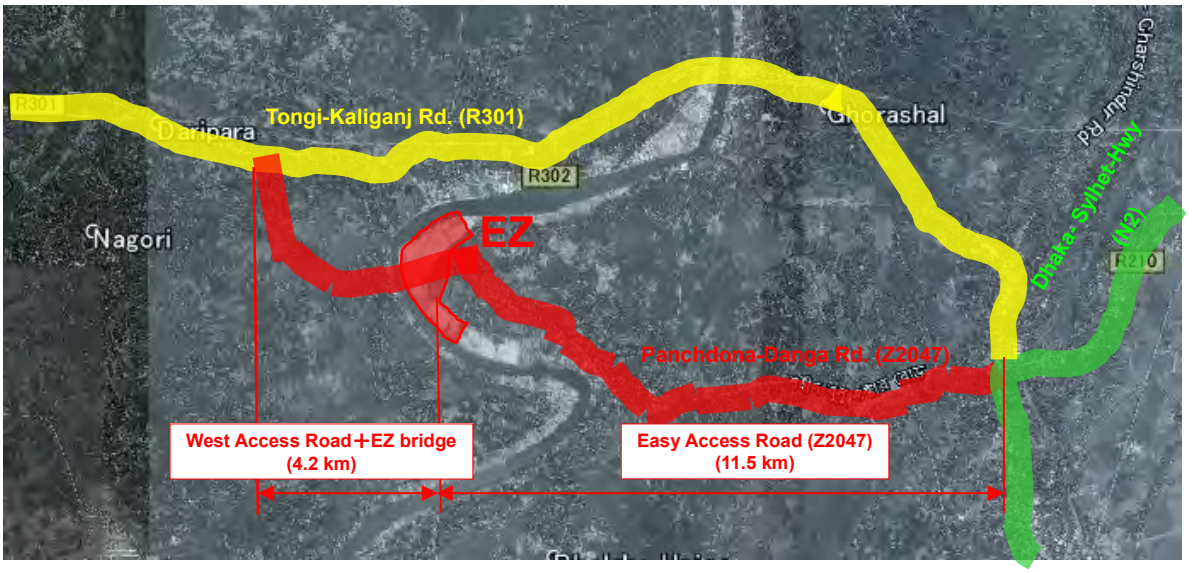
The new Economic Zone (EZ) is planned to operate from 2016 as a response to increasing domestic demand in the future due to recent remarkable economic growth and shortage of capacity in the current EPZ of the Dhaka district. At present, to start the operation, various infrastructure developments are 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

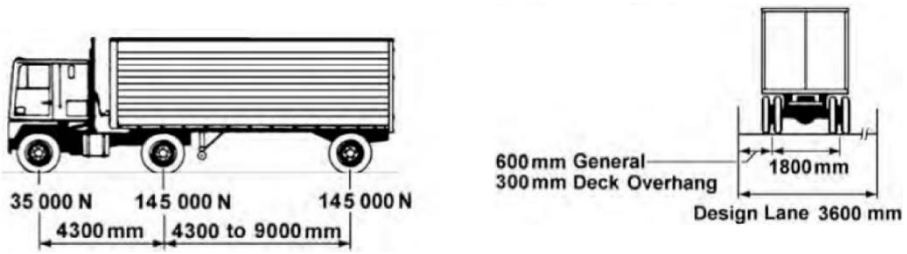
According to AASHTO LRFD, live loads on the roadways of the bridges shall consist of the;

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

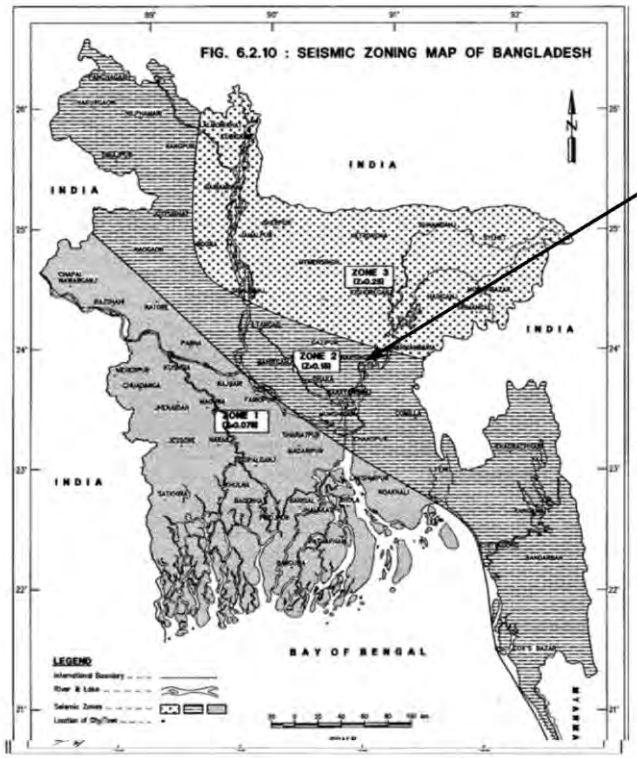
The design lane load consists of a uniform load of 9.3 kN/m.

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).

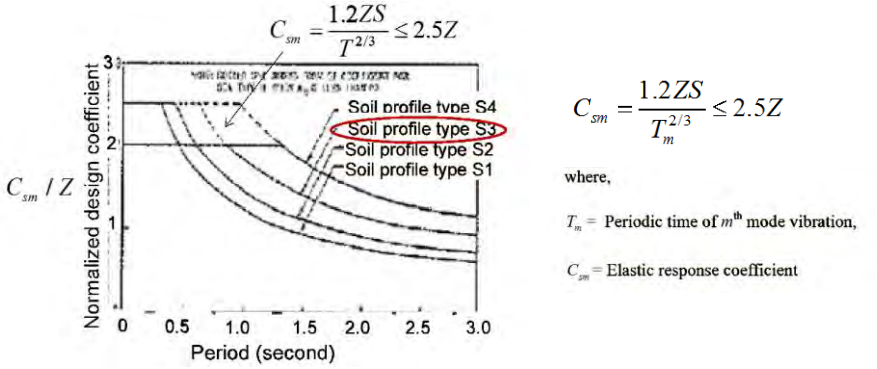
Table 14.7.2 Site Coefficient (BNBC)

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

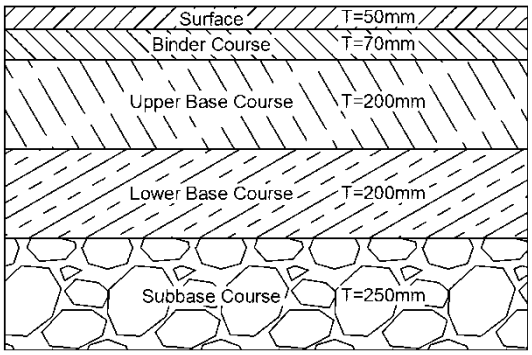
For calculating the formula regarding pavement layer thickness, refer to 7.3.7 (5).

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

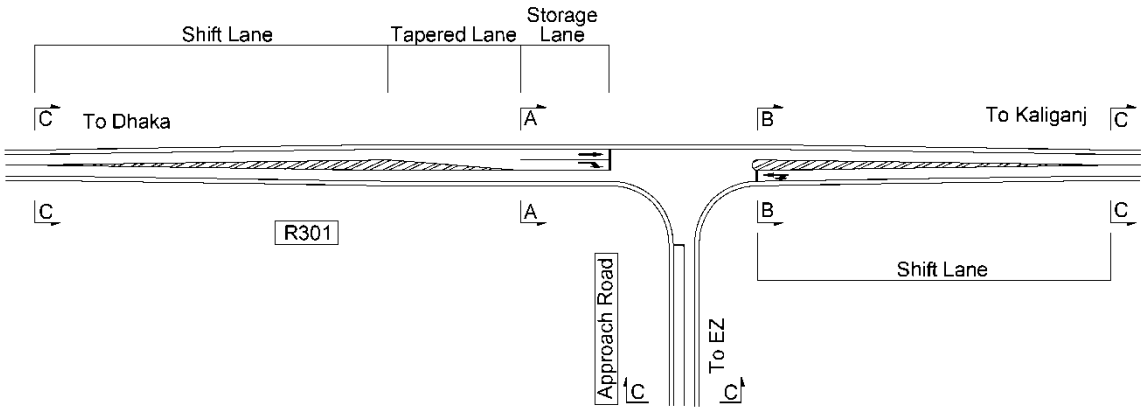
It is expected that a large number of trailers will come and go between Dhaka and Economic Zone and pass through this intersection. Therefore, a storage lane (i.e., right turn lane) is set in order to avoid traffic congestion as shown in below figure.

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)*



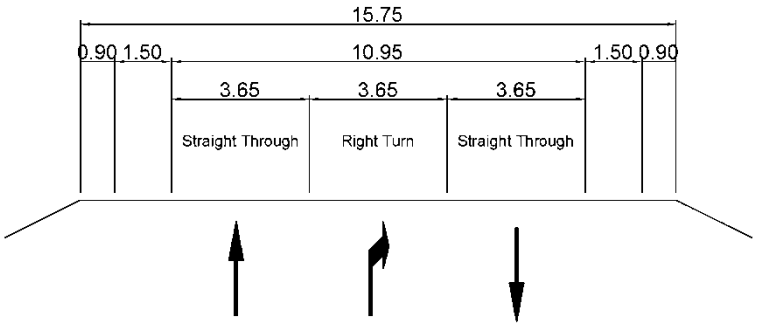
Source: JICA Survey Team

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.

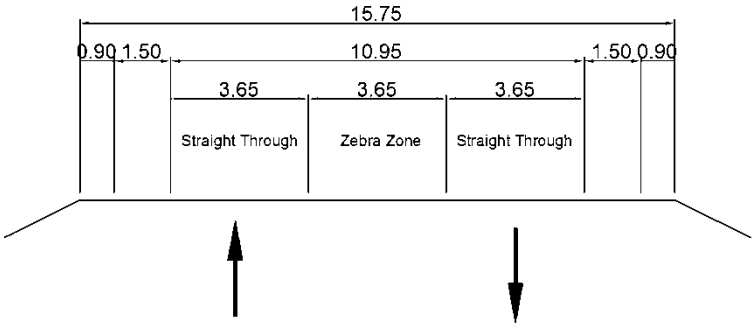
b) Cross Section for Intersection

The cross sections of section A-A, B-B and C-C are shown in Figure 14.7.6 to 14.7.8.



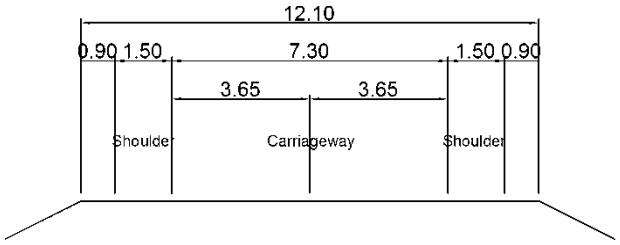
Source: JICA Survey Team

Figure 14.7.6 Section A-A



Source: JICA Survey Team

Figure 14.7.7 Section B-B

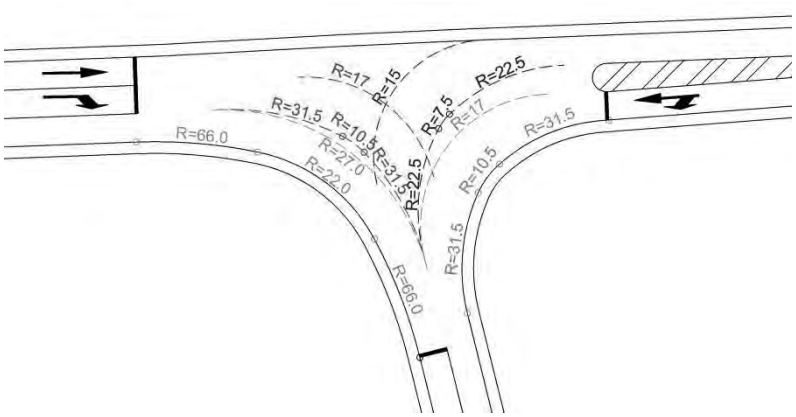


Source: JICA Survey Team

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.



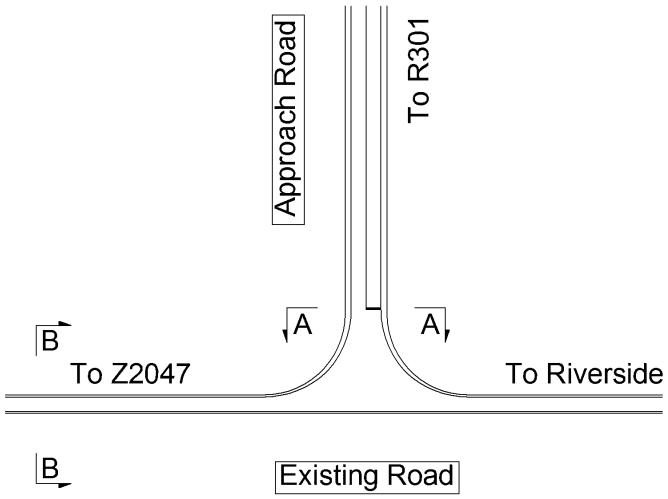
Source: JICA Survey Team

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.

