5. TRAFFIC DEMAND FORECAST

5.1 Introduction

This chapter outlines the forecast of future traffic volume on the 105 Project bridges[1] (whose selection is detailed in "Chapter 3 Selection of Project Bridges"). National OD and network data prepared for the National Road Master Plan in 2009 was considered for use in the forecast, as data had not updated since the report's completion, but this data was difficult to apply to the Project. Therefore, the growth rate of traffic indicators was used to forecast future traffic demand, and traffic demand induced by large scale developments in western Bangladesh were considered. This chapter summarizes the traffic indicators used for traffic demand forecast, large scale development plans, and the results of the traffic demand forecast. (The target year of traffic demand forecast is 2031, 10 years of construction, in accordance with RHD standards.)

5.2 Traffic Demand Forecast Methodology

5.2.1 Current Traffic Volume

(1) Current Traffic Volume on Selected Bridges

24-hour traffic count surveys were conducted from February 2014 to March 2014 to understand the current traffic volume. Current Traffic Volume on selected bridges is shown in Table 5.2.1 and Table 5.2.2.

[1] Although 106 candidate bridges were selected (as shown in Chapter 3), 1 bridge was found to be under construction in another project, so the number of bridges for preliminary design was reduced to 105.

Table 5.2.1 24 Hour Traffic Volume (vehicle/day) (1)

SN	Zone	Bridge ID	Name of Bridge	Road Class	Truck	Bus	Minibus	Utility	Car	Auto-Rickshaw	Motor Cycle	Total
2		N509_19a	Sharnamoti Bridge		231	92	110	169	61	1,027	1,485	3,175
6		N5_235a	Mohosthan Bridge		4,800	3,039	1,473	1,288	907	3,912	1,996	17,415
10		N5_265a	Bupinath Bridge		2,628	1,863	727	555	568	1,541	1,705	9,587
11		N5_350b	Barati Bridge		891	680	359	468	297	373	1,563	4,631
24		N5_356a	Nangtichara (Taraganj) Bridge		891	680	359	468	297	373	1,563	4,631
31		N5_378a	Gaudangi Bridge		827	449	398	422	307	1	1,601	4,005
36		N5_188a	Ghogar Bridge		6,183	4,250	1,820	1,322	1,586	1,738	1,649	18,548
38		N518_4a	Khorkhori bridge	National Road	827	449	398	422	307	1	1,601	4,005
45		N5_344c	Kharobaj Bridge		891	680	359	468	297	373	1,563	4,631
46		N5_382a	Ichamoti Bridge		827	449	398	422	307	1	1,601	4,005
47		N5_360a	Chikli Bridge		891	680	359	468	297	373	1,563	4,631
66		N5_260b	Katakhali Bridge		2,628	1,863	727	555	568	1,541	1,705	9,587
79		N5_458a	Pathoraj Bridge		623	223	377	276	130	535	4,453	6,617
80		N5_488a	Chawai Bridge		1,450	132	704	855	454	530	1,779	5,904
102		N5_435a	Sattapir Bridge		1,073	396	470	418	188	306	4,270	7,121
62	Rangpur	R545_115c	Mongle bari kuthibari Bridge		750	260	554	657	480	2,263	2,769	7,733
76		R550_28b	Bottoli Bridge	Regional Road	977	256	622	298	224	718	2,281	5,376
93		R585_80a	Bhela Bridge		1,372	293	685	311	251	169	2,582	5,663
48		Z5025_55a	Kakra Bridge		439	126	277	271	132	33	2,458	3,736
49		Z5025_64a	Gabura Bridge.		439	126	277	271	132	33	2,458	3,736
50		Z5401_45a	Matpara Bridge		881	458	328	319	264	2,720	2,208	7,178
51		Z5072_14a	Bombgara Bridge		373	2	20	15	70	917	1,321	2,718
52		Z5025_60a	Madarganj Bridge		439	126	277	271	132	33	2,458	3,736
53		Z5472_6a	Rakhta Dha Bridge		-	-	7	4	12	67	129	219
55		Z5552_10a	Barodia Khali Bridge		224	52	172	292	99	1,351	2,028	4,218
59		Z5015_22a	Bahagili Bridge	Zilla Road	77	20	42	63	21	82	1,146	1,451
60		Z5701_1a	Anandababur Pool		187	34	100	167	28	563	2,850	3,929
61		Z5701_9a	Duhuli Bridge		96	24	101	236	39	662	1,441	2,599
88		Z5008_1a	Choto Dhepa bridge.		214	65	256	163	140	84	3,312	4,234
89		Z5024_5c	Shampur Bridge.		224	1	73	67	61	-	790	1,216
90		Z5025_46a	Bondorer pool Bridge		458	17	236	253	176	477	2,014	3,631
91		Z5040_4a	Khottapara Bridge		446	2	11	29	18	2,339	569	3,414
3		N5_119a	Chanda Bridge		1,332	942	743	540	518	1,388	835	6,298
4		N5_127a	Palgari Bridge		1,332	942	743	540	518	1,388	835	6,298
5		N5_176a	Bhuyagati Bridge		5,029	2,751	1,410	1,320	1,021	1,980	1,146	14,657
7		N5_120a	Chanda Bridge		1,332	942	743	540	518	1,388	835	6,298
8		N5_128a	Goilhar Bridge		1,458	512	322	326	482	1,845	1,999	6,944
9		N5_158a	Purbodalua Bridge		2,078	947	820	935	474	2,238	1,171	8,663
16		N5_134a	Nukali Bridge		1,458	512	322	326	482	1,845	1,999	6,944
17		N6_97a	Dattapara Bridge		3,407	1,138	677	642	383	1,512	2,790	10,549
19		N5_140a	Jugnidaha Bridge	National Road	1,458	512	322	326	482	1,845	1,999	6,944
20		N5_118a	Punduria Bridge		1,332	942	743	540	518	1,388	835	6,298
27	Rajshahi	N505_2a	Kazir Hat Bridge		81	3	43	26	16	286	537	992
33		N5_156a	Chowkidhoh Bridge		2,078	947	820	935	474	2,238	1,171	8,663
34		N5_172a	Notun Dhoh Bridge		5,029	2,751	1,410	1,320	1,021	1,980	1,146	14,657
35		N5_179a	Dhatia Bridge		6,183	4,250	1,820	1,322	1,586	1,738	1,649	18,548
37		N5_126a	Vitapara Bridge		1,332	942	743	540	518	1,388	835	6,298
54		N5xx_Sa	Pura Mukto Monch Bridge		2,078	947	820	935	474	2,238	1,171	8,663
18		R681_10a	Horisonkorpur Bridge		167	12	35	46	12	310	695	1,277
28		R548_28b	Atrai Bridge		219	-	104	274	104	370	1,928	2,999
73		R548_40a	Mohis Mari Bridge	Regional Road	190	134	198	294	39	662	1,212	2,729
74		R451_1a	Naiori Bridge		1,510	761	1,241	1,269	882	3,565	1,640	10,868
75		R451_7a	Chondi Das Bridge		1,510	761	1,241	1,269	882	3,565	1,640	10,868

*:SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges
Source: Traffic Count Survey Result 2014, JICA Survey Team

Table 5.2.2 24 Hour Traffic Volume (vehicle/day) (2)

SN	Zone	Bridge ID	Name of Bridge	Road Class	Truck	Bus	Minibus	Utility	Car	Auto-Rickshaw	Motor Cycle	Total
87	Rajshahi	Z6010_12b	Faliarbil Bridge	Zilla Road	185	-	18	63	11	392	754	1,423
100		Z5041_2a	Debokbazar Bridge		362	31	205	208	68	893	863	2,630
1	Barisal	N8_178a	Boalia Bazar Bridge	National Road	1,556	1,076	1,504	1,859	1,150	1,510	3,473	12,128
12		N8_182a	Bakerganj Steel Bridge		1,556	1,076	1,504	1,859	1,150	1,510	3,473	12,128
26		N8_095a	Amgram bridge		965	904	596	590	305	795	1,232	5,387
56		N8_152c	Rahamatpur bridge		1,034	1,167	520	557	253	1,548	2,967	8,046
57		N8_127b	gounagata bridge		796	939	459	295	199	1,369	2,452	6,509
64		N8_123a	Souderkhal bridge		796	939	459	295	199	1,369	2,452	6,509
69		N8_129a	Asokoti bridge		796	939	459	295	199	1,369	2,452	6,509
86		N8_69a	Kumar Bridge		1,683	1,165	1,250	1,273	409	3,037	2,692	11,509
104		N805_24a	Garakola Bridge		2,335	1,427	1,549	1,116	936	725	1,429	9,517
42		R890_45a	Dowry Bridge	Regional Road	1,596	975	1,166	1,590	771	1,460	2,514	10,072
70		R890_16a	Bangla Bazar Bridge		495	235	255	286	220	354	1,467	3,312
71		R890_21a	Boksheali Bridge		495	235	255	286	220	354	1,467	3,312
72		R890_28a	Sheyali Bailey Bridge		495	235	255	286	220	354	1,467	3,312
77		R860_31a	Paprail Bailey Bridge		498	96	286	306	161	773	754	2,874
83		R860_34a	Jajihar Bridge		498	96	286	306	161	773	754	2,874
84		R860_44c	Gazipur Bridge		498	96	286	306	161	773	754	2,874
85		R860_53d	Balar Bazar Bridge		498	96	286	306	161	773	754	2,874
99		R860_35a	Shajonpur Bailey Bridge		498	96	286	306	161	773	754	2,874
58		Z8052_009d	Gabtala Steel Bridge	Zilla Road	155	50	294	239	177	465	2,147	3,527
65		Z8701_3d	Bottala Bridge		230	175	149	228	159	669	1,346	2,956
78		Z8708_1c	Algy Bridge		3	2	26	20	13	389	963	1,416
81		Z8708_12b	Satani Bridge		235	-	135	216	236	333	1,653	2,808
82		Z8033_017a	Raiyer hat bridge		169	641	108	253	127	1,934	1,500	4,732
92		Z8810_13a	Madhabkhali bridge		155	50	294	239	177	465	2,147	3,527
94		Z8033_008a	Kalijira bridge		112	134	178	255	86	1,460	1,046	3,271
95		Z8033_019a	Masrong bridge		351	759	589	508	260	827	1,341	4,635
96		Z8034_011a	Padarhat bridge		45	106	27	110	48	10	2,900	3,246
97		Z8044_004a	Talukdarhat Bailey Bridge		317	8	456	232	146	234	2,973	4,366
13	Khulna	N7_025a	Jhuldibazar Bridge	National Road	2,799	1,352	307	483	561	664	1,472	7,638
14		N7_039a	Karimpur Bridge		1,942	1,214	400	650	296	552	1,394	6,448
15		N7_049a	Porkitpur Bridge		1,984	1,202	394	728	330	669	1,067	6,374
21		N704_43a	Khulna-Kushtia-Churash Bridge		6,577	2,124	1,717	1,269	939	4,796	5,358	22,780
22		N7_248c	Gora bridge		1,322	205	374	324	224	258	1,229	3,936
23		N7_054a	Barashia Bridge		1,984	1,202	394	728	330	669	1,067	6,374
25		N7_246a	Balai bridge.		1,322	205	374	324	224	258	1,229	3,936
29		N7_036c	Kanaipur Bridge		1,942	1,214	400	650	296	552	1,394	6,448
30		N7_048a	Brahmonkanda Bridge		1,984	1,202	394	728	330	669	1,067	6,374
32		N7_047a	Bimankanda bridge		1,984	1,202	394	728	330	669	1,067	6,374
39		N7_141b	Buri Bhairab Bridge		2,797	569	364	612	305	803	1,552	7,002
41		N703_Sd	Dhopa Ghata Bridge		1,373	922	815	758	675	5,794	5,353	15,688
43		N704_14a	Barda Bridge		4,343	1,535	1,385	1,098	828	1,126	1,713	12,028
44		N704_33b	Balipara Bridge		3,761	1,046	709	1,003	544	986	1,417	9,466
67		N704_27b	Bittipara Bridge		3,761	1,046	709	1,003	544	986	1,417	9,466
101		N706_14b	Jhikorgacha Bridge		4,320	1,723	1,302	1,060	1,160	1,647	5,058	16,270
103		N704_12c	Chandi Pur Bridge		4,343	1,535	1,385	1,098	828	1,126	1,713	12,028
40		R720_44a	Gurakhali Bridge	Regional Road	144	65	29	52	35	403	1,157	1,885
63		R760_049c	Shakdaha bridge		1,146	443	160	341	291	649	2,812	5,842
68		R750_22c	Bhangura Bridge		660	587	337	438	267	243	1,196	3,728
105		R750_25a	Tularampur Bridge		660	587	337	438	267	243	1,196	3,728
106		Z7503_5a	Hawai khali Bridge	Zilla Road	1,034	565	701	1,037	473	1,020	2,002	6,832

*1:: Bridge No.98 was excluded from 106 candidate bridges, but it was included to calculate the traffic growth rate

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

Source: Traffic Count Survey Result 2014, JICA Survey Team

(2) Traffic Volume by Road Class

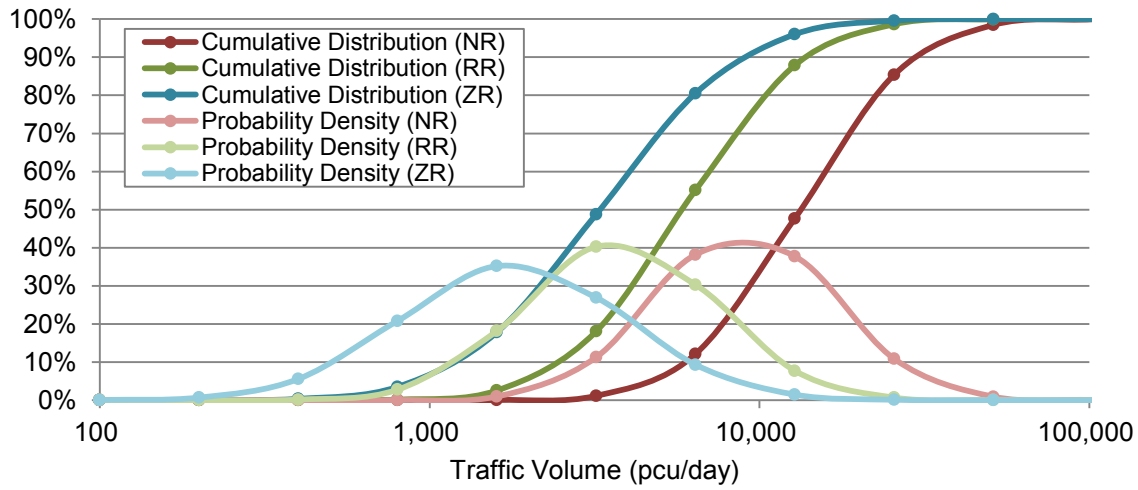
Based on the results of the 2014 traffic count survey and the PCU (Passenger Car Unit) factors shown in Table 5.2.3, the traffic volume characteristics were identified by road class.

Table 5.2.3 PCU Factor

Vehicle Type	PCU Factor
Truck	3.0
Bus	3.0
Minibus	3.0
Utility	1.0
Car	1.0
Auto-Rickshaw	0.75
Motorcycle	0.75

Source: Geometric Design of RHD Roads Ver.4

As a result, trends of cumulative distribution and probability density were identified by road class as shown in Figure 5.2.1.



Source: JICA Study Team made this data based on Traffic Count Survey Result 2014

Figure 5.2.1 Cumulative Distribution and Probability Density by Road Class

Table 5.2.4 lists each the average traffic volume (pcu/day), median (pcu/day), standard deviation, kurtosis[2] and skewness for each road class. The standard deviation was 9,378 for national roads, 4,793 for regional roads, and 2,311 for zilla roads. The kurtosis was negative at -0.06 for regional roads, but positive at 1.60 for national roads, and 2.21 for zilla roads. The skewness was positive for all roads: 1.38 for national roads, 1.05 for regional roads, and 1.19 for zilla roads.

[2] The kurtosis indicates degree of peakedness of cumulative probability distribution and the skewness indicates a measure of the asymmetry of the probability distribution. Both measures are zero for a normal distribution.

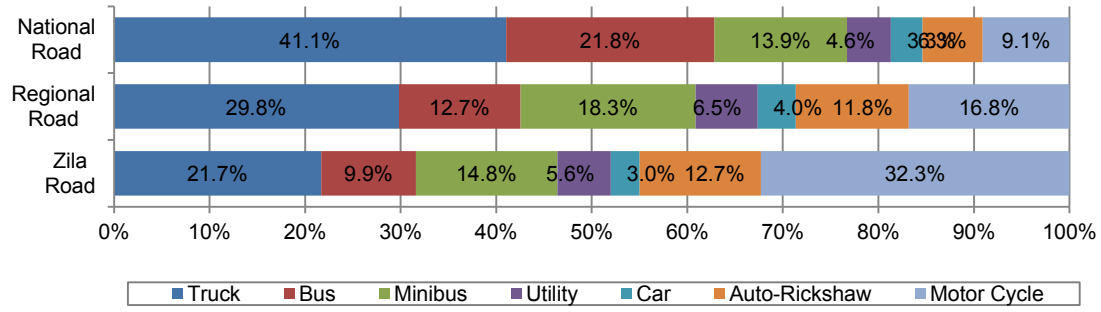
Table 5.2.4 Standard Deviation, Kurtosis and Skewness by Road Class

Items	National Roads	Regional Roads	Zilla Roads
Average Traffic Volume (pcu/day)	15,722	7,214	4,023
Median (pcu/day)	13,074	4,827	3,718
Standard Deviation	9,378	4,793	2,311
Kurtosis	1.60	-0.06	2.21
Skewness	1.38	1.05	1.19

Source: Analysis by JICA Study Team based on Traffic Count Survey Result 2014

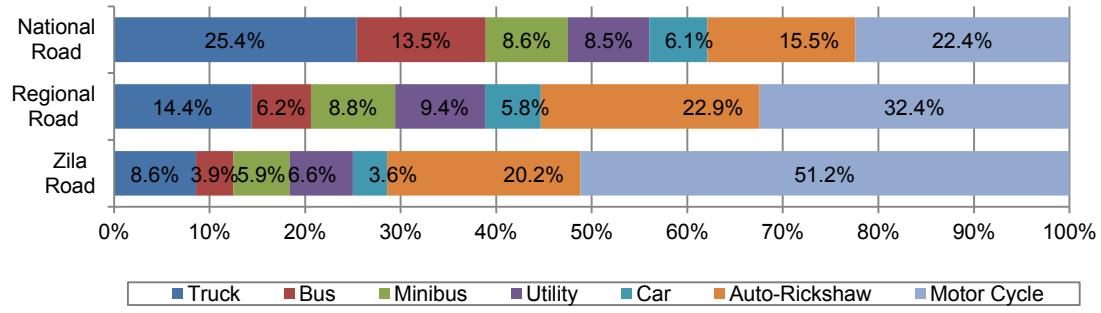
(3) Vehicle Share by Road Class

Using PCU factors specified by RHD (Table 5.2.3) and the results of the above-mentioned traffic count survey, the vehicle share in western Bangladesh was calculated by road class. The results indicate that the road classes have different vehicle-share characteristics. The share of large vehicles (trucks, buses, etc.) increases with increasing road class (ZR, RR, NR), while the share of small vehicles (motorcycles, auto-rickshaws, etc.) decreases. The vehicle share by road class is shown in Figure 5.2.2 and Figure 5.2.3.



Source: JICA Survey Team

Figure 5.2.2 Vehicle Share by Road Class (PCU)



Source: JICA Survey Team

Figure 5.2.3 Vehicle Share by Road Class (Vehicles)

5.2.2 Future Traffic Growth

Past traffic growth rates were applied as traffic indicators in this study. The traffic growth was calculated based on the results attained from preparatory surveys and other surveys conducted by RHD from 2004 to 2011, under the assumption that the traffic growth rate will remain fairly constant until 2031. The annual traffic growth rates in western Bangladesh were found to be 6.25% for national roads, 5.62% for regional roads and 5.15% for zilla roads. It is observed that high-class roads have higher growth rate than low-class roads. The annual number of registered vehicles was also considered for use as a traffic indicator, but it was not selected due to the possibility of a large discrepancy between the number of registered vehicles and the actual number of vehicles on the road.

Table 5.2.5 Recent Traffic Growth

SN	Bridge ID	Name of Bridge	Traffic Volume of Motorized Vehicles (PCU/Day)					Annual Growth Rate	Average Annual Growth Rate
			2007	2008	2009	2011	2014		
14	N7_039a	Karimpur Bridge	–	–	–	4,827	6,448	10.1%	
16	N5_134a	Nukali Bridge	–	–	–	5,624	6,944	7.3%	
17	N6_97a	Dattapara Bridge	–	–	6,845	–	10,549	9.0%	
21	N704_43a	Khulna-Kushtia-Churash Bridge	12,380	–	–	–	22,780	9.1%	
22	N7_248c	Gora bridge	–	–	–	3,510	3,936	3.9%	
26	N8_095a	Amgram bridge	–	–	4,335	–	5,387	4.4%	
34	N5_172a	Notun Dhoh Bridge	–	–	13,873	–	14,657	1.1%	6.25%
46	N5_382a	Ichamoti Bridge	–	–	–	3,253	4,005	7.2%	
56	N8_152c	Rahamatpur bridge	–	–	–	6,338	8,046	8.3%	
57	N8_127b	gounagata bridge	–	–	4,335	–	6,509	8.5%	
66	N5_260b	Katakhali Bridge	–	–	7,471	–	9,587	5.1%	
80	N5_488a	Chawai Bridge	5,091	–	–	–	5,904	2.1%	
101	N706_14b	Jhikorgacha Bridge	11,475	–	–	–	16,270	5.1%	
28	R548_28b	Atrai Bridge	2,752	–	–	–	2,999	1.2%	
40	R720_44a	Gurakhali Bridge	1,404	–	–	–	1,885	4.3%	
62	R545_115c	Mongle bari kuthibari Bridge	6,664	–	–	–	7,733	2.1%	
63	R760_049c	Shakdaha bridge	–	3,349	–	–	5,842	9.7%	
71	R890_21a	Boksheali Bridge	2,840	–	–	–	3,312	2.2%	5.62%
75	R451_7a	Chondi Das Bridge	6,761	–	–	–	10,868	7.0%	
93	R585_80a	Bhela Bridge	–	2,454	–	–	5,663	15.0%	
98	R760_003a	Gollamari bridge	9,828	–	–	–	12,385	3.4%	
50	Z5401_45a	Matpara Bridge	4,849	–	–	–	7,178	5.8%	
55	Z5552_10a	Barodia Khali Bridge	3,555	–	–	–	4,218	2.5%	
58	Z8052_009d	Gabtala Steel Bridge	–	2,640	–	–	3,527	4.9%	
59	Z5015_22a	Bahagili Bridge	–	1,056	–	–	1,451	5.4%	5.15%
87	Z6010_12b	Faliarbil Bridge	–	1,010	–	–	1,423	5.9%	
90	Z5025_46a	Bondorer pool Bridge	3,263	–	–	–	3,631	1.5%	
96	Z8034_011a	Padarhat bridge	1,666	–	–	–	3,246	10.0%	

*1: The traffic growth rate was calculated after the converted by PCU factor due to the difference of vehicle classification in the survey years. The regional growth rate was not adapted to achieve the accuracy

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

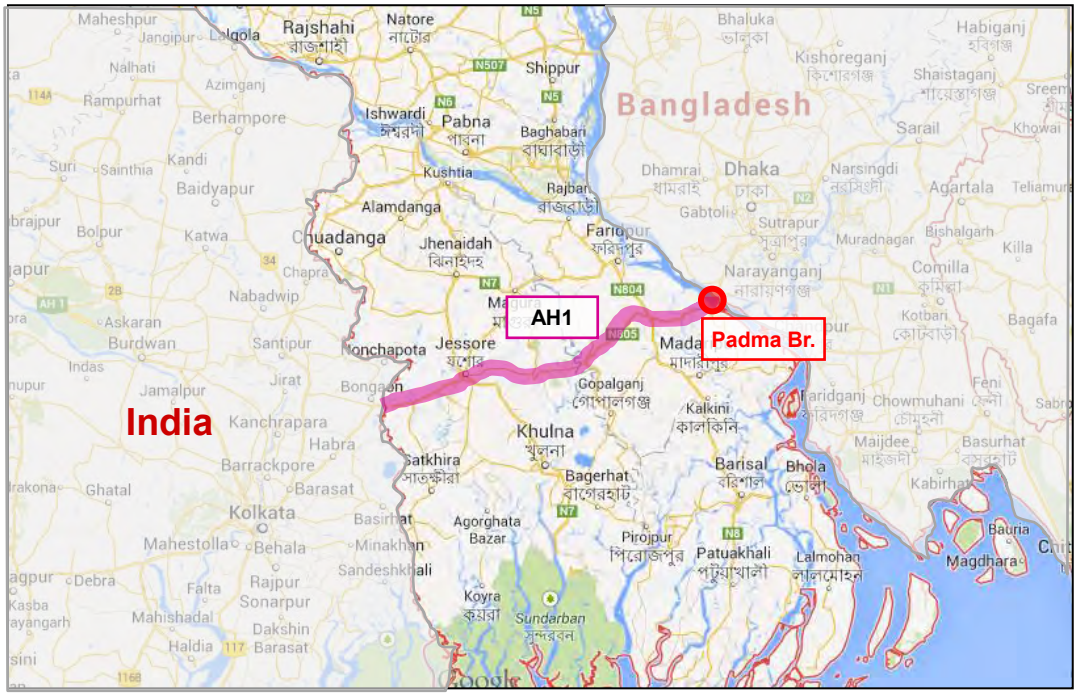
Source: JICA Survey Team

5.2.3 Adjustment in Consideration of Large Scale Development

Two large-scale development projects, the construction of Padma Bridge and the improvement of AH1 (part of Road Master Plan 2009), are expected to influence traffic demand, so these were both considered in calculations of the traffic demand forecast.

(1) Location of Padma Bridge and Route of AH1

The location of Padma Bridge and the route of AH1 are shown in Figure 5.2.4. After the construction of Padma Bridge, vehicles will be able to move between Dhaka and western Bangladesh/India without the need for a car ferry. In addition, this improved connectivity is expected to induce significant traffic volume on AH1.

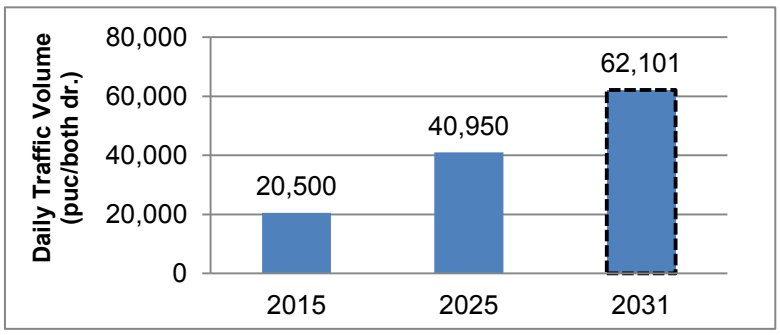


Source: JICA Survey Team

Figure 5.2.4 Location of Padma Bridge and Route of AH1

(2) Induced Traffic Volume of Padma Bridge

Induced traffic volume on Padma Bridge in 2031 is forecasted assuming of the continuation of the growth rate from 2015 and 2025 as described in “The Feasibility Study of Padma Bridge in the People’s Republic of Bangladesh 2005, JICA”.



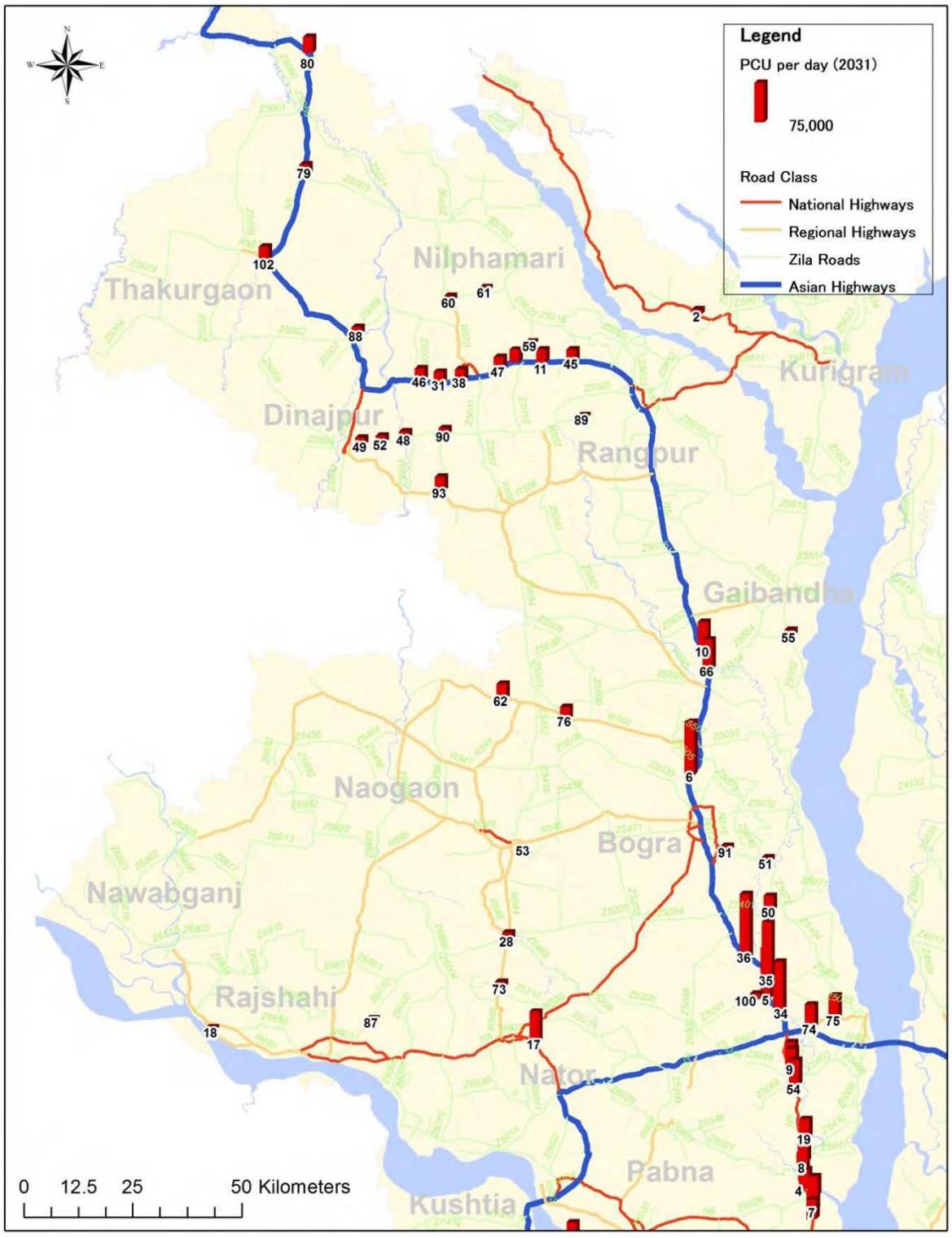
Source: The Feasibility Study of Padma Bridge in the People Republics of Bangladesh, 2005 JICA Study (only 2015 and 2025)

Figure 5.2.5 Projection of Induced Traffic Volume on Padma Bridge

5.3 Result of Traffic Demand Forecast in 2031

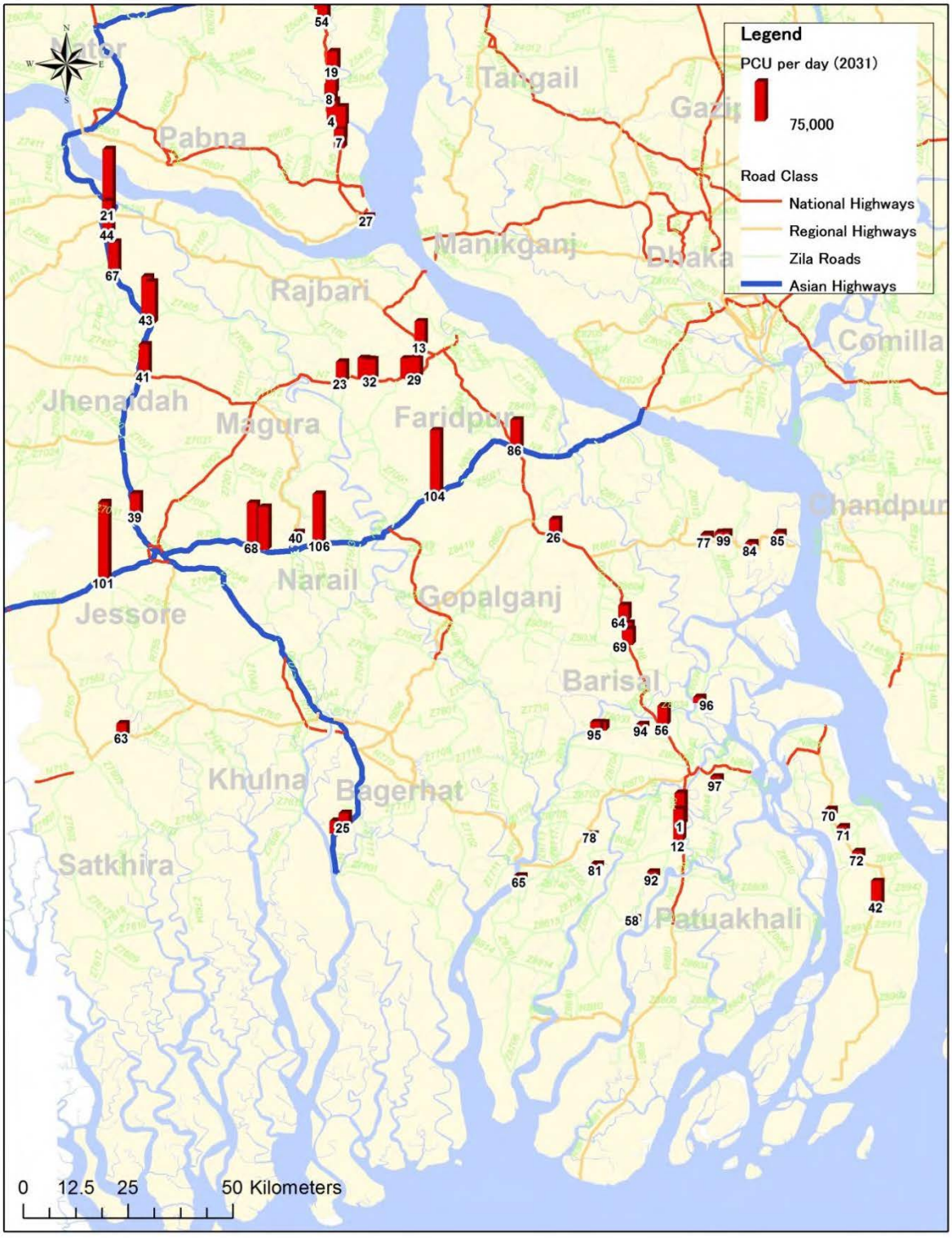
The traffic demand forecast for 2031 is summarized in Figure 5.3.1 and Figure 5.3.2. The estimated peak hourly traffic volume was used in the determination of the required number of lanes. The peak rate was calculated to be 8% for national roads and 10% for both regional roads and zilla roads based on RHD road standards.

