6. TRAFFIC DEMAND FORECAST

6.1 Present Traffic Situation around the Target Roads

6.1.1 Outline of the Traffic Surveys

In order to understand the present traffic situation around the target roads, a traffic count (T/C) survey and a roadside OD survey were implemented.

The T/C surveys were conducted for the 3-day survey (for 12 and 24 hours on weekdays, for 12 hours on weekend) at 2 locations, for the 24-hour survey at 6 locations and for the 12-hour survey at 2 locations. The roadside OD survey, which included a 14-hour OD interview survey and 24-hour T/C surveys, was conducted at 5 locations.

The location and survey types of these traffic surveys are shown in Figure 6.1.1 and Figure 6.1.2. Also, the surveyed vehicle type is shown in Table 6.1.1.

T/C survey were implemented for all types of vehicles (①–⑭), and OD interview survey were implemented for the ③Passenger car (Sedan, SUV) & taxi – ⑪Utility, which are motorized vehicles except ①motorbike, ②CNG (Auto-rickshaw)/Baby taxi and non-motorized light vehicles used for the short distance trips, in order to grasp the origin and destination of the inter-city middle and long trip traffic.

Table 6.1.1 Surveyed vehicle type

Survey Type	Vehicle code	Vehicle type
T/C Only	①	Motorbike
	②	CNG (Auto-rickshaw)/Baby taxi
T/C + O/D	③	Passenger car (Sedan, SUV), Taxi
	④	Micro bus (up to 15 seats)
	⑤	Medium bus (16-39 seats)
	⑥	Large bus (40 seats or more)
	⑦	Small truck (2 axles, less than 3 tons)
	⑧	Medium truck (2 axles, over 3 tons)
	⑨	Large truck (3 axles or more)
	⑩	Trailer truck
	⑪	Utility (Jeep, Pickup, Legna)
T/C Only	⑫	Bicycle
	⑬	Cycle rickshaw
	⑭	Others

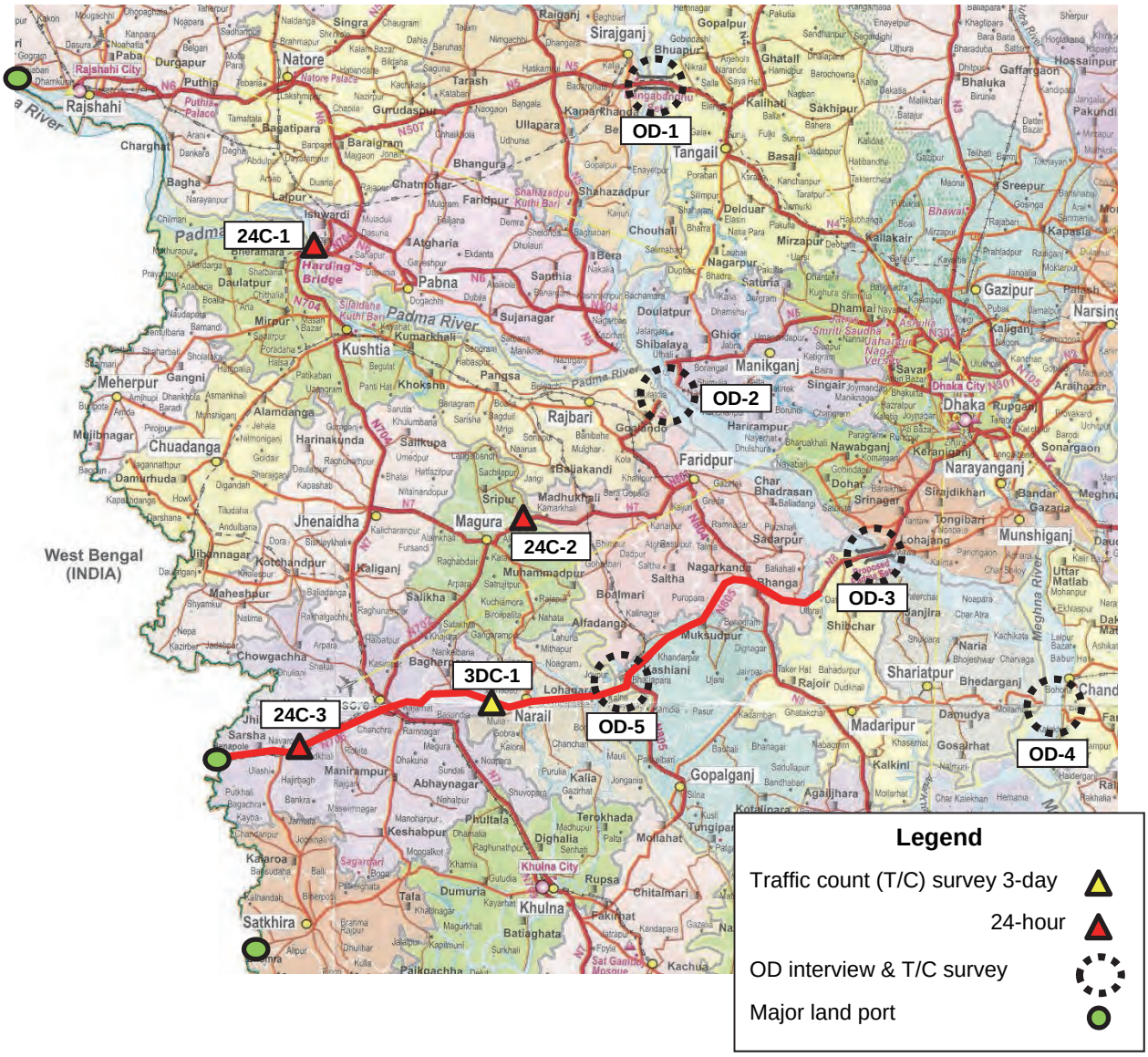


Figure 6.1.1 Survey Locations (West)

Figure 6.1.2 Survey Locations (East)

6.1.2 T/C Survey Results

(1) 3-day T/C survey result

The 3-day T/C survey, which includes 2 (12-hour and 24-hours) weekday and 1 (12-hour) weekend surveys, was conducted at 2 middle section locations in order to understand the present traffic situation of Section-A and Section-C of the road. Major aspects of the results are as follows.

1) 3DC-1 location (in Section-A)

- Weekday traffic was 2,780 vehicles/day in both directions, and motorbike and bicycles which were mainly used for short-distance trips accounted for 54% of the traffic. However, there were few cycle rickshaws.
- The rate of motorized vehicle traffic accounted for 84% of total, and the rate of motorbike and CNG accounted for 44% of the traffic. However, there were few trailer trucks.
- The rate of non-motorized light vehicles accounted for 14% of total, and the most of vehicles were bicycles.
- Day-night ratio (24-hour/12-hour traffic volume) of the total vehicles was 1.32; however, the day-night ratio of trucks and utilities were in the range of 1.48–1.88.
- Weekend daytime traffic was slightly higher than the weekday traffic, in spite of decrease of truck traffic.

Table 6.1.2 T/C Survey Result at 3DC-1

(Unit: veh/day)

	Dir	Survey hour	Motorized												Non-motorized			Others	Total
			Motor bike	CNG	Car	Micro bus	M bus	L bus	S truck	M truck	L truck	Trailer truck	Utility	Sub total	Bi cycle	Rick shaw	Sub total		
Weekday (W)	To Benapole	Day 12h	459	49	55	39	60	63	18	32	78	0	36	889	169	0	169	17	1,075
		Night12h	115	7	15	8	3	13	12	19	36	0	30	258	31	1	32	12	302
		24 hour	574	56	70	47	63	76	30	51	114	0	66	1,147	200	1	201	29	1,377
	To Dhaka	Day 12h	426	43	59	34	101	21	62	81	26	0	24	877	144	3	147	14	1,038
		Night12h	102	10	19	12	18	4	26	52	55	0	18	316	41	0	41	9	366
		24 hour	528	53	78	46	119	25	88	133	81	0	42	1,193	185	3	188	23	1,404
	Both direction	Day 12h	885	92	114	73	161	84	80	113	104	0	60	1,766	313	3	316	31	2,113
		Night12h	217	17	34	20	21	17	38	71	91	0	48	574	72	1	73	21	668
		24 hour	1,102	109	148	93	182	101	118	184	195	0	108	2,340	385	4	389	52	2,781
		24 hour /Day12h	1.25	1.18	1.30	1.27	1.13	1.20	1.48	1.63	1.88	-	1.80	1.33	1.23	1.33	1.23	1.68	1.32
Weekend (E)	To Benapole	Day 12h	488	52	65	46	23	97	12	20	64	0	37	904	225	2	227	28	1,159
	To Dhaka	Day 12h	436	65	102	53	132	7	25	45	23	2	52	942	104	5	109	17	1,068
	Both	Day 12h	924	117	167	99	155	104	37	65	87	2	89	1,846	329	7	336	45	2,227

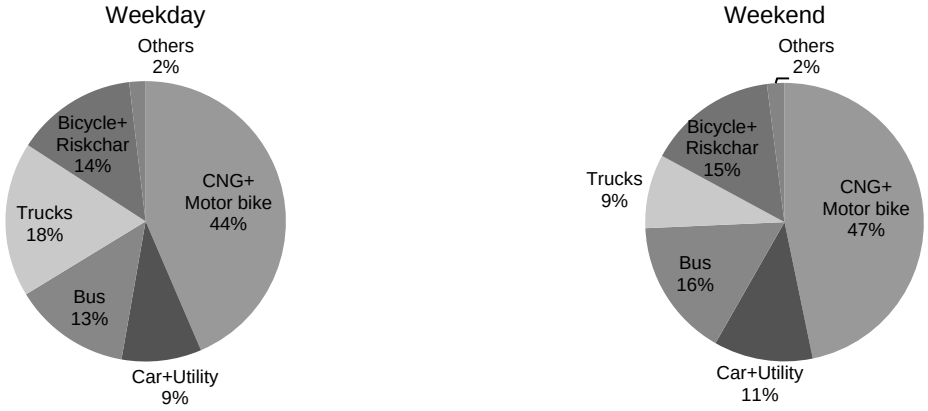


Figure 6.1.3 Ratio of vehicle type of the through traffic at 3DC-1

2) 3DC-2 Location (in Section-C)

- The rate of motorized vehicle traffic accounted for 90% of the total, and the rate of motorbike and CNG accounted for 52% of the traffic. However, there were few trailer trucks.
- The rate of non-motorized light vehicle traffic accounted for 8% of the total, and the share of bicycles and rickshaws half of the total.
- The day-night ratio of the trucks was 1.45, and it was higher than that of other survey locations.
- Especially, the day-night ratios of large trucks and trailers were very high, at 4.41 and 3.83, respectively. The reason was that trucks and trailers could not pass in the Dhaka City during the day (from 7:00 to 20:00) because of the truck ban.[7]
- Weekend daytime traffic was lower than the weekday traffic, in spite of the increase of cars, micro buses and utility traffic.

[7] There is no big city between Dhaka and Chittagong except Comida District, where locates in the northern part of Chittagong Division, and most of traffic except heading to Sylhet Division where locates north-east part of Bangladesh need to pass the Dhaka Metropolitan Area. Therefore most of large truck and trailers passing on the Section C are possible to be influenced by the truck ban for Dhaka City.

Table 6.1.3 T/C Survey Result at 3DC-2

(Unit: veh/day)

	Dir	Survey hour	Motorized												Non-motorized			Others	Total
			Motor bike	CNG	Car	Micro bus	M Bus	L bus	S truck	M truck	L truck	Trailer truck	Utility	Sub total	Bi cycle	Rick shaw	Sub total		
Weekday (W)	To Cox's Bazar	Day 12h	326	2,244	122	233	84	206	260	180	31	3	93	3,782	144	133	277	65	4,124
		Night12h	38	792	76	194	8	144	105	252	38	10	78	1,735	17	29	46	61	1,842
		24 hour	364	3,036	198	427	92	350	365	432	69	13	171	5,517	161	162	323	126	5,966
	To Chittagong	Day 12h	375	2,219	173	400	131	258	244	226	40	3	109	4,178	292	288	580	97	4,855
		Night12h	94	712	106	311	32	137	143	163	204	7	91	2,000	50	98	148	40	2,188
		24 hour	469	2,931	279	711	163	395	387	389	244	10	200	6,178	342	386	728	137	7,043
	Both direction	Day 12h	701	4,463	295	633	215	464	504	406	71	6	202	7,960	436	421	857	162	8,979
		Night12h	132	1,504	182	505	40	281	248	415	242	17	169	3,735	67	127	194	101	4,030
		24 hour	833	5,967	477	1,138	255	745	752	821	313	23	371	11,695	503	548	1,051	263	13,009
		24 hour /Day12h	1.19	1.34	1.62	1.80	1.19	1.61	1.49	2.02	4.41	3.83	1.84	1.47	1.15	1.30	1.23	1.62	1.45
Weekend (E)	To Cox's Bzr	Day 12h	248	2,104	179	338	149	217	267	121	26	0	141	3,790	153	124	277	45	4,112
	To Chittag.	Day 12h	398	2,304	180	315	68	219	165	130	31	0	135	3,945	261	144	405	107	4,457
	Both	Day 12h	646	4,408	359	653	217	436	432	251	57	0	276	7,735	414	268	682	152	8,569

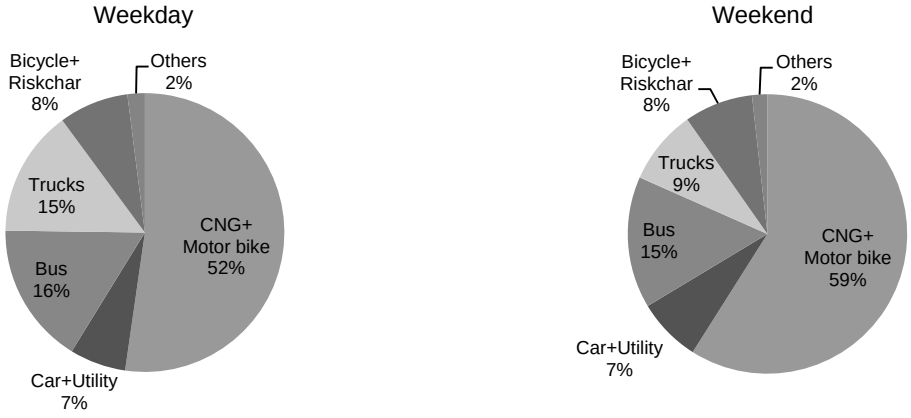


Figure 6.1.4 Ratio of vehicle type of the through traffic at 3DC-2

(2) 24-Hour T/C Survey Result

The 24-hour T/C surveys were implemented at the 5 OD survey locations and another 6 locations on the major roads, and the 12-hour T/C surveys were implemented at 2 supplementary locations in Section-B. Major features of the results are as follows.

1) West Bangladesh

- Most of the traffic between Dhaka and the West side of Bangladesh needed to cross the river by the Jamuna Bridge (at OD-1) or ferries (at OD-2, 3, 4), and the highest traffic volume was recorded at OD-1, followed by OD-2 and OD-3, respectively.
- As for the traffic proportion by vehicle type, trucks made up the highest proportion, followed by buses.
- Regarding the traffic in Section-A, the highest traffic was observed at 24C-3, which is located on the west side of Jessore, and CNG & motorbike made up the highest proportion of the traffic, followed by trucks.
- The share of CNG & motorbikes in Section-A was higher than that of the other sections; therefore, the road in Section-A was used as a local road, not as an intercity road.

2) East Bangladesh

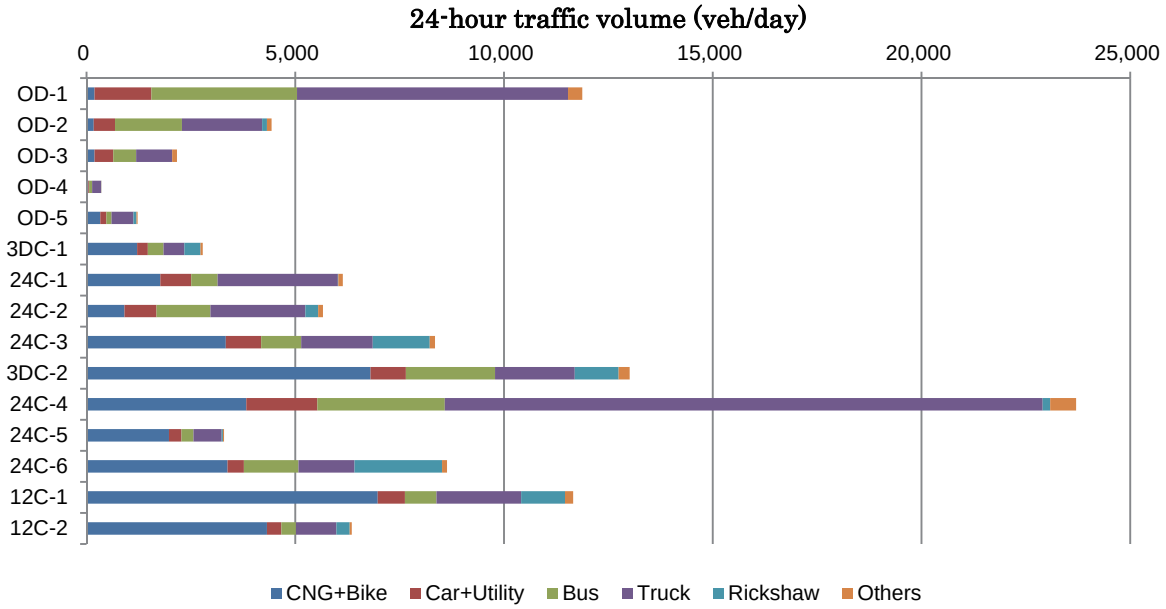
- As for the traffic of national road N1, the traffic at 24C-4 located in the southern part of Feni was the highest with 23,700 veh/day, and the traffic decreases as it heads to the south.
- The share of the trucks was the highest with 60% of the 24C-4 traffic.
- The share of CNG & motorbike is quite high with 60–66% at Section-B.

Table 6.1.4 24-Hour Traffic Volume (Weekday)

(Unit: Vehicle/day)

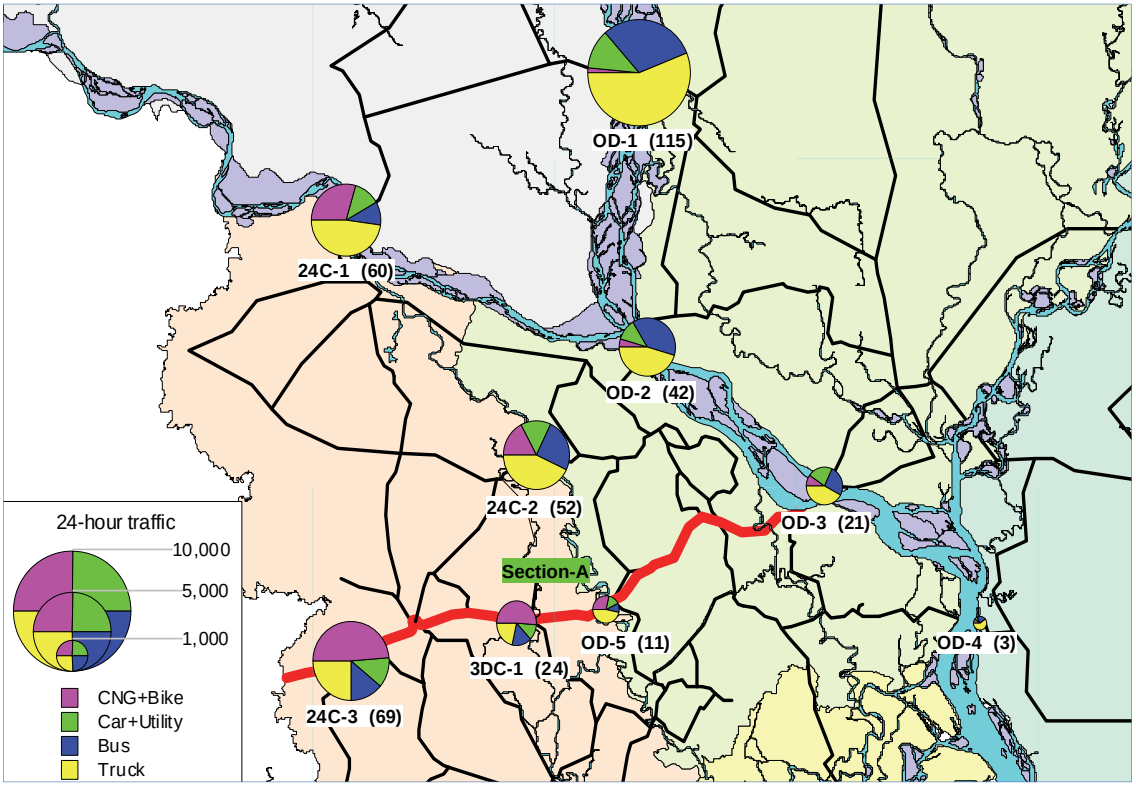
Survey Location		Motorized Vehicle					Bicycle, Rickshaw	Others	Total
		CNG+Bike	Car+Utility	Bus	Truck	Sub Total			
West Bangladesh	OD-1	190	1,360	3,493	6,490	11,533	1	3,39	11,873
	OD-2	173	510	1,603	1,918	4,204	116	1,13	4,433
	OD-3	189	452	548	862	2,051	0	1,13	2,164
	OD-4	40	20	73	215	348	2	3	353
	OD-5	330	144	125	523	1,122	74	28	1,224
	3DC-1	1,211	256	376	497	2,340	389	52	2,781
	24C-1	1,766	741	631	2,880	6,018	12	1,09	6,139
	24C-2	906	769	1,293	2,271	5,239	309	1,13	5,661
	24C-3	3,336	847	956	1,714	6,853	1,365	1,28	8,346
East Bangladesh	3DC-2	6,800	848	2,138	1,909	11,695	1,051	2,63	13,009
	24C-4	3,826	1,703	3,050	14,321	22,900	183	6,19	23,702
	24C-5	1,975	297	288	677	3,237	30	27	3,294
	24C-6	3,378	392	1,304	1,342	6,416	2,100	1,19	8,635
	12C-1*	6,972	652	756	2,029	10,409	1,051	1,95	11,655
	12C-2*	4,320	344	351	970	5,985	319	50	6,534

Note: The numerical value of the 12-hour T/C survey was converted into 24-hour traffic by using the day-night ratio that was obtained from the 24C-5 survey data.



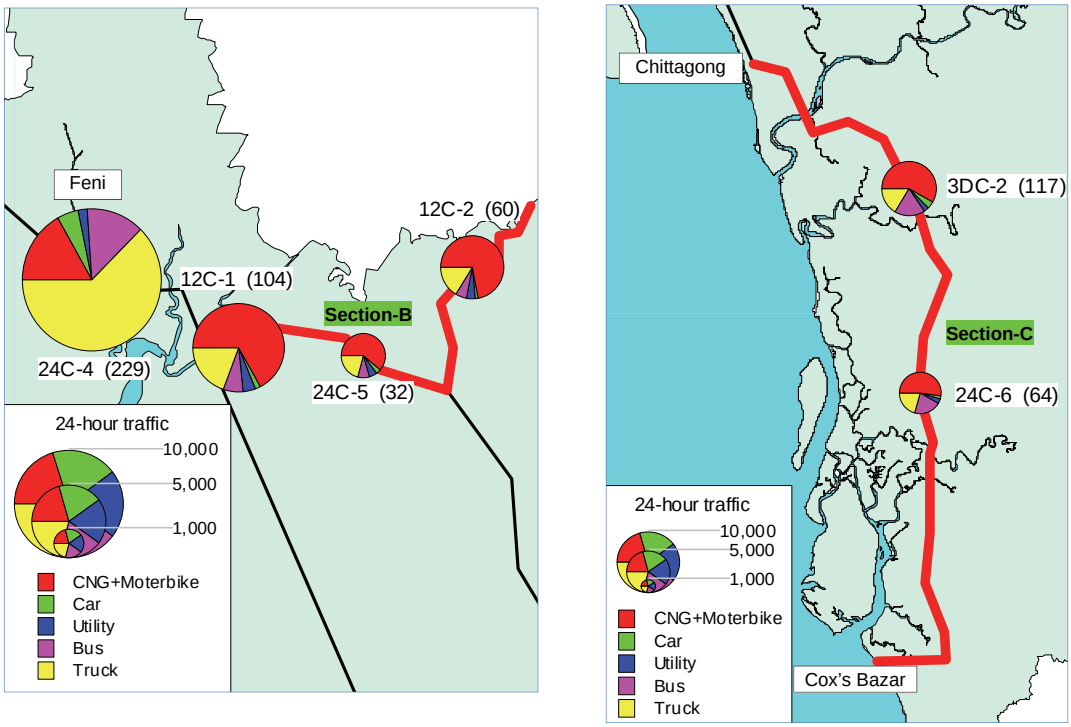
Note: The numerical value of the 12-hour T/C survey was converted into 24-hour traffic by using the day-night ratio that was obtained from the 24C-5 survey data.

Figure 6.1.5 24-Hour Traffic Volume (Weekday)



In ( ), section traffic volume is shown. (100veh/day)

Figure 6.1.6 T/C Survey Result (West Bangladesh)



In ( ), section traffic volume is shown. (100veh/day)

Note: The numerical value of the 12-hour T/C survey was converted into 24-hour traffic by using the day-night ratio that was obtained from the 24C-5 survey data.

Figure 6.1.7 T/C Survey Result (East Bangladesh)

6.1.3 OD Interview Survey Results

Figure 6.1.8–Figure 6.1.12 show the result of assignment of the OD traffic at each crossing point, and Figure 6.1.13 shows the result of assignment of all the traffic crossing the river.

- The traffic passing through the OD-1, Jamuna Bridge, (31,200 pcu[8]/day) was much higher than the ferry traffic.
- Most of traffic passing through OD-1 was of vehicles travelling between Dhaka/Chittagong and the north west part of Bangladesh (Rajshahi Division, Rngpur Division), and there was little traffic travelling to the south west part of Bangladesh.
- As for the traffic between Dhaka/Chittagong and the southwest part of Bangladesh, traffic passing through OD-2 by the Daulatdia-Paturia ferry (11,100 pcu/day) was about double the traffic passing through OD-3 (5,000 pcu/day) by the Mawa-Janjira ferry.
- The traffic passing through OD-4 (800 pcu/day) was smaller than that of the other crossings, and most of the traffic was travelling between Feni/Chittagong and south west part of Bangladesh.
- The traffic passing through Section-A was 1,200–2,200 pcu/day between Benapole and Jessore, 100–900 pcu/day between Jessore and Kalna ferry terminal, and 2,900 pcu/day between Kalna ferry terminal and Bhanga, and 5,000 pcu/day between Bhanga and Mewa.

[8] pcu (passenger car unit) value: Car=1.0, Utility=1.0, Bus=3.0, Truck=3.0
Geometric Design Standards for Roads & Highways Department, Draft Verson 4, Ministry of Communications Roads and Railways Division, October 2000

(Unit: 100 pcu/day)

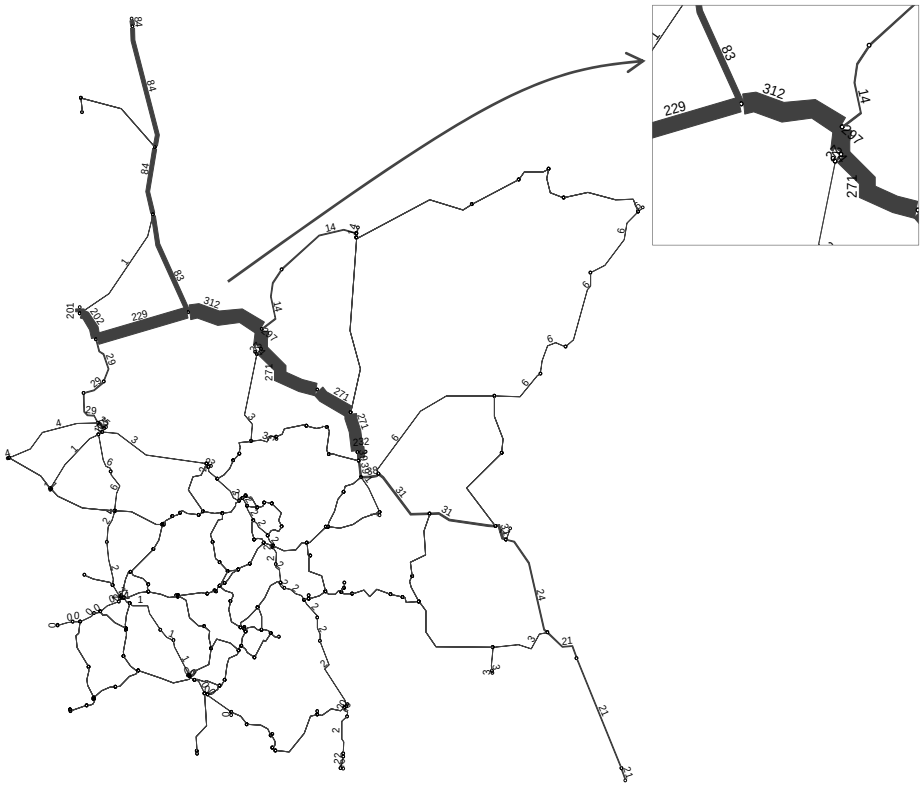


Figure 6.1.8 Traffic Passing through OD-1 (Jamuna Bridge)

(Unit: 100 pcu/day)

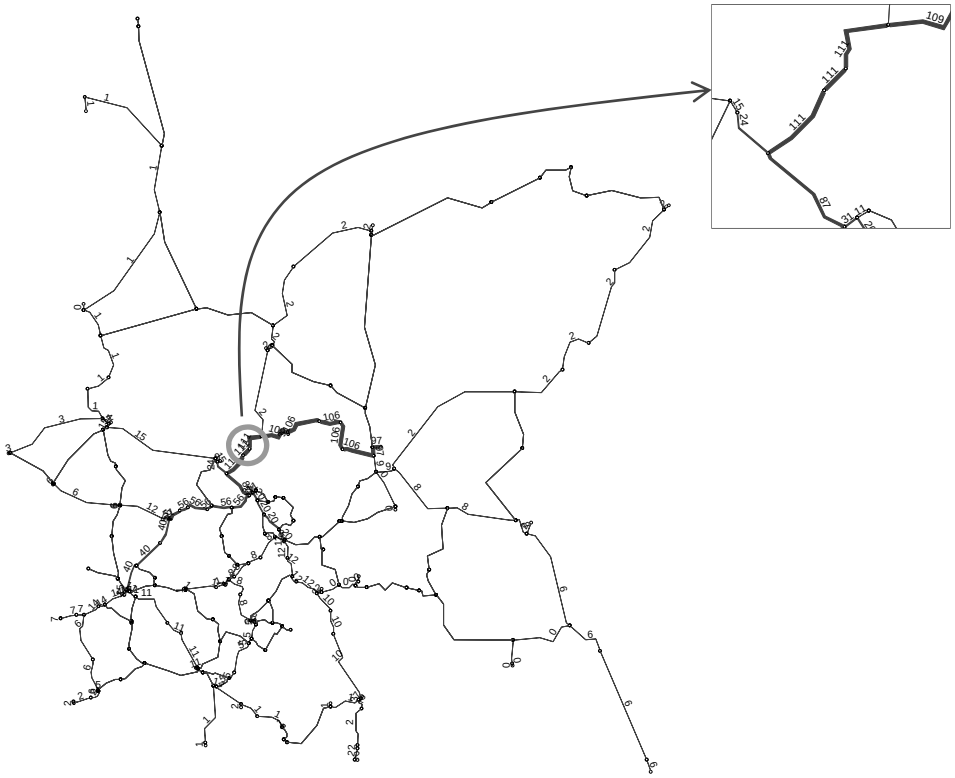


Figure 6.1.9 Traffic Passing through OD-2 (Daulatdia-Paturia Ferry)

(Unit: 100 pcu/day)

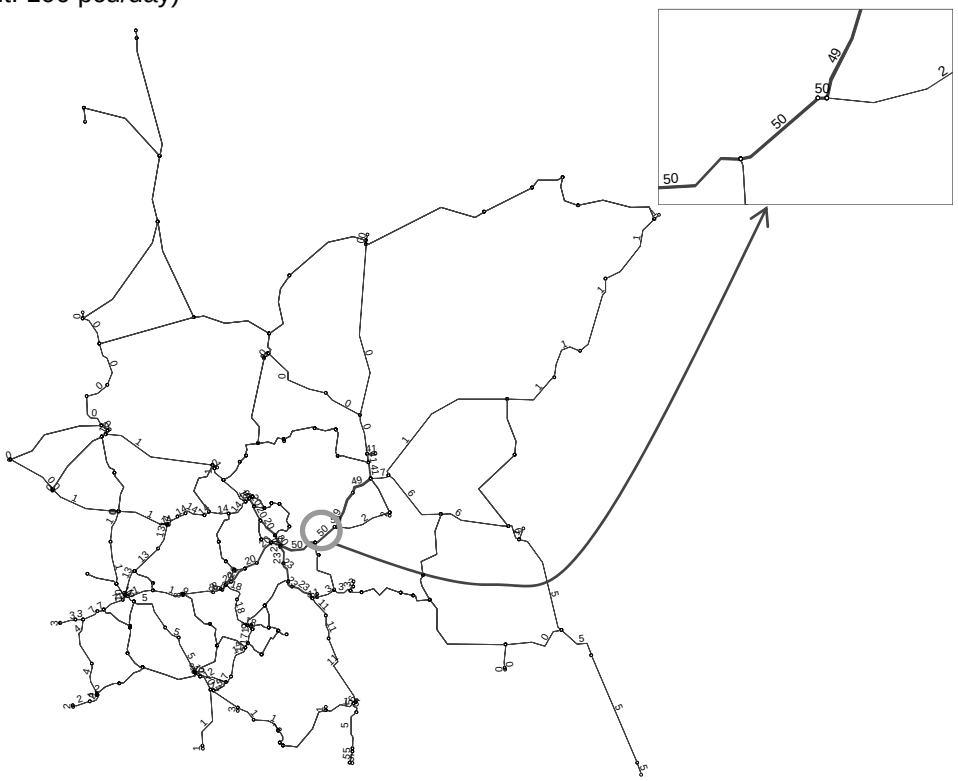


Figure 6.1.10 Traffic Passing through OD-3 (Mawa-Janjira Ferry)

(Unit: 100 pcu/day)

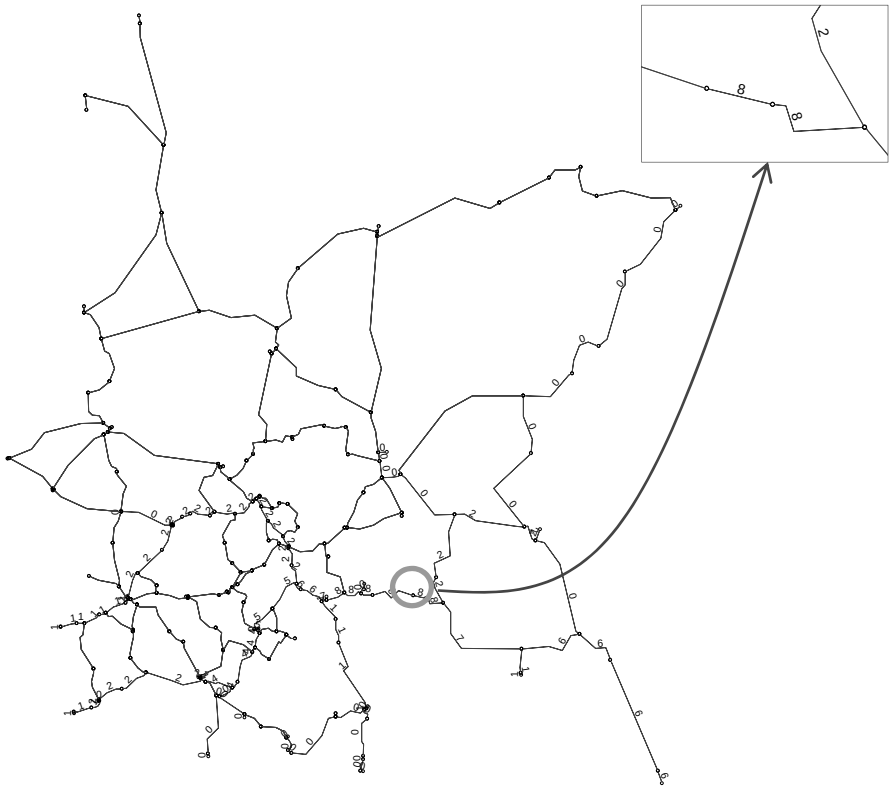


Figure 6.1.11 Traffic Passing through OD-4 (Chandpur-Bhedarganj Ferry)

(Unit: 100 pcu/day)

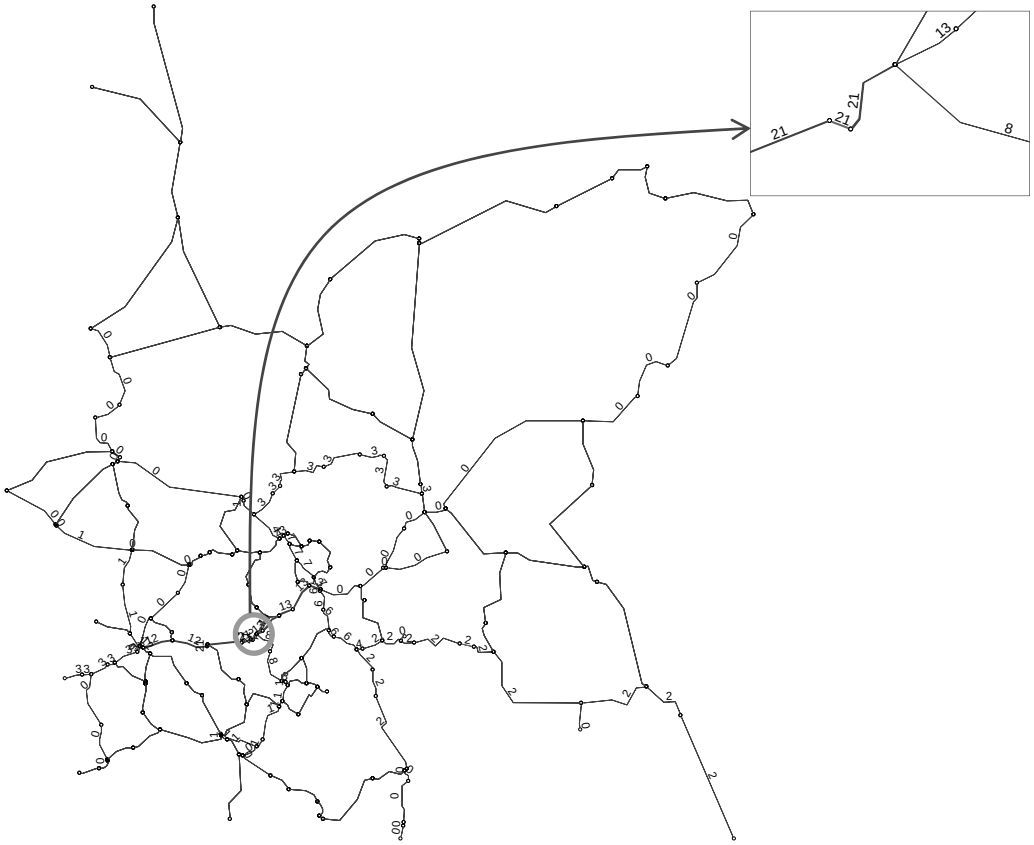


Figure 6.1.12 Traffic Passing through OD-5 (Kalna Ferry)

(Unit: 100 pcu/day)

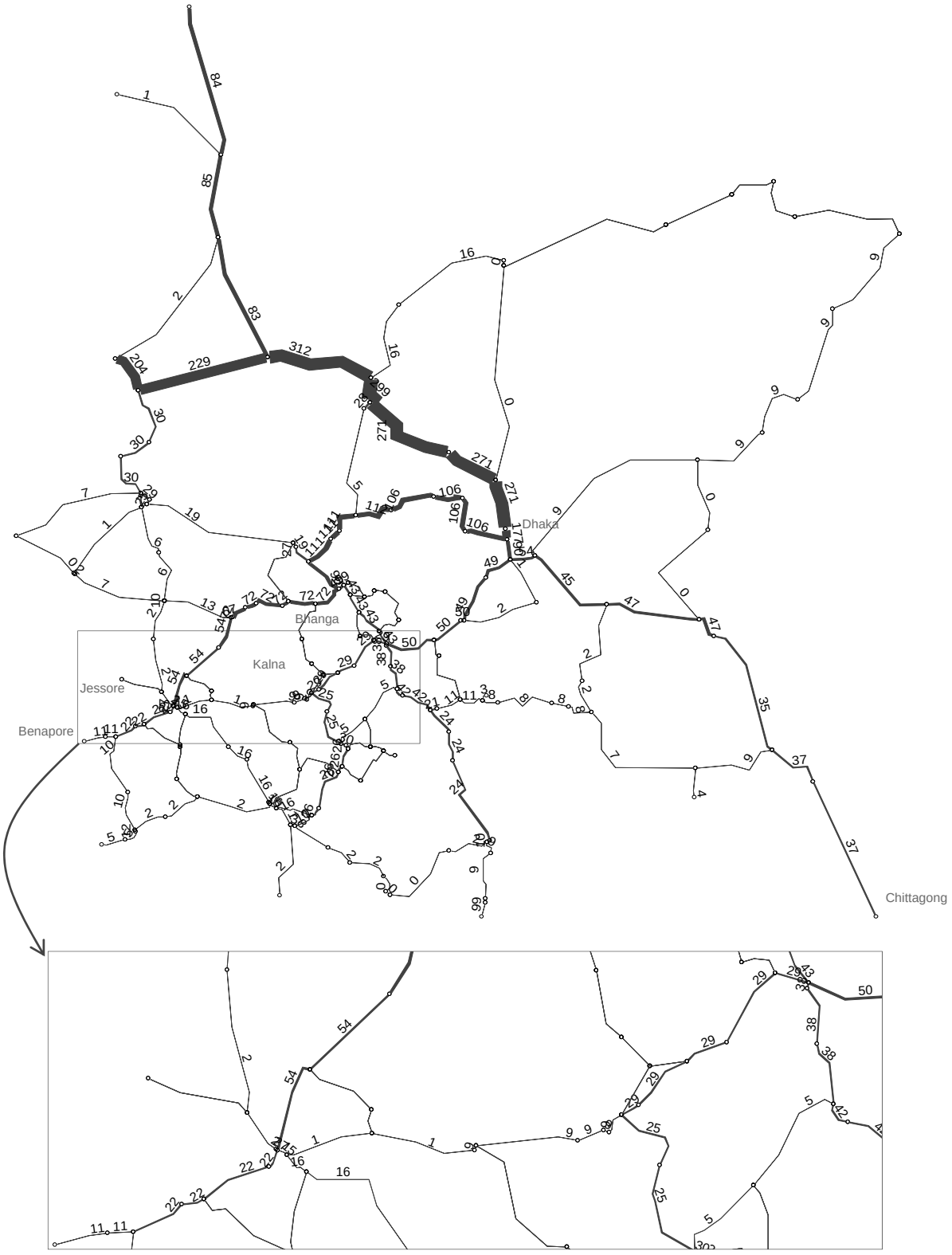


Figure 6.1.13 All the Traffic Crossing the River

6.2 Future Traffic Demand Forecasting

6.2.1 Forecasting Procedure

The future traffic demand in the Section-A is expected to grow considerably by the diversion of traffic from another routes, because the Padma Bridge will open after a few years, and ADB has a plan to widen Section-A to a 4-lane road. Therefore, it is indispensable to build a comprehensive traffic forecasting model that includes not only Section-A but also extensive road networks, in order to forecast the future demand that considers those influences.

For this purpose, we implemented the traffic survey to grasp the OD data on Section-A and on the river crossing points of alternative routes (see Section 6.1.3), and also we estimated the ideal OD matrix by using the present population by zone and existing observed traffic volumes, and then made the present OD matrix by combining those data. After preparing the present OD matrix, we formulated the mathematical model to reflect the universal relation between present traffic situations and socioeconomic data.

Furthermore, the international transit traffic which will go through Bangladesh were forecasted and added to the related road network, under the premise that BBIN-VBA is concluded and it will be enforced by 2020. Here is the outline flowchart of the demand forecasting.

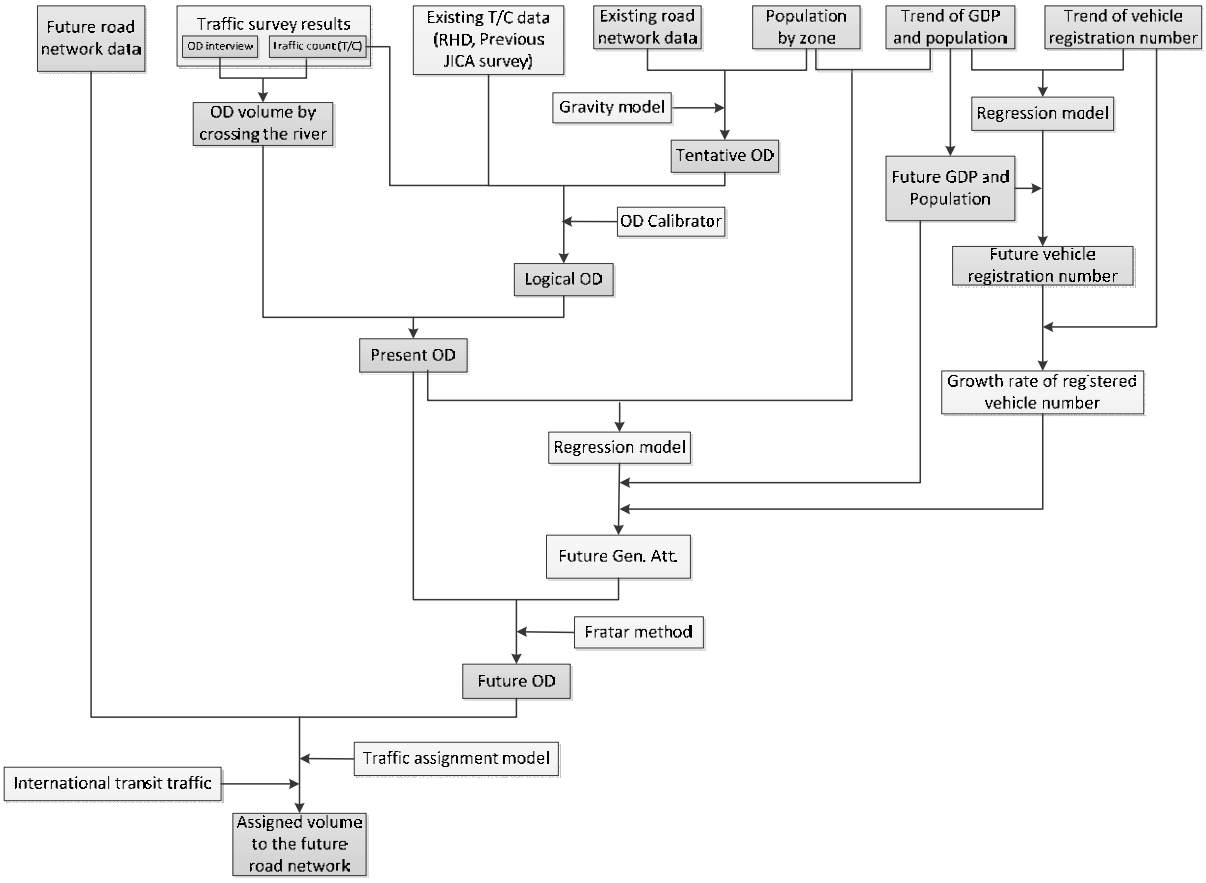


Figure 6.2.1 Outline flowchart of demand forecasting

6.2.2 Zoning

Zoning is set by district-base along the Section-A, and by division-base outside in Bangladesh. Furthermore, major land ports and Mongla seaport are numbered each, and total zone number is 34.