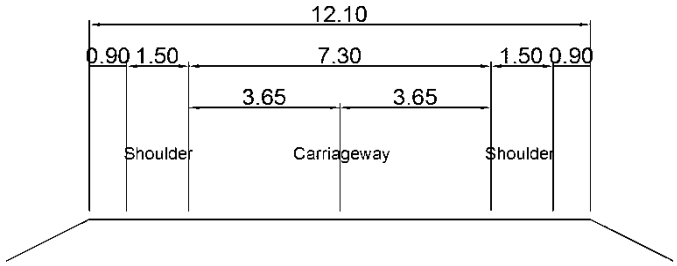


Source: JICA Survey Team

Figure 14.7.10 No.2 Intersection

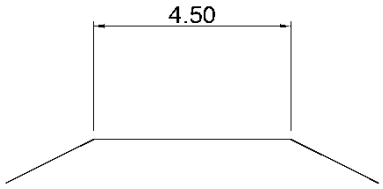
b) Cross Section

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

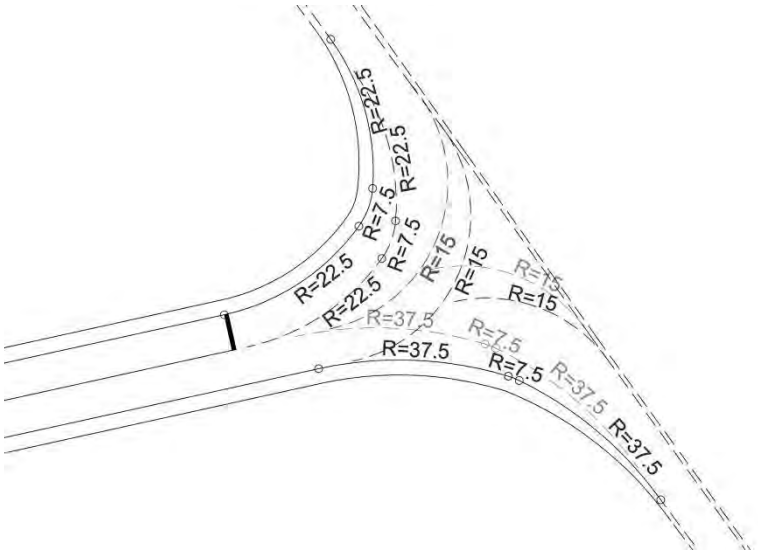


Source: JICA Survey Team

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

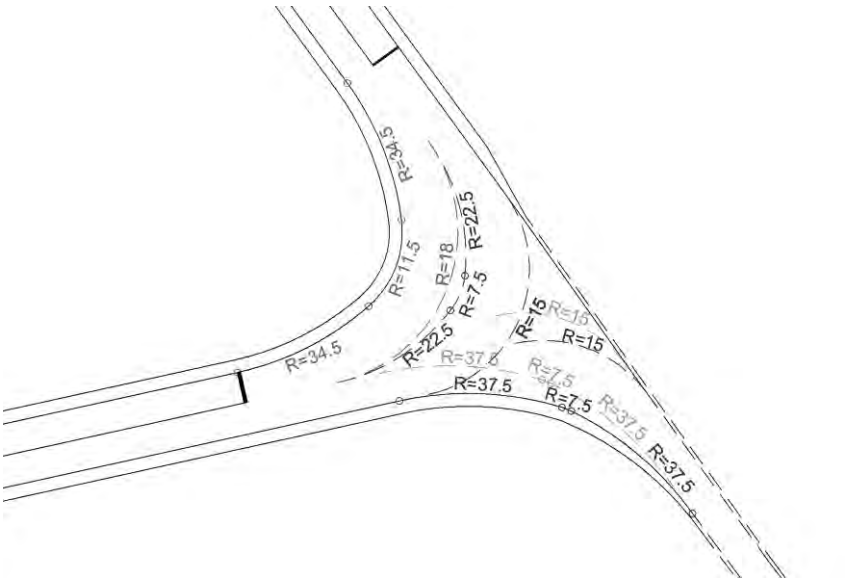


Figure 14.7.14 Turning Path at No.2 Intersection (Alternative-1)

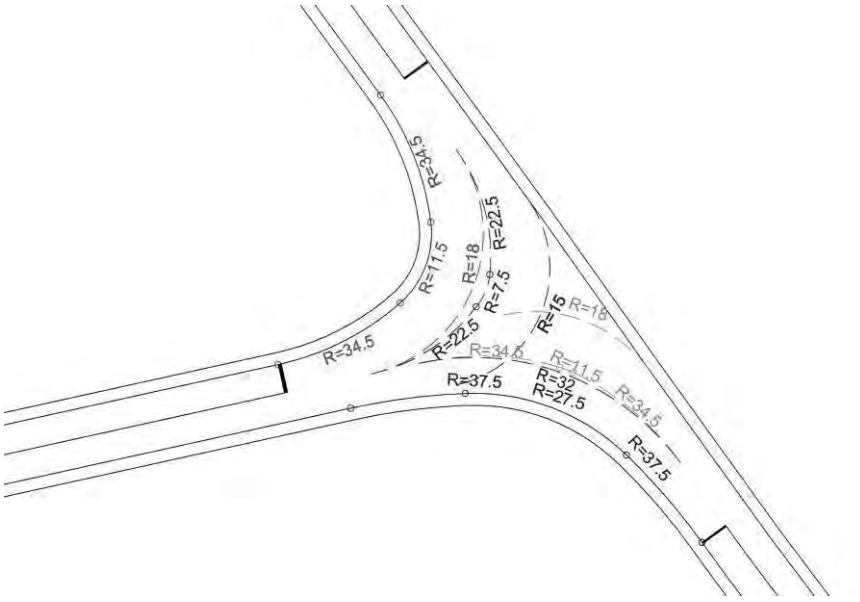


Figure 14.7.15 Turning Path at No.2 Intersection (Alternative-2)

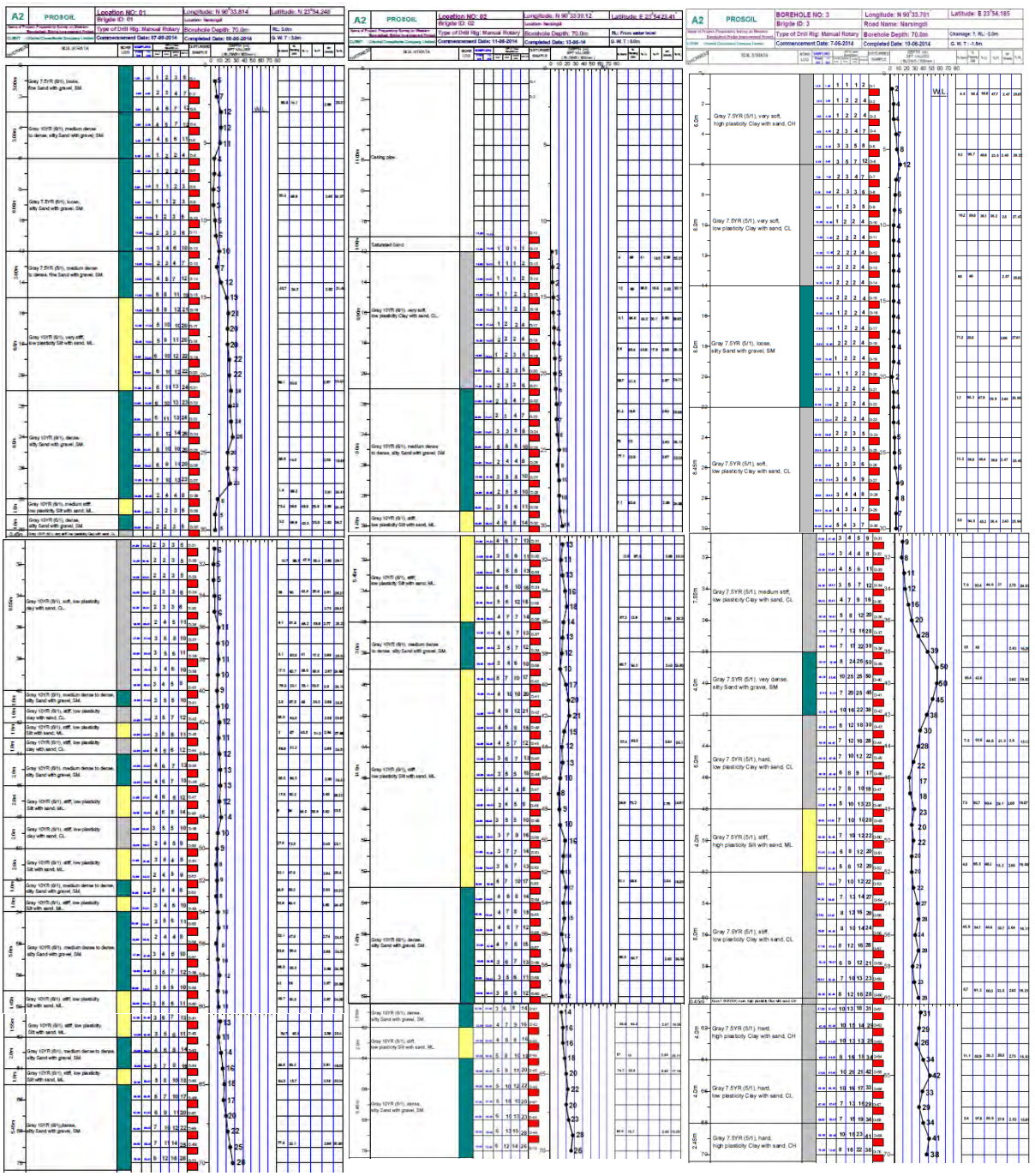
14.7.4 Bridge Design

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 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.

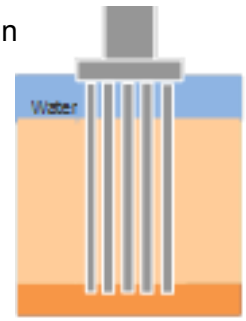
Table 14.7.19 Applicability Criteria of Foundation Types (inside River)

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.

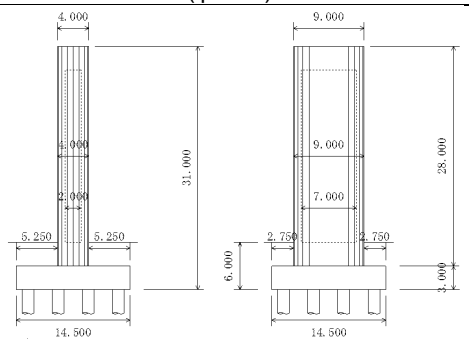
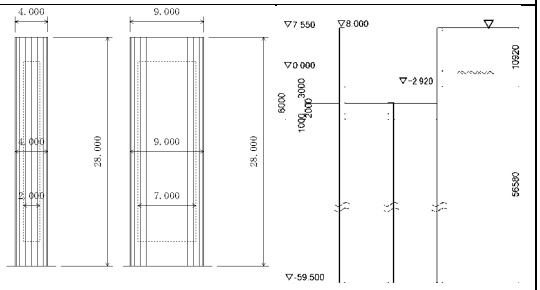
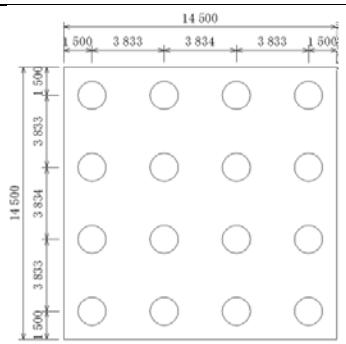
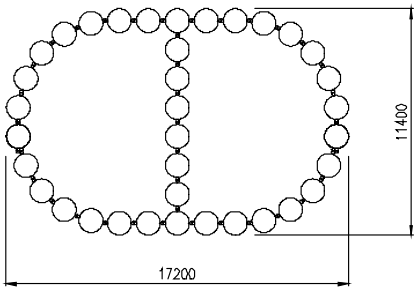
As for the cast-in-place concrete pile, pile-bent type is very common in Bangladesh. However, this type frequently leads to a whirlpool during a flood, and is easy to catch wood flowing down the river. In addition, it is unfavorable due to a lack of stability in the pier. Therefore, this foundation type 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)

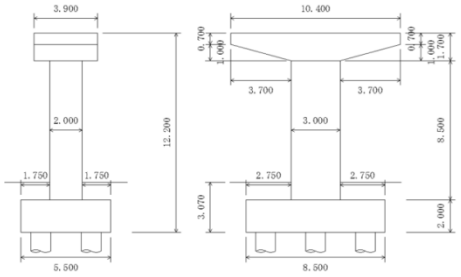
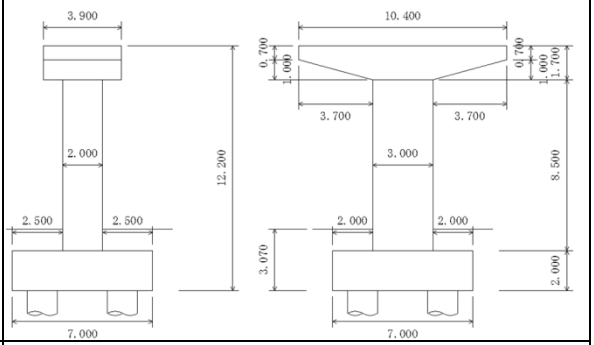
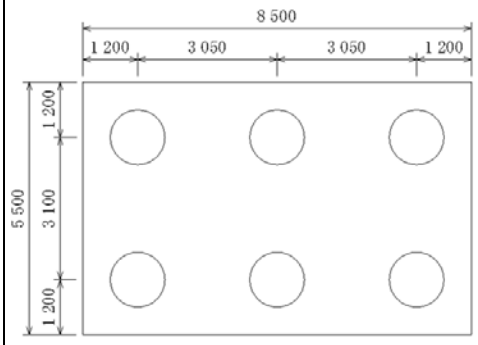
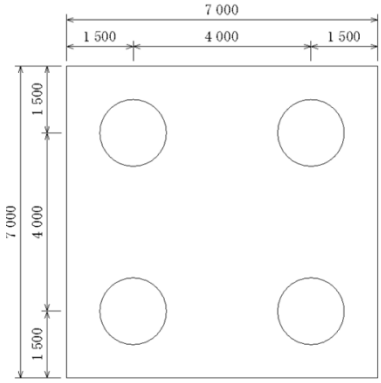
	Option 1: Cast-in-place Concrete Pile (φ1500)	Option 2: Steel Pipe Sheet Pile
Pier and Foundation Shape		
Plan View	 φ1500-16、L=54.0m	 φ1200-36, L=67.5m
Work Period	**Suitable** -Work period for the foundation takes slightly more time than Option 2 since a temporary cofferdam is required. However, it 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.

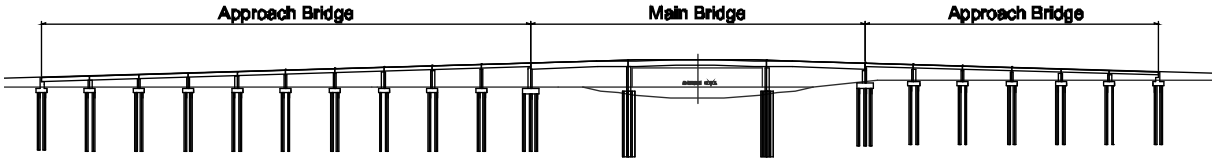
Table 14.7.21 Comparison of Diameter of Cast-in-place Concrete Pile (P17)

	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.



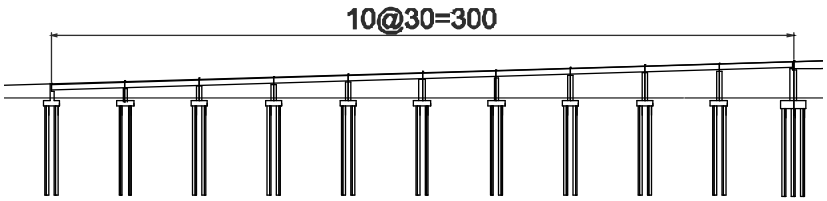
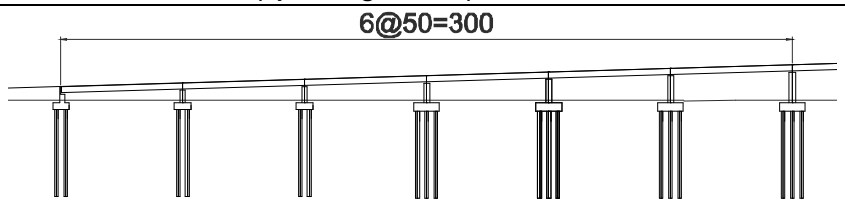
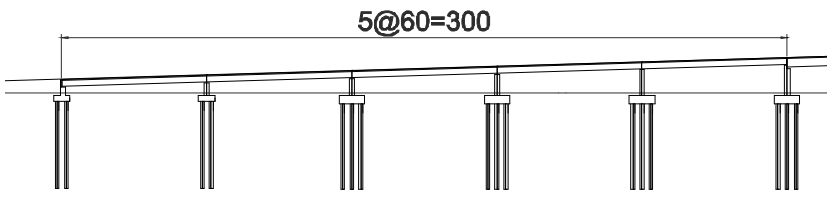
Source: JICA Survey Team

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.