As shown in Figure 5.3.1 and Figure 5.3.2, Bangladesh can be divided into 3 parts (eastern Bangladesh, northwestern Bangladesh, and southwestern Bangladesh) by two major rivers: the Padma which divides east and west, and the Jamuna which divides western Bangladesh into north and south. It was predicated that, Asian Highways and national roads will have high peak traffic volume in both directions (north-south and east-west) due to the concentration of vehicles on bridges crossing these rivers.



Note: The number in the map indicates the serial number of the project candidate bridges.
Source: JICA Survey Team

Figure 5.3.1 Result of Traffic Demand Forecast (North area)



Note: The number in the map indicates the serial number of the project candidate bridges.
Source: JICA Survey Team

Figure 5.3.2 Result of Traffic Demand Forecast (South area)

Table 5.3.1 Result of Traffic Demand Forecast (1)

SN	Zone	Bridge ID	Name of Bridge	Road Class	Asian Highway	Induced Traffic	2014	2031			
							Daily Traffic Volume (pcu/day)	Base Traffic Volume (pcu/day)	Induced Traffic (pcu/day)	Daily Traffic Volume (pcu/day)	Peak Hour Traffic Volume (pcu/hr.)
2	Rangpur	N509_19a	Barodia Khali Bridge	National Road			3,487	9,777	-	9,777	782
6		N5_235a	Bahagili Bridge		✓		35,903	100,671	-	100,671	8,054
10		N5_265a	Shakdaha bridge		✓		20,082	56,308	-	56,308	4,505
11		N5_350b	Souderkhal bridge		✓		8,466	23,738	-	23,738	1,899
24		N5_356a	Paprail Bailey Bridge		✓		8,466	23,738	-	23,738	1,899
31		N5_378a	Gazipur Bridge		✓		7,882	22,099	-	22,099	1,768
36		N5_188a	Shampur Bridge.		✓		43,832	122,904	-	122,904	9,832
38		N518_4a	Khottapara Bridge		✓		7,882	22,099	-	22,099	1,768
45		N5_344c	Gollamari bridge		✓		8,466	23,738	-	23,738	1,899
46		N5_382a	Shajonpur Bailey Bridge		✓		7,882	22,099	-	22,099	1,768
47		N5_360a	Debokbazar Bridge		✓		8,466	23,738	-	23,738	1,899
66		N5_260b	Katakhali Bridge		✓		20,082	56,308	-	56,308	4,505
79		N5_458a	Pathoraj Bridge		✓		8,088	22,678	-	22,678	1,814
80		N5_488a	Chawai Bridge		✓		10,904	30,574	-	30,574	2,446
102		N5_435a	Sattapir Bridge		✓		10,383	29,114	-	29,114	2,329
62		R545_115c	Mongle bari kuthibari Bridge	Regional Road			11,493	29,110	-	29,110	2,911
76		R550_28b	Bottoli Bridge				9,269	23,478	-	23,478	2,348
93		R585_80a	Bhela Bridge				10,847	27,475	-	27,475	2,747
48		Z5025_55a	Jhikorgacha Bridge	Zilla Road			5,672	13,317	-	13,317	1,332
49		Z5025_64a	Sattapir Bridge				5,672	13,317	-	13,317	1,332
50		Z5401_45a	Chandi Pur Bridge				11,990	28,149	-	28,149	2,815
51		Z5072_14a	Garakola Bridge				3,423	8,035	-	8,035	803
52		Z5025_60a	Tularampur Bridge				5,672	13,317	-	13,317	1,332
53		Z5472_6a	Hawai khali Bridge				201	472	-	472	47
55		Z5552_10a	Barodia Khali Bridge				4,713	11,065	-	11,065	1,107
59		Z5015_22a	Bahagili Bridge				2,027	4,759	-	4,759	476
60		Z5701_1a	Anandababur Pool				3,872	9,090	-	9,090	909
61		Z5701_9a	Duhuli Bridge				2,725	6,398	-	6,398	640
88		Z5008_1a	Choto Dhepa bridge.				6,017	14,126	-	14,126	1,413
89		Z5024_5c	Shampur Bridge.				1,978	4,643	-	4,643	464
90		Z5025_46a	Bondorer pool Bridge				5,056	11,870	-	11,870	1,187
91		Z5040_4a	Khottapara Bridge				3,716	8,724	-	8,724	872
3	Rajshahi	N5_119a	Rahamatpur bridge	National Road			13,371	37,492	-	37,492	2,999
4		N5_127a	gounagata bridge				13,371	37,492	-	37,492	2,999
5		N5_176a	Gabtala Steel Bridge		✓		34,053	95,482	-	95,482	7,639
7		N5_120a	Anandababur Pool				13,371	37,492	-	37,492	2,999
8		N5_128a	Duhuli Bridge				12,437	34,873	-	34,873	2,790
9		N5_158a	Mongle bari kuthibari Bridge				17,310	48,536	-	48,536	3,883
16		N5_134a	Asokoti bridge				12,437	34,873	-	34,873	2,790
17		N6_97a	Bangla Bazar Bridge				21,033	58,974	-	58,974	4,718
19		N5_140a	Sheyali Bailey Bridge				12,437	34,873	-	34,873	2,790
20		N5_118a	Mohis Mari Bridge				13,371	37,492	-	37,492	2,999
27		N505_2a	Chawai Bridge				2,346	6,579	-	6,579	526
33		N5_156a	Kumar Bridge				17,310	48,536	-	48,536	3,883
34		N5_172a	Faliarbil Bridge		✓		34,053	95,482	-	95,482	7,639
35		N5_179a	Choto Dhepa bridge.		✓		43,832	122,904	-	122,904	9,832
37		N5_126a	Bondorer pool Bridge				13,371	37,492	-	37,492	2,999
54		N5xx_Sa	Pura Mukto Monch Bridge				17,310	48,536	-	48,536	3,883
18		R681_10a	Boksheali Bridge	Regional Road			2,513	6,364	-	6,364	636
28		R548_28b	Satani Bridge				5,298	13,418	-	13,418	1,342
73		R548_40a	Mohis Mari Bridge				4,040	10,232	-	10,232	1,023
74		R451_1a	Naiori Bridge				17,433	44,155	-	44,155	4,415
75		R451_7a	Chondi Das Bridge				17,433	44,155	-	44,155	4,415

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

Table 5.3.2 Result of Traffic Demand Forecast (2)

SN	Zone	Bridge ID	Name of Bridge	Road Class	Asian Highway	Induced Traffic	2014	2031			
							Daily Traffic Volume (pcu/day)	Base Traffic Volume (pcu/day)	Induced Traffic (pcu/day)	Daily Traffic Volume (pcu/day)	Peak Hour Traffic Volume (pcu/hr.)
87	Rajshahi	Z6010_12b	Faliarbil Bridge	Zilla Road			2,004	4,704	-	4,704	470
100		Z5041_2a	Debokbazar Bridge				4,317	10,135	-	10,135	1,013
1	Barisal	N8_178a	Pura Mukto Monch Bridge	National Road			21,401	60,008	-	60,008	4,801
12		N8_182a	Bottala Bridge				21,401	60,008	-	60,008	4,801
26		N8_095a	Pathoraj Bridge				10,835	30,382	-	30,382	2,431
56		N8_152c	Rahamatpur bridge				13,152	36,878	-	36,878	2,950
57		N8_127b	gounagata bridge				10,600	29,721	-	29,721	2,378
64		N8_123a	Souderkhal bridge				10,600	29,721	-	29,721	2,378
69		N8_129a	Asokoti bridge				10,600	29,721	-	29,721	2,378
86		N8_69a	Kumar Bridge		✓		19,408	54,419	-	54,419	4,353
104		N805_24a	Garakola Bridge		✓	✓	21,119	59,215	62,101	121,316	9,705
42		R890_45a	Masrong bridge	Regional Road			18,584	47,070	-	47,070	4,707
70		R890_16a	Bangla Bazar Bridge				5,221	13,223	-	13,223	1,322
71		R890_21a	Boksheali Bridge				5,221	13,223	-	13,223	1,322
72		R890_28a	Sheyali Bailey Bridge				5,221	13,223	-	13,223	1,322
77		R860_31a	Paprail Bailey Bridge				4,857	12,303	-	12,303	1,230
83		R860_34a	Jajihar Bridge				4,857	12,303	-	12,303	1,230
84		R860_44c	Gazipur Bridge				4,857	12,303	-	12,303	1,230
85		R860_53d	Balar Bazar Bridge				4,857	12,303	-	12,303	1,230
99		R860_35a	Shajonpur Bailey Bridge				4,857	12,303	-	12,303	1,230
58		Z8052_009d	Gabtala Steel Bridge	Zilla Road			5,494	12,898	-	12,898	1,290
65		Z8701_3d	Bottala Bridge				4,066	9,546	-	9,546	955
78		Z8708_1c	Algy Bridge				1,246	2,925	-	2,925	293
81		Z8708_12b	Satani Bridge				3,979	9,340	-	9,340	934
82		Z8033_017a	Raiyer hat bridge				6,563	15,407	-	15,407	1,541
92		Z8810_13a	Madhabkhali bridge				5,494	12,898	-	12,898	1,290
94		Z8033_008a	Kalijira bridge				4,127	9,688	-	9,688	969
95		Z8033_019a	Masrong bridge				8,358	19,622	-	19,622	1,962
96		Z8034_011a	Padarhat bridge				4,785	11,232	-	11,232	1,123
97		Z8044_004a	Talukdarhat Bailey Bridge				6,127	14,385	-	14,385	1,438
13	Khulna	N7_025a	Katakhali Bridge	National Road			16,392	45,963	-	45,963	3,677
14		N7_039a	Bittipara Bridge				13,494	37,835	-	37,835	3,027
15		N7_049a	Bhangura Bridge				13,713	38,451	-	38,451	3,076
21		N704_43a	Naiori Bridge		✓		44,923	125,961	-	125,961	10,077
22		N7_248c	Chondi Das Bridge		✓		8,532	23,924	-	23,924	1,914
23		N7_054a	Bottoli Bridge				13,713	38,451	-	38,451	3,076
25		N7_246a	Algy Bridge		✓		8,532	23,924	-	23,924	1,914
29		N7_036c	Raiyer hat bridge				13,494	37,835	-	37,835	3,027
30		N7_048a	Jajihar Bridge				13,713	38,451	-	38,451	3,076
32		N7_047a	Balar Bazar Bridge				13,713	38,451	-	38,451	3,076
39		N7_141b	Madhabkhali bridge		✓		14,864	41,679	-	41,679	3,334
41		N703_Sd	Kalijira bridge				20,795	58,307	-	58,307	4,665
43		N704_14a	Padarhat bridge		✓		28,169	78,986	-	78,986	6,319
44		N704_33b	Talukdarhat Bailey Bridge		✓		21,466	60,191	-	60,191	4,815
67		N704_27b	Bittipara Bridge		✓		21,466	60,191	-	60,191	4,815
101		N706_14b	Jhikorgacha Bridge		✓	✓	31,265	87,665	62,101	149,766	11,981
103		N704_12c	Chandi Pur Bridge		✓		28,169	78,986	-	78,986	6,319
40		R720_44a	Bhela Bridge	Regional Road	✓		2,442	6,847	-	6,847	548
63		R760_049c	Shakdaha bridge				9,566	24,229	-	24,229	2,423
68		R750_22c	Bhangura Bridge		✓	✓	7,059	19,794	62,101	81,895	6,552
105		R750_25a	Tularampur Bridge		✓	✓	7,059	19,794	62,101	81,895	6,552
106		Z7503_5a	Hawai khali Bridge	Zilla Road	✓	✓	11,793	33,066	62,101	95,167	7,613

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

5.4 Traffic Capacity

Traffic capacity is set based on Geometric Design Standard for RHD. The traffic capacities and required lane numbers for national roads, regional roads and zilla roads are shown in below table.

Table 5.4.1 Traffic Capacity and Number of Lane

Road Type	Traffic Capacity (pcu/direction/peak hour)	Number of Lanes
National Roads	4500 - **8500**	6 lanes (Design Type 1)
	2100 - **4500**	4 lanes (Design Type 2)
	800 - **2100**	2 lanes (Design Type 3 or 4)
Regional Roads	2100 - **4500**	4 lanes (Design Type 2)
	400 - **2100**	2 lanes (Design Type 3, 4 or 5)
Zilla Roads	400 - **1600**	2 lanes (Design Type 4 or 5)
	- **400**	1 lanes (Design Type 6)

Source: Geometric Design Standard for RHD

5.5 Number of Lanes

5.5.1 Required Number of Lanes based on Traffic Demand Forecast

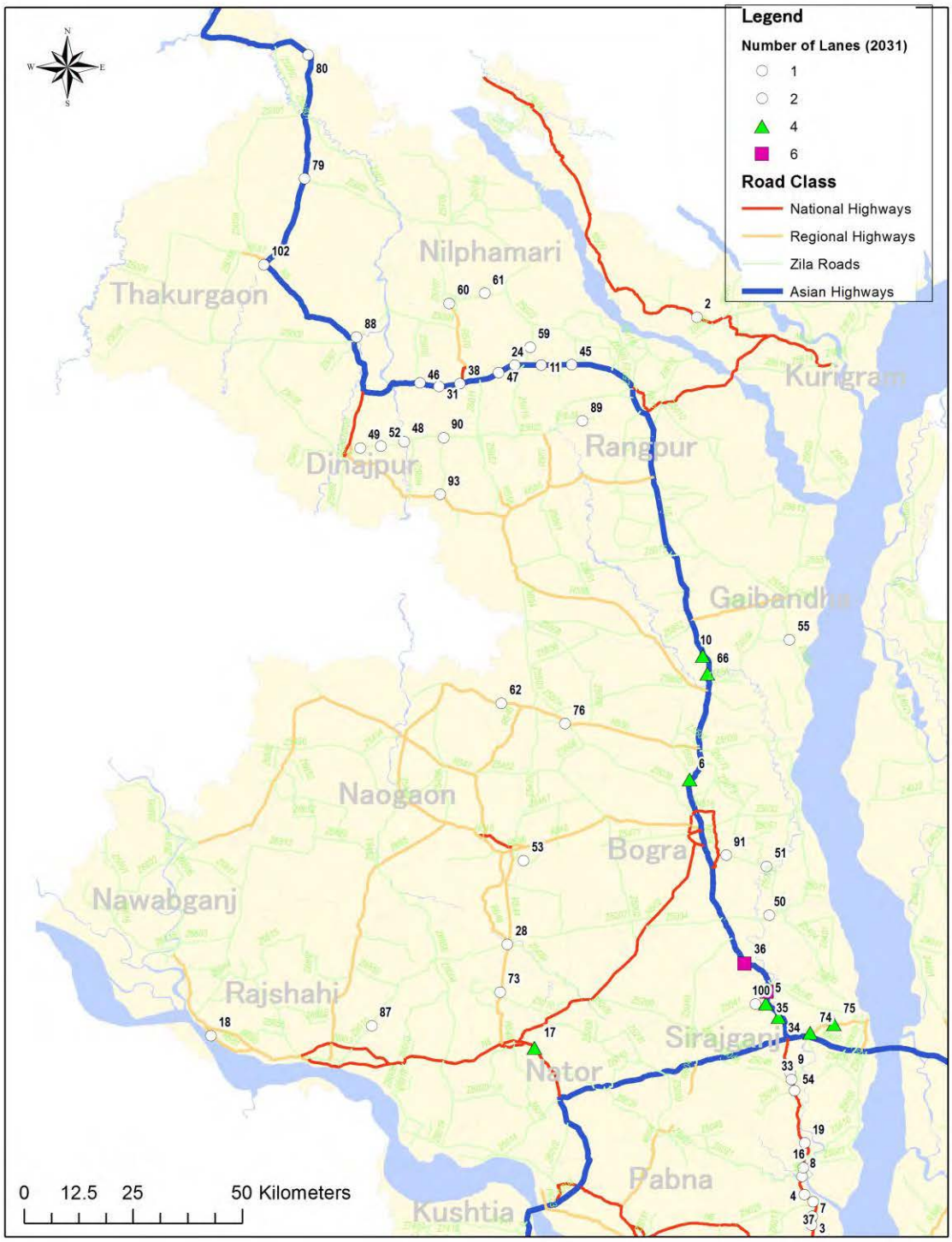
The required number of lanes for each of the 105 Project bridges estimated based on the traffic demand forecast and traffic capacity is shown in Table 5.5.1 and Figure 5.5.1 to Figure5.5.2.

25 bridges (19 bridges for national roads, 5 bridges for regional roads and 1 bridge for zilla road) out of 105 bridges require 4 or 6 lanes. On the Asian Highway network, 18 bridges (15 bridges for national roads, 2 bridges for regional roads and 1 bridge for zilla roads) out of 32 bridges require 4 or 6 lanes.

Table 5.5.1 Required Number of Lanes

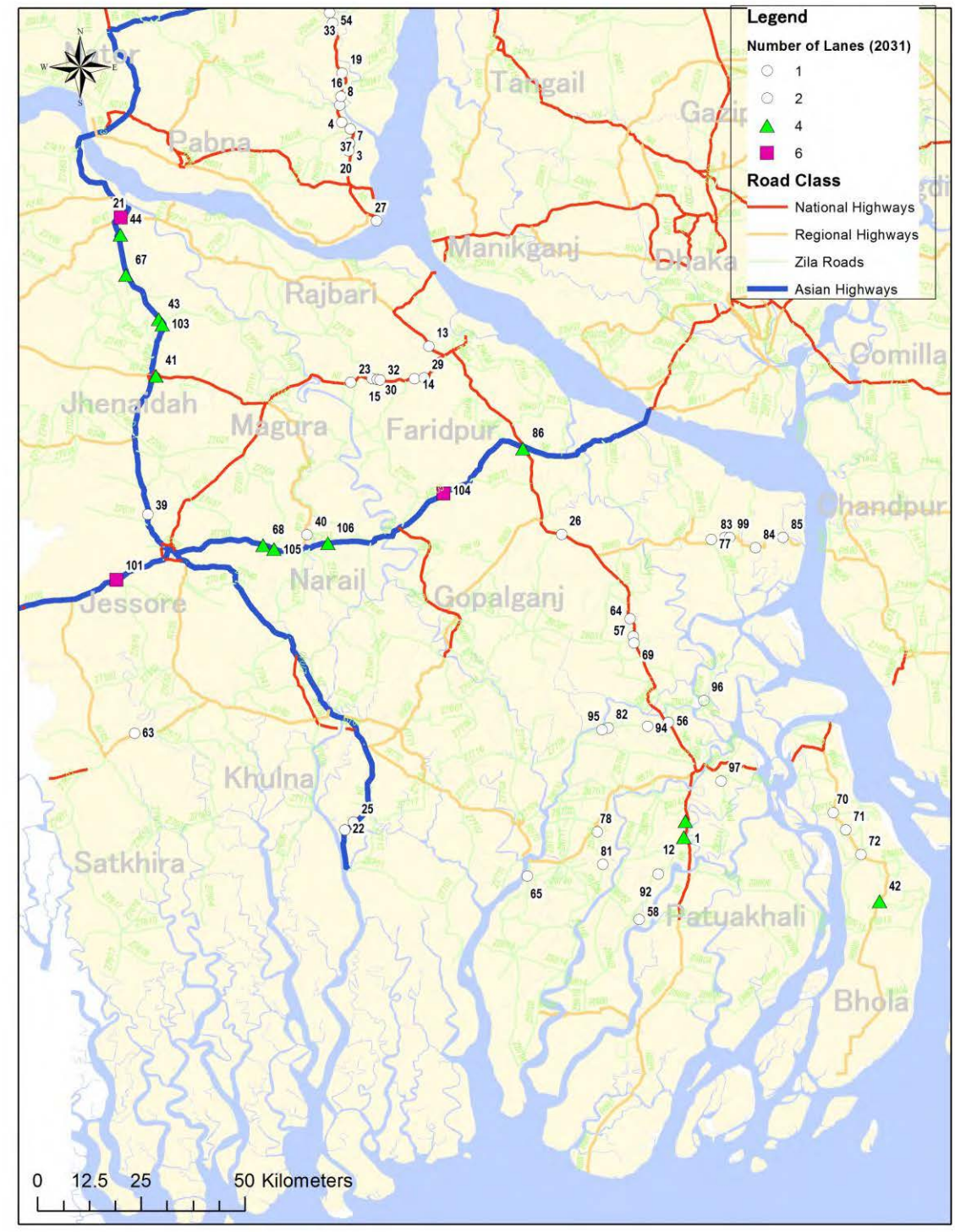
Road Type	Required Number of Lanes	Number of Bridges (Number of Bridge on Asian Highway)
National Roads	6 lanes	5 bridges (AH: 5 bridges)
	4 lanes	14 bridges (AH: 10 bridges)
	2 lanes	38 bridges (AH: 13 bridges)
	Total	**57 bridges (AH: 28 bridges)**
Regional Roads	4 lanes	5 bridges (AH: 2 bridges)
	2 lanes	16 bridges (AH: 1 bridge)
	Total	**21 bridges (AH: 3 bridges)**
Zilla Roads	4 lanes	1 bridges (AH: 1 bridges)
	2 lanes	26 bridges (AH: 0 bridge)
	Total	**27 bridges (AH: 1 bridges)**
Total		**105 bridges (AH: 32 bridges)**

Source: JICA Survey Team



Source: JICA Survey Team

Figure 5.5.1 Required Number of Lane (1)



Source: JICA Survey Team

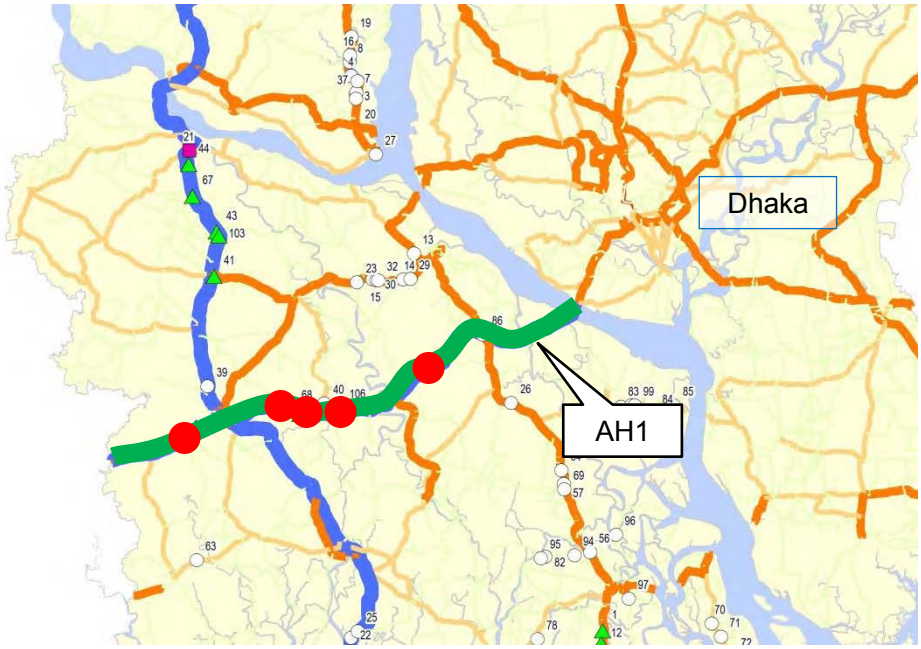
Figure 5.5.2 Required Number of Lane (2)

5.5.2 Number of Lane in the Project

In the Project, the majority the bridges, including those that require more than 4 lanes based on the traffic demand forecast, will be constructed as 2-lane bridges based on the following considerations:

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

However, in the meeting between JICA, MORTB, RHD and JICA Survey Team held on April 27, 2014, it was determined that 5 bridges on Asian Highway 1 (AH1) will be constructed with 4 lanes in conformity with a future 4-lane widening plan (see Figure 5.5.3).



Source: JICA Survey Team

Figure 5.5.3 4-lane Bridges on Asian Highway

6. DETERMINATION OF BRIDGE TYPE

6.1 Methodology of Bridge Type Decision

In the bridge selection process in Chapter 3, 106 bridges were selected as the candidate bridges of the Project. However, the preliminary design was conducted for 105 bridges since it was confirmed that 1 bridge is under construction in another project.

This Project includes the construction of small and mid-sized bridges, but no large bridges.

For small bridges, PC-I girder is widely recognized as the most suitable and economical bridge type in almost all site conditions, and many PC-I girder bridges have been constructed in Bangladesh by RHD.

For mid-sized bridges, the most appropriate bridge type shall be selected upon comparison of multiple bridge type candidates (PC-Box girder and Steel-I girder). Conditions for comparison include earthquake strength, construction difficulties, cost efficiency, owner's maintenance performance, and others.

Small size bridge: PC-I
Middle size bridge: PC-Box, Steel-I (painted or weathering steel) — Range of WBBIP
Large size bridge: PC-extra dosed, Cable-stayed, Suspension, others

Table 6.1.1 Applicable Bridge Span for Bridge Type

Bridge size	Bridge type	Applicable bridge span / Economical bridge span 30 40 50 60 70 80 (m)
Small size	PC-I	■■■■
Middle size	PC-Box	▒▒ ■■■■
	Steel-I	▒▒ ■■■■
	Steel-Box	▒▒ ■■■■
		Range of WBBIP

Source: JICA Survey Team

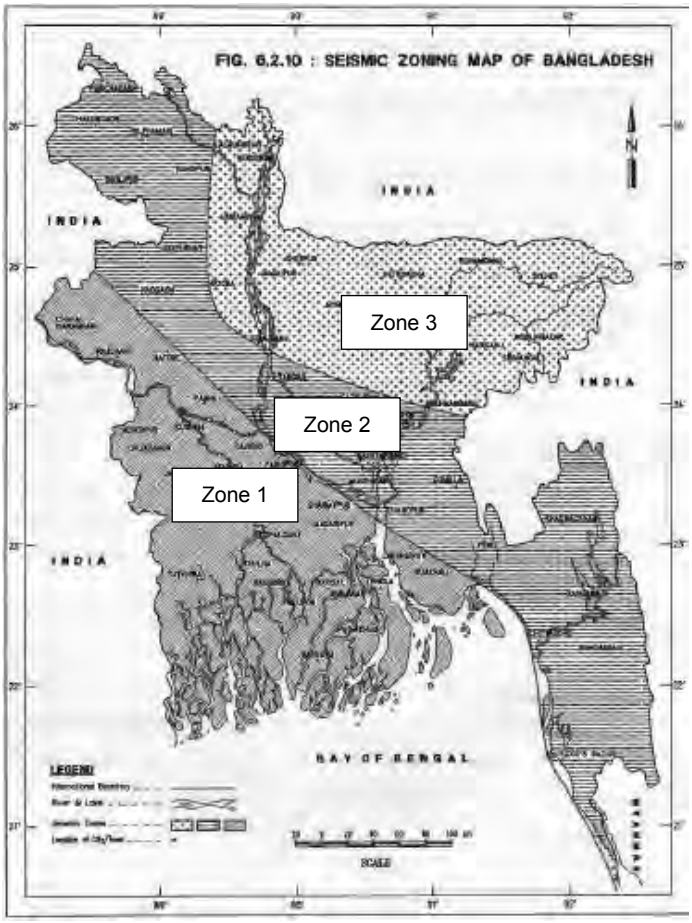
6.2 Grouping for Bridge Design

For bridge design, all bridges are classified into 2 groups: Group A and Group B. Earthquake strength shall be considered for the grouping, since it affects bridge design and its cost. Grouping for bridge design is defined in consideration of bridge length and height as well as seismic coefficient, which is different for each zone.