Table 6.2.1 Zoning table

No.	Division	Zone name (District name)
1	Khulna	Jessore
2	Khulna	Narail
3	Khulna	Magura
4	Khulna	Jhenaidah
5	Khulna	Kushtia
6	Khulna	Meherpur
7	Khulna	Chuadanga
8	Khulna	Satkhira
9	Khulna	Khulna
10	Khulna	Bagerhat
11	Dhaka	Gopalganj
12	Dhaka	Madaripur
13	Dhaka	Faridpur
14	Dhaka	Rajbari
15	Dhaka	Shariatpur
16	Dhaka	Jamalpur, Sherpur, Mymemsingh, Netrakona, Kishoreganj
17	Dhaka	Tangail
18	Dhaka	Manikganj
19	Dhaka	Dhaka, Narayanganj, Gazipur
20	Dhaka	Munshiganj
21	Rajshahi	All
22	Rangpur	All
23	Sylhet	All
24	Chittagong	Brahmanbaria, Comilla, Feni
25	Chittagong	Chandpur, Lakshmipur, Noakhali
26	Chittagong	Chittagong, Khagrachhari, Rangamati, Bandarban, Cox's Bazar
27	Barisal	Barisal
28	Barisal	Pirojpur
29	Barisal	Jhalakati
30	Barisal	Barguna, Patuakhali, Bhola
31	-	Benapole Land Port
32	-	Bhomra Land Port
33	-	Mongla Sea Port
34	-	Hilli Land Port

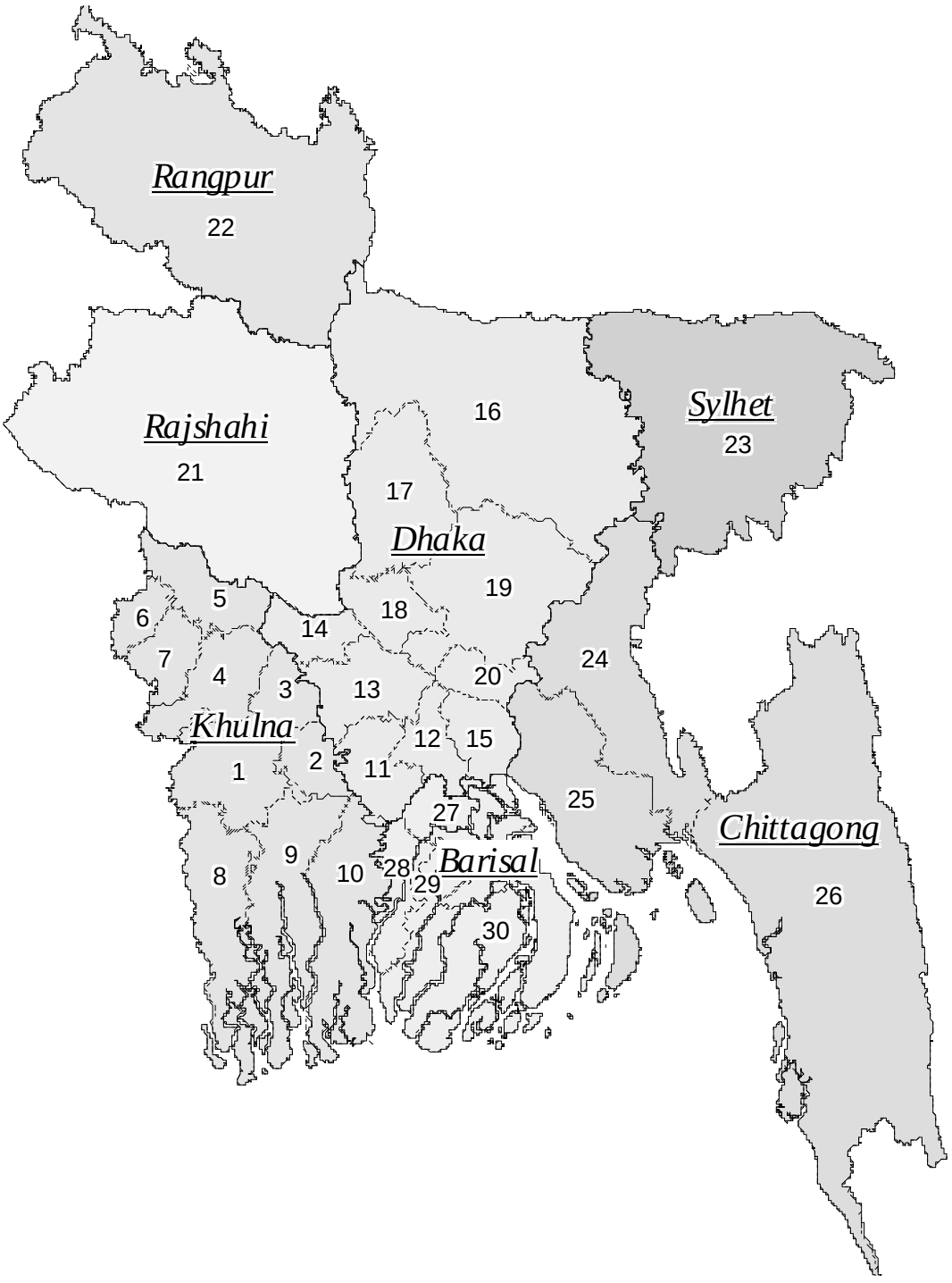


Figure 6.2.2 Zoning map

6.2.3 Future socioeconomics structure

(1) Population

1) Population in Bangladesh

The number of population in Bangladesh in the future was estimated by using the result of the population in 2050[9] that had issued in March 2006, and the result of population census in 2001 and 2011 by Bangladesh Bureau of Statistics (BBS) (see Figure 6.2.3 and Table 6.2.2).

The population will increase by 33% in 2045, from 151 million to 201 million people.

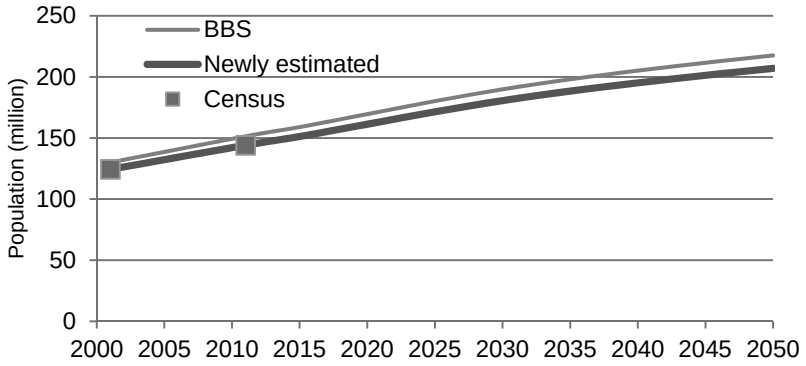


Figure 6.2.3 Future population in Bangladesh

Table 6.2.2 Future population in Bangladesh

(Unit: million people)

	2001	2011	2015	2020	2025	2030	2035	2040	2045
BBS	130.02	151.41	158.96	169.54	180.20	189.85	198.03	205.12	211.61
Pop. Census	124.36	144.04	-	-	-	-	-	-	-
Newly estimated	124.36	144.04	151.23	161.29	171.43	180.61	188.40	195.14	201.31

2) Population by division

Future population by division was estimated based on the trend using the result of population census in 2001 and 2011 at first, and then total number was adjusted as shown in Table 6.2.2. Furthermore, future population by division was calculated on the basis of the assumption that the population growth in Khulna division will be the same as that of the nationwide average growth in 2045, because the population in Khulna division will grow considerably after 2025 by the opening of the Padma Bridge and by the widening of Section-A to 4 lanes (see Table 6.2.3)

.

[9] *Sectorial Need-based Projections in Bangladesh*. Bangladesh Bureau of Statistics, March 2006

Table 6.2.3 Future population by division

(Upper: million people/ Lower: Average annual growth rate)

Division	Census		Annual growth	Estimated population						
	2001	2011		2015	2020	2025	2030	2035	2040	2045
Barisal	8.17	8.33	0.2%	8.30 (-0.1%)	8.28 (0.0%)	8.28 (0.0%)	8.28 (0.0%)	8.28 (0.0%)	8.28 (0.0%)	8.28 (0.0%)
Chittagong	24.29	28.42	1.6%	29.94 (1.3%)	32.04 (1.4%)	34.10 (1.3%)	35.90 (1.0%)	37.35 (0.8%)	38.52 (0.6%)	39.51 (0.5%)
Dhaka	39.04	47.42	2.0%	50.70 (1.7%)	55.28 (1.7%)	59.94 (1.6%)	64.30 (1.4%)	68.16 (1.2%)	71.62 (1.0%)	74.84 (0.9%)
Khulna	14.71	15.69	0.6%	15.92 (0.4%)	16.27 (0.4%)	16.70 (0.5%)	17.14 (0.5%)	17.56 (0.5%)	18.02 (0.5%)	18.59 (0.6%)
Rajshahi	16.35	18.48	1.2%	19.20 (1.0%)	20.20 (1.0%)	21.12 (0.9%)	21.86 (0.7%)	22.35 (0.4%)	22.65 (0.3%)	22.84 (0.2%)
Rangpur	13.85	15.79	1.3%	16.46 (1.0%)	17.38 (1.1%)	18.26 (1.0%)	18.98 (0.8%)	19.49 (0.5%)	19.84 (0.4%)	20.09 (0.2%)
Sylhet	7.94	9.91	2.2%	10.71 (2.0%)	11.84 (2.0%)	13.01 (1.9%)	14.15 (1.7%)	15.21 (1.4%)	16.20 (1.3%)	17.16 (1.2%)
Total	124.36	144.04	1.5%	151.23 (1.2%)	161.29 (1.3%)	171.41 (1.2%)	180.61 (1.0%)	188.40 (0.8%)	195.13 (0.7%)	201.31 (0.6%)

3) Population by zone

Future population by zone was estimated based on the trend, using the result of population census in 2001 and 2011 at first, and then total number by division was adjusted as shown in Table 6.2.3. Furthermore, the future population by zone was modified on the basis of the assumption that the population growth rate in zone 1 and 2 in Khulna Division, where the Section-A comes across, will be the same as that of the nationwide average growth rate in 2045, because the population in zone 1 and 2 will grow considerably from 2025 by the opening of the Padma Bridge and by the widening Section-A to 4 lanes Section.

And also, assuming that the population growth rate in zone 11, 12, 13 and 15, where the Section-A comes across, and located in the west bank of the Padma river in Dhaka Division, will be the same as that of zone 1 and 2, the population of the zones were modified (see Table 6.2.4).

Table 6.2.4 Future population by zone

(Unit: million people)

Division	Zone		2015	2020	2025	2030	2035	2040	2045
Khulna	1	Jessore	2.86	2.98	3.22	3.55	3.99	4.55	5.25
	2	Narail	0.72	0.72	0.75	0.80	0.86	0.94	1.04
	3	Magura	0.95	0.99	1.03	1.05	1.07	1.07	1.08
	4	Jhenaidah	1.83	1.91	1.99	2.05	2.08	2.10	2.11
	5	Kushtia	2.01	2.10	2.18	2.24	2.28	2.30	2.30
	6	Meherpur	0.68	0.70	0.73	0.74	0.75	0.76	0.76
	7	Chuadanga	1.17	1.22	1.27	1.31	1.33	1.34	1.35
	8	Satkhira	2.01	2.05	2.08	2.08	2.07	2.03	1.99
	9	Khulna	2.27	2.21	2.14	2.05	1.95	1.83	1.71
	10	Bagerhat	1.43	1.38	1.32	1.25	1.18	1.09	1.01
Dhaka	11	Gopalganj	1.16	1.14	1.15	1.19	1.24	1.31	1.40
	12	Madaripur	1.16	1.15	1.17	1.21	1.27	1.35	1.44
	13	Faridpur	1.72	1.68	1.69	1.74	1.80	1.89	2.00
	14	Rajbari	1.09	1.12	1.15	1.15	1.13	1.10	1.06
	15	Shariatpur	1.17	1.19	1.24	1.31	1.41	1.53	1.68
	16	Mymensingh,etc	14.37	14.89	15.24	15.32	15.14	14.75	14.23
	17	Tangail	3.69	3.79	3.84	3.82	3.74	3.61	3.44
	18	Manikganj	1.42	1.45	1.46	1.45	1.41	1.35	1.28
	19	Dhaka,etc	23.36	27.21	31.29	35.35	39.25	42.97	46.59
	20	Munshiganj	1.56	1.65	1.72	1.76	1.76	1.75	1.72
Rajshahi	21	Rajshahi	19.20	20.20	21.12	21.86	22.35	22.65	22.84
Rangpur	22	Rangpur	16.46	17.38	18.26	18.98	19.49	19.84	20.09
Sylhet	23	Sylhet	10.71	11.84	13.01	14.15	15.21	16.20	17.16
Chittagong	24	Kumilla,etc	13.89	14.83	15.75	16.55	17.17	17.65	18.05
	25	Noakhali,etc	10.32	10.88	11.41	11.84	12.13	12.31	12.43
	26	Chittagong,etc	5.73	6.32	6.93	7.52	8.06	8.55	9.03
Barisal	27	Barisal	2.29	2.25	2.21	2.17	2.14	2.10	2.07
	28	Pirojpur	1.10	1.09	1.08	1.07	1.06	1.05	1.04
	29	Jhalakati	0.67	0.66	0.65	0.64	0.62	0.61	0.60
	30	Barguna,etc	4.24	4.29	4.35	4.40	4.46	4.52	4.58
Total			151.23	161.29	171.43	180.61	188.40	195.14	201.31

(2) GDP and GRDP

1) GDP

The future real GDP annual growth was set at 7% until 2025, 6.5% from 2026 to 2035, and 6% from 2036 to 2045 by using the real GDP growth from 2005 to 2013.

The GDP per capita, which is 59,000 TK (1.0) in 2015, will grow to 102,000 TK (1.7 times), 174,000 TK (2.9 times), and 291,000 TK (4.9 times) in 2025, 2035 and 2045, respectively.

The decennial annual GDP growth is 5.6% (2015–2025), 5.5% (2025–2035), and 5.3% (2035–2045).

Table 6.2.5 Real GDP (Base year: 2005)

(Unit: billion TK)

FY	Real GDP	Estimated GDP	AAGR (%)	Population (million)	GDP/capita (TK)	Multiplying factor
2005	4,823.37					
2006	5,163.83					
2007	5,474.37					
2008	5,750.56		6.10%			
2009	6,070.97					
2010	6,463.42					
2011	6,884.93			144.04	48,000	
2012	7,298.97					
2013		7,761.90	6.34%			
2014		8,279.71	6.67%			
2015		8,859.29	7.00%	151.23	59,000	1.0 (Base)
2020		12,425.61	7.00%	161.29	77,000	1.3
2025		17,427.56	7.00%	171.43	102,000	1.7
2030		23,877.26	6.50%	180.61	132,000	2.2
2035		32,713.92	6.50%	188.40	174,000	2.9
2040		43,778.60	6.00%	195.14	224,000	3.8
2045		58,585.64	6.00%	201.31	291,000	4.9

2) GRDP by division

BBS didn't disclose GRDP to the public; therefore GRDP by division was estimated by using the GRDP by district in 1995 and 2005 which had been estimated by CPD (Centre for Policy Dialogue), and then total of GRDP was adjusted as shown in Table 6.2.5.

And then, GRDP by division was modified on the basis of the assumption that the GRDP growth rate in Khulna Division where the Section-A comes across will be the same as that of the nationwide average growth rate in 2045, because the population in Khulna Division will grow considerably from 2025 by the opening of the Padma Bridge and the widening to 4 lanes of the Section-A (see Table 6.2.6).

Table 6.2.6 Real GRDP by division（Base year: 2005）

(Unit: billion TK)

Division	2015	2020	2025	2030	2035	2040	2045
Barishal	586.52	813.75 (6.8%)	1,128.09 (6.8%)	1,526.51 (6.2%)	2,064.07 (6.2%)	2,724.02 (5.7%)	3,592.30 (5.7%)
Chittagong	3,332.57	4,741.99 (7.3%)	6,742.09 (7.3%)	9,356.69 (6.8%)	12,975.49 (6.8%)	17,562.36 (6.2%)	23,753.03 (6.2%)
Dhaka	1,797.97	2,527.87 (7.0%)	3,551.26 (7.0%)	4,869.73 (6.5%)	6,672.66 (6.5%)	8,923.84 (6.0%)	11,925.65 (6.0%)
Khulna	1,133.11	1,555.74 (6.6%)	2,144.81 (6.6%)	2,900.60 (6.3%)	3,939.48 (6.3%)	5,248.72 (6.0%)	7,023.97 (6.0%)
Rajshahi	714.95	978.95 (6.5%)	1,339.39 (6.5%)	1,788.73 (5.9%)	2,387.01 (5.9%)	3,109.02 (5.4%)	4,046.40 (5.4%)
Rangpur	777.07	1,082.53 (6.8%)	1,506.87 (6.8%)	2,047.40 (6.3%)	2,779.75 (6.3%)	3,683.53 (5.8%)	4,877.55 (5.8%)
Sylhet	517.10	724.78 (7.0%)	1,015.05 (7.0%)	1,387.60 (6.4%)	1,895.46 (6.4%)	2,527.11 (5.9%)	3,366.74 (5.9%)
Total	8,859.29	12,425.61 (7.0%)	17,427.56 (7.0%)	23,877.26 (6.5%)	32,713.92 (6.5%)	43,778.60 (6.0%)	58,585.64 (6.0%)

3) GRDP by zone

GRDP by zone was estimated based on the trend by using the GRDP by district in 1995 and 2005 which had been estimated by CPD, and then the total of each division was adjusted as Table 6.2.6 shows.

And then, GRDP by zone was modified on the basis of the assumption that the GRDP growth rate in zone 1 and 2 in Khulna Division, where the Section-A comes across, will be the same as that of the nationwide average growth rate in 2045, because the population in zone 1 and 2 will grow considerably after 2025 by the opening of the Padma Bridge and the widening to 4 lanes of the Section-A.

And also, assuming that the GRDP growth rate in zone 11, 12, 13 and 15 where the Section-A comes across and located in the west bank of the Padma river in Dhaka Division, will be the same as the growth rate in zone 1 and 2, the population in zones were modified (see Table 6.2.7).

Table 6.2.7 Real GRDP by zone (Base year: 2005)

(Unit: billion TK)

Zone			2015	2020	2025	2030	2035	2040	2045
Khulna	1	Jessore	202.07	279.04	386.73	525.51	716.81	958.73	1,287.39
	2	Narail	41.55	54.00	70.43	90.06	115.61	145.52	183.90
	3	Magura	56.23	76.92	105.59	142.13	192.05	254.44	338.45
	4	Jhenaidah	114.49	158.01	218.87	297.25	405.24	541.71	727.03
	5	Kushtia	106.63	140.70	186.32	241.93	315.32	402.98	517.06
	6	Meherpur	37.12	49.67	66.70	87.82	116.07	150.42	195.71
	7	Chuadanga	57.62	75.99	100.58	130.54	170.06	217.23	278.59
	8	Satkhira	137.13	192.48	271.17	374.56	519.36	706.11	963.83
	9	Khulna	251.90	348.82	484.78	660.59	903.58	1,211.91	1,631.92
	10	Bagerhat	128.36	180.11	253.64	350.21	485.39	659.66	900.07
Dhaka	11	Gopalganj	26.29	34.33	44.76	56.91	72.21	89.36	110.41
	12	Madaripur	26.24	35.00	46.63	60.58	78.56	99.33	125.40
	13	Faridpur	43.39	58.43	78.54	102.95	134.70	171.86	218.90
	14	Rajbari	23.36	31.15	41.47	53.84	69.78	88.20	111.27
	15	Shariatpur	24.21	32.35	43.14	56.10	72.83	92.20	116.51
	16	Mymensingh	326.98	437.52	584.35	761.02	989.39	1,254.23	1,587.31
	17	Tangail	95.09	132.57	184.47	250.30	339.03	447.78	590.43
	18	Manikganj	37.25	50.68	68.82	91.14	120.48	155.29	199.84
	19	Dhaka	1,161.69	1,670.89	2,398.87	3,358.26	4,693.14	6,395.25	8,700.15
	20	Munshiganj	33.50	44.95	60.21	78.64	102.54	130.36	165.45
Rajshahi	21	Rajshahi	714.95	978.95	1,339.39	1,788.73	2,387.01	3,109.02	4,046.40
Rangpur	22	Rangpur	777.07	1,082.53	1,506.87	2,047.40	2,779.75	3,683.53	4,877.55
Sylhet	23	Sylhet	517.10	724.78	1,015.05	1,387.60	1,895.46	2,527.11	3,366.74
Chittagong	24	Kumilla	895.42	1,269.54	1,798.18	2,485.62	3,432.67	4,626.04	6,228.57
	25	Noakhali	602.39	834.74	1,155.55	1,561.15	2,107.15	2,775.40	3,652.22
	26	Chittagong	1,834.75	2,637.71	3,788.36	5,309.92	7,435.66	10,160.92	13,872.24
Sylhet	27	Barisal	176.38	250.57	355.59	492.43	681.25	919.62	1,240.16
	28	Pirojpur	72.22	99.47	136.85	183.74	246.45	322.55	421.73
	29	Jhalakati	45.38	62.76	86.68	116.85	157.35	206.75	271.39
	30	Barisal	292.53	400.95	548.97	733.48	979.02	1,275.09	1,659.02
Total			8,859.29	12,425.61	17,427.56	23,877.26	32,713.92	43,778.60	58,585.64

6.2.4 Road network data for the traffic assignment

The daily road capacity and maximum speed, which are the part of road network data, are set by the following ways:

- Multilane road: $C_D = C_B \times f_{lw} \times f_{rs} \times f_{pv} \times f_{los} \times \frac{N}{2} \times \frac{100}{K} \times \frac{100}{D}$
- 2-lane 2-way road: $C_D = C_B \times f_{lw} \times f_{rs} \times f_{pv} \times f_{los} \times \frac{100}{K}$
- Maximum speed: $V_{max} = V_B \times (1 - \frac{S_r}{100})$

Where

C_D: Daily capacity (pcu/day)
C_B: Basic capacity (pcu/hour)
f_{lw}: Adjustment factor for the lane width
f_{rs}: Adjustment factor for the roadside condition
f_{pv}: Adjustment factor for the pavement condition
f_{los}: Adjustment factor for the level of service
N: Number of lanes in both directions
K: Proportion of daily capacity in the peak direction (%)
D: Proportion of peak-hour traffic in the peak direction (%)
V_{max}: Maximum speed (km/h)
V_B: Basic speed (km/h)
S_r: Speed reduction rate (%)

The capacity and speed for ferry are set by the result of interview to the ferry operator.

Table 6.2.8 Basic capacity

Multi lanes or one-way road	2,200 pcu /h /lane
2 way 2 lanes road	2,500 pcu /h /2 lanes
2 way 1 lane road	500 pcu /h /lane

Table 6.2.9 Adjustment factors for the lane width

Lane width (m)	f_{lw}
W≧3.25	1.0
3.25＞W≧3.00	0.94
3.00＞W≧2.75	0.88
2.75＞W≧2.50	0.82

Table 6.2.10 Adjustment factors for the roadside condition

Zone	1or 2 lanes	3 lanes or more
Urban	0.70	0.75
Others	0.85	0.90

Table 6.2.11 Adjustment factors for the pavement condition and speed reduction rate

Description	IRI rank (m/km)	fpv	Sr (%)
Excellent	<3.0	1.00	0%
Good	<5.5	0.95	10%
Fair	<7.0	0.90	20%
Poor	<10.0	0.85	30%
Bad	≧10.0	0.80	40%

Table 6.2.12 Adjustment factor for the level of service

Road class	f_{los}	LOS
National Highway	0.70	C
Others	0.85	D

Table 6.2.13 K value, D value

Zone	K (%)	D (%)
Urban	8	60
Others	12	55

Table 6.2.14 Basic speed

Road type	Vmax (km/h)	
	Urban	Others
National Highway	60	80
Regional Highway	40	50
Zilla Road, Others (2 lanes)	30	40
Zilla Road, Others (1 lane)	-	30

Table 6.2.15 Ferry capacity and maximum speed

Name of the locations	Distance (km)	Travel time (min)	Capacity (veh/ ferry)	Loading & unloading time (min)	Avg. travel time (min)	Freq. (/day)	No. of ferries operated	Capacity (veh/day)	Speed (km/h)
Daulatdia-Paturia	3.3	35	12	25	60	12	18	5,180	3
Mawa-kawrakandi	15	120	12	30	150	5	12	1,440	6
Chandpur-Shariatpur	9	80	10	30	110	6	3	360	5
Kalna	0.5	7	12	15	22	20	1	480	2

Table 6.2.16 Daily capacity and maximum speed

	Lanes	Basic capacity (pcu/day)	Lane width (m)	Area	Pavement condition	Qmax (pcu/day)	Vmax (km/h)
National Highway	8	2,000	3.25	Urban	Fair	78,800	48
	6	2,000	3.25	Urban	Fair	59,100	48
				Others	Fair	51,500	64
	4	2,000	3.25	Urban	Fair	39,400	48
				Others	Good	36,300	72
					Fair	34,400	64
	2	2,500	3.25	Urban	Fair	13,800	48
				Others	Good	11,800	72
					Fair	11,200	64
					Poor	10,500	56
					Bad	9,900	48
Regional Highway	4	2,000	3.00	Urban	Fair	44,900	32
				Others	Good	41,400	45
					Fair	39,200	40
	2	2,500	3.00	Others	Good	13,400	45
					Fair	12,700	40
					Poor	12,000	35
			2.75	Others	Good	12,600	45
					Fair	11,900	40
					Poor	11,300	35
					Bad	10,600	30
Zilla road, Street	2	2,500	2.75	Others	Fair	11,900	32
					Poor	11,300	28
					Bad	10,600	24
			2.50	Others	Fair	11,100	32
					Poor	10,500	28
					Bad	9,900	24
	1	500	5.00	Others	Fair	2,700	24
					Poor	2,600	21
					Bad	2,400	18
Others	Daulatdia-Paturia ferry					5,180	3
	Mawa-kawrakandi ferry					1,440	6
	Chandpur-Shariatpur ferry					360	5
	Kalna ferry					480	2
	Dummy link					999,999	30

6.2.5 Present and future ODs

(1) Present OD

The OD of traffic crossing the river in the Section-A and alternative routes was grasped by the traffic surveys (see Section 6.1.3), but other OD if traffic not crossing the river were unknown and it was not possible to make the trip generation model which shows the relation between socioeconomic indices by zone and traffic demand in this study. Therefore, present OD table was made by the following steps:

i. Tentative OD table was made by using the present population by zone and distance between zones.

ii. Logical OD table was estimated by making the tentative table fit to the traffic volumes assigned to the network and observed traffic volumes in iterative process.

iii. Present OD table was made by using the actual measured OD that was made in Section 6.1.3 instead of the corresponding values in the logical OD-table.

(2) Future total traffic production

Generally, it is known that traffic production volume correlates highly with the number of the vehicle registration. However, there are no traffic production data in Bangladesh; the traffic production is assumed to be proportional to the expansion of the number of vehicle registration in this study. Therefore, the logarithm approximation model was made from the growth of GDP and the number of the vehicle registration, and then the number of the vehicle registration in the future was forecasted based on it.

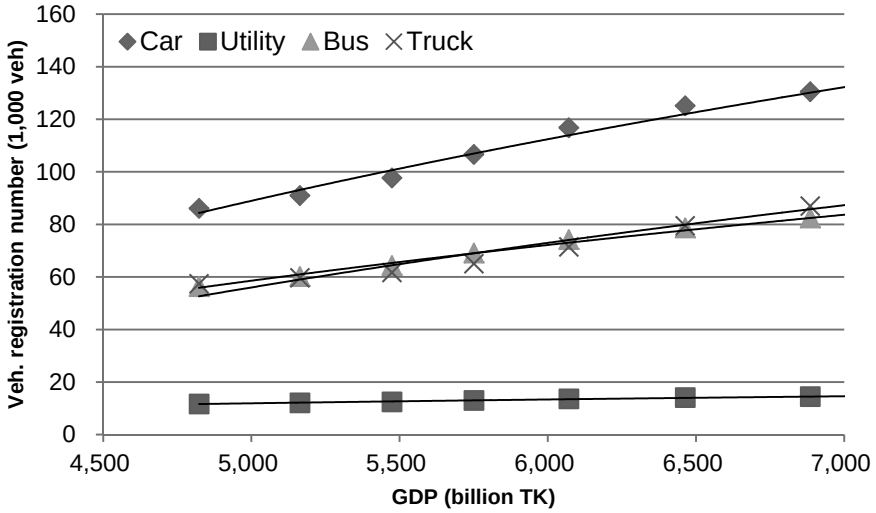


Figure 6.2.4 Relation between GDP and the vehicle registration number

Table 6.2.17 Parameters of the vehicle registration number forecasting model

Vehicle type	a	b	R2
Car	128,600.09	-1,894,677.15	0.982
Utility	7,976.07	-111,106.55	0.989
Bus	74,592.98	-1,092,020.42	0.994
Truck	93,030.77	-1,378,987.31	0.950

$$\text{Vehicle registration Number} = a \times \ln(\text{GDP [million TK]}) + b$$

Table 6.2.18 Present and future vehicle registration numbers

(Unit: vehicles)

	FY	Car	Utility	Bus	Truck
Actually measured	2005	86,100	11,704	56,347	57,399
	2006	90,962	12,090	60,163	59,674
	2007	97,661	12,506	64,390	61,717
	2008	106,664	13,028	69,143	65,064
	2009	116,824	13,625	74,207	71,424
	2010	125,177	14,119	78,676	79,462
	2011	130,517	14,489	82,466	86,985
	2012	134,800	14,803	85,811	94,324
Estimated	2015	162,500	16,500	101,200	109,200
	2020	206,000	19,200	126,500	140,700
	2025	249,500	21,900	151,700	172,200
	2030	290,000	24,400	175,200	201,500
	2035	330,500	26,900	198,700	230,800
	2040	368,000	29,200	220,400	257,900
	2045	405,500	31,600	242,200	285,000

The amount of present total traffic production was multiplied by the growth rate of the estimated number of vehicle registration, and the future total traffic production was calculated.

Table 6.2.19 Future total traffic production

(Unit: vehicle/day)

FY	Car	Utility	Bus	Truck
2015	8,200	4,900	26,300	44,400
2020	10,300	6,200	33,400	56,300
2025	12,500	7,500	40,400	68,200
2030	14,500	8,700	47,000	79,200
2035	16,600	9,900	53,600	90,300
2040	18,500	11,000	59,600	100,500
2045	20,300	12,200	65,700	110,800

(3) Future traffic generation by zone

The traffic generation model was made by the linear regression by using a socio economic indicator and dummy variables, and present traffic generation by zone that was calculated from the present OD table.

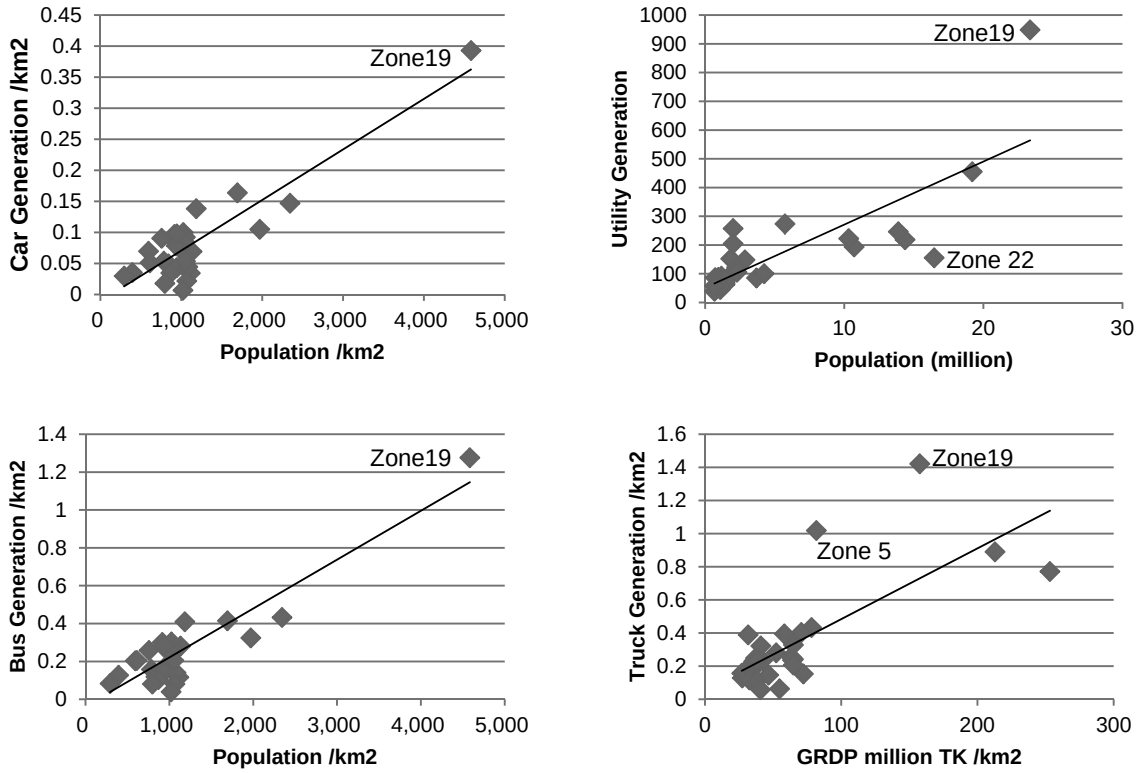


Figure 6.2.5 Relation between traffic generation by vehicle type and the explanatory variables

Table 6.2.20 Parameters of vehicle generation models

Vehicle type	Dependent variable	Independent variable			R2
		X	Dummy1	Dummy2	
Car	Gen./Area	Population/Area	Zone 19	Zone 5	0.933
		$6.6202e^{-5}$	0.0893	0.0596	
Utility	Generation	Population	Zone 19	Zone 22	0.954
		$1.5568e^{-5}$	511.945	-173.582	
Bus	Gen./Area	Population/Area	Zone 19	Zone 5	0.945
		$2.0290e^{-4}$	0.3465	0.1690	
Truck	Gen./Area	GRDP/Area	Zone 19	Zone 5	0.948
		$3.9161e^{-3}$	0.8047	0.6988	

The future traffic generations by zone by vehicle type were calculated by using the above-mentioned models, and then those were modified so that total amount of traffic generation

would be the same as the total traffic production, and the results are assumed to be the future traffic generation (=attraction) by zone.

(4) Land port traffic

It was difficult to grasp the movement of traffic related to the land ports by the section traffic count survey which had been implemented in this study; therefore, the traffic related to the land port was estimated by converting the annual freight volume handed by the land port to daily truck volume. Moreover, all trucks are assumed to return to the origin empty after they carry goods to the destination, so that traffic volume is double of truck numbers. The future traffic related to the land port was estimated by using the growth rate of GDP in Bangladesh.

Table 6.2.21 Future traffic volume related to the land port

Land port	FY2013 (ton)				Land port related traffic (veh/day/both directions)							
	Import	Export	Total	t/day	2013	2015	2020	2025	2030	2035	2040	2045
Benapole	1,252,250	300,274	1,552,524	4,253	850	970	1,360	1,910	2,620	3,580	4,790	6,420
Bhomra	1,458,413	44,299	1,502,712	4,117	830	940	1,320	1,850	2,540	3,470	4,650	6,220
Hilli	851,759	23,870	875,629	2,399	480	550	770	1,080	1,480	2,020	2,710	3,620
Akhaura	251	278,377	278,628	763	150	170	240	340	470	640	860	1,150

Note: The average load capacity of a truck is assumed to be 10 tons.

(5) Mongla seaport traffic

According to the ADB report[10], 89,000 tons of the 117,000 tons exported through the Mongla seaport in 2008 were frozen foods, mostly produced in Khulna. The average load capacities of the 40ft reefer container and general truck are assumed to be 25 ton and 10 ton respectively. And the traffic related to Mongla seaport in a day was assumed as 25 trucks in one way, 10 trucks coming from Khulna, and 15 trucks from Dhaka.

Table 6.2.22 Mongla seaport traffic in 2008

	Total volume (ton/year)	Breakdown			Conversion factor (ton/veh)	veh/day (one way)	Major Org/dest
		Cargo type	ton/year	ton/day			
Export	117,100	Flozen food	89,000	244	25	10	Khulna
		General	28,100	77	10	8	Dhaka
Import	25,300	General	25,300	69	10	7	Dhaka

The future traffic related to the Mongla seaport was estimated by using the growth rate of GDP in Bangladesh.

[10] *Bangladesh: Port and Logistics Efficiency Improvement, Section 2: Summary and Recommendation for Mongla Port,* Asian Development Bank, July 2011

Table 6.2.23 Future traffic volume related to the Mongla seaport

(Unit: veh/day/one way)

FY	Khulna	Dhaka
2008	10	15
2015	15	23
2020	22	32
2025	30	45
2030	42	62
2035	57	85
2040	76	114
2045	102	153

(6) Future OD Table

Future OD table was calculated by the Fratar method by using the present OD table and future generation and attraction by zone that were obtained in (3) and (4) at first, and then traffic related to the Mongla seaport that was obtained in (5) was added to the table.

(7) International transit in Bangladesh

The traffic between north-east area of India /Bhutan and West Bengal and to the west /Seaports make a detour a lot, because such international transit traffic is not permitted to pass in Bangladesh up to now. However, Bangladesh, Bhutan, India, and Nepal concluded an agreement (BBIN-MVA) that concerns international transit traffic in July 2015, and the international transit traffic will be permitted to pass through Bangladesh by 2020. Therefore, traffic currently making a detour will pass through Bangladesh in the future.

1) Truck

The international freight traffic that may pass through Bangladesh is as shown in Table 6.2.24, according to the “Transit through Bangladesh: Prospect and Challenges”[11]

[11] Mohammad Yunus, Senior Research Fellow, Bangladesh Institute of Development Studies (Oct. 2014)

Table 6.2.24 Potential international transit freight traffic by corridor (2015)

Road Transit Corridors	Amount (TEUs)
RD-1: Gdwahati-Dawki/Tamabil-Mawa-Narail-Jessore-Benapole/Petrapole -Kolkata	-
RD-2: Silchar-Sutakandi -Mawa-Narail-Jessore-Benapole/Petrapole -Kolkata	163,497
RD-3: Agartala-Akhaura -Mawa-Narail-Jessore-Benapole/Petrapole -Kolkata	14,762
Sub-total	178,259
RD-4: Guwahati-Dawki/Tamabil -Chittagong Seaport	7,177
RD-5: Silchar-Sutarkandi -Chittagong Seaport	34,638
RD-6: Agartala-Sabsun/Ramgarh -Chittagong Seaport	41,640
Sub-total	83,455
RD-7: Kathmandu-Kakarvita-Phulbari/Banglabandha -Mongla Seaport	45,719
RD-8: Thimphu-Phuentsholing/Jaigagon-Chengrabandha/Burimari -Mongla Seaport	8,689

Source: Table 5: Potential Diversion of Traffic through Different Transit Corridors, Transit through Bangladesh: Prospect and Challenges

All international freights are assumed to carry 20-feet container and 40-feet container to the destination in halves, and return empty containers to the origin. In such case, the traffic that pass Section A and B becomes 732 and 346 veh/day by round trip respectively.

Table 6.2.25 Potential international transit freight traffic by section (2015)

Section	TEU/year	TEU/day	20-ft trailer (veh/day)	40-ft trailer (veh/day)	Traffic volume (Veh/day)
A	178,259	488	244	122	732
B	83,455	229	115	58	346

The future transit traffic, that is assumed to be proportional to the annual growth rate (5.0%)[12] of the real GDP of India in the future, is shown in Table 6.2.26.

Table 6.2.26 International transit freight traffic by section in the future

(Unit: veh/day)

Section	2020	2025	2030	2035	2040	2045
A	750	769	788	808	828	849
B	355	364	373	382	392	402

2) Bus and passenger car

Two round trip buses that connect north-eastern India and Kolata and pass through Bangladesh have started operation in 2015; this traffic is equal to 1 veh/day. On the other hand, the transit passenger vehicle traffic is assumed to be 5 veh/day at most in 2015, because of the long distance.

The future traffic is assumed to be proportional to annual growth rate (5.0%) of the real GDP of India.

[12] *The world in 2050 Will the shift in global economic power growth* (Feb. 2015), by PwC

The international transit traffic that will pass the Section-A in the future is as shown in Table 6.2.27.

Table 6.2.27 International transit traffic passing Section-A in the future

Veh type	2015	2020	2025	2030	2035	2040	2045
Bus (veh/day)	1	1	2	2	3	3	4
Car (veh/day)	5	6	8	10	13	17	22
Truck (veh/day)	732	750	769	788	808	828	849
Total (pcu/day)	2,204	2,259	2,321	2,380	2,446	2,510	2,581

6.2.6 Traffic assignment

The traffic assignment was based on the incremental assignment method (assignment rate: 35%, 25%, 15%, 10%, 10%, and 5%).

Table 6.2.28 Assignment cases

Case name	Road condition (Benapole – Mawa)	Br-1 Jhikorgacha	Br-2 Tularampur	Br-3 Hawai Khali	Br-4 Kalna	Br-5 Garakola
With	NH level, 4 lanes, good pavement condition road, Padma Bridge open.	National Highway level, 4 lanes, good pavement condition, bridges open.				
Without		NH level, 2 lanes (5.5 m), bad condition, bridge closed	RH level, 2 lanes (6.8 m), bad condition, bridge closed	Zilla road level, 2 lanes (7.3 m), bad condition, bridge closed	Bridge is not constructed. Ferry is operated.	NH level, 2 lanes (7.5 m), bad condition, bridge closed
X1111		×(closed)	○(opened)	○	○	○
1X111		○	×	○	○	○
11X11		○	○	×	○	○
11101		○	○	○	(Ferry only)	○
1111X		○	○	○	○	×

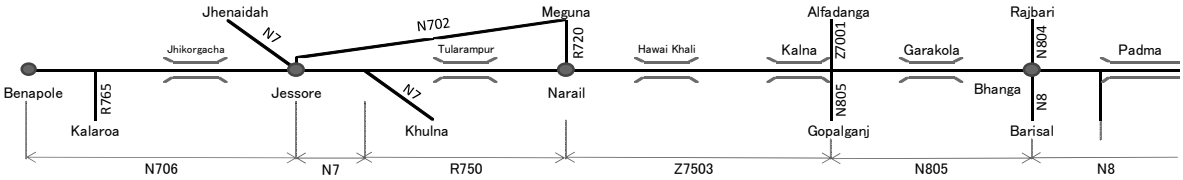
After finishing the assignment, the international transit traffic that pass through Section-A, which was shown in Table 6.2.27, was added to the result.

Figure 6.2.6 and 6.2.7 show the assignment results by each road link in the Section-A for “with” and “without” cases respectively.

In case all bridges are constructed in 2045, traffic in the Section-A will be 22,500-46,000 pcu/day in the Benapole-Jessore section, 54,200-66,100 pcu/day in the Jessore-Narail section, and 54,200-58,800 pcu/day in the Narail-Bhanga section.

On the other hand, in case these bridges will be blocked, traffic in the Section-A will be reduced. In 2045, the traffic volume at ⑮, which is located near where N8 intersects Section-A, will be 58,800 pcu/day for “With” case. On the other hand, traffic volume will reduce for “Without” case. For example, it will be 0 for “1111X” case (when the Br-5 is blocked), 31,800 pcu/day for “11X11” case (when the Br-3 is blocked), and 52,500 pcu/day for “11101” case (when the Kalna ferry is operating, and the Br-4 is blocked).

Moreover, the assignment shows that traffic volume on the N7, which is located on the east side of Jessore (at ⑤), will be 66,100 pcu/day for "With" case. On the other hand, traffic volume will reduce for "Without" case. For example, it will be 24,200 for "1X111" case (when the Br-2 is blocked), and 51,000 pcu/day for "11101" case (when the Kalna ferry is operating, and the Br-4 is blocked).



(Unit: 100 pcu/day)

Year	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	⑭	⑮	⑯	⑰
2020	67	206	206	206	238	228	228	213	213	213	213	213	229	229	229	337	337
2025	84	234	234	234	299	284	284	266	266	266	266	266	288	288	288	411	411
2030	107	270	270	270	362	338	338	318	318	318	318	318	352	352	352	482	482
2035	137	311	311	311	440	405	405	381	381	381	381	381	416	416	416	546	546
2040	175	368	368	368	534	486	486	458	458	458	458	458	506	506	506	634	634
2045	225	460	460	460	661	571	571	542	542	542	542	542	588	588	588	740	740

(Unit: 100 pcu/day)

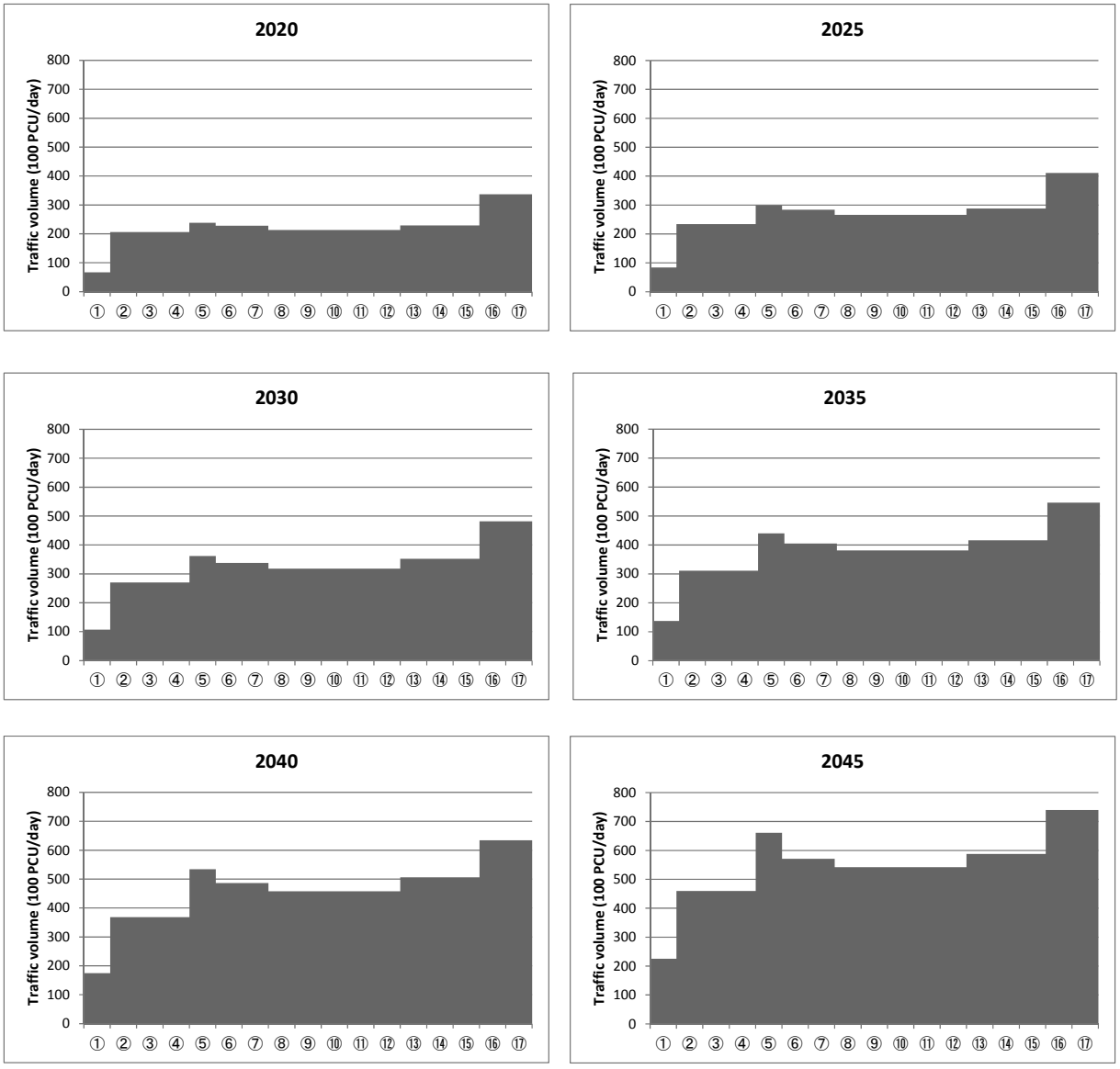
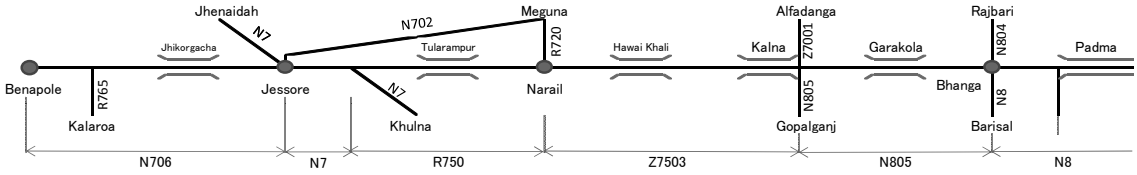


Figure 6.2.6 Assignment volume by section ("With" Case)



(Unit: 100 pcu/day)

Year	Case	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	⑭	⑮	⑯	⑰
2020	x1111	67	0	0	0	192	222	222	207	207	207	207	207	224	224	224	337	337
	1x111	67	172	172	172	69	0	0	65	52	52	52	52	114	114	114	328	328
	11x11	67	173	173	173	107	65	65	0	0	0	0	0	103	103	103	323	323
	11101	67	189	189	189	146	109	109	76	76	76	76	76	137	137	137	330	330
	1111x	67	190	190	190	133	96	96	75	75	75	75	75	0	0	0	325	325
2025	x1111	84	0	0	0	228	245	245	227	227	227	227	227	277	277	277	409	409
	1x111	84	217	217	217	91	0	0	72	72	72	72	72	158	158	158	389	389
	11x11	84	218	218	218	139	70	70	24	0	0	0	0	134	134	134	377	377
	11101	84	233	233	233	181	131	131	93	93	93	93	93	173	173	173	389	389
	1111x	84	229	229	229	166	121	121	96	96	96	96	96	0	0	0	381	381
2030	x1111	107	0	0	0	269	286	286	265	265	265	265	265	338	338	338	480	480
	1x111	107	262	262	262	126	0	0	80	91	91	91	91	211	211	211	460	460
	11x11	107	264	264	264	183	76	76	28	0	0	0	0	182	182	182	444	444
	11101	107	266	266	266	232	157	157	113	113	113	113	113	226	226	226	453	453
	1111x	107	265	265	265	210	144	144	121	122	122	122	122	0	0	0	440	440
2035	x1111	137	0	0	0	318	333	333	310	310	310	310	310	388	388	388	540	540
	1x111	137	309	309	309	127	0	0	87	120	120	120	120	255	255	255	528	528
	11x11	137	307	307	307	193	88	88	40	0	0	0	0	198	198	198	513	513
	11101	137	310	310	310	295	186	186	143	140	140	140	140	275	275	275	518	518
	1111x	137	310	310	310	267	194	194	168	169	169	169	169	0	0	0	497	497
2040	x1111	175	0	0	0	365	384	384	356	356	356	356	356	458	458	458	634	634
	1x111	175	368	368	368	172	0	0	96	208	208	208	208	349	349	349	616	616
	11x11	175	371	371	371	268	110	110	63	0	0	0	0	224	224	224	603	603
	11101	175	370	370	370	389	222	222	179	172	172	172	172	328	328	328	617	617
	1111x	175	374	374	374	369	272	272	248	247	247	247	247	0	0	0	594	594
2045	x1111	225	0	0	0	436	437	437	408	414	414	414	414	525	525	525	740	740
	1x111	225	445	445	445	242	0	0	106	240	240	240	240	400	400	400	719	719
	11x11	225	451	451	451	352	179	179	122	0	0	0	0	318	318	318	705	705
	11101	225	451	451	451	510	313	313	270	214	214	214	214	404	404	404	722	722
	1111x	225	461	461	461	403	376	376	348	305	305	305	305	0	0	0	679	679

(Year 2045) (Unit: 100 pcu/day)

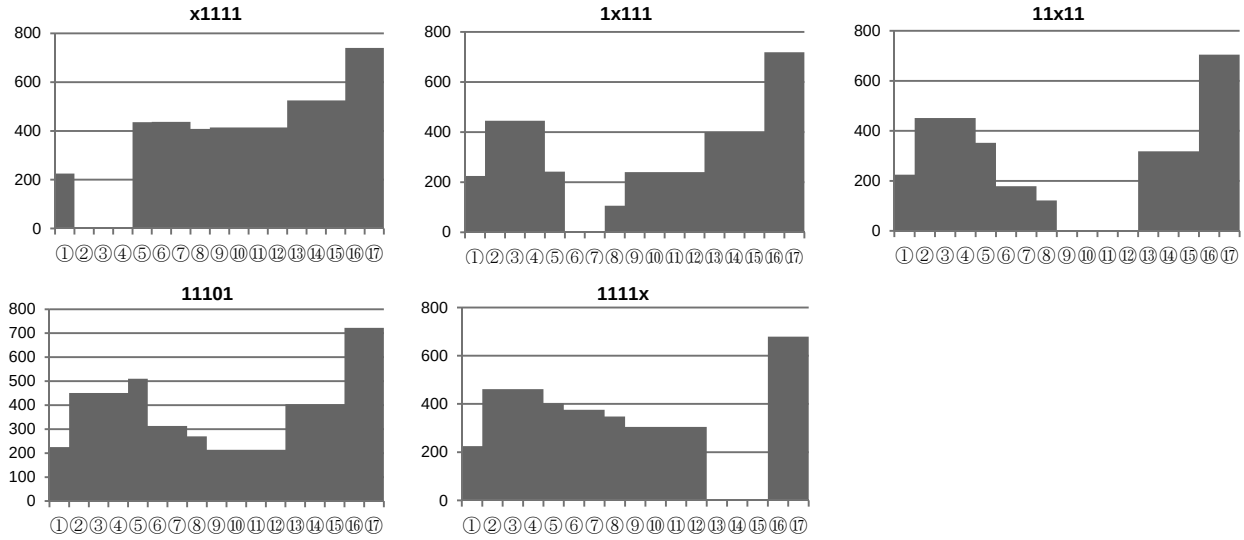


Figure 6.2.7 Assignment volume by section ("Without" Case in 2045)

6.2.7 Future traffic volume in the Section-B and C

The future traffic volumes in Section-B and C were estimated by multiplying the growth rate of the future vehicle registration number that was shown in Table 6.2.18 by the present traffic count survey results. In addition, international transit volume (see Table 6.2.27) was added for Section-B.