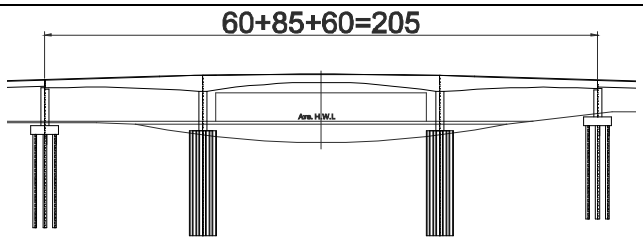
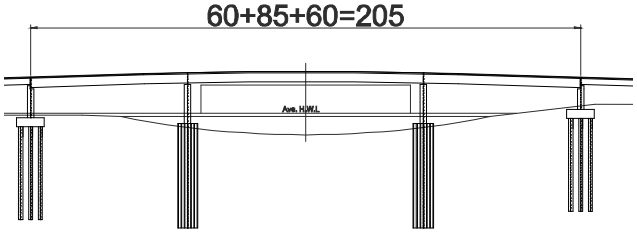
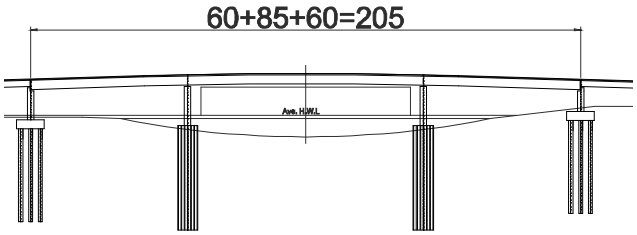
Bridge types are related to the bridge span, and applicable/economical bridge span for major bridge types are shown in Table 14.7.23. As for the Steel Box Girder, weathering the steel bridge is extracted as one alternative in consideration of the bridge life cycle cost (LCC). The alternatives for the 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

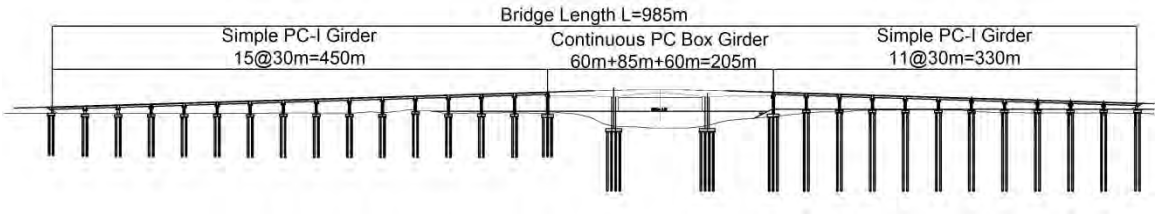
1) Approach Bridge

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.

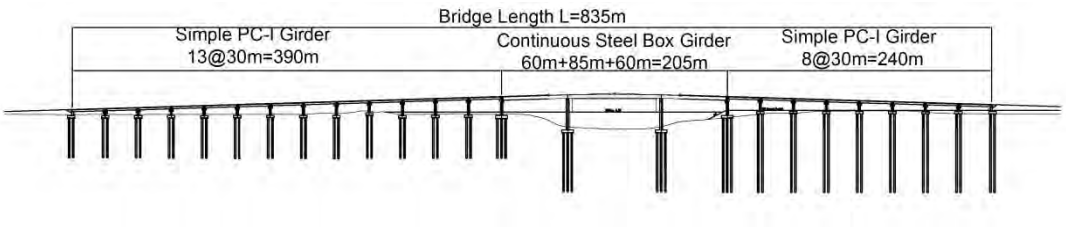
2) Main Bridge

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)

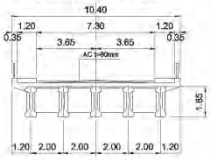
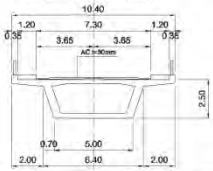
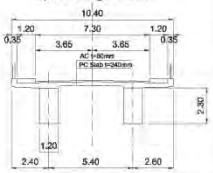


Note: The type of Approach Bridge adopts PC-I Girder in all Alternatives.
Source: JICA Survey Team

Figure 14.7.18 Alternatives for EZ Bridge

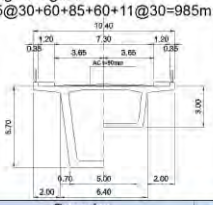
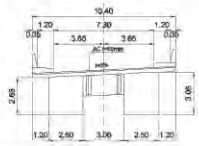
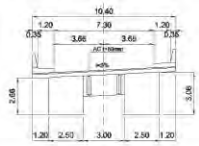
The comprehensive evaluation result for the three alternatives of the Main Bridge is shown in Table 14.7.26. Alternative 3 has some vital factors such as shortest construction period, advantageous earthquake resistance, Life Cycle Cost, and aesthetic view. Specifically, the lengths of Approach Bridge 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.

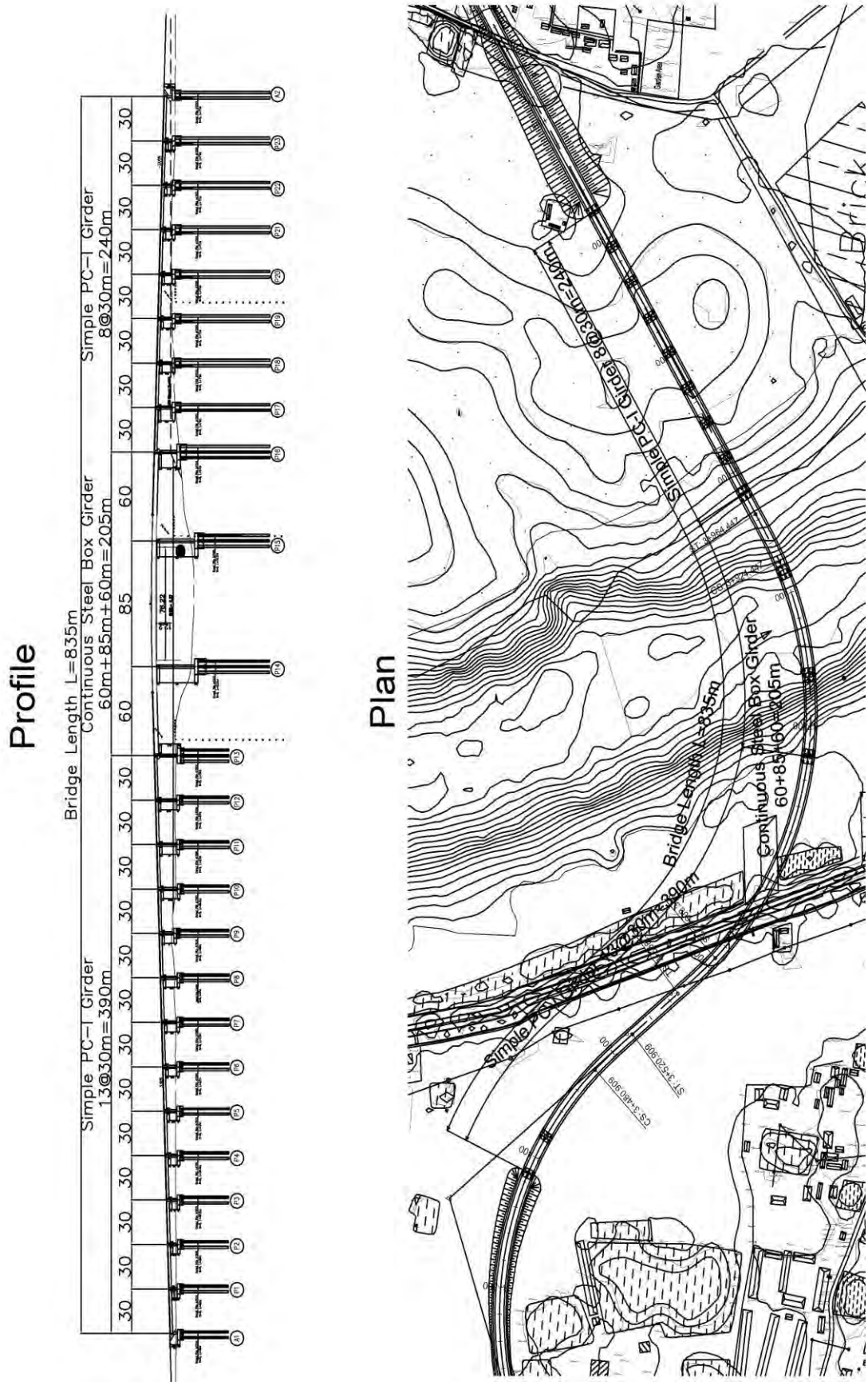
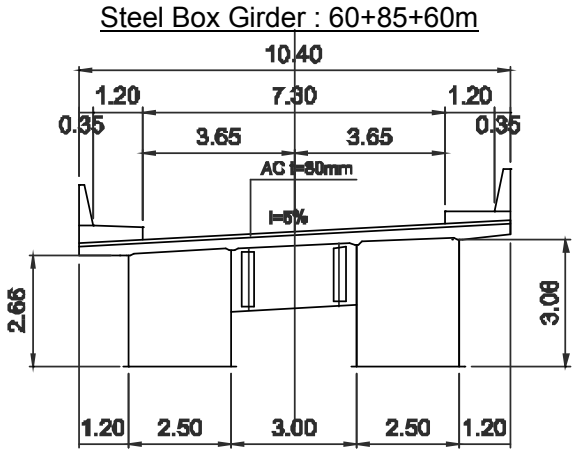


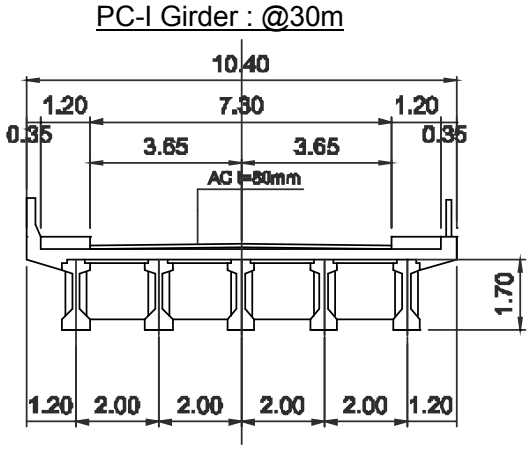
Figure 14.7.19 General View of the EZ Bridge

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

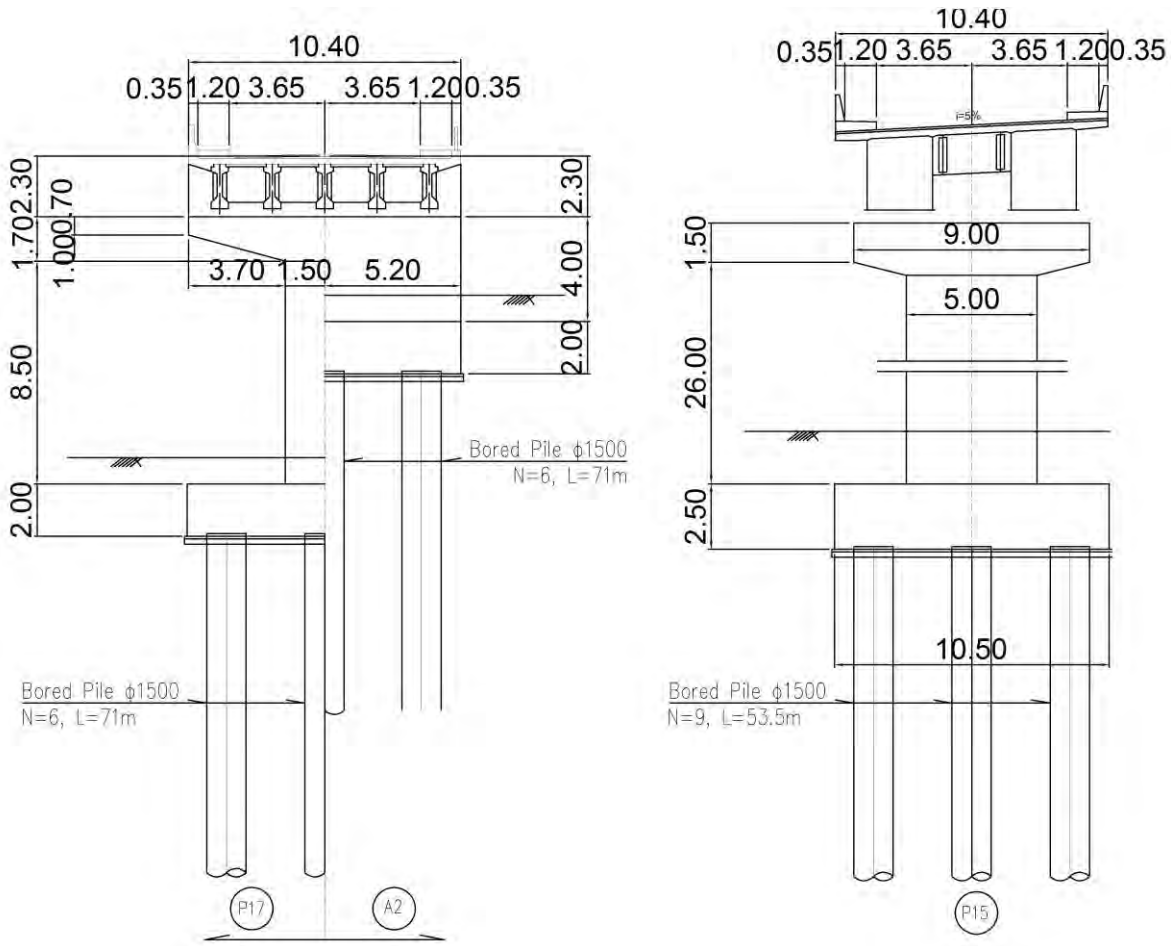
Figure 14.7.21 Cross-section of PC-I Girder for Approach Bridge

(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

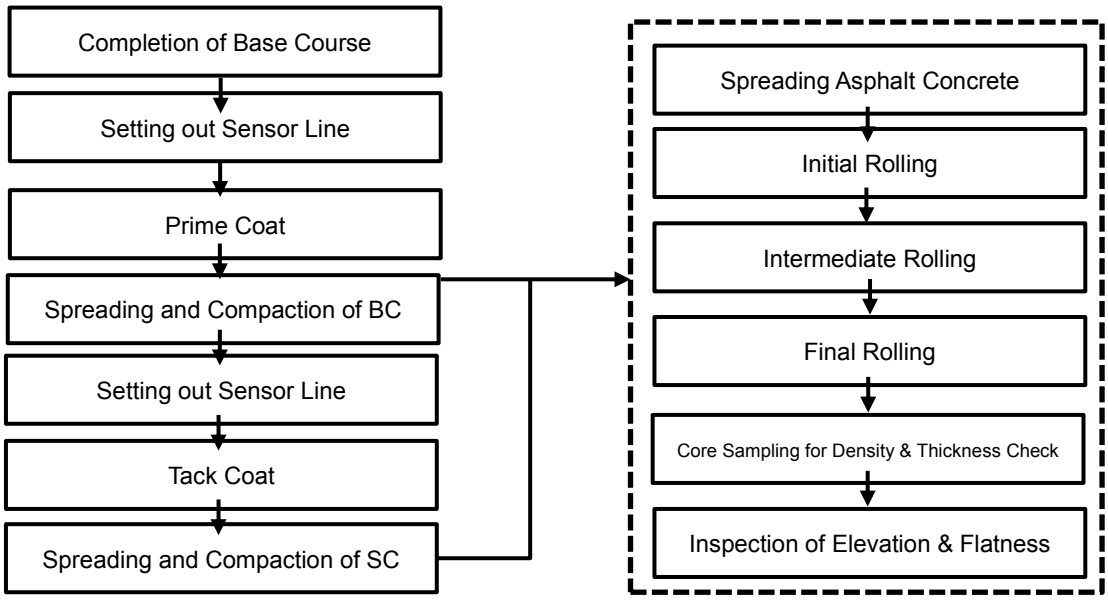
The slope of the embankment is formed by a back hoe after it is compacted by a bulldozer. And then slope protection work, such as planting, is carried out.