Table 6.2.1 Earthquake Zone Coefficient Z (BNBC)

Seismic zone	Zone coefficient
1	0.075
2	0.15
3	0.25

Source: Bangladesh National Building Code (BNBC)



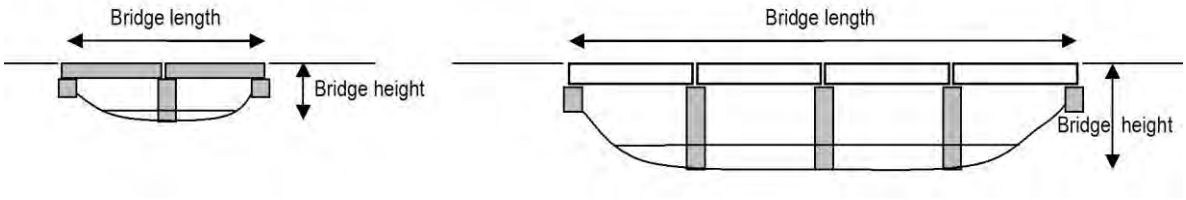
Source: Bangladesh National Building Code (BNBC)

Figure 6.2.1 Seismic Zoning Map (BNBC)

Group A in each zone is defined as follows:

- North zone (Z = 0.15 or 0.25): length < 100 m and height < 10 m
- South zone (Z = 0.075): length < 150 m and height < 15 m

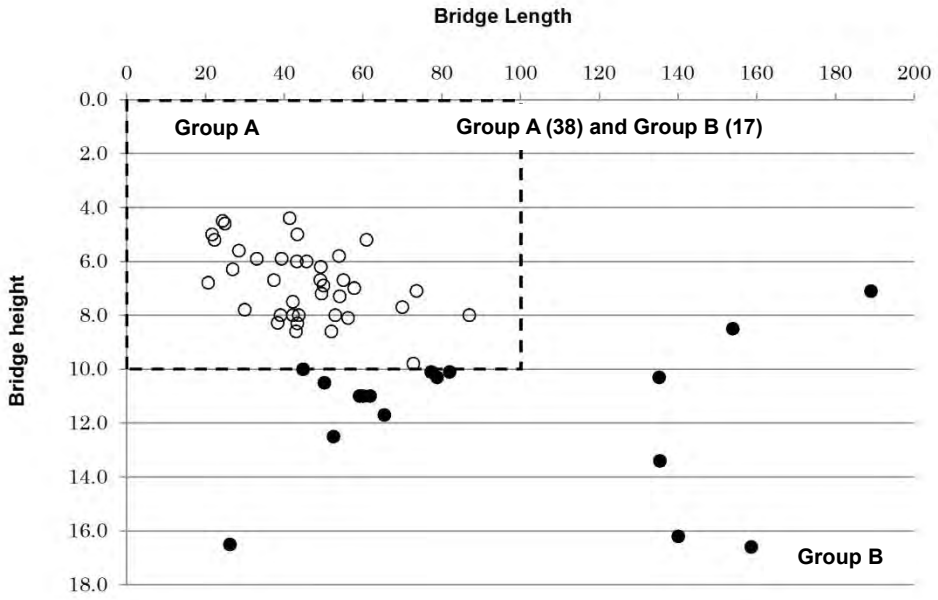
Group B is defined as bridges falling outside of the above definition.



Group A Group B

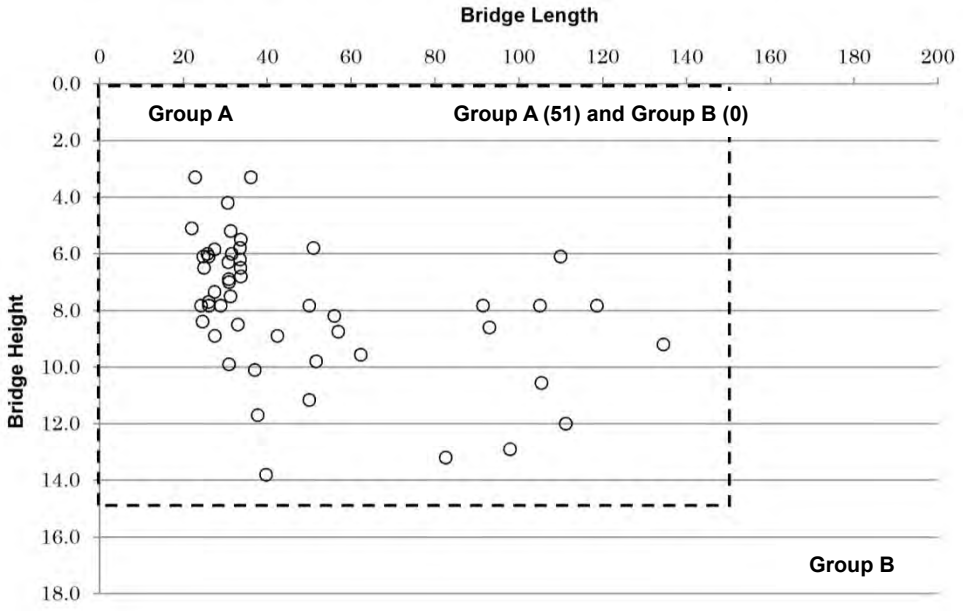
Figure 6.2.2 Grouping of Bridges

Using the above-stated definition, all bridges in the WBBIP are plotted in Figures 6.2.3 and Figure 6.2.4. Note that bridges in northern zones belong to both Group A and Group B bridges, whereas all bridges in the southern zone (zone 1) belong to Group A.



Source: JICA Survey Team

Figure 6.2.3 55 Bridges in Northern Zone



Source: JICA Survey Team

Figure 6.2.4 51 Bridges in Southern Zone

6.3 Bridge Type for Group A

Group A Bridges are shorter and lower. Accordingly, as these are small bridges having short span length (Span < 40m), PC-I girder bridges are to be used for Group A Bridges.

6.4 Bridge Type for Group B in Northern Zone

Group B Bridges (all of which are in the northern zone) are longer and higher. Accordingly as these are mid-size bridge having medium-span length (40m < Span < 60m), both PC-Box girder bridges and Steel-I girder bridges are compared for use. For the Steel-I girders, both ordinary painted steel and weathering steel are considered in the comparison.

As the result of the comparison of PC-Box girder bridges, Painted Steel-I girder bridges and Weathering Steel-I girder bridges (as shown in Table 6.4.1), Weathering Steel-I girder bridges are recommended as the most appropriate bridge type for Group B bridges. Reasons include the following:

- Constructability: While PC box girder bridges require longer construction periods due to on-site girder construction, weathering steel bridges require shorter periods for construction due to the use of pre-fabricated girders. Thus, the negative impact on regional economy due to construction is less in the case of weathering steel.
- Maintenance: In order to increase the durability of bridges, PC box girders may require surface treatment, which in turn requires periodic retreatment. However, weathering steel does not require such treatment or painting.

- Structural performance: Weathering steel bridges have an advantage in earthquake resistance over PC box girder bridges, which have to be heavier and more costly in order to ensure the earthquake resistance. Note that all Group B bridges are in northern Bangladesh, which is categorized as Seismic Zone II (medium-level seismic activity) and III (high-level seismic activity).
- Technology transfer: While Bangladesh already has experience in PC box girder bridge construction, it does not yet have experience in weathering steel bridge construction. Thus, selection of weathering steel bridges as the bridge type would bring weathering steel technology to Bangladesh through good technological transfer from Japan, which has good experience in this technology. The skills gained will surely prove to be indispensable for future bridge construction in Bangladesh.

Table 6.4.1 Comparison of Bridge Type for Group B Bridge in Northern Zone

Bridge type		PC Box Girder	Steel I Girder (Painting)	Steel I Girder (Weathering Steel)
Image				
Structural Performance	Durability	- Enough durability. (Fair)	- Enough durability. (Fair)	- Enough durability. (Fair)
	Earthquake Resistance	- Disadvantage due to heavyweight. (Poor)	- Advantage due to light weight. (Good)	- Advantage due to light weight. (Good)
Constructability	Construction Difficulty	- Normal construction method (Cantilever). (Fair)	- Normal construction method (Erection by truck crane). (Fair)	- Normal construction method (Erection by truck crane). (Fair)
	Quality Control	- Normal quality control. (Fair)	- Normal quality control. (Fair)	- Normal quality control. (Fair)
	Construction Period	- Long period with girder construction at site. (Poor)	- Short period with pre-fabricated girder. (Good)	- Short period with pre-fabricated girder. (Good)
Maintenance	Re-painting/Surface Treatment	- Need surface treatment.(Poor)	- Need painting. (Poor)	- No need painting. (Good)
Environmental Impact		- No specific environmental impact. (Good)	- Special care is required when re-painting. (Poor)	- No specific environmental impact. (Good)
Cost	Initial Cost	- 1.00 (Good)	- 1.15 (Fair)	- 1.19 (Fair)
	Regular Maintenance Cost (% of Initial Cost, Annual)	- 1.5% (Fair)	- 1.5% (Fair)	- 1.5% (Fair)
	Re-painting/Surface Treatment Cost (% of Initial Cost)	- 4.0% (by 30 Years) (Fair)	- 12.0% (by 15 Years) (Poor)	- No painting (Good)
	LCC for 50 Years (Price Increase 6% per Annual)	- 1.00 (Good)	- 1.21 (Fair)	- 1.18 (Fair)
Technical Transfer		- Expected but experienced in Bangladesh. (Fair)	- Expected for new technology in Bangladesh. (Good)	- Expected for new and modern technology in Bangladesh. (Good)
Evaluation				**Recommended** - Advantage to earthquake resistance - Short construction period - Easy maintenance - No specific environmental impact - Fair initial and life cycle costs - Good technical transfer

6.5 Bridge Length and Span Arrangement

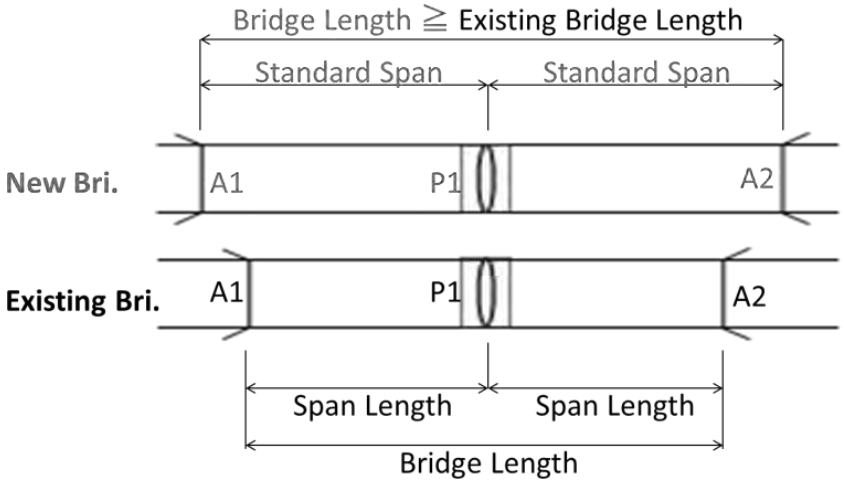
The bridge span lengths are standardized with a series of spans in order to be easily applied to all 105 bridge locations. Standard bridge spans are as follows:

- PC-I : standard span 25, 30, 35, 40 m
- Steel-I : standard span 40, 50, 60 m

The following two points should be considered when determining the bridge length and span arrangement of new bridges.

- Pier locations of new bridges shall be matched with the existing bridges as much as possible so as not to obstruct the river flow.
- Bridge lengths and span lengths shall generally be longer than that of the existing bridges in order to secure sufficient cross-sectional area for the river flow.

Figure 6.5.1 shows the general concept of the span arrangement for new bridges.



Source: JICA Survey Team

Figure 6.5.1 Concept of Span Arrangement of New Bridge

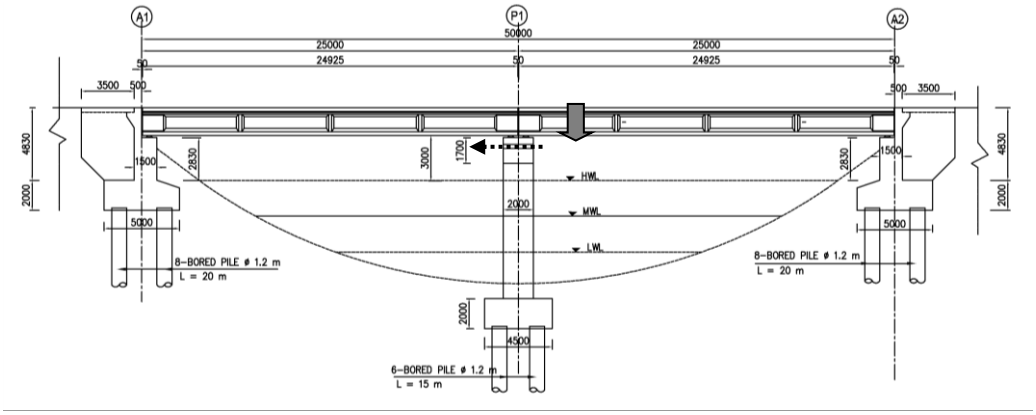
6.6 Girder Type in Consideration of Earthquakes

Seismic design must be considered to avoid crucial disasters in Bangladesh. In order to deal with seismic loading, measures to prevent superstructure collapse shall be considered.

So far PC-I girder bridges in Bangladesh have been constructed as shown in Figure 6.6.1. When a large earthquake occurs, this structure may induce large motion of pier head and there is possibility of girder collapse.

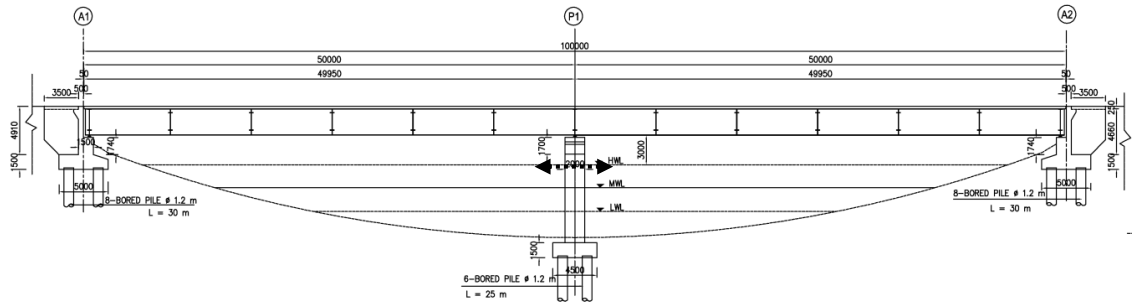
Accordingly, measures to prevent superstructure collapse are proposed for both selected girders types. Continuous girders are proposed for Steel-I girder bridges as shown in Figure

6.6.2. “Chaired girders” (in which pier head movement is restricted by connecting girders) are proposed for PC-I girder bridges as shown in Figure 6.6.3.



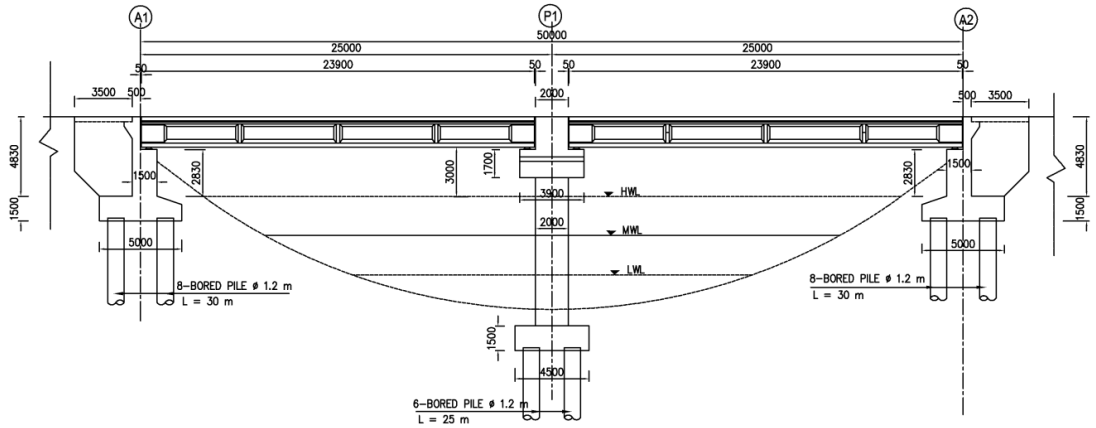
Source: JICA Survey Team

Figure 6.6.1 Traditional PC-I Girder Bridge (Single Span Girders)



Source: JICA Survey Team

Figure 6.6.2 Steel-I Girder Bridge in WBBIP (Continuous Girder)



Source: JICA Survey Team

Figure 6.6.3 PC-I Girder Bridge in WBBIP (Chaired Single Span Girders)

7. PRELIMINARY DESIGN

7.1 Design Criteria for Roads

7.1.1 Design Standards

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

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

Table 7.1.1 Design Standards for the Road

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

Source: JICA Survey Team

7.1.2 Standard for Roads in Bangladesh

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

(1) Road Class

Roads in Bangladesh are divided into the following three classifications.

Table 7.1.2 Functional Road Class

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

Source: RMMS Database, RHD

(2) Design Classes

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

Table 7.1.3 Road Design Types

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

Source: Road geometric design standard by RHD

(3) Geometric Design Criteria for Each Road Class

1) National Roads

Summary of geometric design criteria are shown in Table 7.1.4.

Table 7.1.4 Geometric Design Criteria for National Roads

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

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

Source: JICA Survey Team

2) Regional Roads

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

Table 7.1.5 Geometric Design Criteria for Regional Road

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

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

Source: JICA Survey Team

3) Zilla Road

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

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

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

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

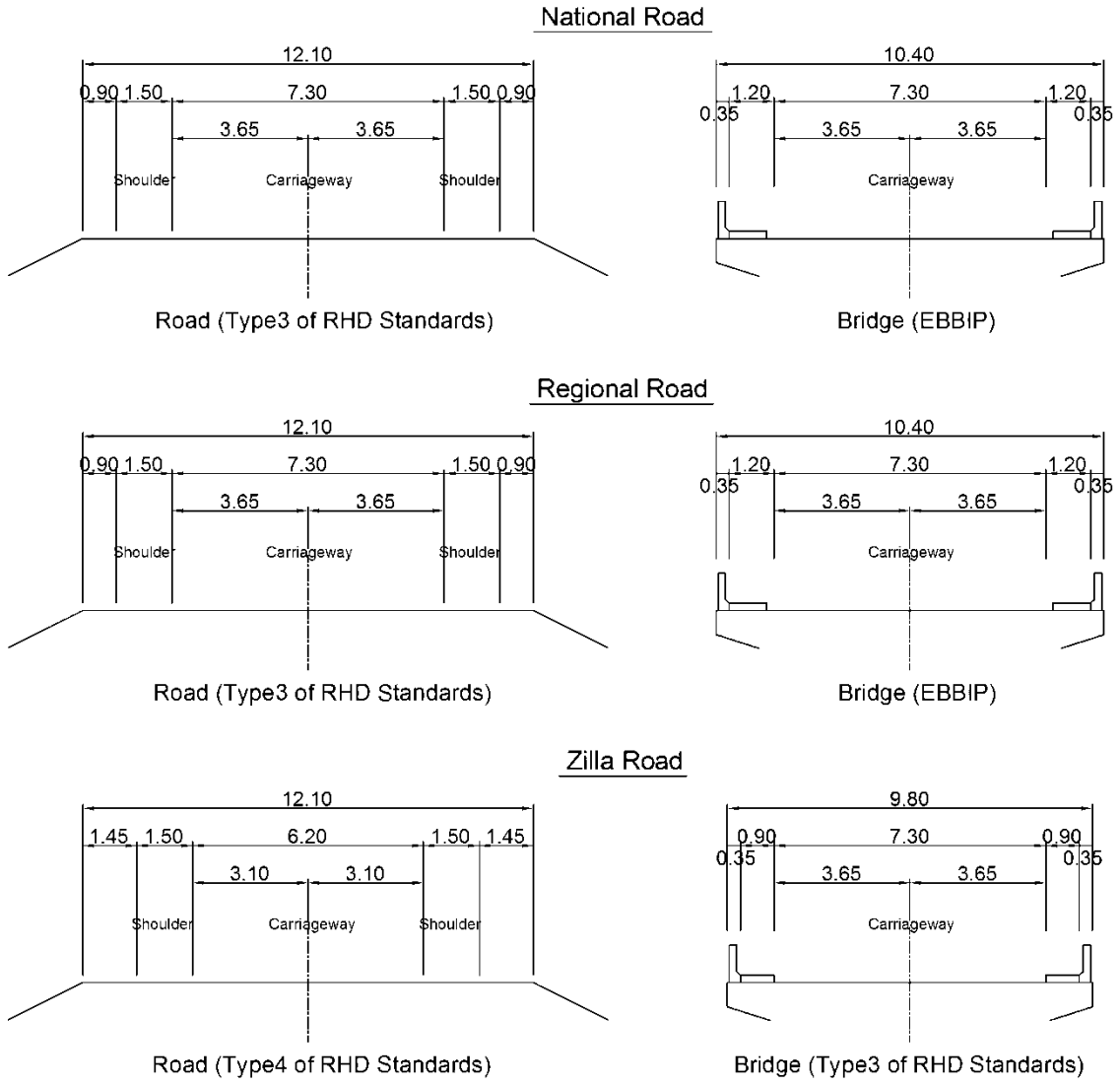
Source: JICA Survey Team

7.1.3 Typical Cross Section

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

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

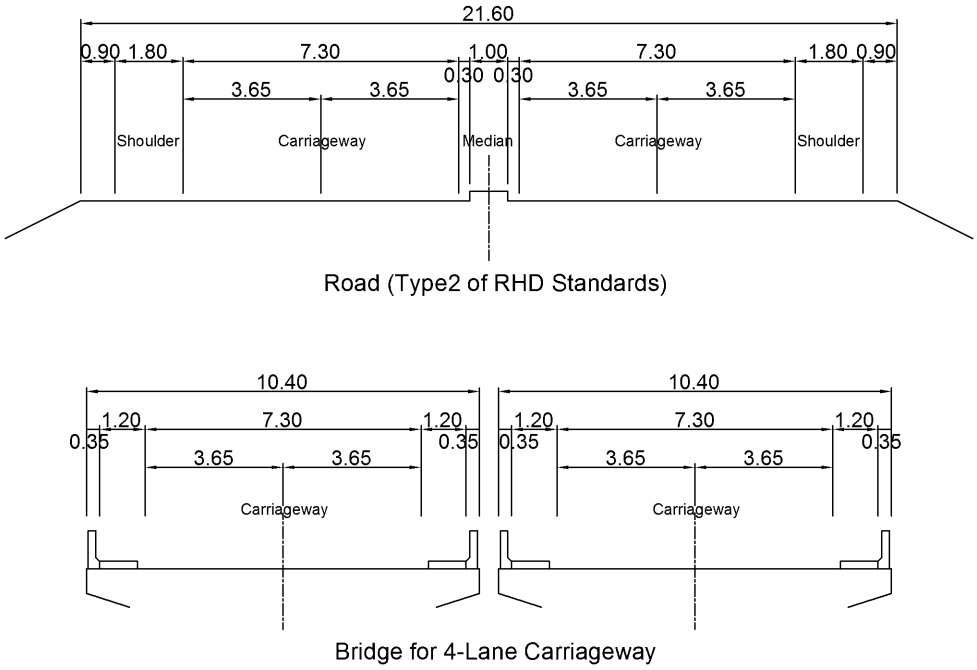
Typical cross sections for National, Regional and Zilla roads are shown in Figure 7.1.1.



Source: JICA Survey Team

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

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



Source: JICA Survey Team

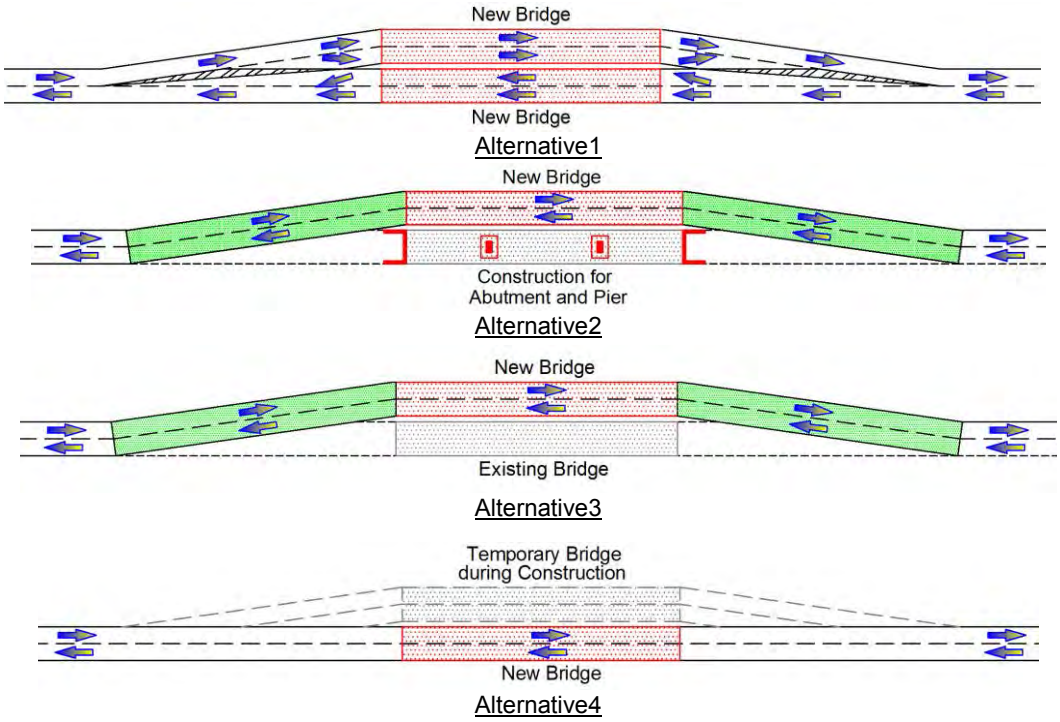
Figure 7.1.2 Typical Cross Section for AH1

7.1.4 Basic Principle for the Location of New Bridge

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

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

Table 7.1.7 The Location of New Bridge

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

Source: JICA Survey Team

7.2 Design Criteria for Bridges

7.2.1 Design Standards to be followed in Bangladesh

(1) Design Standards

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

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

7.2.2 Navigation Waterway Limitation and Design High Water Level

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

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

Table 7.2.1 Navigation Waterways Limitation

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

Source：BIWTA (1991)

Table 7.2.2 Design High Water Level and Bridge Girder Bottom Height

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

Source：JICA Survey Team

7.2.3 Design Loads

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

(1) Dead Load

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

Table 7.2.3 Unit Weight of Bridge Materials for Dead Load Calculation

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

Source: JICA Survey Team

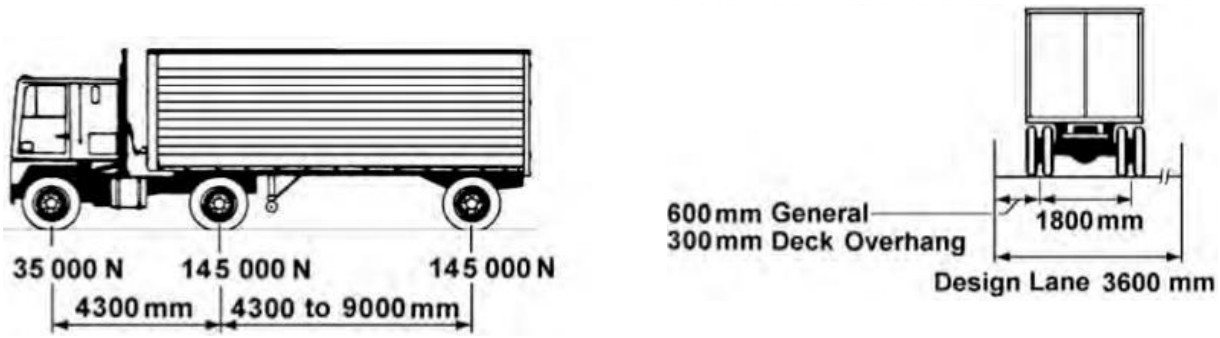
(2) Live Loads

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

- Design truck load
- Design lane load

1) Design Truck Load

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



Source: JICA Survey Team

Figure 7.2.1 Design Truck Load

2) Design Lane Load

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

Table 7.2.4 Lane Load Specification for Girder and Substructure Design

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

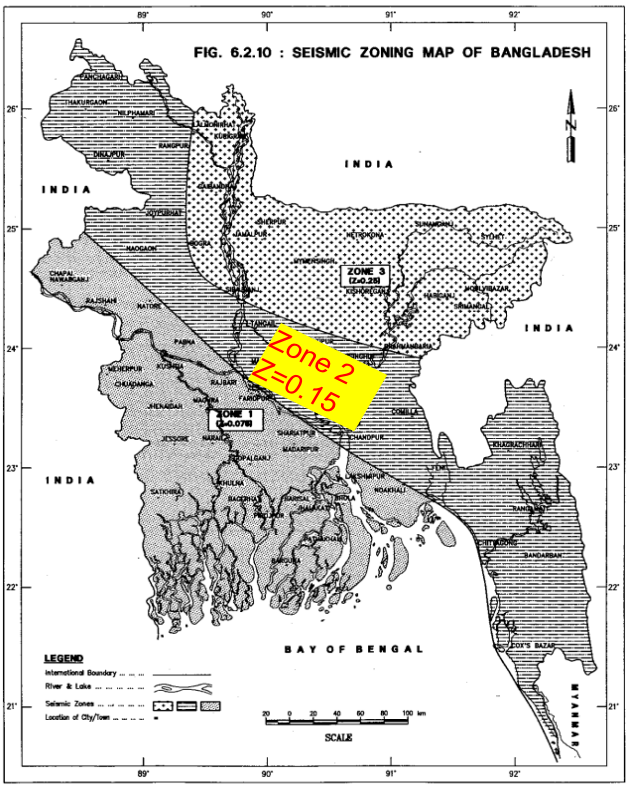
Source: JICA Survey Team

(3) Earthquake Load

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

1) Zone coefficient

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



Source: JICA Survey Team

Figure 7.2.2 Seismic Zoning Map of Bangladesh

Table 7.2.5 Zone Coefficient Z (BNBC)

Seismic zone	Zone coefficient
1	0.075
2	0.15
3	0.25

Source: JICA Survey Team

2) Site Coefficient S

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

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

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

Source: JICA Survey Team

3) Design Response Spectrum (RS)

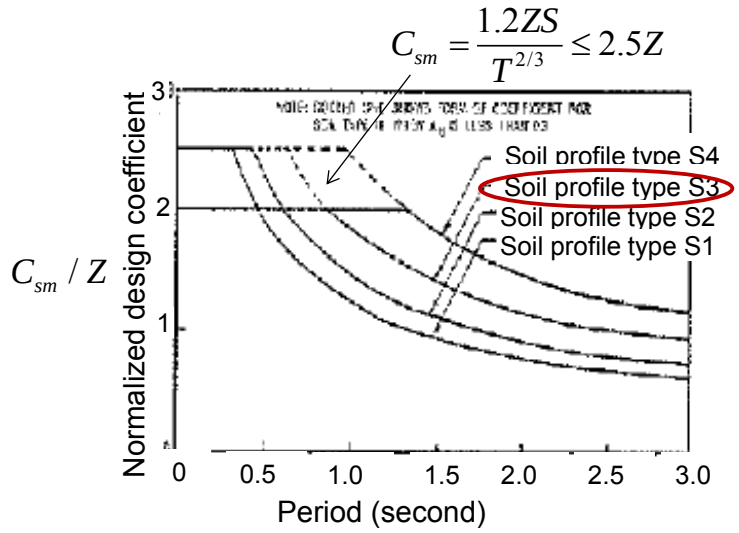
Generally, a design RS shall be developed based on geologic, seismologic and soil characteristics associated with the specific site. In this regard, BNBC has a provision on design RS whose magnitude is almost equal to the magnitude of the response spectra proposed by AASHTO LRFD (2007). The design RS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

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

where,

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

C_{sm}: *Elastic response coefficient*



Source: JICA Survey Team

Figure 7.2.3 Design Response Spectrum

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

7.2.4 Technical Specifications for Construction Materials

(1) Concrete

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

Table 7.2.7 Strength Requirements of Concrete for Bridges

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

Source: JICA Survey Team

(2) Reinforcing steel bars

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

Table 7.2.8.

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

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

Source: JICA Survey Team

(3) Prestressing Steel

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

Table 7.2.9 Nominal Stress of Prestressing Steel

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

Source: JICA Survey Team

(4) Weathering Steel

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

Table 7.2.10 Nominal Stress of Steel

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

Source: JICA Survey Team

7.3 Road Design

7.3.1 Design Speed

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

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

Table 7.3.1 Design Speed for National, Regional and Zilla Road

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

Source: JICA Survey Team

7.3.2 Horizontal Alignment

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

Rated values and adopted values are described below, respectively.