Table 6.2.29 Future traffic volume in Section B and C

(Unit: veh/day)

Location		Year	Car	Utility	Bus	Truck	International transit truck	Total
Section-B								
24C-5		2015	119	178	288	677	-	1,262
		2020	151	207	360	872	355	1,945
		2025	183	236	432	1,067	364	2,282
		2030	212	263	498	1,249	373	2,595
		2035	242	291	565	1,430	382	2,910
		2040	269	316	627	1,598	392	3,202
		2045	297	341	689	1,766	402	3,495
Section-C								
North	3DC-2	2015	477	371	2,138	1,909	-	4,895
		2020	605	432	2,671	2,459	-	6,167
		2025	732	492	3,204	3,009	-	7,437
		2030	851	549	3,700	3,521	-	8,621
		2035	970	605	4,196	4,033	-	9,804
		2040	1,080	658	4,655	4,507	-	10,900
		2045	1,190	710	5,114	4,981	-	11,995
South	24C-6	2015	125	267	1,304	1,342	-	3,038
		2020	158	311	1,629	1,729	-	3,827
		2025	192	354	1,954	2,115	-	4,615
		2030	223	395	2,257	2,475	-	5,350
		2035	254	436	2,559	2,835	-	6,084
		2040	283	473	2,839	3,168	-	6,763
		2045	312	511	3,119	3,501	-	7,443

The above-mentioned result was divided according to the road link, by using the ratio of the traffic survey results which was implemented by RHD[13]. The result is shown below.

[13] *Annual Average Daily Traffic (AADT) Survey year: 2013*, Road & Highways Department of Bangladesh

Table 6.2.30 Future traffic volume by road link in Section B and C

(Unit: 100 pcu/day)

Section	Road	Seq.	Names of the two ends	2015	2020	2025	2030	2035	2040	2045
B	R151	①	Karehat – Herako	32	51	60	68	77	84	92
	R152	②	Herako – Ramgarh	19	29	34	38	43	47	51
C North	N1	③	Int w. Z1018 – Int w. N107	142	180	217	252	286	318	351
		④	Int w. N107 – Patiya	171	215	259	300	341	379	417
		⑤	Patiya – Chandanaish	157	198	239	277	315	350	385
		⑥	Chandanaish – Int. w. N108	130	164	199	231	263	292	322
C South		⑦	Int. w. N108 – Chunati	272	345	417	485	552	615	677
		⑧	Chunati – Int. w. R172	130	164	198	230	261	291	320
		⑨	Int. w. R172 – Dulahazara	149	189	229	266	304	338	373
		⑩	Dulahazara – Int. w. Z1009	83	105	128	148	169	188	207

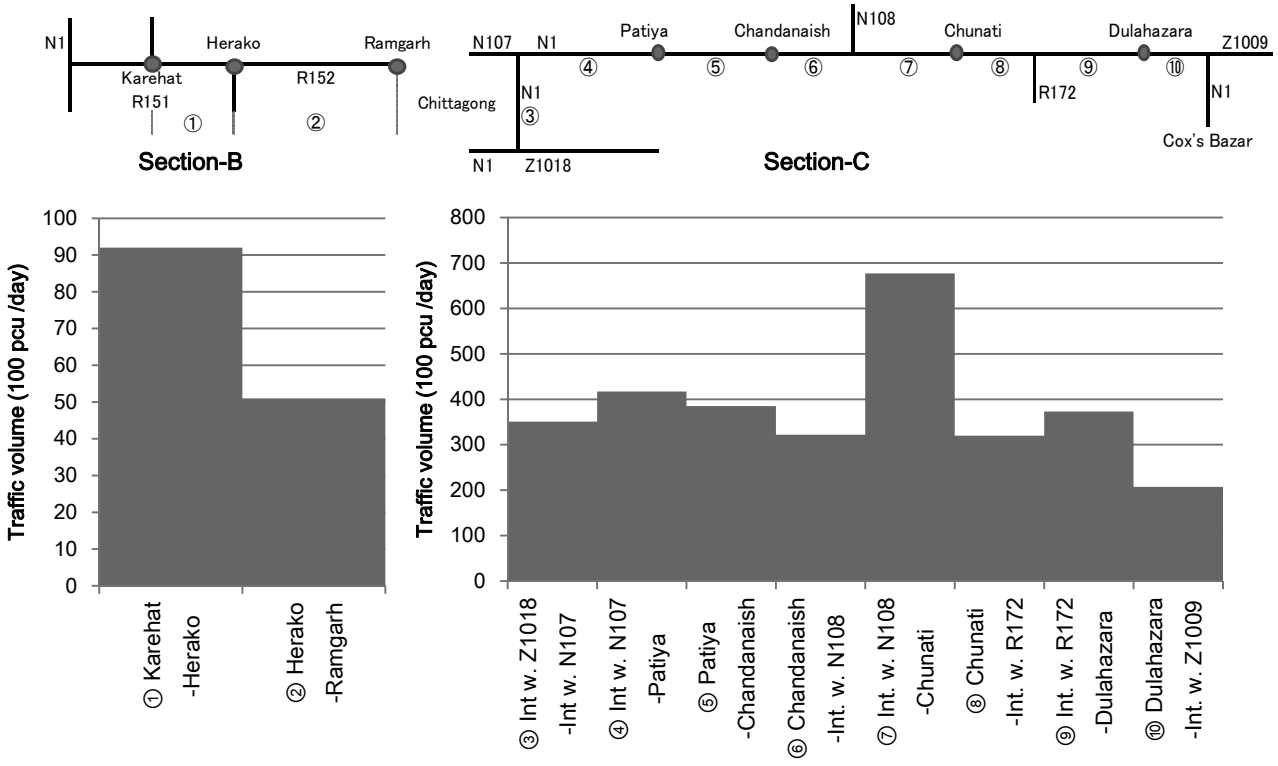


Figure 6.2.8 Future traffic volume by road link of Section B and C in 2045

6.2.8 Review of validity of the demand forecast result

Figure 6.2.9 shows the relation among the estimated future GDP, number of the vehicle registration in the country and estimated future traffic volume at representative points on the target roads.

The left axis of the graph is shows that the number of vehicle registration and the right axis shows the estimated future traffic volume at the representative points on the target roads.

As the graph shows, the number of registered vehicle increases with the increase of the GDP.

Cars record highest growth rate followed by trucks, buses and utility vehicles respectively. Also, the number of traffic volume in the section increases with the increase of the GDP and the number of registered vehicle. Section-A records highest growth rate, followed by Section-C (North), Section-C (South) and Section-B respectively.

Especially, the growth of estimated future traffic volume in the section-A is higher than the growth of number of vehicle registration in the country.

This shows that the development in the area along the section-A will proceed at a rate higher than that of the nationwide average, and the newly developed and induced traffic volume will be added into the result of the demand forecasting.

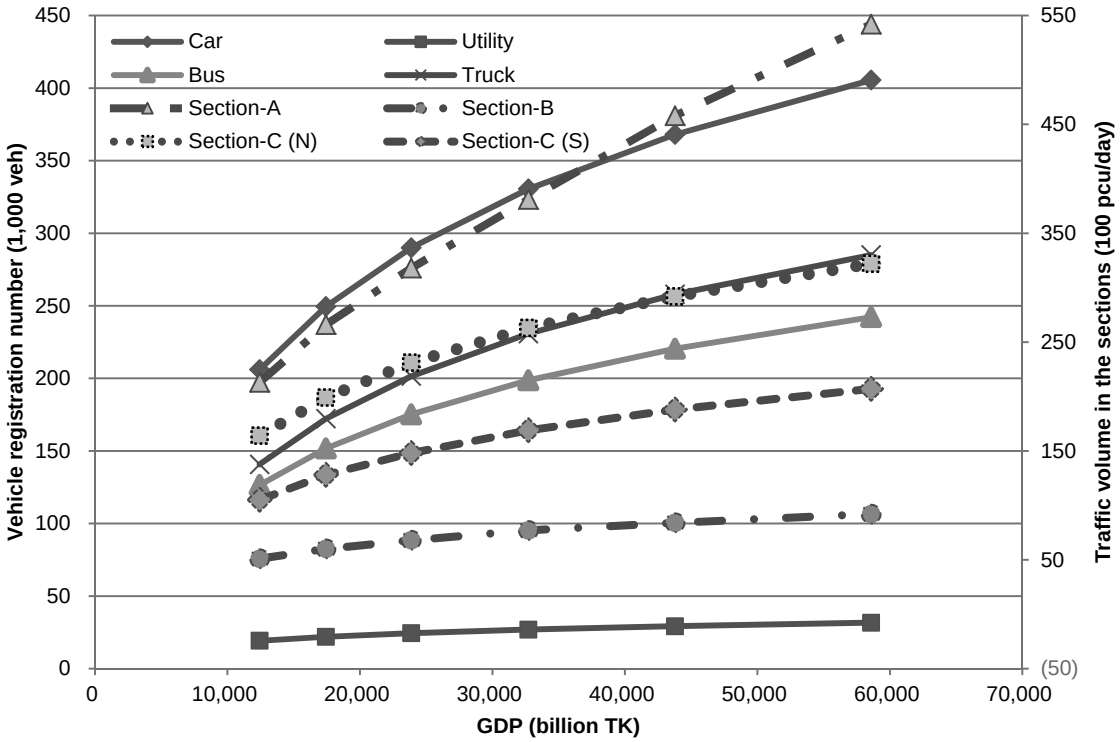


Figure 6.2.9 Relation among GDP, vehicle registration number and traffic volume

7. PRELIMINARY DESIGN FOR ROADS AND FACILITIES

7.1 Required Number of Lanes

The required numbers of lanes are calculated based on the Bangladesh Standard. Table 7.1.1 shows the relation between design types, traffic capacity and necessary number of lanes.

Table 7.1.1 Relation between Design Types, Traffic Capacity and Necessary Number of Lanes

Design Type	Design year traffic volume		No. of lanes	Carriage-way width (m)	Road Classification
	PCU/peak hour	Typical MV AADT			
1	4,500-8,500	19,000-36,000	6	3.65	National
2	2,100-4,500	7,000-19,000	4	3.65	National/Regional
3	1,600-2,100	5,000-7,000	2	3.65	National/Regional
4	800-1,600	1,000-5,000	2	3.10	National/Regional/Zilla
5	530-800	600,1,000	2	2.75	Regional/Zilla
6	<530	<600	1	3.70	Zilla

Source: Geometric Design Standards Manual (Revised) 2005; RHD

Based on the Bangladesh Standard, the design year is 10 years after operation. Then, the target year is applied Year 2030. For setting of the numbers of lanes, it is desirable to unify it within the each section. And, the maximum traffic demand of sub-section is represented in the each section. Table 7.1.2 shows the maximum traffic demand through the section in target year and the necessary numbers of lanes.

Table 7.1.2 Maximum Traffic Demand and Required Number of Lanes by Each Section

Section	Typical Sub-Section		Traffic Demand		Necessary No. of lanes
	Seq.	Start - End	100PCU/day	100PCU/ peak hour	
A	⑭	N805 - N804 (Garakola Br.)	352	42	4
B	①	Karehat - Heyako	68	8	2
C	④	Int w. N107 - Patiya	300	36	4

Source: JICA Survey Team

As the results of calculation, Section A and C are decided to apply with 4 lanes, and Section B is 2 lanes, respectively.

7.2 Design Standards and Criteria

The establishment of design criteria is related to the function of the road, volume of traffic and type of terrain, roadside condition and so forth. At first, 3 sections in this project were classified into 2 types; e.g. Sections A and C are located on the Asian Highway and are assumed to become 4-lane roads, and Section B is assumed to be a 2-lane road. For the study of design standards, the following related standards of each donner, Asian Highway and/or the related projects are compared. However, the current Bangladesh Standard was established in reference with the Australian Standard. And, the design elements for alignment are excessive values due to lack of consideration of Bangladeshi situations; for example, the alignment of the route at Kalna Bridge designed by RHD didn't follow the current Bangladesh Standard. Therefore, the Bangladesh Standard is only referred to for the study of typical cross sections.

The following standards have been referred to:

- Asian Highway Classification and Design Standards (UN ESCAP: Year 2003)
- Geometric Design Standards Manual (Revised) 2005 (Bangladesh RHD: Year 2005)
- Road Design Standard (Japan: Year 2004)
- A Policy on Geometric Design of Highways and Streets (US AASHTO: Year 2011)

(1) Sections A and C

The related standards are compared in Sections A and C. For reference, design criteria of SRTPPF Project in Section C which was financed by ADB are incorporated. The design criteria shall at least satisfy the Asian Highway Standard because Sections A and C are located on the Asian Highway.

Also, typical cross sections are basically applied that conform to the Asian Highway Standard with consideration for the Bangladesh Standard. On the other hand, design elements for alignment are established based on the Japanese Standard because those design elements are similar to both the Japanese and Asian Standards. Standard cross sections of the related standards for 4-lane roads on embankment sections are illustrated in Figure 7.2.1

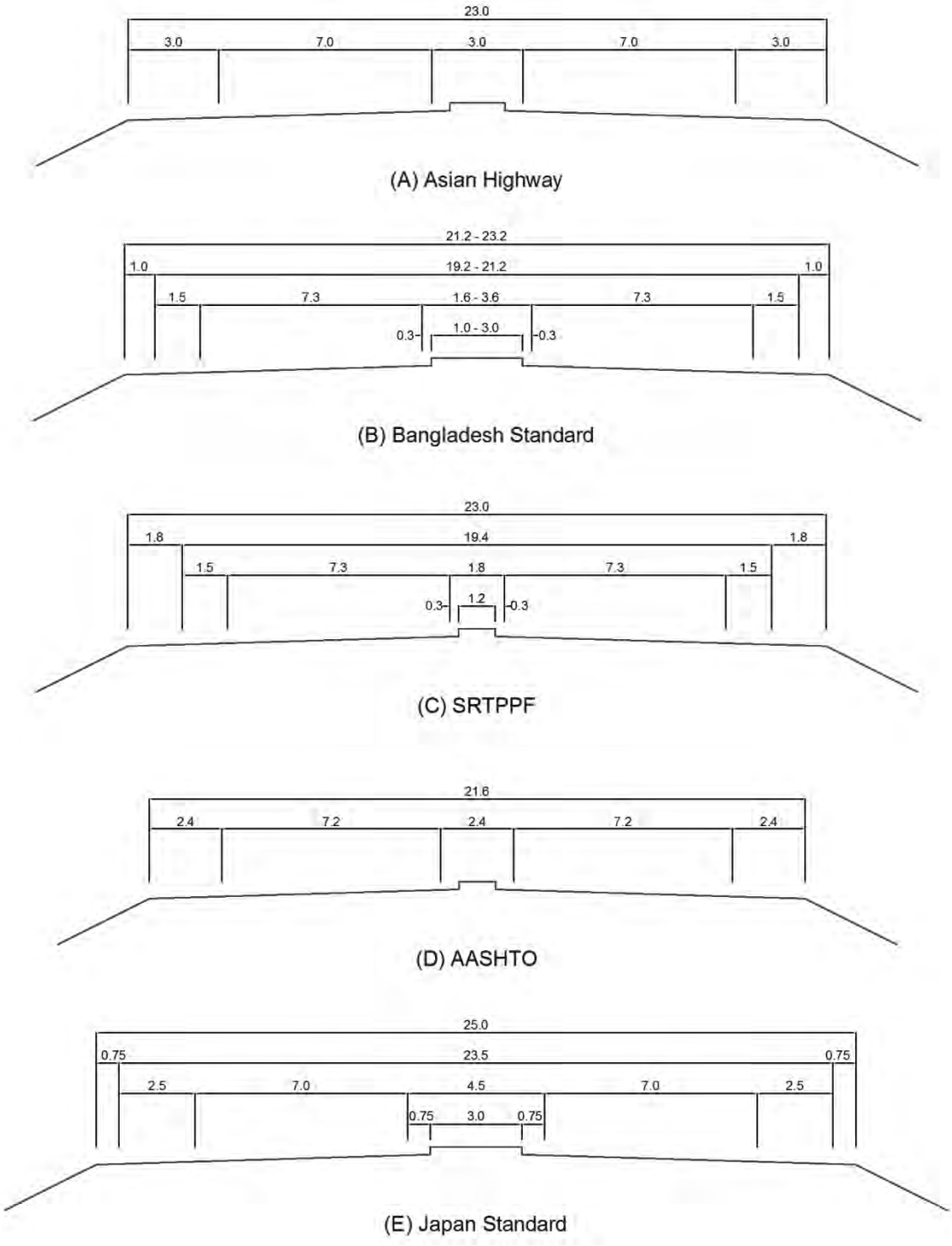
Through the discussion with RHD based on the proposed design criteria and typical cross sections, the maximum superelevation and the minimum K-values are revised from 6.0 % to 7.0 % and from 65 to 70, respectively. The adopted design criteria and typical cross sections in Section A and C are shown in Table 7.2.1 and Figure 7.2.2

Table 7.2.1 Comparison between Related Standards and Adopted Design Criteria (Section A and C)

Standard/Criteria	Asian Highway	Bangladesh (2005)	SRTPPF	AASHTO	Japan	Adopted
Category	Class I	Design Type 2	-	Rural Arterials	Class 1-2	-
Terrain	Level	Plain	-	Level	Plain	Plain
Design Speed (km/h)	100	100	80	100	100	100
Stopping Sight Distance (m)	-	180	120	185	160	160
Cross Section (m)						
Right-of-Way	40	-	-		-	-
Carriageway	3.50	3.65	3.65	3.60	3.50	3.65
Median	3.00	3.00 (1.60)	1.80	2.40 (1.20)	4.50 (3.00)	3.00
Median Marginal Strips	-	1.00 (0.30)	0.30	-	0.75	0.60
Shoulder	3.00	1.50	1.50	2.40 (1.20)	2.50 (1.75), [3.25]	2.70
Verge	-	1.00	1.00-1.80	-	0.75	1.00
Carriageway Crossfall (%)	2.0	3.0	3.0	1.5-2.0	2.0	3.0
Shoulder Crossfall (%)	3.0-6.0	3.0/5.0	3.0	2.0-6.0	2.0	3.0
Type of Pavement	AC/RCC	AC/RCC	AC	AC/RCC	AC/RCC	AC
Min. Horizontal Curve Radius (m)	350 [600]	1,000	500	394	460 (380)	460
Min. Horizontal Curve Radius without Transition Curves (m)	1,500	-	-	-	3,000 (1,500)	1,500
Min. Transition Curve Length (m)	85	95	55	56	85	85
Max. Superelevation (%)	10.0	7.0	5.0	8.0	6.0	7.0
Max. Vertical Grade (%)	4.0	3.0	4.0	3.0	3.0	3.0
Min. Vertical Curve Length (m)	-	60	-	-	85	85
Min. Vertical Curve K-Value	-	70	70	Crest 52, Sag 45	Crest 65, Sag 30	70
Remarks					Apply to Expressway	

*1: Figure in ( ) shows absoluted value.
2: Figure in [ ] shows desirable value.
3: AC/RCC shows Asphalt Concrete/Reinforced Cement Concrete.

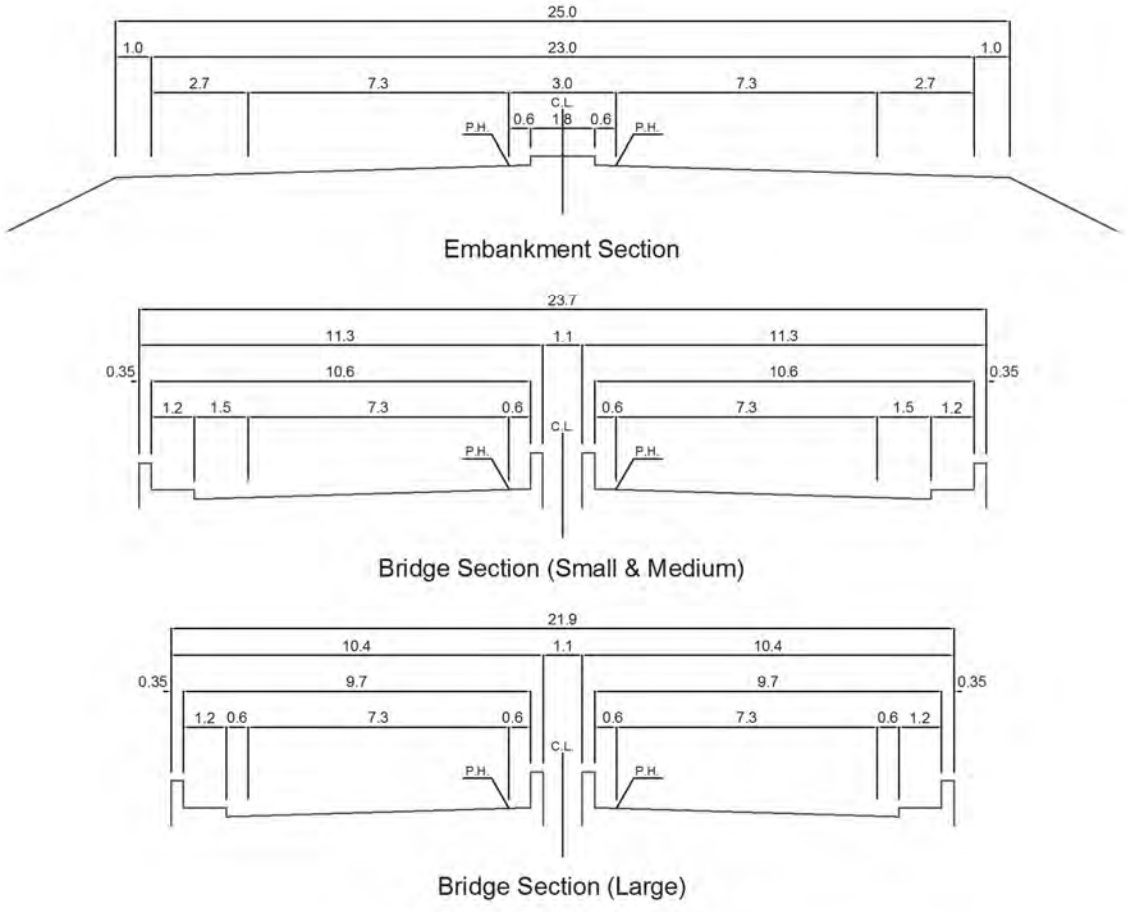
Source: JICA Survey Team



Unit: m

Source: JICA Survey Team

Figure 7.2.1 Standard Cross Sections of Related Standards (4-lane on Embankment Section)



Unit: m

Source: JICA Survey Team

Figure 7.2.2 Adopted Typical Cross Section (Section A and C)

(2) Section B

The related standards are compared in Sections B. Section B is not located on the Asian Highway. However, it will be an important international highway as one of the cross border facilities. Therefore, the adopted design criteria shall at least satisfy Class II of the Asian Highway Standard. And also, Section B is classified Design Type 4 based on the Bangladesh Standard and traffic demand. However, Design Type 3 is referred for the comparison due to the above reason. And, Section B is categorized as a Mountainous/Hilly Area.

For the proposal of design criteria in this section, the policy is the same as Sections A and C.

Standard cross sections of the related standards for 2-lane roads on embankment sections are illustrated in Figure 7.2.3.

Through the discussion with RHD based on the proposed design criteria and typical cross sections, the maximum superelevation and the minimum K-values are revised from 6.0 % to 7.0 % and from

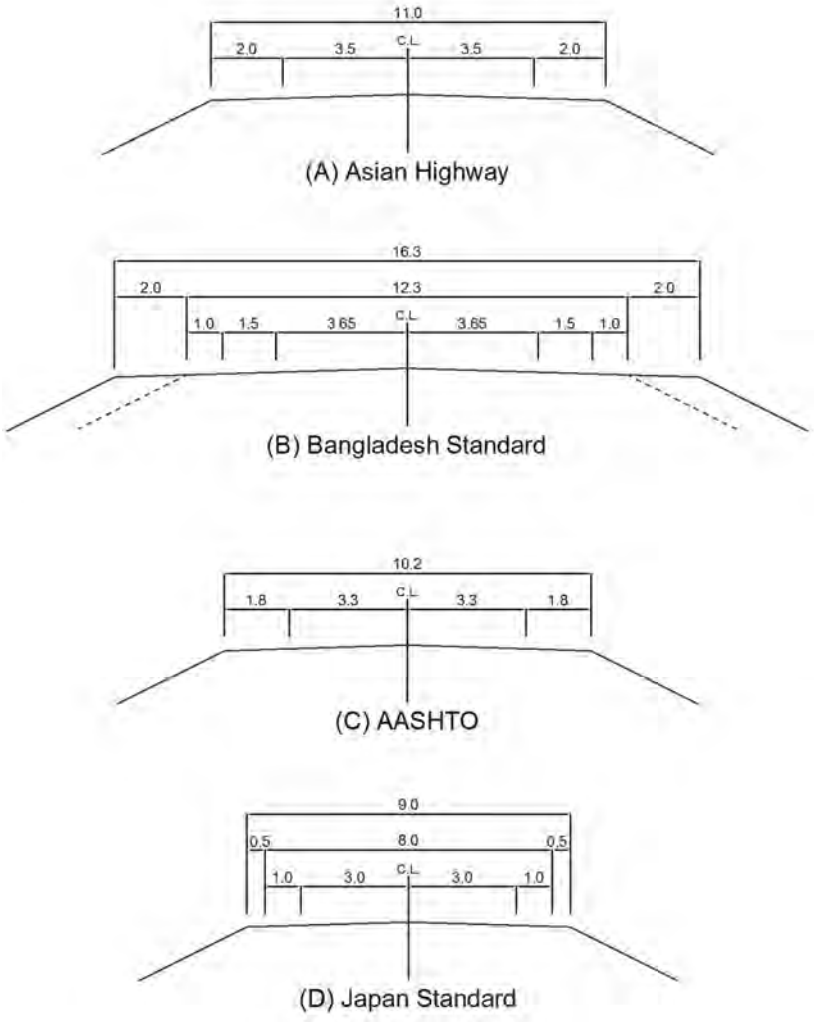
8 to 9, respectively. The adopted design criteria and typical cross sections in Section B are shown in Table 7.2.2 and Figure 7.2.4.

Table 7.2.2 Comparison between Related Standards and Adopted Design Criteria (Section B)

Standard/Criteria		Asian Highway	Bangladesh (2005)	AASHTO	Japan	Adopted
Category		Class II	Design Type 3	Rural Collectors	Class 3-3	-
Terrain		Mountain	Hilly	Mountain	Mountain	Mountain
Design Speed (km/h)		50	50	50	50	50
Stopping Sight Distance (m)		-	60	65	55	55
Cross Section (m)						
	Right-of-Way	40	-	-	-	-
	Carriageway	3.50	3.65	3.3	3.00	3.65
	Median	N/A	N/A	N/A	N/A	N/A
	Shoulder	2.00	1.50	1.80	0.75 (0.50)	1.85
	Verge	-	1.00-3.00	-	0.50	1.00
Carriageway Crossfall (%)		2.0	3.0	1.5-2.0	1.5	3.0
Shoulder Crossfall (%)		3.0-6.0	3.0/5.0	2.0-6.0	1.5	3.0
Type of Pavement		AC/RCC	AC/RCC	AC/RCC	AC/RCC	AC/RCC
Min. Horizontal Curve Radius (m)		80	120	73	100 (80)	100
Min. Horizontal Curve Radius without Transition Curves (m)		350	-	-	700 (350)	350
Min. Transition Curve Length (m)		40	45	28	40	40
Max. Superelevation (%)		10.0	7.0	8.0	6.0	7.0
Max. Vertical Grade (%)		6.0	7.0	10.0	6.0	6.0
Min. Vertical Curve Length (m)		-	30	-	40	40
Min. Vertical Curve K-Value		-	9	Crest 7, Sag 13	Crest 8, Sag 7	9
Remarks				1,500-2,000 veh/day	Design speed range is 40-60 km/h	

*1: Figure in ( ) shows absoluted value.
2: AC/RCC shows Asphalt Concrete/Reinforced Cement Concrete.

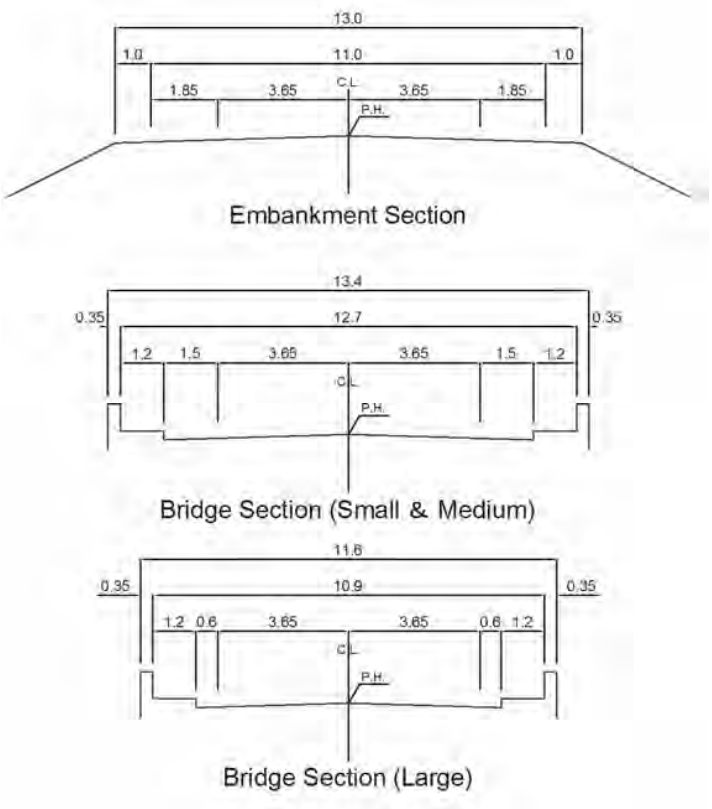
Source: JICA Survey Team



Unit: m

Source: JICA Survey Team

Figure 7.2.3 Standard Cross Sections of Related Standards (2-lane on Embankment Section)



Unit: m

Source: JICA Survey Team

Figure 7.2.4 Adopted Typical Cross Section (Section B)

(3) Bridge Classification

Taking into account with economical efficiency, mobility and so on, bridges are classified based on the bridge length as below;

- Small and medium bridges: bridge length is less than 100 m.
- Large bridge: bridge length is 100 m and longer.

7.3 Selection of Optimum Routes and Alignments

Although the routes, excluding the Kalna Bridge in Section A, were decided in the WBBIP (Western Bangladesh Bridge Improvement Project), Jhikorgacha Bridge shall be studied for the route selection according to the stake holder's opinion during WBBIP.

Additionally, the route for Kalna Bridge (new bridge) was studied by GOB. However, its route shall be reviewed in order to reduce affected houses.

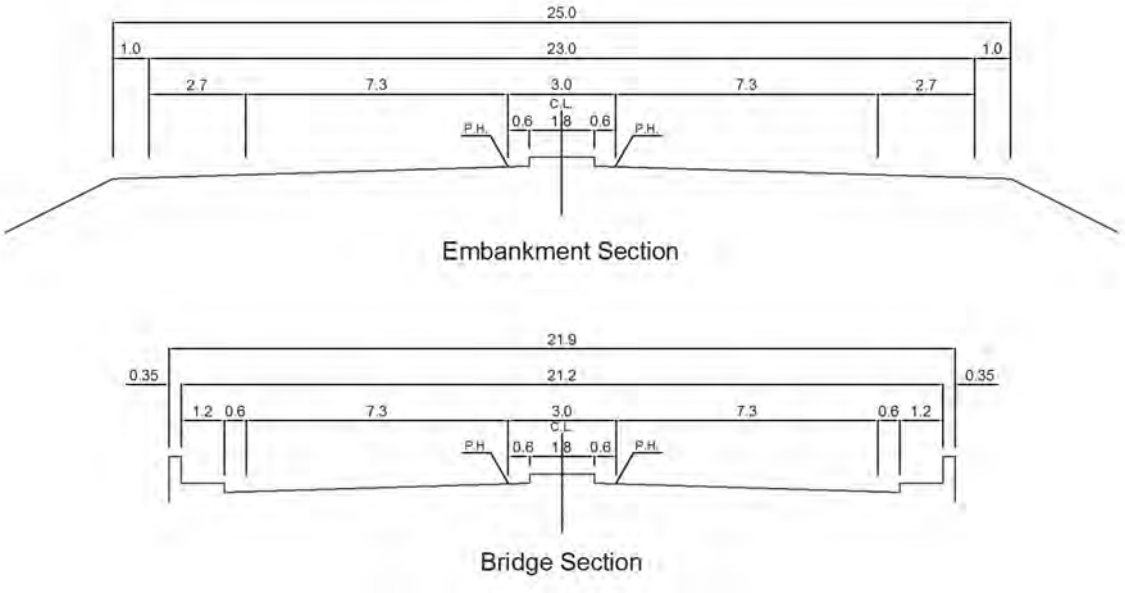
For the above reason, the following route selections will be studied.

(1) Kalna Bridge

RHD operates the Kalna Ferry crossing Madhumati River on National Highway N806 as a part of the Asian Highway in Section A. Alternative routes, including bridge crossing locations, have been studied to construct an all-weather road and bridge over Madhumari River.

The route for Kalna Bridge had been studied by RHD of GOB. However, the RHD route affects a lot of houses. Also, Madhumati River is extremely dynamic and the river bed shifts whenever a large flood occurs. Therefore, the RHD route has been reviewed and several alternatives are set out and compared.

Bridge type of main bridge is selected special type (Nilsen type; refer to Chapter 8). Typical cross sections for Kalna Bridge are shown in Figure 7.3.1 for the route comparison.



Unit: m

Source: JICA Survey Team

Figure 7.3.1 Applied Typical Cross Section for Kalna Bridge

Figure 7.3.2 shows the shifting of the course of Madhumati River since 1972 based on satellite images. The river shifted for a distance more than the river width in 1977 and 1987 due to large flooding. The direction of river morphology is toward the east and it meanders toward the northeast. However, the river channel has been stable since 2001 on the whole. The river has been stable near the ferry terminals since 1989 and downstream from the ferry terminals since 1978.

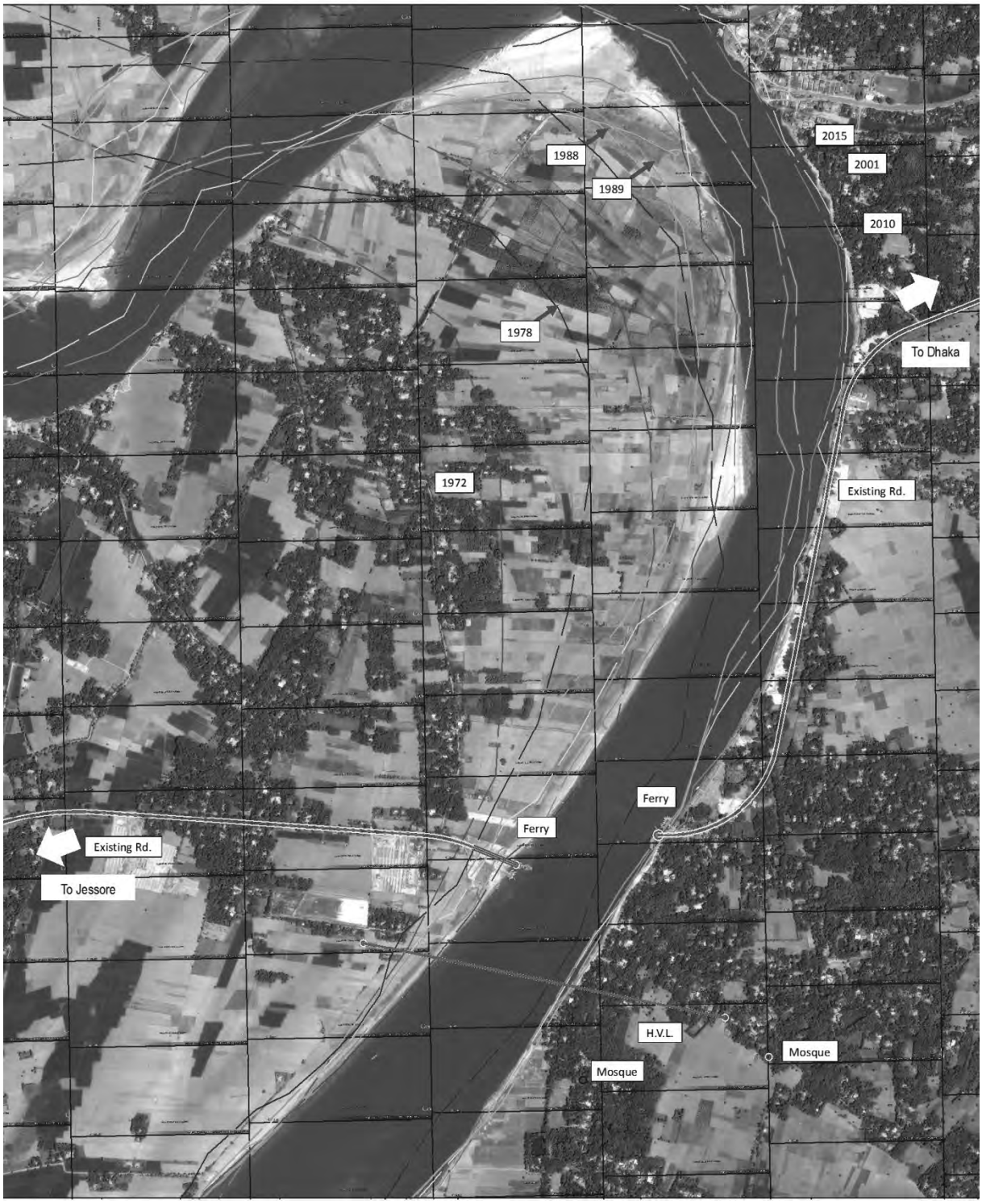
Taking into account the above river morphology, the existing ferry terminals, mosques, high-voltage lines, and houses, the following 3 alternatives are set out.

- ALT-A: The river crossing location is approximately 500 m upstream from the RHD route and the area has been basically stable since 2001. This alternative minimizes the road length and the affected houses.

- ALT-B: The river crossing location is approximately 300 m downstream from the RHD route and the area has been basically stable since 1978. This alternative minimizes the affected houses as much as possible.
- ALT-C: The river crossing location is approximately 700 m downstream from the RHD route and the area has been basically stable since 1978. This alternative avoids the high-voltage line completely.

Figure 7.3.3 shows the alignments of the 3 alternatives for Kalna Bridge to avoid the shifting course of Madhumati River. The route comparison is shown in Table 7.3.1.

After examination of the 3 alternatives, ALT-B was selected because the river course is most stable and the numbers of affected are fewest among them. It is supposed that this alternative won't affect the high-voltage lines. However, some countermeasures including relocations may be necessary, if this alternative affects them.



Source: JICA Survey Team

Figure 7.3.2 Shifting of the Course of Madhumati River

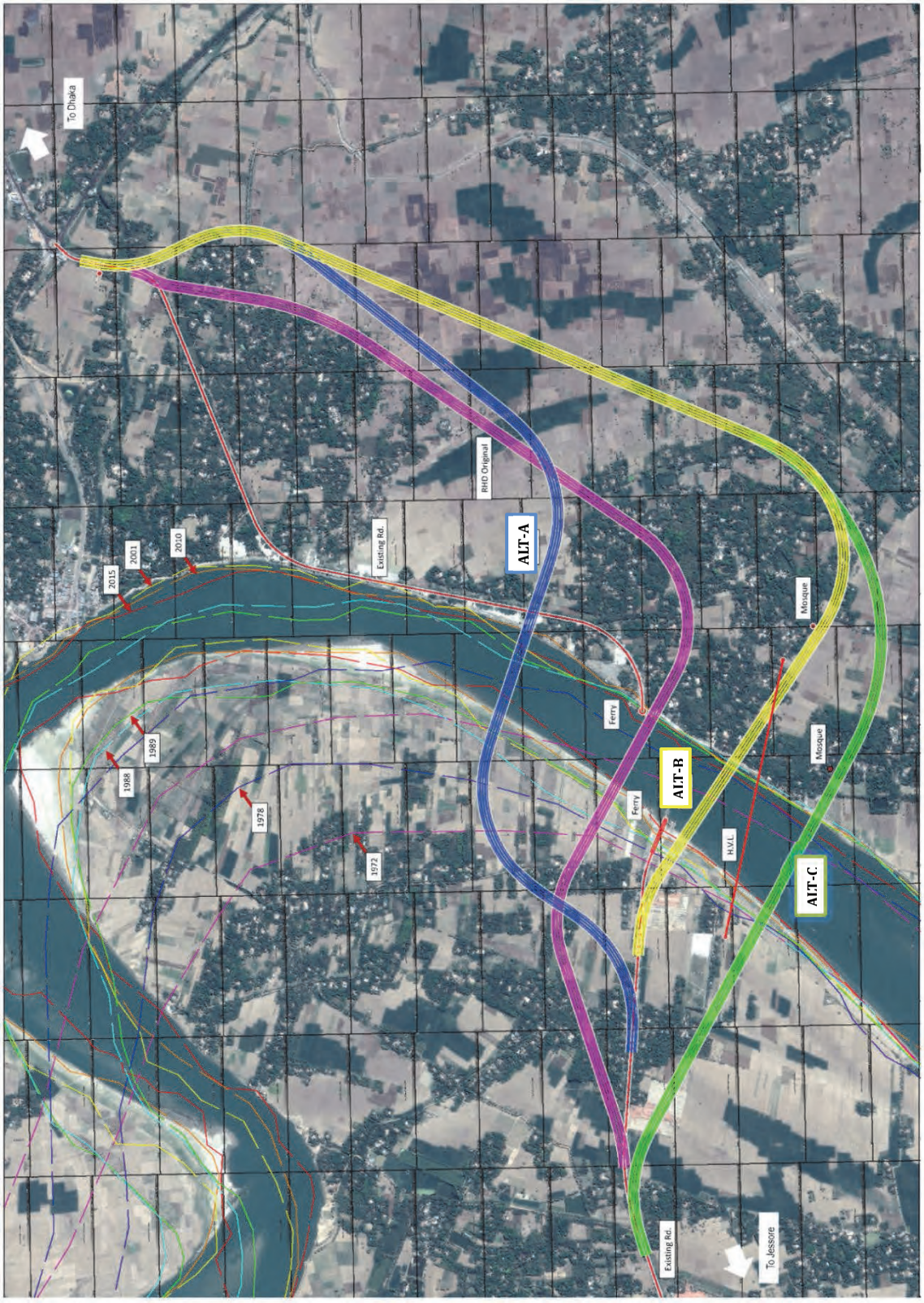
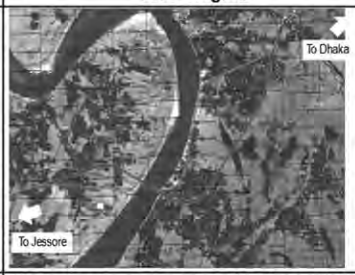
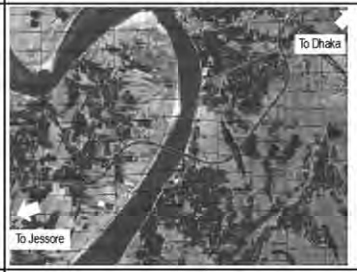
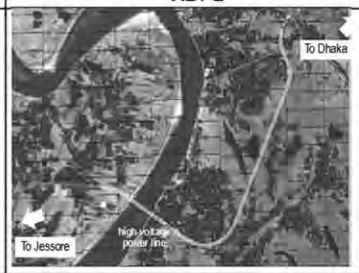


Figure 7.3.3 Alternative Routes for Kalna Bridge

Source: JICA Survey Team

Table 7.3.1 Route Comparison for Kalna Bridge

Alternative	RHD Original	ALT-A	ALT-B	ALT-C
Route Outline				
Route Summary	The route was analyzed by RHD for preliminary design. Bridge crosses over between both ferry terminals.	Bridge crosses over at approx. 500 m upstream from RHD Original Route.	Bridge crosses over at approx. 300 m downstream from RHD Original Route.	Bridge crosses over at approx. 700 m downstream from RHD Original Route.
Road Length (incl. bridge) [km]	4.66	4.35	4.77	5.89
Min. Horizontal Curve Radius [m]*1	400	440	440	440
No. of Horizontal Curves	7	5	4	4
River Crossing Angle (degree)	85.0	75.0	90.0	80.3
Deepest Depth of River Bed [m]	-10.0	-6.0	-3.5	-2.3
River Morphology	Almost stable since **Year 1989**.	Almost stable since **Year 2001**.	Almost stable since **Year 1978**	Almost stable since **Year 1978**
No. of Affected Buildings (Area)*2	86	33	41	44
Affected Area (ha)	17.46	16.19	17.89	22.34
Impact on Bridge Type	Slight impact on approach bridge due to transition curve	Slight impact on approach bridge due to transition curve	Slight impact on approach bridge due to transition curve	No impact
Constructability	Existing ferry terminal on western bank requires shifting to upstream and requires construction of temporary access road. And construction site crosses over the road.	Construction site crosses over existing NH.	Close to high-voltage power line and intersects in plane.	Close to high-voltage power line.
Road Construction Cost*3	1.1	1.0	1.1	1.4
Bridge Construction Cost*3	1.0	1.0	1.0	1.0
Evaluation			Recommendation	
	River banks are more stable than ALT-A. Social impacts are significant compared to 4 alternatives.	Some river training works may be required because the river crossing are located around the upstream limit of less river meanderings since 2001. Social impacts are assumed to be lowest among 4 alternatives, and road length is shortest.	River banks are most stable as well as ALT-C, and river crossing is almost perpendicular to the riverbank. Social impacts are assumed to be less. If sufficient vertical clearance is not secured under high-voltage power line, then it will be necessary to relocate.	River banks are most stable as well as ALT-B. River crossing is little bit under skew angle. Moreover, the road length is longest among 4 alternatives, thereby, cost increases by 40 % compared to ALT-A. Social impacts are almost same as ALT-B.
Remarks			Increase the number of affected buildings due to the widening of existing road between ALT-B and ALT-C on Jessore side.	Additional cost requires for relocation of Brick Field.

*1: Excl. the vicincity of intersection at ending point side. *2: 50% increasing based on Satellite Image (excl. RHD Original). *3: Comparison ratio based on ALT-A (1.0).

Source: JICA Survey Team

(2) Jhikorgach Bridge

The existing Jhikorgacha Bridge is located on National Highway N706 as a part of the Asian Highway in Section A, but it is deteriorated. In WBBIP, it was planned to reconstruct the bridge with 4-lanes. However, the stake holders didn't agree with the proposed plan.

Prior to the route comparison, typical cross sections to be applied are studied. There are a series of shops along the approach roads before/after Jhikorgacha Bridge as shown in the below photographs. Therefore, foot paths are required in the view of traffic safety. Also, the design speed of main highway is applied 100 km/h, and the provision of frontage roads in the both sides is desirable due to the same reason.

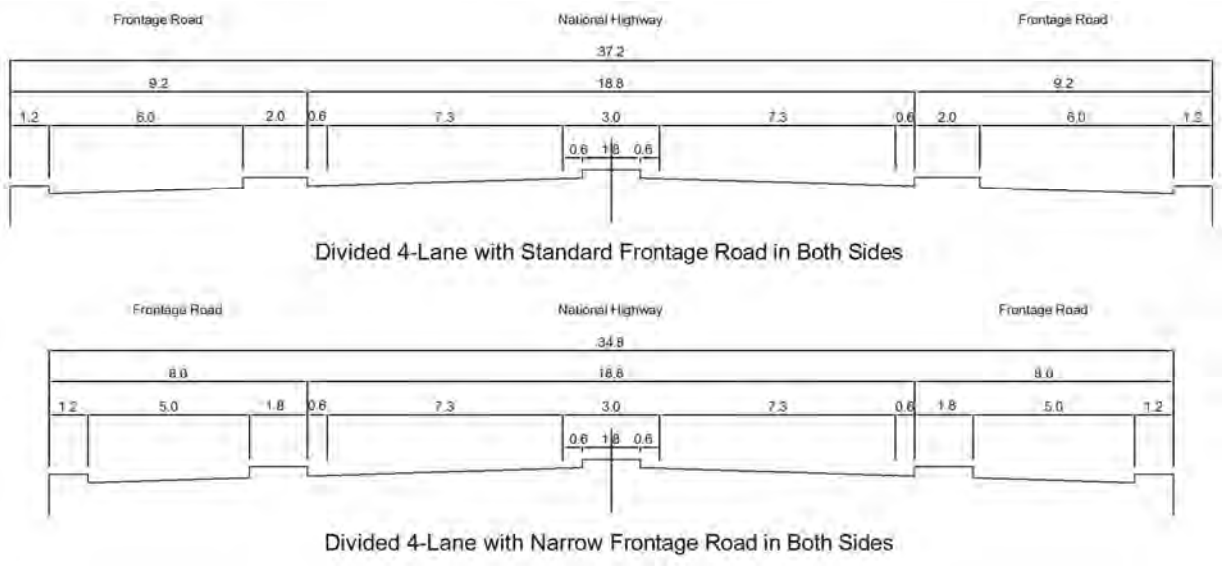
The existing right-of-way is wider than 30 m in apart from Jhikorgacha Bridge. On the other hand, it is approximately 6.5 m at the 150 m sections before/after the bridge. (narrowest location is less than 5.0 m.)