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.

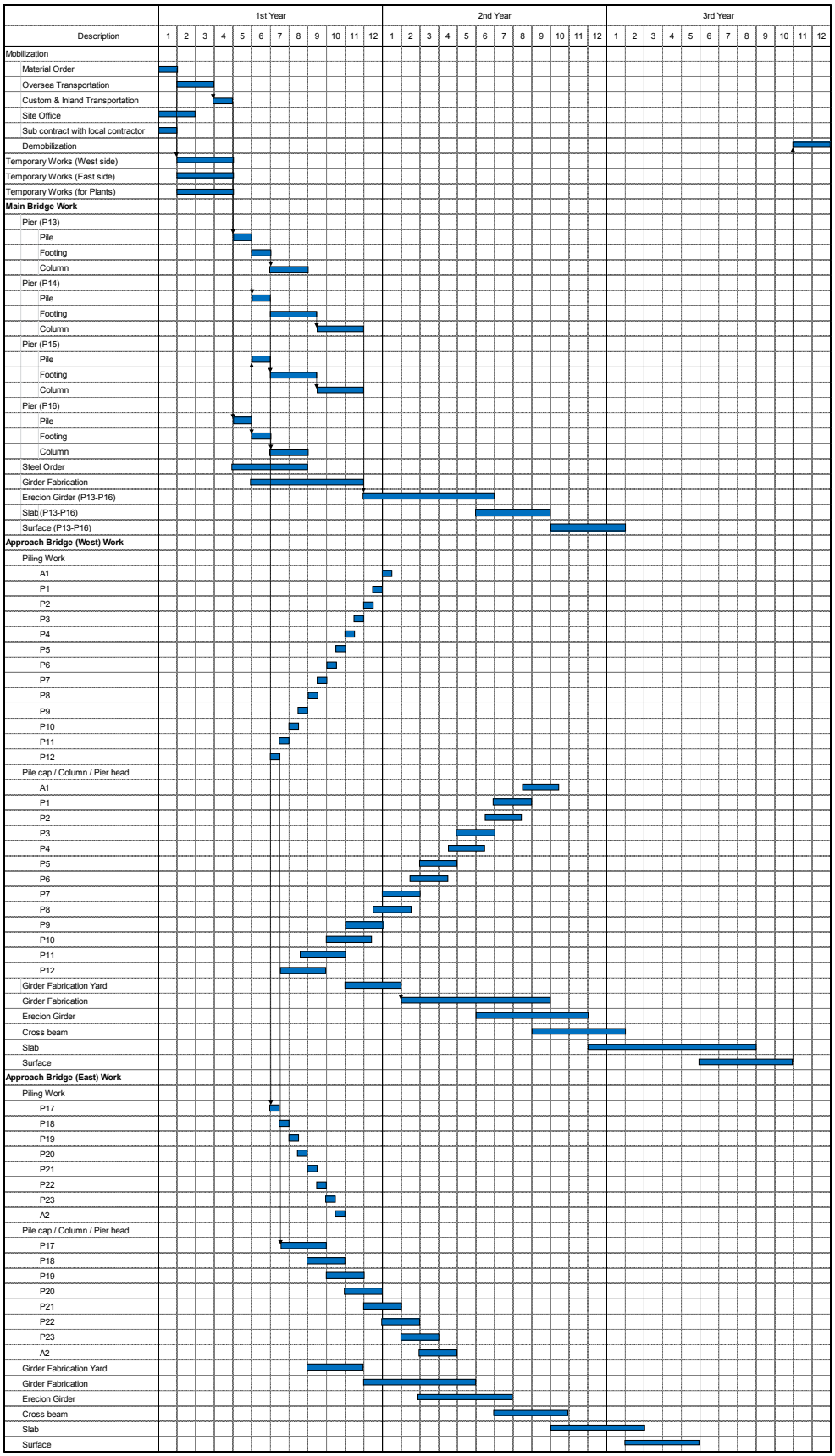


Source: JICA Survey Team

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

	Approach road (left)	Approach bridge (left)	Main bridge	Approach bridge (right)	Approach road (right)	Total
Length (m)	3,387	390	205	240	806	5,028
Cost (BDT)	825,151,747	333,993,482	409,339,193	237,870,271	196,360,292	2,002,714,986
Cost (US$)	670,150	3,454,794	9,021,803	2,438,757	159,475	15,744,978
Cost (BDT Equivalent)	877,088,340	601,739,988	1,108,528,929	426,873,923	208,719,575	3,222,950,756
Ratio	27%	19%	34%	13%	6%	100%

Source: JICA Survey Team

Table 14.10.2 Civil Works Cost of the EZ Bridge and Road

				Approach road (left)			Approach bridge (left)			Main bridge			Approach bridge (right)			Approach road (right)			Total		
	Bridge Width = 10.4	m		3,387	m		390	m		205	m		240	m		806	m		5,028	m	
	Exchange Rate 1 USD = 77.5	TK	Q'ty	Cost(L)	Cost(F)	Q'ty	Cost(L)	Cost(F)	Q'ty	Cost(L)	Cost(F)	Q'ty	Cost(L)	Cost(F)	Q'ty	Cost(L)	Cost(F)	Q'ty	Cost(L)	Cost(F)
a	Abutment																				
1	Excavation and Backfill	cu.m		-	-	384	82,208	983		-	-	384	82,208	983		-	-	768	164,416	1,967
2	Sand backfill for structure	cu.m		-	-	192	197,069	-		-	-	192	197,069	-		-	-	384	394,138	0
3	Concrete, Class A2-2 (Abutment)	cu.m		-	-	156	1,898,812	13,541		-	-	156	1,898,812	13,541		-	-	313	3,797,623	27,081
4	High yield deformed reinfocing bars (fy=400Mpa)	ton		-	-	29	1,739,623	16,890		-	-	29	1,739,623	16,890		-	-	58	3,479,247	33,780
				-	-		-	-		-	-		-	-		-	-		-	-
b	Pier			-	-		-	-		-	-		-	-		-	-		-	-
1	Excavation and Backfill	cu.m		-	-	1,134	242,676	2,903		-	-	662	141,561	1,693		-	-	1,796	384,237	4,596
2	Concrete, Class A2-1 (Pierhead,Column)	cu.m		-	-	1,523	18,581,029	131,906	2,674	32,620,126	231,568	889	10,838,933	76,945		-	-	5,086	62,040,088	440,419
3	Concrete, Class A2-2 (Pile cap)	cu.m		-	-	567	6,885,648	49,102	535	6,494,611	46,314	331	4,016,628	28,643		-	-	1,433	17,396,887	124,059
4	High yield deformed reinfocing bars (fy=400Mpa)	ton		-	-	312	18,763,680	182,177	481	28,927,340	280,856	182	10,945,480	106,270		-	-	975	58,636,500	569,303
c	SUPER STRUCTURE																			
1	Bituminous Wearing Course(62mm)	sq.m		-	-	2,847	1,871,225	16,472	1,492.8	981,134	8,637	1,752	1,151,523	10,137		-	-	6,092	4,003,882	35,246
2	Concrete, Class A3-2 (Side walk, Railing)	cu.m		-	-	283	2,182,301	24,813	141.6	1,092,852	12,426	174	1,342,954	15,269		-	-	599	4,618,107	52,507
3	Concrete, Class A3-4 (footpath)	cu.m		-	-	60	387,090	5,233	29.9	193,847	2,620	37	238,209	3,220		-	-	126	819,145	11,073
4	Concrete, Class A2-2 (Deck Slab)	cu.m		-	-	1,144	13,888,126	99,038	616.0	7,480,385	53,343	704	8,546,539	60,946		-	-	2,463	29,915,051	213,327
5	Concrete, Class A4 (precast formwork)	cu.m		-	-	148	909,130	13,150		-	-	91	559,465	8,092		-	-	239	1,468,595	21,243
6	High yield deformed reinfocing bars (fy=400Mpa)	ton		-	-	302	18,177,478	176,485	145.7	8,761,388	85,064	186	11,186,140	108,606		-	-	634	38,125,005	370,156
				-	-		-	-		-	-		-	-		-	-		-	-
7	Concrete, Class A2-2 (Diaphragm,Cross beam)	cu.m		-	-	91	1,105,104	7,881		-	-	56	680,064	4,850		-	-	147	1,785,168	12,730
8	Concrete, Class A2-1 (RC Girder)	cu.m		-	-		-	-		-	-		-	-		-	-	0	0	0
9	Concrete, Class A1 (PC Girder)	cu.m		-	-	1,388	25,695,008	117,084		-	-	854	15,812,313	72,052		-	-	2,243	41,507,321	189,136
10	High yield deformed reinfocing bars (fy=400Mpa)	ton		-	-	274	16,457,921	159,790		-	-	168	10,127,951	98,332		-	-	442	26,585,872	258,123
11	Pre-stressing strands for PC Girder	ton		-	-	115	8,491,245	312,804		-	-	71	5,225,382	192,495		-	-	186	13,716,627	505,300
12	Steel (SMA490W/400W) for Steel-Box Br.	ton		-	-		-	-	761.5	92,246,916	4,749,257		-	-		-	-	761	92,246,916	4,749,257
13	Steel (SMA400, etc)	ton		-	-		-	-	23.4	2,148,252	110,592		-	-		-	-	23	2,148,252	110,592
14	High Tension Bolt	ton		-	-		-	-	16.2	1,159,870	59,710		-	-		-	-	16	1,159,870	59,710
				-	-		-	-		-	-		-	-		-	-		-	-
15	Elastomeric bearing for RCG	each		-	-		-	-		-	-		-	-		-	-	0	0	0
16	Elastomeric bearing for PCG	each		-	-	130	773,500	93,600		-	-	80	476,000	57,600		-	-	210	1,249,500	151,200
17	Elastomeric bearing for Steel-Box Br.	each		-	-		-	-	10	595,000	216,000		-	-		-	-	10	595,000	216,000
18	Expantion Joint for Steel-Box Br.	m		-	-		-	-	120	807,240	226,447		-	-		-	-	120	807,240	226,447
18	Expantion Joint	m		-	-	270	1,818,981	170,082	21	139,922	13,083	166	1,119,373	104,666		-	-	458	3,078,275	287,830
19	Bridge draining	m		-	-	780	1,498,380	-	120	230,520	-	780	1,498,380	-		-	-	1,680	3,227,280	0
d	PILE																			
1	Drilling of Pile (Dia.1.2 m)	m		-	-	5,616	12,422,592	143,320		-	-	4,608	10,192,896	117,596		-	-	10,224	22,615,488	260,916
2	Concrete ,Class A3-1 (Bored pile Dia.1.2 m)	cu.m		-	-	6,352	50,520,200	492,054		-	-	5,212	41,452,472	403,737		-	-	11,563	91,972,671	895,791
3	High yield deformed reinfocing bars (fy=400Mpa)	ton		-	-	1,179	70,926,710	688,628	214	12,869,960	124,955	968	58,196,275	565,028		-	-	2,361	141,992,946	1,378,611
4	Loading test (Dia. 1.2 m)	LS		-	-	13	14,913,379	86,232		-	-	8	9,177,464	53,066		-	-	21	24,090,843	139,298
5	Drilling of Pile (Dia.1.5 m)	m		-	-		-	-	1,787	4,460,352	51,466		-	-	-	-	-	1,787	4,460,352	51,466
6	Concrete ,Class A3-1 (Bored pile Dia.1.5 m)	cu.m		-	-		-	-	3,158	33,059,947	244,642		-	-		-	-	3,158	33,059,947	244,642
7	Loading test (Dia. 1.5 m)	LS		-	-		-	-	8	9,177,464	53,066		-	-		-	-	8	9,177,464	53,066
8	Erection staging	m2		-	-		-	-	2,500	112,500,000	1,275,000		-	-		-	-	2,500	112,500,000	1,275,000
e	APPROACH ROAD	m																		
1	Embankment Fill Height = 1.80	cu.m	5,500	2,398,213	4,400		-	-		-	-		-	-	1,309	570,700	1,047	6,809	2,968,912	5,448
2	Sub Base 1000 mm 1.00	cu.m	49,315	200,513,652	-		-	-		-	-		-	-	11,735	47,715,974	-	61,050	248,229,625	0
3	Aggregate lower base 400 mm 0.40	cu.m	19,726	89,575,257	-		-	-		-	-		-	-	4,694	21,316,108	-	24,420	110,891,365	0
4	Aggregate upper base 350 mm 0.35	cu.m	17,260	144,519,253	18,814		-	-		-	-		-	-	4,107	34,391,059	4,477	21,368	178,910,312	23,291
5	Bituminous binder course 200 mm 0.20	cu.m	9,863	125,456,646	429,235		-	-		-	-		-	-	2,347	29,854,756	102,145	12,210	155,311,404	531,380
6	Bituminous wearing course 50 mm 0.05	cu.m	2,466	33,894,007	130,289		-	-		-	-		-	-	587	8,065,713	31,005	3,053	41,959,720	161,294
	Approach Road Length	m																		
f	SOFT SOIL TREATMENT																			
1	Temporary approach road	m3	40,389	121,166,229	-		-	-		-	-		-	-	9,611	28,833,771	-	50,000	150,000,000	0
g	Other civil , General, Preparation, Safety, etc. 15%			107,628,489	87,411		43,564,367	450,625		53,392,069	1,176,757		31,026,557	318,099		25,612,212	20,801		261,223,694	2,053,693
	Total cost Foreign ratio (%), Local (TK), Foreign (USD)		5.9%	825,151,747	670,150	44.5%	333,993,482	3,454,794	63.1%	409,339,193	9,021,803	44.3%	237,870,271	2,438,757	5.9%	196,360,292	159,475	37.9%	2,002,714,986	15,744,978
	Combine cost (TK)				877,088,340			601,739,988			1,108,528,929			426,873,923			208,719,575			3,222,950,756
	Length (m)				3,387			390			205			240			806	Br. Only			835
	Average cost (TK / m)				258,957			1,542,923			5,407,458			1,778,641			258,957				3,859,821
	Area (m2)				35,225			4,056			2,132			2,496			8,382	Br. Only			8,684
	Average cost (TK / m2)				24,900			148,358			519,948			171,023			24,900				371,137

Source: JICA Survey Team

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.