(1) Minimum Horizontal Curve Radius

Table 7.3.2 Minimum Horizontal Curve Radius

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

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

Source: JICA Survey Team

(2) Minimum Transition Length

Table 7.3.3 Minimum Transition Length

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

Source: JICA Survey Team

7.3.3 Vertical Alignment

(1) Concepts of Vertical Alignment

Vertical alignment is designed in consideration of the following concepts.

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

(2) Vertical Curve, K

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

Table 7.3.4 Minimum Vertical Curve, K

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

Source: JICA Survey Team

7.3.4 Crossfall

Crossfall is set in accordance with the RHD standards as shown in Table 7.3.5.

Table 7.3.5 Crossfall for Road and Bridge

Road	Bridge
3.0 %	2.0 %

Source: JICA Survey Team

7.3.5 Superelevation

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

Table 7.3.6 Superelevation for Radius of Curve

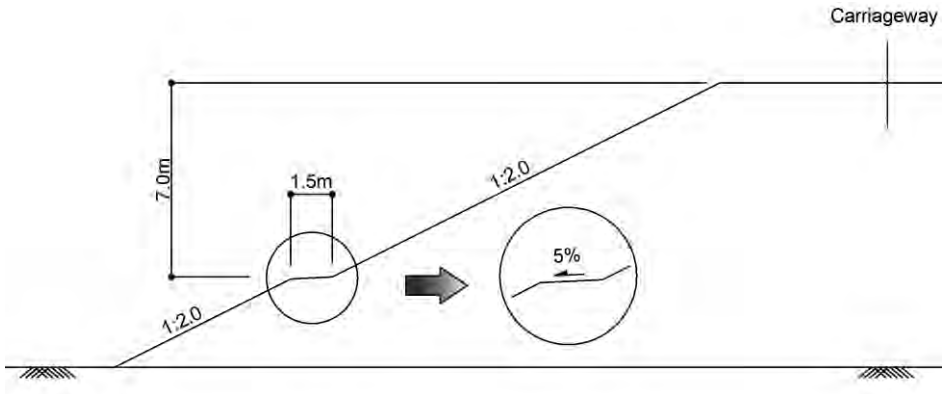
Design Speed (km/h)	Radius of Curve (m)					
	65	120	250	500	1000	2000
50	7 %	5 %	3 %	Nil	Nil	Nil
65	-	7 %	5 %	3 %	Nil	Nil
80	-	-	7 %	5 %	3 %	Nil

Source: JICA Survey Team

7.3.6 Embankment

(1) Height of Embankment

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

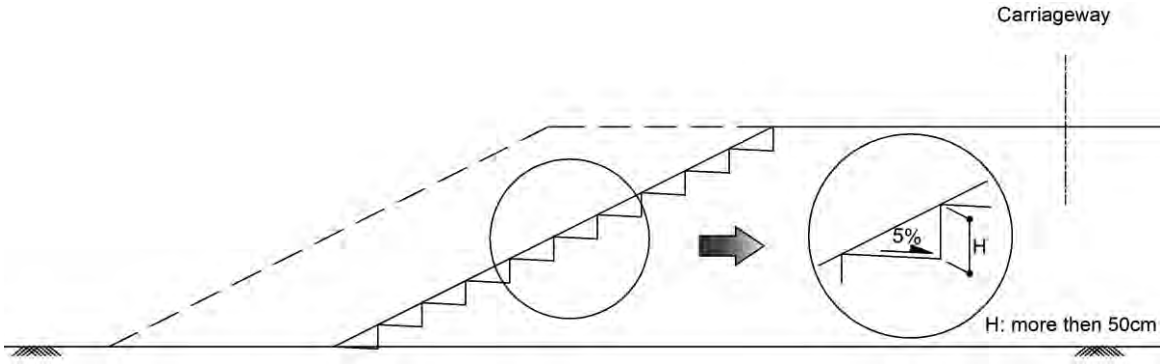


Source: JICA Survey Team

Figure 7.3.1 Embankment

(2) Bench Cut

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



Source: JICA Survey Team

Figure 7.3.2 Detail for Bench Cut

7.3.7 Pavement Design

(1) Introduction

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

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

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

where

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

Z_R: *Standard normal deviate*

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

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

M_R: *Resilient modulus (psi)*

SN: *Design structural number*

(2) Design Condition

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

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

The design period was determined in consideration of the following:

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

Table 7.3.7 Axle Load Equivalency Factor

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

Source: JICA Survey Team

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

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

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

Source: JICA Survey Team

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

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

Source: JICA Survey Team

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

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

Source: JICA Survey Team

2) Standard Normal Deviate (Z_R)

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

Table 7.3.11 Standard Normal Deviate (Z_R)

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

Source: AASHTO Pavement Guide

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

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

4) Serviceability Index Difference (∆PSI)

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

Table 7.3.12 Serviceability Index Difference, P_t (∆PSI)

P_o	4.2
P_t	2.5
∆PSI	**1.7**

Source: AASHTO Pavement Guide

5) Resilient Modulus (psi) (M_R)

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

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

6) Design Structural Number (SN)

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

Table 7.3.13 SN for National, Regional, Zilla Road

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

Source: JICA Survey Team

(3) Pavement Layer Thickness

Pavement layer thickness is calculated by the following formula.

$$SN = a_1D_1+a_2D_2m_2+a_3D_3m_3$$

where

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

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

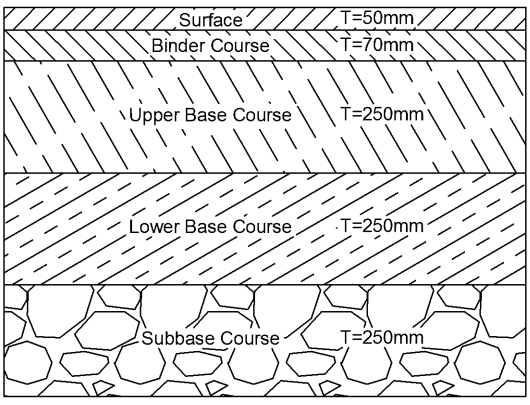
m_2, m_3: *Drainage coefficients for base and subbase layers, respectively*

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

Table 7.3.14 Pavement Layer Thickness for National Roads

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

Source: JICA Survey Team



Source: JICA Survey Team

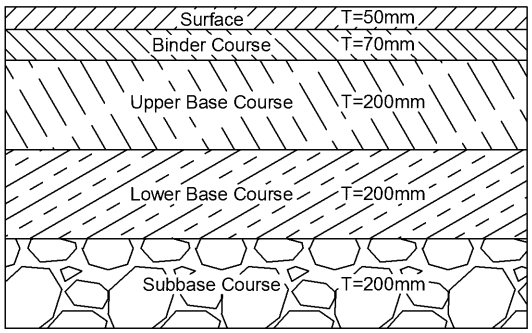
Figure 7.3.3 Pavement Layer Thickness for National Roads

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

Table 7.3.15 Pavement Layer Thickness for Regional Roads

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

Source: JICA Survey Team



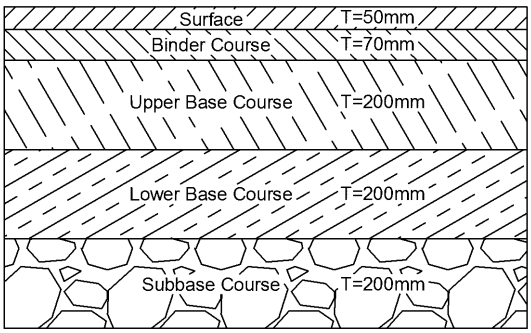
Source: JICA Survey Team

Figure 7.3.4 Pavement Layer Thickness for Regional Roads

Table 7.3.16 Pavement Layer Thickness for Zilla Roads

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

Source: JICA Survey Team



Source: JICA Survey Team

Figure 7.3.5 Pavement Layer Thickness for Zilla Roads

7.4 Bridge Design

7.4.1 Superstructures

(1) Girder Type and Standard Spans

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

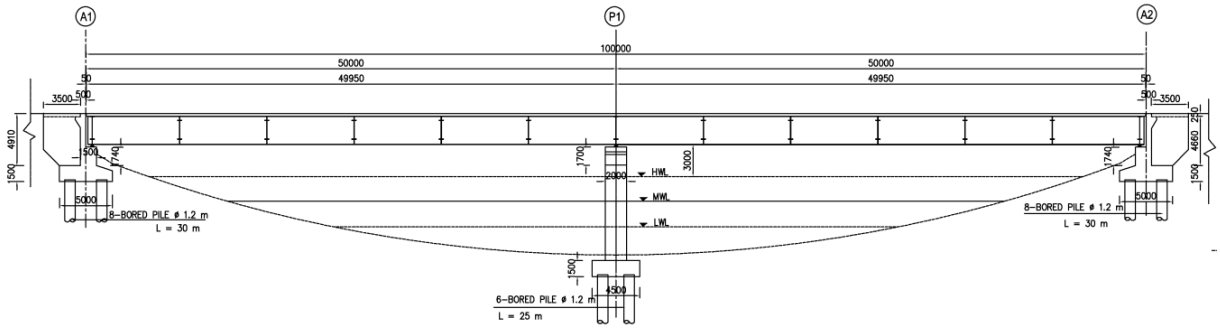
Northern zone (55 bridges):	38 small PC-I girder bridges, and
	17 mid-sized Steel-I (weathering steel) girder bridges
Southern zone (50 bridges):	All small PC-I girder bridges

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

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

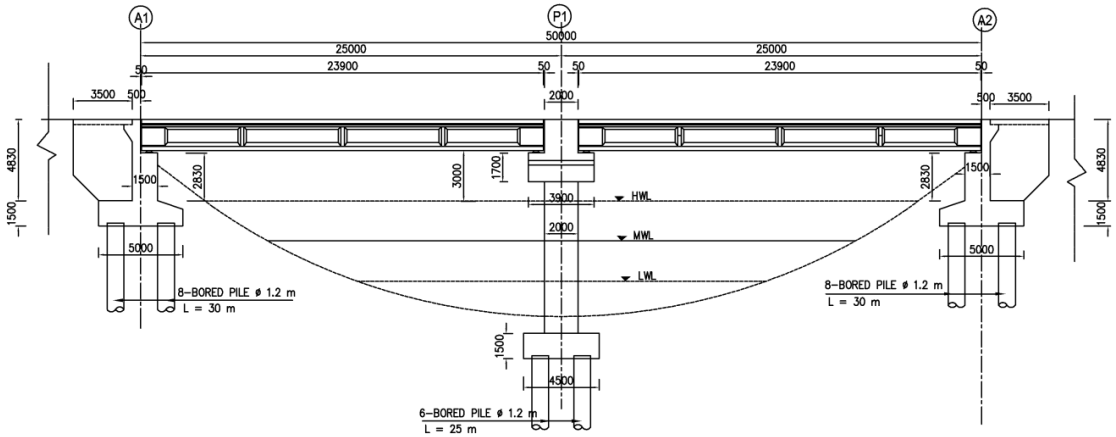
Steel-I : standard span 40, 50, 60 m

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



Source: JICA Survey Team

Figure 7.4.1 Steel-I Girder (Continuous Girder)

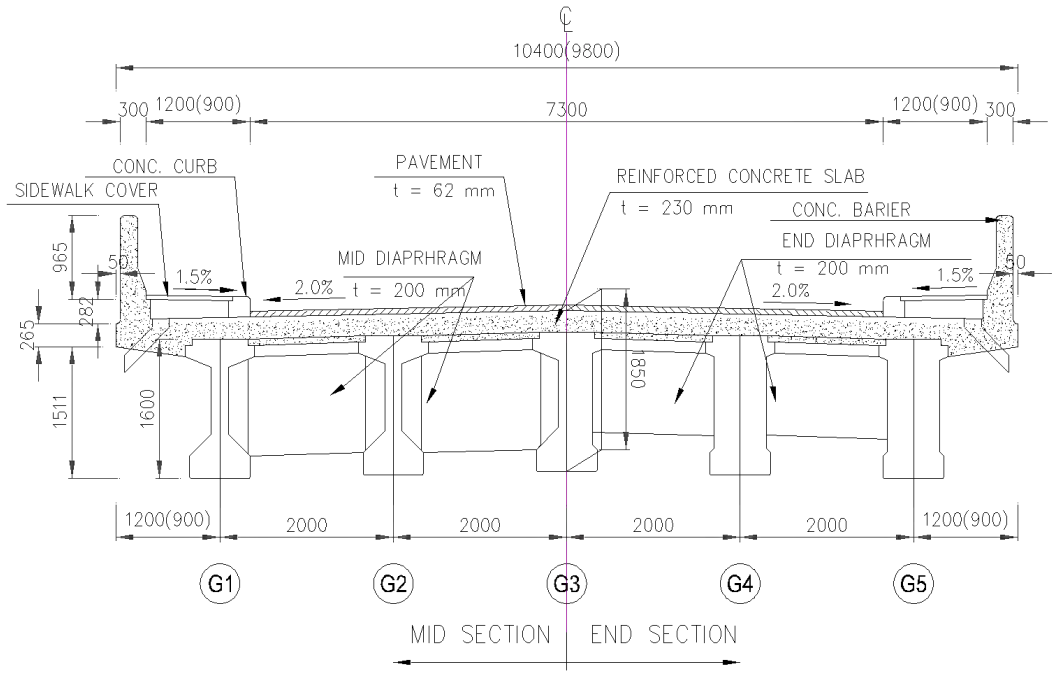


Source: JICA Survey Team

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

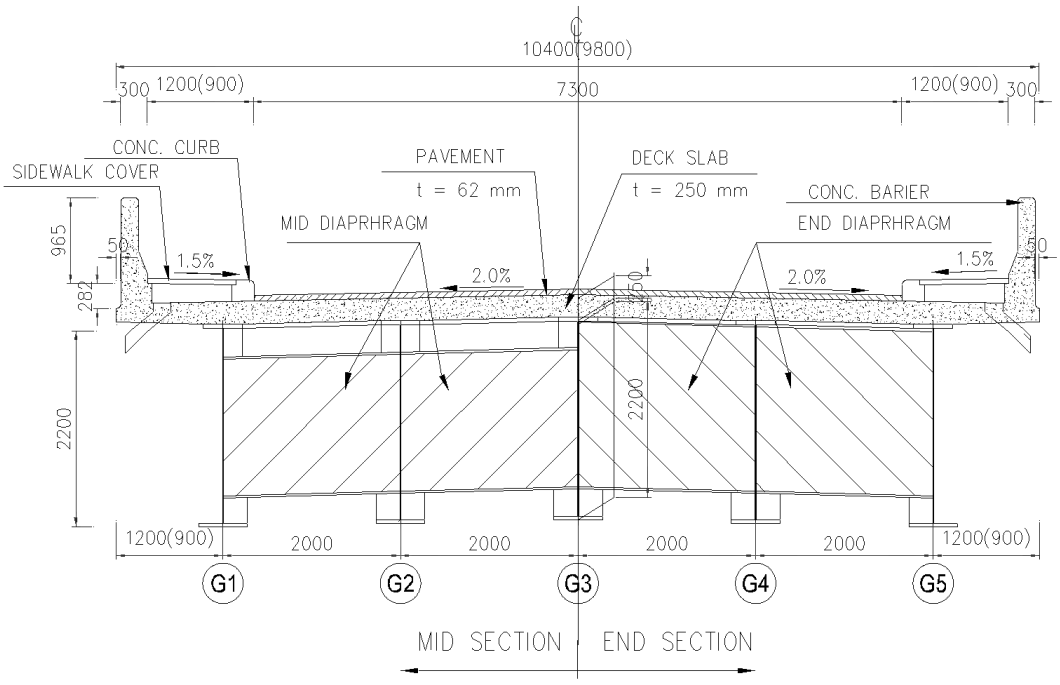
(2) Cross Sections

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



Source: JICA Survey Team

Figure 7.4.3 Cross Section for PC-I Girder



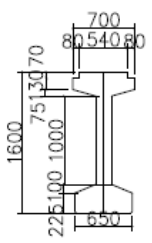
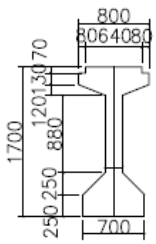
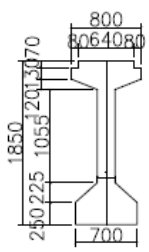
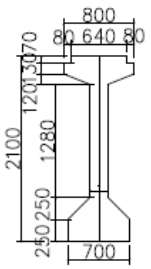
Source: JICA Survey Team

Figure 7.4.4 Cross Section for Steel-I Girder

(3) Result of Preliminary Design

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

Table 7.4.1 Summary of Preliminary Design of PC-I

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

Source: JICA Survey Team

Table 7.4.2 Summary of Preliminary Design of Steel-I

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

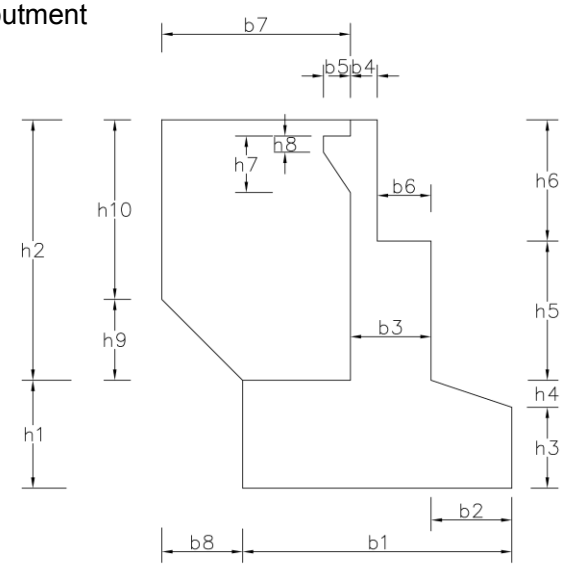
Source: JICA Survey Team

7.4.2 Substructures

(1) Abutments and Piers

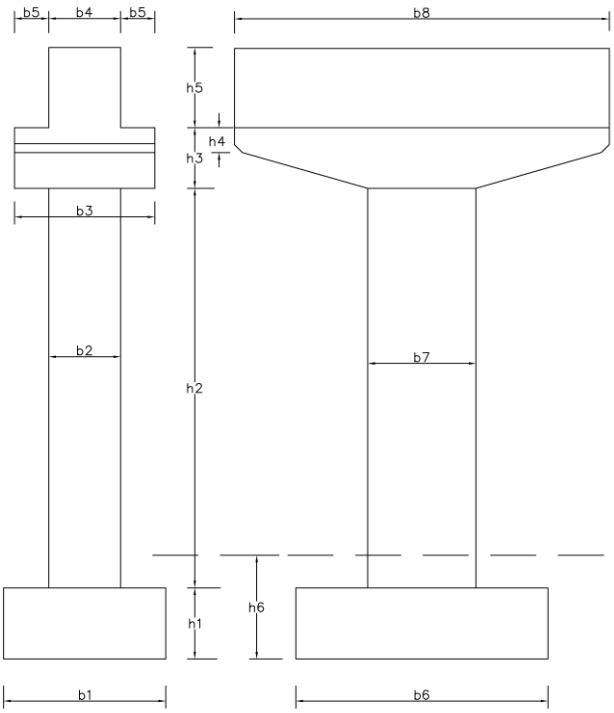
As with superstructures, substructures (i.e. abutments and piers) are also standardized as shown in Figure 7.4.5.

Abutment



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

Pier



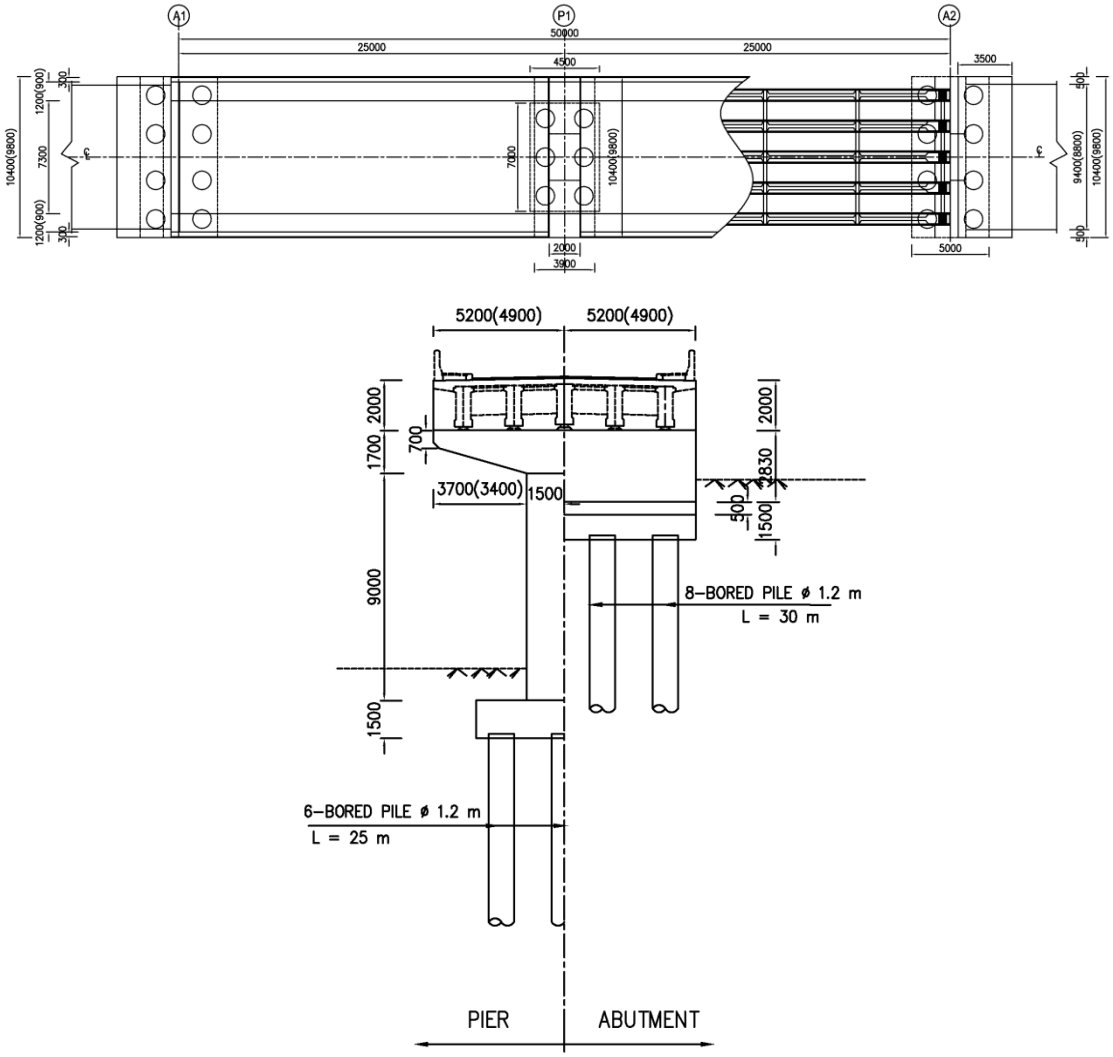
h1 =	2.00 m	b1 =	4.50 m
h2 =	11.21 m	b2 =	2.00 m
h3 =	1.70 m	b3 =	3.90 m
h4 =	0.70 m	b4 =	2.00 m
h5 =	2.25 m	b5 =	0.95 m
h6a =	3.90 m	b6 =	7.00 m
h6b =	3.30 m	b7 =	3.00 m
		b8 =	10.40 m

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

Figure 7.4.5 Standard Abutment and Pier

(2) Piles

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



Source: JICA Survey Team

Figure 7.4.6 Pile Arrangement

7.4.3 Summary of Preliminary Design

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

Table 7.4.3 Design Summary of 105 Bridges (1)

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

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

Source: JICA Survey Team

Table 7.4.4 Design Summary of 105 Bridges (2)

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

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

Source: JICA Survey Team

Table 7.4.5 Comparison of Existing and New Bridges

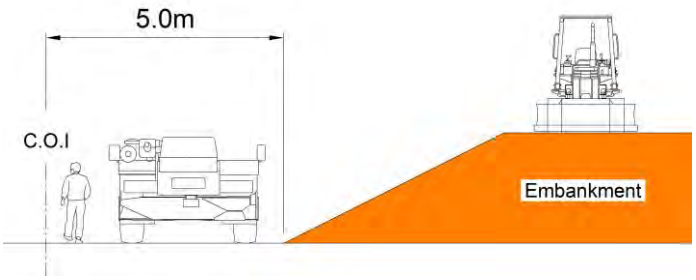
		No. of Bridges	Average Width	Average Length	Total Length
Existing Bridge		105	6.16	54.1	5,682
New Bridge	PC-I	88	10.85	56.88	5,005
	Steel-I	17	10.22	113.53	1,930
	Total	105	10.75	66.05	6,935
Ratio New total/ Existing		-	1.75	1.22	1.22

Source: JICA Survey Team

7.5 Right of Way

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

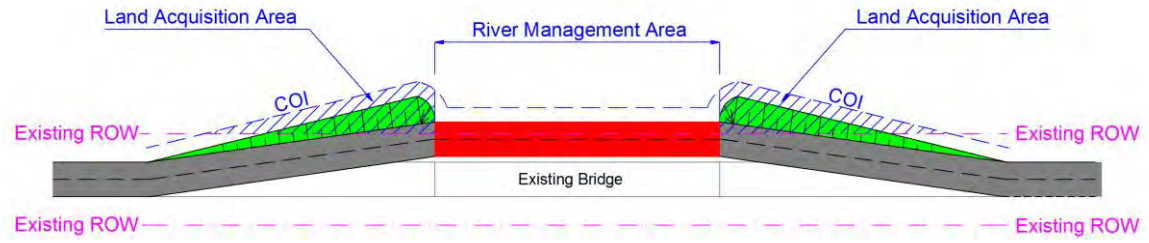
acquisition is required, it is carried out with the Corridor of Impact (COI) set at 5m from the bottom of the embankment as shown in Figure 7.5.1. The COI is set to the minimum required area for construction activities in order to minimize resettlement and compensation.



Source: JICA Survey Team

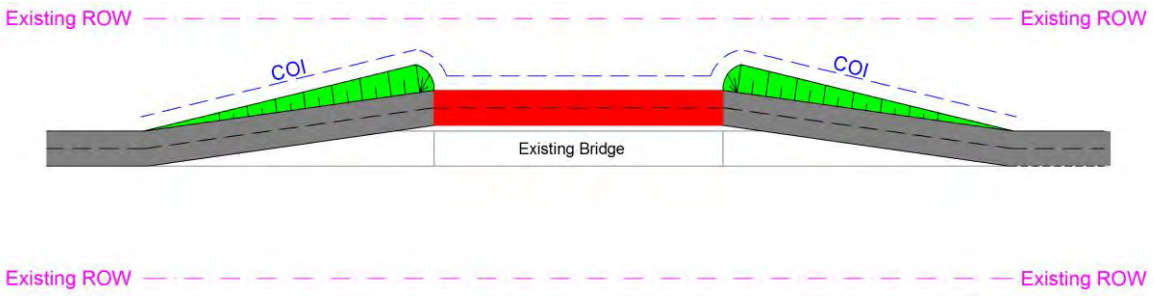
Figure 7.5.1 Corridor of Impact (COI)

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



Source: JICA Survey Team

Figure 7.5.2 Outside of Existing ROW



Source: JICA Survey Team

Figure 7.5.3 Inside of Existing ROW

8. APPLICATION OF MODERN TECHNOLOGIES

8.1 Introduction

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

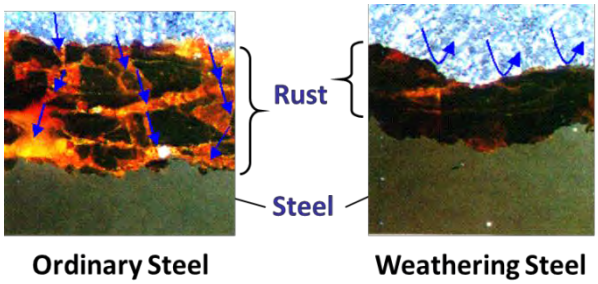
- Constructability: While PC box girder bridges require longer construction periods due to on-site girder construction, weathering steel bridges require shorter periods for construction due to the use of pre-fabricated girders. Thus, the negative impact on regional economy due to construction is less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

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

8.2 Weathering Steel

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

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



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

Source: JICA Survey Team

Figure 8.2.1 Mechanism of Corrosion Resistance of Weathering Steel

(mass%)

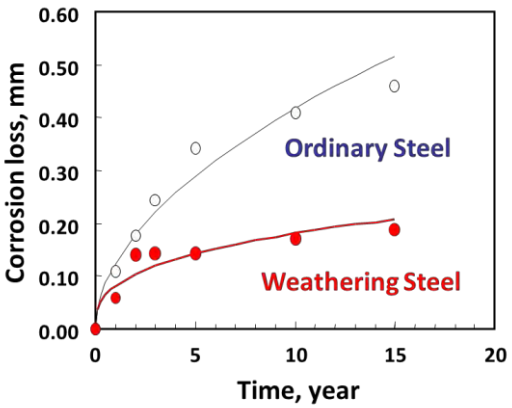
C	Si	Mn	Cu	Ni	Cr
0.12	0.40	0.90	0.35	0.20	0.50

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

Source: JICA Survey Team

Figure 8.2.2 Chemical Composition of Weathering Steel

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



The corrosion rate of weathering steel decreased gradually.

Weathering steel could be used without paint.