Jossore Side

Benapole Side

In the case to apply the standard width of frontage road for motorized vehicles in the both sides, total road width is 37.2 m on the fill section. On the other hand, in reference with the frontage road in Japan Standard, option with the frontage road with the narrow width is set out due to the land constrain, and the total road width is 34.8 m on the fill section. However, it is difficult that the ROW will be widened more than 30 m. Finally, the 30.0 m width with NMV lane in the both sides on the fill section is adopted as the results of the meeting with RHD.

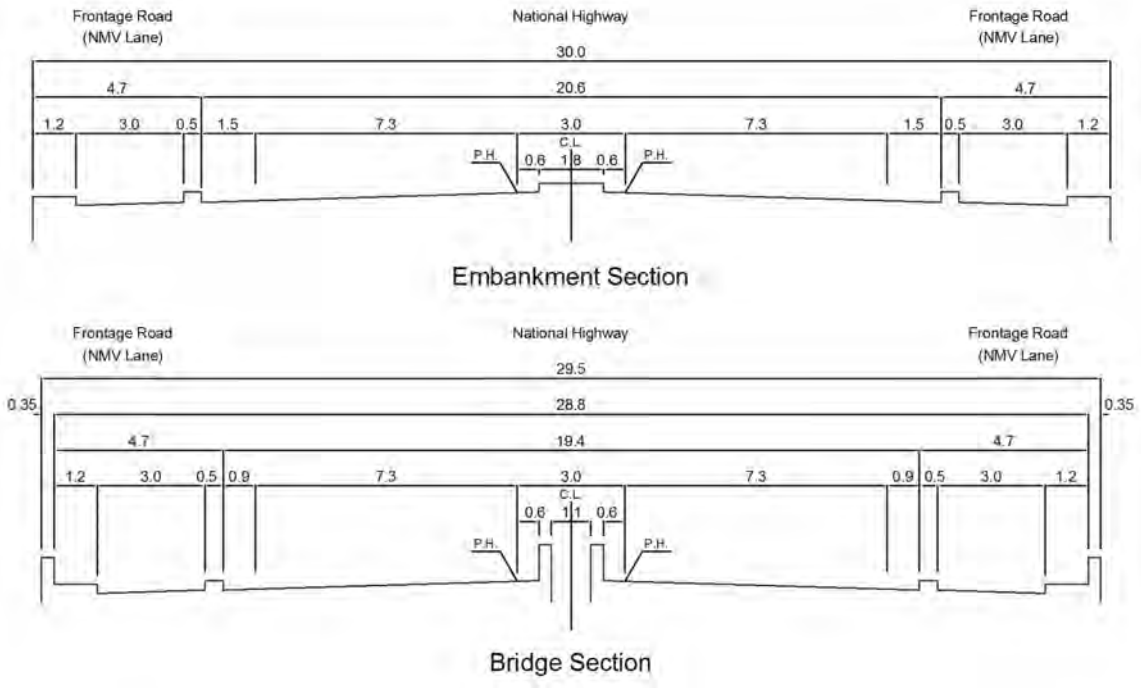
Figure 7.3.4 shows the options for comparison of typical cross section, and Figure 7.3.5 shows the applied typical cross sections for Jhikorgacha Bridge.



Unit: m

Source: JICA Survey Team

Figure 7.3.4 Options of Typical Cross Section for Jhikorgacha Bridge



Unit: m

Source: JICA Survey Team

Figure 7.3.5 Applied Typical Cross Section for Jhikorgacha Bridge

For the route comparison, taking into account the mosques and houses, the following 3 alternatives, ALT-A, B and C were set out. However, an additional alternative, ALT-D, which was requested in SHM of 2015 is incorporated and studied.

- ALT-A: New bridge is constructed upstream and the existing bridge will be replaced by a new one at the same location. (one-side widening the same as WBBIP)
- ALT-B: New bridges are constructed with their centerlines along both sides of the existing bridge (both-sides widening).
- ALT-C: New bridge is constructed downstream near the railway bridge (Bypass option)
- ALT-D: New bridge is constructed upstream far from the existing bridge (Bypass option the same as SH opinion)

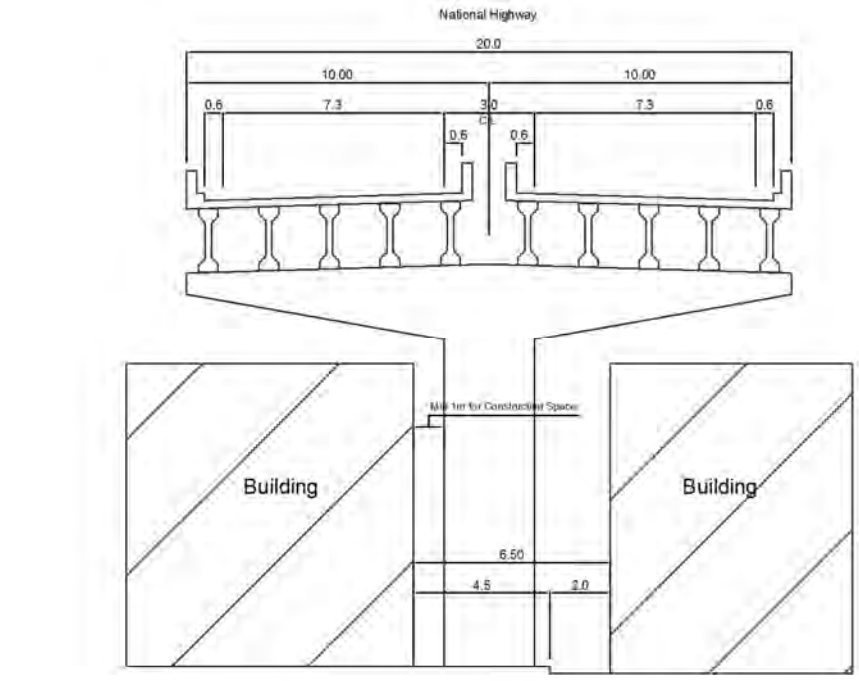
And, a flyover is another opinion. However, that is excluded from comparison due to the following reasons (refer to Figure 7.3.6);

- In the “Without Resettlement” case, there are no spaces to construct piers within the existing ROW. Therefore, this case requires to resettlement along the road. And, it is impossible to provide a detour road during construction stage. Moreover, this alternative might have some issues regarding law such as surface rights, the right to sunlight and so forth.
- In the “With Resettlement” case, the width of Flyover Alternative is two third of the one of standard 4-lane highway with frontage roads in both sides. However, the bridge length of Flyover Alternative requires approximately 5 times of the one of standard 4-lane highway.

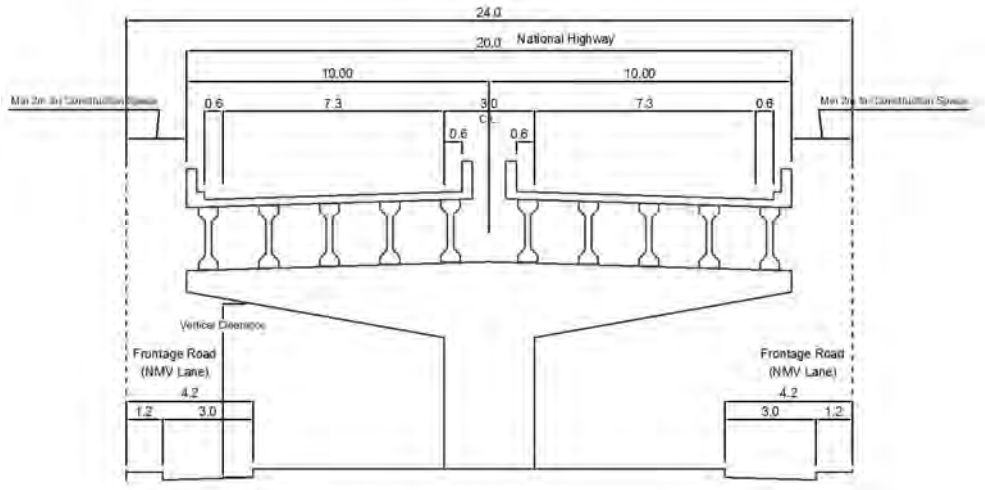
Figure 7.3.7 and Figure 7.3.8 show the alignments of 4 alternatives for Jhikorgacha Bridge. The route comparison is shown in Table 7.3.2.

After examination of the 4 alternatives, ALT-A and ALT-B are suitable among them. ALT-B has some potential negatives such as bridge construction cost increase and time extension due to temporary bridges and its changeover. However, ALT-B is superior than ALT-A regarding road construction cost and alignment. Finally, ALT=B was selected because social impacts on stakeholders on both sides can be concluded in an amicable manner, and it could be optimum for road widening and easiest for RHD to receive consensus from the stakeholders.

On the other hand, it is unnecessary to compare ALT-D essentially because ALT-D is not on the Asian Highway and RHD doesn’t have willingness to change alignment in large-scale. However, after examination, it is clear that ALT-D has the lowest evaluation among the 4 alternatives in terms of cost and the number of affected households.



(a) Cross Section without Resettlement

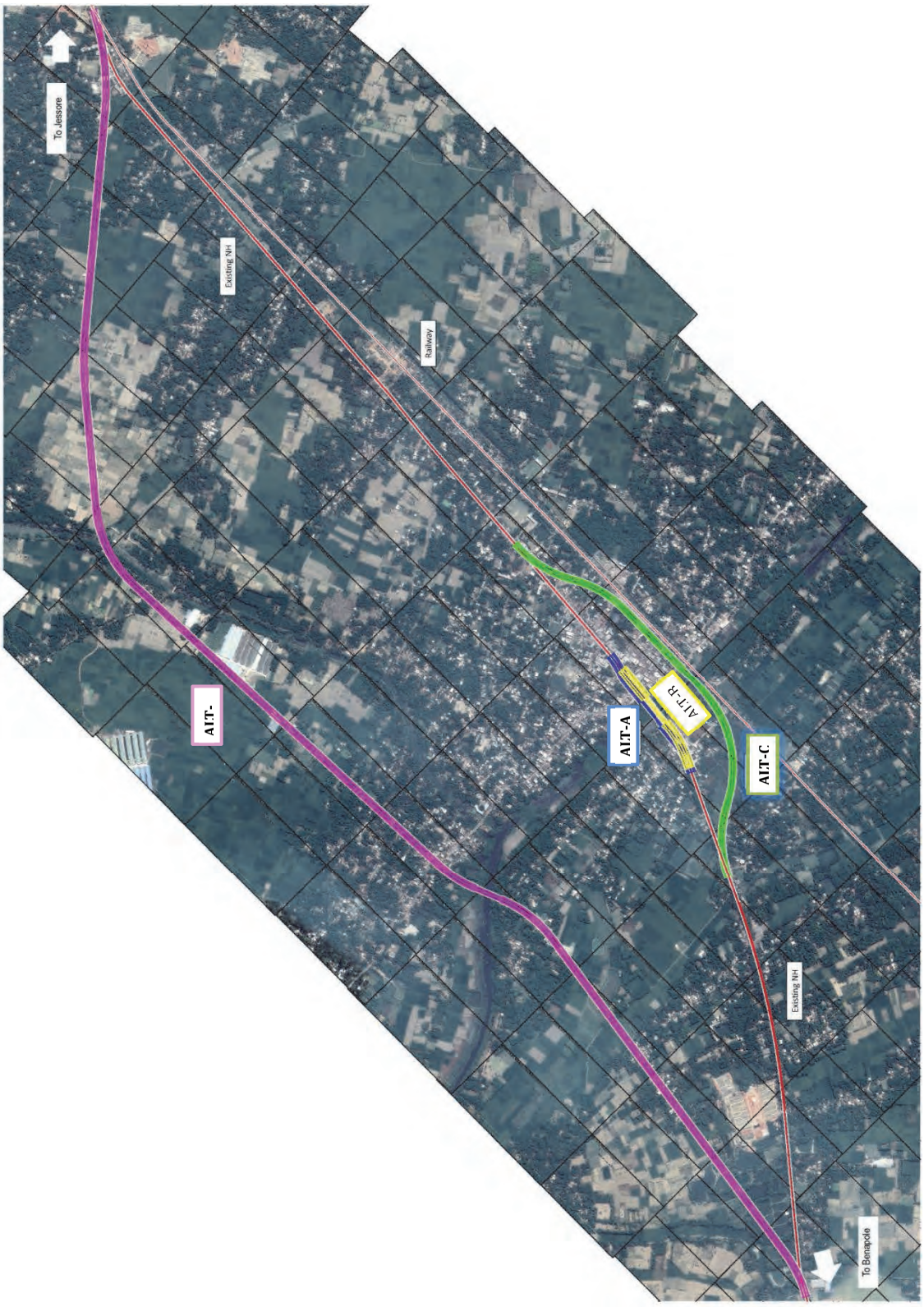


(b) Cross Section with Resettlement

Unit: m

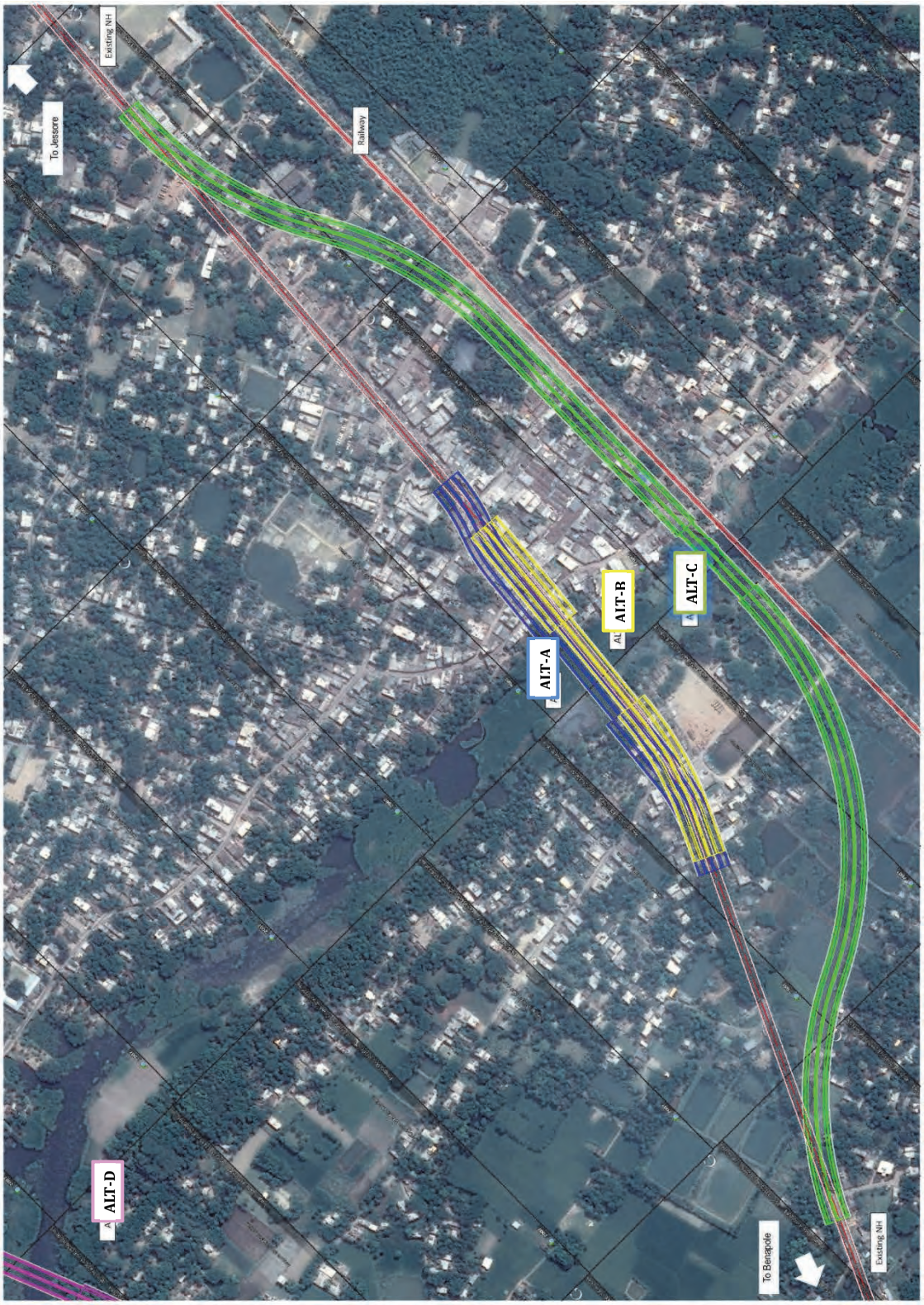
Source: JICA Survey Team

Figure 7.3.6 Cross Section for Flyover Alternative



Source: JICA Survey Team

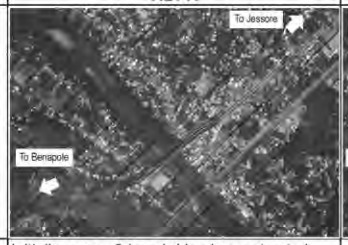
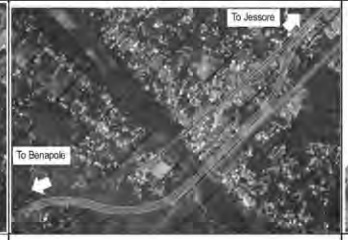
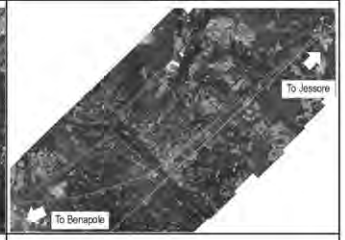
Figure 7.3.7 Alternative Routes for Jhikorgacha Bridge (Wide View)



Source: JICA Survey Team

Figure 7.3.8 Alternative Routes for Jhikorgacha Bridge (Details)

Table 7.3.2 Route Comparison for for Jhikorgacha Bridge

Alternaties	ALT-A	ALT-B	ALT-C	ALT-D
Route Outline				
Route Summary	Initially, a new 2-lane bridge is constructed beside the existing one on an upstream side and temporalily used in both directions. Subsequently, the existing bridge will be demolished to construct another 2-lane bridge and finally 4-lane, 2-way bridge is completed. (one-side widening as same as WBBIP)	A new bridge will be constructed keeping its centerline along that of existing bridge (both-sides widening). The existing bridge will be demolished.	A new bridge is constructed in the downstream near railway bridge (Bypass option)	A new bridge is constructed in the upstream far from the existing bridge (Bypass option as same as SHM's opinion)
Road Length (incl. bridge) [km]	0.56	0.47	1.70	6.14
Min. Horizontal Curve Radius [m]	230	380	440	440
No. of Horizontal Curves	3	2	4	6
No. of Affected Buildings*1	75	85	130	191
Construction Area (ha)	1.72	1.38	4.79	18.13
Land Acqusition Area (ha)	1.09	1.02	4.19	17.53
Traffic Situation	Traffic capacity doubles with 4 lanes.	Traffic capacity doubles with 4 lanes.	Traffic capacity is increased because traffic will be distributed by bypass.	Traffic capacity is increased because traffic will be distributed by bypass.
Constructability	A temporary bridge is unnecessary.	Temporary bridges are necessary and demolition of the existing bridge with diversion of existing traffic is required before bridge construction.	The existing bridge will be kept untouched. However, new bridge construction beside the existing railway bridge requires special precaution.	The existing bridge will be kept untouched. However, widening of the existing railway crossing (near the east end of the bypass) requires special precaution.
Road Constuction Cost*2	1.2	1.0	3.6	13.1
Bridge Constuction Cost*2	0.95	1.0	0.95	0.95
Evaluation		Recommended		
	・Number of affected buildings, which are located outside ROW, are the smallest among 4 alternatives. ・Construction area and required land acquisition area are relatively small, after those of ALT-B. ・Bridge construction cost is relatively low compared to ALT-B, because the temporary bridge is not required. ・Relatively easy in constructon of the bridge.	・Number of affected buildings, which are located outside ROW, are a little bit larger than ALT-A. ・Road length is shortest among 4 alternatives. ・Construction area and required land acquisition area are the smallest among 4 Alternatives. ・Road construction cost is the lowest among 4 Alternatives. ・Bridge constructon cost is a little costly compared to the other Alternatives.	・Traffic capacity of the bypass route is increased because local traffic will be diverted to the existing bridge route. ・However, the cost for repair/rehabilitation is required so as to maintain the existing bridge. ・A long bypass route brings about not only a large amount of land acquisition area but also road construction cost.	・Traffic capacity of the bypass route is increased because local traffic will be diverted to the existing bridge route. ・However, like ALT-C, the cost for repair/rehabilitation of the existng brdge will be required so as to maintain the existing bridge. ・This alternative route is significantly long and requires addtional bridge, and eventually the most costly in construction of bypass road section. ・Since this route passes through potential flooding area, additional embankment to the existing road level is required.
Remarks	Min. horizontal curve radius is smaller so as to set back to the existing alignment without relocation of mosque. However, it requires to reduce the design speed due to its location under developed area.	Bridge construction cost increases and construction period is longer a bit because temporary bridges and several diversion of existing traffic are required.		

*1: ALT-A & B are based on topographic survey results, and ALT-C & D are based on Satellite Image. *2: Comparative Index based on ALT-B =1.0).

Source: JICA Survey Team

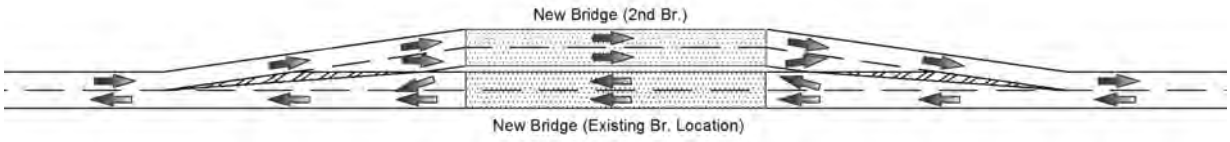
7.4 Preliminary Highway Design

Preliminary highway design is conducted based on the hydrological results, the preliminary bridge design and the site survey results. Main components are as below;

7.4.1 Section A (between Dhaka and Benapole)

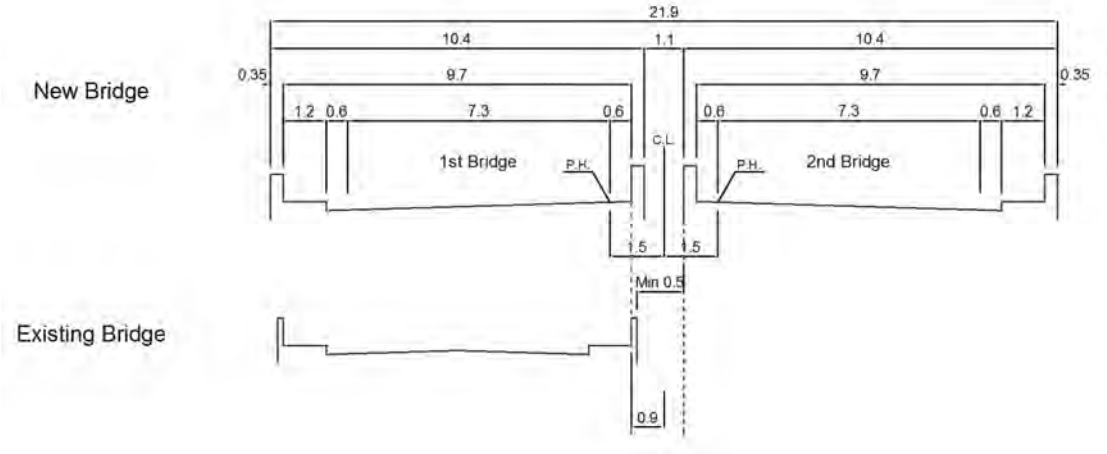
Target bridges are 5 locations in Section A. All bridges are planned to be 4-lane bridges, however, the existing roads are 2-lane. Therefore, it is required to taper between 2-lane and 4-lane in the approach embankment sections. The widening of the existing road in Section A excluding the target bridges is supposed to implement by ADB fund because it is included in the ADB prioritized projects. Hereinafter, the widening to 4-lane from Benapole to Padma Bridge is called as "the Completion Stage", and the only bridge widening to 4-lane is as "the Initial Stage". Also, BP side and EP side mean Benapole side and Dhaka side, respectively.

It is possible to reduce the construction cost and implementation schedule using the existing bridge (the 1st Bridge) as a temporary bridge for traffic during construction stage. Therefore, the 2nd Bridge location will be constructed beside the existing bridge as shown in Figure 7.4.1. (One side widening.) The center line will be basically set out at the position of 0.9 m apart from the inner of the existing bridge railing. The minimum distance of 2 bridges should be secured 0.5 m in width between the outer of the existing bridge railing and the outer of the 2nd Bridge railing for the construction space.



Source: JICA Survey Team

Figure 7.4.1 Image of One Side Widening



Unit: m

Source: JICA Survey Team

Figure 7.4.2 Setting Out of Center Line

The horizontal alignment is designed to meet with the applied design criteria of design speed 100 km/h in consideration with the Completion Stage. However, the design speed for the tapering between 2-lane and 4-lane is applied 80 km/h because (i) the maximum design speed of Bangladesh Standard is 80 km/h, and (ii) the duplication sections between construction works in the Completion Stage and the Initial Stage should be minimized as far as possible.

As same as the horizontal alignment, the vertical alignment is designed to meet with the applied design criteria of design speed 100 km/h, and the design speed for the tapering between the 2nd Bridge level and the existing road level is applied 80 km/h.

Table 7.4.1 shows comparison between the related standards for design speed 80 km/h and the applied design criteria of approach roads for the Initial Stage.

Table 7.4.1 Comparison between Related Standards and Proposed Design Criteria for the Initial Stage (Section A and C)

Standard/Criteria	Asian Highway	Bangladesh (2005)	SRTPPF	AASHTO	Japan	Adopted
Category	Class II	Design Type 2	-	Rural Collectors	Class 3-1	-
Terrain	Level	Plain	-	Level	Plain	Plain
Design Speed (km/h)	100	80	80	80	80	80
Stopping Sight Distance (m)	-	120	120	130	110	110
Min. Horizontal Curve Radius (m)	210	500	500	229	280 (230)	280
Min. Horizontal Curve Radius without Transition Curves (m)	900	-	-	-	2,000 (900)	900
Min. Transition Curve Length (m)	70	75	55	44	70	70
Max. Superelevation (%)	10.0	7.0	5.0	8.0	6.0	7.0
Max. Vertical Grade (%)	4.0	3.0	4.0	6.0	4.0	4.0
Min. Vertical Curve Length (m)	-	50	-	-	70	70
Min. Vertical Curve K-Value	-	35	70	Crest 26, Sag 30	Crest 30, Sag 20	35
Remarks						

*1: Figure in ( ) shows absoluted value.

Source: JICA Survey Team

The tapering method of lanes and median are referred to Japan Standard. At first, the parallel section is provided next to the abutment. The length of parallel section is secured 70 m as same as the minimum length of transition curve. And, the lane and median are tapered to the existing road using tapering ratio of 1/50 which is applied for design speed of 80 km/h in rural area.

On the other hand, it is required to taper the shoulder between the bridge and the embankment because those widths are different. The tapering is applied with the tapering ratio of 1/30 in reference with Japan Standard. The tapering length of each section is shown in Table 7.4.2. Also, the tapering of shoulder between the approach road and the existing road are unified at the taper section of lane and median.

Table 7.4.2 Taper Length (Section A and C)

		Tapering Ratio	Shifting Width	Tapering Length	Remarks
			m	m	
Parallel Section				70.0	
Taper Section for Lanes		1/50	3.65	180.0	Rounded
Taper Section for Median			1.50	75.0	
Taper Section for Shoulder	S/M Br. - Fill Sec.	1/30	1.20	36.0	
	L Br. - Fill Sec.		2.10	63.0	

Source: JICA Survey Team

Based on the above method, preliminary highway design was conducted and the design summary in each bridge is shown in Table 7.4.3. The design outline of each bridge location is presented as below:

Table 7.4.3 Design Summary in Section A

Sl. no.	Bridge name	Road No	Applied Design Speed (km/h)					Approach Road Length (m)		
			Bridge		Approach Road			A1 Side	A2 Side	Total
			Horizontal	Vertical	Horizontal	Vertical	Taper			
Section A (Dhaka-Benapole)										
A1	Jhikorgacha Bridge	N-706	100	100	100	80	60	205.000	205.000	410.000
A2	Tularampur Bridge	R-750	100	100	100	100	80	325.000	411.821	736.821
A3	Haw ai khali Bridge	Z-7503	100	100	100	80	80	325.000	330.000	655.000
A4	Kalna Bridge	N-806	100	100	100	100	80	325.000	3,897.457	4,222.457
A5	Garakola Bridge	N-805	100	100	100	80	80	315.000	366.405	681.405

Source: JICA Survey Team

(1) Jhikorgacha Bridge

Jhikorgacha Bridge is set out the horizontal and vertical alignment based on the results of optimum route study and the above design policy. However, it is applied that the design speed for tapering of lane and median is 60 km/h taking into account of the current situation such as land constrain, urbanization and so on. Therefore, the tapering ratio of 1/30 which is applied for design speed of 60 km/h in urban area is adopted to minimize the duplication sections as far as possible.

And, it is planned to construct the retaining walls along both sides to minimize the land acquisition. To minimize the duplication section as far as possible, the same width of typical cross section is constructed up to the tapering section boundary between lane and median, and it is tapered to the existing road in the tapering section of median. The tapering of lane is presented by lane markings only. Also, the parallel section is adopted 50 m in length which is equivalent with minimum length of transition curve for design speed 60 km/h. The tapering length of Jhikorgacha Bridge is shown in Table 7.4.4.

Table 7.4.4 Taper Length (Jhikorgacha Bridge)

	Tapering Ratio	Shifting Width	Tapering Length	Remarks
		m	m	
Parallel Section			50.0	
Taper Section for Lanes	1/30	3.65	110.0	Rounded
Taper Section for Median		1.50	45.0	
Taper Section for Shoulder	1/30	0.60	18.0	

Source: JICA Survey Team

(2) Tularampur Bridge

Surrounding Tularampur Bridge, a bazar is located at the south of A1 (BP side). However, the river is sharply curved in the upstream side (north side). Therefore, the 2nd Bridge is planned at the downstream side (south side) to avoid the influence of river meandering.

(3) Hawai Khali Bridge

Surrounding Hawai Khali Bridge, a mosque is located at the north of A1 (BP side). Therefore, the 2nd Bridge is planned at the downstream side (south side).

(4) Khalna Bridge

Khalna Bridge is set out to the horizontal and vertical alignment with design speed 100 km/h based on the results of optimum route study and the above design policy. However, it is applied that the design speed for tapering of lane and median is 80 km/h at the BP side. On the other hand, the 4-lane road directly connects with the roundabout at the EP side. For setting out of the horizontal alignment, the followings are taken into account;

- As the results of topographic survey, the sub-tower of high-voltage lines on A2 side (EP side) is located at the south side compared with the satellite image. The main and sub towers should be avoided,
- Based on the hydrological analysis, the center line should be at right angles to the flow direction as much as possible, and
- Mosques should be avoided and also the affected houses should be minimized.

For setting out of the vertical alignment on the Madumati River, the navigation clearance with Class III, which has 30.48 m in width and 7.62 m in height on SHWL of 6.34 m on MSL, shall be accommodated. On the other hand, the followings are written in the Bangladesh Standard regarding the design levels on the fill section.

- It is normal practice to build roads so that the carriageway surface will have a freeboard of 1.0m above the highest flood level recorded in the locality. (Year 2000)
- It is desirable to build roads so that the bottom level of the pavement (sub-base) will have a freeboard of 1.0 m above the flood level to be calculated for a 30 year return period. (Year 2005)

The highest flood level recorded is 6.29 m which was observed in Year 1952, and the flood level to be calculated for a 30 year return period is 6.08 m. Then, the estimated surface levels are 7.29 m for the former one, and 8.06 m for the later one in assumption with 1.0 m of pavement thickness, respectively. The ground elevation around inhabitant area at A2 side (EP side) is approximately 4.0 m on MSL. To minimize the embankment height, the former one is adopted, and the lowest embankment height is applied 7.29 m on MSL.

In next, Kalna Bridge has a plan to collect the toll fee. Then, it should be avoided that the access roads will connect between toll facility and bridge. On the other hand, some local roads are across the project road at A2 side (EP side). It is undesirable in the view of traffic safety and community that those roads connect with the high level road with at-grade intersections. A one of solutions is provision of frontage roads on both sides. However, it has some demerits such as increasing land acquisition area and number of affected houses, long distance of detour road and so on. Then, the minimum embankment height is set out as 7.29 m. On the other hand, the ground level is around 4.0 m in that area. The different height is 3.29 m, and it is high. Therefore, those local roads are across under the project road by box culverts. The size of box culvert is basically 3.0 m in width and 3.0 m in height for the target of smaller vehicles such as CNG and car in consideration with the existing traffic and road conditions. And, the local road at Sta.1+600 seems the widest road along the project road. Then, the box culvert at Sta.1+600 is planned to accommodate with the 2-lane road with 6.0 m in width and 5.1 m in height which is vertical clearance of Bangladesh Bridge Design Standard.

And, in consideration with the network of the axle load control facilities in the whole country as mentioned in Chapter 4, the axle load control facility is not planned with the toll facilities in Kalna Bridge.

(5) Garakola Bridge

The existing Garakola Bridge had reconstructed in 2004 on downstream side (South side) of the old one. And, it is new and is classified in Category A which means a good condition. Therefore, the existing will be remained and utilized as the 1st bridge. And, the 2nd bridge will be only constructed on the upstream side (North side) which was located at the old bridge because the ROW had been secured.

7.4.2 Section B (between Ramgarh and Baraiyarhat)

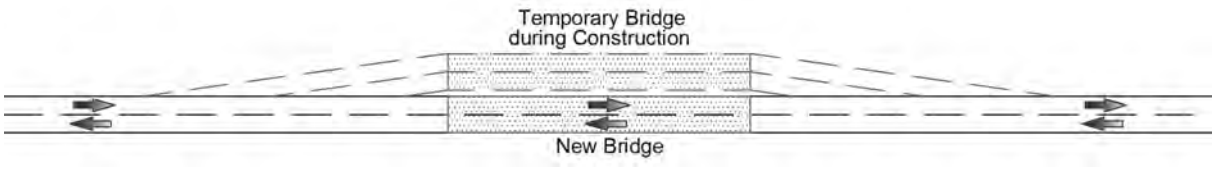
Targets are 8 locations and 7 box culverts in Section B. The all existing road conditions are narrow width and winding with sharp curves. However, the road is required to upgrade to the international road as a cross border infrastructure. Therefore, it is necessary to conduct the preliminary highway design in the whole stretch. The upgrading of the existing roads and bridges in Section B excluding the above 8 target bridges and 7 target box culverts is supposed to implement by GoB fund of ADB fund because it is included in the ADB prioritized projects. Hereinafter, the upgrading of the whole stretch from Bariyarhat to Ramgarh is called as “the Completion Stage”, and the only 8 bridges and 7 box

culverts upgrading is as “the Initial Stage”. Also, BP side and EP side mean Bariyarhat side and Ramgarh side, respectively.

For the preliminary highway design, it is desirable to utilize the ROW of the existing as far as possible. The design policy is to follow the existing road (replacement) in fundamental. However, the existing road is low level as the above mentioned. Then, it is impossible to follow the existing road alignment in the whole stretch.

On the other hand, when the construction of the Completion Stage will be implemented after simply replacement of the above 8 target bridges and 7 box culverts at the same location, some issues will be occurred such as the number of affected houses will drastically increase or another new bridge is required due to passing steep valley and so on. Therefore, prior to the design of the above 8 target bridges and 7 target box culverts, it is required to set out of the alignment in the Completion Stage at first. And then, the alignment of approach roads in the Initial Stage can be set out to taper between the bridges in the Completion Stage and the existing roads.

To follow the above design policy, the new bridge location will be basically located at the existing one (replacement) with temporary bridge beside of the existing one as shown in Figure 7.4.3. However, it will be determined based on the alignment in the Completion Stage.



Source: JICA Survey Team

Figure 7.4.3 Image of Bridge Replacement

The alignment is designed to meet with the applied design criteria of design speed 50 km/h in consideration with the Completion Stage. On the other hand, the design speed of the approach roads for the Initial Stage is applied 40 km/h because (i) the design speed of the existing roads is less than 40 km/h, and (ii) the duplication sections between construction works in the Completion Stage and the Initial Stage should be minimized as far as possible. However, the alignment of the bridges keeps design speed of 50 km/h as well as the Completion Stage.

However, in some cases, it is difficult to taper to the existing roads with maintaining the alignment on bridge in the Completion Stage due to the alignment has transition curve on the bridge. In this case, it is necessary to adjust that 2-lane travelled-way in the Initial Stage will be accommodated within the bridge effective width in the Completion Stage, utilizing or being similar with the center line of the Completion Stage as far as possible.

Table 7.4.5 shows comparison between the related standards for design speed 40 km/h and the applied design criteria of approach roads for the Initial Stage.

Table 7.4.5 Comparison between Related Standards and Proposed Design Criteria for the Initial Stage (Section B)

Standard/Criteria	Asian Highway	Bangladesh (2005)	AASHTO	Japan	Adopted
Category	Class III	Design Type 4	Rural Collectors	Class 3-4	-
Terrain	Mountain	Hilly	Mountain	Mountain	Mountain
Design Speed (km/h)	40	40	40	40	40
Stopping Sight Distance (m)	-	45	50	40	40
Min. Horizontal Curve Radius (m)	50	65	41	60 (50)	60
Min. Horizontal Curve Radius without Transition Curves (m)	250	-	-	500 (250)	250
Min. Transition Curve Length (m)	35	35	22	35	35
Max. Superelevation (%)	10.0	7.0	8.0	6.0	7.0
Max. Vertical Grade (%)	6.0	7.0	11.0	7.0	6.0
Min. Vertical Curve Length (m)	-	20	-	35	35
Min. Vertical Curve K-Value	-	4	Crest 4, Sag 9	4.5	4.5
Remarks			Design speed range is 30-100 km/h	Design speed range is 30-50 km/h	

*1: Figure in ( ) shows absoluted value.

Source: JICA Survey Team

The tapering method of roadway is referred to Japan Standard as well as Section A. At first, the parallel section is provided next to the abutment. The length of parallel section is secured 35 m as same as the minimum length of transition curve. And, the roadway is uniformly tapered to the existing road within the improving length in the Initial Stage. Also, the tapering between the bridge and embankment is applied with the tapering ratio of 1/30 as well as Section A. The tapering length of each section is shown in Table 7.4.6.

Table 7.4.6 Taper Length (Bridges in Section B)

		Tapering Ratio	Shifting Width	Tapering Length	Remarks
			m	m	
Parallel Section				35.0	
Taper Section for Shoulder	S/M Br. - Fill Sec.	1/30	0.35	10.5	

Source: JICA Survey Team

Based on the above method, preliminary highway design was conducted and the design summary of the 8 target bridges is shown in Table 7.4.7.

Table 7.4.7 Design Summary for Bridges in Section B

Sl. no.	Bridge name	Road No	Applied Design Speed (km/h)					Approach Road Length (m)		
			Bridge		Approach Road			A1 Side	A2 Side	Total
			Horizontal	Vertical	Horizontal	Vertical	Taper			
Section B (Baraiyarhat-Ramgarh)										
B2	Telipool Bridge	R-151	50	50	50	40	40	141.707	144.200	285.907
B3	Lakshmi chara Bridge	R-151	50	50	50	40	40	91.807	120.025	211.832
B9	Kalapani Bridge-2	R-151	50	50	50	40	40	90.402	103.363	193.765
B12	Koilabazar Bridge	R-151	50	50	40	40	40	89.440	118.597	208.037
B13	Balutila Bridge	R-151	50	50	50	40	40	94.873	93.017	187.890
B16	Heako Bridge	R-152	50	50	50	40	40	102.179	82.168	184.347
B18	Chikon Chara Bridge	R-152	50 (40)	50	40	40	40	85.431	137.435	222.866
B25	East baganbazar Bridge	R-152	50	50	40	40	40	128.962	107.877	236.839

Note: ( ) shows the initial stage.

Source: JICA Survey Team

On the other hand, the typical cross section on box culverts is the same as of the embankment. And, the roadway is uniformly tapered to the existing road within the improving length in the Initial Stage. The design summary of the 7 target box culverts is shown in Table 7.4.8.

Table 7.4.8 Design Summary for Box Culverts in Section B

Sl. no.	Bridge name	Road No	Box Culvert			Approach Road Length (m)
			Cell No.	Wisth (m)	Height (m)	
Section B (Baraiyarhat-Ramgarh)						
B14	Fulchari Bridge	R-151	2	3.0	3.0	248.666
B15	Heaku Bazar B ridge	R-151	1	3.0	3.0	210.134
B19	Chikon Chara Bridge	R-152	2	3.0	3.0	250.800
B20	Banglabazar bridge	R-152	1	3.0	3.0	251.034
B22	Borobil Bridge	R-152	1	2.0	2.0	238.400
B23	Gadar dokan Bridge	R-152	2	3.0	3.0	243.100
B24	Bagan Bazar Bridge	R-152	1	3.0	3.0	196.534

Source: JICA Survey Team

Additionally, the B26 Bridge is out of scope because the DPP of this bridge had approved and this bridge will be replaced by the GoB budget. However, there is a mosque at the BP side. Then, the alternative bridge location has been proposed, when the alignment of the whole stretch for the Completion Stage are set out.

And, among 4 bridges, which had been determined to utilize the existing one in prioritization of projects due to the good conditions, the B1 and B21 bridges are required to be bridge in the future, based on the hydrological analysis. Then, those 2 bridges had been conducted a preliminary highway design for the "Future Stage" in consideration of the replacement in the future due to deterioration (as of reference).

7.4.3 Section C (between Chittagong and Cox's Bazar)

Target bridges are 4 locations in Section C. All bridges are planned to be 4-lane bridges, however, the existing roads are 2-lane as well as Section A. Therefore, design policy, bridge location, tapering method and so on are the same as the one of Section A. Also, it seems Section C had been improved in the past because some brick abutments are found beside the existing bridges. It is desirable to utilize those ROW, but unfortunately, those ROW can't be found in the 4 target bridges. The widening of the existing road in Section C excluding the target bridges has possibility to be implemented by ADB fund because ADB implemented the study. Hereinafter, the widening to 4-lane from Chittagong to Cox's Bazar is called as "the Completion Stage", and the only bridge widening to 4-lane is as "the Initial Stage". Also, BP side and EP side mean Chittagong side and Cox's Bazar side, respectively.

Based on the above method, preliminary highway design was conducted and the design summary in each bridge is shown in Table 7.4.9. The design outline of each bridge location is presented as below:

Table 7.4.9 Design Summary in Section C

Sl. no.	Bridge name	Road No	Applied Design Speed (km/h)					Approach Road Length (m)		
			Bridge		Approach Road			A1 Side	A2 Side	Total
			Horizontal	Vertical	Horizontal	Vertical	Taper			
Section C (Chittagong-Cox's Bazar)										
C8	Patiya Bridge	N-1	100	100	100	100	80	354.016	325.000	679.016
C12	Mazar Point Bridge	N-1	100	100	100	80	80	325.000	352.407	677.407
C13	Sangu Bridge	N-1	100	100	100	100	80	434.312	341.339	775.651
C26	Mathamuhuri Bridge	N-1	100	100	100	100	80	300.000	410.134	710.134

Source: JICA Survey Team

(1) Patiya Bridge

Surrounding Patiyai Bridge, there are RHD lands on the upstream side (east side). Also, it is desirable that new bridge will be constructed on the upstream side, based on the public opinion in the SHM. Therefore, the 2nd Bridge is planned at the upstream side (east side). And, there is a mosque on the upstream side (east side) near the BP (Chittagong side). For setting out the alignment, it should be avoided.

(2) Mazar Point Bridge

There are sharp curves before and after the existing bridge. When the 2nd Bridge will be constructed in parallel with the existing one, the affected and improved area will increase. Also, there are curves with the different direction on each approach road. Then, new alignment like a bypass is set out on the downstream side (west side), utilizing those adverse curves. Therefore, temporary bridge will be unnecessary because the existing bridge will be used during construction stage.

There are mosques on the upstream side (east side) at the both side (BP and EP sides). For setting out the alignment, it should be avoided. Also, there is a small bridge near the EP. It is proposed to replace by a box culvert because it is supposed that the flow volume is less and box culvert has enough capacity.

(3) Sangu Bridge

There is a grave yard on the upstream side (east side) near A1 (BP side). Therefore, the 2nd Bridge is planned at the downstream side (west side).

(4) Mathamuhuri Bridge

Surrounding Mathamuhuri Bridge, the upstream side (east side) is better than the downstream side (west side) regarding the less number of affected houses and setting out of good alignment with existing road. Therefore, the 2nd Bridge is planned at the upstream side (east side).

There is a small bridge near the BP, and then, the parallel section is shortened to 45 m and improvement section avoids it.

7.4.4 Pavement Design

The following standards have been referred to for the pavement design:

- AASHTO Guide for Design of Pavement Structures (US: Year 1993)
- Pavement Design Guide for Roads & Highways Department (Bangladesh RHD: Year 2005)

(1) Axle Load Equivalent Factors (LEF)

As the above mention, one of the traffic characteristics in Bangladesh is a high ratio of the over loaded vehicles. It is supposed that the ratio of the over loaded vehicles will be higher on the target roads because it is located on the cross border routes. Then, the pavement structures on the target roads are required to consider those conditions. On the other hand, the axle load equivalent factors recommended by RHD in consideration with those traffic characteristics seem to be set out. However, the RHD's LEF is too high, compared with the common LEF. And, the individual LEF were set out in the other projects. Then, the LEF for this project is also set out based on the axle load survey results. The axle load survey was conducted at one each in Section A and on NH-1 near Section C, respectively. (refer to Chapter 6.) However, the surveyed number of vehicle and vehicle

types is not much. Therefore, based on the survey results on NH-1 near Section C, the following study is conducted.

Also, the vehicle categories are 4+1 (car, utilities, bus, truck + trailer) in the traffic demand. However, the surveyed vehicle types are classified more details such as medium trucks and large trucks. Then, using the vehicle type component ratio of survey results at 3DC-2 which is the observation point on NH-1 near Section C, the LEFs of trucks, trailers and buses are estimated as shown in Table 7.4.10. Also, LEFs of a car, small bus and large bus are applied the common value of 0.0008, 0.50 and 1.00, respectively. (refer to Appendix regarding the details of LEFs by Survey.)

Table 7.4.10 Applied Axle Load Equivalent Factors

Vehicle Category	RHD Standard	LEFs by Survey	Traffic Volume (Weekday)		Design LEFs
			veh./day*	Ratio	
Medium Truck	4.62	1.1104	821	72.4%	
Large Truck	4.80	3.0140	313	27.6%	
Truck			1,134		**1.6358**
Trailer		1.3498			**2.2901**
Small Bus	0.50		255	25.5%	
Large Bus	1.00		745	74.5%	
Bus			1,000		**0.8725**
Trailer					**0.0008**

*: Traffic Survey Results at 3DC-2
Source: JICA Survey Team

(2) Pavement Structure

The approach roads for Kalna Bridge is basically planned to meet with the Completion Stage. On the other hand, the approach roads for the other bridges are planned as the Initial Stage. Then, the pavement design is divided into two and conducted; namely, Kalna Bridge and the other bridges.

1) Design Period

For Kalna Bridge, the design period is determined after comparison with 3 cases; namely, 10 years, 15 years and 20 years. On the other hand, the design period of the other bridges are applied 10 years due to the following reasons;

- Those approach roads are designed in the Initial Stage, and the pavement may be reconstructed when the construction in the Completion Stage will start.
- The design traffic volume is applied the highest one in each section, and thus applying 20 years as the design period is excessive and over-investing.

2) Design CBR

According to the Bangladesh Standard, the subgrade with CBR 5 and more is unnecessary to improvement it and is defined as the lowest value for pavement design. Therefore, the Design CBR value of the subgrade in the Project is adopted 5.0 in the view of safety side.

3) Applied Pavement Structure

Design Structural Numbers (Design SN) for Kalna Bridge are calculated as 5.7, 6.1 and 6.5 in corresponding with the design period 10 years, 15 years and 20 years, respectively, also, pavement thicknesses are 82 cm, 91 cm and 100 cm, respectively. Compared with those results, the design period for Kalna Bridge is applied 10 years due to the following reasons;

- Deisgn SNs excluding the design period of 10 years are over 6.0. And, those pavement thicknesses are more than 90 cm, and the pavement structures are wasteful.
- When the pavement thickness is required more than 90 cm, the Asphalt Treated Base (ATB) is recommended, but it is high price.
- The pavement thicknesses excluding the design period of 10 years are very thick and those initial costs are high. Then, it is suitable to treat with a suitable maintenance.
- Target year of the geometric design standard in Bangladesh is 10 years after public use. It is necessary to coordinate with the design period of pavement design.

The applied pavement structures of each section are shown in Table 7.4.11. (refer to Appendix regarding the details of pavement structures.) However, the applied the Design CBR 5.0 is low. Then, the pavement design shall be considered in the detailed design stage based on the material survey and the detailed geological survey results.