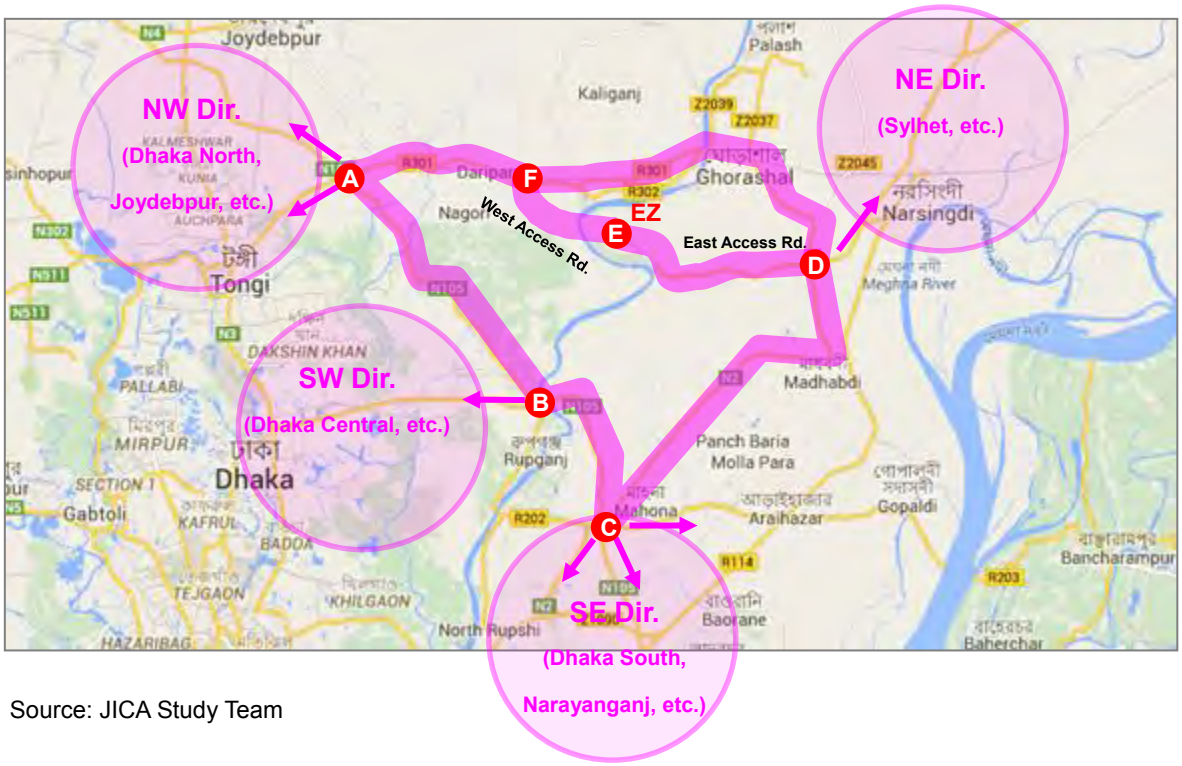
(2) Setting of Operation Indicator

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)

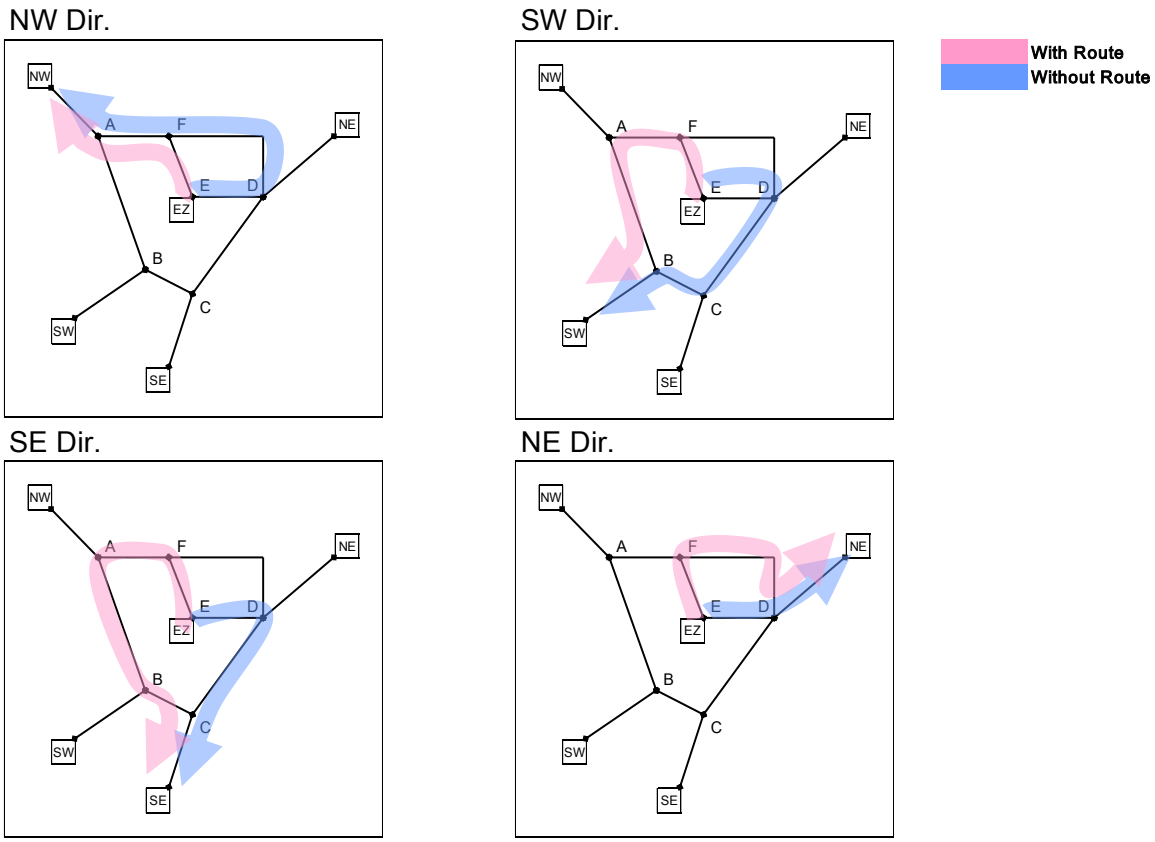
Auto rickshaw	Car	Bus	20ft Container	Medium Truck	Small Truck	Total
880	2,020	109	1,632	2,216	2,012	8,869

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

	Financial Cost	Foreign Cost	Local Cost	Economic Cost
Civil Works	3,259	1,256	2,003	2,418
Price Escalation	545	107	438	0
Physical Contingency	380	136	244	284
Consulting Services	483	327	156	337
Land Acquisition	3,154	0	3,154	3,154
Administrative Cost	467	0	467	0
VAT	475	0	475	0
Import Tax	450	0	450	0
Interest during Construction	3	0	0	0
Commitment Charge	0	0	0	0
Total	9,216	1,826	7,387	6,193

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

SQ	Year	Discounted Cost			Discounted Benefit			Net Benefit
		Construction Cost	O & M Cost	Cost Total	VOC	TTC	Discounted Benefit	
1	2015	0.0		0.0				0.0
2	2016	239.2		239.2				-239.2
3	2017	892.1		892.1				-892.1
4	2018	788.8		788.8				-788.8
5	2019	899.5		899.5				-899.5
6	2020	541.6		541.6				-541.6
7	2021	495.7		495.7				-495.7
8	2022	116.9		116.9				-116.9
9	2023	36.8	13.8	50.6	131.2	1,003.8	1,135.0	1,084.4
10	2024	0.0	12.3	12.3	127.4	974.5	1,101.9	1,089.6
11	2025	0.0	11.0	11.0	123.7	946.1	1,069.8	1,058.8
12	2026	0.0	9.8	9.8	120.1	918.5	1,038.6	1,028.8
13	2027	0.0	8.8	8.8	116.6	891.7	1,008.3	999.6
14	2028	0.0	7.8	7.8	113.2	865.7	978.9	971.1
15	2029	0.0	7.0	7.0	109.9	840.5	950.4	943.4
16	2030	0.0	6.2	6.2	106.7	816.0	922.7	916.4
17	2031	0.0	5.6	5.6	103.6	1,050.5	1,154.1	1,148.6
18	2032	0.0	5.0	5.0	95.2	965.3	1,060.5	1,055.5
19	2033	0.0	4.4	4.4	87.4	887.0	974.4	970.0
20	2034	0.0	4.0	4.0	80.4	815.0	895.3	891.4
21	2035	0.0	3.5	3.5	73.8	748.9	822.7	819.1
22	2036	0.0	3.2	3.2	67.8	688.1	755.9	752.8
23	2037	0.0	2.8	2.8	62.3	632.2	694.6	691.8
24	2038	0.0	2.5	2.5	57.3	580.9	638.2	635.7
25	2039	0.0	2.2	2.2	52.6	533.8	586.4	584.2
26	2040	0.0	2.0	2.0	48.4	490.5	538.8	536.8
27	2041	0.0	1.8	1.8	44.4	450.7	495.1	493.3
28	2042	0.0	1.6	1.6	40.8	414.1	454.9	453.3
29	2043	0.0	1.4	1.4	37.5	380.5	418.0	416.6
30	2044	0.0	1.3	1.3	34.5	349.6	384.1	382.8
31	2045	0.0	1.1	1.1	31.7	321.3	352.9	351.8
32	2046	0.0	1.0	1.0	29.1	295.2	324.3	323.3
33	2047	0.0	0.9	0.9	26.7	271.2	298.0	297.1
Total		4,010.7	121.0	4,131.7	1,922.4	17,131.5	19,053.9	14,922.3

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

Sl. No	Description of items	Cost (million Tk)	Remarks	Cost borne by
A	Air/Water/Soil Quality	3.6	0.1x36	Contractor (involved in Contract)
B	Dust Control	-	Personnel expense is involved in #A	Contractor (involved in Contract)
C	Noise Control	0.003	0.003 Personnel expense is involved in #A	Contractor (involved in Contract)
D	Waste Management	-	Personnel expense is involved in #A	Contractor (involved in Contract)
E	Working conditions and Accident	0.07	1 L.S.	Contractor (involved in Contract)
F	Turf	14.7	5m x 2 x 4,200m x Tk35/sqm	Contractor (involved in BoQ)
G	Cleaning and Grubbing	0.04	1 L.S.	Contractor (involved in BoQ)
	Total sum	18.41		

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

Sl. No	Description of items	Cost (million Tk)	Remarks	Cost borne by
I	ARP Implementing Agency	0.80		RHD
II	External Monitoring	0.10		RHD
	Total sum	0.98		

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

The total estimated cost for implementation of the ARP is BDT **2,563,369,973** including the 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 as shown in Table 14.12.8.

Table 14.12.8 Land Acquisition and Resettlement Budget

No.	Category of loss	Unit	Quantity.	Rate (Tk)	Amount (Tk)
A.	***Land with Types***				
1	Residential/Commercial	ha	5.62	183,332,844.03	1,030,367,250
2	Agriculture/Others	ha	6.87	150,000,327.55	1,030,367,250
	Subtotal Land Acquisition		***12.49***		***2,060,734,500***
B.	***Stamp duty and Registration fees (@10.5%)***				***216,377,123***
C.	***Main Structure (Residential and Commercial)***				
1	Thatched	Sqm	-	3,368	-
2	Katcha	Sqm	302	3,626	1,095,052
3	Semipucca	Sqm	1,288	8,575	11,044,600
4	Pucca	Sqm	682	14,569	9,936,058
5	Tin	Sqm	1,437	6,133	8,813,121
	Subtotal of Main Structure		***3,709***		***30,888,831***
D.	***Secondary Structure***				
1	Latrine (Pucca)	#	36	29,706	1,069,416
2	Latrine (Slab)	#	-	7,076	-
3	Latrine (Katcha)	#	-	5,594	-
4	Tube well	#	34	14,077	478,618
5	Boundary wall (Pucca and Tin)	Rm	-	1,689	-
	Subtotal of Secondary Structures				***1,548,034***
E.	***Trees (Calculation made on average rate)***				
1	Large	#	3,241	12,000	38,892,000
2	Medium	#	1,448	8,000	11,584,000
3	Small	#	724	2,000	1,448,000
4	Sapling	#	342	100	34,200
5	Bamboo	#	3,120	200	624,000
6	Banana	#	3,384	300	1,015,200
	Subtotal of Trees		***12,259***		***53,597,400***
F.	***Resettlement Benefit***				

No.	Category of loss	Unit	Quantity.	Rate (Tk)	Amount (Tk)
1	Crop compensation (90% of Agriculture/Others @ 400/dec* or 98,800/ha)	ha	6.18	98,800	610,800
2	Fish Stock (10% of Agriculture/Others) @ 500/dec* (123,500/ha)	ha	0.69	123,500	84,833
3	Dislocation allowance for arable land and ponds @ Taka 100/dec* or 24700/ha	ha	6.87	24,700	169,667
4	Dislocation allowance for Residential/Commercial @ Taka 200/dec* or 49,400/ha)	ha	5.62	49,400	277,638
5	Transfer grant (On Govt, or Private land) @ 12.5% of main structure value				3,861,104
6	Reconstruction grant (On Govt, or Private land) @ 12.5% of main structure value				*3,861,104*
7	Additional Cash Grant for vulnerable households Tk. 3000	#	2	3,000	6,000
8	Additional Cash Grant for women-headed households Tk. 3000	#	3	3,000	9,000
9	Fruit compensation (30% of timber value for fruit bearing trees, big and medium)	#	3,571	2,000	7,142,000
10	Sapling for displaced households	#	39	500.00	19,500
	Subtotal-F				***16,041,646***
	Subtotal of (A-F)				***2,379,187,534***
G.	***Others***				
1	Social Development Fund for livelihood Restoration and Training	#			20,000
2	Operation Cost for ARP implementing NGO (INGO)			LS	800,000
3	Contingency for unforeseen issues @ 5% of total budget (Item A-F)			LS	118,959,377
4	Administration cost of DC on compensation (Item A, C,D and E) @ 3%			LS	64,403,063
	Grand Total				***2,563,369,973***

*Note: A “decimal” is a unit of area approximately equal to 40.46 m^2.

Source: Census & Socioeconomic survey, July 2014

(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 14.12.9 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 14.12.10 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 14.12.11 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 14.12.12 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.