Source: JICA Survey Team

Figure 8.2.3 Corrosion Rate of Weathering Steel

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

8.3 Tests of Weathering Steel

8.3.1 Test Criteria for Weathering Steel

(1) Applied Test Criteria

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

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

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

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

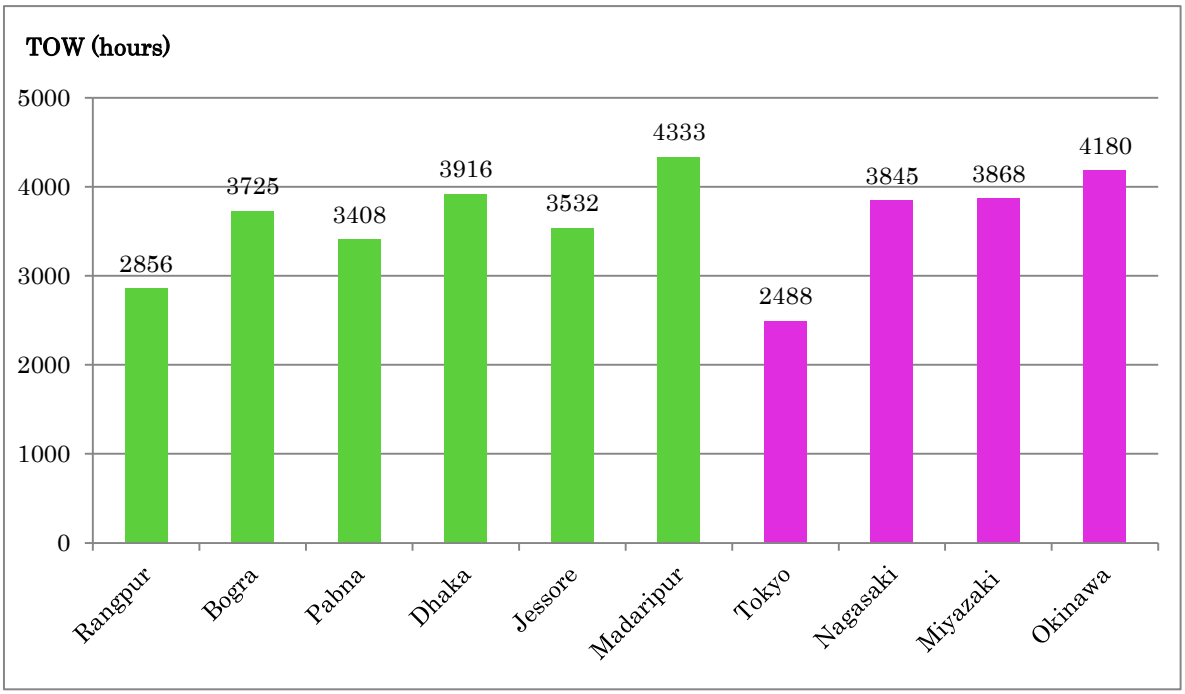
(2) Application of Japanese Criteria in Bangladesh

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

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

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

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



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

*TOW in Bangladesh is measured in this survey

Source: JICA Survey Team

Figure 8.3.1 TOW in Bangladesh and Japan

* Time of Wetness (TOW)

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

8.3.2 Test Locations

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

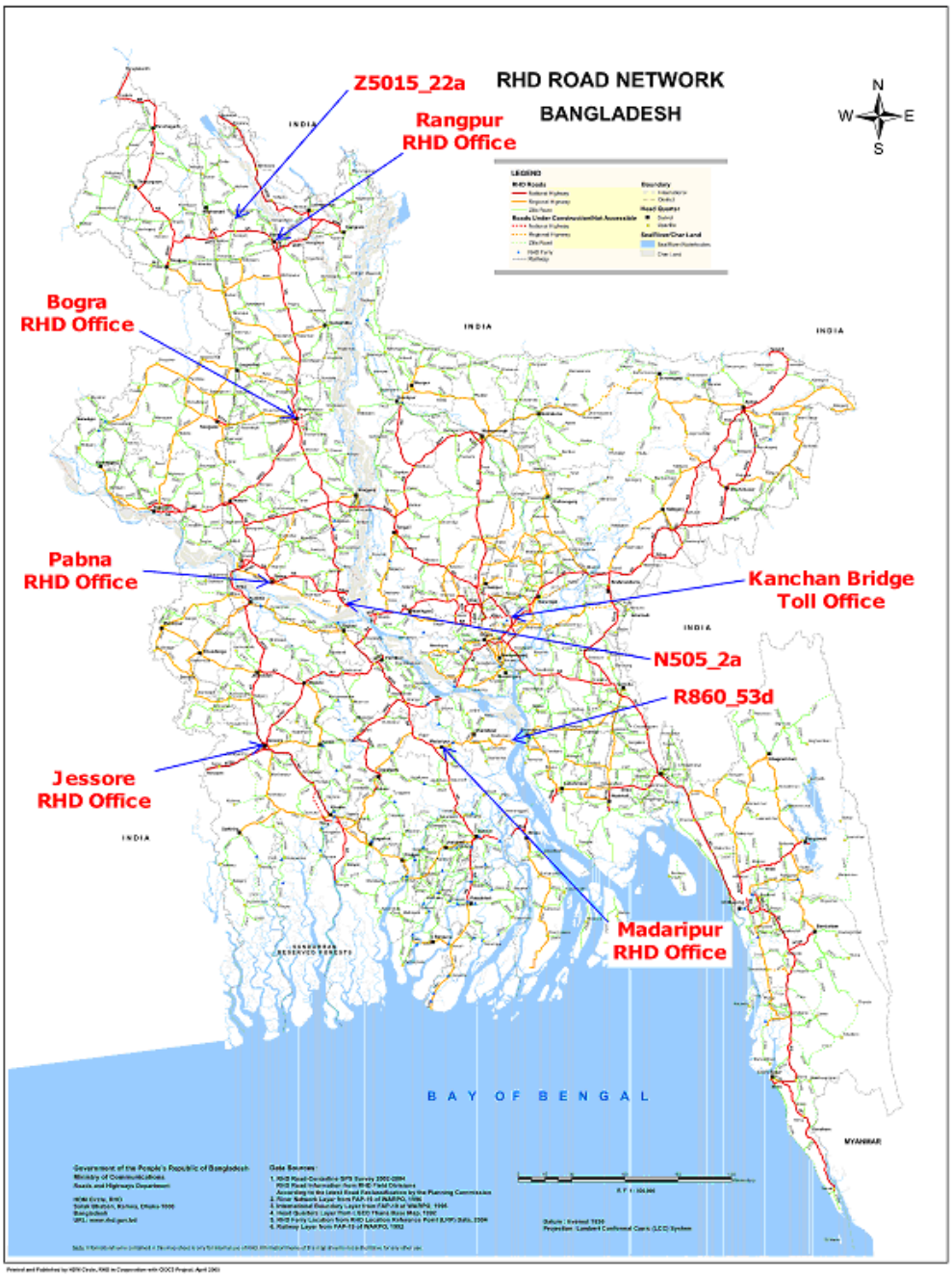
Exposure tests are carried out at the same locations as the airborne salt tests, as well as at existing bridges in order to understand the corrosion conditions at bridges.

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

Table 8.3.1 Locations for Exposure Tests and Airborne Salt Tests

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

Source: JICA Survey Team



Source: JICA Survey Team

Figure 8.3.2 Locations for Exposure Tests and Airborne Salt Tests

8.4 Test Method and Schedule

8.4.1 Airborne Salt Test

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

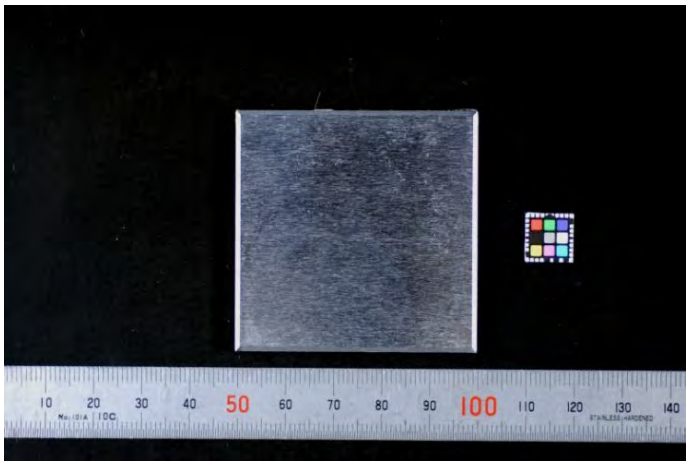
Source: JICA Survey Team

Figure 8.4.1 Gauze Frame for Airborne Salt Test

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

8.4.2 Exposure Test for Weathering Steel

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



Source: JICA Survey Team

Figure 8.4.2 Exposure Test Specimen

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

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

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

8.4.3 Installation of Test Specimens

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

Source: JICA Survey Team

Figure 8.4.3 Installation of Test Specimens on Office Rooftops

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

Figure 8.4.4 Installation of Exposure Test Specimens at Existing Bridges

8.5 Test Results

8.5.1 Airborne Salt Test Results

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

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

Table 8.5.1 Airborne Salt Test Results

Table. 8. 5. 1 Airborne Salt

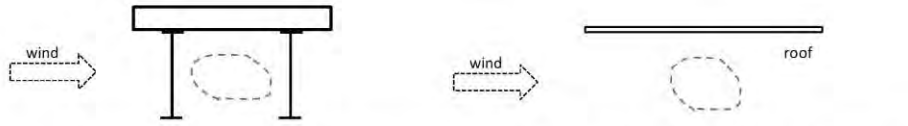
mdd=mg/deci-m2/day

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

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

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

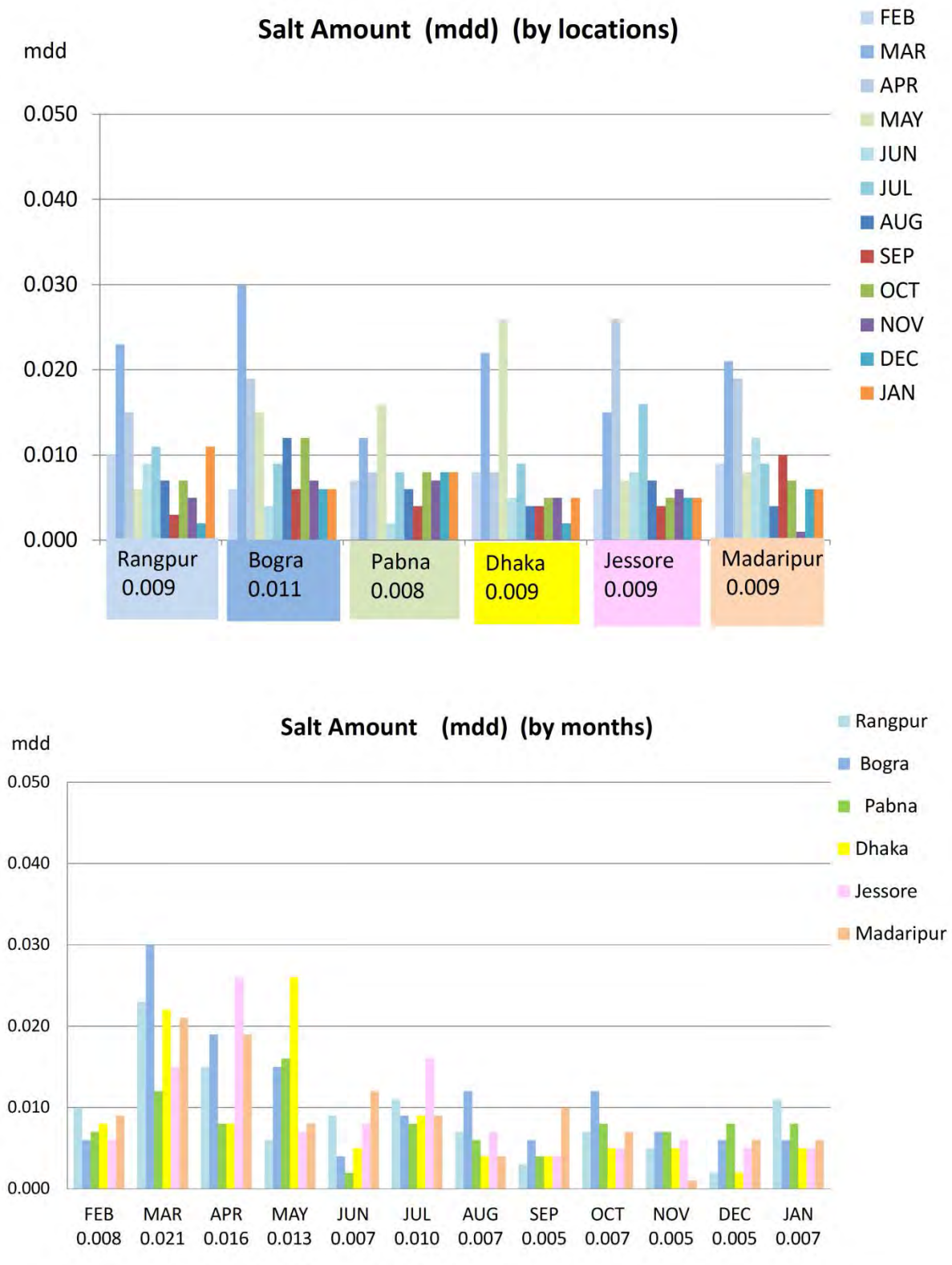
*** 3 months(2014Dec,2015Jan,2015Feb) Average was devoted to Dec. and Jan. equally.



[In Girders Value] is measured between bridge girders.

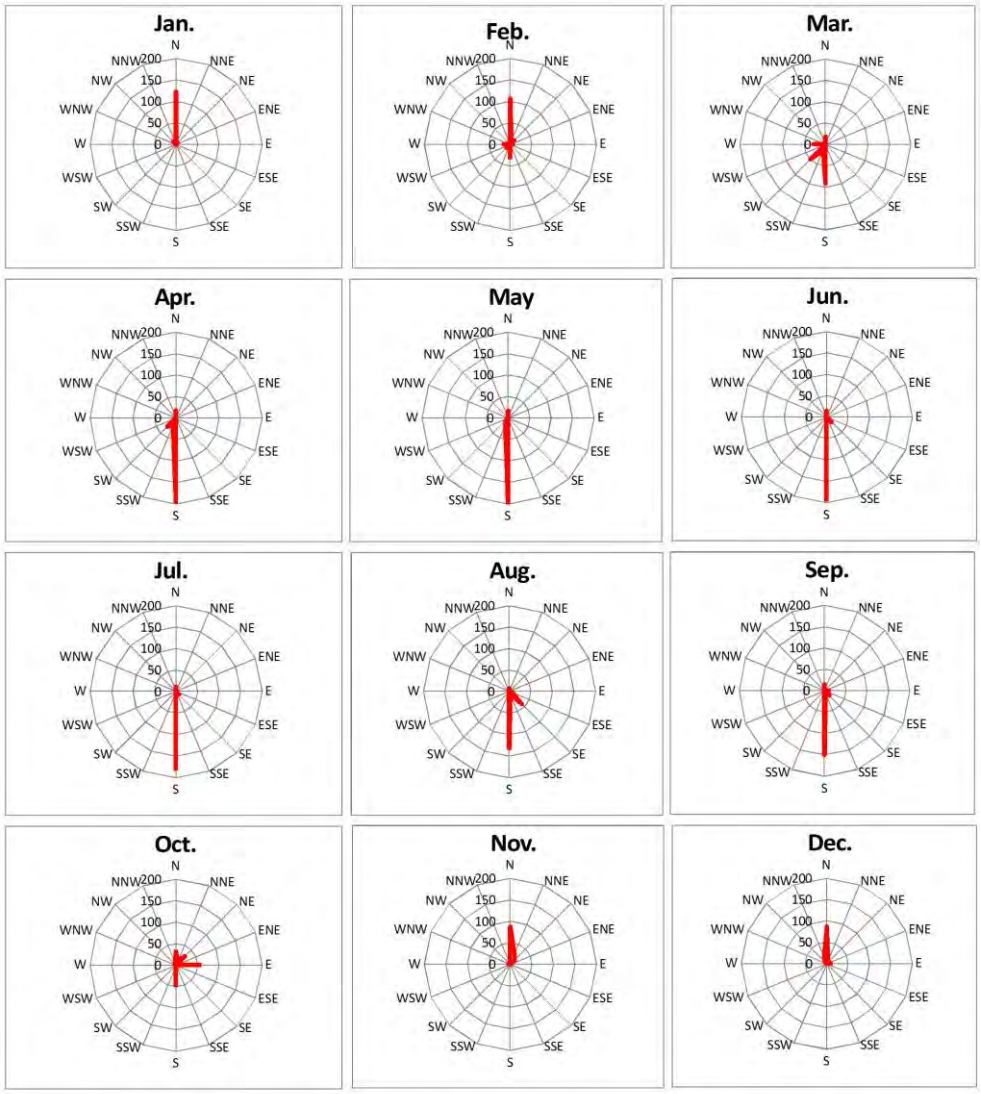
[Measurement Value] is measured in open environment

Source: JICA Survey Team



Source: JICA Survey Team

Figure 8.5.1 Airborne Salt Test Results



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

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

8.5.2 Exposure Test Results

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

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

Table 8.5.2 Exposure Test Results after 6 Months

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

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

Source: JICA Survey Team

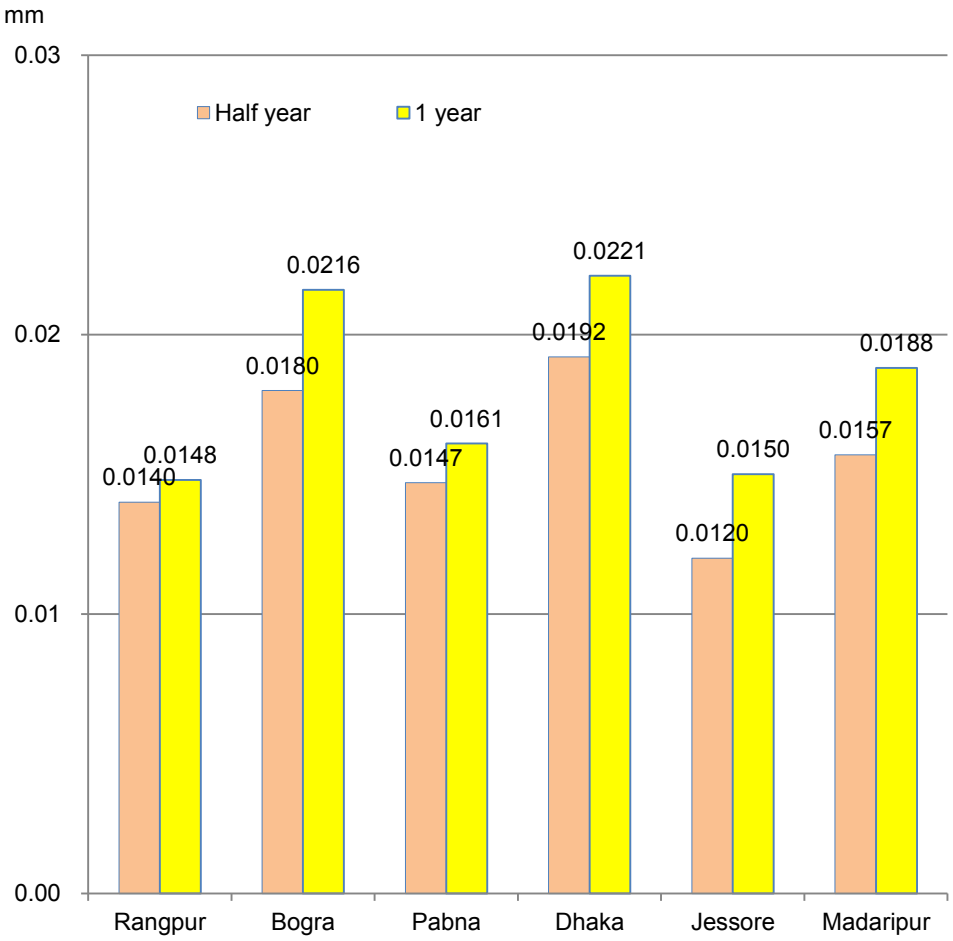
Table 8.5.3 Exposure Test Results after 1 Year

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

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

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

Source: JICA Survey Team



Source: JICA Survey Team

Figure 8.5.3 Exposure Test Results

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

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

Table 8.5.4 Exposure Test Results at Exiting Bridge

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

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

8.6 Evaluation and Conclusion

8.6.1 Evaluation

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

Table 8.6.1 Summary of Airborne Salt Test and Exposure Test Results

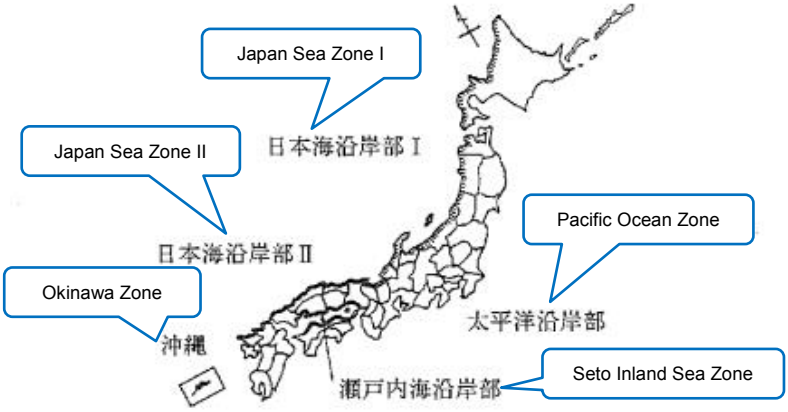
Evaluetion Item		Criteria	Annual Test Results					
			Rangpur	Bogra	Pabna	Dhaka	Jessore	Madaripur
Main Item	Airborne Salt Amount (mdd)	Less than 0.05mdd (annual average)	0.009	0.011	0.008	0.009	0.009	0.009
Sub Item	Corrosion Loss (Thickness Reduction) (mm)	Less than 0.03mm (annual)	0.0148	0.0216	0.0161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

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

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

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

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



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

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

Source: Specifications for Highway Bridges, Japan Road Association

Figure 8.6.1 Areas where Airborne Salt Test is not Required

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

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

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

Figure 8.6.2 First Weathering Steel Bridge in Japan

Figure 8.6.3 Weathering Steel Bridge in Japan

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

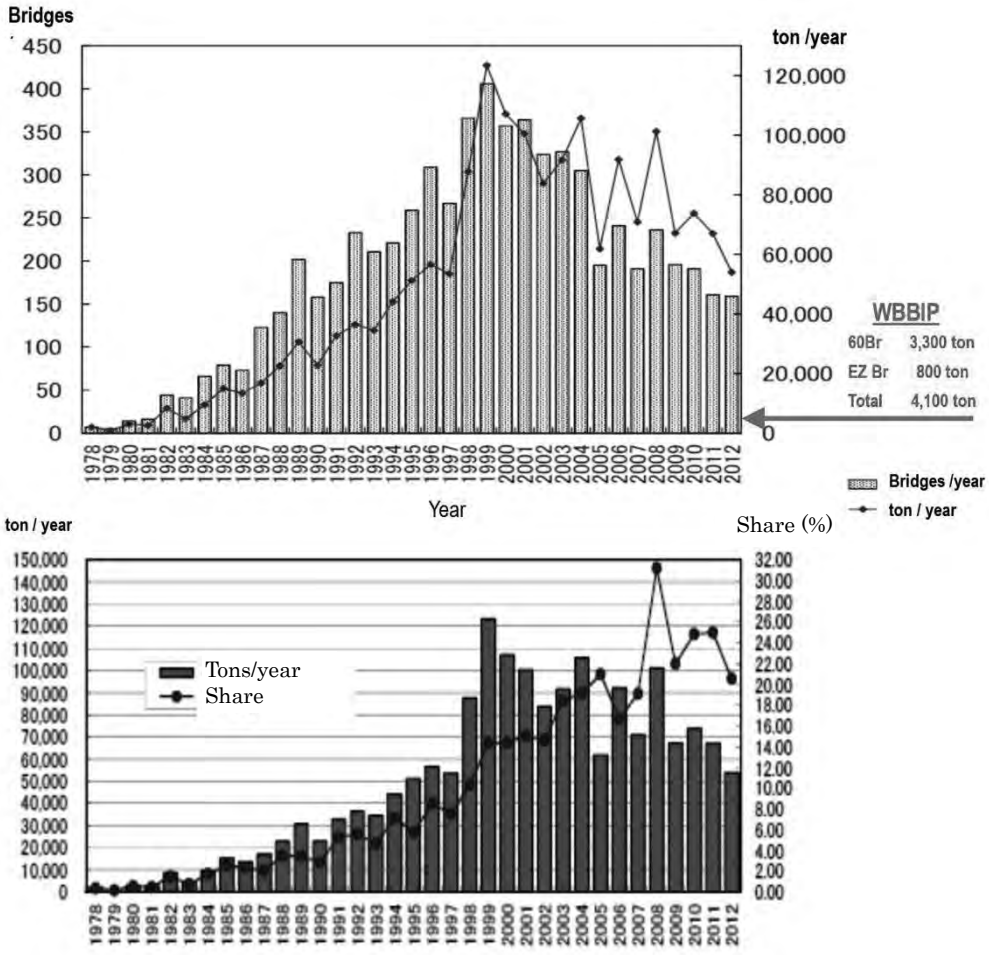


Figure 8.6.4 Share of Weathering Steel Bridge in Japan

8.6.2 Conclusion

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

9. CONSTRUCTION PLAN

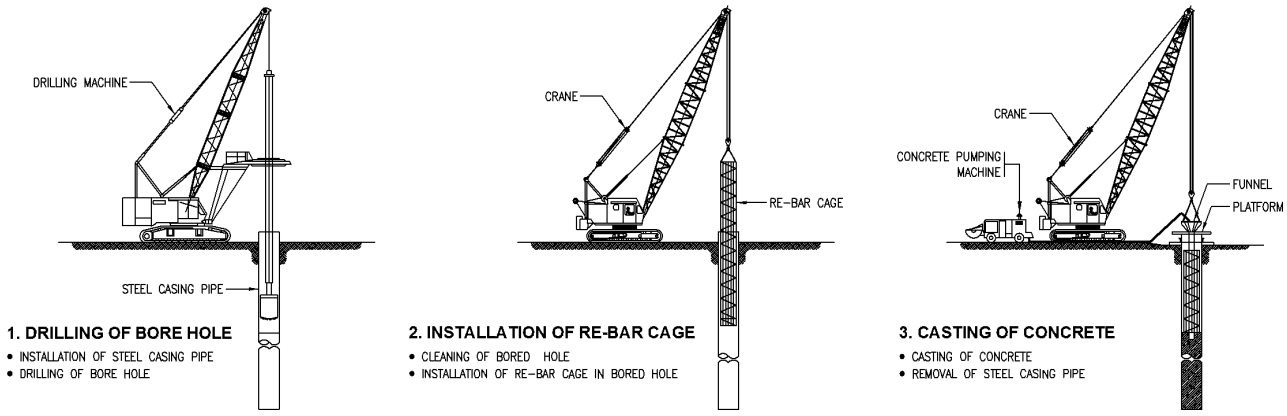
9.1 Introduction

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

9.2 Bored Pile

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

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



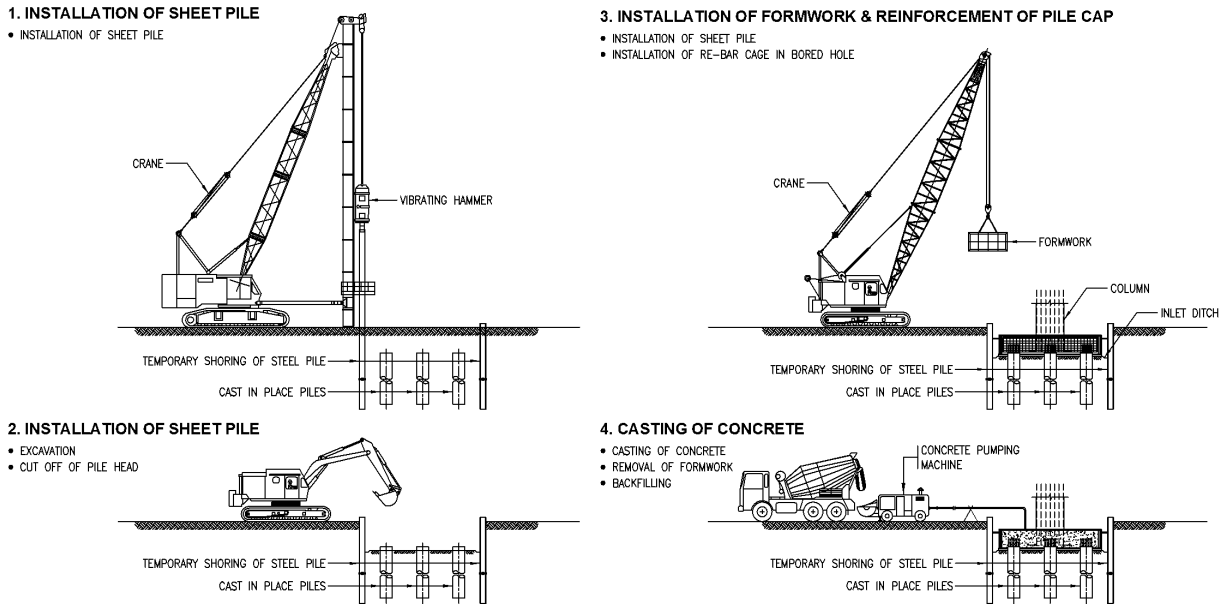
Source: JICA Survey Team

Figure 9.2.1 Construction Method for Bored Piles

9.3 Pile Cap

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

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



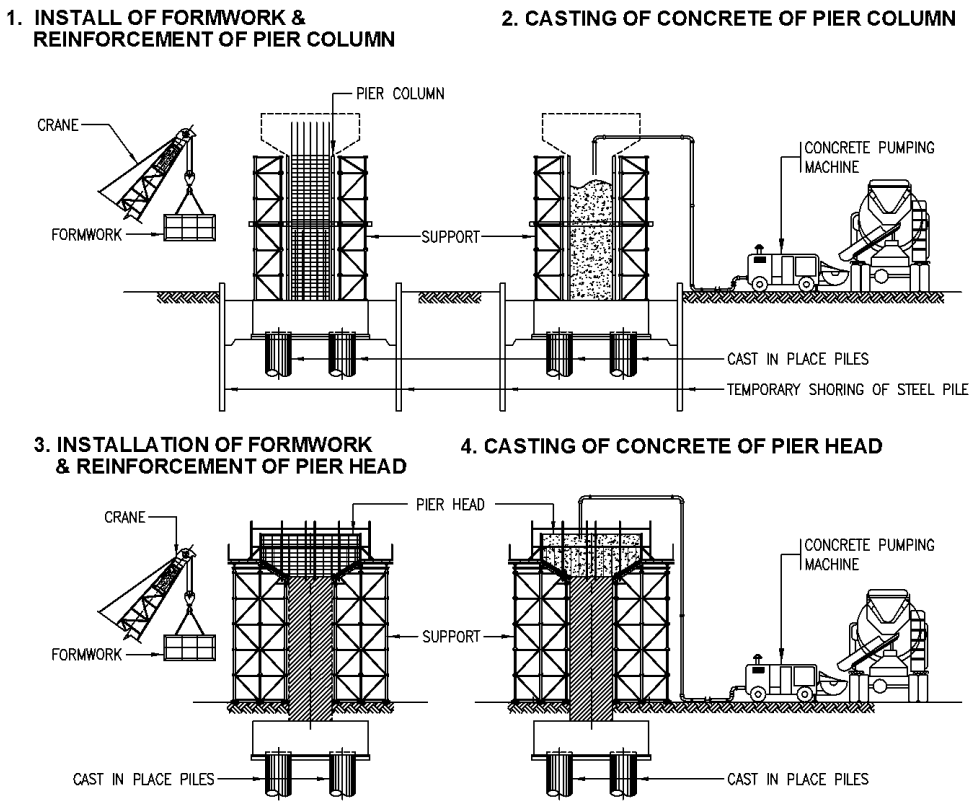
Source: JICA Survey Team

Figure 9.3.1 Construction Method for Pile Caps

9.4 Pier

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

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



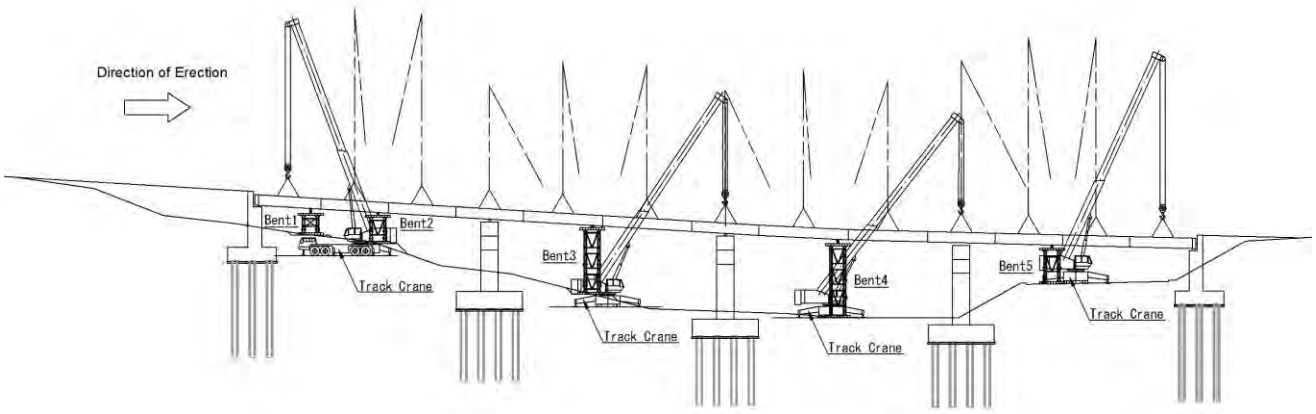
Source: JICA Survey Team

Figure 9.4.1 Construction Method for Piers

9.5 Superstructure (Steel-I Girder)

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

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

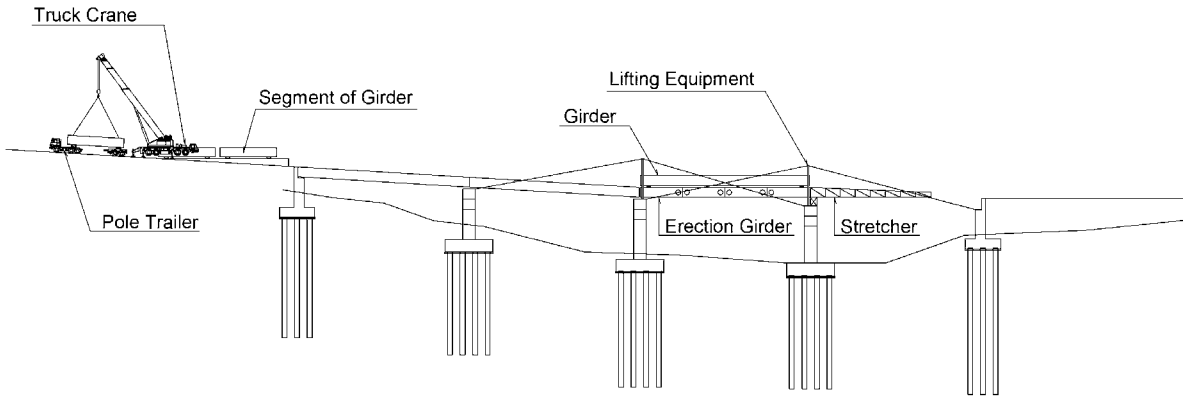


Source: JICA Survey Team

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

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

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



Source: JICA Survey Team

Figure 9.5.2 Construction of Superstructure using Erection Girder Method

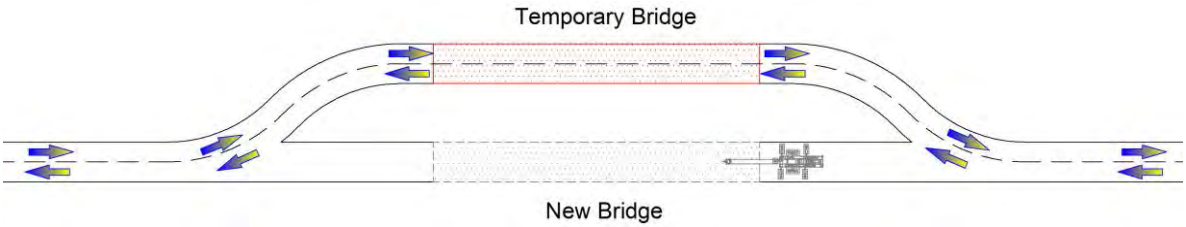
9.6 Superstructure (PC-I girder)

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

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

9.7 Traffic Control during Construction

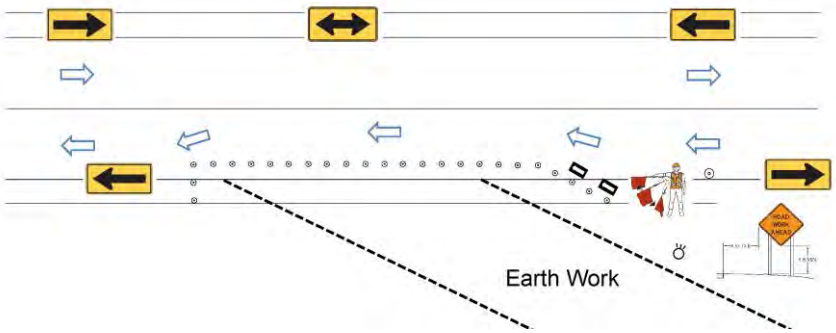
As previously mentioned, project bridges will be constructed in the same position as existing bridges, and thus, temporary bridges are necessary during construction.