Table 7.4.11 Applied Pavement Structure

Section	Kalna	A (excluding Kalna)	B	C
Design Period (year)	10	10	10	10
	2021-2030	2022-2031		
SN	5.7	5.7	4.7	5.3
Total thickness (cm)	82	82	68	78
Surface Course (cm)	5	5	5	5
Binder Course (cm)	10	10	8	8
Base Course (cm)	30	30	25	30
Sub-base Course (cm)	37	37	30	35
CBR	5			

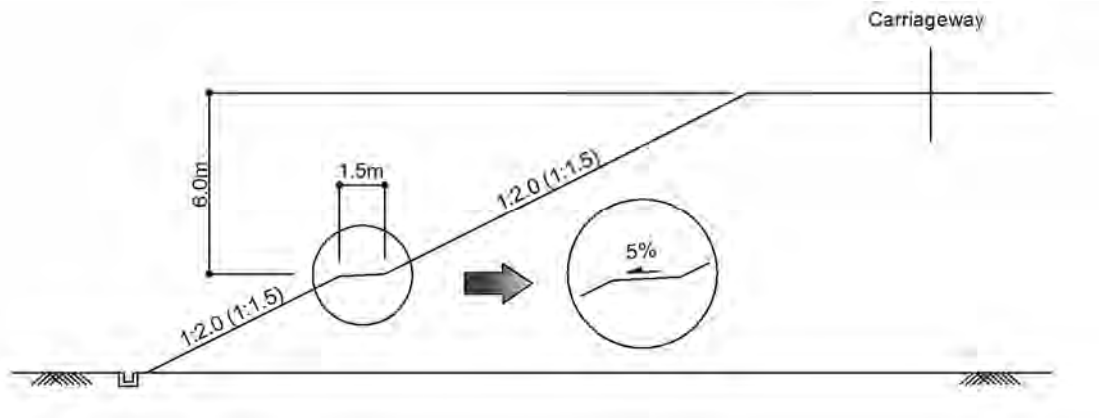
Source: JICA Survey Team

7.4.5 Standard Cross Section for Cutting and Filling

(1) Embankment Height and Slope

The slope of the embankment should be 1V:2H at plain terrain in accordance with RHD standards. However, when this slope (1:2) is applied at hilly terrain in Section B, the embankment slope will be longer. On the other hand, it is supposed that the geological condition in hilly area of Section B is better than the one at the plain area. Then, the slope of the embankment is 1V:1.5H at hilly terrain in reference with Japan standards.

And, for every 6m rise, a step of width 1.5m shall be set in order to prevent erosion by rainwater and inspection. The height of the step and the slope of embankment shall be considered in the detailed design stage based on the slope stability analysis and the detailed geological survey results.

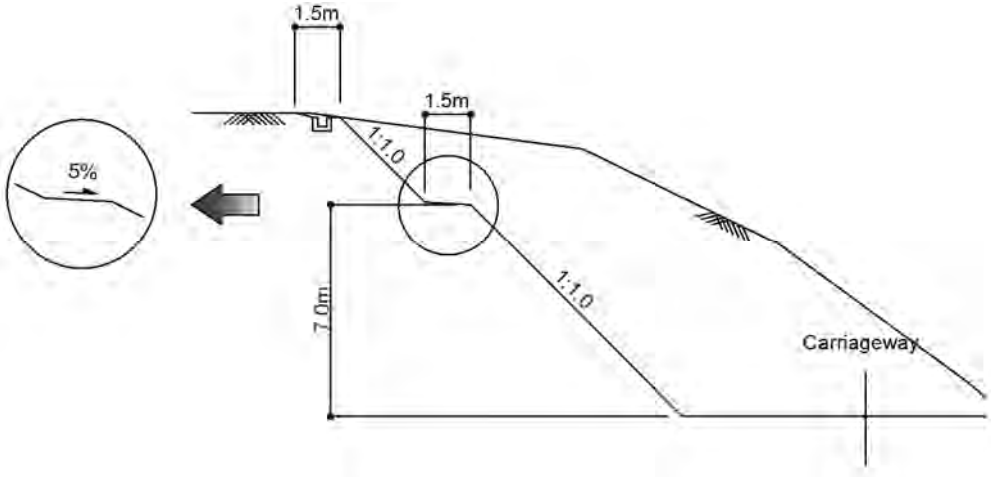


Source: JICA Survey Team

Figure 7.4.4 Standard Embankment Section

(2) Cutting Height and Slope

The slope of the cutting is 1V:1.0H at hilly terrain in reference with Japan standards. And, for every 7 m rise, a step of width 1.5 m shall be set as well as the embankment. The height of the step and the slope of cutting shall be considered in the detailed design stage as well as the embankment.



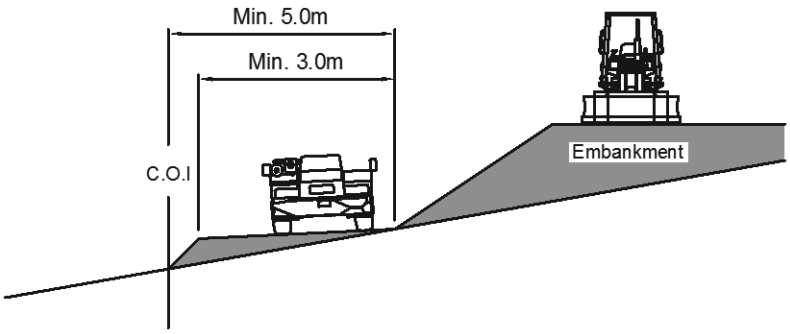
Source: JICA Survey Team

Figure 7.4.5 Standard Cutting Section

7.4.6 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 excluding Section B because ROW maps in Section B are old, and unknown. The Corridor of Impact (COI) is set at 5 m as of minimum width from the bottom of the embankment or the top of the excavation including construction temporary road of 3 m in width as shown in Figure 7.4.6, and is set to the minimum required area for construction activities in order to

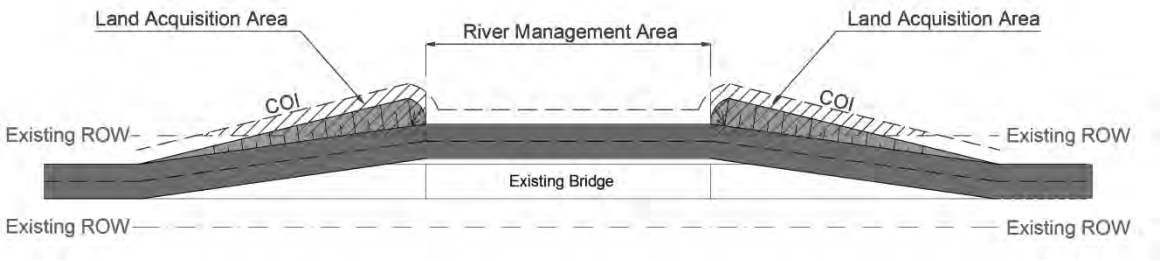
minimize resettlement and compensation. And, compared with the result of the existing ROW survey, the land acquisition area is calculated. The COI shall be considered in the detailed design stage based on the detailed construction plan.



Source: JICA Survey Team

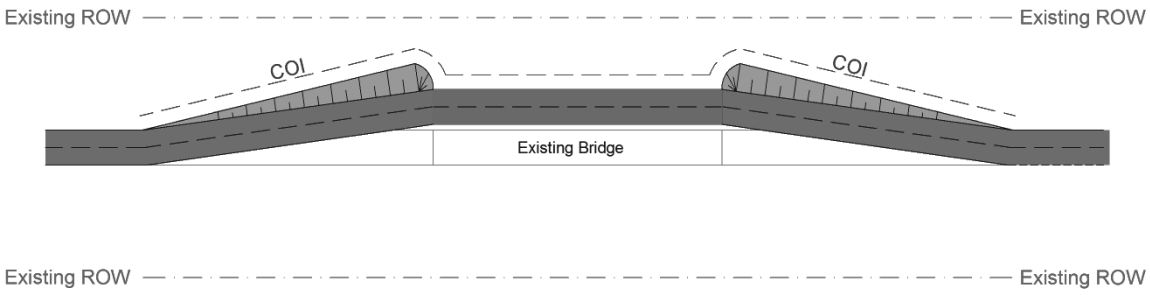
Figure 7.4.6 Corridor of Impact (COI)

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 7.4.7 and Figure 7.4.8.



Source: JICA Survey Team

Figure 7.4.7 Outside of Existing ROW



Source: JICA Survey Team

Figure 7.4.8 Inside of Existing ROW

However, as previously mentioned, Jhikorgacha Bridge in Section A is planned to construct the retaining walls along both sides under the strict constrain of land acquisition. Also, the height of retaining walls is not so high. Therefore, the Corridor of Impact (COI) is set at 0.3 m from the outer

edge of the retaining wall, which is a minimum space for installation of the forms. And, the required land acquisition area is determined.

7.5 Other Facility Plans

7.5.1 Toll Collection Facility

Kalna Bridge has a plan to be toll bridge because Kalna Bridge will be newly constructed instead of the existing Daulatdia Ferry on Madumati River. The design standard is not available in Bangladesh, and then, the toll collection facilities are planned to refer with the Japan Standard.

(1) Necessary Number of Lanes

Based on the traffic demand results, the target traffic volume is estimated under the following conditions;

- Target Year: 2030 (after 10 years from operation)
- AADT: 5,749 veh./day
- K-value: 12 %
- D-value: 55 %

Using the above, the target traffic volume is calculated as 380 veh./peak hour/direction.

Then, the minimum number of lanes is estimated as 2-lane per one direction based on the following conditions and Table 7.5.1.

- Type of Toll Collection: Barrier Type
- Service Time: 8 second (Operation Time)
- Service Level: 1 veh. (Number of Average Queuing Vehicles)

Finally, the necessary number of lanes is determined as 3-lane per one direction in consideration with 2-lane per one direction on the main road.

Table 7.5.1 Relation between Number of Lanes, Service Time, Service Level and Traffic Capacity

Unit: veh./hour

Service Time / Service Level / Required No.of Lanes	6 second		8 second		14 second	
	1.0	3.0	1.0	3.0	1.0	3.0
1	300	450	230	340	130	190
2	850	1,040	640	780	360	440
3	1,420	1,630	1,070	1,230	610	700
4	2,000	2,230	1,500	1,670	860	960
5	2,590	2,830	1,940	2,120	1,110	1,210

Source: NEXCO Design Standard; Japan

(2) Location of Toll Collection Facilities

According to the Japan Standard, the location of toll collection facilities should be satisfied the following geometric conditions;

- Horizontal Alignment: Same as the design criteria of the main road
- Vertical Grade: 2.0 % and less
- Vertical Curve: Same as the design criteria of the main road

The standard length of toll plaza including tapering section is 75 m before/after the center of toll gates, and the total length is 150 m. And, the 3 alternative locations of toll collection facilities are set out to close to the bridge as far as possible as shown in Figure 7.5.1.

Source: JICA Survey Team

Figure 7.5.1 Alternatives of Location for Toll Collection Facilities

Among 3 alternatives, ALT-3 is selected due to the following reasons;

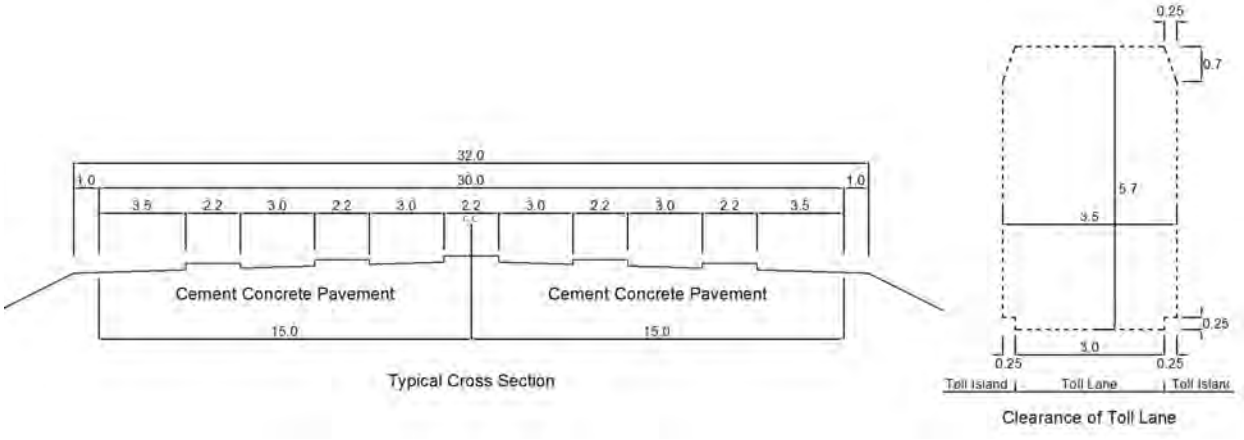
- ALT-3 is farthest from the bridge. However, ALT-3 is most suitable alignment among 3 alternatives to construct the toll collection facilities.

- ALT-2 is satisfied the design standard for the location of toll collection facilities. However, the location is close to the horizontal curve and is located at the vertical curve section. Therefore, it is inferior than ALT-3.

- The scope of the project will be longer and the frontage road will be required or longer, if the toll collection facilities will be constructed at ALT-1. And, the construction cost will increase, and also, it is possibility that the number of affected houses will increase because it is required to meet with the Completion Stage.

(3) Layout of Toll Collection Facilities

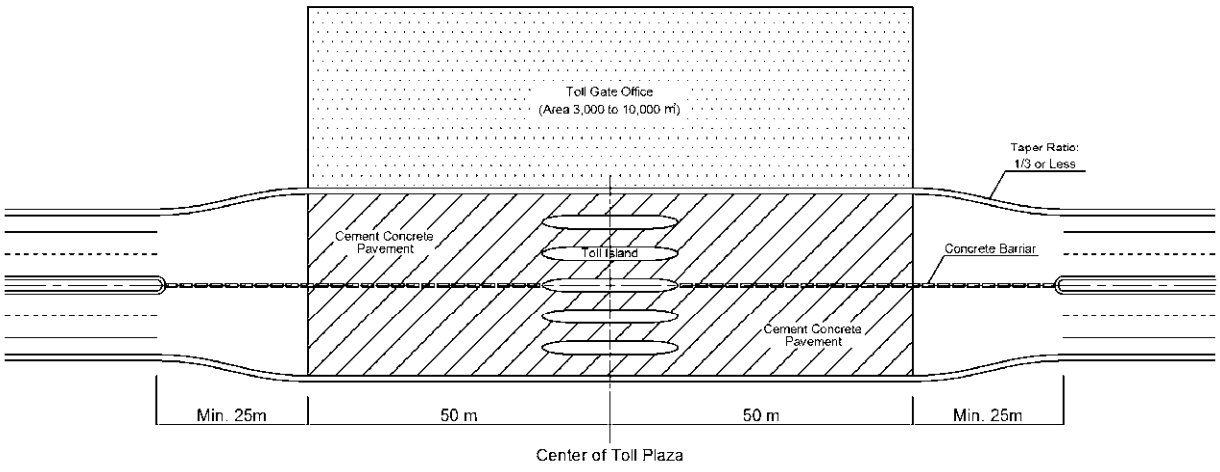
The layout of toll collection facilities is also referred with Japan Standard. The length of toll plaza is 50 m before/after the center of toll gates, totally 100 m. The tapering ratio between the toll plaza and the normal embankment section is 1/3 and less. Figure 7.5.2 and Figure 7.5.3 show the typical cross section at toll gate and the sample layout of toll plaza.



Unit: m

Source: JICA Survey Team

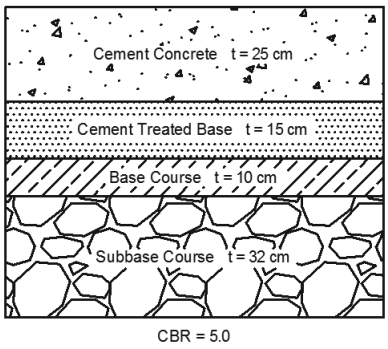
Figure 7.5.2 Typical Cross Section of Toll Gate



Source: JICA Survey Team

Figure 7.5.3 Sample Layout of Toll Plaza

The pavement type at toll plaza is applied the cement concrete pavement to reinforce the durability against the oil leakage, rutting and so forth. The standard cement concrete pavement structure at the toll plaza is shown in Figure 7.5.4.



Source: JICA Survey Team

Figure 7.5.4 Standard Cement Concrete Pavement (Toll Plaza)

7.5.2 Axle Load Control Facility

As the above mention, one of the traffic characteristics in Bangladesh is a high ratio of the over loaded vehicles. If those over loaded vehicles will leave as it is, the pavement will deteriorate rapidly and the maintenance cost of RHD will increase seriously. It is desirable to enforce those vehicles properly. Therefore, as mentioned in Chapter 4, the axle load control facilities are planned at Benapole in Section A and Ramgarh in Section B. Bangladesh has been issued the Notification No. RRD/BRTA/Overload-38/96(P-1)-653 dated on the 16th of November, 2003 regarding maximum permissible axle and laden weighs limit for motor vehicle. However, the design standard is not available in Bangladesh, and then, the axle load control facilities are planned to refer with the Japan Standard.

(1) Necessary Number of Axle Load Scale Lanes

Applying with the future international cargo traffic as the results of the traffic demand, the target traffic volume is estimated under the following conditions;

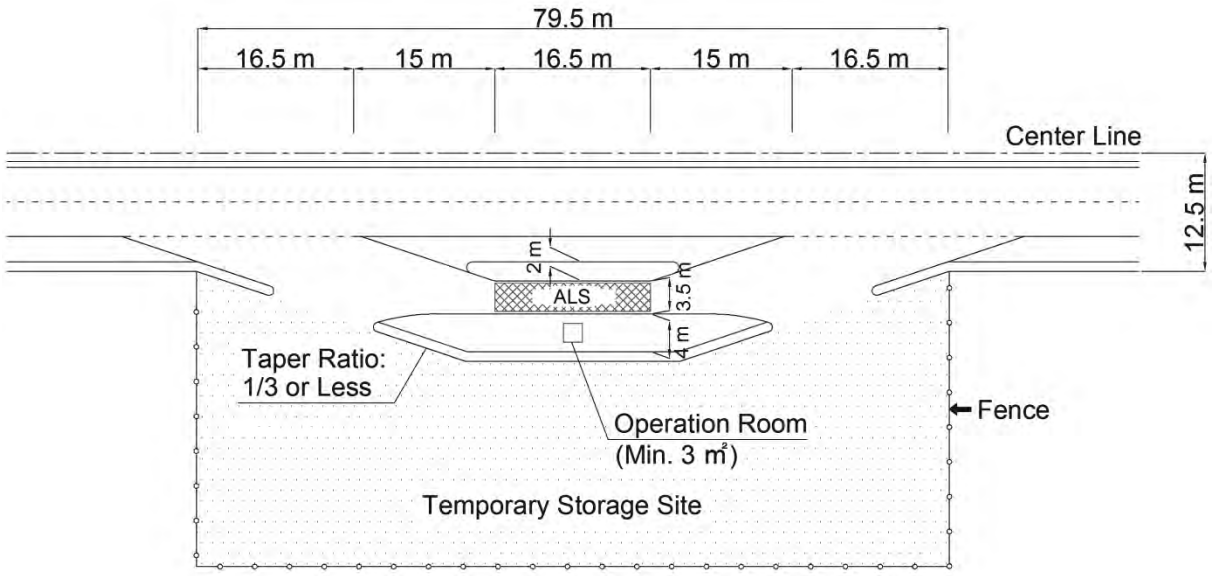
- Target Year: 2030 (after 10 years from operation)
- AADT [Section A]: 788 veh./day
- AADT [Section B]: 373 veh./day
- K-value: 12 %
- D-value: 55 %

Using the above, the target traffic volume is calculated as 52 veh./peak hour/direction in Section A and 25 veh./peak hour/direction in Section B.

Standard capacity of 1 axle load station is 60 veh./hour. Therefore, the necessary number of axle load scale lane is determined as 1-lane per one direction at Benapole and Ramgarh, respectively.

(2) Layout of Axle Load Control Facility

The layout of the axle load control facility in the Completion Stage, in reference with Japan Standard. On the other hand, Bangladesh seems to introduce the system which the vehicles are allowed to pass after unloading the overload at the temporary storage site by ADB recommendation. Then, the layout combines those systems as illustrated in Figure 7.5.5.

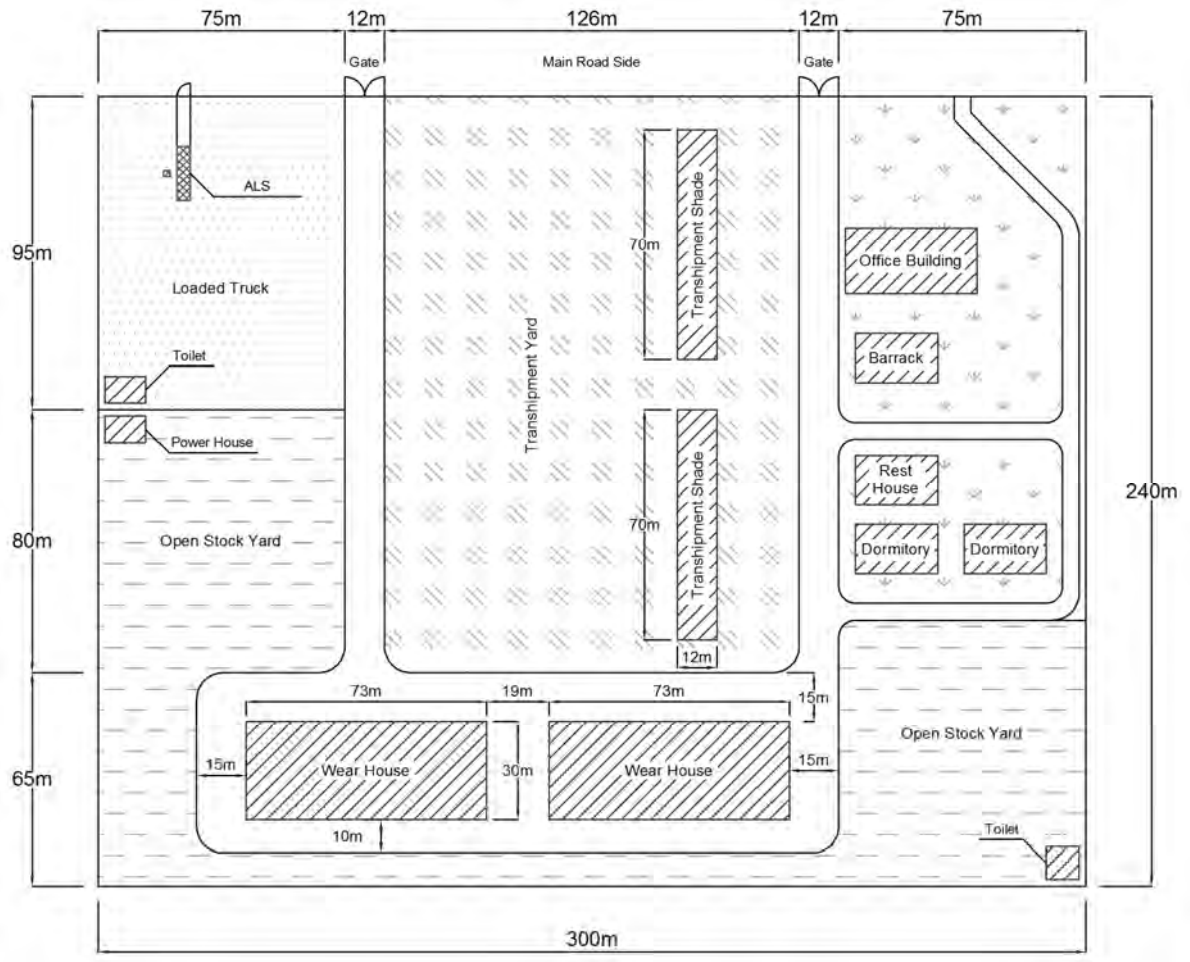


Source: JICA Survey Team

Figure 7.5.5 Layout of Axle Load Control Facility

7.5.3 Cross-Border Facility

It is better that the layout of land port facilities (Cross border facilities) will be planned to refer with the Bomra Land Port, which is recently constructed. The land port facilities should be fundamentally composed the office buildings, roads, transshipment yard, open stock yard, ware houses and axle load scale. Figure 7.5.6 shows the layout based on the Bomra Land Port.



Source: JICA Survey Team

Figure 7.5.6 Sample Layout of Land Port (Cross Border Facilities)

8. PRELIMINARY DESIGN FOR BRIDGE

8.1 Design Criteria for Bridges

8.1.1 Design Standards to be followed in Bangladesh

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 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)

8.1.2 Navigation Clearance and Design High Water Level

The navigation waterway limitations are classified by navigation-waterways and its class which is specified by BIWTA (Bangladesh Inland Water Transport Authority) as shown in Table 8.1.1, and targeted bridges shall be in compliance with the navigation limitation. Regarding Kalna Bridge, there is a navigation channel which is class-III. The water level to secure the navigation clearance is defined as SHWL (Standard High Water Level), which is the fortnightly Mean Water Levels with 5% exceedance by BIWTA. For normal navigation waterways, the values in Table 8.1.1 against 1.1 years probability high water level will be ensured.

The design high water level at targeted bridges is calculated as a 50 year flood level for Regional roads and 100 year flood level for Asian Highways and National roads, and the clearance with the bridge-girder bottom will ensure the requirements of Table 8.1.2.

Table 8.1.1 Navigation Waterways Limitation

Classification of Waterways	Minimum Vertical Clearance	Minimum Horizontal Clearance	Remarks
Class- I	18.30 m (60 ft)	76.22 m (250 ft)	
Class- II	12.20 m (40 ft)	76.22 m (250 ft)	
Class- III	7.62 m (25 ft)	30.48 m (100 ft)	Kalna Bridge
Class- IV	5.00 m (16.5 ft)	20.00 m (66 ft)	

Source: BIWTA (1991)

Table 8.1.2 Design High Water Level and Bridge Girder Bottom Height

Classification of Roadway (Bridge)	Regional Road	High Standard Bridge (Asian Highway, National Road)
Design High Water Level	50 year High Flood Level	100 year High Flood Level
Design Concept for Bridge Girder Bottom Height (Maximum Height of the Right Column)	Design High Water Level + Freeboard (Fb)	Design High Water Level + Freeboard (Fb)
	Historical High Water Level by Interview + 0.60 m	same as on the left
	Girder Bottom Height of Existing Bridge	same as on the left
	1.1 year Flood Level + 1.5 m (for normal Navigation)	1.1 year Flood Level + 1.5 m (for normal Navigation) In case of Kalna Bridge, SHWL+7.62m (for Class-III Navigation)
	If a bridge is over an official navigation waterway, it is SHWL + Necessary vertical clearance.	

Note: Freeboard (Fb) is classified by design discharge of each bridge. The case of less than 200 m^3/s for the design discharge is 0.6 m, "200 and up to 500 m^3/s" is 0.8 m, "500 and up to 2,000 m^3/s" is 1.0 m, "2,000 and up to 5,000 m^3/s" is 1.2 m, "5,000 and up to 10,000 m^3/s" is 1.5 m and "10,000 and over" is 2.0 m.

Source: JICA Survey Team

8.1.3 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 8.1.3 Unit Weight of Bridge Materials for Dead Load Calculation

Material	Unit weight (kN/m^3)
Steel	77.0
Plain Concrete	23.0
Reinforced Concrete	24.5
Pre-stressed Concrete	24.5
Asphalt mix	22.5

Source: JICA Survey Team

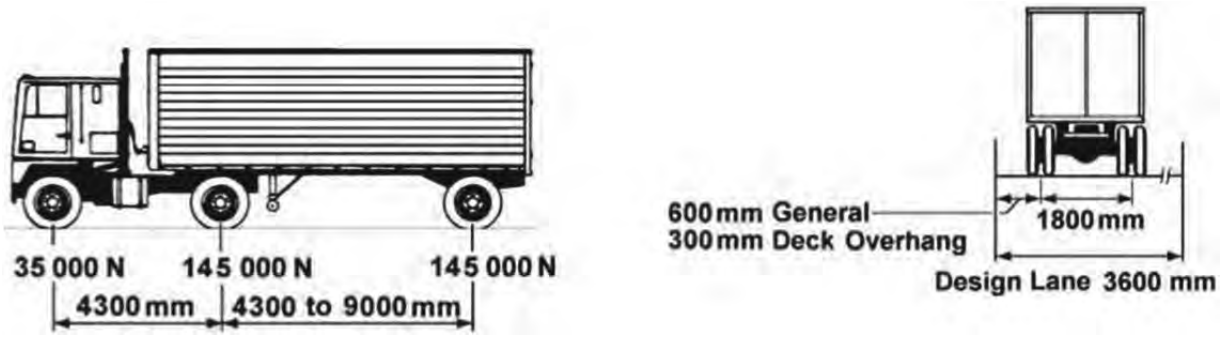
(2) Live Loads

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 specifications shown in Figure 8.1.1



Source: JICA Survey Team

Figure 8.1.1 Design Truck Load

2) Design Lane Load

The lane load for girder and substructure design is summarized in Table 8.1.4. A uniform load of 9.3 kN/m is distributed in the longitudinal direction and spreads over a lane of 3 m width. The lane load shall not be subjected to dynamic load allowance. A 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 8.1.4 Lane Load Specifications for Girder and Substructure Design

Specification	Truck load per lane (concentrated load)	Lane 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

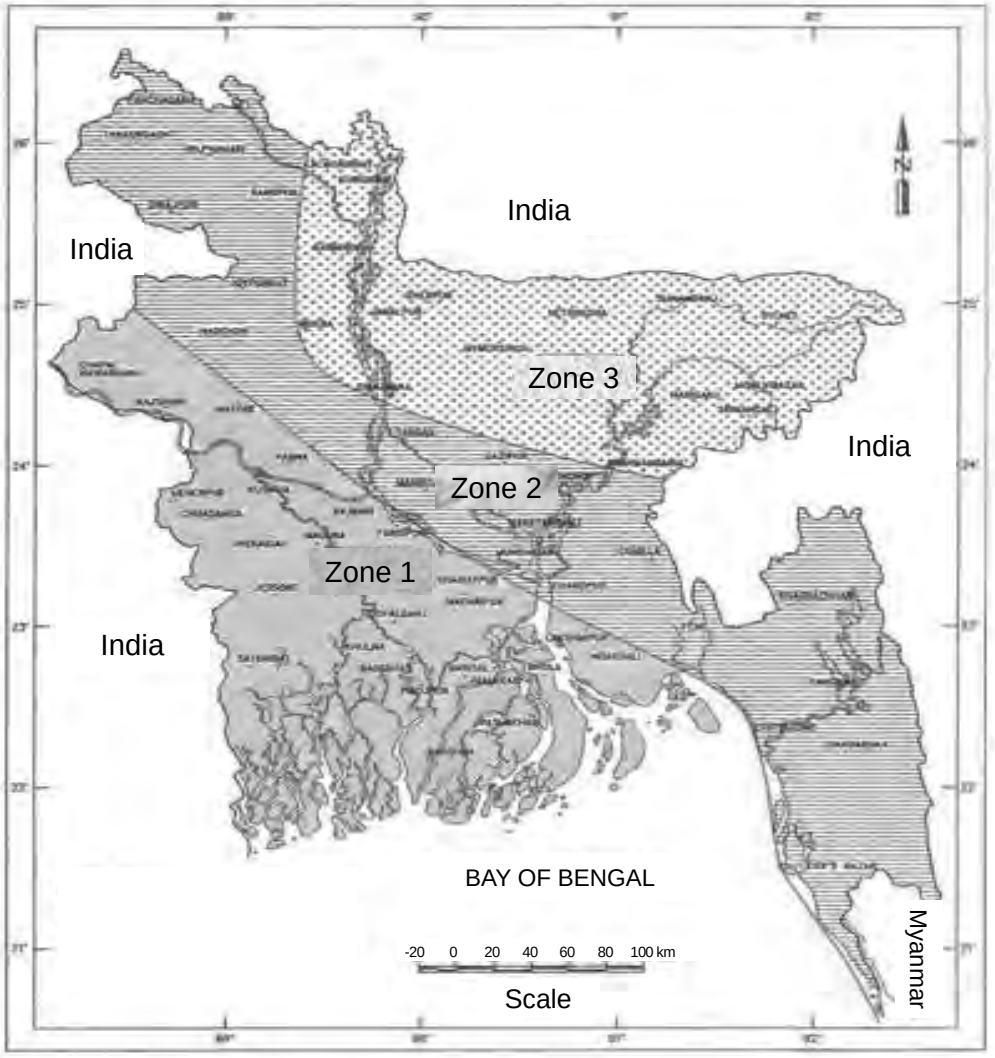
Source: JICA Survey Team

(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 8.1.2). Based on the severity of the probable intensity of seismic ground motion and damages, Bangladesh is divided into three seismic zones which are shown with their zone coefficients in Table 8.1.5.



Source: JICA Survey Team

Figure 8.1.2 Seismic Zoning Map of Bangladesh

Table 8.1.5 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, 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 8.1.6. In accordance with geological data surveyed for this project.

Table 8.1.6 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 21 m or more in depth and 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

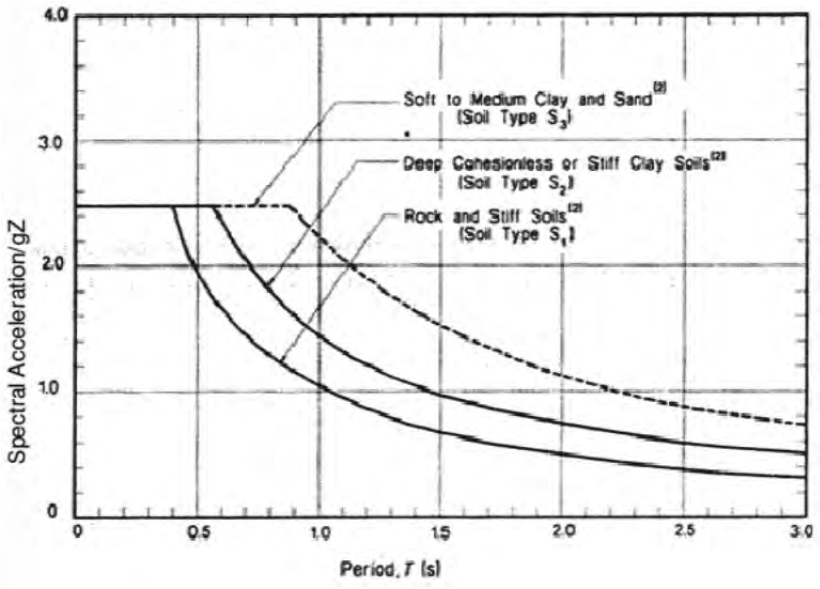
3) Design Response Spectrum (RS)

Generally, a design Response Spectrum shall be developed based on geologic, seismologic and soil characteristics associated with the specific site. In this regard, BNBC has a provision regarding design Response Spectra (RS) whose magnitude is almost equal to the magnitude of the response spectra proposed by AASHTO LRFD (2007). The design Response Spectra are formulated in Eq. (4.2.1) and schematically shown in Figure 8.1.3.

$$C_{sm} = \frac{1.2ZS}{T_m^{2/3}} \leq 2.5Z \qquad \text{Eq. (8.1.1)}$$

T_m = Periodic time of m^{th} mode vibration,

C_{sm} = Elastic response coefficient



Source: JICA Survey Team

Figure 8.1.3 Design Response Spectrum

The RSs shown in Figure 8.1.3 were derived based on the return period of 475 years as per the specification of AASHTO.

8.1.4 Technical Specifications for Construction Materials

(1) Concrete

In accordance with RHD practice, the values for 28-day-compressive strength of concrete cylinders for substructure components (RC bored piles, abutments, piers) shall be 25 MPa, whereas the concrete strength of deck slabs shall be 30 Mpa, and pre-stressed concrete girders shall be 40 MPa as per JRA specification. The concrete strength values according to bridge component are listed in Table 8.1.7.

Table 8.1.7 Strength Requirements of Concrete for Bridges

Bridge Components	28-day compressive strength of concrete cylinder, σ_{ck} (MPa)
RCC piles, abutments, piers, other structural components (RHD)	25
Concrete deck slab (JRA)	30
Prestressed concrete girder (JRA)	40

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 the American Society for Testing Materials (ASTM). The ASTM specifications for the said two grades are shown in Table 8.1.8.

Table 8.1.8 Nominal Stress of Reinforcing Steel Bars for Bridges

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) Pre-stressing Steel

Uncoated low relaxation seven-wire strands and prestressing bars shall be used as prestressing steel in PC girder bridges. Both forms of prestressing steel shall conform to the JRA specifications shown in Table 8.1.9.

Table 8.1.9 Nominal Stress of Pre-stressing Steel

Prestressing steel	Grade	Yield stress σ_y (MPa)	Tensile strength σ_u (MPa)
Strand (7-wire)	SWPR7BL	1,583	1,860
Bar	SBPR930	930	1,180

Source: JICA Survey Team

(4) Steel Material

As per JRA/JIS specification, the steel material used in this project are summarized in Table 8.1.10 with tensile strength and yield stress.

Table 8.1.10 Nominal Stress of Steel

Steel grade ($16 < t \leq 40$ mm)	Yield stress σ_y (MPa)	Tensile strength σ_u (MPa)
SM400	235	400
SM490Y	355	490
SM570	450	570
SBHS500	500	570

Source: JICA Survey Team

8.2 Selection of Bridge Type

8.2.1 Small Size Bridges

The selection of bridge type shall be done by the comparison of candidates, in which several candidates are prepared for each bridge size. By considering general bridge types being recognized worldwide and also bridge construction experiences in Bangladesh, three bridge sizes are categorized by span length as below. In this survey both small and middle size bridges are included, but large size bridges, which require a very special bridge type, are not included.

- ✓ Small size bridges: 25 m < span ≦ 45 m ---- range of this Survey
- ✓ Middle size bridges: 45 m < span ≦ 150 m ---- range of this Survey
- ✓ Large size bridges: 150 m < span ---- out of this Survey

For small size bridges PC-I girder is widely recognized as the most suitable and economical bridge type in all site conditions, and this is true in Bangladesh, therefore, many PC-I girder bridges have been constructed by RHD. In this Survey PC-I girder can be selected for small size bridges without special comparison, and a standard general view is shown in Figure 8.2.1. The bridge list of this Survey is summarized in Table 8.2.1 and all bridges excepting Kalana Bridge are PC-I girders with span length between 25 – 45 m.

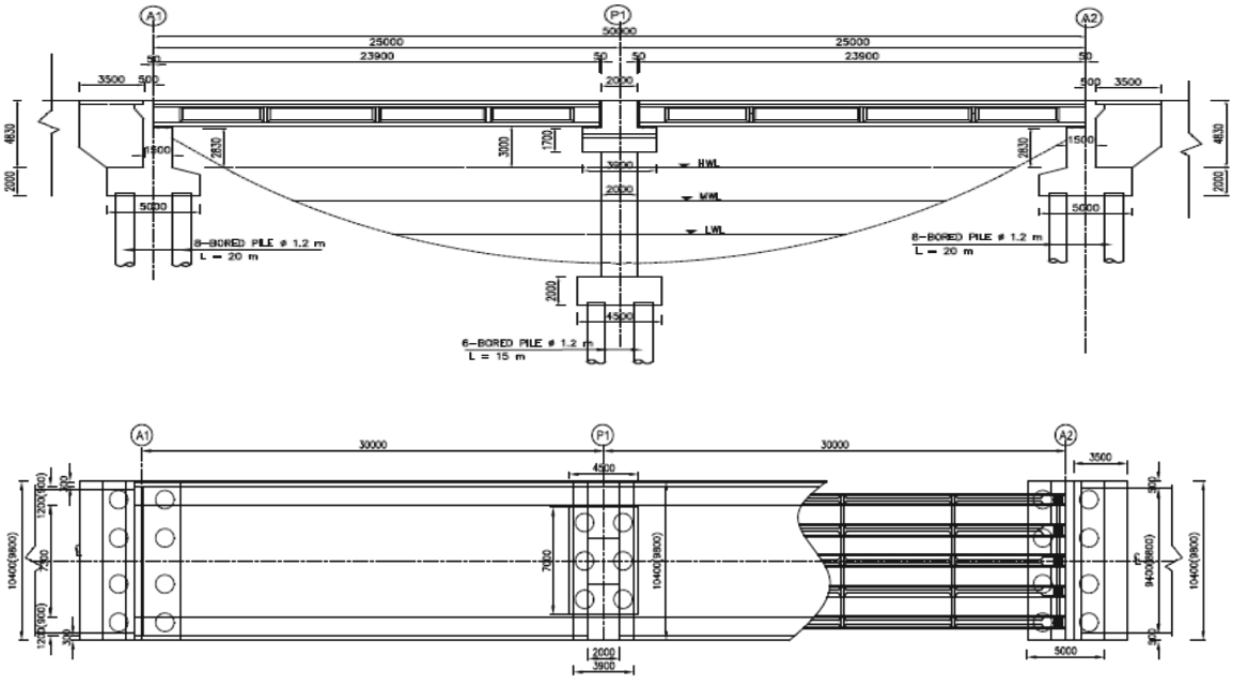


Figure 8.2.1 PC-I Girder Bridge

Table 8.2.1 Bridge List in Section-A, B, C

Bridge Information					Existing Bridge			New Bridge				
No.	Bridge ID	Zone	Road No	Bridge Name	Span Arrangement	Width (m)	Total length (m)	Bridge type	No of Spans	Span Arrangement	Total Length	Width
A1	N-706_14b	Khulna	N-706	Jhikorgacha Br.	18.3+14.35+11.8+29.20 +12.15+14.30+18.38	7.30	118.7	PC-I	4	30+30+35+30	125	14.2+14.2
A2	R-750_25a	Khulna	R-750	Tularampur Br.	13.40+64.70+13.40	8.23	91.5	PC-I	3	30+35+35	100	10.4+10.4
A3	Z-7503_5a	Khulna	Z-7503	Hawai khali Br.	4.50+17.10+4.50	7.90	26.1	PC-I	1	35	35	11.3+11.3
A4	N-806	Gopalganj	N-806	Kalna				PC-I + Steel	13	(44+45*4+46) +150 + (46+45*4+44)	690	21.9
A5	N-805_24a	Gopalganj	N-805	Garakola Br.	35.00 + 35.00 + 35.00	10.00	105.1	PC-I	3	35+40+35	110	10.4+10.4
B1	R-151_3a	Chittagong	R-151	Purbo Hinguli Br.	18.5	7.83	18.5	PC-I (GOB)	2	30+25	55	13.4
B2	R-151_4a	Chittagong	R-151	Telipool Br.	15.24	4.18	15.2	PC-I	1	25	25	13.4
B3	R-151_4c	Chittagong	R-151	Lakshmi chara Br.	15.42	4.21	15.4	PC-I	1	40	40	13.4
B4	R-151_11a	Chittagong	R-151	Tulatuli Lohar Br.	24.45	5.03	24.5	Embankment				
B5	R-151_11c	Chittagong	R-151	tulatuli Br.	24.3	7.15	24.3	Embankment				
B6	R-151_12a	Chittagong	R-151	Buro Camp Br.	24.2	7.20	24.2	Embankment				
B7	R-151_12c	Chittagong	R-151	Bangra Tabor Br.	24.32	7.18	24.3	Embankment				
B8	R-151_12e	Chittagong	R-151	Kalapani Br.-1	24.4	7.18	24.4	Embankment				
B9	R-151_14a	Chittagong	R-151	Kalapani Br.-2	6.22+12.2+5.95	4.07	24.8	PC-I	1	35	35	13.4
B10	R-151_14c	Chittagong	R-151	Niharkanti Das Br.	42	8.63	42.0	Box Culvert	1	1 cell@B2.0 ×H2.0		
B11	R-151_15a	Chittagong	R-151	Koilapara Br.	24.4	7.10	24.4	Embankment				
B12	R-151_16a	Chittagong	R-151	Koilabazar Br.	36.8	4.85	36.8	PC-I	2	30+25	55	13.4
B13	R-151_16c	Chittagong	R-151	Balutila Br.	21.35	4.03	21.4	PC-I	1	30	30	13.4
B14	R-151_18a	Chittagong	R-151	Fulchari Br.	15.3	4.12	15.3	Box Culvert	2	2 cell@B3.0 ×H3.0		
B15	R-151_22a	Chittagong	R-151	Heaku Bazar Br.	12.5	4.08		Box Culvert	1	1 cell@B3.0 ×H3.0		
B16	R-152_Sa	Chittagong	R-152	Heako Br.	12.4	4.06		PC-I		25	25	13.4
B17	R-152_3a	Chittagong	R-152	Amtali Br.	3.8+12.16+3.8	7.22	19.8	Box Culvert	1	1 cell@B6.0xH4.0		
B18	R-152_7a	Chittagong	R-152	Chikon Chara Br.	4.46+15.27+4.45	7.30	24.2	PC-I	1	30	30	13.4
B19	R-152_8a	Chittagong	R-152	Chikon Chara Br.	6.02+6.52	4.24		Box Culvert	1	1 cell@B3.0 ×H3.0		
B20	R-152_8c	Chittagong	R-152	Banglabazar Br.	6.08+6.58	4.31		Box Culvert	1	1 cell@B3.0 ×H3.0		
B21	R-152_10a	Chittagong	R-152	Borobil Br.	6.18+18.31+6.12	7.16	30.6	PC-I (GOB)	1	35	35	13.4
B22	R-152_10c	Chittagong	R-152	Borobil Br.	7.60+7.60	4.13		Box Culvert	1	1 cell@B2.0 ×H2.0		
B23	R-152_11b	Chittagong	R-152	Gadar dokan Br.	6.7+6.5	4.20		Box Culvert	2	2 cell@B3.0 ×H3.0		
B24	R-152_13a	Chittagong	R-152	Bagan Bazar Br.	18.37	4.15	18.4	Box Culvert	1	1 cell@B3.0 ×H3.0		
B25	R-152_14a	Chittagong	R-152	East baganbazar Br.	12.3+12.25+12.2	4.20	36.8	PC-I	2	25+25	50	13.4
B26	R-152_15a	Chittagong	R-152	Sonaipool Br.	12.3+12.16+12.43	4.13	36.9	under construction by GOB fund				
C8	N-1_257a	Chittagong	N-1	Patiya Br.	25.15+25.15	8.40	50.3	PC-I	2	25+30	55	11.3+11.3
C12	N-1_272a	Chittagong	N-1	Mazar Point Br.	12.7+12.7+12.7+12.7	7.20	50.8	PC-I	2	35+25	60	11.3+11.3
C13	N-1_279a	Chittagong	N-1	Sangu Br.	36.3+45.8+47+46.4+35.2	7.20	211.0	PC-I	6	2@40+4@35	220	10.4+10.4
C26	N-1_328a	Chittagong	N-1	Mathamuhuri Br.	42+42+42+42+42+42	7.20	294.2	PC-I	8	6@40+2@35	310	10.4+10.4
18	Bridges without Kalna				Total of 18 Bridges (without Kalna) =		1,450			Total of 18 Bridges (without Kalna) =	1,395	

Source: JICA Survey Team

8.2.2 Medium Size Bridges

As shown in Table 8.2.1, only Kalna Bridge is categorized as a middle size bridge which passes over a larger river and the required conditions for Kalna Bridge are summarized as follows.

- Normal river width is approximately 300 m, with a maximum of 600 m at high water level
- Required navigation clearance is horizontally 35.0 m and vertically 7.62 m
- Span length at river center is more than 100 m to avoid river scoring (by BUET)
- Symbolic bridge is preferred by GOB and RHD

For the selection of bridge type for the main span of Kalna Bridge, seven candidates of middle size bridges as listed below are compared.

- PC-Box Bridge
- Steel-Box Bridge
- Truss Bridge (steel)
- Arch Bridge (steel)
- Nielsen-Lohse Bridge (steel)
- Extra-Dosed Bridge (PC)
- Cable-stayed Bridge (steel)

The comparison result is shown in Table 8.2.2 and a Nielsen-Lohse Bridge (Steel) is selected for the main reasons which are shown below.

- Cost efficiency for the high-cost main span bridge which has only a single span of 150 m length, and does not need three continuous spans to balance as other bridges require
- Symbolic landscape with arch and cable shape. There are no other examples of this style in Bangladesh
- Less maintenance works are required, by applying a heavy painting system on steel plates and galvanizing for the cables

For the side span of Kalna Bridge, PC-I girder bridges are applied with a maximum span length of 45 m by using larger pier heads.

Table 8.2.2 Bridge Type Comparison for Kalna Bridge

Main Span Bridge	Type	PC-Box Br	Steel-Box Br	Truss Br	Arch Br	Nielsen Br	Extra-Dosed Br	Cable-Stayed Br
	Material	Concrete	Steel (weathering steel)	Steel-Concrete (composite)	Steel	Steel	Concrete	Steel-Concrete (composite)
	length (m)	230	230	230	150	150	230	230
	Image							
Side Span Bridge	Type		Concrete PC-I Girder Bridge (because of economical feature)					
	Material							
	length (m)	430	430	430	510	510	430	430
Experience in Bangladesh (Main span Br)		done	on-going	on-going	not yet	not yet	done	not yet
Landscape point		moderate	moderate	good	good	Excellent	Excellent	Excellent
Initial Cost Ratio (Main & Side Br)		1.00	1.26	1.23	1.13	1.14	1.32	1.34
Maintenance feature		less	less	moderate	moderate	moderate	less	moderate
Maintenance works		cable re-painting	use weathering-steel	use heavy-painting system	use heavy-painting system	use heavy-painting system	cable re-painting	use heavy-painting system
Recommendation						recommended		
Reason		New bridge type in Bangladesh, economical by special bridge type at main span only with 150 m length						
Comment		Good landscape are gotten by using cable or curved shape with flexible steel material, and not so much maintenance works are required for steel structures by using heavy-painting system which is applied to on-going Megna, Kanchpur, Gumti bridge project						

8.3 Preliminary Design

8.3.1 Small Size Bridges (PC-I girder)

(1) Super Structures

For the preliminary design, the bridge span is standardized with some series of spans to apply easily to all bridge locations, of which the standard bridge spans are:

PC-I standard span 25, 30, 35, 40 m and 45 m (for only Kalna side spans)

As for anti-falling measures for super-structures against earthquakes, PC-I girders with chaired pier heads are adopted as shown in Figure 8.3.1, where pier head motion can be restricted by both side girders.