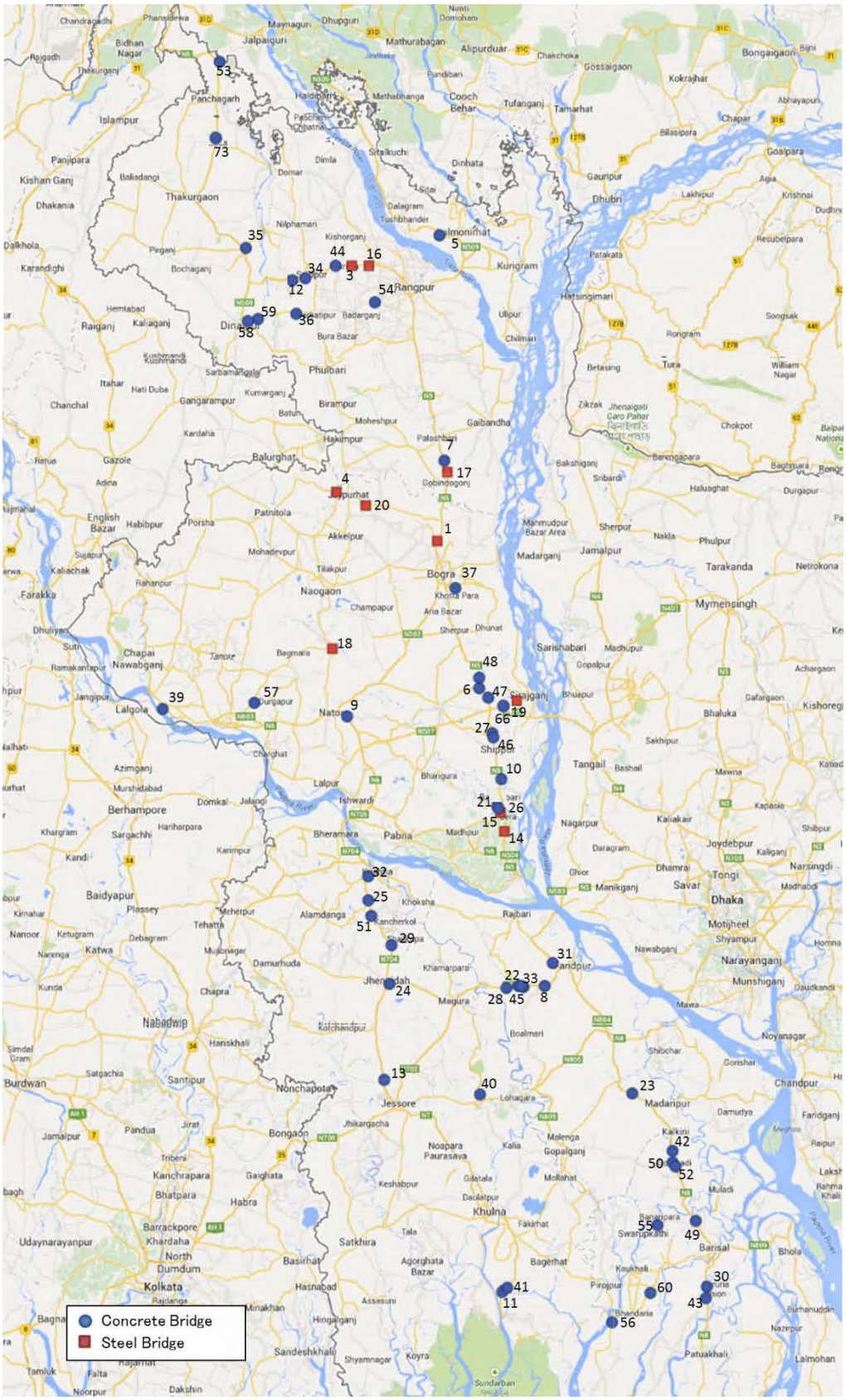
Table 15.2.4 2 List of Final Project Bridges

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

It is recommended that the Project be implemented with 6 contract packages in 6 zones in order to ensure smooth administration by RHD. Project bridges in the respective 6 contract packages are shown in Table 15.3.1 and Figure 15.3.1.

- North 1 Package: 19 bridges
- North 2 Package: 16 bridges
- South 1 Package: 9 bridges
- South 2 Package: 9 bridges
- South 3 Package: 7 bridges
- EZ Package: 1 bridge

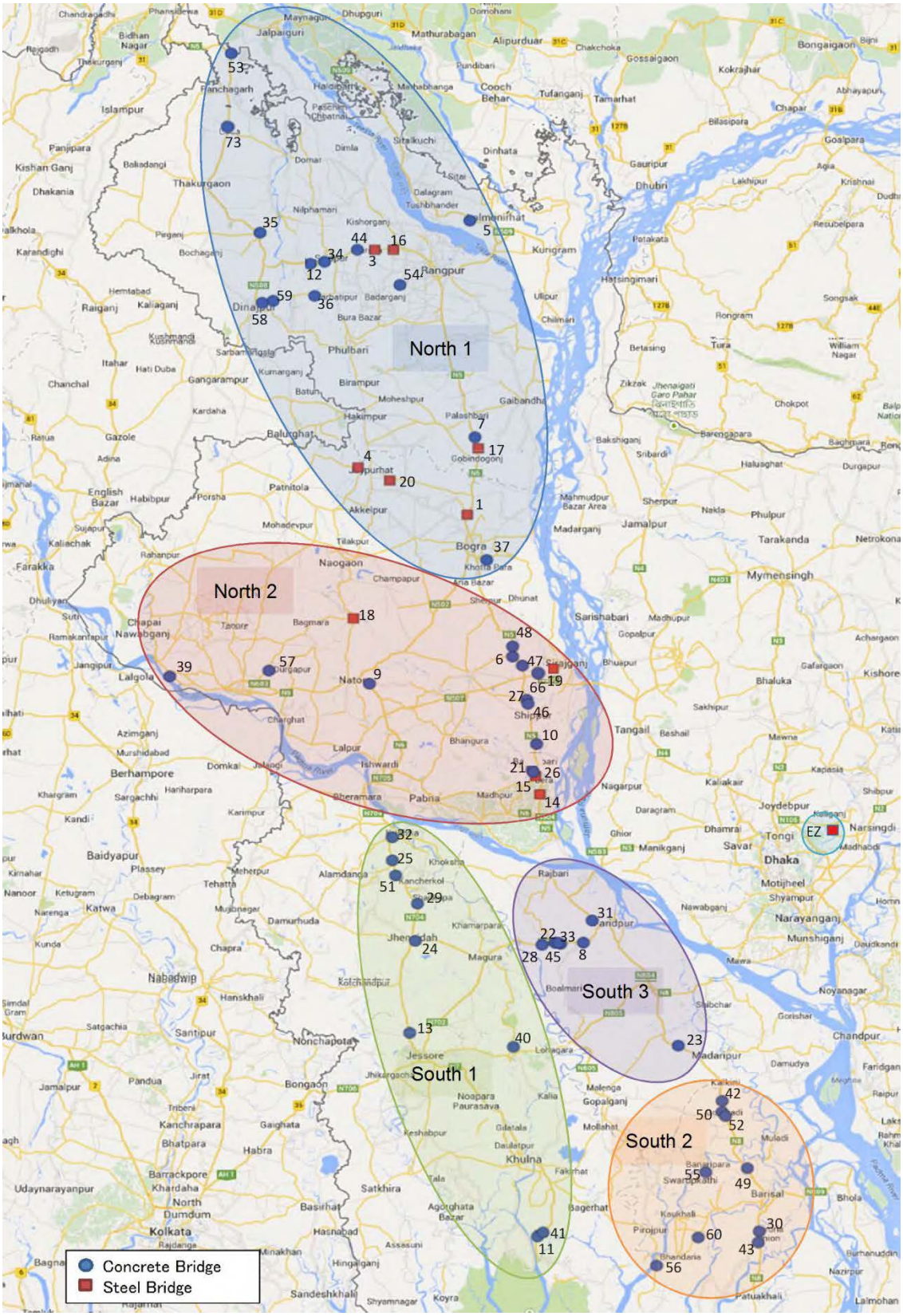
Table 15.3.1 List of Project Bridges in 6 Packages

Package	Rank	SN	Zone	Bridge Name
North 1	1	6	Rangpur	Mohosthan Bridge
	3	11		Barati Bridge
	4	62		Mongle bari kuthibari Bridge
	5	2		Sharnamoti Bridge
	7	10		Bupinath Bridge
	12	31		Gaudangi Bridge
	16	45		-
	17	66		Katakhali Bridge
	20	76		Bottoli Bridge
	34	38		Khorkhori bridge
	35	88		Choto Dhepa bridge.
	36	90		Bondorer pool Bridge
	37	91		-
	44	24		-
	53	80		Chawai Bridge
	54	89		Shampur Bridge.
	58	49		Gabura Bridge.
	59	52		Madarganj Bridge
	73	79		-
North 2	6	5	Rajshahi	Bhuyagati Bridge
	9	17		Dattapara Bridge
	10	19		Jugnidaha Bridge
	14	20		Punduria Bridge
	15	37		Vitapara Bridge
	18	28		Atrai Bridge
	19	75		Chondi Das Bridge
	21	8		Goilhar Bridge
	26	4		Palgari Bridge
	27	9		Purbodalua Bridge

Package	Rank	SN	Zone	Bridge Name
	39	18		Horisonkorpur Bridge
	46	33		Chowkidhoh Bridge
	47	34		Notun Dhoh Bridge
	48	35		Dhatia Bridge
	57	87		Faliarbil Bridge
	66	74		Naiori Bridge
	11	22		Gora bridge
	13	39		Buri Bhairab Bridge
	24	41		Dhopa Ghata Bridge
	25	44		Balipara Bridge
South 1	29	43	Khulna	Barda Bridge
	32	21		-
	40	40		Gurakhali Bridge
	41	25		Balai bridge.
	51	67		Bittipara Bridge
	30	1		Boalia Bazar Bridge
	42	64		Souderkhal bridge
	43	12		Bakerganj Steel Bridge
	49	56		Rahamatpur bridge
South 2	50	57	Barisal	Gounagata bridge
	52	69		Asokoti bridge
	55	82		Raiyer hat bridge
	56	65		Bottala Bridge
	60	78		-
	8	14		Karimpur Bridge
	22	15		Porkitpur Bridge
	23	26		Amgram bridge
South 3	28	23	Gopalganj	Barashia Bridge
	31	13		Jhuldibazar Bridge
	33	32		Bimankanda bridge
	45	30		Brahmonkanda Bridge
EZ	EZ Bridge	-	Dhaka	-

*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 15.3.1 Area of 5 Packages in Western Bangladesh