Source: JICA Survey Team

Figure 9.7.1 Detour during Construction

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



Source: JICA Survey Team

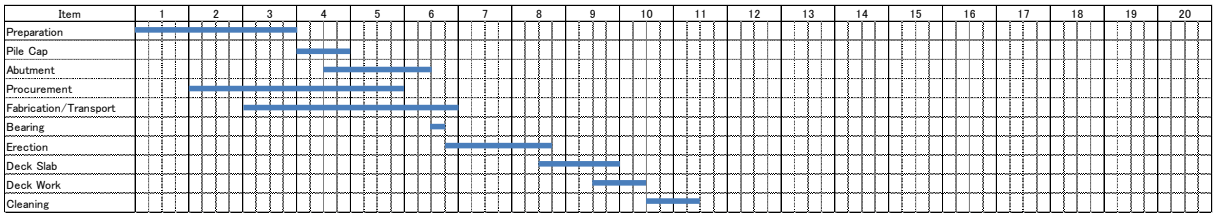
Figure 9.7.2 Traffic Control during Construction

9.8 Construction Schedule

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

9.8.1 Steel Bridge (Steel-I Girder)

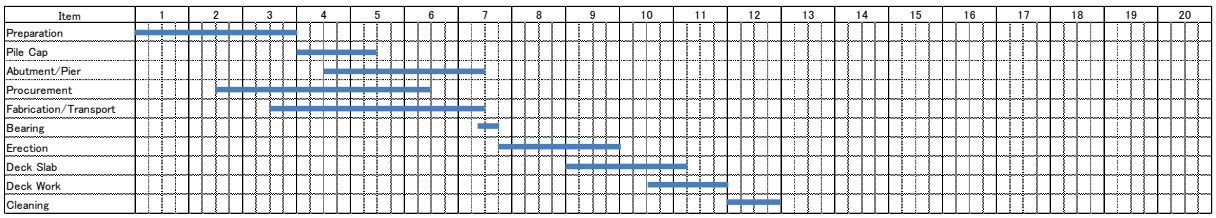
(1) Case-1: Steel-I Girder L=60m



Source: JICA Survey Team

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

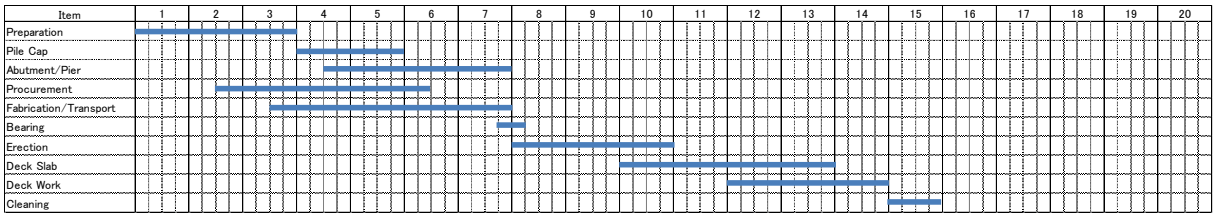
(2) Case-2: Steel-I Girder L=100m (60m + 40m)



Source: JICA Survey Team

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

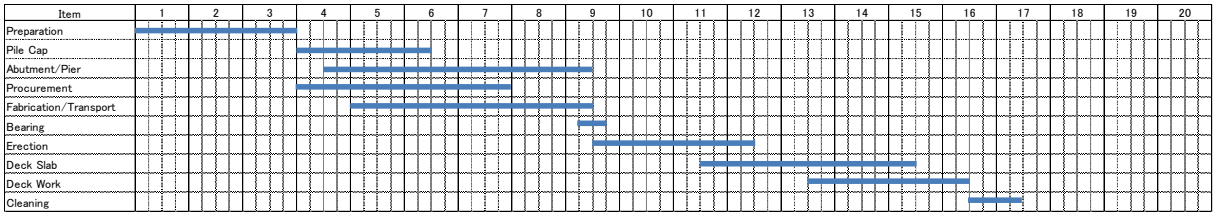
(3) Case-3: Steel-I Girder L=180m (60m x 3)



Source: JICA Survey Team

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

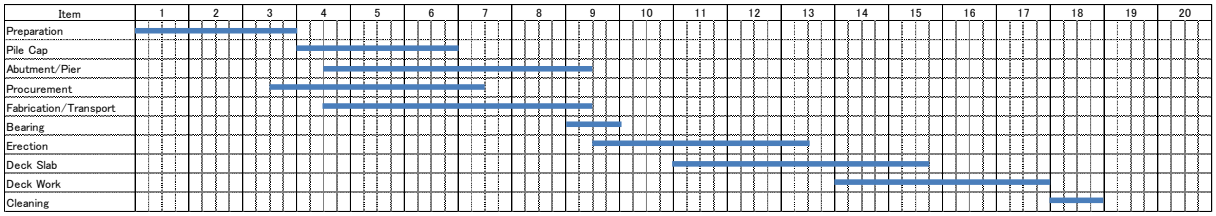
(4) Case-4: Steel-I Girder L=160m (40m x 4)



Source: JICA Survey Team

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

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

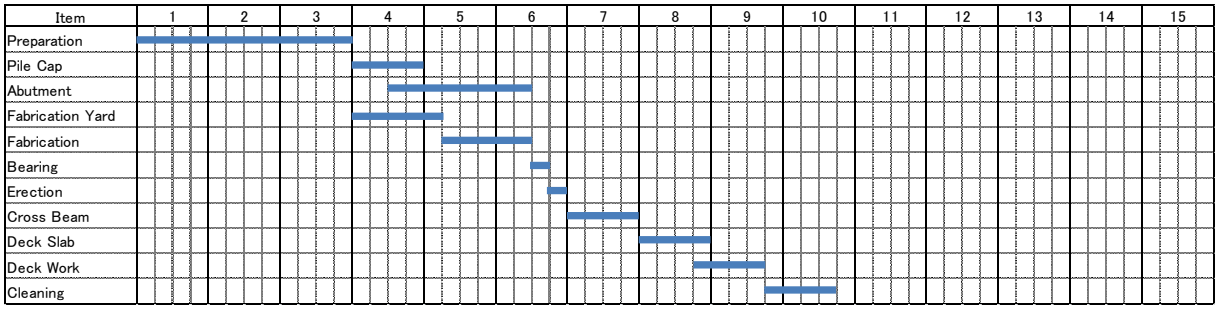


Source: JICA Survey Team

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

9.8.2 Concrete Bridge (PC-I Girder)

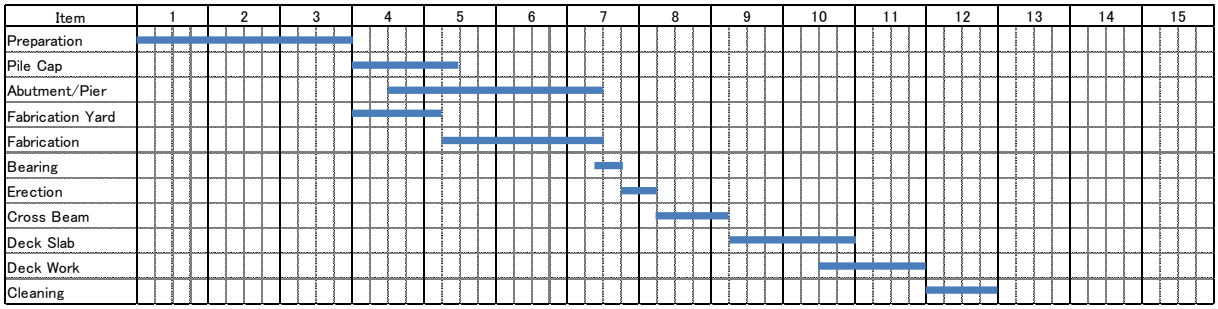
(1) Case-1: PC-I Girder L=40m



Source: JICA Survey Team

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

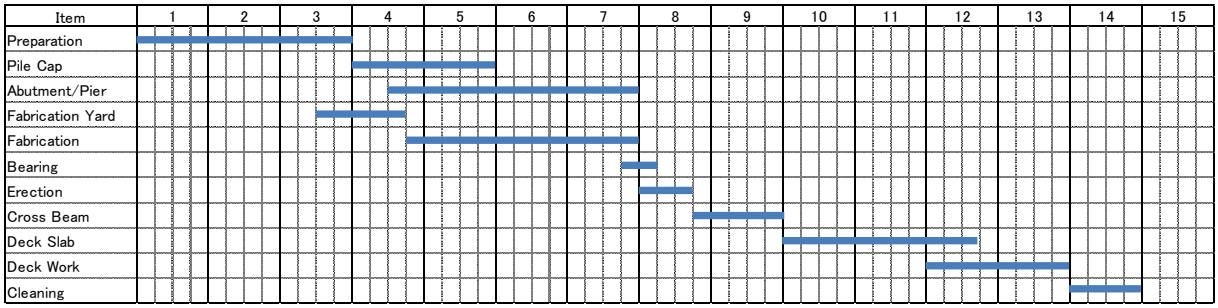
(2) Case-2: PC-I Girder L=80m (40m x 2)



Source: JICA Survey Team

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

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



Source: JICA Survey Team

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

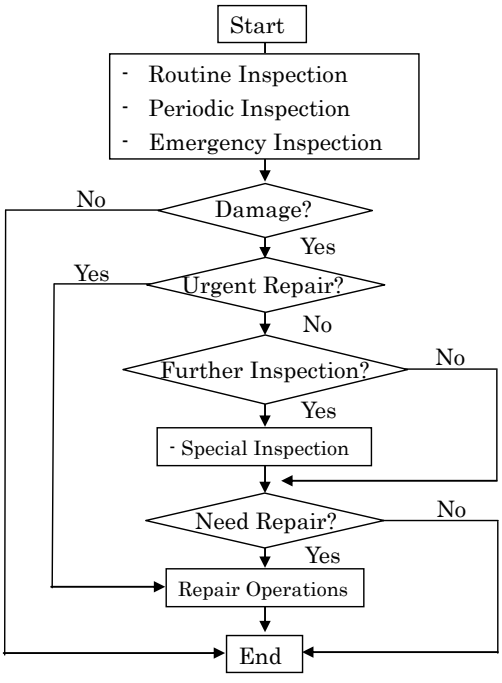
10. OPERATION AND MAINTENANCE PLAN

10.1 Operation and Maintenance Plan for the Project Bridges

10.1.1 General

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

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



Source :JICA Survey Team

Figure 10.1.1 Maintenance Procedure

10.1.2 Inspection

(1) Purpose of Inspection

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

(2) Type of Inspection

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

Table 10.1.1 Classification of Inspection Work

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

Source: JICA Survey Team

1) Routine inspection

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

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

2) Periodic inspection

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

3) Emergency inspections

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

10.1.3 Maintenance

(1) Maintenance Work

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

1) Routine maintenance

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

2) Periodic maintenance

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

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

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

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

3) Emergency maintenance

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

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

10.1.4 Special Maintenance for Weathering Steel Bridge

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

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

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

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

(2) Monitoring by equipment (every six years)

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

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

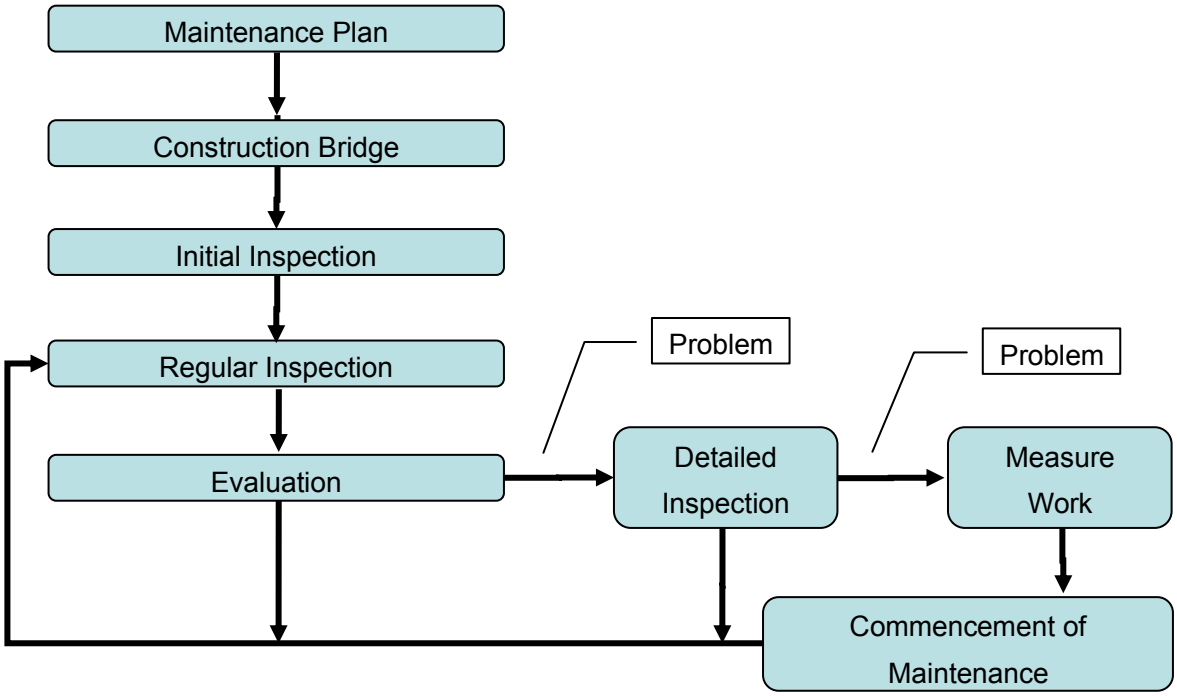


Figure 10.1.2 Weathering Steel Bridge Survey

10.2 Organization

10.2.1 Ministry of Road Transportation and Bridges

(1) Ministry of Road Transport and Bridges

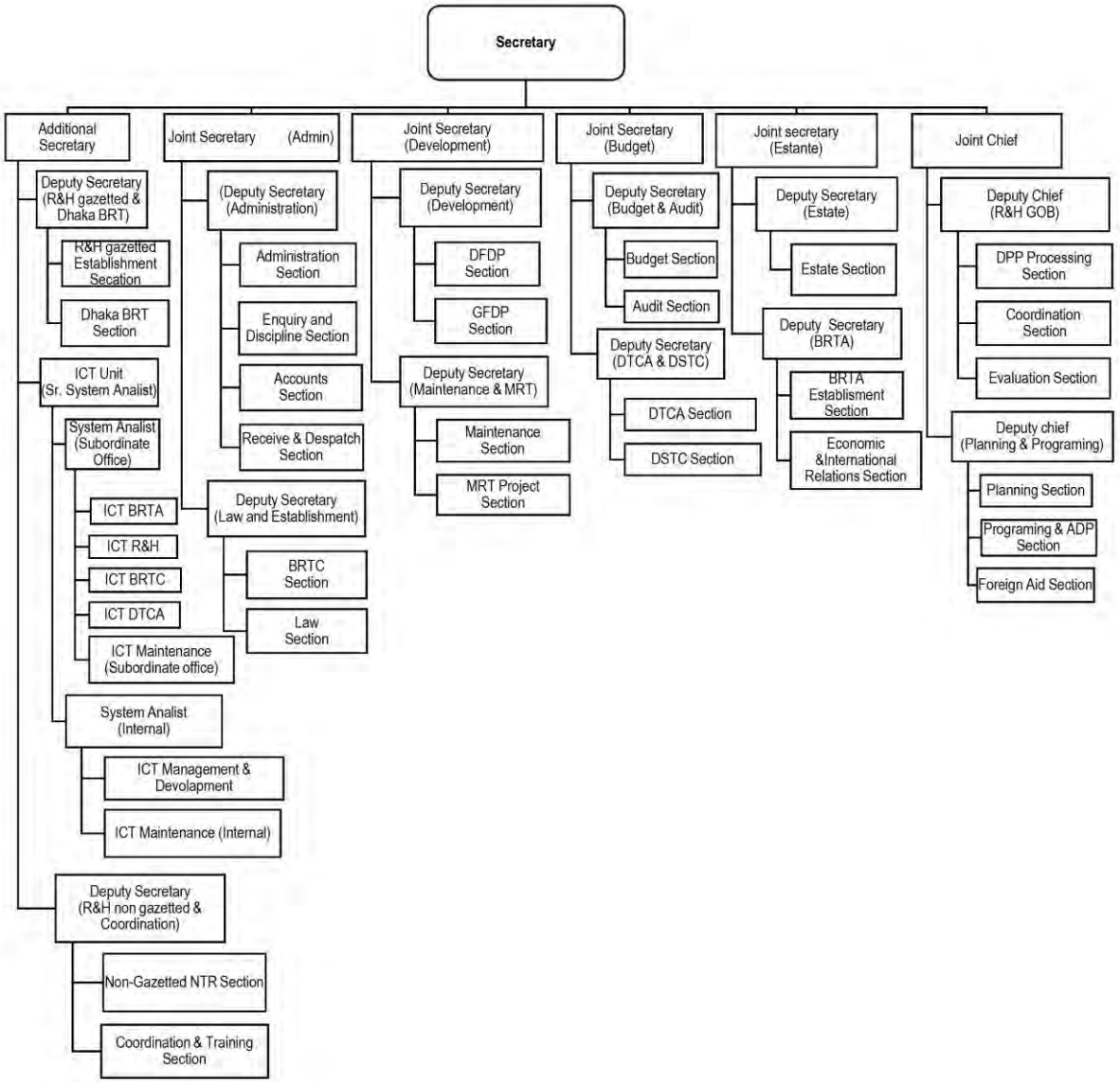
The Ministry of Road Transport and Bridges (MORTB) is comprised of two divisions, namely the Road Transport and Highways Division (RTHD) and the Bridges Division (BD). RTHD deals with major road networks in Bangladesh, whereas BD deals with all matters relating to bridges longer than 1500m. MORTB plays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

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

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

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

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



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

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

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

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

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

10.2.2 Roads and Highways Department (RHD)

(1) Introduction

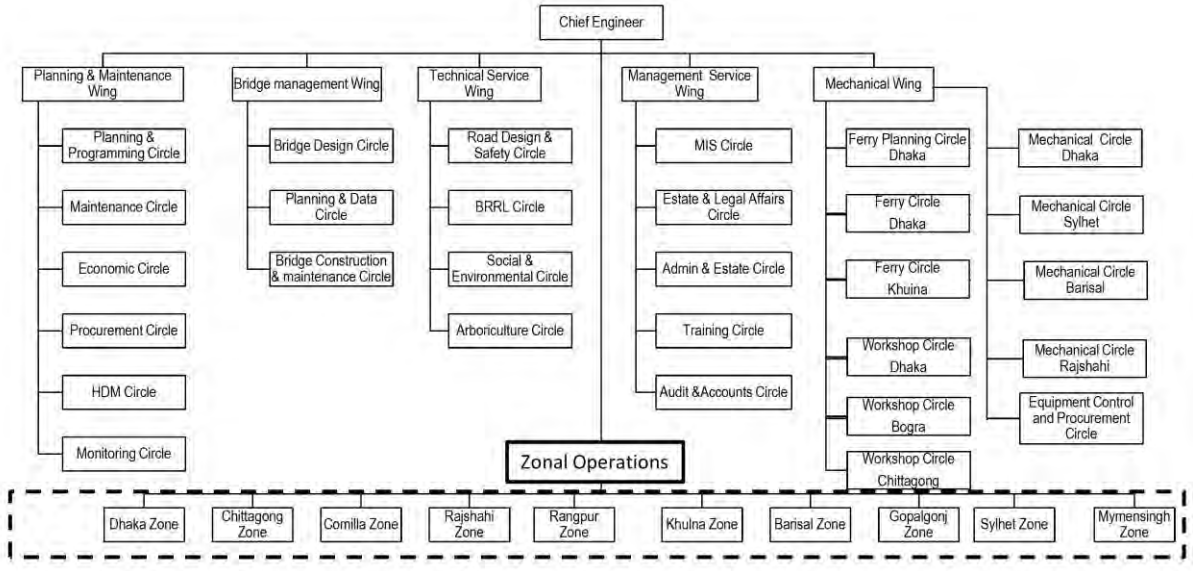
The Roads and Highways Department (RHD) was founded in 1962 under the former road division of MORTB. The department is responsible for the construction and maintenance of the major road network of Bangladesh.

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

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

(2) Organization Chart of RHD

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



Source: RHD Web site

Figure 10.2.2 Organization Chart of RHD

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

Table 10.2.2 Summary of Staff of RHD

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

Source: RHD (As of Oct 21, 2014)

10.2.3 Department Relevant to Bridge Management

(1) Bridge Management Wing

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

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

The main activities of the wing are as follows.

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

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

(2) Planning and Maintenance Wing

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

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

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

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

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

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

(3) Zonal Offices

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

The main activities of zonal offices are as follows.

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

10.3 Budgetary Situation of Road and Bridge Development and Maintenance

10.3.1 National Revenue and Expenditure

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

Table 10.3.1 Consolidated Receipts and Expenditures of the Government of Bangladesh

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

Source:Statistical YearBook of Bangladesh 2012 Unit:Million BDT

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

10.3.2 Development and Maintenance Allocation for RHD Roads and Bridges

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

Table 10.3.2 Development and Maintenance Allocation for RHD Roads and Bridges

Financial Year	Allocation (in Million Taka)		
	Development	Maintenance	Total
2001-02	22,828.4	3,310.0	26,138.4
2002-03	23,699.5	3,750.0	27,449.5
2003-04	24,876.8	5,766.0	30,642.8
2004-05	23,613.1	8,668.6	32,281.7
2005-06	19,898.7	8,615.5	28,514.2
2006-07	22,454.4	4,379.8	26,834.2
2007-08	18,522.9	6,273.7	24,796.6
2008-09	13,992.8	7,175.1	21,167.9
2009-10	23,082.1	6,100.0	29,182.1
2010-11	20,636.1	6,678.0	27,314.1
2011-12	24,309.0	7,049.0	31,358.0
2012-13	33,828.7	11,356.1	45,184.8
2013-14	34,476.1	12,396.4	46,872.5

Source: RHD

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

Table 10.3.3 Requested and Allocated Maintenance Budget

Financial year	Amount (in Million Taka)		Allocated Percentage (%)
	Requested	Allocated	
2007-08	41,140	6,374	15.2
2008-09	42,050	7,175	17.1
2009-10	40,040	6,100	15.2
2010-11	47,450	6,678	14.1
2011-12	51,000	7,049	13.8
2012-13	39,791	11,356	14.6
2013-14	77,729	12,396	15.9

Source: RHD

10.4 Current Issues faced in Bridge Operation and Maintenance

10.4.1 Lack of Budget

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

10.4.2 Inappropriate Operation and Maintenance Work

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

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

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

10.4.3 Ineffective Utilization of BMMS

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

However BMMS has not been utilized efficiently as yet.

10.4.4 Overloaded Vehicle

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

10.5 Recommendations for Operation and Maintenance

10.5.1 Stable Financing for Roads and Bridges Maintenance

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

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

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

10.5.2 Establishment of Efficient Maintenance Plan

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

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

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

10.5.3 Prohibition and Control of Overloaded Vehicles

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

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

10.6 Proposal of Future Japanese Support

10.6.1 Technical Cooperation Project Regarding Bridge Operation & Maintenance

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

Summary of the technical cooperation project is as follows.

(1) Objectives of the Project

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

(2) Project Outcomes

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

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

(3) Project Activities

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

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

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

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

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

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

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

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

selection for repair/improvement.

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

(4) Japanese Expert

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

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

(5) Project Period

- 30 months

10.6.2 Overseas Training on Weathering Steel

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

Table 10.6.1 Overseas Training Program on Weathering Steel (Draft)

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

Source: JICA Survey Team

10.7 Operation and Maintenance Cost

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

Table 10.7.1 Operation and Maintenance Costs (1)

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

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

Source: JICA Survey Team

Table 10.7.2 Operation and Maintenance Costs (2)

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

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

Source: JICA Survey Team

11. COST ESTIMATES

11.1 Introduction

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

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

11.2 General Condition of Cost Estimates

(1) Term of Cost Estimates

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

(2) Exchange rate

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

US$ 1 = Yen 119

US$ 1 = BDT 77.5

BDT 1 = Yen 1.54

(3) Eligible Portion by GOJ

1) Civil Work Cost

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

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

2) Consulting Services

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

3) Physical Contingency

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

4) Price Escalation Rate

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

5) Interest During Construction

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

(4) Non-eligible Portion Covered by GOB

1) Land Acquisitions and Resettlement Cost

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

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

2) Administration Cost

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

3) VAT (Value Added Tax)

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

4) Custom Duty

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

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

Table 11.2.1 Rate of Import Tax

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

5) Income Taxes (IT)

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

11.3 Civil Work Cost

11.3.1 Unit Rate of Major Pay Items

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

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

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

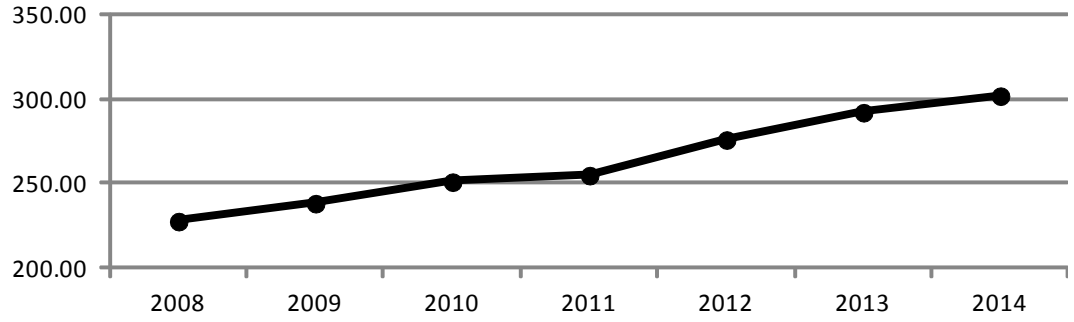
Table 11.3.1 Consumer Price Index (CPI)

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

1 CPI of "Transport & Communication of National" from statistic book Bangladesh

2 Base CPI of 1996 as 100

3 CPI of 2014 is derived from CPI of the past years



Source: JICA Survey Team

Table 11.3.2 Unit Rate of Major Pay Items for Civil Works

Unit: USD 1.0 = BDT 77.5

Item no.	Description	Unit	Total unit cost	Rate		
				Local	Foreign ratio	Foreign
			(BDT)	(BDT)		(USD)
1	Bituminous Wearing Course (62mm)	Sq.m.	1,107	657	41%	5.79
2	Concrete, Class A3-2 (Side walk, Railing)	cu.m.	14,532	7,716	47%	87.73
3	Concrete, Class A3-4 (footpath)	cu.m.	13,306	6,490	51%	87.73
4	Concrete, Class A2-2 (Deck slab)	cu.m.	18,873	12,144	36%	86.60
5	Concrete, Class A4 (precast formwork)	cu.m.	13,073	6,155	53%	89.03
6	High yield deformed reinforcing bars (fy=400MPa)	ton	105,509	60,140	43%	583.90
7	Concrete, Class A2-2 (Diaphragm, Cross beam)	cu.m.	18,873	12,144	36%	86.60
8	Concrete, Class A2-1 (RC girder)	cu.m.	18,928	12,199	36%	86.60
9	Concrete, Class A1 (PC girder)	cu.m.	25,063	18,509	26%	84.34
10	Pre-stressing strands for PC girder	ton	284,087	73,553	74%	2,709.58
11	Weathering steel (SMA 490W/400W) for Steel-I	ton	510,392	102,078	80%	5,255.00
12	Weathering steel (SMA 490W/400W) for Steel-box	ton	605,759	121,144	80%	6,237.00
13	Weathering steel (SMA400, etc.)	ton	459,401	91,880	80%	4,730.00
14	Weathering H.T.Bolt	ton	357,323	71,465	80%	3,679.00
15	Elastomeric bearing for RCG	each	49,515	4,760	90%	576.00
16	Elastomeric bearing for PCG	each	61,894	5,950	90%	720.00
17	Elastomeric bearing for STG	each	618,940	59,500	90%	7,200.00
18	Elastomeric bearing for STG for Steel-box	each	1,737,820	59,500	97%	21,600.00
19	Expansion joint	m	55,602	6,727	88%	629.02
20	Expansion joint fro Sttel-box	m	153,352	6,727	96%	1,887.06
21	Bridge draining	m	1,921	1,921	0%	0.00
22	Excavation and Backfill	cu.m.	414	214	48%	2.56
23	Sand backfill for structure	cu.m.	1,026	1,026	0%	0.00
24	Concrete, Class A2-2 (Abutment)	cu.m.	18,873	12,144	36%	86.60
25	Concrete, Class A2-1 (Pier head, column)	cu.m.	18,928	12,199	36%	86.60
26	Concrete, Class A2-2 (Pile cap)	cu.m.	20,589	13,248	36%	94.47
27	Drilling of pile (Dia 1.2m)	lm	4,195	2,212	47%	25.52
28	Bored pile A3-1 (Dia 1.2m)	cu.m.	13,973	7,954	43%	77.47
29	Loading test	ls	1,662,584	1,147,183	31%	6,633.22
30	Drilling of pile (Dia 1.5m)	lm	4,734	2,496	47%	28.80
31	Bored pile A3-1 (Dia 1.5m)	cu.m.	16,488	10,469	37%	77.47
32	Loading test (Dia 1.5m)	ls	1,662,584	1,147,183	31%	6,633.22
33	Embankment fill	cu.m./m	498	436	12%	0.80
34	Sub-base	cu.m./m	4,066	4,066	0%	0.00
35	Aggregate lower base 400mm	cu.m./m	4,541	4,541	0%	0.00
36	Aggregate upper base 350mm	cu.m./m	8,458	8,373	1%	1.09
37	Bituminous binder course 200mm	cu.m./m	16,101	12,720	21%	43.52
38	Bituminous wearing course 50mm	cu.m./m	17,852	13,746	23%	52.84