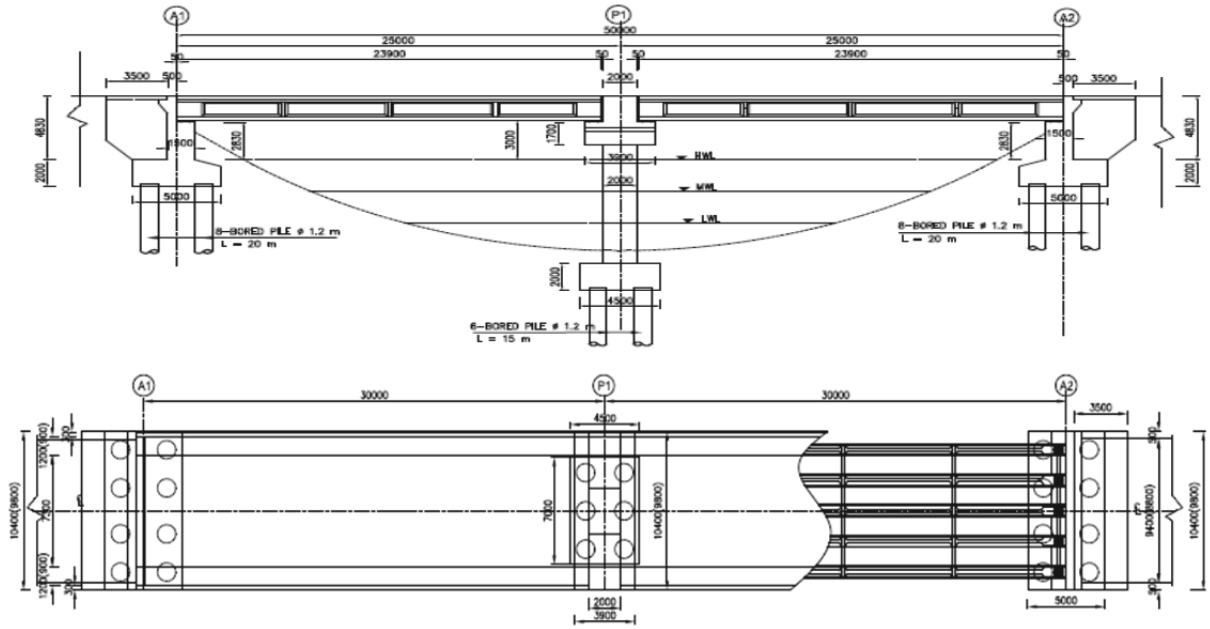
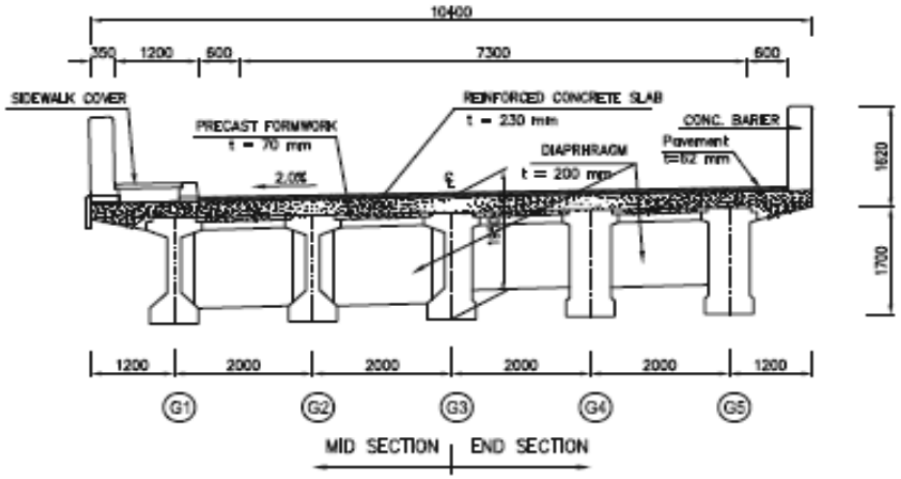


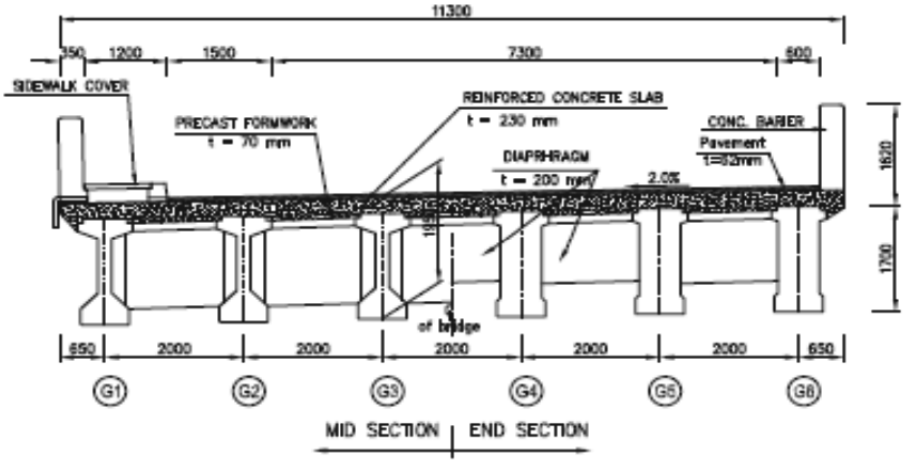
Figure 8.3.1 PC-I Girder with Chaired Pier Head

(2) Cross sections

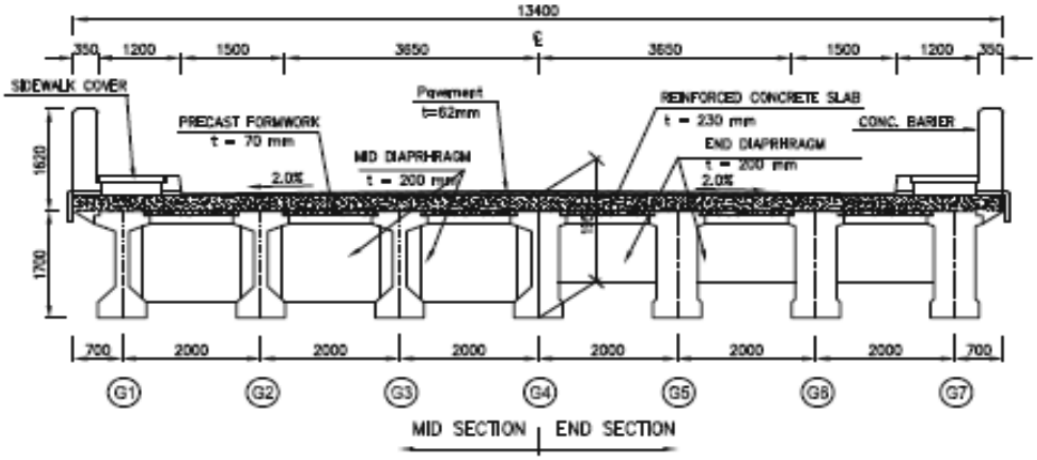
Standard cross sections of a PC-I girder for bridge widths of 10.4 m, 11.3 m, 13.4 m are shown in Figure 8.3.2, where the number of girders and girder arrangement are determined. Slab thickness of 25cm is adopted. Cross section of Jhikorgacha Bridge and Kalna side bridge are given as 2*14.2 m and 21.9 m respectively.



Long Size Bridge Type in Section A and Section C



Small and Middle Size Bridge Type In Section A and Section C



Small and Middle Size Bridge Type In Section B

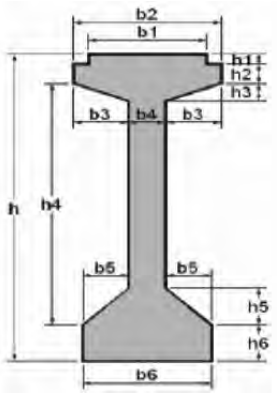
Figure 8.3.2 Standard Cross Sections for PC-I Girder

(3) Dimension of PC-I Girders

According to the bridge design criteria written in 8.3.1, PC-I girders with series of standard spans have been designed on a preliminary basis and the result are summarized in Table 8.3.1.

Table 8.3.1 Dimension of PC-I Girders

Bridge Width (m)	Size of PC-I	Span Length (m)				
		25	30	35	40	45
10.4, 11.3, 13.4	b6 (m)	0.70	0.70	0.65	0.65	0.80
	H (m)	1.60	1.70	1.85	2.10	2.20



(4) Standard Drawings

As a preliminary design for civil cost calculation purposes, seventeen standard drawings are prepared as listed in Table 8.3.2.

Table 8.3.2 Standard Drawings

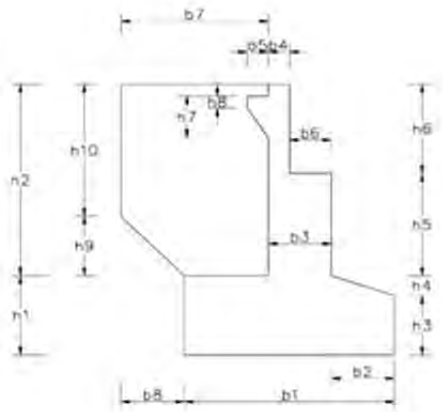
1 span		25	30	35	40	45
width	10.4					
	11.3		●	●		
	13.4	●	●	●	●	
2 span		25+25	30+30	35+35	40+40	45+45
width	10.4					
	11.3	●	●			
	13.4	●				
3 span		25+25+25	30+30+30	35+35+35	40+40+40	45+45+45
width	10.4		●	●	●	●
	11.3		●	●	●	●
	13.4					

8.3.2 Sub Structures for Small Size Bridges

(1) Abutment and pier

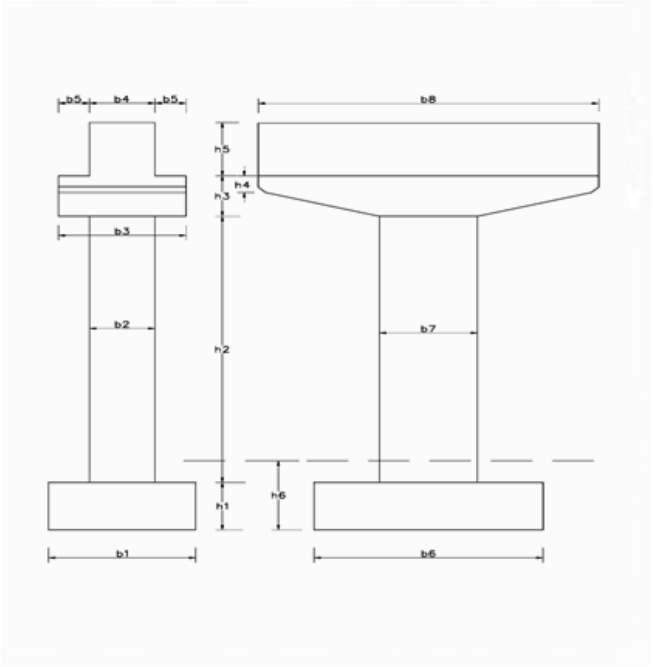
Same as super structures, substructures are also standardized as a preliminary design basis shown in Figure 8.3.3 and typical bridge drawings are prepared to calculate quantities.

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

Figure 8.3.3 Standard Abutment and Pier

(2) Piles

Same as other bridges in Bangladesh, cast-in-place concrete piles are selected for its ease of constructability and procurement of material/equipment. By preliminary calculations, for abutment of 8-10 piles with 1.2 m diameter and for pier 6-8 piles with 1.2 m diameter are arranged, which is shown in Table 8.3.3 and Figure 8.3.4. The pile length for each bridge shall be determined by a soil survey conducted at each location.

Table 8.3.3 Number of Pile (Diameter 1.2 m)

Width (m)	Sub Structure	Span Length (m)				
		25	30	35	40	45
10.4	Abutment Pier	8 6				10 8
11.3	Abutment Pier	8 6				10 8
13.4 (14.2)	Abutment Pier	10 8				N.A

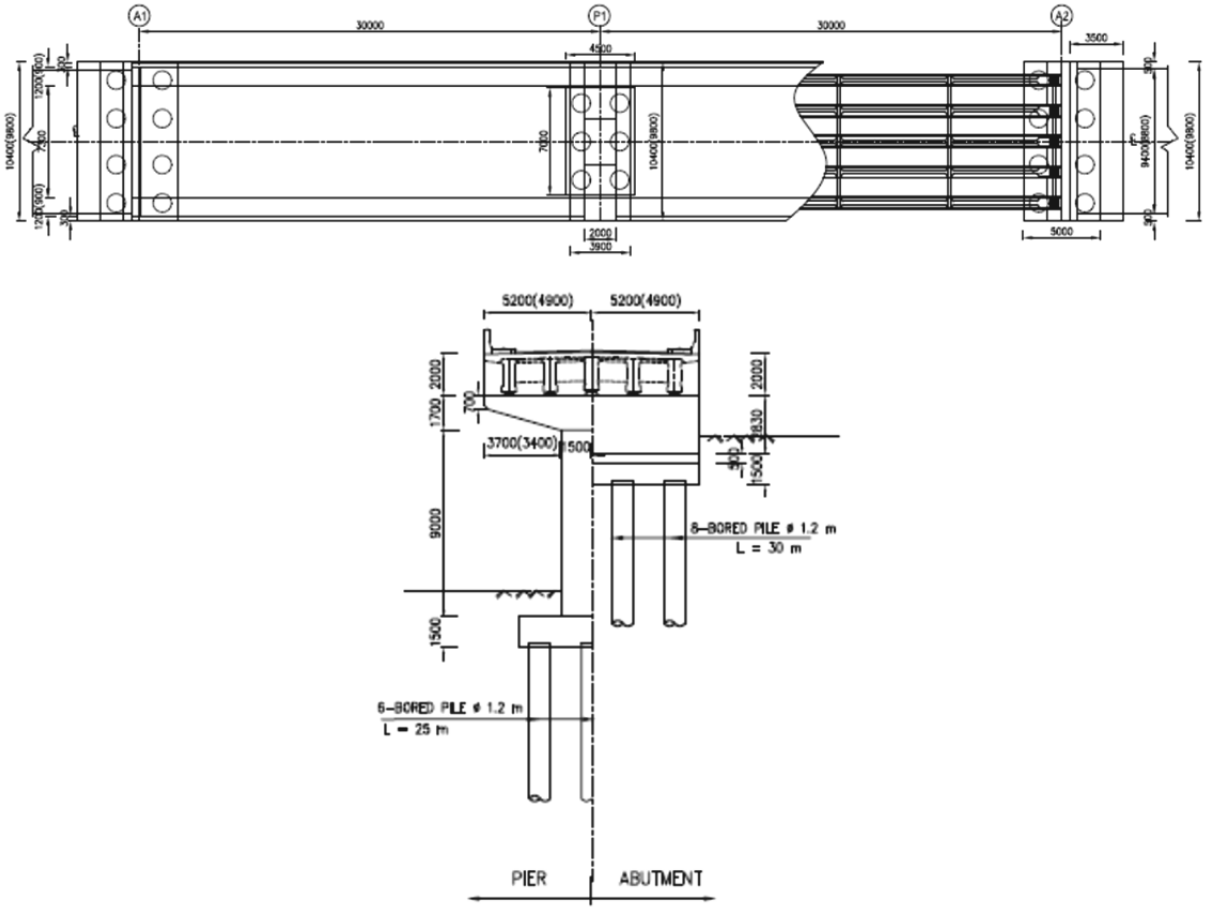


Figure 8.3.4 Pile Arrangement

8.3.3 Middle Size Bridge (Nielsen-Lohse Type)

As explained in 8.2.2, the bridge type for the main span of Kalna Bridge is selected as the Nielsen-Lohse type with a span length of 150m. By the result of the preliminary design, the general view is shown in Figure 8.3.5.

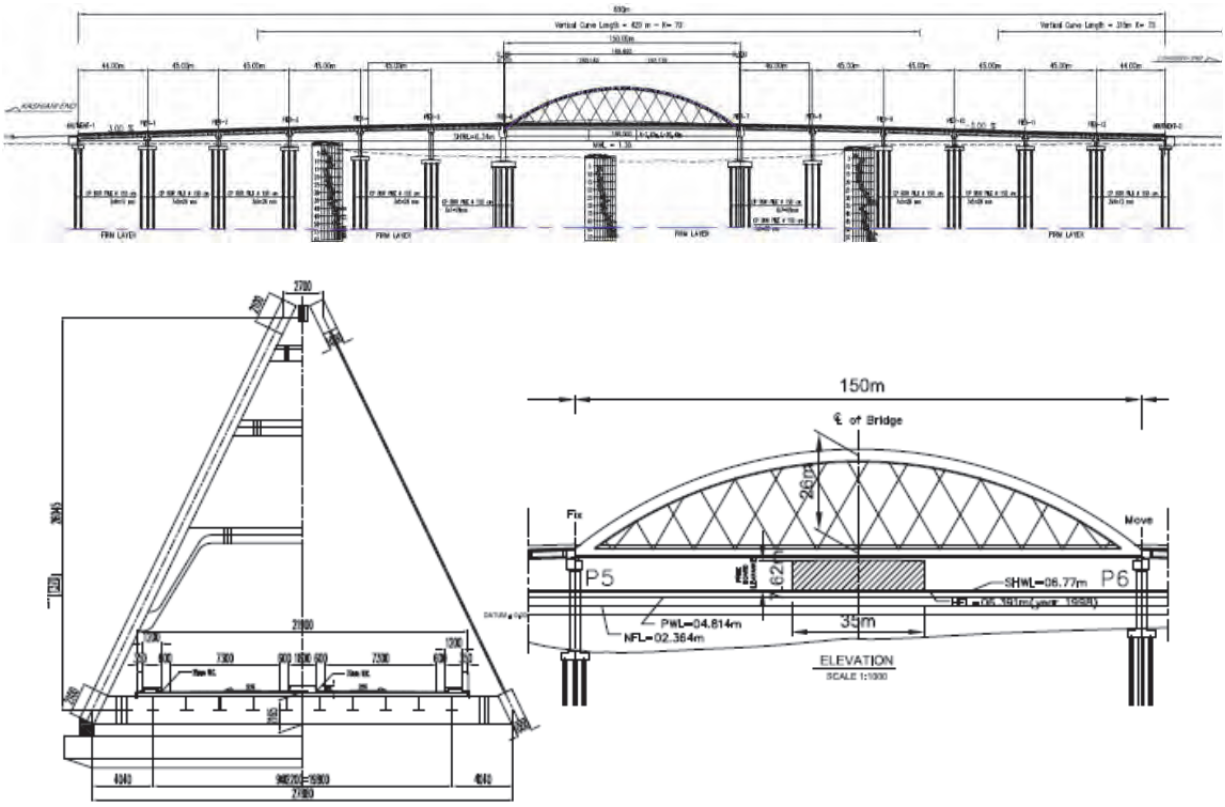


Figure 8.3.5 General View of Kalna Bridge

As the most important structural part of the Kalna main bridge, arch corners must support concentrated large forces as shown in Figure 8.3.6, then require complicated structures with thicker (30-50 mm) and higher strength (grade SM570) steel plates being welded to each other.

If using standard steel material grade SM570, special treatment of pre-heating 80-100℃ is definitely required before starting welding and this treatment can affect the welding quality and bridge design life.

"Steels for Bridge High Performance Structure (SBHS)" was developed to ensure the quality of welding without pre-heating, then SBHS-500 is applied for the arch corners of the Kalna main bridge to maintain quality.

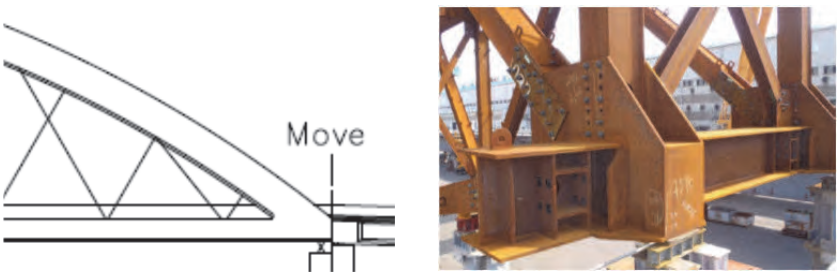


Figure 8.3.6 Arch Corner of Kalna Main Bridge

The quantities of Kalna Bridge are summarized in Table 8.3.4 and used for cost calculation.

Table 8.3.4 Summary of Quantity for Kalna Bridge

		unit	Side (6) span	Main bridge	Side (6) span	Total
			270 m	150 m	270 m	690 m
Abutment						
1	Excavation and Backfill	Cu.m	3,032.9		3,032.9	6,066
2	Sand backfill for structure	Cu.m	1,516.4		1,516.4	3,033
3	Concrete, Class A2-2 (Abutment)	Cu.m	585.4		585.4	1,171
4	High yield deformed reinforcing bars (fy=400Mpa)	ton	35.1		35.1	70
Pier						
1	Excavation and Backfill	Cu.m	21,060.0		21,060.0	42,120
2	Concrete, Class A2-1 (Pier-head, Column)	Cu.m	3,087.9	2,655.1	2,729.8	8,473
3	Concrete, Class A2-2 (Pile cap)	Cu.m	2,731.3	3,233.0	2,731.3	8,696
4	High yield deformed reinforcing bars (fy=400Mpa)	ton	349.1	353.3	327.7	1,030
Super structure						
1	Bituminous Wearing Course(62mm)	Sq.m	4,590.0	2,550.0	4,590.0	11,730
2	Concrete, Class A3-2 (Railing)	Cu.m	226.8	126.0	226.8	580
3	Concrete, Class A3-4 (footpath)	Cu.m	194.4	108.0	194.4	497
4	Concrete, Class A2-2 (Deck Slab)	Cu.m	1,478.3	821.3	1,478.3	3,778
5	Concrete, Class A4 (precast formwork)	Cu.m	384.3	213.5	384.3	982
6	High yield deformed reinforcing bars (fy=400Mpa)	ton	709.0	381.9	709.0	1,800
7	Concrete, Class A2-2 (Diaphragm, Cross beam)	Cu.m	216.0		216.0	432
8	Concrete, Class A2-1 (RC Girder)	Cu.m				0
9	Concrete, Class A1 (PC Girder)	Cu.m	2,924.7		2,924.7	5,849
10	High yield deformed reinforcing bars (fy=400Mpa)	ton	292.5		292.5	585
11	Pre-stressing strands for PC Girder	ton	102.8		102.8	206
12	Steel works (SM400, SM490Y, SBHS500)	ton		1,725.9		1,726
13	Steel cable works	ton		42.2		42
14	H.T.Bolt	ton		42.0		42
15	Election of Arch	ton		1,810.0		1,810
16	Elastomeric bearing for PCG	each	144		144	288
17	Elastomeric bearing for Nielsen Arch	each		4		4
18	Expansion Joint for main bridge	m		43.8		44
18	Expansion Joint	m	262.8		262.8	526
19	Bridge draining	m	540.0	300.0	540.0	1,380
Pile						
1	Drilling of Pile (Dia.1.2 m)	m				0
2	Concrete ,Class A3-1 (Bored pile Dia.1.2 m)	Cu.m				0
3	Loading test (Dia. 1.2 m)	LS				0
4	Drilling of Pile (Dia.1.5 m)	m	4,213.7	1,950.8	4,303.0	10,468
5	Concrete ,Class A3-1 (Bored pile Dia.1.5 m)	Cu.m	7,446.2	3,447.3	7,604.1	18,498
6	Loading test (Dia. 1.5 m)	LS	12	4	12	28
7	High yield deformed reinforcing bars (fy=400Mpa)	ton	744.6	344.7	760.4	1,850
8	Cofferdam	m2	1,696.6	3,582.0	1,125.9	6,404
9	Temporary access bridge	m	270.0		270.0	540

8.3.4 Summary of Preliminary Design

The summary of the preliminary design for the PC-I bridges (18 bridges) and the Kalna Bridge are shown in Table 8.3.5 and civil cost calculation will be done accordingly.

Table 8.3.5 Summary of Preliminary Design

Bridge Information					Existing Bridge			New Bridge							Total Length Increase	
No.	Bridge ID	Zone	Road No	Bridge Name	Span Arrangement	Width (m)	Total length (m)	Bridge type	No of Spans	Span Arrangement	Total Length	Width	Abutment Pile Length	Pier Pile Length	New / Exist	New - Exist
A1	N-706_14b	Khulna	N-706	Jhikorgacha Br.	18.3+14.35+11.8+29.20 +12.15+14.30+18.38	7.30	118.7	PC-I	4	30+30+35+30	125	14.2+14.2	42	38	1.05	6
A2	R-750_25a	Khulna	R-750	Tularampur Br.	13.40+64.70+13.40	8.23	91.5	PC-I	3	30+35+35	100	10.4+10.4	39	30	1.09	9
A3	Z-7503_5a	Khulna	Z-7503	Hawai khali Br.	4.50+17.10+4.50	7.90	26.1	PC-I	1	35	35	11.3+11.3	43		1.34	9
A4	N-806	Gopalganj	N-806	Kalna				PC-I + Steel	13	(44+45*4+46) +150 + (46+45*4+44)	690	21.9	55	39		
A5	N-805_24a	Gopalganj	N-805	Garakola Br.	35.00 + 35.00 + 35.00	10.00	105.1	PC-I	3	35+40+35	110	10.4+10.4	39	29	1.05	5
B1	R-151_3a	Chittagong	R-151	Purbo Hinguli Br.	18.5	7.83	18.5	PC-I (GOB)	2	30+25	55	13.4	36		2.97	37
B2	R-151_4a	Chittagong	R-151	Telipool Br.	15.24	4.18	15.2	PC-I	1	25	25	13.4	36		1.64	10
B3	R-151_4c	Chittagong	R-151	Lakshmi chara Br.	15.42	4.21	15.4	PC-I	1	40	40	13.4	59		2.59	25
B4	R-151_11a	Chittagong	R-151	Tulatuli Lohar Br.	24.45	5.03	24.5	Embankment								
B5	R-151_11c	Chittagong	R-151	tulatuli Br.	24.3	7.15	24.3	Embankment								
B6	R-151_12a	Chittagong	R-151	Buro Camp Br.	24.2	7.20	24.2	Embankment								
B7	R-151_12c	Chittagong	R-151	Bangra Tabor Br.	24.32	7.18	24.3	Embankment								
B8	R-151_12e	Chittagong	R-151	Kalapani Br.-1	24.4	7.18	24.4	Embankment								
B9	R-151_14a	Chittagong	R-151	Kalapani Br.-2	6.22+12.2+5.95	4.07	24.8	PC-I	1	35	35	13.4	10		1.41	10
B10	R-151_14c	Chittagong	R-151	Niharkanti Das Br.	42	8.63	42.0	Box Culvert	1	1 cell@B2.0 ×H2.0						
B11	R-151_15a	Chittagong	R-151	Koilapara Br.	24.4	7.10	24.4	Embankment								
B12	R-151_16a	Chittagong	R-151	Koilabazar Br.	36.8	4.85	36.8	PC-I	2	30+25	55	13.4	10	10	1.49	18
B13	R-151_16c	Chittagong	R-151	Balutila Br.	21.35	4.03	21.4	PC-I	1	30	30	13.4	10		1.41	9
B14	R-151_18a	Chittagong	R-151	Fulchari Br.	15.3	4.12	15.3	Box Culvert	2	2 cell@B3.0 ×H3.0						
B15	R-151_22a	Chittagong	R-151	Heaku Bazar Br.	12.5	4.08		Box Culvert	1	1 cell@B3.0 ×H3.0						
B16	R-152_Sa	Chittagong	R-152	Heako Br.	12.4	4.06		PC-I		25	25	13.4	38			25
B17	R-152_3a	Chittagong	R-152	Amtali Br.	3.8+12.16+3.8	7.22	19.8	Box Culvert	1	1 cell@B6.0xH4.0						
B18	R-152_7a	Chittagong	R-152	Chikon Chara Br.	4.46+15.27+4.45	7.30	24.2	PC-I	1	30	30	13.4	13		1.24	6
B19	R-152_8a	Chittagong	R-152	Chikon Chara Br.	6.02+6.52	4.24		Box Culvert	1	1 cell@B3.0 ×H3.0						-
B20	R-152_8c	Chittagong	R-152	Banglabazar Br.	6.08+6.58	4.31		Box Culvert	1	1 cell@B3.0 ×H3.0						-
B21	R-152_10a	Chittagong	R-152	Borobil Br.	6.18+18.31+6.12	7.16	30.6	PC-I (GOB)	1	35	35	13.4	13		1.14	4
B22	R-152_10c	Chittagong	R-152	Borobil Br.	7.60+7.60	4.13		Box Culvert	1	1 cell@B2.0 ×H2.0						-
B23	R-152_11b	Chittagong	R-152	Gadar dokan Br.	6.7+6.5	4.20		Box Culvert	2	2 cell@B3.0 ×H3.0						-
B24	R-152_13a	Chittagong	R-152	Bagan Bazar Br.	18.37	4.15	18.4	Box Culvert	1	1 cell@B3.0 ×H3.0						
B25	R-152_14a	Chittagong	R-152	East baganbazar Br.	12.3+12.25+12.2	4.20	36.8	PC-I	2	25+25	50	13.4	20	20	1.36	13
B26	R-152_15a	Chittagong	R-152	Sonaipool Br.	12.3+12.16+12.43	4.13	36.9	under construction by GOB fund								
C8	N-1_257a	Chittagong	N-1	Patiya Br.	25.15+25.15	8.40	50.3	PC-I	2	25+30	55	11.3+11.3	50	46	1.09	5
C12	N-1_272a	Chittagong	N-1	Mazar Point Br.	12.7+12.7+12.7+12.7	7.20	50.8	PC-I	2	35+25	60	11.3+11.3	34	29	1.18	9
C13	N-1_279a	Chittagong	N-1	Sangu Br.	36.3+45.8+47+46.4+35.2	7.20	211.0	PC-I	6	2@40+4@35	220	10.4+10.4	37	27	1.04	9
C26	N-1_328a	Chittagong	N-1	Mathamuhuri Br.	42+42+42+42+42+42	7.20	294.2	PC-I	8	6@40+2@35	310	10.4+10.4	29	21	1.05	16
18	Bridges without Kalna				Total of 18 Bridges (without Kalna) =		1,450	Total of 18 Bridges (without Kalna) =			1,395	Ave. =	32.3	28.9	1.42	10.2

9. CONSTRUCTION PLAN

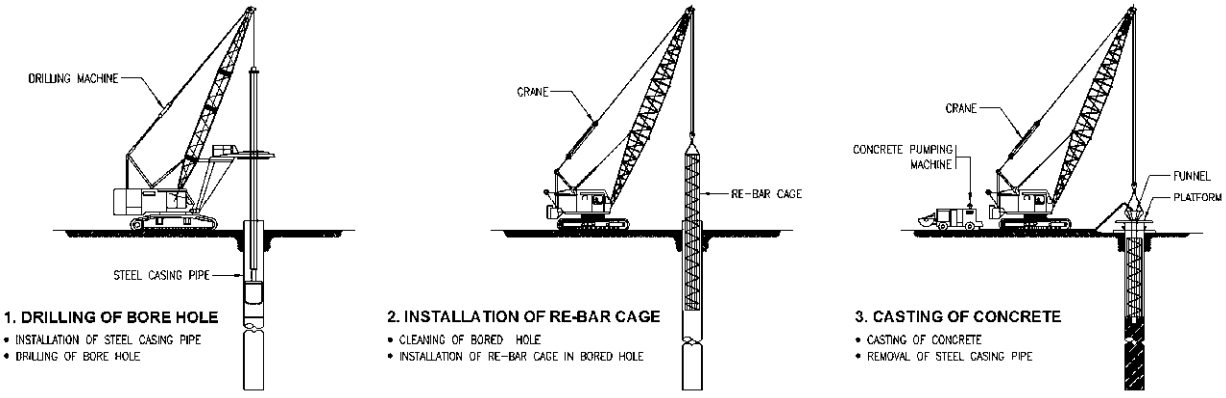
9.1 Introduction

Project bridges under Section B will be constructed at the same location of existing bridges in consideration of impact on local residences/shops, construction cost, etc. However, project bridges on Asian Highways will be constructed next and parallel to the existing bridges in consideration of easy future widening. Therefore, even for busy highways, traffic control is mostly unnecessary during bridge construction work.

9.2 Cast-in-Place RC Pile (CIP RC Pile)

CIP RC Piles are selected to construct bridge foundation. After installation of temporary steel casing into the ground using vibrator, the soil inside the casing will be removed, and bentonite slurry will be used to stabilize the soil and prevent the excavated hole from collapsing.

After installation of the reinforcement cage into the bored hole, the 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.



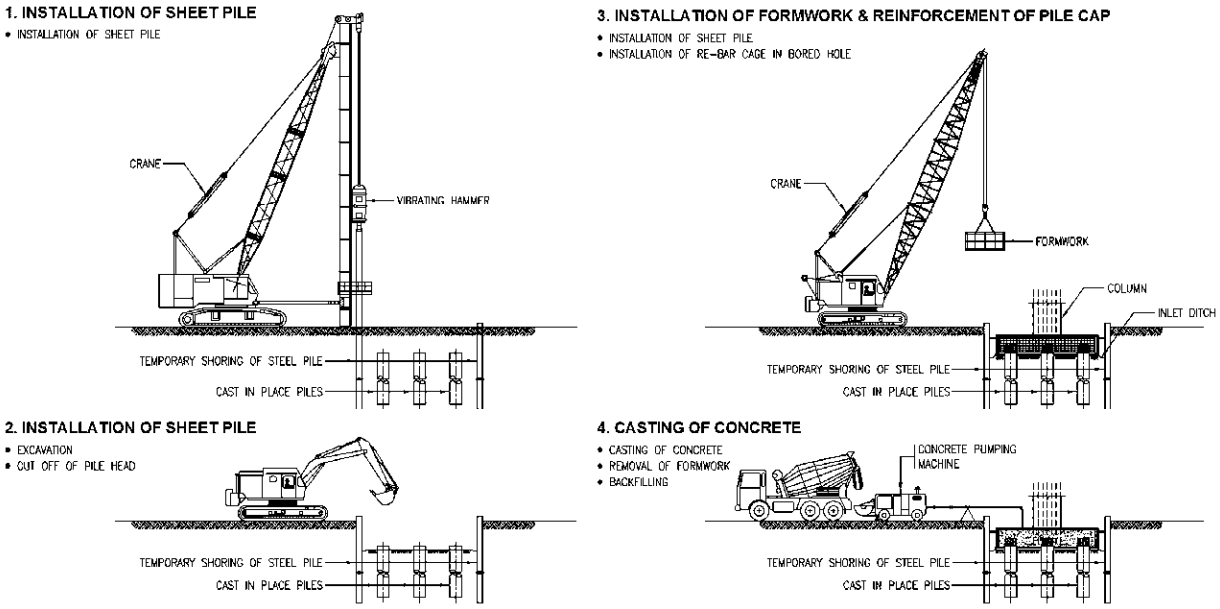
Source: JICA Survey Team

Figure 9.2.1 Construction Method for CIP RC Piles

9.3 Pile Cap

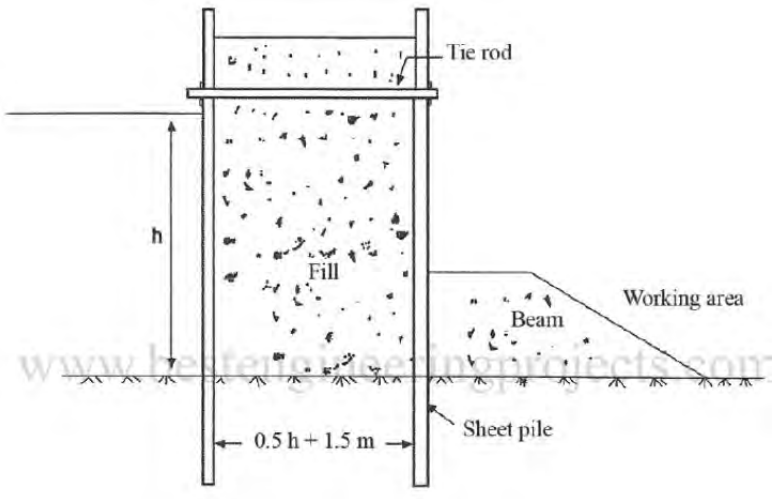
After installation of steel sheet piles, excavation works will be carried out up to the required level. Then, lean concrete will be poured so as to prepare a plane surface on which the formwork and

re-bar can be installed. After casting the pile cap and removal of the formwork, the backfill work will be carried out up to the top surface of pile cap shortly afterwards.



(a) Pile cap construction sequence

The height of steel sheet pile as cofferdam basically depends on water level when construction will be executed. A typical shape of double walled steel sheet pile pointing the cofferdam height with freeboard as safety is shown below. The detail use of steel sheet piles whether in a form of single wall or double wall shall be studied during detailed design stage.



(b) Double walled steel sheet pile as cofferdam

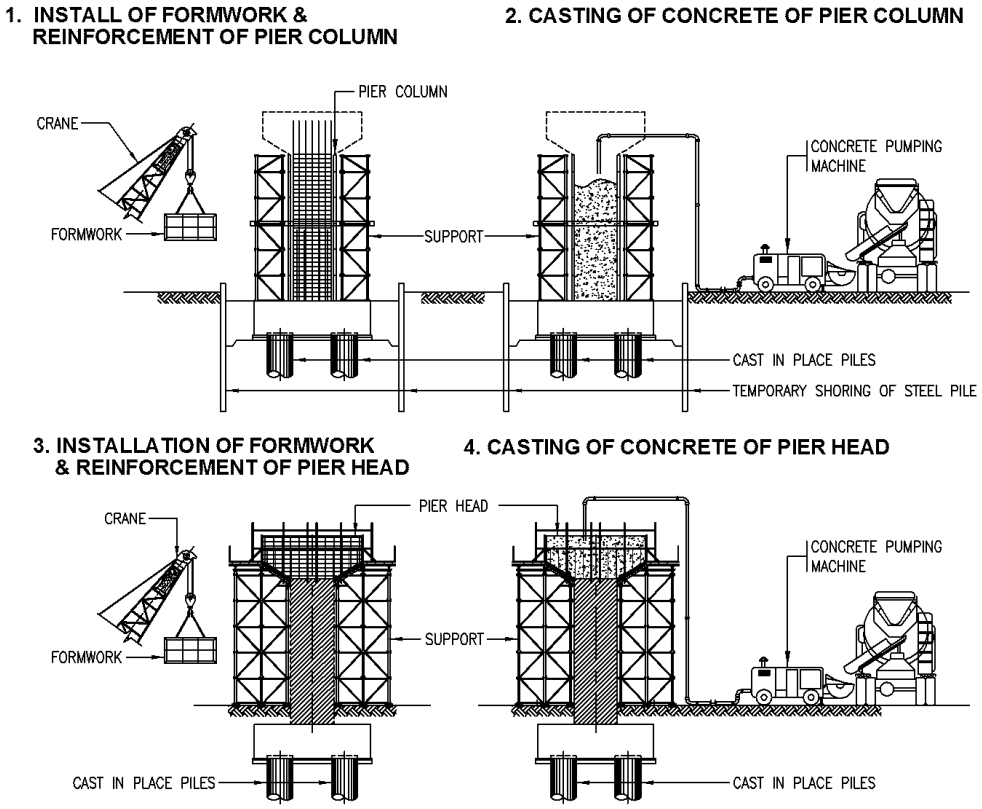
Source: JICA Survey Team

Figure 9.3.1 Pile Cap Construction within Cofferdam as Temporary Works

9.4 Pier

After installing re-bars overlapping the starter bars of the pile cap, vertical formwork will set up and concrete casting will be done eventually.

For the pier head, support should be assembled from the ground and the formwork will then be installed on top of pier head. After that the installation of re-bars and the pier head casting will be done sequentially.



Source: JICA Survey Team

Figure 9.4.1 Construction Method for Piers

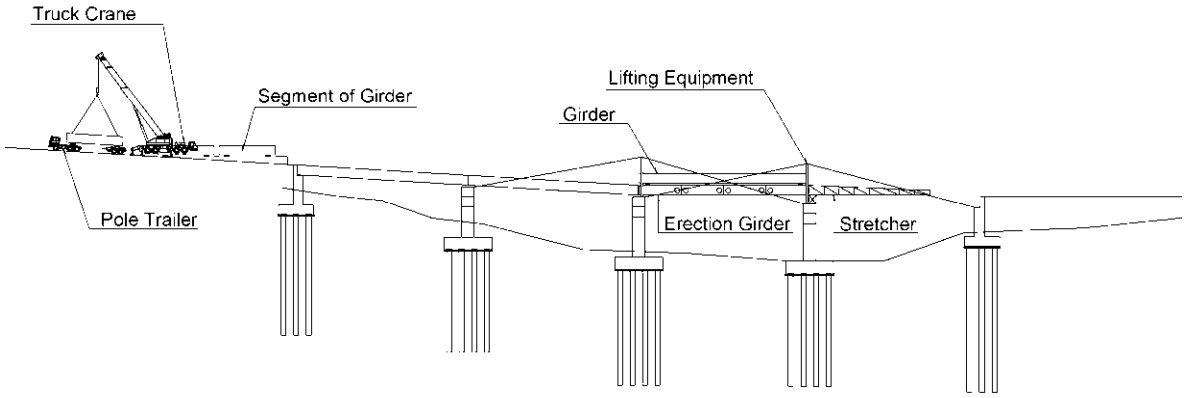
9.5 Superstructure

9.5.1 PC-I Girder

During the construction of substructures, PC-I girders will be manufactured in advance at fabrication yards near the site. After completion of the piers, PC-I girders should be erected using truck cranes.

If the construction by truck cranes becomes impossible, the construction by erection girders can be followed. This shall be considered in the detailed design stage if the necessity becomes an critical issue.

As shown in Figure 9.5.1, this method involves casting long sections of the bridge superstructure in a stationary formwork behind abutment, and carrying completed sections towards bridge longitudinal axis following girder erection method.



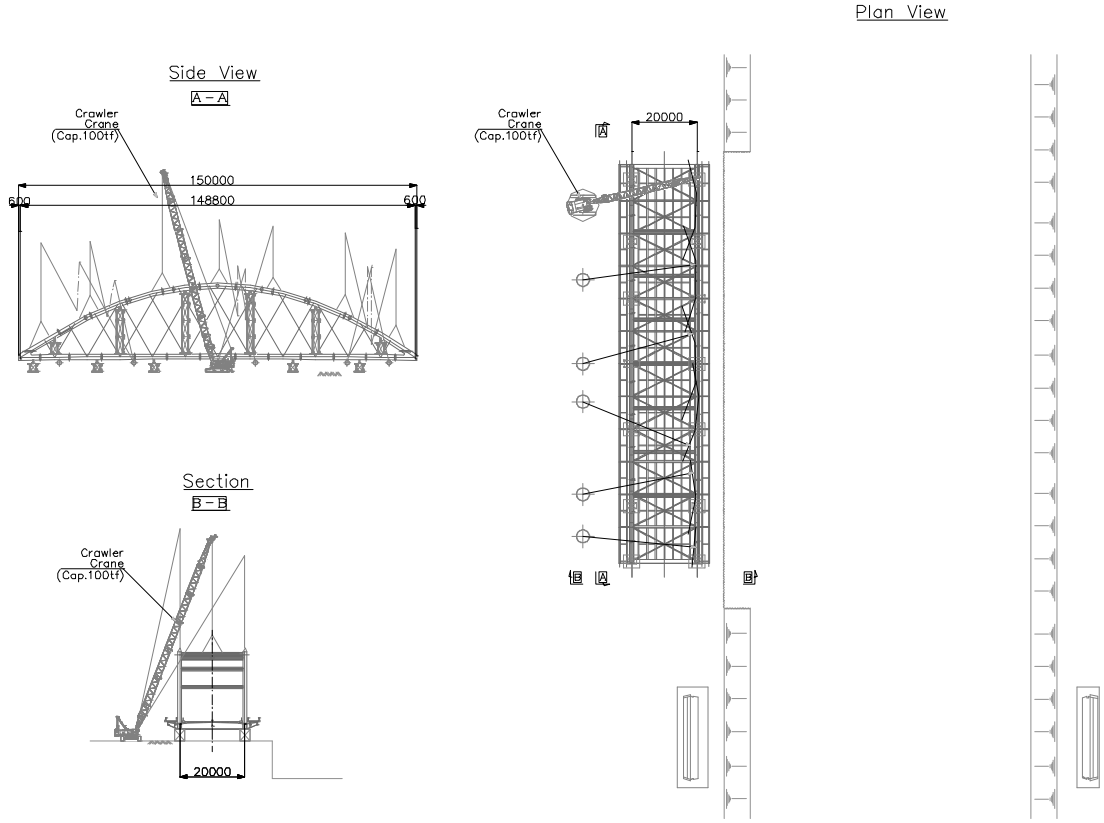
Source: JICA Survey Team

Figure 9.5.1 Construction of Superstructure using Girder Erection Method

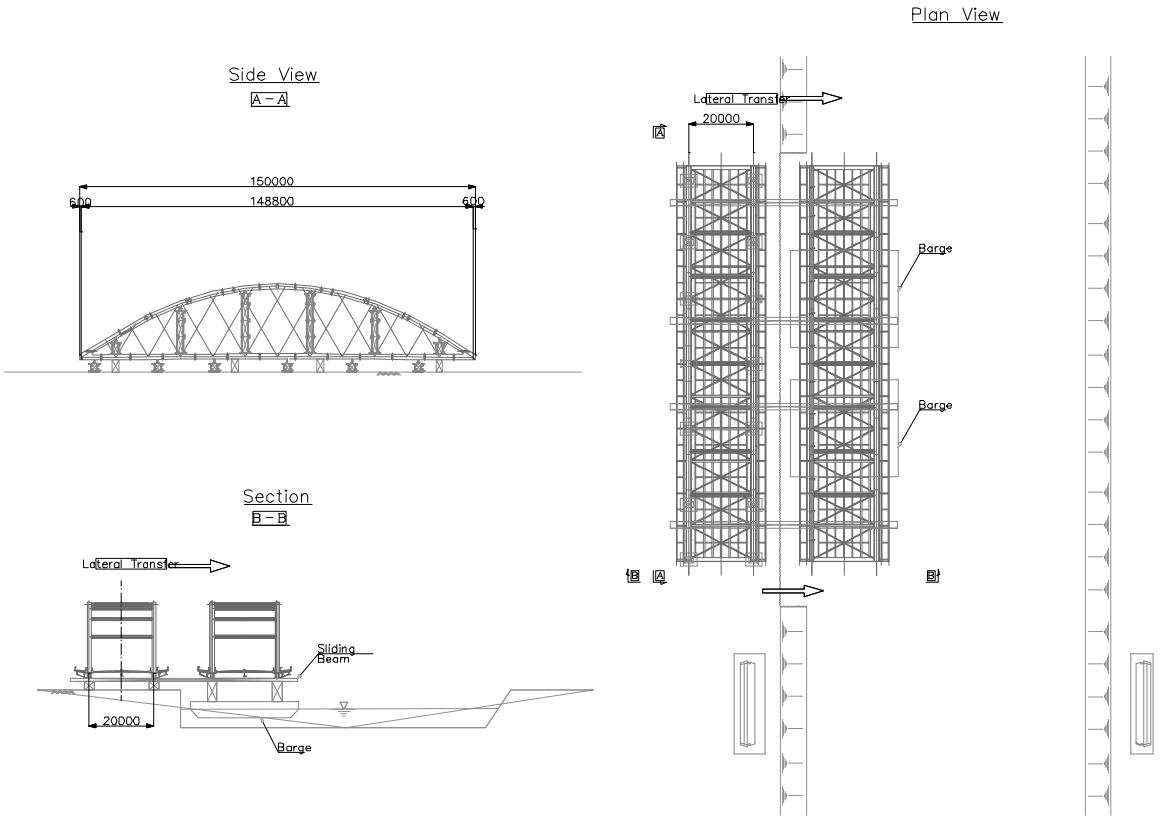
9.5.2 Nielsen Lohse Arch for Kalna Bridge

Whole steel portion of Nielsen-Lohse Bridge will be constructed at river side and lifted onto the floating barge. Then, the barge will transport the bridge to the center of river and the bridge will be jacked up on the bridge piers. In particular, this erection of steel arch section shall be followed in three steps:

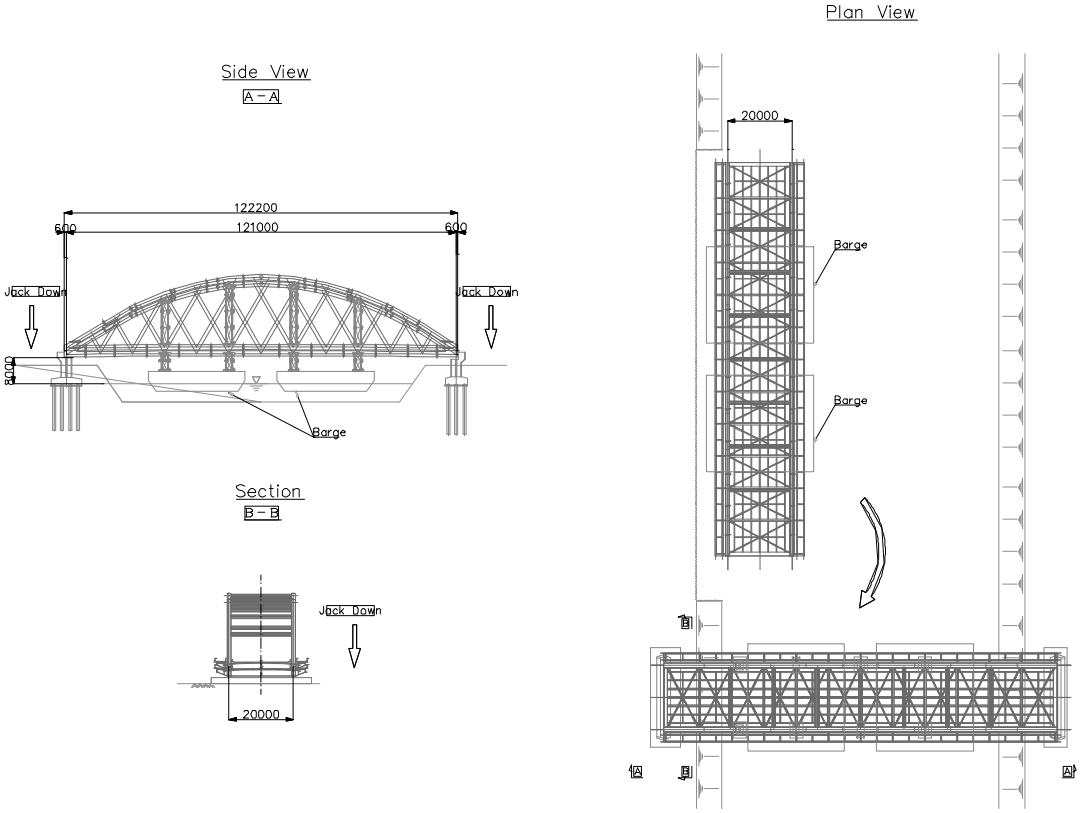
Step-1: Arch Assemblage



Step-2: Lateral Transfer using floating barge



Step-3: Jack Down



Source: JICA Survey Team

Figure 9.5.2 Erection Method of Nielsen Lohse Bridge (Kalna Bridge)

9.6 Approach/ Access Road

The sequence of construction for approach/access road is planned according to the following steps:

(1) Site Cleaning

Prior to starting the embankment works, site cleaning including the removal of trees root should be removed by a bulldozer.