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

Rank	SN	Zone	Bridge Name	Road Type	Bridge Type	Width (m)	No of Spans	Span Arrangement (m)	Total Length (m)	Bridge Area (m2)	Abutment Pile Length(m)	Pier Pile Length (m)	Left Approach Road (m3)	Right Approach Road (m3)	Super Structure		Abutment		Pier		Pile		Approach Road		Temporary and		Soft Soil Treatment		Over Head		Total				
															Local (TK)	Foreign (USD)	Local (TK)	Foreign (USD)	Local (TK)	Foreign (USD)	Local (TK)	Foreign (USD)	Local (TK)	Foreign (USD)	Local (TK)	Foreign (USD)	Local (TK)	Foreign (USD)	Local (TK)	Foreign (USD)	Local (TK)	Foreign (USD)	Foreign Ratio	Comb. (TK)	Unit (TK/m2)
1	6	Rangpur	Mohosthan Bridge	N	Steel-I	10.4	3	40+40+40	120	1,248	30.0	25.8	6,849	9,983	50,407,968	2,234,170	6,338,306	51,283	5,524,614	45,818	19,889,495	190,549	32,738,240	37,030	0	0			17,234,793	383,828	132,133,417	2,942,678	63.3%	360,190,980	288,615
3	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	67,210,624	2,978,893	6,338,306	51,283	8,286,921	68,727	16,275,758	155,928	19,546,083	22,109	0	0			17,648,654	491,541	135,306,346	3,768,481	68.3%	427,363,644	256,829
4	62	Rangpur	Mongle bari kuthibari Bridge	R	Steel-I	10.4	2	40+50	90	936	19.7	15.1	4,288	8,973	37,805,976	1,675,627	6,338,306	51,283	2,762,307	22,909	10,232,596	98,032	25,792,645	29,174	36,360,000	0			17,893,775	281,554	137,185,605	2,158,580	54.9%	304,475,558	325,294
5	2	Rangpur	Shamamoti Bridge	N	PC-I	10.4	2	35+35	70	728	20.6	17.6	10,570	14,939	16,574,376	215,051	7,264,678	58,253	3,889,847	32,066	11,219,682	107,581	49,615,394	56,120	0	0			13,284,596	70,361	101,848,573	539,432	29.1%	143,654,522	197,328
6	5	Rajshahi	Bhuyagati Bridge	N	PC-I	10.4	3	25+30+25	80	832	26.9	20.8	18,607	8,467	18,942,144	245,773	7,264,678	58,253	7,779,694	64,133	17,496,446	167,766	52,658,405	59,562	0	0			15,621,205	89,323	119,762,571	684,809	30.7%	172,835,258	207,735
7	10	Rangpur	Bupinath Bridge	N	PC-I	10.4	2	35+25	60	624	23.8	19.0	6,838	6,266	14,206,608	184,330	7,264,678	58,253	3,889,847	32,066	12,745,438	122,210	25,486,074	28,827	0	0			9,538,897	63,853	73,131,542	489,539	34.2%	111,070,839	177,998
8	14	Gopalganj	Karimpur Bridge	N	PC-I	10.4	2	40+25	65	676	48.9	42.3	9,505	7,450	15,390,492	199,690	7,264,678	58,253	3,889,847	32,066	26,674,098	255,766	32,977,105	37,301	0	0	57,837,936		21,605,123	87,461	165,639,280	670,538	23.9%	217,605,939	321,902
9	17	Rajshahi	Dattapara Bridge	N	PC-I	10.4	1	40.0	40	416	22.6	0	4,059	3,201	9,471,072	122,886	7,264,678	58,253	0	0	9,312,164	89,290	14,120,700	15,972	0	0			6,025,292	42,960	46,193,906	329,361	35.6%	71,719,419	172,402
10	19	Rajshahi	Jugnidaha Bridge	N	PC-I	10.4	2	40+25	65	676	24.7	20.8	15,410	8,290	15,390,492	199,690	7,264,678	58,253	3,889,847	32,066	13,366,880	128,169	46,096,500	52,140	0	0			12,901,260	70,548	98,909,657	540,866	29.8%	140,826,790	208,324
11	22	Khulna	Gora bridge	N	PC-I	10.4	1	30	30	312	49.2	0	3,614	3,172	7,103,304	92,165	7,264,678	58,253	0	0	20,252,269	194,190	13,198,817	14,929	0	0			7,172,860	53,931	54,991,928	413,467	36.8%	87,035,644	278,960
12	31	Rangpur	Gaudangi Bridge	N	PC-I	10.4	2	40+25	65	676	24.7	23.7	9,337	9,735	15,390,492	199,690	7,264,678	58,253	3,889,847	32,066	13,817,004	132,485	37,095,040	41,958	0	0			11,618,559	69,668	89,075,620	534,121	31.7%	130,469,985	193,003
13	39	Khulna	Buri Bhairab Bridge	N	PC-I	10.4	1	35	35	364	36.6	0	3,898	871	8,287,188	107,526	7,264,678	58,253	0	0	15,057,933	144,384	9,275,705	10,492	0	0			5,982,826	48,098	45,868,329	368,752	38.4%	74,446,610	204,524
14	20	Rajshahi	Punduria Bridge	N	Steel-I	10.4	3	40+50+40	130	1,352	22.7	17.6	14,261	11,922	54,608,632	2,420,350	6,338,306	51,283	5,524,614	45,818	14,422,584	138,174	50,927,351	57,604	0	0	47,302,810		26,868,645	406,985	205,992,942	3,120,215	54.0%	447,809,577	331,220
15	37	Rajshahi	Vitapara Bridge	N	Steel-I	10.4	2	60+40	100	1,040	31.1	24.4	29,320	19,825	42,006,640	1,861,808	6,338,306	51,283	2,762,307	22,909	16,214,051	155,337	95,588,422	108,121	0	0			24,436,459	329,919	187,346,185	2,529,377	51.1%	383,372,874	368,628
16	45	Rangpur	Kharua Vanga Bridge	N	Steel-I	10.4	1	40.0	40	416	26.6	0	5,759	6,259	16,802,656	744,723	6,338,306	51,283	0	0	10,719,508	102,697	23,374,932	26,440	0	0	19,907,335		11,571,411	138,771	88,714,148	1,063,915	48.2%	171,167,530	411,460
17	66	Rangpur	Katakhali Bridge	N	Steel-I	10.4	3	60+60+50	170	1,768	26.5	20.0	14,180	9,144	71,411,288	3,165,074	6,338,306	51,283	5,524,614	45,818	16,699,050	159,983	45,365,764	51,313	0	0			21,800,853	521,021	167,139,875	3,994,493	64.9%	476,713,068	269,634
18	28	Rajshahi	Atrai Bridge	R	Steel-I	10.4	3	50+50+60	160	1,664	25.0	14.0	18,058	23,488	67,210,624	2,978,893	6,338,306	51,283	5,524,614	45,818	14,294,288	136,945	80,806,970	91,401	64,640,000	0			35,822,220	495,651	274,637,022	3,799,991	51.7%	569,136,360	342,029
19	75	Rajshahi	Chondi Das Bridge	R	Steel-I	10.4	2	40+40	80	832	41.9	34	6,466	6,750	33,605,312	1,489,446	6,338,306	51,283	2,762,307	22,909	22,035,350	211,107	25,705,120	29,075	32,320,000	0			18,414,959	270,573	141,181,354	2,074,394	53.2%	301,946,924	362,917
20	76	Rangpur	Bottoli Bridge	R	Steel-I	10.4	2	40+40	80	832	12.1	6.5	5,700	4,785	33,605,312	1,489,446	6,338,306	51,283	2,762,307	22,909	5,847,018	56,017	20,393,325	23,067	32,320,000	0			15,189,940	246,408	116,456,208	1,889,131	55.7%	262,863,859	315,942
21	8	Rajshahi	Goilhar Bridge	N	PC-I	10.4	2	35+25	60	624	33.8	29.0	12,980	14,262	14,206,608	184,330	7,264,678	58,253	3,889,847	32,066	18,402,922	176,458	52,985,690	59,932	0	0			14,512,462	76,656	111,262,206	587,694	29.0%	156,808,509	251,296
22	15	Gopalganj	Porkitpur Bridge	N	PC-I	10.4	1	30	30	312	31.1	0	7,713	7,602	7,103,304	92,165	7,264,678	58,253	0	0	12,807,726	122,808	29,787,947	33,693	0	0	7,713,378	53,454	9,701,555	54,056	74,378,588	414,428	30.2%	106,496,756	341,336
23	26	Gopalganj	Amgram bridge	N	PC-I	10.4	1	40	40	416	34.8	0	10,140	8,739	9,471,072	122,886	7,264,678	58,253	0	0	14,319,944	137,308	36,719,655	41,534	0	0	9,785,927	67,817	11,634,191	64,170	89,195,467	491,967	29.9%	127,322,876	306,065
24	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	35,516,520	460,824	7,264,678	58,253	15,559,388	128,265	28,086,191	269,306	10,559,989	11,944	0	0			14,548,015	139,289	111,534,780	1,067,881	42.6%	194,295,582	124,548
25	44	Khulna	Balipara Bridge	N	PC-I	10.4	1	40	40	416	25.1	0	6,329	4,733	9,471,072	122,886	7,264,678	58,253	0	0	10,319,486	98,949	21,515,201	24,336	0	0			7,285,566	45,664	55,856,002	350,088	32.7%	82,987,790	199,490
26	4	Rajshahi	Palgari Bridge	N	PC-I	10.4	2	35+25	60	624	33.4	27.1	19,386	13,062	14,206,608	184,330	7,264,678	58,253	3,889,847	32,066	17,954,085	172,154	63,111,360	71,386	0	0	39,852,751		21,941,899	77,728	168,221,228	595,916	21.5%	214,404,730	343,597
27	9	Rajshahi	Purbodalua Bridge	N	PC-I	10.4	3	25+30+25	80	832	25.4	19.1	3,335	9,571	18,942,144	245,773	7,264,678	58,253	7,779,694	64,133	16,350,957	156,782	25,102,170	28,393	0	0			11,315,946	83,000	86,755,590	636,333	36.2%	136,071,426	163,547
28	23	Gopalganj	Barashia Bridge	N	PC-I	10.4	3	25+40+25	90	936	52.7	44.8	5,142	4,502	21,309,912	276,494	7,264,678	58,253	7,779,694	64,133	35,528,983	340,672	18,756,277	21,215	0	0	17,441,870		16,212,212	114,115	124,293,626	874,882	35.3%	192,096,966	205,232
29	43	Khulna	Barda Bridge	N	PC-I	10.4	3	40+40+25	105	1,092	29.9	22.6	973	2,759	24,861,564	322,577	7,264,678	58,253	7,779,694	64,133	19,300,441	185,063	7,258,351	8,210	0	0			9,969,709	95,735	76,434,437	733,971	42.7%	133,317,170	122,085
30	1	Barisal	Boalia Bazar Bridge	N	PC-I	10.4	1	40	40	416	44.9	0	7,593	10,247	9,471,072	122,886	7,264,678	58,253	0	0	18,471,542	177,116	34,697,439	39,246	0	0	42,529,546		16,865,142	59,625	129,299,418	457,126	21.5%	164,726,694	395,978
31	13	Gopalganj	Jhuldibazar Bridge	N	PC-I	10.4	1	30	30	312	38.0	0	8,722	8,290	7,103,304	92,165	7,264,678	58,253	0	0	15,649,312	150,054	33,087,056	37,425	0	0			9,465,653	50,685	72,570,003	388,581	29.3%	102,685,051	329,119
32	21	Khulna	G.K. Bridge	N	PC-I	10.4	2	30+25	55	572	26.1	23.7	289	1,742	13,022,724	168,969	7,264,678	58,253	3,889,847	32,066	14,398,757	138,063	3,950,295	4,468	0	0			6,378,945	60,273	48,905,246	462,092	42.3%	84,717,389	148,107
33	32	Gopalganj	Bimankanda bridge	N	PC-I	10.4	2	35+25	60	624	35.6	29.8	14,034	10,903	14,206,608	184,330	7,264,678	58,253	3,889,847	32,066	19,277,481	184,843	48,500,715	54,859	0	0	114,181,851		31,098,177	77,153	238,419,357	591,504	16.1%	284,260,912	455,546
34	38	Rangpur	Khorkhori bridge	N	PC-I	10.4	2	35+25	60	624	24.7	19.5	5,201	6,866	14,206,608	184,330	7,264,678	58,253	3,889,847	32,066	13,207,350	126,639	23,470,373	26,547	0	0			9,305,828	64,175	71,344,685	492,011	34.8%	109,475,521	175,442
35	88	Rangpur	Choto Dhepa bridge.	Z	PC-I	9.8	2	30+25	55	539	18.2	12.9	4,096	5,435	12,271,413	159,221	7,264,678	58,253	3,889,847	32,066	9,487,395	90,970	18,537,795	20,968	22,220,000	0			11,050,669	54,222	84,721,798	415,700	27.6%	116,938,540	216,955
36	90	Rangpur	Bondorer pool Bridge	Z	PC-I	9.8	2	30+30	60	588	34.6	30.7	4,070	2,401	13,386,996	173,695	7,264,678	58,253	3,889,847	32,066	18,990,234	182,089	12,586,095	14,236	24,240,000	0			12,053,678	69,051	92,411,528	529,390	30.7%	133,439,271	226,938
37	91	Rangpur	Khottapara Bridge	Z	PC-I	9.8	1	40.0	40	392	24.8	0	3,112	4,642	8,924,664	115,797	7,264,678	58,253	0	0	10,213,235	97,930	15,081,530	17,059	16,160,000	0			8,646,616	43,356	66,290,723	332,394	28.0%	92,051,274	234,825
39	18	Rajshahi	Horisonkorpur Bridge	R	PC-I	10.4	2	25+25	50	520	20.6	16.6	1,406	1,195	11,838,840	153,608	7,264,678	58,253	3,889,847	32,066	11,047,179	105,927	5,058,945	5,722	20,200,000	0			8,894,923	53,336	68,194,412	408,912	31.7%	99,885,093	192,087
40	40	Khulna	Gurakhali Bridge	R	PC-I	10.4	2	30+25	55	572	46.3	41	5,997	5,827	13,022,724	168,969	7,264,678	58,253	3,889,847	32,066	25,322,028	242,802	22,997,680	26,013	22,220,000	0			14,207,544	79,215	108,924,501	607,318	30.2%	155,991,622	272,713
41	25	Khulna	Balai bridge.	N	PC-I	10.4	2	25+35	60	624	53.6	51.1	3,015	3,976	14,206,608	184,330	7,264,678	58,253	3,889,847	32,066	29,975,794	287,425	13,597,495	15,380	0	0			10,340,163	86,618	79,274,585	664,071	39.4%	130,740,125	209,519
42	64	Barisal	Souderkhal bridge	N	PC-I	10.4	1	35	35	364	41.2	0	8,197	4,838	8,287,188	107,526	7,264,678	58,253	0	0	16,967,149	162,691	25,353,075	28,677	0	0			8,680,813	53,572	66,552,903	410,718	32.4%	98,383,519	270,284
43	12	Barisal	Bakerganj Steel Bridge	N	PC-I	10.4	1	35	35	364	37.3	0	6,627	7,893	8,287,188	107,526	7,264,678	58,253	0	0	15,373,802	147,413	28,241,984	31,945	0	0			8,875,148	51,770	68,042,799	396,906	31.1%	98,803,002	271,437
44	24	Rangpur	-	N	PC-I	10.4	1	30.0	30	312	22.8	0	4,724	6,496	7,103,304	92,165	7,264,678	58,253	0	0	9,405,648	90,187	21,822,900	24,684	0	0			6,839,480	39,793	52,436,010	305,081	31.1%	76,079,807	243,846
45	30	Gopalganj	Brahmonkanda Bridge	N	PC-I	10.4	1	30	30	312	33.2	0	9,010	16,707	7,103,304	92,165	7,264,678	58,253	0	0	13,670,086	131,076	50,020,927	56,579	0	0	20,473,146		14,779,821	50,711	113,311,962	388,784	21.0%	143,442,701	459,752
46	33	Rajshahi	Chowkidhoh Bridge	N	PC-I	10.4	2	35+25	60	624	30.6	24.5	9,183	8,661	14,206,608	184,330	7,264,678	58,253	3,889,847	32,066	16,374,277	157,006	34,706,580	39,257	0	0			11,466,298	70,637	87,908,288	541,548	32.3%	129,878,237	208,138
47	34	Rajshahi	Notun Dhoh Bridge	N	PC-I	10.4	2	35+25	60	624	35.1	29.7	8,167	11,170	14,206,608	184,330	7,264,678	58,253	3,889,847	32,066	19,034,454	182,513	37,609,687	42,541	0	0	23,735,422		15,861,104	74,955	121,601,800	574,657	26.8%	166,137,747	266,246
48	35	Rajshahi	Dhatia Bridge	N	PC-I	10.4	2	40+25	65	676	24.7	21.8	10,971	10,151	15,390,492	199,690	7,264,678	58,253	3,889,847	32,066	13,557,555	129,997	41,082,951	46,469	0	0	40,605,700		18,268,683	69,971	140,059,907	536,447	22.9%	181,634,572	268,690
49	56	Barisal	Rahamatpur bridge	N	PC-I	10.4	2	30+30	60	624	38.2	33.4	8,132	5,386	14,206,608	184,330	7,264,678	58,253	3,889,847	32,066	20,889,772	200,303	26,292,510	29,740	0	0			10,881,512	75,704	83,424,928	580,395	35.0%	128,405,511	205,778
50	57	Barisal	gounagata bridge	N	PC-I	10.4	1	35	35	364	58.4	0	4,694	7,086	8,287,188	107,526	7,264,678	58,253	0	0	24,050,522	230,610	22,912,100	25,916	0	0			9,377,173	63,346	71,891,661	485,650	34.4%	109,529,515	300,905
51	67	Khulna	Bittipara Bridge	N	PC-I	10.4	1	35	35	364	19.4	0	6,134	5,820	8,287,188	107,526	7,264,678	58,253	0	0	7,989,386	76,607	23,250,530	26,299	0	0	10,842,791		8,645,186	40,303	66,279,758	308,986	26.5%	90,226,195	247,874
52	69	Barisal	Asokoti bridge	N	PC-I	10.4	1	30	30	312	39.8	0	3,475	5,170	7,103,304	92,165	7,264,678	58,253	0	0	16,390,595	157,162	16,814,525	19,019	0	0	41,681,772		13,388,231	48,990	102,643,105	375,588	22.1%	131,751,209	422,280
53	80	Rangpur	Chawai Bridge	N	PC-I	10.4	2	35+35	70	728	13.8	10.9	5,684	9,654	16,574,376	215,051	7,264,678	58,253	3,889,847	32,066	7,366,502	70,634	29,832,410	33,744	0	0			9,739,172	61,462	74,666,985	471,210	32.8%	111,185,763	152,728
54	89	Rangpur	Shampur Bridge.	Z	PC-I	9.8	1	35.0	35	343	21.8	0	4,878	4,949	7,809,081	101,322	7,264,678	58,253	0	0	8,977,763	86,084	19,113,515	21,619	14,140,000	0			8,595,756	40,092	65,900,793	307,370	26.5%	89,721,948	261,580
55	82	Barisal	Raiyer hat bridge	Z	PC-I	9.8	2	25+25	50	490	46.8	41.0	3,419	4,424	11,155,830	144,746	7,264,678	58,253	3,889,847	32,066	25,605,157	245,517	15,254,635	17,255	20,200,000	0			12,505,522	74,675	95,875,669	572,512	31.6%	140,245,315	286,215
56	65	Barisal	Bottala Bridge	Z	PC-I	9.8	1	35	35	343	33.9	0	3,410	3,050	7,809,081	101,322	7,264,678	58,253	0	0	13,960,834	133,864	12,564,700	14,212	14,140,000	0			8,360,894	46,148	64,100,186	353,799	30.0%	91,519,593	266,821
57	87	Rajshahi	Faliarbil Bridge	Z	PC-I	9.8	1	35.0	35	343	19.5	0	5,744	4,911	7,809,081	101,322	7,264,678	58,253	0	0	8,030,568	77,002	20,723,975	23,441	14,140,000	0			8,695,245	39,003	66,663,547	299,020	25.8%	89,837,598	261,917
58	49	Rangpur	Gabura Bridge.	Z	PC-I	9.8	3	30+30+30	90	882	21.5	17.2	1,537	634	20,080,494	260,543	7,264,678	58,253	7,779,694	64,133	14,166,746	135,839	4,222,595	4,776	36,360,000	0			13,481,131	78,531	103,355,338	602,074	31.1%	150,016,100	170,086
59	52	Rangpur	Madarganj Bridge	Z	PC-I	9.8	3	25+30+40	95	931	49.4	44.2	5,910	5,735	21,196,077	275,017	7,264,678	58,253	7,779,694	64,133	33,996,071	325,973	22,649,525	25,619	38,380,000	0			19,689,907	112,349	150,955,952	861,344	30.7%	217,710,135	233,845
60	78	Barisal	Afalbarir Khal Bridge	Z	PC-I	9.8	1	40	40	392	32.1	0	3,554	4,368	8,924,664	115,797	7,264,678	58,253	0	0	13,219,550	126,756	15,408,290	17,428	16,160,000	0			9,146,577	47,735	70,123,760	365,969	28.8%	98,486,390	251,241
66	74	Rajshahi	Naiori Bridge	R	PC-I	10.4	2	30+30	60	624	32.1	28.4	5,400	4,169	14,206,608	184,330	7,264,678	58,253	3,889,847	32,066	17,605,476	168,811	18,611,705	21,052	24,240,000	0			12,872,747	69,677	98,691,061	534,188	29.6%	140,090,649	224,504
73	79	Rangpur	-	N	PC-I	10.4	1	35.0	35	364	17.5	0	2,139	2,457	8,287,188	107,526	7,264,678	58,253	0	0	7,206,920	69,104	8,939,220	10,111	0	0			4,754,701	36,749	36,452,707	281,742	37.5%	58,287,744	160,131

*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

Unit: (JPY million)