Source: JICA Survey Team

11.3.2 Cost Calculation for Standard Bridges (18 types)

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

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

Table 11.3.3 Standard Bridges to be Calculated

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

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

Source: JICA Survey Team

11.3.3 Unit Prices for Bridge Component

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

Table 11.3.4 Unit Prices for Bridge Component

Item	unit	unit price	PC-I	Steel-I	note
Super Structure	m2	Local (BDT)	22,767	40,391	related to the new bridge area (length * whole width)
		Foreign (USD)	295.4	1,790	
Abutment	nos	Local (BDT)	3,632,339	3,169,153	standard abutment height assumed as 5 m
		Foreign (USD)	29,126	25,642	
Pier	nos	Local (BDT)	3,889,847	2,762,307	by standard bridge design
		Foreign (USD)	32,066	22,909	
Pile	m	Local (BDT)	25,739	25,166	related to the pile length at each bridge location
		Foreign (USD)	246.8	241.1	
Approach Road	m3	Local (BDT)	1,945	1,945	standard abutment height assumed as 5 m
		Foreign (USD)	2.2	2.2	
Temporary Bridge and Demolish Bridge	m	Local (BDT)	440,000	440,000	related to the new bridge length
		Foreign (USD)	0	0	
Soft Soil Treatment	nos	Local (BDT)	given from Chapter 6		construction method and estimated cost by road design
		Foreign (USD)			
Over Head	%	Local (BDT)	15% of sum of above		practice of EBBIP
		Foreign (USD)	15% of sum of above		

Source: JICA Survey Team

11.3.4 Civil Work Cost of 105 Bridges

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

Table 11.3.5 Summary of Civil Work Costs by Bridge Component

	Cost (BTD)	Cost (US$)	Foreign Ratio	Total Cost (BDT equiv.)	Share
Superstructure	2,054,579,692	51,623,558	66.1%	6,055,405,468	32.9%
Abutment	747,042,866	5,998,047	38.4%	1,211,891,478	6.6%
Pier	329,677,424	2,721,170	39.0%	540,568,068	2.9%
Pile	1,773,658,157	17,004,796	42.6%	3,091,529,869	16.8%
Approach Road	2,841,720,952	3,214,286	8.1%	3,090,828,110	16.8%
Temporary and Demolish Bridge	1,361,480,000	0	0.0%	1,361,480,000	7.4%
Soft Soil Treatment	614,781,519	388,896	4.7%	644,920,966	3.5%
Overhead	1,458,441,092	12,142,613	39.2%	2,399,493,594	13.0%
Total	11,181,381,702	93,093,366	39.2%	18,396,117,553	100.0%

Source: JICA Survey Team

Table 11.3.6 Summary of Civil Works Cost by Bridge Type

	Number of Bridge	Average Bridge Length (m)	Cost (BTD)	Cost (US$)	Total Cost (BDT equivalent)
Steel-I Girder	17	114	2,703,213,368	45,852,628	6,256,792,065
PC-I Girder	88	57	8,478,168,334	47,240,737	12,139,325,488
All Bridges	105	66	11,181,381,702	93,093,366	18,396,117,553

Source: JICA Survey Team

Table 11.3.7 Civil Work Cost for 105 Bridges (1)

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	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
2	Rangpur	Sharnamoti 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
3	Rajshahi	Chanda Bridge	N	PC-I	10.4	2	35+25	60	624	29.5	24	5,518	2,840	14,206,608	184,330	7,264,678	58,253	3,889,847	32,066	15,890,075	152,363	16,256,310	18,388	0	0			8,626,128	66,810	66,133,645	512,209	37.5%	105,829,837	169,599
4	Rajshahi	Palgari Bridge	N	PC-I	10.4	2	35+25	60	624	33.4	27	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
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
6	Rangpur	Mohosthan Bridge	N	Steel-I	10.4	3	40+40+40	120	1,248	30.0	26	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
7	Rajshahi	Chanda Bridge	N	PC-I	10.4	2	35+25	60	624	26.7	21.4	3,411	4,422	14,206,608	184,330	7,264,678	58,253	3,889,847	32,066	14,296,522	137,083	15,235,185	17,233	0	0	17,437,911		10,849,613	64,345	83,180,364	493,309	31.5%	121,411,797	194,570
8	Rajshahi	Golihar 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
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
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
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
12	Barisal	Bakerganj Steel Bridge	N	PC-I	10.4	1	35	35	364	37.3	0.0	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
13	Gopalganj	Jhuldibazar Bridge	N	PC-I	10.4	1	30.0	30	312	38.0	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
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
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
16	Rajshahi	Nukali Bridge	N	Steel-I	10.4	1	50.0	50	520	33.8	0.0	14,352	12,053	21,003,320	930,904	6,338,306	51,283	0	0	13,615,813	130,445	51,357,896	58,091	0	0			13,847,300	175,609	106,162,635	1,346,332	49.6%	210,503,352	404,814
17	Rajshahi	Dattapara Bridge	N	PC-I	10.4	1	40.0	40	416	22.6	0.0	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
18	Rajshahi	Horisonkorpur Bridge	R	PC-I	10.4	2	25+25	50	520	20.6	17	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
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
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
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
22	Khulna	Gora bridge	N	PC-I	10.4	1	30.0	30	312	49.2	0.0	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
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
24	Rangpur	-	N	PC-I	10.4	1	30	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
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
26	Gopalganj	Amgram bridge	N	PC-I	10.4	1	40	40	416	34.8	0.0	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
27	Rajshahi	Kazir Hat Bridge	N	Steel-I	10.4	4	40+40+40+40	160	1,664	26.3	20.5	6,224	8,197	67,210,624	2,978,893	6,338,306	51,283	8,286,921	68,727	19,861,460	190,280	28,049,024	31,726	0	0			19,461,950	498,137	149,208,285	3,819,047	66.5%	445,184,421	267,539
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
29	Gopalganj	Kanaipur Bridge	N	PC-I	10.4	1	40	40	416	35.2	0	4,301	1,860	9,471,072	122,886	7,264,678	58,253	0	0	14,515,149	139,179	11,982,173	13,553	0	0	50,432,399		14,049,821	50,081	107,715,291	383,952	21.6%	137,471,589	330,461
30	Gopalganj	Brahmonkanda Bridge	N	PC-I	10.4	1	30.0	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
31	Rangpur	Gaudangi Bridge	N	PC-I	10.4	2	40+25	65	676	24.7	24	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
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
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
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
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
36	Rangpur	Ghoga Bridge	N	PC-I	10.4	2	35+25	60	624	19.9	17.2	8,650	9,961	14,206,608	184,330	7,264,678	58,253	3,889,847	32,066	10,863,557	104,166	36,196,975	40,943	0	0	8,114,433	56,233	12,080,415	71,399	92,616,512	547,389	31.4%	135,039,126	216,409
37	Rajshahi	Vitapara Bridge	N	Steel-I	10.4	2	60+40	100	1,040	31.1	24	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
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
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
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	Khulna	Dhopa Ghata Bridge	N	PC-I	10.4	5	25+30+40+30+25	150	1,560	29.9	26	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
42	Barisal	Dawrey Bridge	R	PC-I	10.4	2	30+35	65	676	43.6	41.0	5,720	4,128	15,390,492	199,690	7,264,678	58,253	3,889,847	32,066	24,287,320	232,880	19,154,360	21,666	26,260,000	0			14,437,005	81,683	110,683,702	626,239	30.5%	159,217,200	235,528
43	Khulna	Barda Bridge	N	PC-I	10.4	3	40+40+25	105	1,092	29.9	23	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
44	Khulna	Balipara Bridge	N	PC-I	10.4	1	40	40	416	25.1	0.0	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
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
46	Rangpur	Ichamoti Bridge	N	PC-I	10.4	2	40+25	65	676	36.3	33.9	5,038	2,944	15,390,492	199,690	7,264,678	58,253	3,889,847	32,066	20,201,100	193,699	15,525,379	17,561	0	0			9,340,724	75,190	71,612,220	576,460	38.4%	116,287,877	172,023
47	Rangpur	Chikli Bridge	N	PC-I	10.4	2	35+25	60	624	26.2	22	2,426	1,645	14,206,608	184,330	7,264,678	58,253	3,889,847	32,066	14,209,678	136,250	7,917,512	8,956	0	0			7,123,248	62,978	54,611,571	482,833	40.7%	92,031,097	147,486
48	Rangpur	Kakra Bridge	Z	Steel-I	9.8	3	60+60+50	170	1,666	23.4	17	6,204	7,949	67,291,406	2,982,473	6,338,306	51,283	5,524,614	45,818	14,556,014	139,452	27,527,585	31,137	68,680,000	0			28,487,689	487,525	218,405,614	3,737,688	57.0%	508,076,449	304,968
49	Rangpur	Gabura Bridge.	Z	PC-I	9.8	3	30+30+30	90	882	21.5	17	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
50	Rangpur	Mathpara Bridge	Z	Steel-I	9.8	2	40+40	80	784	22.8	15	4,515	6,475	31,666,544	1,403,517	6,338,306	51,283	2,762,307	22,909	11,452,543	109,720	21,375,550	24,178	32,320,000	0			15,887,288	241,741	121,802,538	1,853,348	54.1%	265,437,020	338,568
51	Rangpur	Bombgara Bridge	Z	PC-I	9.8	2	30+30	60	588	24.0	19.4	5,173	4,265	13,386,996	173,695	7,264,678	58,253	3,889,847	32,066	12,863,168	123,339	18,356,910	20,764	24,240,000	0			12,000,240	61,218	92,001,839	469,335	28.3%	128,375,266	218,325
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
53	Rangpur	Raktodaho Bridge	Z	PC-I	9.8	3	25+25+25	75	735	16.1	15	9,882	8,233	16,733,745	217,119	7,264,678	58,253	7,779,694	64,133	11,201,613	107,407	35,233,675	39,853	30,300,000	0			16,277,011	73,015	124,790,416	559,779	25.8%	168,173,307	228,807

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

Source: JICA Survey Team

Table 11.3.8 Civil Work Cost for 105 Bridges (2)

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)
54	Rajshahi	ura Mukto Monch Brid	N	PC-I	10.4	2	25+25	50	520	16.3	14	3,755	3,439	11,838,840	153,608	7,264,678	58,253	3,889,847	32,066	8,828,477	84,652	13,992,330	15,827	0	0	14,400,572		9,032,212	51,661	69,246,955	396,067	30.7%	99,942,149	192,196
55	Rangpur	Barodia Khali Bridge	Z	Steel-I	9.8	1	60	60	588	23	0	12,763	12,740	23,749,908	1,052,638	6,338,306	51,283	0	0	9,422,150	90,268	49,603,335	56,107	24,240,000	0			17,003,055	187,544	130,356,754	1,437,840	0	241,789,335	411,206
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
57	Barisal	gounagata bridge	N	PC-I	10.4	1	35.0	35	364	58.4	0.0	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
58	Barisal	Gabtala Steel Bridge	Z	PC-I	9.8	1	30.0	30	294	55.9	0.0	3,167	2,841	6,693,498	86,848	7,264,678	58,253	0	0	23,020,962	220,738	11,685,560	13,218	12,120,000	0			9,117,705	56,858	69,902,402	435,914	32.6%	103,685,743	352,673
59	Rangpur	Bahagili Bridge	Z	Steel-I	9.8	4	50+50+50+50	200	1,960	20.9	19	5,082	6,090	79,166,360	3,508,792	6,338,306	51,283	8,286,921	68,727	16,807,868	161,026	21,729,540	24,578	80,800,000	0			31,969,349	572,161	245,098,344	4,386,568	58.1%	585,057,365	298,499
60	Rangpur	Anandababur Pool	Z	PC-I	9.8	1	35.0	35	343	24.1	0	2,157	1,534	7,809,081	101,322	7,264,678	58,253	0	0	9,924,958	95,166	7,178,995	8,120	14,140,000	0			6,947,657	39,429	53,265,369	302,290	30.5%	76,692,863	223,594
61	Rangpur	Duhuli Bridge	Z	PC-I	9.8	1	25+25	50	490	19.0	0	3,117	751	11,155,830	144,746	7,264,678	58,253	0	0	7,841,129	75,185	7,523,260	8,510	20,200,000	0			8,097,735	43,004	62,082,632	329,697	29.2%	87,634,177	178,845
62	Rangpur	ongle bari kuthibari Brid	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
63	Khulna	Shakdaha bridge	R	PC-I	10.4	1	25+25	50	520	64.1	0	8,304	8,176	11,838,840	153,608	7,264,678	58,253	0	0	26,397,918	253,118	32,053,600	36,256	20,200,000	0			14,663,255	75,185	112,418,292	576,420	28.4%	157,090,833	302,098
64	Barisal	Souderkhal bridge	N	PC-I	10.4	1	35	35	364	41.2	0.0	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
65	Barisal	Bottala Bridge	Z	PC-I	9.8	1	35	35	343	33.9	0.0	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
66	Rangpur	Katakhali Bridge	N	Steel-I	10.4	3	60+60+50	170	1,768	26.5	20	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
67	Khulna	Bttipara Bridge	N	PC-I	10.4	1	35.0	35	364	19.4	0.0	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
68	Khulna	Bhangura Bridge	R	PC-I	20.8	1	35	35	728	43.7	0	11,933	9,323	16,574,376	215,051	7,264,678	58,253	0	0	17,996,709	172,563	41,342,920	46,763	14,140,000	0	14,020,308	97,161	16,700,849	88,469	128,039,839	678,259	29.1%	180,604,908	248,084
69	Barisal	Asokoti bridge	N	PC-I	10.4	1	30.0	30	312	39.8	0.0	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
70	Barisal	Banglabazar Bridge	R	PC-I	10.4	1	25+25	50	520	51.5	0	1,571	1,817	11,838,840	153,608	7,264,678	58,253	0	0	21,208,936	203,363	6,589,660	7,454	20,200,000	0			10,065,317	63,402	77,167,431	486,079	32.8%	114,838,554	220,843
71	Barisal	Box-a-ali Bridge	R	PC-I	10.4	1	30	30	312	45.4	0.0	4,795	4,217	7,103,304	92,165	7,264,678	58,253	0	0	18,698,457	179,291	17,528,943	19,827	12,120,000	0			9,407,307	52,430	72,122,689	401,966	30.2%	103,275,067	331,010
72	Barisal	Borhanuddin Bridge	R	PC-I	10.4	1	40.0	40	416	45.7	0	5,028	5,305	9,471,072	122,886	7,264,678	58,253	0	0	18,802,648	180,290	20,097,977	22,733	16,160,000	0			10,769,456	57,624	82,565,831	441,787	29.3%	116,804,296	280,780
73	Rajshahi	Mohis Mari Bridge	R	PC-I	10.4	1	25+25	50	520	18.1	0	7,506	8,287	11,838,840	153,608	7,264,678	58,253	0	0	7,445,778	71,394	30,717,385	34,745	20,200,000	0			11,620,002	47,700	89,086,683	365,699	24.1%	117,428,389	225,824
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
75	Rajshahi	Chondi Das Bridge	R	Steel-I	10.4	2	40+40	80	832	41.9	34.2	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
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
77	Gopalganj	Paprail Bailey Bridge	R	PC-I	10.4	1	40	40	416	24.0	0	7,041	5,467	9,471,072	122,886	7,264,678	58,253	0	0	9,883,776	94,771	24,328,060	27,518	16,160,000	0			10,066,138	45,514	77,173,724	348,942	25.9%	104,216,727	250,521
78	Barisal	Afalbarir Khal Bridge	Z	PC-I	9.8	1	40.0	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
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
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
81	Barisal	Boda Bridge	Z	PC-I	9.8	2	30+30	60	588	34.8	26	3,657	3,921	13,386,996	173,695	7,264,678	58,253	3,889,847	32,066	18,407,503	176,501	14,739,074	16,671	24,240,000	0			12,289,215	68,578	94,217,313	525,765	30.2%	134,964,107	229,531
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
83	Gopalganj	Jajihar Bridge	R	PC-I	10.4	2	25+25	50	520	31.6	27.0	5,172	4,949	11,838,840	153,608	7,264,678	58,253	3,889,847	32,066	17,173,576	164,670	19,684,470	22,265	20,200,000	0			12,007,712	64,629	92,059,122	495,491	29.4%	130,459,698	250,884
84	Gopalganj	Gazipur Bridge	R	PC-I	10.4	4	30+35+35+30	130	1,352	50.7	42	21,989	21,301	30,780,984	399,381	7,264,678	58,253	11,669,541	96,199	40,188,257	385,348	84,199,050	95,238	52,520,000	0			33,993,376	155,163	260,615,886	1,189,581	26.1%	352,808,381	260,953
85	Gopalganj	Balar Bazar Bridge	R	PC-I	10.4	3	30+40+30	100	1,040	38.9	35	5,342	3,388	23,677,680	307,216	7,264,678	58,253	7,779,694	64,133	26,700,249	256,017	16,979,792	19,206	40,400,000	0			18,420,314	105,724	141,222,406	810,548	30.8%	204,039,856	196,192
86	Gopalganj	Kumar Bridge	N	PC-I	10.4	3	40+40+40	120	1,248	43.9	33.9	25,352	32,373	28,413,216	368,659	7,264,678	58,253	7,779,694	64,133	28,549,699	273,751	112,275,125	126,995	0	0	16,483,661	114,232	30,114,911	150,903	230,880,984	1,156,925	28.0%	320,542,681	256,845
87	Rajshahi	Fallarbil Bridge	Z	PC-I	9.8	1	35	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
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
89	Rangpur	Shampur Bridge.	Z	PC-I	9.8	1	35.0	35	343	21.8	0.0	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
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
91	Rangpur	Khottapara Bridge	Z	PC-I	9.8	1	40.0	40	392	24.8	0.0	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
92	Barisal	Banogram Bridge	Z	PC-I	9.8	2	30+30	60	588	64.5	57.6	6,317	6,050	13,386,996	173,695	7,264,678	58,253	3,889,847	32,066	35,458,046	339,992	24,053,815	27,207	24,240,000	0			16,244,007	94,682	124,537,390	725,895	31.1%	180,794,264	307,473
93	Rangpur	Bhela Bridge	R	PC-I	10.4	1	40	40	416	19.1	0	504	646	9,471,072	122,886	7,264,678	58,253	0	0	7,865,838	75,422	2,236,750	2,530	16,160,000	0			6,449,751	38,864	49,448,089	297,955	31.8%	72,539,582	174,374
94	Barisal	Kalijira bridge	Z	PC-I	9.8	3	40+35+40	115	1,127	50.8	45	11,463	9,344	25,658,409	332,916	7,264,678	58,253	7,779,694	64,133	34,943,266	335,056	40,469,615	45,775	46,460,000	0			24,386,349	125,420	186,962,012	961,552	28.5%	261,482,283	232,016
95	Barisal	Masrong bridge	Z	PC-I	9.8	1	40.0	40	392	62.8	0.0	3,787	2,856	8,924,664	115,797	7,264,678	58,253	0	0	25,862,547	247,985	12,920,635	14,615	16,160,000	0			10,669,879	65,497	81,802,403	502,146	32.2%	120,718,713	307,956
96	Barisal	Padarhat bridge	Z	PC-I	9.8	2	25+25	50	490	34.3	32.7	1,304	2,139	11,155,830	144,746	7,264,678	58,253	3,889,847	32,066	19,186,057	183,967	6,695,915	7,574	20,200,000	0			10,258,849	63,991	78,651,176	490,596	32.6%	116,672,380	238,107
97	Barisal	alukdarhat Bailey Brid	Z	PC-I	9.8	1	40.0	40	392	36.7	0	4,658	3,387	8,924,664	115,797	7,264,678	58,253	0	0	15,112,294	144,905	15,648,906	17,701	16,160,000	0			9,466,581	50,498	72,577,123	387,153	29.2%	102,581,511	261,688
98	Khulna	Gollamari bridge	R		10.4			-	-	-	-	-	-																	-	-	-	-	-
99	Gopalganj	hajonpur Bailey Bridg	R	PC-I	10.4	1	35	35	364	32.1	0.0	8,208	9,384	8,287,188	107,526	7,264,678	58,253	0	0	13,212,961	126,693	34,217,646	38,704	14,140,000	0			11,568,371	49,676	88,690,844	380,852	25.0%	118,206,839	324,744
100	Rajshahi	Debokbazar Bridge	Z	Steel-I	9.8	2	40+40	80	784	31.9	25	6,909	12,306	31,666,544	1,403,517	6,338,306	51,283	2,762,307	22,909	16,571,056	158,757	37,373,175	42,273	32,320,000	0			19,054,708	251,811	146,086,096	1,930,550	50.6%	295,703,747	377,173
I	Khulna	Jhikorgacha Bridge	N	PC-I	20.8	3	35+35+35	105	2,184	38.9	34.5	3,977	920	49,723,126	645,154	7,264,678	58,253	7,779,694	64,133	26,675,900	255,784	9,524,665	10,773	42,420,000	0			21,508,210	155,114	164,896,274	1,189,210	35.9%	257,060,055	117,701
II	Rangpur	-	N	PC-I	10.4	1	40	40	416	17.5	0	3,248	3,025	9,471,072	122,886	7,264,678	58,253	0	0	7,206,920	69,104	12,200,985	13,801	0	0			5,421,548	39,607	41,565,203	303,650	36.1%	65,098,089	156,486
III	Khulna	Chandi Pur Bridge	N	PC-I	10.4	1	30	30	312	31.2	0	4,627	3,796	7,103,304	92,165	7,264,678	58,253	0	0	12,848,909	123,203	16,382,735	18,531	0	0			6,539,944	43,823	50,139,570	335,973	34.2%	76,177,488	244,159
IV	Gopalganj	Garakola Bridge	N	PC-I	20.8	3	35+40+35	110	2,288	37.8	28.5	9,418	8,510	52,090,896	675,875	7,264,678	58,253	7,779,694	64,133	24,369,685	233,670	34,869,960	39,442	44,440,000	0			25,622,237	160,706	196,437,150	1,232,078	32.7%	291,923,201	127,589
V	Khulna	Tularampur Bridge	R	PC-I	20.8	3	30+35+30	95	1,976	35.5	27.1	1,742	3,138	44,987,592	583,710	7,264,678	58,253	7,779,694	64,133	22,990,075	220,442	9,491,600	10,736	38,380,000	0			19,634,046	140,591	150,527,685	1,077,864	35.7%	234,062,173	118,453
VI	Khulna	Hawai khali Bridge	Z	PC-I	20.8	1	30	30	624	40.6	0	13,613	15,006	14,206,608	184,330	7,264,678	58,253	0	0	16,720,054	160,321	55,663,955	62,962	12,120,000	0			15,896,294	69,880	121,871,590	535,745	25.4%	163,391,833	261,846

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

Source: JICA Survey Team

12. PROJECT EFFECT

12.1 Operation and Effect Indicators

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

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

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

12.1.1 Selection of Operation and Effect Indicators

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

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

Table 12.1.1Selection of Operation and Effect Indicators

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

Source: JICA Study team

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

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

(2) Travel Cost from Detour when Bridge Collapsed

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

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

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

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

(4) Unserviceability rate

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

12.1.2 Proposed Operation and Effect Indicators

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

Table 12.1.2 Proposed Operation and Effect Indicator 1

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

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

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

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

Table 12.1.3 Proposed Operation and Effect Indicator 2

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

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

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

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

12.2 Economic Evaluation

12.2.1 General

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

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

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

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

12.2.2 Basic Assumptions and Conditions

(1) Basic Concept of Benefit

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

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

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

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

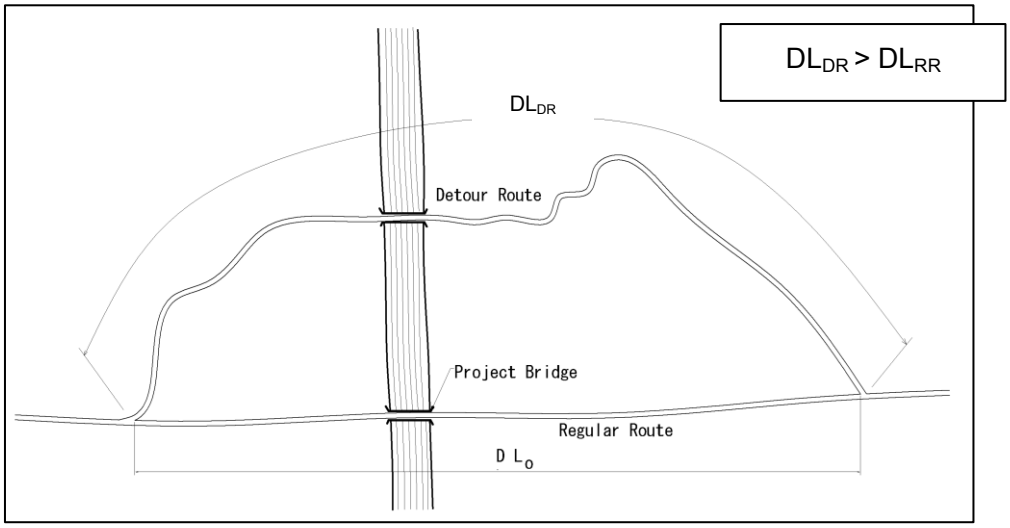


Figure 12.2.1 Travel Distance of Regular Route vs Detour Route

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

(2) Implementation Schedule

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

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

(3) Project Life

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

(4) Discount Rate

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

12.2.3 Economic Cost Estimate

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

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

Table 12.2.1 Economic Cost Estimate

Breakdown of Cost	Financial Cost	Foreign Cost	Local Cost	Economic Cost
Civil Works Sub Total	21,633	8,449	13,184	18,996
Price Escalation	3,535	709	2,826	0
Physical Contingency	2,517	916	1,601	2,334
Consulting Services	1,820	977	843	1,625
Land Acquisition	4,344	0	4,344	4,344
Administration Cost	2,951	0	2,951	0
VAT	2,915	0	2,915	0
Import Tax	3,022	0	3,022	0
Interest during Construction	18	18	0	0
Commitment Charge	0	0	0	0
Total	42,755	11,069	31,686	27,299

Source: JICA Study team Figure in million BDT

12.2.4 Benefit Measurement

(1) Type of Benefits

Benefits derived from the bridge projects are considered the followings:

- Reduction of vehicle operating cost (VOC)

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

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

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

(2) Unit Road Users Cost

1) Vehicle Operating Cost (VOC)

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

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

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

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

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

Table 12.2.3 IRR by Road Condition

Condition	IRI
Good	4
Fair	6
Bad	8
Very bad	10

Source: JICA Study Team

Table 12.2.4 CPI Index and Growth Index

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

Source: IMF World Economic Outlook, 2014

2) Travel Time Cost (TTC)

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

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

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

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

(3) Benefit Measurement Model for Reconstruction of Bridge

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

1) Bridge Life

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

2) Probability Model for Bridges to be Unusable

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

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

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

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

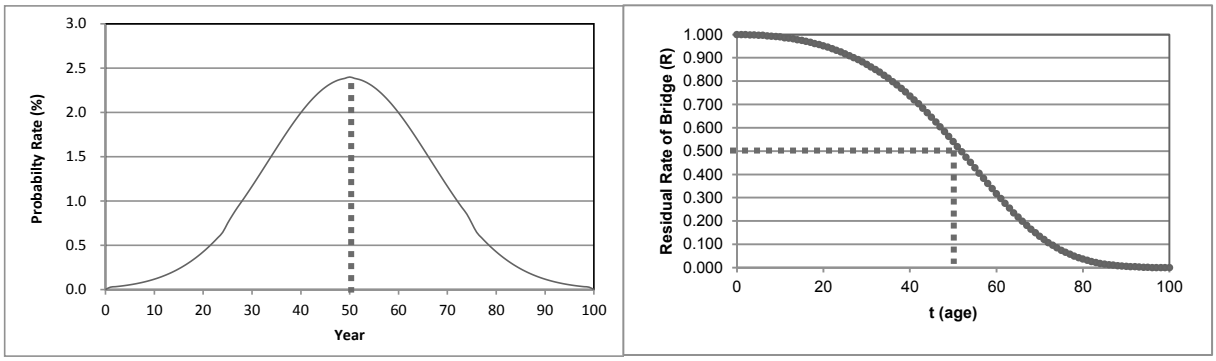
The reliability function R(t) can be expressed as shown in Figure 12.2.2(a) while the “Residuals Rate of Unserviceability” f(t)can be expressed as shown in Figure 12.2.2(b).It can be seen that the function follows a normal distribution. With a mean of 50 years and a standard deviation of 16.7 years,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

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

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

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

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

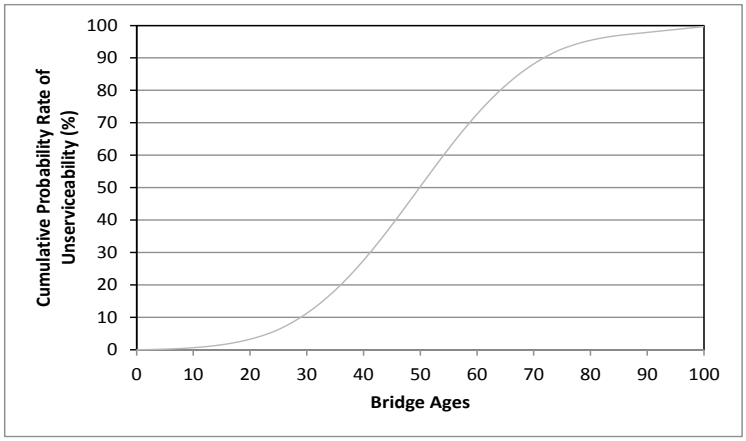


(a)Probability Rate of Unserviceability of Existing Bridge

(b) Residuals Rate of Unserviceability

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

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



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

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

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

Table 12.2.6 Probability Rate of Unserviceability by Bridge Types

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

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

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

3) Probability Model for Bridges to be Unusable after Reconstruction

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

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

Where

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

L : *Bridge length (m)*

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

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

Where

f : *probability for a bridge to be unusable*

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

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

4) Benefit Calculation

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

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

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

where:

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

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

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

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

d *:Number of days required for bridge reconstruction*

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

DL_o *:Length of detour route (km)*

DL_w *:Length of regular route (km)*

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

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

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

C *:Bridge reconstruction cost*

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

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

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

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

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

1) Probability Density for Temporary Bridges

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

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

Table 12.2.7 Probability Density of Bridge Unserviceability for Temporary Bridges

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

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

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

Table 12.2.8 Period Required for Temporary Restoration

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

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

2) Benefit Measurement for Temporary Bridges

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

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

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

Where:

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

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

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

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

d *:Number of days required for bridge reconstruction*

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

DL_0 *:Length of detour route (km)*

DL_w *:Length of regular route (km)*

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

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

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

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

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

C *:Bridge reconstruction cost*

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

3) Incremental Benefit Measurement from Widening Bridge

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

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

Incremental VOC:

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

Incremental TTC:

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

Where:

VOC :Incremental VOC

TTC :Incremental TTC

A :dl Encounter

B :No. of encounters per day

C :dl none encounter

D :AADT

E :dl waiting

F :No. of waiting vehicles per day

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1) Basic representative VOC (Taka/km)

2) Basic representative TTC (Taka/sec)

G :Crossing time in seconds

H :Deceleration + acceleration encounters in seconds

I :Deceleration + acceleration non-encounters in seconds

J :Waiting time in seconds

4) Maintenance Cost Saving

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

a) Routine Maintenance Cost Savings

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

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

Table 12.2.9 Maintenance Cost Required for Temporary Bridge

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

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

b) Routine Maintenance Cost Savings

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

Table 12.2.10 Maintenance Costs for Temporary Bridges

(Units: 1,000 Taka)

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

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

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

12.2.5 Results of Economic Evaluation

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

Table 12.2.11 Results of Economic Evaluation by Region

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

Source: JICA Survey Team

Table 12.2.12 Summary of Economic Evaluation by Bridge (1)

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

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

Source: JICA Survey Team

Table 12.2.13 Summary of Economic Evaluation by Bridge (2)

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

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

Source: JICA Survey Team

13. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

13.1 Environmental and Social Considerations

13.1.1 Project Components which may cause Impacts

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

13.1.2 Present Natural and Social Condition

(1) Climate and Temperature

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

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

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

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

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

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

(2) Topography and Geology

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

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

(3) Air Quality

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

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

Table 13.1.2 National Air Quality Standards for Bangladesh

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

Source: Environment Conservation Rules, 1997

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

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

(4) Water Quality

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

during this study.