(2) Embankment Work

The material of the embankment will be carried by dump truck from the borrow pit and compacted by a pneumatic tire roller.

(3) Slope Protection Work

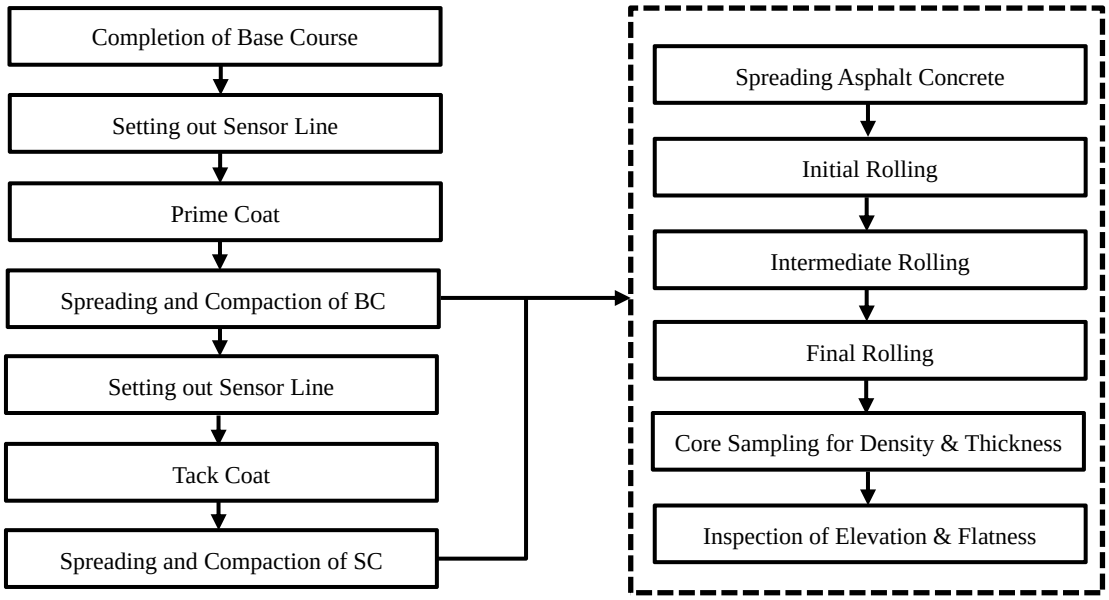
The slope of the embankment will be formed by backhoe after compaction by bulldozer. After that, slope protection works including planting and shaping should be done.

(4) Pavement Work

Generally, Base Course and Subbase Course are leveled by motorized grader, and compacted by road roller and a pneumatic tire roller.

For Surface Course (SC) and Binder Course (BC), the asphalt mixture is leveled by asphalt finisher, and then compacted by a pneumatic tire roller.

A typical work flow for road construction is shown in Figure 9.6.1.



Source: JICA Survey Team

Figure 9.6.1 Work Flow of Pavement Work

9.7 Traffic Control during Construction

(1) Plan-1: Temporary Bridge

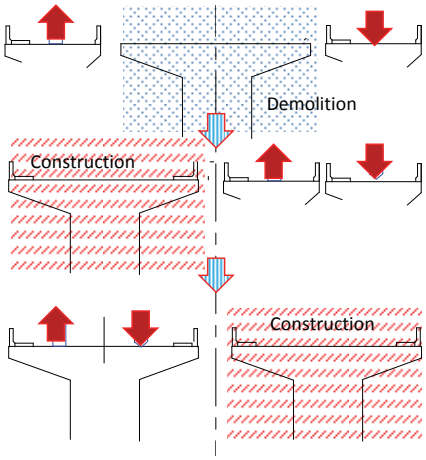
The project bridges except B25 under Section B will be constructed at the same location of existing bridges, and thus temporary bridges are necessary for diversion of existing traffics during construction.

(a) Diversion measures for bridges under Section B

Step-1:
- Temporary diversion in both sides
- Existing bridge demolition

Step-2:
- 2-lane new bridge construction

Step-3:
- Traffic diversion through new bridge
- Another 2-lane new bridge construction at next



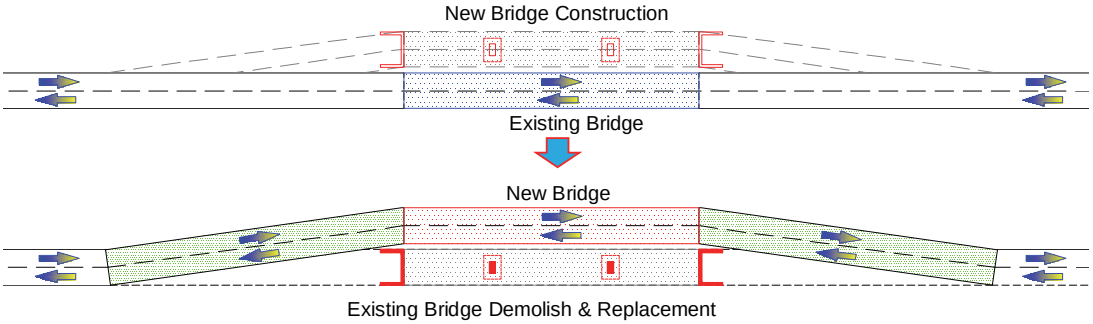
(b) Diversion measures for Jhikorgacha Bridge

Source: JICA Survey Team

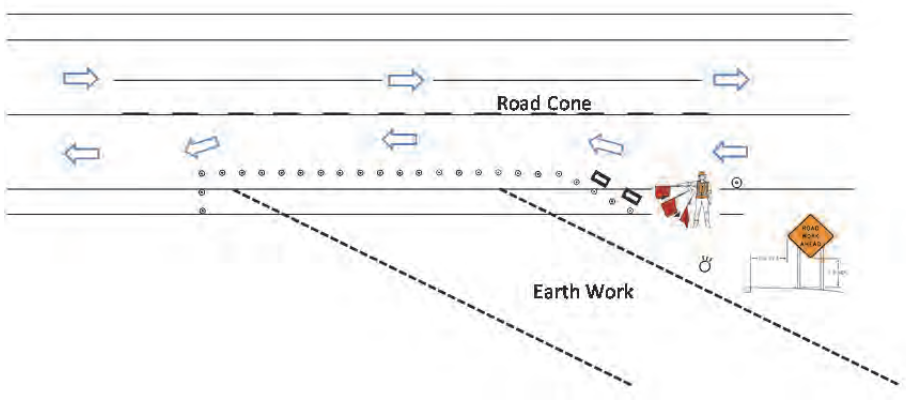
Figure 9.7.1 Traffic Diversion Plan during Construction (Section-B and Jhikorgacha)

(2) Plan-2: Alternate Diversion Including Shoulder Control

The project bridges under Section A and C excluding Kalna and Jhikorgacha will be constructed next and parallel to the existing bridges. The existing traffic will use existing bridge while new bridge will be under construction. The existing traffics will be diverted through new bridge after completion of construction. Afterwards the existing bridge will be demolished and replaced by another 2-lane new bridge. Therefore, unlikely Plan-1 (b), the traffic control by temporary bridge 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 (b).



(a) Alternate traffic diversion



(b) Shoulder Control

Source: JICA Survey Team

Figure 9.7.2 Diversion Measures for Bridges under Section A and C (excluding Jhikorgacha)

(3) Plan-3: Ferry crossing

The Kalna Bridge will be constructed at completely new location offset from existing Ferry Ghat. Therefore, new bridge along with access road construction will not cause any interruption to the existing traffic movement. They can easily cross the river by existing ferry while new bridge under construction.

Source: JICA Survey Team

Figure 9.7.3 Existing Traffic Crossing by Kalna Ferry

Table 9.7.1 Traffic Diversion Measures during Construction

Sl. no.	Bridge name	Diversion Plan
Section A		
A1	Jhikorgacha Bridge	Plan-1(b)
A2	Tularampur Bridge	Plan-2
A3	Hawai khali Bridge	Plan-2
A4	Kalna Bridge	Ferry Crossing (Plan-3)
A5	Garakola Bridge	Use of existing bridge
Section B		
B2	Telipool Bridge	Plan-1(a)
B3	Lakshmi chara Bridge	Plan-1(a)
B9	Kalapani Bridge-2	Plan-1(a)
B12	Koilabazar Bridge	Plan-1(a)
B13	Balutila Bridge	Plan-1(a)
B14	Fulchori Bridge	Plan-1(a)
B15	Heaku Bazar Bridge	Plan-1(a)
B16	Heako Bridge	Plan-1(a)
B18	Chikon Chara Bridge	Plan-1(a)
B19	Chikon Chara Bridge	Plan-1(a)
B20	Bangla Bazar Bridge	Plan-1(a)
B22	Borobil Bridge	Plan-1(a)
B23	Gadar Dokan Bridge	Plan-1(a)
B24	Baganbazar Bridge	Plan-1(a)
B25	East Baganbazar Bridge	Use of existing bridge
Section C		
C8	Patiya Bridge	Plan-2
C12	Mazar Point Bridge	Plan-2
C13	Sangu Bridge	Plan-2
C26	Mathamuhuri Bridge	Plan-2

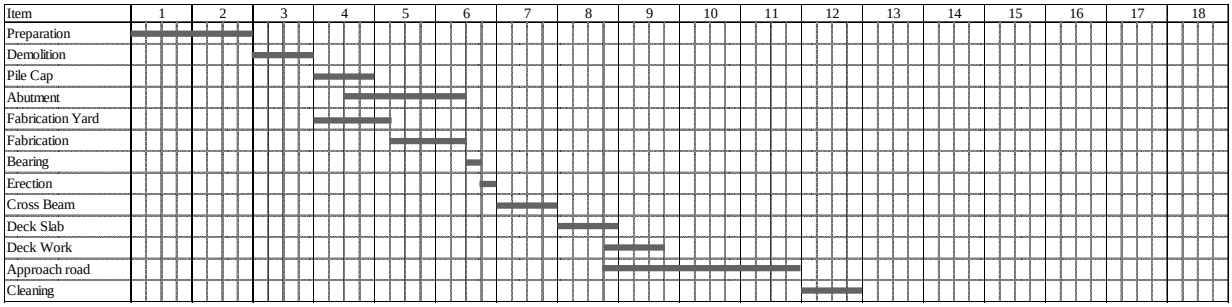
Source: JICA Survey Team

9.8 Construction Schedule

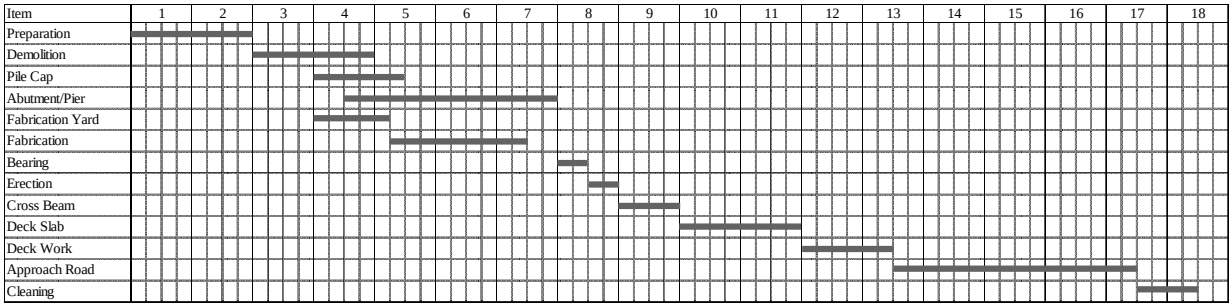
The typical construction schedule of PC-I type bridge according to bridge length and lane number is shown in the following figures.

9.8.1 Concrete Bridge (PC-I Girder)

(1) Case-1: 2-lane, Single Span, L=40m

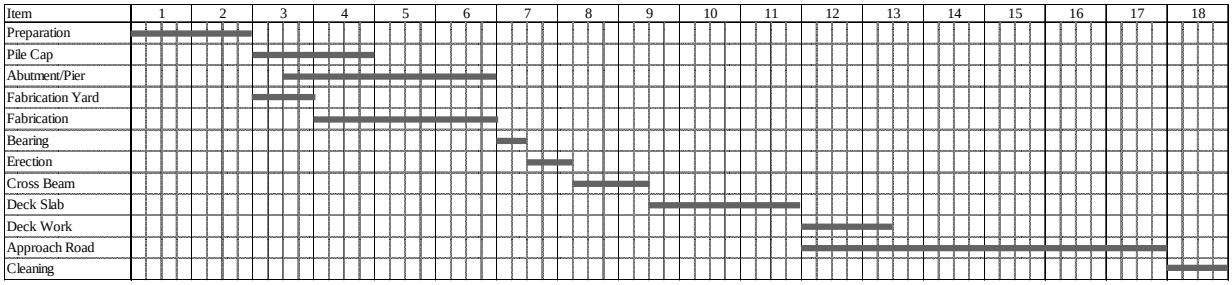


(2) Case-2: 2-lane, 2-Span, L=55m



(3) Case-3: 2-lane, 3-Span, L=110m

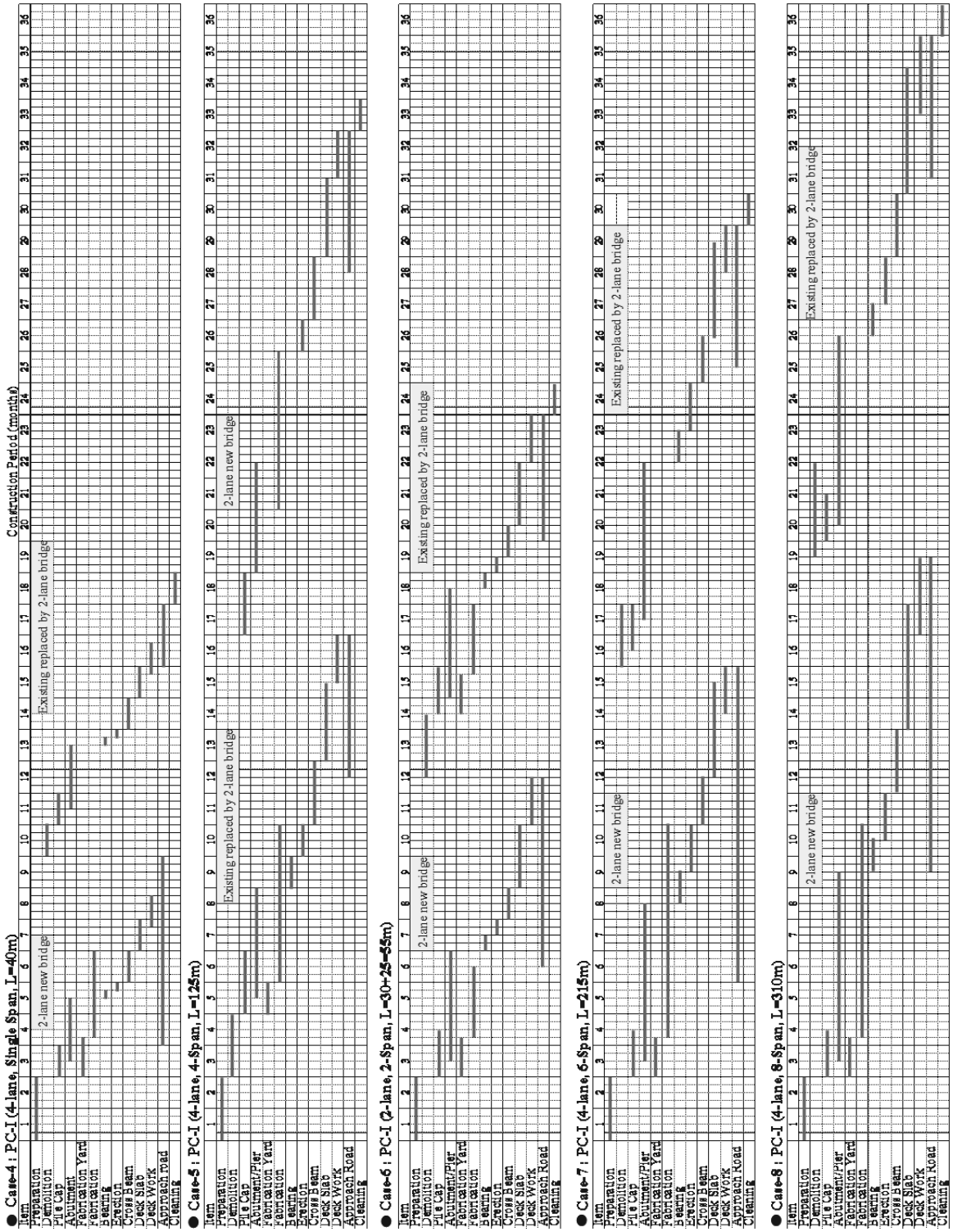
(No demolition and use existing bridge as diversion)



Source: JICA Survey Team

Figure 9.8.1 Construction Schedule for 2-Lane PC-I Girder Bridge

(4) Case-4: Other PC-I Girder Bridges (4-lane etc.)



Source: JICA Survey Team

Figure 9.8.2 Construction Schedule of 4-Lane PC-I Girder Bridge

(5) Overall Construction Schedule for PC-I Girder Bridge/RC Box Culverts

The overall construction schedule of PC-I Girder bridges (excluding Kalna) and RC Box Culverts is shown in Figure 9.8.3. The construction of bridges under Package A2 and B are planned to complete by 33 months, whereas those under Package C are scheduled to complete by 36 months.

Bridge Name	No. of	Construction Sequence (months)									Package Total
[A2 Package] 2-Party	Lane	4	8	12	16	20	24	28	32	36	(months)
A1:Jhikorgacha Bridge (125m)	4										33
A3: Hawai khali Bridge (35m)	4										
A2:Tularampur Bridge (100m)	4										
A5:Garakola Bridge (110m)	2										
[B Package] 5-Party											
B2: Telipool Bridge (25m)	2										33
B3: Lakshmi chara Bridge (40)	2										
B9: Kalapani Bridge-2 (35m)	2										
B14,B15,B19&B20(Box Culverts)	2										
B13: Balutila Bridge (35m)	2										
B16: Heako Bridge (25m)	2										
B18: Chikon Chara Bridge (30m)	2										
B22, B23 and B24 (Box culverts)	2										
B12: Koilabazar Bridge (55m)	2										
B25:East baganbazar Bridge (50m)	2										
[C Package] 2-Party											
C13: Sangu Bridge (215m)	4										36
C8: Patiya Bridge (55m)	4										
C26: Mathamuhuri Bridge (310m)	4										
C12: Mazar Point Bridge (60m)	4										

Note: Bar Chart with two different colors represents 2-lane new bridge construction followed by existing bridge replacement or vice versa

Source: JICA Survey Team

Figure 9.8.3 Overall Construction Schedule of PC-I Girder Bridges/RC Box Culverts

9.8.2 Construction Schedule of Kalna Bridge (PC-I +Steel)

The construction of Kalna Bridge is planned to complete by three (3) years in which construction of approach bridge on both sides, main bridge and access road including the installation of toll collection system will start simultaneously.

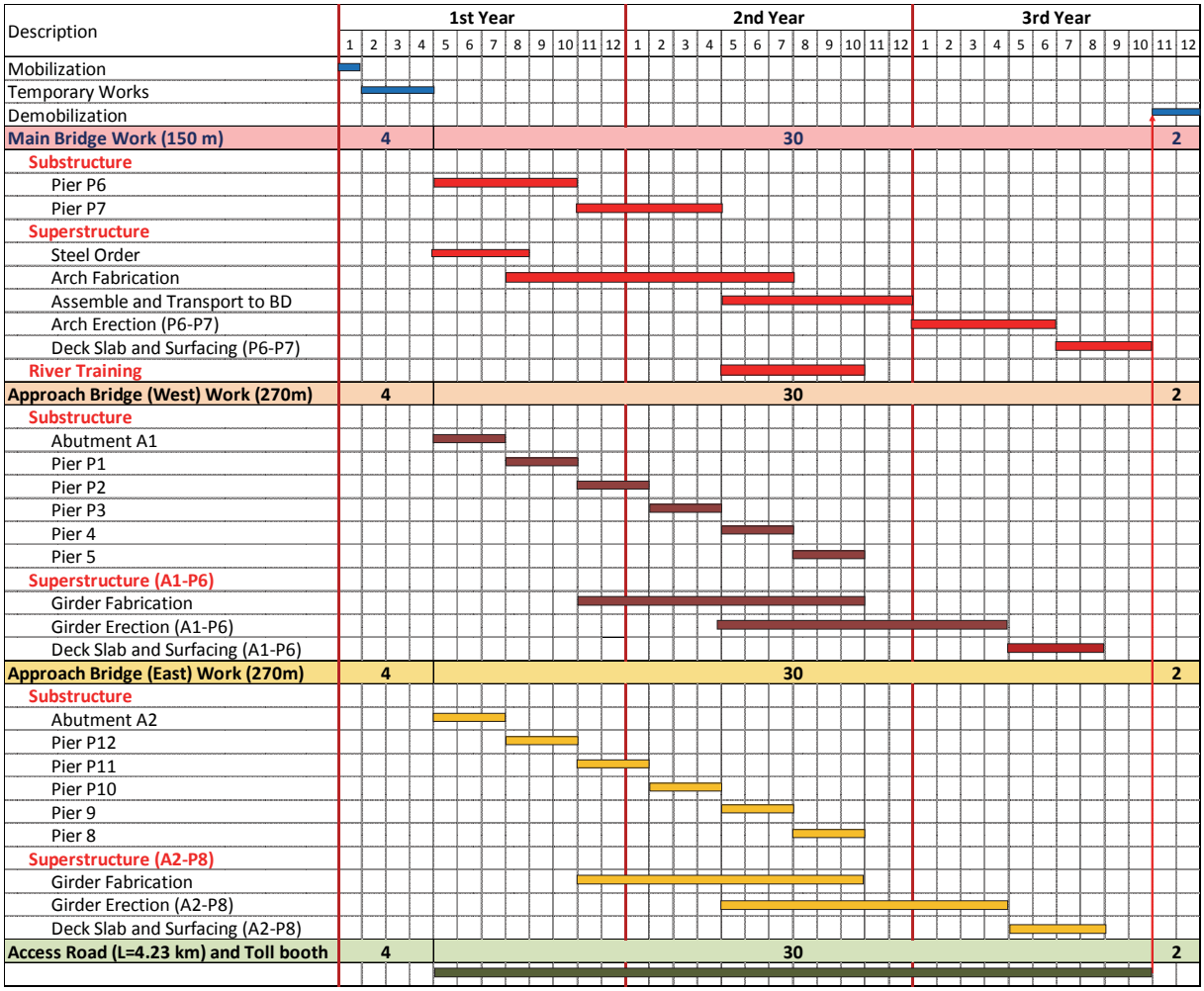


Figure 9.8.4 Kalna Bridge Construction Schedule

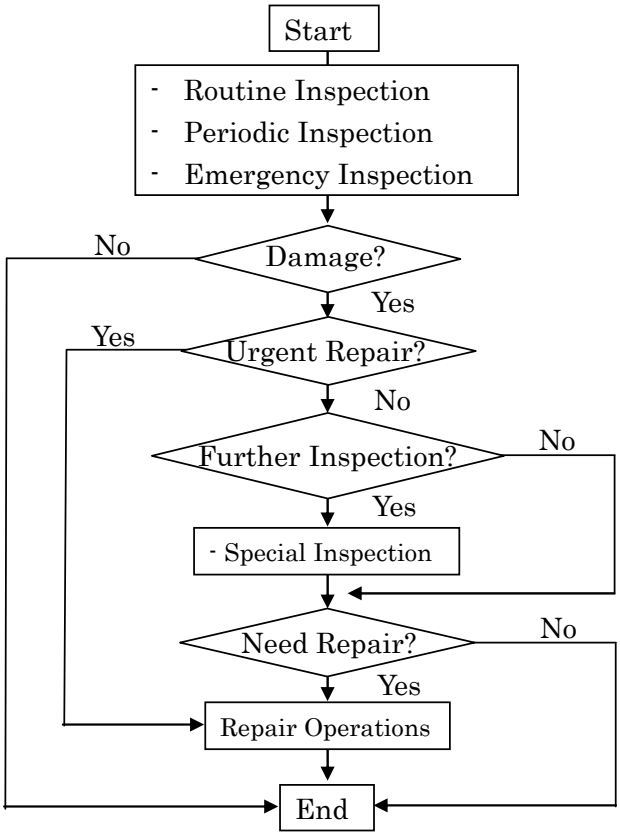
10. OPERATION AND MAINTENANCE PLAN

10.1 Operation and Maintenance Plan

10.1.1 Introduction

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 Inspection

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 Buildup of Regulation for Over Load Vehicles

It is necessary that regulation for over load vehicles should be structured more strictly because over load causes deterioration of vehicle function and traffic accident. Additionally, the damage of pavement, bridges and other structures are damaged by over load vehicles. These are also caused the cost increase. Thus, as previously mentioned, axle load scale shall be installed in order to avoid the road structures.

Defect of existing axle load scale is as follows:

- Total weight of vehicle cannot be gauged.
- Measuring of axle load is necessary that vehicle must stop or reduce the speed.
- Permanence period is 2 years or 3 years.

Although new axle load scale shall be installed, the equipment cannot meet many rules of Bangladesh. Thus, it is necessary to consider installing of new axle load scale and streamlining the rules.

10.2 Organization

10.2.1 Ministry of Road Transport and Bridges

(1) Ministry of Road Transport and Bridges

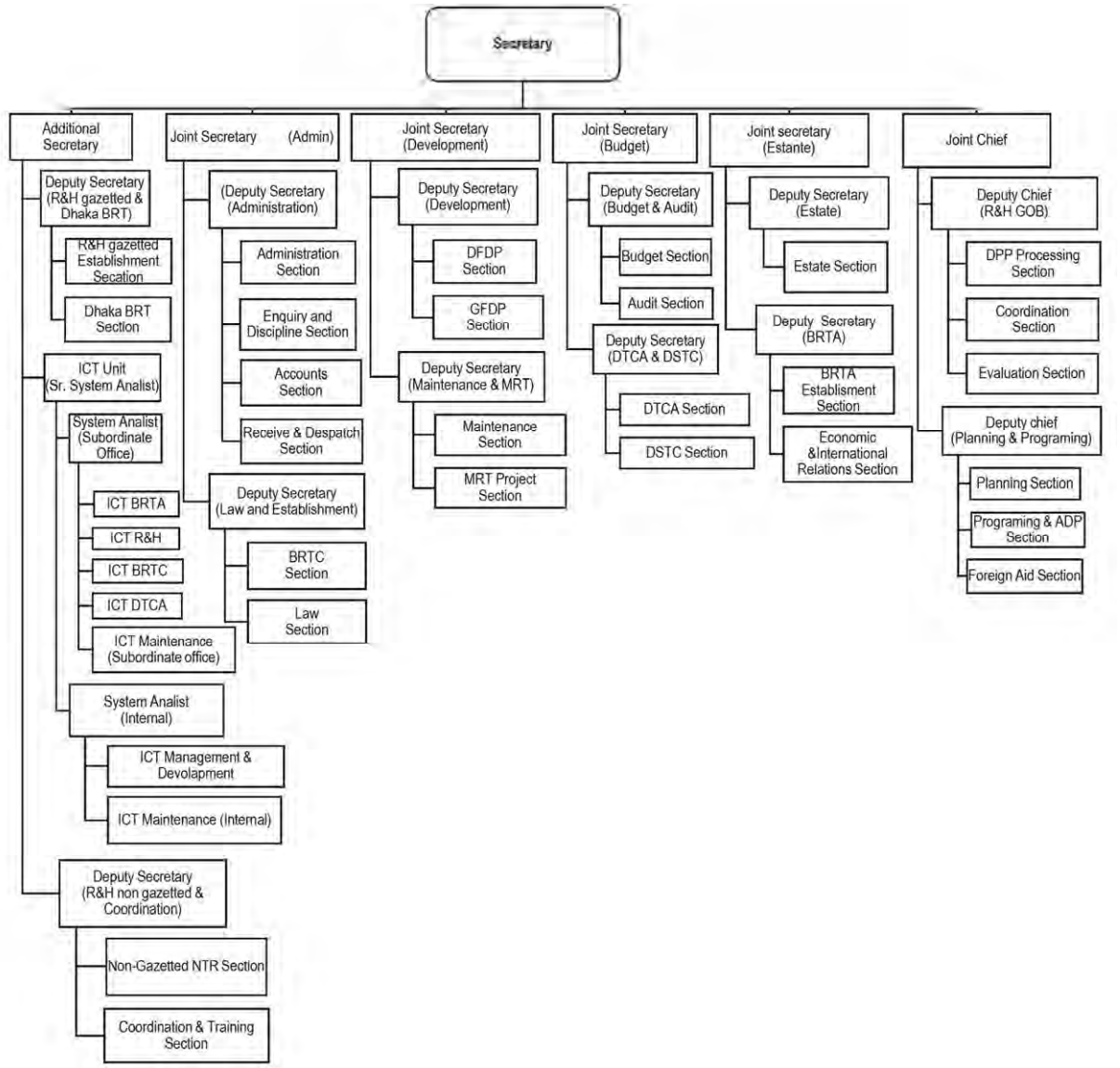
The Ministry of Road Transport and Bridges (MORTB) is comprised of two divisions, namely the Road Transport and Highways Division (RTHD) and the Bridges Division (BD). RTHD deals with major road networks in Bangladesh, whereas BD deals with all matters relating to bridges longer than 1,500m. MORTB plays 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) Organogram of Road Transport and Highways Division under MORTB

The organizational structure of RTHD under MORTB is explained below. As of MORTB's official website data available in November, 2015, the total number of RTHD officers is 191. Under RTHD's administration, the engineering and technical issues on road infrastructure development are fully managed by Roads and Highways Department (RHD). The details of RHD's organization and technical capability are described in following Subsection 10.2.2.



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

Figure 10.2.1 Organization of Road Transport and Highways Division, MORTB

Table 10.2.1 RTHD's Officers Class and Number

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. Maintenance 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 (http://www.rthd.gov.bd)

10.2.2 Roads and Highways Department (RHD)

(1) Overview

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.

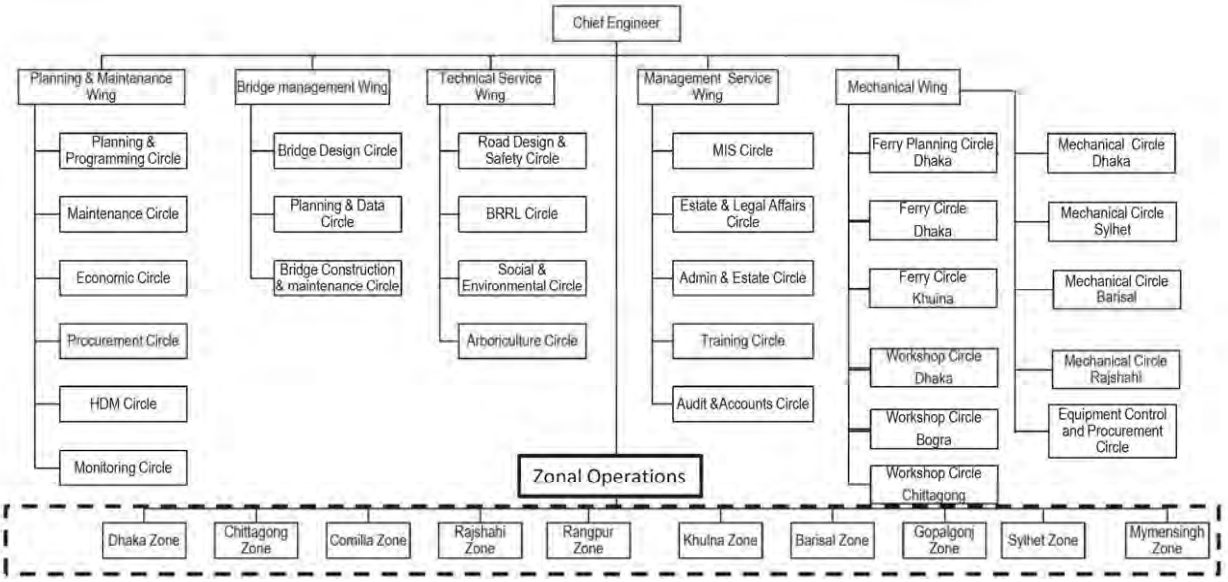
It is officially defined as follows: "The Roads and Highways Department has a sustainable capacity to plan, manage and deliver its full range of responsibilities in respect of the main road and bridge network and to be accountable for these duties".

(2) Organization Chart of RHD

The Roads and Highways Department (RHD) under Ministry of Road Transport and Bridges (MORTB) will implement this Project and will be responsible to manage the operation and maintenance of bridges after opening to the road users. This department is headed by one (1) Chief Engineer (CE) who is supported by fifteen (15) Additional Chief Engineers (ACEs). The recent structure for RHD consists of 5 headquarters 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. The Training and Bridge Design functions are now located in the Management Service Wing and Bridge Management Wing respectively.

The Technical Service Wing acts as service providers within RHD into a single Wing to provide in-house services where possible, and manage outsourcing of such services when resources are inadequate to meet demand. This Wing ensures best practices in RHD by developing Design and Quality Standards (geometric, pavement, bridge, road safety and quality control) and contributes to

social and environmental improvement, embankment protection, demolition and utilization of RHD land through the effective management of an arboriculture program.



Source: RHD Web site

Figure 10.2.2 Organization Chart of Road Transport and Highways Division, MORTB

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.

RHD is capable enough to design and construct PC-I Girder Bridge with RC pile type foundation within their limited financial resources. Besides, several new bridge construction technologies such as PC box girder and PC Extradosed Box Girder Bridge were introduced through foreign aided projects, and those technologies were transferred to RHD through On-the-Job Training (OJT) scheme. However, the implementation of 'Nielsen Lohse Steel Arch' Type Bridge planned for Kalna will add a new dimension to the RHD's bridge construction industry and will obviously take a significant role to enrich their knowledge whenever OJT program will be undertaken.

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

Name of Post	Number
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 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.

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 last five years since 2008 is shown in Table 10.3.1.

Table 10.3.1 GOB's Consolidated Receipts and Expenditures

(Unit: million BDT)

Heads	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013
1. Total Receipts (a+b+c)	**936,920**	**1,068,780**	**1,351,480**	**1,692,160**	**1,995,960**
(a) Revenue Receipts	**640,910**	**759,050**	**951,870**	**1,183,850**	**1,396,700**
(i) Tax	528,670	624,850	790,520	957,850	1,168,240
(ii) Non-Tax	112,300	134,200	161,350	226,000	228,460
(b) Other Internal Receipts	**202,270**	**158,200**	**248,170**	**272,080**	**334,840**
(c) Foreign grants and loan receipts	**93,680**	**151,530**	**151,440**	**236,230**	**264,420**
(i) Project and non-ADP project aid	42,810	5,200	134,300	207,200	239,730
(ii) Food, Commodity and others	50,810	146,330	17,140	29,030	24,690
2. Total Expenditure (a+b)	**804,450**	**990,840**	**1,160,070**	**1,377,530**	**1,116,750**
(a) Revenue Expenditure	**607,450**	**731,670**	**831,770**	**1,029,030**	**229,400**
(i) Wages and Salaries	154,640	163,650	213,120	225,350	130,330
(ii) Commodities and services	83,250	78,000	110,690	122,220	386,270
(iii) Transfer	350,630	457,590	297,740	346,420	370,750
(iv) Capital Expenditure	18,930	32,430	210,220	335,040	476,530
(b) Development Expenditure	**197,000**	**259,170**	**328,300**	**348,500**	**103,012**
(i) Agriculture, Flood control, Water Resources and Rural Institution	53,173	63,465	80,393	75,336	
(ii) Industry	4,125		-	-	-
(iii) Transport and Communication	21,910	4,524	5,730	4,471	6,114
(iv) Others	117,792	35,943	45,530	60,096	82,172
As Percent of GDP		155,238	196,647	208,597	285,232
Total Receipts	17	17	17	18	19
Tax Revenue	9	9	10	10	11
Development Receipts	6	4	5	6	6
Total Expenditure	13	14	15	15	15
Development Expenditure	3	4	4	4	5

Source: National Accounting Wing, BBS

For last 5 years since 2008, the national total revenue has been increasing every year at an average of 22.61% (i.e., (1,995,960-936,920)/ 936,920*100/5), whereas the rate of Developments Receipts turns to around 1/3 of Total Receipts calculated on the basis of percent of GDP.

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 13 years is shown in Table 10.3.2. 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 BDT)		
	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
2014-2015*	-	9,960,000	-

Source: RHD *Financial Express Report (10th June, 2015)

Table 10.3.3 Requested and Allocated Maintenance Budget

Financial year	Amount (in million BDT)		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
2014-15	-	9,960,000	-

Source: RHD

Table 10.3.3 shows both of requested budget and allocated budget for maintenance. There are consistently significant discrepancies between the two values. FY 2014-2015, the Government of Bangladesh approved BDT 9.96 billion road maintenance project of RHD through ECNEC (Executive Committee of the National Economic Council) held on 9th June, 2015. A fund of BDT 9.96 billion will be available in addition to BDT 14 billion allocation in the revenue budget of the current FY 2014-15 for road repair, maintenance and rehabilitation works across the country.

10.4 Issues on Operation and Maintenance for Roads and Bridges

10.4.1 Insufficient Budget

As mentioned in previous section, 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 Inadequate Operation and Maintenance Works

There are many bridges with severe deck slab damage. 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. Therefore, it is important to establish efficient management plan and train RHD staff accordingly.

10.4.3 Updates of BMMS (Bridge Maintenance Management System)

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. Therefore, it is necessary to prioritize bridge repair works utilizing efficient budget expenditure. To this regard, BMMS will play an important instrument to establish an efficient bridge maintenance plan. However, update of existing BMMS has not been executed yet.

10.4.4 Prohibition of Overloaded Vehicle Movement

One of the major causes of damage on bridges (especially deck slab) is overloaded vehicle movement. Overloaded vehicles inflict significant damage on roads and bridges. In order to prevent damage, overloaded vehicle should be properly regulated under strict highway laws. The necessity for regulating overloaded vehicles is also described in the Road Master Plan (2009-2029).

10.5 Proposal on Effective Operation and Maintenance

10.5.1 Sufficient 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 establish a stable financing source in accordance with the Road Fund referred in the Road Master Plan (2009-2029):

> **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 Effective and Efficient Maintenance Plan

The proposal from EBBIP formulated under capacity building and maintenance plan preparing under Technical Cooperation Project (on-going) are addressed and referenced for effective and efficient maintenance plan of Cross-Border Project.

Through the capacity building component of EBBIP, the following results were proposed:

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

Through this Project implementation, RHD staff's knowledge on maintenance and management is expected to broaden. Their skills in inspection, damage evaluation and planning for maintenance will be improved. Moreover, skills in maintenance and management methodology should be further improved through technical cooperation project, of which the details are explained in Subsection 10.6.1. The above experience to be gained will enhance the knowledge of PC-I Concrete Bridge maintenance. In addition, the special O/M plan required for Kalna Bridge (PC-I+Steel) is addressed in Section 10.7.

10.5.3 Prohibition of Overloaded Vehicle Movement

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 moveable axle load measuring equipment and establishment of axle load control center at specific location
- Enforcing rebound to some extent overloading and over that issuing penalty tickets

10.6 Proposal of Future Japanese Support

10.6.1 Technical Cooperation Project on Bridge Operation & Maintenance (On-going)

JICA-assisted a technical cooperation project on bridge operation & maintenance is currently under implementation since August, 2015 and will continue intermittently until March, 2018. Summary of the technical cooperation project is as follows.

(1) Objectives of the Project

- Improvement of RHD's capacity building 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 maintenance and management system (BMMS)
- (Outcome 4) Enhancing the skill of RHD personnel 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 maintenance and management system (BMMS)

- To review the existing BMMS
- To study the method for utilization of new BMMS with RHD
- To establish new BMMS
- To move the data from existing BMMS to new BMMS
- To create draft BMMS 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) JICA Expert for RHD

JICA expert is necessarily to be dispatched periodically 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

Currently JICA expert is deployed in the period of Sep. 2014-Dec. 2016, who is servicing and advising RHD. In, particular, his job responsibility includes:

- Advise RHD regarding on-going/new bridge project
- Site survey required for roads/bridges
- Assessment of exiting condition of roads/bridges, which is pre-requisite to appraise O/M plan
- Advise any improved method on O/M plan.

10.6.2 Overseas Training on Steel Arch Bridge

In addition to the technical cooperation project, the overseas training on Steel Arch Bridge is proposed, which is planned to execute during detailed design and construction stage of CBRNIP. A draft program of the overseas training is shown in Table 10.6.1. An extensive knowledge on Nielsen Lohse Arch Bridge and Bridge with SBSH material can be obtained if the overseas training program planned in Japan is followed. Moreover, this experience will expedite to the lessons from Kalna Bridge construction.

Table 10.6.1 Draft Program of Overseas Training on Steel Arch Bridge

#	Day	Program (Draft)	Mode	Stay
Day 1	Sun	Fly from Dhaka to Tokyo	Air	Tokyo
Day 2	Mon	Introduction and Explanatory session by Consultant	Metro	- ditto -
Day 3	Tue	Technical visit to Tokyo Aqua Line, Tokyo Rainbow Bridge, Tokyo Gate Bridge and Tokyo road network	Minivan	- ditto -
Day 4	Wed	Lecture on Steel Arch Bridge by Consultant	Metro	- ditto -
Day 5	Thu	(AM) Move to Osaka prefecture by Shinkansen (Express Train), (PM) Technical Visit of Nielsen Lohse Bridge located in Osaka Prefecture	JR & Minivan	Osaka
Day 6	Fri	Meeting with Operation & Maintenance Authority to discuss on Design, Construction and Operation & Maintenance of Nielsen Lohse Bridge	Minivan	- ditto -

#	Day	Program (Draft)	Mode	Stay
Day 7	Sat	Free	Minivan	- ditto -
Day 8	Sun	(AM) Move to Hyogo prefecture by JR, (PM) Technical Visit of Akashi Bridge	JR	Kobe or Akashi
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)	JR	Tokyo
Day 10	Tue	Meeting with Ministry of Land, Infrastructure, Transport and Tourism to discuss on Design, Construction and Operation & Maintenance of Bridge	Metro	- ditto -
Day 11	Wed	(AM) Wrap-up at JICA headquarter, (PM) Free	Metro	- ditto -
Day 12	Thu	Fly from Tokyo to Dhaka	Air	-

Source: JICA Survey Team

10.7 Special Maintenance Plan for Kalna Bridge

Addressing to the routine and periodic maintenance described in Subsection 10.1.2, it is recommended to conduct following additions at certain intervals so as to monitor the traffic condition on bridge and access road sections and assess the state of Kalna Bridge health. This can be achieved through the frequent road patrol, the detailed visual inspection and the health monitoring by equipments.

(1) Road Patrol

As Kalna will be under toll operation, frequent road patrol on board is necessary to observe the traffic condition on bridge and access road sections. The road patrol must be conducted 24 hours a day considering with the traffic issue. Each party should include at least 3 members who will be under shifting duty and managed by toll operation administration. They will be responsible for daily inspection of bridge and road sections, and also provide the current condition of structure from their on-board observation.

Road Patrol Car

(2) Detailed Visual Inspection (at least every two years)

Generally a detailed visual inspection is necessary in order to grasp the damage on the structure. It can be conducted from a short distant visual inspection by means of inspection vehicle or preparing temporary scaffolding. For Kalna, this inspection work should be carried out by Aerial Work Platform (AWP) vehicle to check the condition of painted part of steel arch. If any painting part is found exposed to the natural environment due to unforeseen reasons, then instant action should be undertaken in order to restrain further exaggeration of damaged painting.

Figure 10.7.1 Visual Inspection Equipment (Self Propelled Aerial Work Platform)

(3) Health monitoring by equipment (every six years)

The health monitoring should be carried out at every six years for Nielsen Lohse Steel Arch Bridge. Of which, detailed inspection by equipments particularly for cable maintenance work should be carried out. The detailed inspection includes observation of rusting formation on cables and plate connections as well as measuring the tensile force in arch cable.

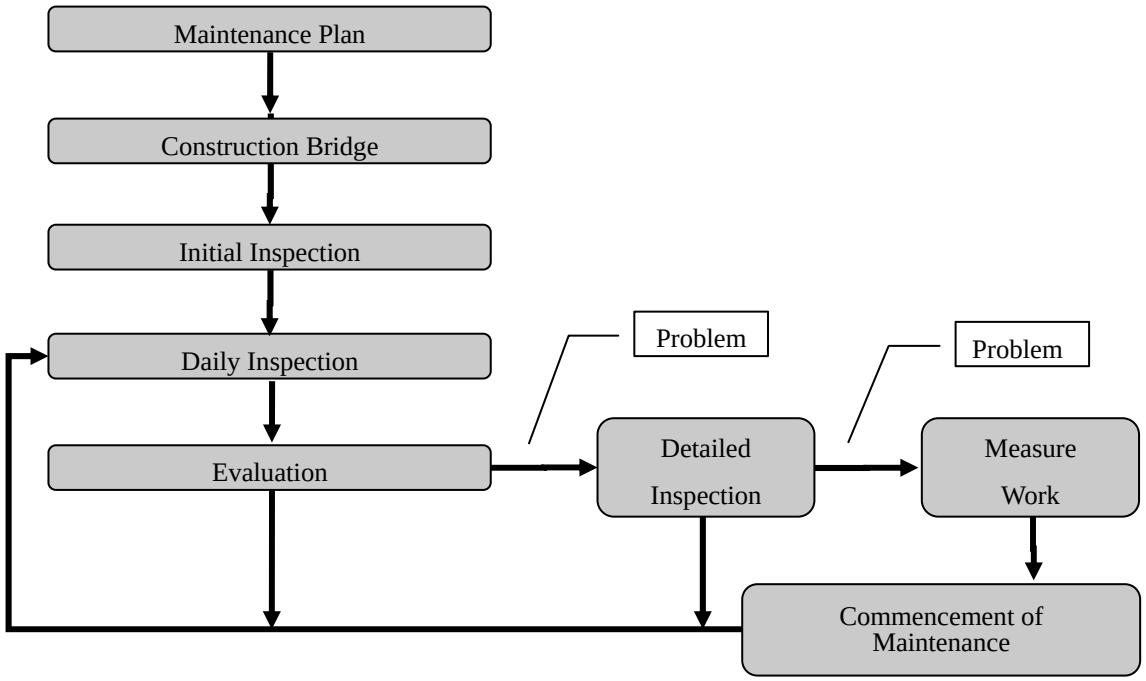
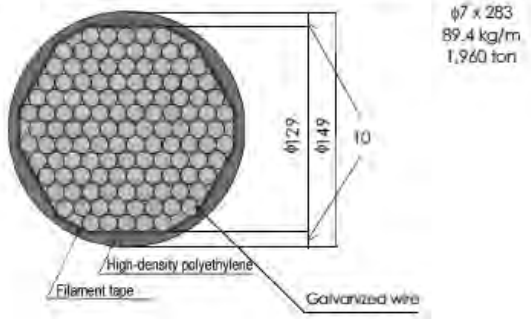


Figure 10.7.2 Health Monitoring Diagram for Nielsen Lohse Steel Arch Bridge (Kalna)

1) Cable section

Steel arch cable should be covered by polyethylene surface treatment to avoid rusting, which is more durable than painting on steel. A typical section and its mechanical properties are shown below, which can be followed prior to installation of cable section or any reinstallation if deemed as necessary.