Breakdown of Cost	Original								
	Foreign Currency Portion			Local Currency Portion			Total		
	Total	JICA Portion	Others	Total	JICA Portion	Others	Total	JICA Portion	Others
Pkg 1 (North 1/Rangpur)	2,615	2,615	0	2,833	2,833	0	5,448	5,448	0
Pkg 2 (North 2/Rajshahi)	2,117	2,117	0	3,116	3,116	0	5,233	5,233	0
Pkg 3 (South 1/Khulna)	592	592	0	998	998	0	1,590	1,590	0
Pkg 4 (South 2/Barisal)	476	476	0	1,158	1,158	0	1,634	1,634	0
Pkg 5 (South 3/Gopalganj)	455	455	0	1,352	1,352	0	1,807	1,807	0
Pkg 6 (EZ/Dhaka)	1,874	1,874	0	3,084	3,084	0	4,958	4,958	0
Dispute Boards (N1, N2, EZ)	61	61	0	0	0	0	61	61	0
Civil Works Sub Total	8,190	8,190	0	12,541	12,541	0	20,731	20,731	0
Price Escalation	690	690	0	2,704	2,704	0	3,394	3,394	0
Physical Contingency	888	888	0	1,525	1,525	0	2,413	2,413	0
Consulting Services	1,504	1,504	0	1,298	1,298	0	2,802	2,802	0
Land Acquisition	0	0	0	6,689	0	6,689	6,689	0	6,689
Administration Cost	0	0	0	2,934	0	2,934	2,934	0	2,934
VAT	0	0	0	2,936	0	2,936	2,936	0	2,936
Import Tax	0	0	0	2,930	0	2,930	2,930	0	2,930
Interest During Construction	12	0	12	0	0	0	12	0	12
Total	11,284	11,272	12	33,557	18,068	15,489	44,841	29,340	15,501

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

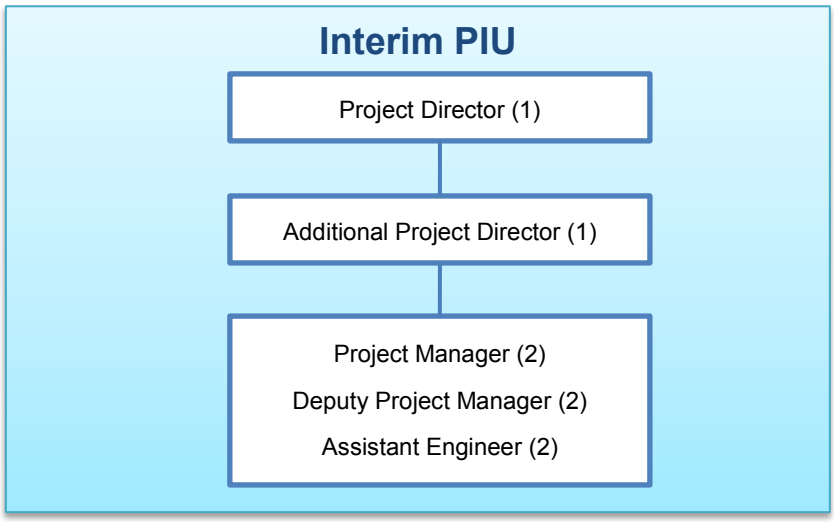
The project organization will be organized so that the GOB can implement the Project smoothly and effectively as well as coordinate with project stakeholders.

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.



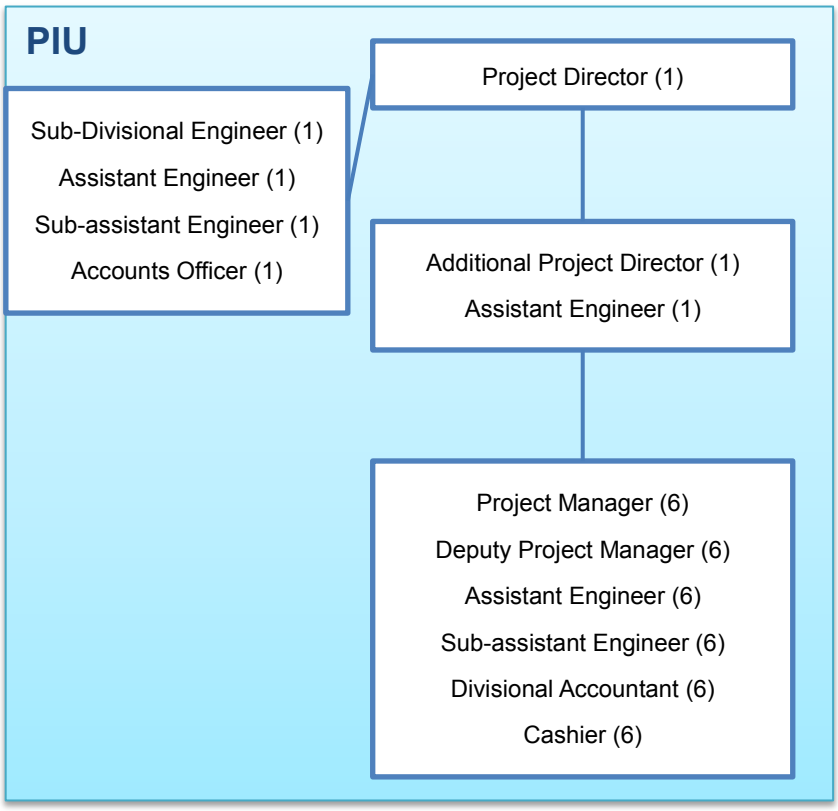
Note: ( ): No. of Post

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

The implementation plan is established based on the month/year for the milestones of key events of the Project. The plan includes the stage of detailed design, tender procedure, and construction work. The construction period was estimated as 3 years for North Packages and the EZ Package, and 2.5 years for South Packages.

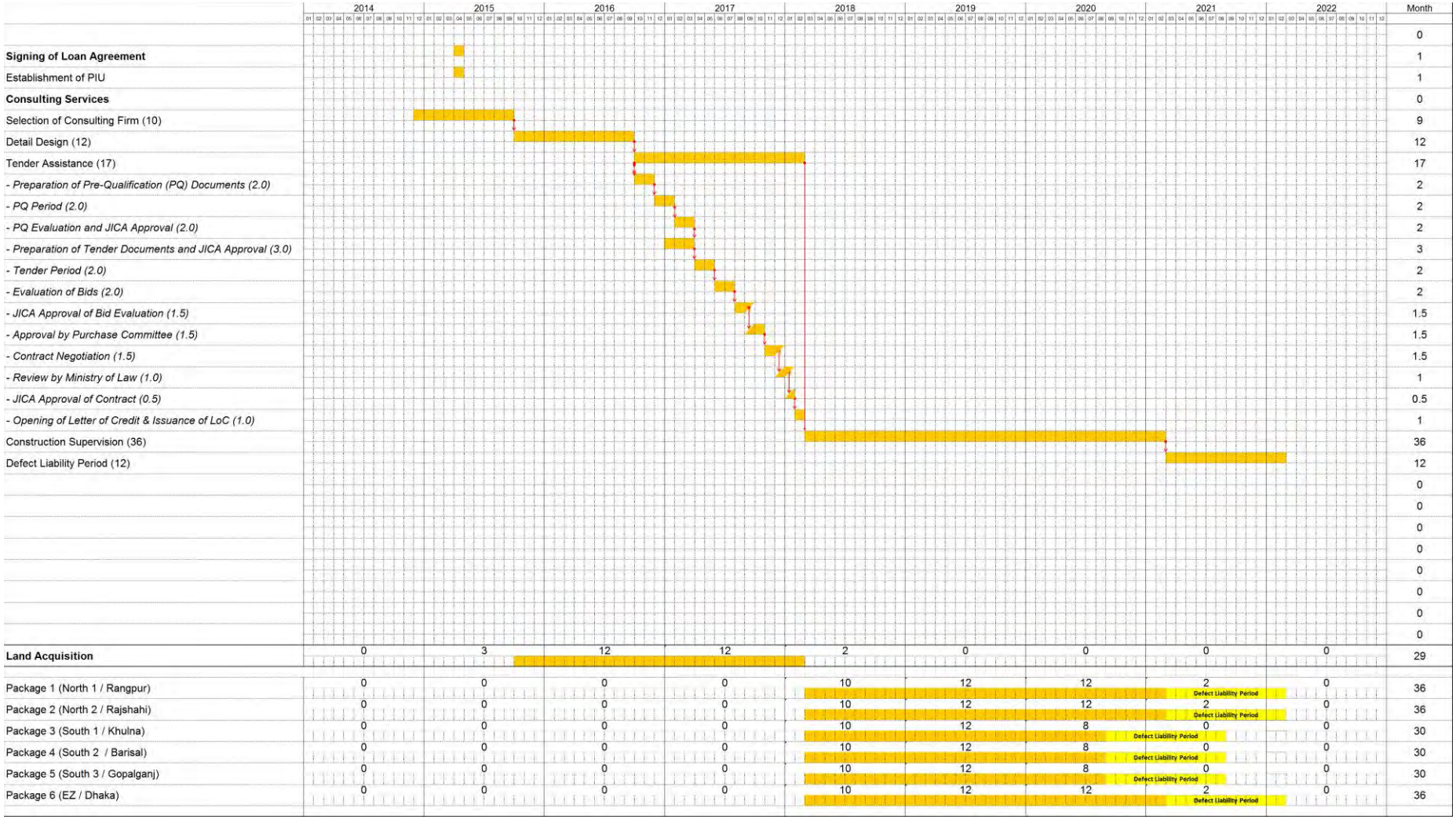
It is assumed that International Competitive Bidding (ICB) is applied for the procurement of the contractor and consultant for the Project. The time required for the procurement is assumed based on the procedures for a financing scheme of a Japanese ODA Loan. The milestones for the implementation of the Project undertaken by a Japanese ODA Loan are formulated as follows:

- A loan agreement (L/A) is expected to be signed in April 2015.
- 10 months will be required for the selection of a consultant for the detailed design, tender assistance, and construction supervision.
- The period of detailed design will be 12 months.

- 17 months will be required for the procurement of a contractor.
- The construction period will be 36 months.

The total implementation period is from signing of L/A (expected in April 2015) to completion of construction (in February 2021).

The implementation schedule for the Project is shown in Figure 15.7.1.



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:

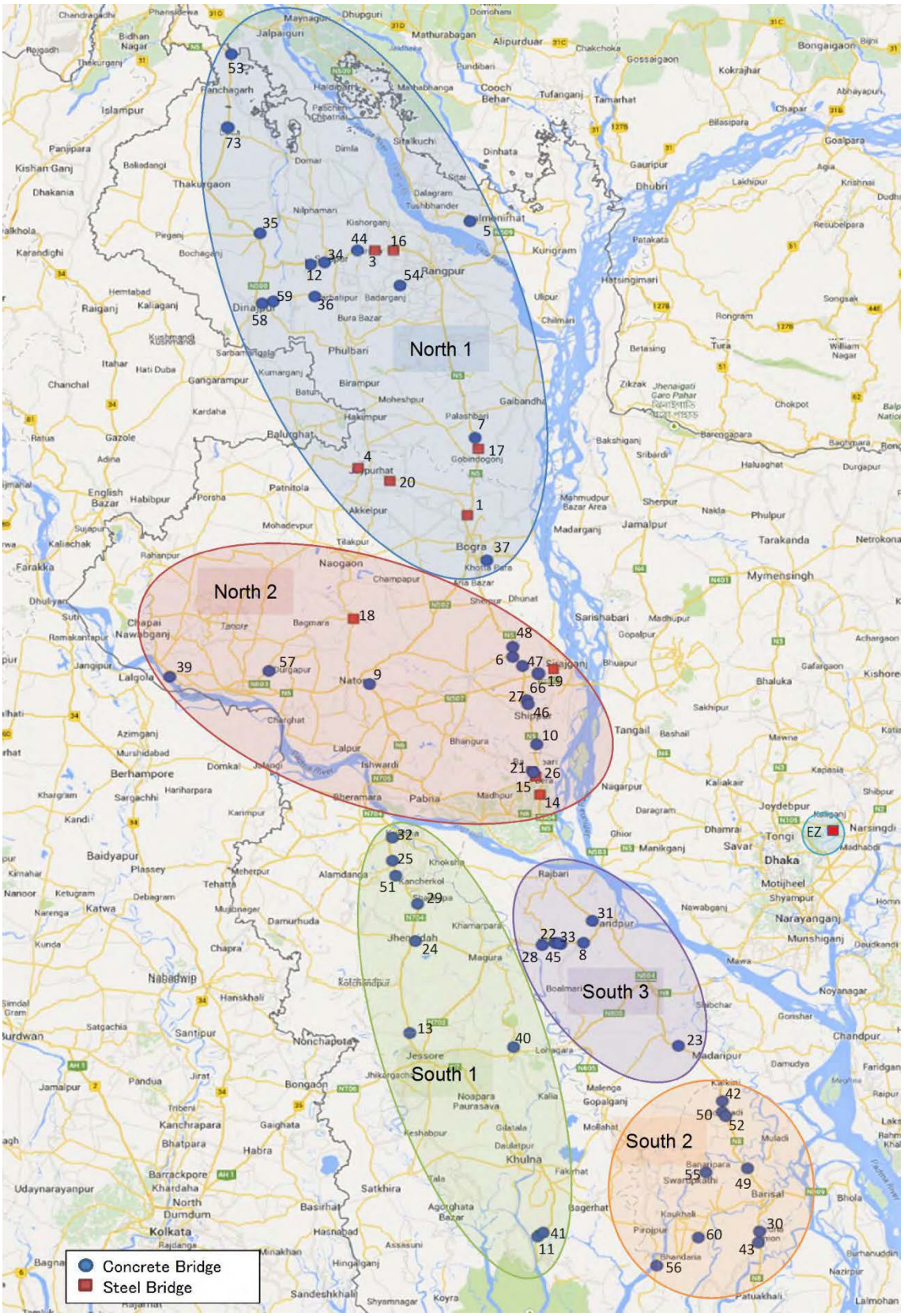
- The Project is technically and economically feasible and environmentally sound.
- Hence, it is justified to implement the Project for national and people's benefits.
- The Project is comprised of 60 small- and middle-size bridges in Western Bangladesh and the EZ Bridge and Road.
- The Project is divided into 6 packages by zones.
- 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

Package	Summary
North 1 Package	• Number of Bridges: 19 bridges • Bridge Type: - PC-I girder bridge: 13 bridges - Steel-I girder bridge: 6 bridges • Zone: Rangpur
North 2 Package	• Number of Bridges: 16 bridges • Bridge Type: - PC-I girder bridge: 12 bridges - Steel-I girder bridge: 4 bridges • Zone: Rajshahi
South 1 Package	• Number of Bridges: 9 bridges • Bridge Type: PC-I girder bridge • Zone: Khulna
South 2 Package	• Number of Bridges: 9 bridges • Bridge Type: PC-I girder bridge • Zone: Barisal
South 3 Package	• Number of Bridges: 7 bridges • Bridge Type: PC-I girder bridge • Zone: Gopalganj
EZ Package	• Length: 5,028m - Bridge: 835m - Approach Road: 4,193m • Number of Bridges: 1 bridge • Bridge Type: - Approach Bridge: PC-I girder bridge (630m) - Main Bridge: Steel-Box girder bridge (205m) • Earth Work: 4,193m • Zone: Dhaka

Source: JICA Survey Team



Note: The number in the Figure indicates the rank in selection of 60 project bridges.
Source: JICA Survey Team

Figure 16.1.1 Summary of the Project

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.