Table 13.1.3 National Standards for Island Surface Water

Best Practice based classification	Parameter			
	pH	BOD5 (mg/L)	DO (mg/L)	Total Coliform (number/100ml)
a. Source of drinking water for supply only after disinfecting:	6.5-8.5	≤2	≥6	≤50
b. Water usable for recreational activity	6.5-8.5	≤3	≥5	≤200
c. Source of drinking water for supply after conventional treatment :	6.5-8.5	≤6	≥6	≤5000
d. Water usable by fisheries	6.5-8.5	≤6	≥5	-
e. Water usable by various process and cooling industries	6.5-8.5	≤10	≥5	≤5000
f. Water usable for irrigation	6.5-8.5	≤10	≥5	≤1000

Source: Environment Conservation Rules, 1997

Table 13.1.4 National Standards for Drinking Water

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

Source: Environment Conservation Rules, 1997

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

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

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

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

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

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

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

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

(5) Noise and Vibration

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

Table 13.1.5 National Standards for Sound for Different Areas

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

Source: Environment Conservation Rules, 1997

(6) Ground Subsidence

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

(7) Bottom Sediment

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

(8) Fauna and Flora

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

Table 13.1.6 Status of the Resident Inland Vertebrate Species in Bangladesh

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

Source: IUCN Red Book (2000)

(9) Water Use

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

(10) Protected Areas

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

(11) Soil and Land-use

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

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

(12) Cultural Assets

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

(13) Indigenous or ethnic Minority

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

(14) Health Care Facilities

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

Table 13.1.7 National Health Services Facilities Available in Bangladesh.

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

Source: BBS 2007

(15) Educational Institutions

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

Table 13.1.8 Total Number and Types of Academic Institutions in Bangladesh

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

Source: BBS 2012

(16) HIV/AIDS

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

(17) Gender

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

(18) Children's Rights

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

(19) Climate Change

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

(20) Fishermen Community

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

(21) Landscape

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

(22) Road Accident

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

13.1.3 EIA System in Bangladesh

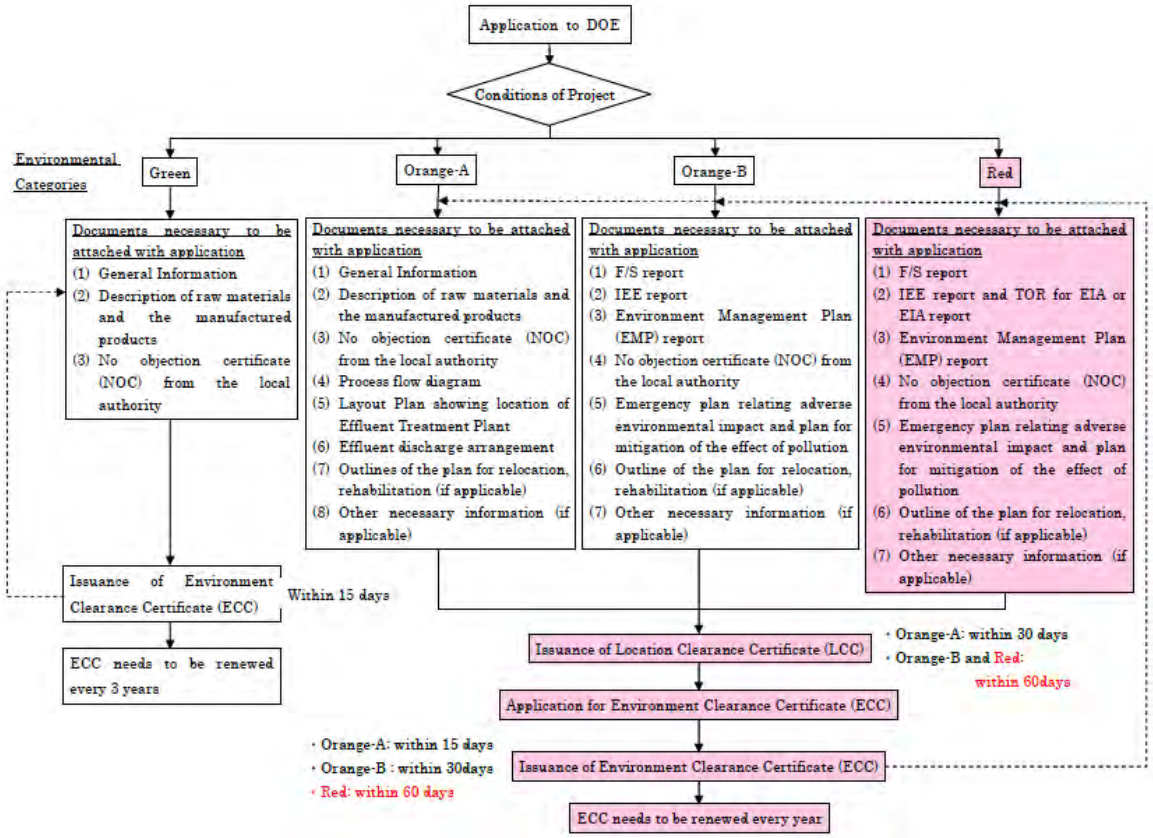
The legislative basis for environmental assessment in Bangladesh is the Environment Conservation Act (1995). The Act was enacted to conserve and improve environmental quality as well as to control pollution. Subsequently, the Environment Conservation Rules was enacted in 1997 to evaluate, review the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

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

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

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

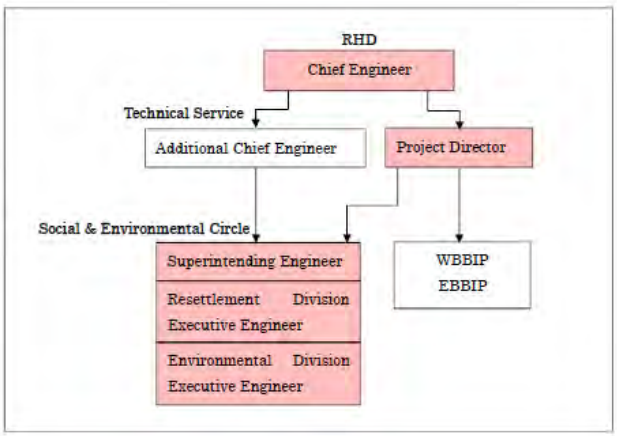
A discussion was made between DoE and JICA Survey Team with the presence of Social & Environment Circle of RHD in November, 2013 in terms of environmental categorization on WBBIP and it was concluded that the "Red Category" procedure will be applied .To obtain Environmental Clearance Certificate (ECC),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



Source: JICA Survey Team

Figure 13.1.1 Procedure to obtain ECC

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



Source: JICA Survey Team

Figure 13.1.2 Organogram of RHD on Environmental and Social Considerations

13.1.4 Alternatives

(1) Alternative Alignment

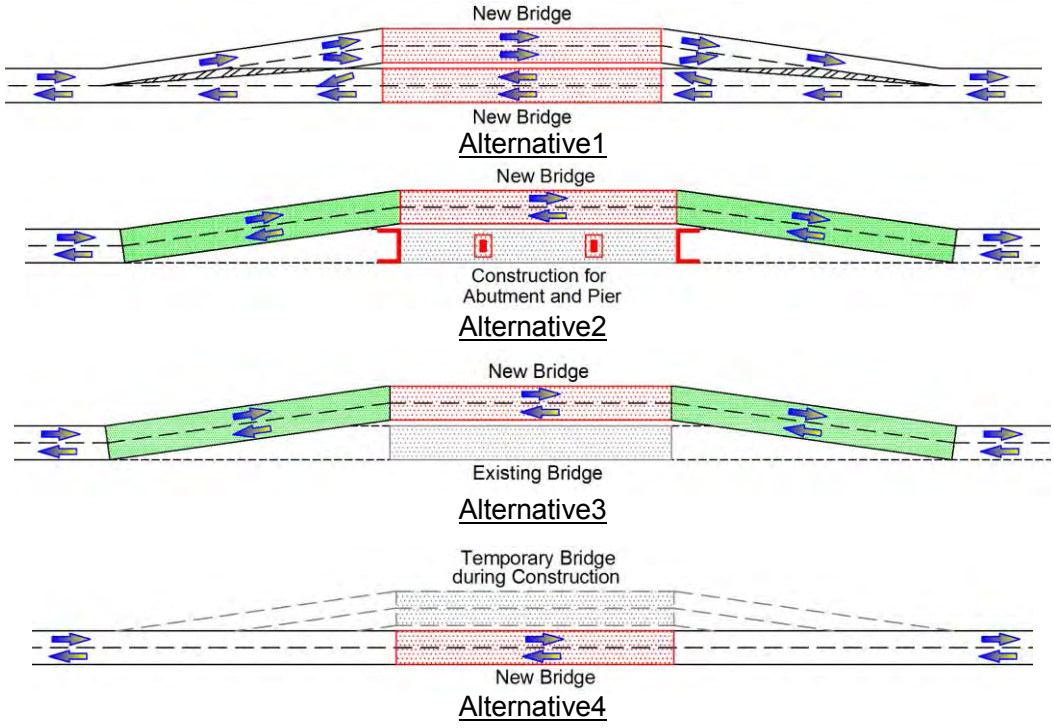
The location of new bridges shall be determined in consideration of impact to existing residences/shops, cost and so on. However, National roads shall also be considered in respect to future widening projects.

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

(2) No Action Alternative

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

Table 13.1.9 Comparison of Alternatives

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

Source: JICA Survey Team

13.1.5 Scoping and ToR on EIA

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

Table 13.1.10 Predicted Scoping Matrix

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

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

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

Source: JICA Survey Team

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

Table 13.1.11 ToR on EIA

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

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

Source: JICA Survey Team

13.1.6 Result of EIA Survey

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

Table 13.1.12 Result of EIA Survey

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

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

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

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

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

Source: JICA Survey Team

13.1.7 Assessment of Impacts

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

Table 13.1.13 Comparison of Scoping before/after EIA Study

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

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

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

Note: A: Remarkable Negative Impact is predicted.

B: Negative Impact is expected to some extent.

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

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

Source: JICA Survey Team

13.1.8 Mitigation Measures and its Cost

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

Table 13.1.14 Mitigation Measures during Pre-construction/Construction Stage

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

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

Source: JICA Survey Team

Table 13.1.15 Mitigation Measures in Operation Stage

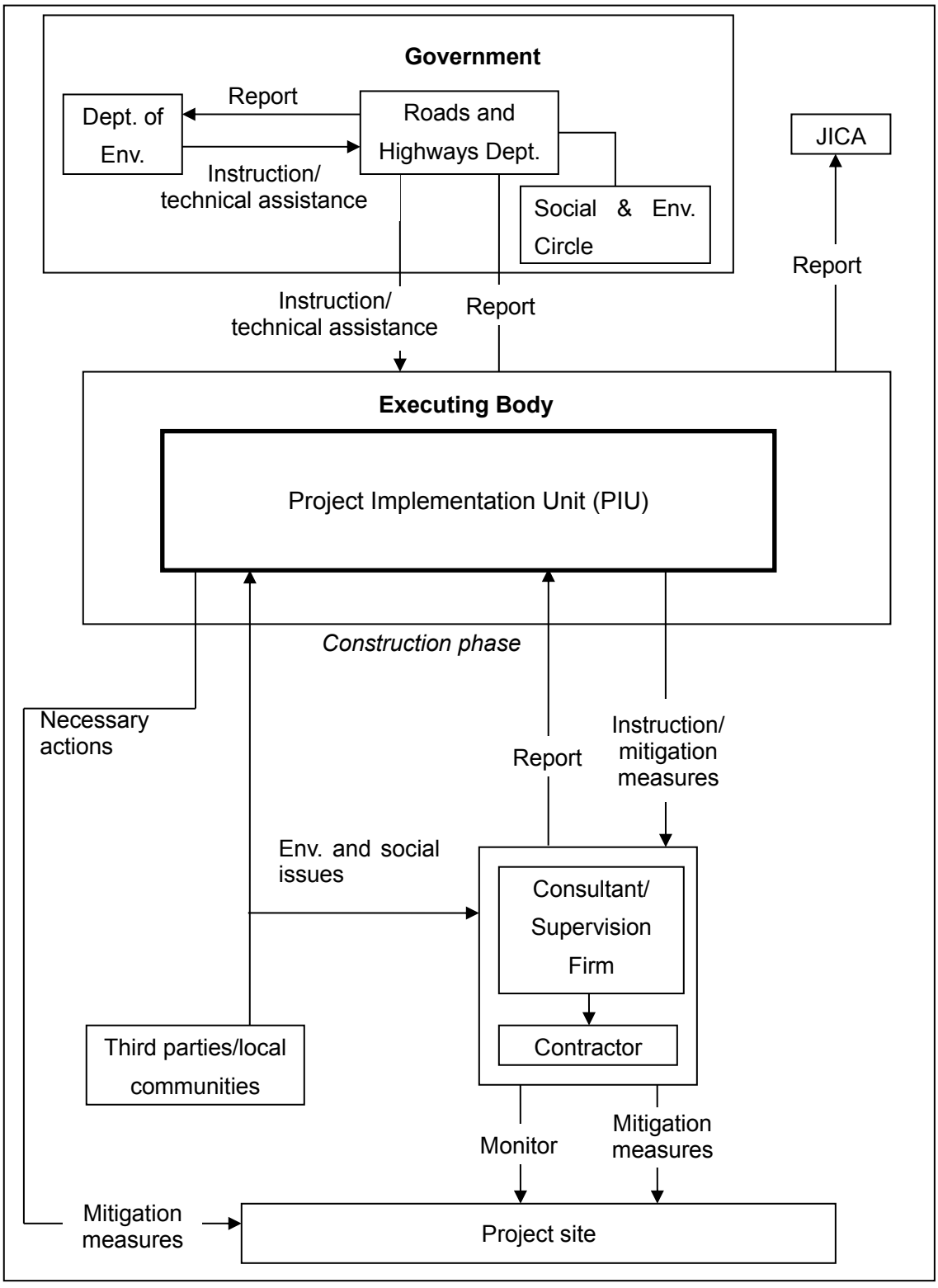
Item of Impact	Mitigation Measures	Implementing Organization	Responsible organization
Noise	- Monitoring and review the result by RHD. - Where noise level exceed the environmental standards, provide hump/planting strip.	Local RHD	RHD
Accident	- Provide hump where school/hospital/market exist.	Local RHD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

Source: JICA Survey Team

13.1.9 Environmental Management Plan (EMP)

(1) Institutional Framework

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



Source: JICA Survey Team

Figure 13.1.3 Institutional Framework for Environmental Management and Monitoring

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

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

Table 13.1.16 Environmental Monitoring Plan in Construction Stage

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

Source: JICA Survey Team

Table 13.1.17 Environmental Monitoring Plan in Operation Stage

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

Source: JICA Survey Team

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

Table 13.1.18 Estimates for Environmental Monitoring Costs Borne by Contractor

	Description of items	Cost (million Tk)	Remarks	Cost borne by
A	Air/Water/Soil Quality	72.0	0.1x12x60	Contractor (involved in Contract)
B	Dust Control	-	Personnel expense is involved in #A	Contractor (involved in Contract)
C	Noise Control	0.2	0.003x60 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	8.3		Contractor (involved in Contract)
F	Turf	48.4		Contractor (involved in BoQ)
G	Cleaning and Grubbing	2.4		Contractor (involved in BoQ)
Total sum		131.3		

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

Table 13.1.19 Estimates for Environmental Monitoring Costs Borne by RHD

No	Description of items	Cost (million Tk)	Cost borne by
I	ARP Implementing Agency	45.0	RHD
II	External Monitoring	4.0	RHD
Total sum		49.0	

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

13.2 Land Acquisition and Resettlement

13.2.1 Necessity of Land Acquisition and Resettlement

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

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

13.2.2 Legal Framework of Land Acquisition and Resettlement

The current legislations governing land acquisition for Bangladesh is the Acquisition and Requisition of Immovable Property Ordinance 1982 and subsequent amendments during 1993 - 1994. The Ordinance requires that compensation be paid for (i) land and assets permanently acquired (including standing crops, fisheries, trees, houses); and (ii) any other damages caused by such acquisition. The Deputy Commissioner (DC) determines the market price of assets based on the approved procedure and in addition to that pays an additional 50 percent (as premium) on the assessed value as the market price established by

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

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

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

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

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

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

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

Table 13.2.1 Gap and Gap Filling Measure

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

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

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

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

Source: JICA Survey Team

13.2.4 Census and Socio-economic Survey

(1) Methodology

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

(2) Project Area

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

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

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

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

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

Source: Census & Socioeconomic survey, June 2014

Table 13.2.3 Displaced Number of Households by Bridge

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

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

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

Source: JICA Survey Team

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

Table 13.2.4 Distribution of Impacts by Zone

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

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

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

Source: Census & Socioeconomic survey, June 2014

(3) Profile of Affected Households

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

Table 13.2.5 Number of Male and Female Population by Zone

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

Source: Census & Socioeconomic survey, June 2014

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

Table 13.2.6 Affected Household Heads by Zone and Gender

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

Source: Census & Socioeconomic survey, June 2014

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

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

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

Source: Census & Socioeconomic survey June 2014

13.2.5 Eligibility Policy and Entitlement Matrix

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

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

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

Table 13.2.8 Compensation and Entitlement Matrix

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

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

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

Source: ARP, September 2014

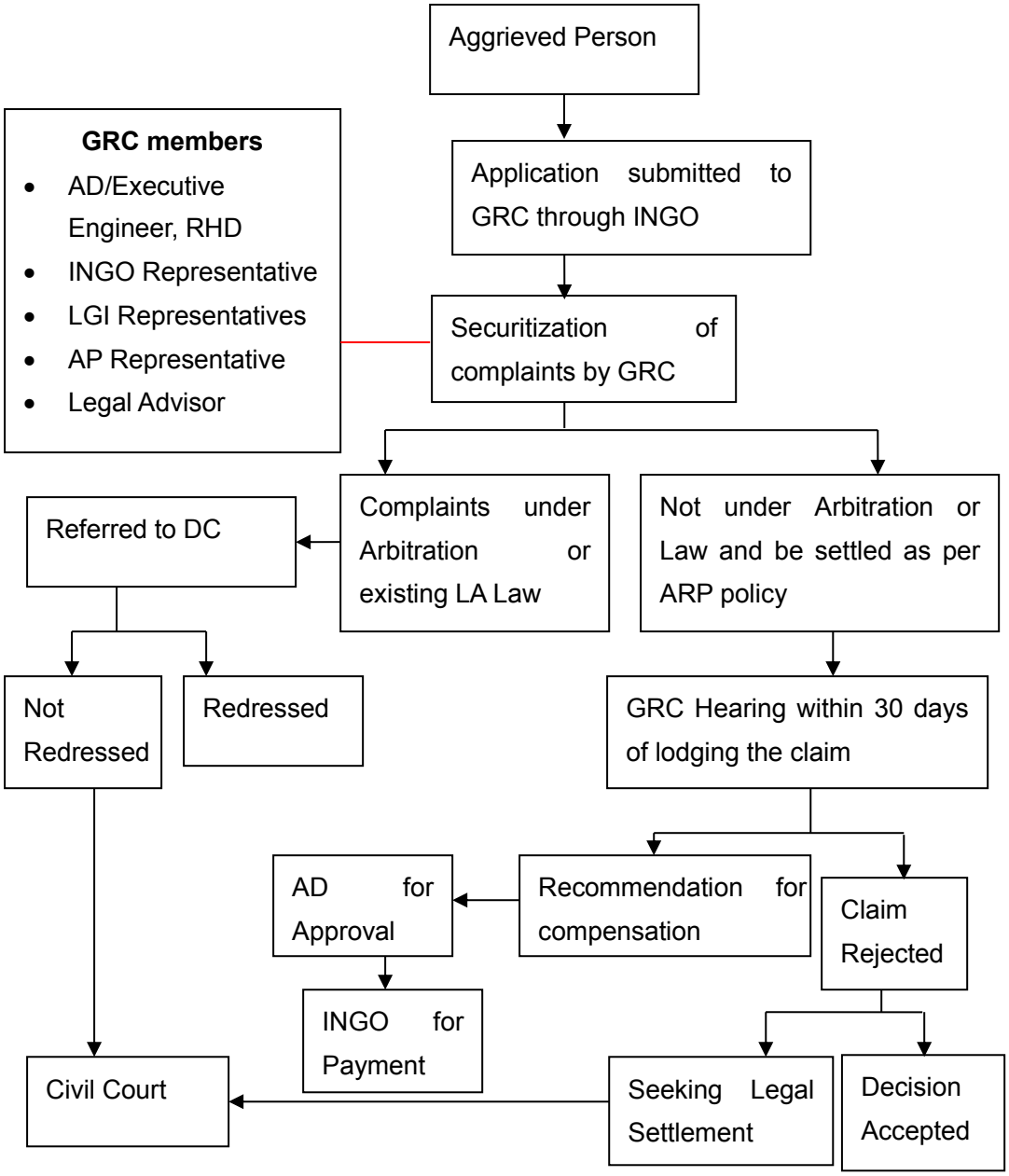
13.2.6 Grievance Redress Committee

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

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

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

The grievance redress mechanism is elaborated in Figure 13.2.1.



Source: JICA Survey Team

Figure 13.2.1 Grievance Redress Mechanism

13.2.7 Implementation Organization

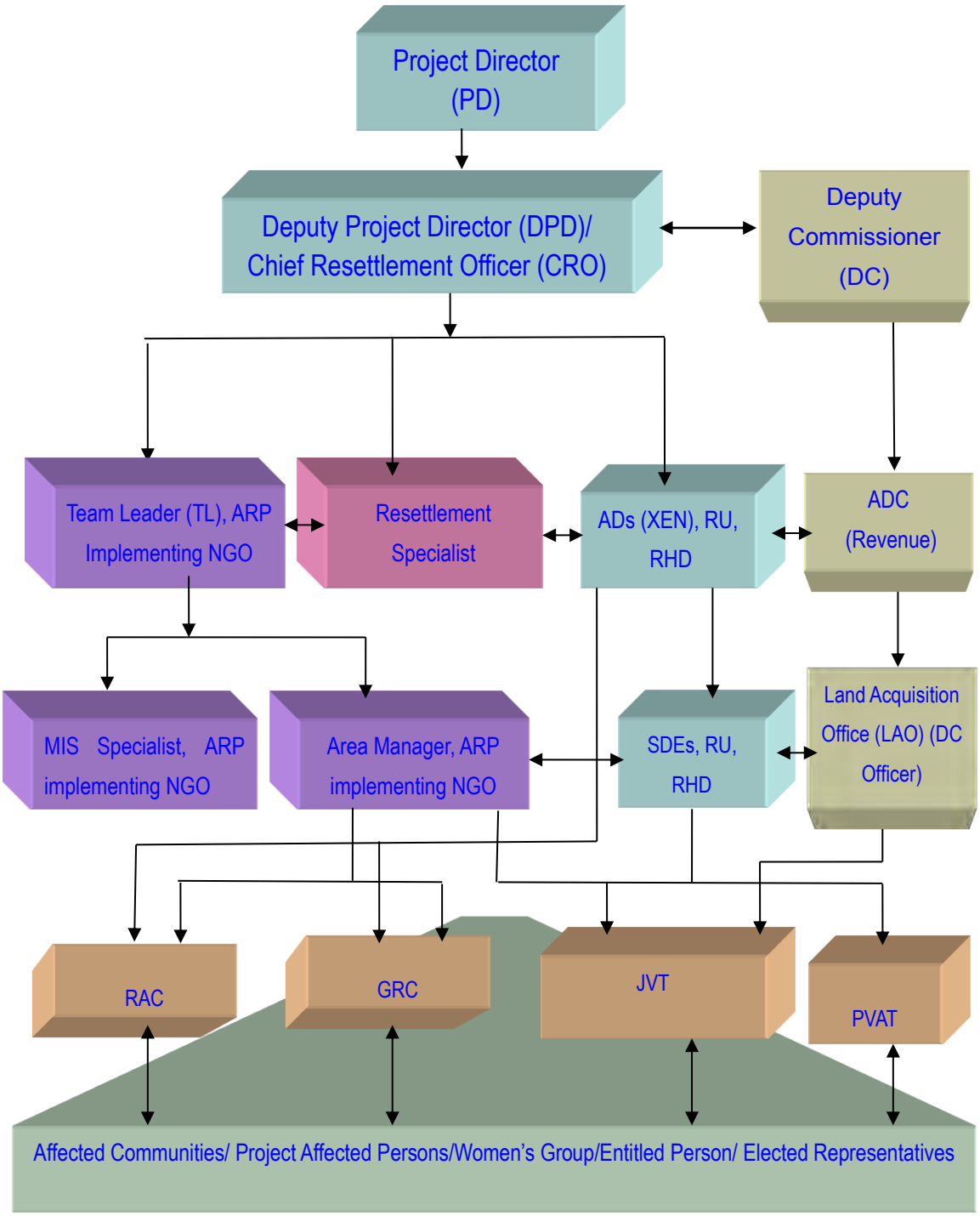
(1) Implementation Organization

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

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

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

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



Source: JICA Survey Team

Figure 13.2.2 ARP implementation organogram

(2) Women Groups in Resettlement Process

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

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

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

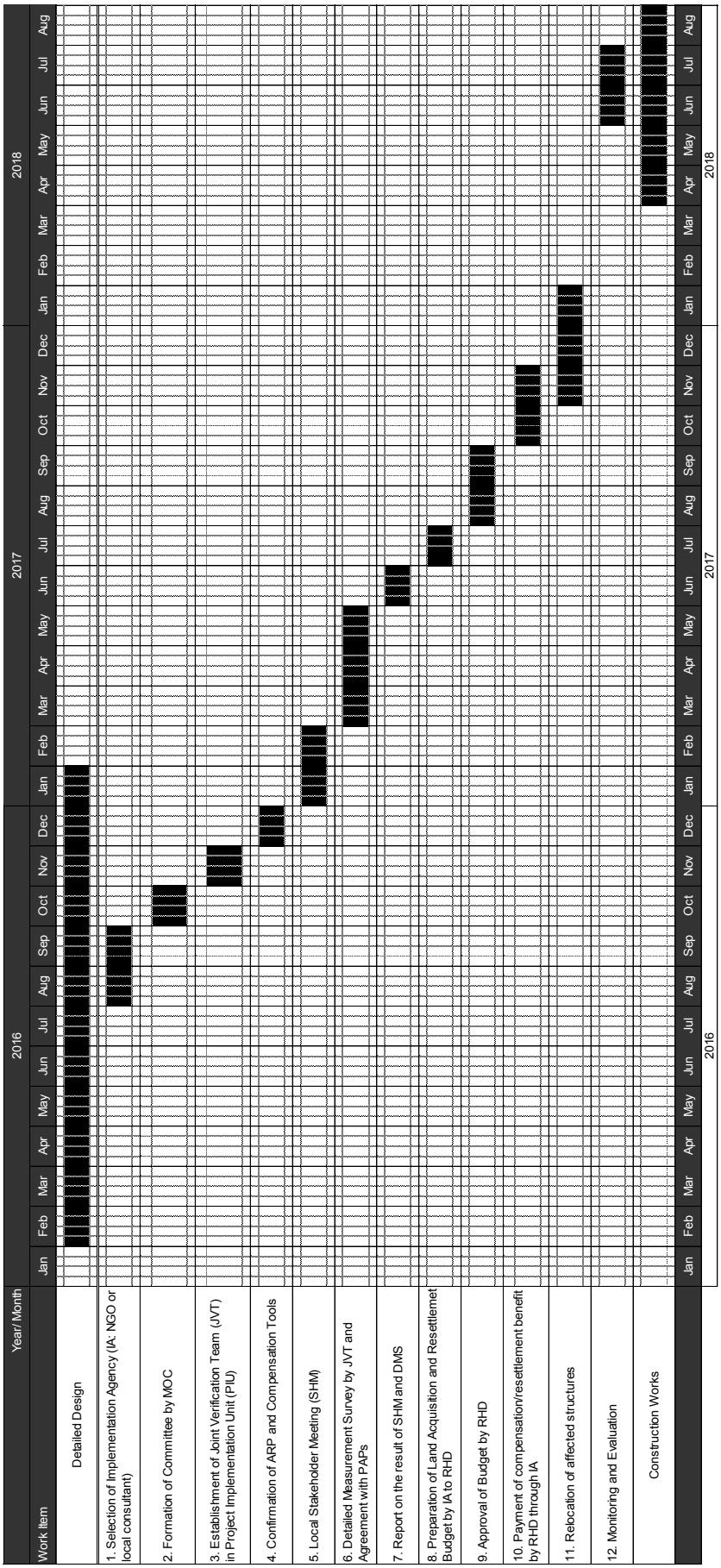
(3) Appointment of Implementing Non-Government Organization (INGO)

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

13.2.8 Implementation Schedule

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

The preliminary implementation schedule over a period of 24 months from August 2016 to July 2018 is devised below.



Source: JICA Survey Team

Figure 13.2.3 ARP 13.2.7 Implementation Schedule

13.2.9 Resettlement and Compensation Costs & Budget

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

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

The budget also includes operational cost of the Implementing Agency (IA) and capacity building training cost of the Executing Agency (EA). The total estimated cost for implementation of the ARP of selected 60 Bridges is BDT **1,178,550,504** including CCL amount to be determined by the DC for land and other physical assets. These estimates and the budget must be regarded as provisional, given the need for updating the ARP (if required) during implementation. Final rates per unit for land, structures, trees and other affected properties will be determined by the PVAT. Based on the rate and ARP policy, a final resettlement budget shall be prepared and approved by the EA. All resettlement funds will be provided by the EA (RHD) based on the financing plan agreed by the GOB.

13.2.10 Monitoring and Evaluation

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

(1) Internal Monitoring

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

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

Table 13.2.9 Format for ARP Implementation Monitoring

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

Source: ARP September, 2014

Table 13.2.10 Potential Monitoring Indicators

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

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

Source: ARP September, 2014

(2) External Monitoring

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

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

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

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

13.2.11 Local Stakeholder Meeting (SHM)

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

(1) Meeting Phase I

In the initial stage of the project in April 2014 the local potential APs of each bridge location

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

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

Table 13.2.11 Stakeholders Consultation Phase I

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

Source: ARP September, 2014

Some photographs of consultation meetings

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

(2) Meeting Phase II

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

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

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

Table 13.2.12 Stakeholders Consultation Phase II

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

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

Source: ARP September, 2014

(3) Meeting Phase III

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