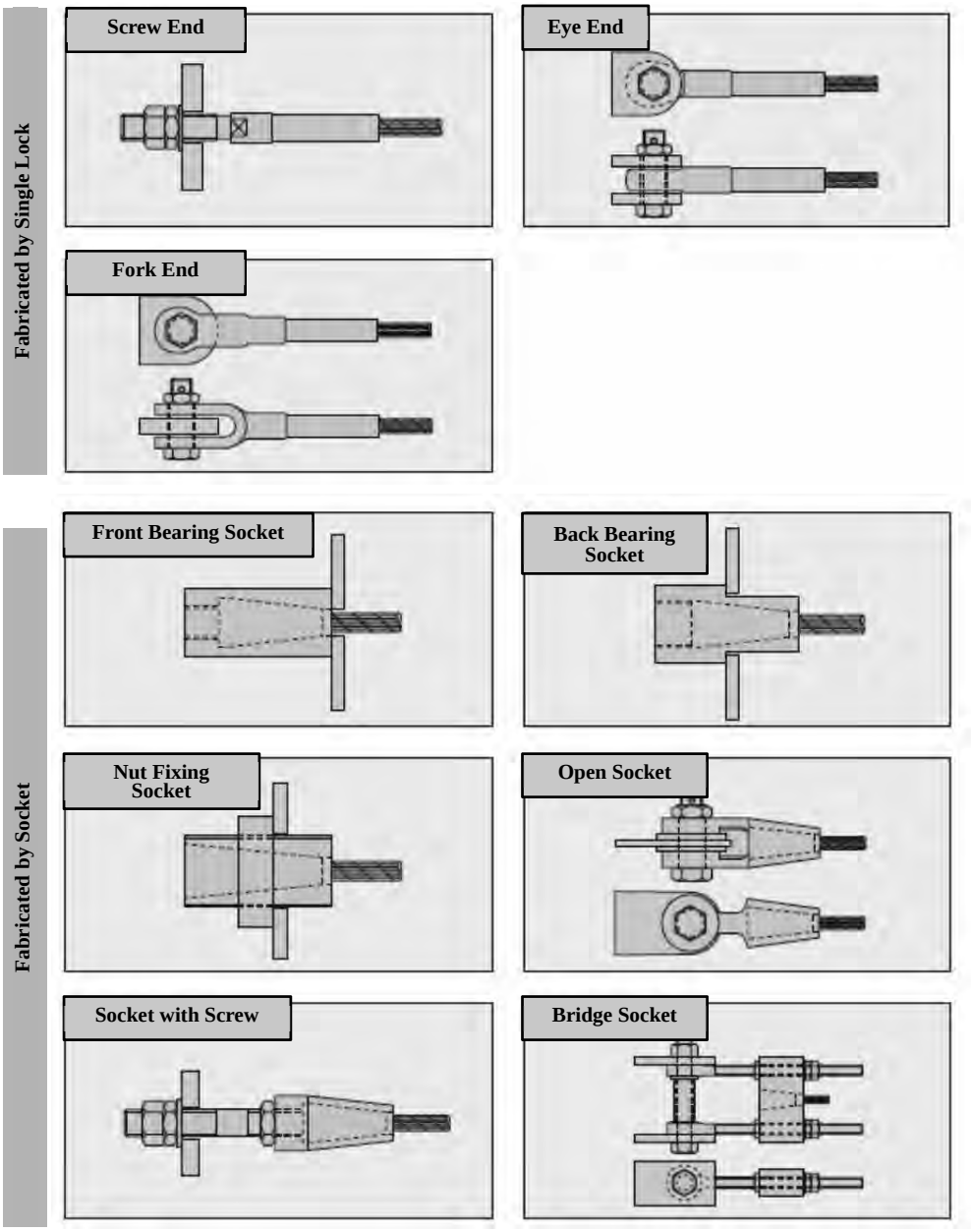
		NEW-PWS Complete Prefabricated Cable
Cable Section and Cable Structure		
Mechanical Property	Tensile Strength	180 kgf／mm²(High Strength Type)
	Elastic Modulus	20,000 kgf／mm²
	Tensile Fatigue Strength	Δσ=25 kgf／mm²
	Bending Fatigue Strength	Bending angle ±0.6°
	Angle of Twist	3.5±0.5°
Corrosion Protection	Wire	Galvanized (300g/mm²)
	Inner Layer	Polyester tape
	Outer Layer	High density polyethylene coating Socket fixing part (Heat-shrinkled tube in socket opening +Sealing material)
	Stranded Wire	—

Source: JICA Survey Team

Figure 10.7.3 Specification of Cable Section

2) Ancillaries works for plate attachment

All surfaces of ancillary plate attachments schematically shown below should be galvanized.

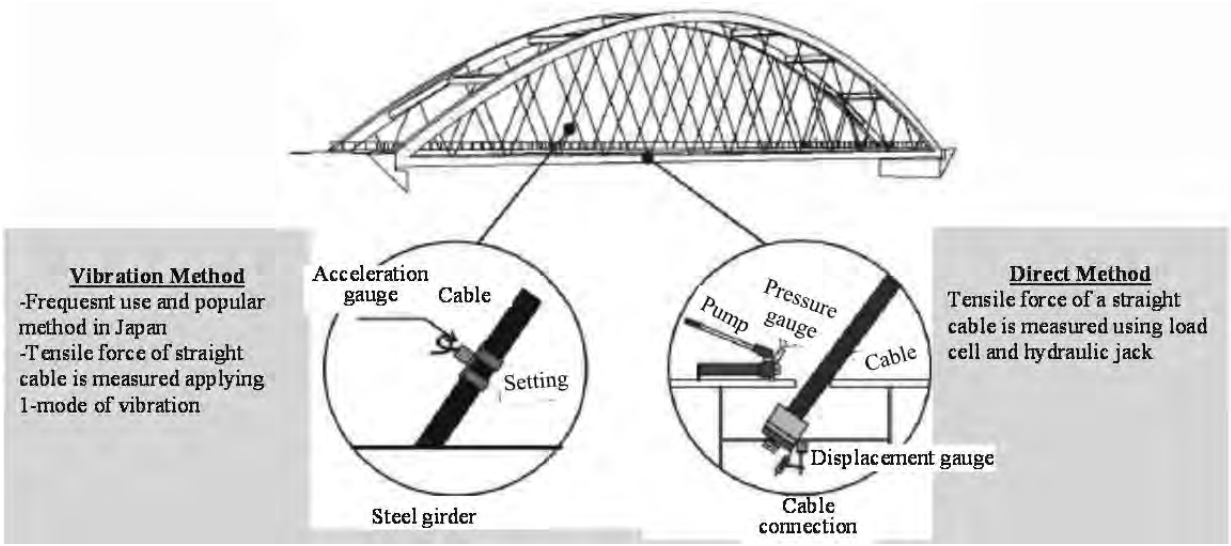


Source: JICA Survey Team

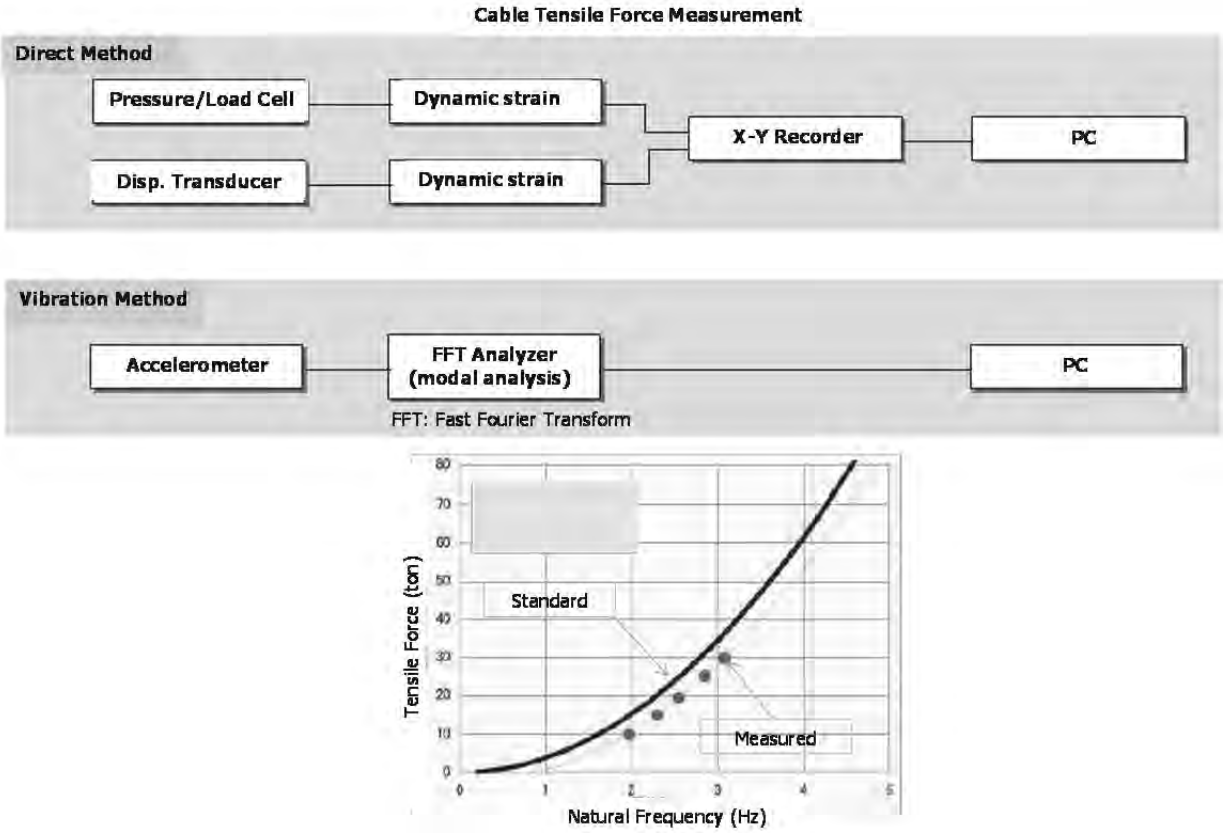
Figure 10.7.4 Anchorage Zone of Cable Section

3) Cable health monitoring

Basically no regular maintenance is required because no rusting occurs on cable surface. However, if the bridge is experienced excessive vibration after long days of its operation, the cable tension should be checked and adjusted, if necessary, following the convenient and popular vibration method.



(a) Cable tension checking by vibration (b) Cable tension checking and adjusting



Source: JICA Survey Team

Figure 10.7.5 Health Monitoring of Arch Cable of Nielsen Lohse Arch Bridge

The vibration method is based on the natural frequency recorded from arch cable and the results to be obtained can be converted into tensile force. The tensile force in arch cable can be monitored and measured by means of electronic device comprising of Data Logger and Personal Computer facilitated with commercial Fast Fourier Transform (FFT) Analysis Software. The field measurement will provide the data which will indicate the state of cable health. It can be evaluated by comparing with that of standard value to be used in design stage.

4) Heavy painting on steel arch and girder surface

The steel girder and arch section should be coated with heavy painting having repainting cycle at least thirty (30) years. In this regard, C-5 type painting system is recommended and its quality should be maintained according to the specifications shown in Table 10.7.1.

Table 10.7.1 C-5 Painting System of Kalna Bridge

outer surface painting C-5 system		Paint name	Standard thickness (μm)
Pre-treatment	First base plate conditioning	Primitive plate blasting	-
	Primer	Inorganic zinc primer	(15)
Factory paint	Secondary base plate conditioning	Assembled member blasting	-
	Under coating 1	Inorganic zinc paint	75
	Mist coating	Under coat epoxy resin paint	-
	Under coating 2	Under coat epoxy resin paint	120
	Intermediate coat	Intermediate fluororesin paint	30
	Top coat	Top coat fluororesin paint	25

Source: JICA Survey Team

10.8 Operation and Maintenance Organization of the Project

Basically, the maintenance works except for inspections are usually executed by an O/M Operator (Outsourcing) under the supervision of RHD's Planning and Maintenance Wing headed by Additional Chief Engineer (ACE) level. This Wing consists of six circles each headed by an officer of Superintending Engineer (SE) level. Of the six circles, maintenance circle is responsible to supervise routine and periodic maintenance works, whereas HDM circle is responsible to estimate budget for maintenance works based on site survey results and existing condition assessment. The maintenance of bridges under Cross-Border Project will be carried out under the supervision of Planning and Maintenance Wing, RHD. The total proposed staffing for the Wing is 344 persons including supporting staffs. The number of personnels of each division under this wing is expressed by an organogram in Figure 10.8.1.

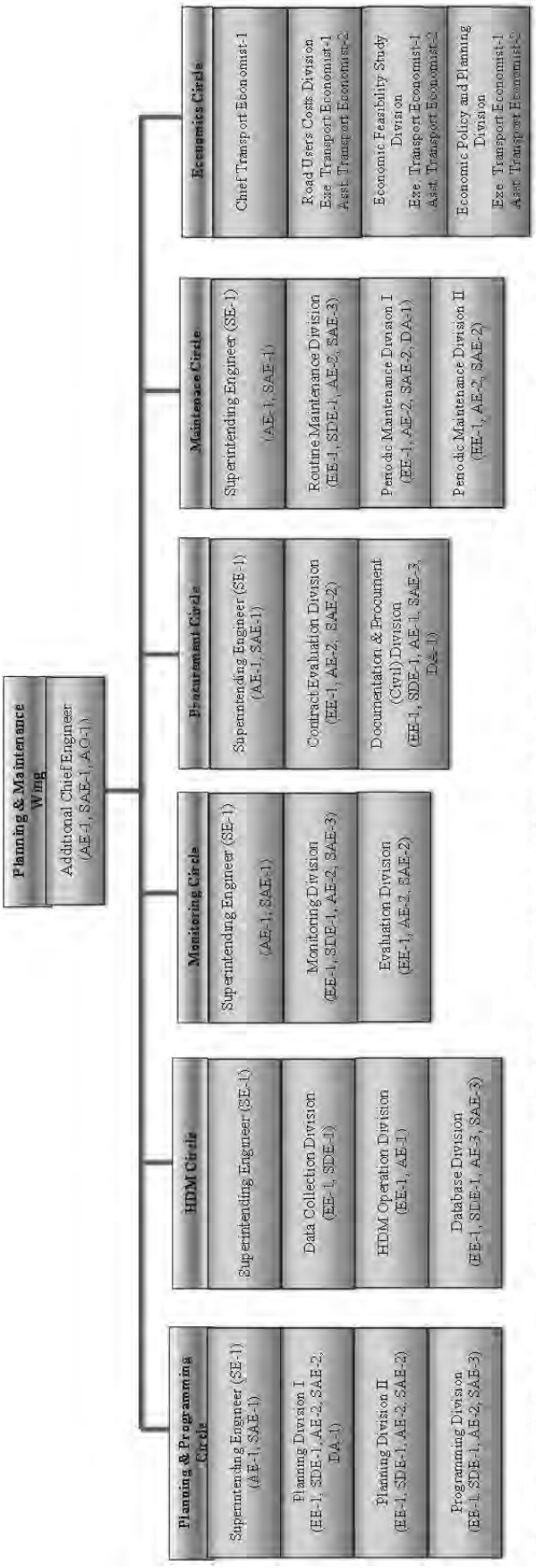


Figure 10.8.1 RHD'S O/M Organization

Note: EE: Executive Engineer, SDE: Sub-divisional Engineer, AE: Assistant Engineer, SAE: Sub-Assistant Engineer, AO: Account Officer, DA: Divisional Accountant, Exe.: Executive, Asst. :Assistant
Source : RHD'S Organization Chart

10.9 Operation and Maintenance Cost of CBRNIP Bridges

Operation and maintenance of PC-I bridges is classified into routine maintenance at every year, periodic maintenance at every 10 years, pavement resurfacing at every 10 years, expansion joint replacement at every 10 years and concrete surface treatment due to carbonation at every 30 years.

In addition, heavy paining at every 30 years and replacement of arch cables at once in life time should necessarily be required for Nielsen Lohse Arch section of Kalna Bridge. Daily operation and inspection of toll booth as well as toll system maintenance at every 10 years should be planned for Kalna toll plaza.

Operation and maintenance costs for the bridges and the approach roads to be constructed under CBRNIP are estimated at around BDT 827 million for first 5 years, BDT 2,882 million for first 10 years and BDT 22,181 million for full life time. Details of O/M cost for full life time are shown in Table 10.9.1. This estimated cost includes the operation and maintenance of patrol car and AWP vehicle which is necessary for Kalna Bridge health monitoring.

It is to be noted that the costs to be incurred for operation and maintenance of seven (7) box culverts are not disclosed in Table 10.9.1. This is because their O/M cost, comprising of routine and periodic maintenance only, should be covered from road O/M cost. It is also assumed that their O/M plan should be undertaken simultaneously when that of entire road sections will be implemented.

Table 10.9.1 Operation and Maintenance Cost of Bridges for Full Life Cycle

Sl. no.	Bridge name	Pavement resurface total@10 years		Routine/Periodic maintenance total@ every year		Concrete Surface Treatment Total @30 Years		Expansion Joint Replacement @ 10 Years		Toll booth operation cost			Steel Surface Painting @30 Years		Replacement of Steel Arch Cable Total @50 Years		Cable Health Monitoring	Patrol Car +AWP O/M	Total O/M Cost (BDT)
		BDT/m2	Total frequency	% of initial cost	Total frequency	Total Frequency	% of Initial Cost	Total Frequency	Total Length (m)	BDT/Year	Total Frequency	Machine Cost 6 Times @10 Years	BDT/m2	Total Frequency	BDT/ Every Time	Total Frequency	Total 12 @ Every 6 Year	Total 74 @ Every Year	
Section A																			
A1	Jhikorgacha Bridge	1,168	6	1.5%	74	2	4%	6	170.4	-			-	-	-	-			1,083,710,580
		94,397,760		839,645,046		49,017,777		100,649,996				-		-		-			
A2	Tularampur Bridge	1,168	6	1.5%	74	2	4%	6	104	-	-	-	-	-	-	-			802,581,678
		133,337,011		581,692,451		26,122,641		61,429,575				-		-		-			
A3	Hawai khali Bridge	1,168	6	1.5%	74	2	4%	6	67.8	-	-	-	-	-	-	-			616,310,608
		110,312,928		452,851,067		13099255.08		40,047,358				-		-		-			
A4	Kalna Bridge	1,168	6	1.5%	74	2	4%	6	328.5	25,000,000	74	307,272,000	4,505	2	85,453,852	1	602,581	2,901,645	12,865,125,789
		842,525,027		6,241,960,937		173,878,113.60		1,457,058,711				3,693,632,000		148,664,439		85,453,852	7,230,968	214,721,742	
A5	Garakola Bridge	1,168	6	1.5%	74	2	4%	6	52	-	-	-	-	-	-	-			837,764,245
		117,847,930		396,717,158		13229621.4		30,714,788				-		-		-			
Section B																			
B2	Telipool Bridge	1,168	6	1.5%	74	2	4%	6	26.80	-	-	-	-	-	-	-			282,168,056
		16,454,784		242,681,152		7,202,190		15,829,929				-		-		-			
B3	Lakshmi Chara Bridge	1,168	6	1.5%	74	2	4%	6	26.80	-	-	-	-	-	-	-			251,796,018
		18,094,656		206,982,823		10,888,610		15,829,929				-		-		-			
B9	Kalapani Bridge-2	1,168	6	1.5%	74	2	4%	6	26.80	-	-	-	-	-	-	-			158,355,768
		18,627,264		117,865,307		6,033,268		15,829,929				-		-		-			
B12	Koilabazar Bridge	1,168	6	1.5%	74	2	4%	6	53.60	-	-	-	-	-	-	-			222,547,052
		18,424,032		163,050,682		9,412,480		31,659,858											
B13	Balutila Bridge	1,168	6	1.5%	74	2	4%	6	26.80	-	-	-	-	-	-	-			197,305,022
		17,695,200		158,302,767		5,477,126		15,829,929				-		-		-			
B16	Heako Bridge	1,168	6	1.5%	74	2	4%	6	40.20	-	-	-	-	-	-	-			182,913,376
		17,765,280		134,025,535		7,377,668		23,744,893											
B18	Chikon Chara Bridge	1,168	6	1.5%	74	2	4%	6	26.80	-	-	-	-	-	-	-			207,063,153
		16,461,792		169,031,090		5,740,342		15,829,929				-		-		-			
B25	East Baganbazar Bridge	1,168	6	1.5%	74	2	4%	6	53.60	-	-	-	-	-	-	-			215,851,352
		20,883,840		154,838,278		8,469,376		31,659,858				-		-		-			
Section C																			
C8	Patiya Bridge	1,168	6	1.5%	74	2	4%	6	90	-	-	-	-	-	-	-			671,958,909
		118,154,880		479,729,767		20,677,785		53,396,477				-		-		-			
C12	Mazar Point Bridge	1,168	6	1.5%	74	2	4%	6	90	-	-	-	-	-	-	-			660,411,049
		117,818,496		470,954,640		18,241,437		53,396,477				-		-		-			
C13	Sangu Bridge	1,168	6	1.5%	74	2	4%	6	166	-	-	-	-	-	-	-			1,379,452,169
		156,257,376		1,067,289,036		57,618,437		98,287,320				-		-		-			
C26	Mathamuhuri Bridge	1,168	6	1.5%	74	2	4%	6	208	-	-	-	-	-	-	-			1,546,101,342
		163,657,824		1,188,801,825		70,782,542		122,859,150				-		-		-			

Source: JICA Survey Team

11. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

11.1 Environmental Impact Assessment (EIA)

11.1.1 Impacts by Project Components

The three sections as requested by GOB, i.e. Section A (between Dhaka and Benapole), Section B (between Ramgarh and Baraiyarhat), Section C (between Chittagong and Cox's Bazar), are quantitatively and qualitatively evaluated, and objective projects are selected. Besides, the objective of project is to carry out in order to improve the network of transport and logistics, the activation of the whole South Asia.

For more information the EIA Main Report prepared separately for Khulna Zone and Chittagong Zone, Addendum No.1 Appendix-I: Project Schedule, Appendix-II: Form of Monitoring, Appendix-III: Environmental Assessment of Bridges, Appendix-IV: Applicable Standards and Appendix-V: Baseline Environmental Monitoring Photographs are made up as separate volume.

Followings are the introduction of three sections.

(1) Section A

The area lies in the midst of the Ganges river floodplain comprising the active floodplain of the Ganges and an adjacent meandering floodplain. Madhumati river, where the proposed Kalna bridge is to be constructed, is integrated as tributaries in the Ganges river system, hence thorough consideration must be given to the meandering behavior of the Madhumati river.

The candidate bridges which will connect between Dhaka and Benapole consist of Asian Highway 1. There are five candidate bridges, namely Jhikorgacha, Tularampur, Hawai khali, Kalna and Garakola. Kalna will be new bridge which has a length of 4.77km including the access road. Other four bridges are existing; however, they are old and narrow with length from 26.1m to 118.7m. Jhikorgacha is locating at the congested area among of all.

(2) Section B

Hilly terrains are dominant in the area which is situated in the northern end of Chittagong Hills tracts and bounded by Feni River on the northern border with India. Several small tributaries of Feni river flow through relatively flat flood plains and valleys lie between hill lines which mainly run in the south to north direction. In the valleys there remain traces of scouring due to flash floods. Any structure in the rivers must be designed with full consideration of scouring.

This route is to connect Asian Highway 41 from Baraiyarhat to Ramgarh. The numbers of candidate bridges are twenty five (25). All of the existing bridges have short length from 12.4m to 36.8m and seven (7) of them will be improved as box culvert. Heako Bridge which locates almost middle of the route is crowded with people and 60 PAPs might be displaced.

(3) Section C

The area lies west of Chittagong Hills between Chittagong in the north and Cox's Bazar in the south. Chittagong coastal plain extends from Chittagong to the mouth of the Matamuhuri delta. It comprises gently sloping piedmont plains. From the Matamuhuri delta to Cox's Bazar narrow flood plains extend adjoining the coastal beaches and dunes.

There are four target bridges on Asian Highway 41 from Chittagong to Cox's Bazar. Two of them are short with length of 51m and remaining are 211m and 294.2m.

The outline of three Sections is illustrated in Figure 11.1.1, and the outlines of Components which might cause the impacts are presented in Table 11.1.1.

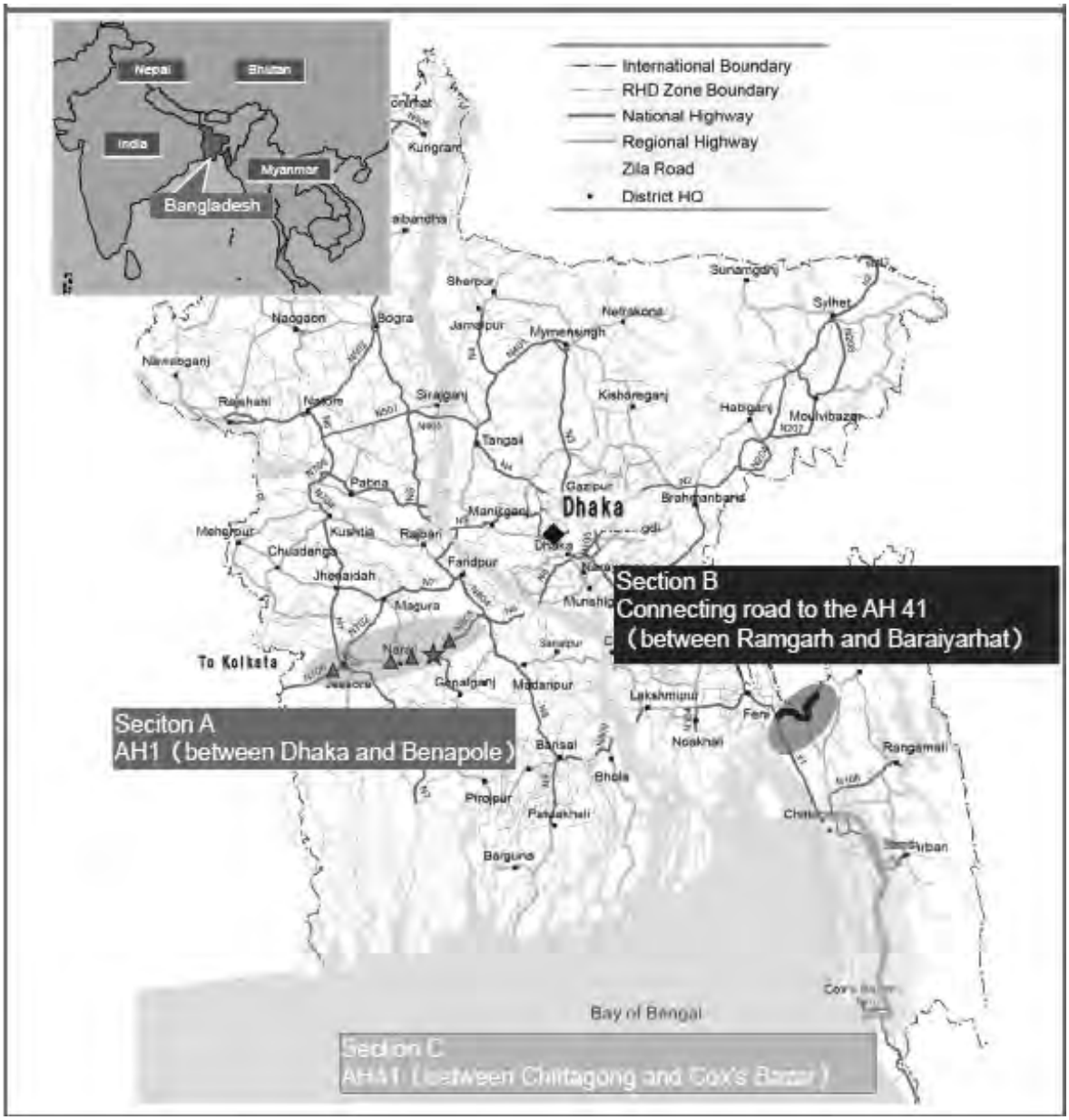


Figure 11.1.1 Physiography of Three Sections

Table 11.1.1 Outline of the Project Components

No.	Structure Name	Bridge Length (m)	Bridge Type	Approach Road Length (m)		
				A1 Side	A2 Side	Total
A1	Jhikorgacha Bridge	125	PC-I Girder	205.0	205.0	410.0
A2	Tularampur Bridge	100	PC-I Girder	325.0	411.8	736.8
A3	Hawai khali Bridge	35	PC-I Girder	325.0	330.0	655.0
A4	Kalna Bridge	540	PC-I Girder	325.0	3,897.5	4,222.5
		150	Nielsen Lohse			
A5	Garakola Bridge	110	PC-I Girder	315.0	366.4	681.4
B2	Telipool Bridge	25	PC-I Girder	141.7	144.2	285.9
B3	Lakshmi chara Bridge	40	PC-I Girder	91.8	120.0	211.8
B9	Kalapani Bridge-2	35	PC-I Girder	90.4	103.4	193.8
B12	Koilabazar Bridge	55	PC-I Girder	89.4	118.6	208.0
B13	Balutila Bridge	30	PC-I Girder	94.9	93.0	187.9
B16	Heako Bridge	25	PC-I Girder	102.2	82.2	184.3
B18	Chikon Chara Bridge	30	PC-I Girder	85.4	137.4	222.9
B25	East baganbazar Bridge	50	PC-I Girder	129.0	107.9	236.8
C8	Patiya Bridge	55	PC-I Girder	354.0	325.0	679.0
C12	Mazar Point Bridge	60	PC-I Girder	325.0	352.4	677.4
C13	Sangu Bridge	215	PC-I Girder	434.3	341.3	775.7
C26	Mathamuhuri Bridge	310	PC-I Girder	300.0	410.1	710.1

Note: In addition to listed bridges above, another seven (7) existing bridges (Bridge ID: B14, 15, 19, 20, 22, 23, and 24) are appraised to be improved because their damage level is categorized as C and D. However, according to the results obtained from hydraulic analysis, they can be replaced by box culvert. Thus, they are targeted to include under Project scopes.

Source: JICA Study Team.

11.1.2 Present Natural and Social Conditions

(1) Section A

1) Temperature

The monthly average minimum and maximum temperatures recorded at the Dhaka weather station are presented below in Table 11.1.2 and Table 11.1.3, respectively. The lowest average temperature recorded in the past 10 years was in January 2003 (11.7°C). The highest average temperature reached 35.1°C in May 2004. Throughout the year the highest temperatures are generally in March through October, and the lowest temperatures are from December to February.

Table 11.1.2 Average Monthly Minimum Temperature (°C), Dhaka Weather Station

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	11.7	16.9	19.4	24.1	24.4	25.8	26.4	26.6	24.9	25.0	19.4	16.4
2004	14.0	16.0	22.4	23.9	26.3	25.0	25.4	26.5	25.5	23.3	18.6	16.2
2005	14.2	18.3	22.4	24.1	24.2	26.8	25.8	26.7	26.0	24.4	19.8	15.7
2006	13.5	19.4	21.9	23.8	25.0	26.1	26.7	26.5	25.8	24.7	19.9	15.8
2007	12.5	16.8	19.6	23.7	25.9	25.5	25.8	26.4	26.5	23.8	19.9	15.0
2008	14.5	15.2	22.0	24.5	24.9	26.3	26.3	26.5	26.2	23.8	19.0	16.9
2009	14.8	17.3	21.4	25.9	25.2	26.7	26.7	26.3	26.3	24.2	20.2	15.4
2010	12.8	16.2	23.3	26.4	25.9	26.7	27.4	27.1	26.6	25.1	20.9	15.5
2011	15.3	17.0	21.5	23.2	24.6	26.3	26.7	26.5	26.4	24.7	19.2	15.0
2012	14.5	16.0	22.1	23.7	25.8	26.9	26.7	26.6	26.8	24.3	19.2	14.5
Average	13.7	16.9	21.6	24.3	25.2	26.2	26.3	26.5	26.1	24.3	19.6	15.6

Source: Bangladesh Meteorological Department, Dhaka.

Table 11.1.3 Average Monthly Maximum Temperature (°C), Dhaka Weather Station

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	21.8	28.0	30.0	34.0	34.0	31.4	32.4	32.5	31.7	31.2	29.8	25.9
2004	23.5	28.3	32.8	32.6	35.1	32.2	31.5	32.3	30.4	31.0	29.5	27.0
2005	24.5	29.1	32.2	34.4	33.2	33.4	31.5	32.1	32.8	30.6	29.1	27.1
2006	25.3	31.3	33.2	33.7	33.8	32.4	32.4	32.5	31.9	32.3	29.7	26.9
2007	24.6	27.1	31.5	33.7	34.8	32.5	31.5	32.5	32.1	31.5	29.1	25.8
2008	24.5	26.1	31.7	34.5	34.7	32.4	31.8	32.1	32.6	31.4	29.7	25.6
2009	25.9	29.7	33.3	35.6	34.6	34.5	32.3	32.5	32.5	32.2	30.2	26.0
2010	23.8	28.9	34.1	35.5	34.3	33.1	33.0	33.1	32.5	32.4	30.1	26.1
2011	23.4	28.7	32.1	33.6	32.4	32.6	32.3	31.1	32.4	32.7	29.7	25.0
2012	24.0	28.5	33.0	33.5	34.6	33.2	32.5	32.5	32.9	32.3	28.7	24.0
Average	24.1	28.5	32.3	34.1	34.1	32.7	32.1	32.3	32.1	31.7	29.5	25.9

Source: Bangladesh Meteorological Department, Dhaka.

2) Topography and Geology

The area lies in the midst of the Ganges river floodplain comprising the active floodplain of the Ganges and an adjacent meandering floodplain. Madhumati river, where the proposed Kalna bridge is to be constructed, is integrated as tributaries in the Ganges river system, hence thorough consideration must be given to the meandering behavior of the Madhumati river. The Ganges alluvium is calcareous in nature and soil of the area is mainly silt or silty clay loam.

The location selected for the investigation was in Kalna. In the Madhumati river, silty sand and clayey sand is widely deposited on the banks and on the river bed. Three borings were conducted, two in the banks and one in the center of the river. The boring in the river was performed using a floating platform on a catamaran boat moored by anchors in the river. The pile bearing strata exists about 55 m below GL (Ground Level) on the banks.

3) Water Resources

Kalna bridge site is part of the Madhumati river system, which ultimately connected to other surrounding main rivers such as Bhairab, Rupsa, Kaliganga etc. and leaded to Padma river system. Madumati river system is connected by large number of tributes which are flowing water from the surrounding water system and is also connected with small canals. The main sources of water flows in these rivers are rainfall during in the wet season. Both stream velocity and water levels remain high in the wet season, which drops down significantly in the dry season.

Beside rivers and canals, the other surface water sources are ponds and few natural depressions in and the project area similarly to other parts of the country. This area also receives sufficient amount of rainfall. There are some low agricultural lands which are seasonally flooded and use as fish culture. .

4) Land Resources

The greater part of this region has smooth relief. River banks generally stand about a meter or less above the level of adjoining basins. The region is characterized by a close network of interconnected tidal rivers and creeks. There is a general pattern of grey, slightly calcareous loamy soils on river banks and grey or dark grey, non-calcareous, heavy silty clays in the basin. Organic matter content is medium (1.7-3.4%). Extremely acid soil (acid sulfate soils) occur patchily in basin. Major cropping pattern in this region is Boro –Fallow-Fallow, Fallow-Shrimp –T.aman, Fallow-T.aus-T.aman and Natural mangrove forest.

5) Land Use

The major land type of the Ratail union is medium highland (802 ha) followed by medium low land (377 ha), high land (314 ha) and low land (79 ha), which indicates that the area is suitable for T. aman paddy cultivation. The low land areas are inundated for 4-5 months continuously at various depths up to 180 cm in the monsoon season.

The major land types of the Lohagara union are medium high land followed by high land. The medium low land is inundated by flood for 3-5 months continuously at various depths up to 180 cm. Land Type of the Section A area is given in Table 11.1.4.

Table 11.1.4 Land Type of the Section A Area

Upazila	Union	Area (Ha)	Land Type (%)
Kashiani	Ratail	2,476	HL-20, MHL-51, MLL-24, LL-4
Lohagara	Lohagara	570	HL-16, MHL-53, MLL-28, LL-3

Note: HL= Highland, MHL= Medium Highland, LL= Lowland, MLL= Medium Lowland
Source: www.landzoning.gov.bd (accessed in August 2015)

6) Demography

In accordance to the Census of Bangladesh (2011), Table 11.1.5 provides a snapshot of the key demographic indicators of the key unions within the project study area.

Table 11.1.5 Demography of the Project Area

Section	Upazila	Union	Total population	Total HHs	Average HH size	Literacy (%)
Section A	Kashiani	Ratail	20,029	4,481	4.4	60.8
	Lohagara	Lohagara	7,571	1,780	4.1	65.7

Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

7) Religion Profile

In the project area, the population primarily consists of Muslims with majority of the same from the Sunni sect. The following Table 11.1.6 indicates the various religious profile of the project study area.

Table 11.1.6 Religion Profile of Project Area

Section	Upazila	Union	Total Pop.	Muslim		Hindu		Christian		Buddhist		Others	
				Pop.	%	Pop.	%	Pop.	%	Pop.	%	Pop.	%
Section A	Kashiani	Ratail	20,029	18,276	91.2	1,713	8.6	40	0.2	0	0.0	0	0.0
	Lohagara	Lohagara	7,571	6,624	87.5	946	15.9	1	0.0	0	0.0	0	0.0

Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

8) Type of Structure and Tenancy

Table 11.1.7 and Table 11.1.8 show the type of housing structure and tenancy in the project area.

Table 11.1.7 Type of Structure in the Project Area

Section	Upazila	Union	Number of Households	Type of Structure (%)			
				Pucka	Semi-pucka	Kutcha	Jhupri
Section A	Kashiani	Ratail	4,481	3.0	15.5	80.7	0.8
	Lohagara	Lohagara	1,780	2.1	20.7	72.9	4.3

Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

Table 11.1.8 Housing Tenancy in the Project Area

Section	Upazila	Union	Number of Households	Housing Tenancy (%)		
				Owned	Rented	Rent free
Section A	Kashiani	Ratail	4,481	96.9	0.5	2.5
	Lohagara	Lohagara	1,780	97.7	0.4	1.9

Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

9) Drinking Water Facility

The following Table 11.1.9 indicates the source of drinking water facility of the project study area.

Table 11.1.9 Sources of Drinking Water and Electricity Facility of the Project Area

Section	Upazila	Union	Total Households	Source of Drinking Water (%)			Electricity Connection (%)
				Tap	Tube-well	Other	
Section A	Kashiani	Ratail	4,481	0.2	98.5	1.3	49.5
	Lohagara	Lohagara	1,780	0.0	99.7	0.3	40.7

Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

(2) Section B

1) Temperature

The monthly average minimum and maximum temperatures recorded at the Shitakunda weather station are presented below in Table 11.1.10 and Table 11.1.11, respectively. The lowest average temperature recorded in the past 10 years was in January 2011 (10.1°C). The highest average temperature reached 35.2°C in May 2012. Throughout the year the highest temperatures are generally in March through October, and the lowest temperatures are from December to February.

Table 11.1.10 Average Monthly Minimum Temperature (°C), Shitakunda Weather Station

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	10.9	15.2	17.8	23.9	25.1	25.0	25.8	25.6	25.3	24.5	17.2	14.3
2004	12.9	14.1	21.0	23.3	25.3	25.1	25.4	25.5	24.9	23.0	16.9	14.3
2005	12.3	16.7	21.5	23.6	24.2	26.5	25.5	25.3	25.2	24.3	17.7	14.8
2006	11.8	17.2	19.4	23.9	24.5	25.7	25.8	25.6	25.0	24.2	18.8	13.5
2007	10.9	15.7	17.2	23.0	25.2	25.2	25.3	25.4	25.4	23.3	20.0	13.7
2008	12.4	13.1	20.3	22.6	24.6	25.5	25.1	25.3	25.1	23.4	17.4	14.9
2009	12.2	12.4	0.0	0.0	0.0	0.0	0.0	25.2	25.3	22.6	18.7	12.7
2010	10.8	13.8	21.5	25.7	25.0	25.4	25.9	25.6	25.4	24.4	19.6	13.6
2011	10.1	14.2	19.7	21.8	23.6	26.0	26.3	26.2	26.1	24.0	17.5	13.5
2012	12.2	13.2	19.0	22.8	24.7	26.2	0.0	0.0	0.0	0.0	0.0	0.0
Average	11.7	14.6	17.7	21.0	22.2	23.1	20.5	23.0	22.8	21.4	16.4	12.5

Source: Bangladesh Meteorological Department, Dhaka

Table 11.1.11 Average Monthly Maximum Temperature (°C), Shitakunda Weather Station

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	25.9	30.4	31.1	33.0	33.0	30.1	32.0	32.0	32.3	32.9	30.9	28.1
2004	26.3	29.3	31.7	31.4	33.9	31.8	30.8	31.6	31.3	31.8	30.5	29.1
2005	27.2	30.2	30.8	33.3	33.0	33.1	31.6	31.3	33.1	33.4	31.1	29.2
2006	28.1	30.6	34.0	33.6	33.3	32.7	31.4	32.6	32.6	33.1	31.0	28.4
2007	26.7	28.3	32.3	32.3	33.5	31.9	30.6	32.3	31.9	32.4	30.9	27.9
2008	27.1	27.6	31.6	34.2	33.8	31.7	30.6	31.4	32.7	32.5	31.2	28.1
2009	28.2	30.9	33.5	33.6	33.7	33.1	31.0	31.8	32.6	32.9	31.4	28.4
2010	27.7	30.6	33.2	33.5	33.3	31.8	32.4	32.7	32.5	33.5	31.8	28.6
2011	22.7	28.3	31.7	33.6	33.4	33.2	32.8	31.5	33.0	33.2	29.4	24.0
2012	23.8	28.2	33.1	33.8	35.2	33.4	0.0	0.0	0.0	0.0	0.0	0.0
Average	26.4	29.0	32.3	33.2	33.6	32.3	28.3	28.7	29.2	29.6	27.8	25.2

Source: Bangladesh Meteorological Department, Dhaka

2) Topography and Geology

Hilly terrains are dominant in the area which is situated in the northern end of Chittagong Hills tracts and bounded by Feni River on the northern border with India. Several small tributaries of Feni River flow through relatively flat floodplains and valleys lie between hill lines which mainly run in the south to north direction. In the valleys there remain traces of scouring due to flash floods. Any structure in the rivers must be designed with full consideration of scouring. The soil is brown sandy to clayey loam and deposited on shale or sandstone bedrock in the hilly area.

The soil conditions vary between hilly areas and flood land. Silty sand is dominant in the hilly areas and clayey silt is dominant in the flood land areas. Soil borings were conducted at 27 locations (26 bridges and 1 hilly area). Pile bearing strata exits at an average 30 m below GL, but it was 50m below GL in the flat land near Barayarhat.

3) Water Resources

The project site of this area has situated twenty six bridges which are commonly connected with three upazila (Mirshari, Fotikchari, Ramgarh). Different types of chara, khal are found in this area such as Hinguli Chara, Sufola khal, Lakshmic chara, Hill thali, Bhabani khal, Vanga tower khal, Kalapani khal, Koila khal, Fotikchari khal, Fulchari khal, Johorful khal, Nangapul chara, Chikon chara, Bangle bazaar khal, Borobil khal, Noloachara khal, Rupi chara, Sonai khal. The main sources of water of these khal and chara are rain water which comes from the hill during the monsoon season. Hinguli Chara, Sonai khal, Rupai chara khal are connected with Feni River which ultimately connected to Bay of Bengal whereas other chara only get water during rainy season and last point of these chara in the valley.

4) Land Resources

Relief is complex. Hills have been dissected to different degrees over different rocks. In general slopes are very steep (more than 45%), but more rolling relief occurs locally and a few low hills have flat summits. Major hill soils are yellow brown to strong brown, permeable, friable loamy, very strongly acidic and low in moisture holding capacity. Top soils contain 2-5% organic matter under forest, they generally have <2% in soils used regularly for shifting (Jhum) cultivation. Major cropping pattern in this region is mixed evergreen and deciduous forest, Thicket and grasses, Boro-Fallow-T.aman, Rubber and Tea.

5) Land Use

The land types of Hinguli union are medium high land (70%) followed by high land (15%), medium low land (10%) and low land (05%). The highlands are not inundated by monsoon flooding but the other lands are inundated for 2-3 months in the monsoon up to maximum 120 cm depending on land types.

Accept hilly areas, the agricultural land types of Karerhat union are medium high land (55%) followed by high land (30%) and medium low land (5%). The highlands are not inundated by monsoon flooding but the other lands are inundated for 2-3 months in the monsoon up to maximum 90 cm depending on land types.

The land types of the Karerhat union are medium high land (40%) followed by highland (30%), medium low land (30%) and low land (05%). The highlands are not inundated by monsoon flooding but the other lands are inundated for 2-3 months in the monsoon up to maximum 120 cm depending on land types.

The land types of the Dantmara union are medium high land (85%) followed by high land (10%) and medium low land (05%). The highlands are not inundated by monsoon flooding but the other lands are inundated for 2-3 months in the monsoon up to maximum 90cm depending on land types. Land Type of the Section B area is given in Table 11.1.12.

Table 11.1.12 Land Type of the Section B Area

Upazila	Union	Area (Ha)	Land Type (%)
Mirsharai	Hinguli	1,847	HL-15, MHL-70, MLL-10, LL-5
	Karerhat	14,812	HL- 30, MHL-55, MLL-15
Fatikchhari	Bagan Bazar	19,129	HL-30, MHL-40, MLL-25, LL-5
	Dantmara	5,006	HL-10, MHL-85, MLL-5

Note: HL= Highland, MHL= Medium Highland, LL= Lowland, MLL= Medium Lowland
Source: www.landzoning.gov.bd (accessed in August 2015)

6) Demography

In accordance to the Census of Bangladesh (2011), Table 11.1.13 provides a snapshot of the key demographic indicators of the key unions within the project study area.

Table 11.1.13 Demography of the Project Area

Section	Upazila	Union	Total population	Total HHs	Average HH size	Literacy (%)
Section B	Mirsharai	Hinguli	29,133	5,889	4.9	52.7
		Karerhat	35,467	7,362	4.8	46.8
	Fatikchhari	Bagan bazar	40,496	8,291	4.9	45.6
		Dantmara	47,526	9,436	5.0	42.9
	Ramgarh	Ramgarh	12,961	2,598	5.0	36.0

Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

7) Religion Profile

In the project area, the population primarily consists of Muslims with majority of the same from the Sunni sect. The following Table 11.1.14 indicates the various religious profile of the project study area.

Table 11.1.14 Religion Profile of Project Area

Section	Upazila	Union	Total Pop.	Muslim		Hindu		Christian		Buddhist		Others	
				Pop.	%	Pop.	%	Pop.	%	Pop.	%	Pop.	%
Section B	Mirsharai	Hinguli	29,133	25,848	88.7	3,277	11.2	0	0.0	8	0.0	0	0.0
		Korerhat	35,467	31,116	87.7	3,516	9.9	16	0.0	1	0.0	818	2.3
	Fatikchhari	Baganbazar	40,496	36,786	90.8	3,196	7.9	1	0.0	16	0.0	497	1.2
		Dantmara	47,526	44,838	94.3	2,501	5.3	1	0.0	61	0.1	125	0.3
	Ramgarh	Ramgarh	12,961	8,589	66.3	1,719	13.3	0	0.0	2,538	19.6	115	0.9

Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

8) Type of Structure and Tenancy

Table 11.1.15 and Table 11.1.16 show the type of housing structure and tenancy in the project area.

Table 11.1.15 Type of Structure in the Project Area

Section	Upazila	Union	Number of Households	Type of Structure (%)			
				Pucka	Semi-pucka	Kutcha	Jhupri
Section B	Mirsharai	Hinguli	5,889	9.3	10.6	79.7	0.3
		Karerhat	7,362	7.0	5.2	86.6	1.2
	Fatikchhari	Baganbazar	8,291	1.4	3.3	92.6	2.7
		Dantmara	9,436	3.1	8.4	82.7	5.8
	Ramgarh	Ramgarh Paurashava	2,598	0.3	1.3	93.0	5.4

Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

Table 11.1.16 Housing Tenancy in the Project Area

Section	Upazila	Union	Number of Households	Housing Tenancy (%)		
				Owned	Rented	Rent free
Section B	Mirsharai	Hinguli	5,889	92.0	6.2	1.8
		Karerhat	7,362	95.4	2.3	2.4
	Fatikchhari	Baganbazar	8,291	90.9	0.9	8.2
		Dantmara	9,436	93.5	2.3	4.2
	Ramgarh	Ramgarh paurashava	2,598	89.2	0.3	10.4

Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

9) Drinking Water Facility

The following Table 11.1.17 indicates the source of drinking water facility of the project study area.

Table 11.1.17 Sources of Drinking Water and Electricity Facility of the Project Area

Section	Upazila	Union	Total Households	Source of Drinking Water (%)			Electricity Connection (%)
				Tap	Tube-well	Other	
Section B	Mirsharai	Hinguli	5,889	1.1	93.9	5.1	67.4
		Korerhat	7,362	0.6	94.4	5.0	48.3
	Fatikchhari	Baganbazar	8,291	1.9	80.5	17.6	32.3
		Dantmara	9,436	3.1	69.4	27.5	31.9
	Ramgarh	Ramgarh Paurashava	2,598	2.6	88.4	9.0	40.2

Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

(3) Section C

1) Temperature

The monthly average minimum and maximum temperatures recorded at the Chittagong weather station are presented below in Table 11.1.18 and Table 11.1.19, respectively. The lowest average temperature recorded in the past 10 years was in January 2011 (13.3°C). The highest average temperature reached 33.7°C in March 2006. Throughout the year the highest temperatures are generally in March through October and the lowest temperatures are from December to February.

Table 11.1.18 Average Monthly Minimum Temperature (°C), Chittagong Weather Station

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	13.6	17.4	19.7	24.5	25.6	25.0	25.8	25.8	25.5	24.8	18.7	16.3
2004	14.9	16.3	22.0	23.9	25.9	25.5	25.4	25.6	25.2	23.7	18.4	16.3
2005	14.5	18.4	22.2	24.5	24.7	26.9	25.6	25.5	25.5	24.7	19.5	17.1
2006	14.6	19.1	21.8	24.7	24.6	25.9	25.7	25.6	25.4	24.6	20.6	15.8
2007	13.5	17.1	19.6	23.6	25.7	25.6	25.3	25.4	25.4	23.3	21.2	15.9
2008	15.0	15.2	21.6	23.8	24.4	25.2	25.1	25.3	25.5	24.1	19.5	17.3
2009	14.9	16.9	21.6	25.3	25.0	25.6	25.5	25.7	25.4	24.1	21.1	15.9
2010	14.0	16.4	22.5	26.0	25.7	25.6	26.0	25.6	25.5	24.9	21.3	16.2
2011	13.3	16.8	20.2	23.9	24.7	25.5	25.5	25.1	25.1	24.4	19.2	16.1
2012	15.4	16.4	21.9	23.8	25.4	25.5	25.5	25.7	25.8	24.2	20.6	14.5
Average	14.4	17.0	21.3	24.4	25.2	25.6	25.5	25.5	25.4	24.3	20.0	16.1

Source: Bangladesh Meteorological Department, Dhaka

Table 11.1.19 Average Monthly Maximum Temperature (°C), Chittagong Weather Station

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	25.8	30.7	31.1	32.8	32.8	29.9	32.2	32.0	32.0	33.0	31.2	28.4
2004	26.2	29.4	31.4	31.5	33.6	31.8	30.5	31.8	31.2	32.0	30.9	29.0
2005	27.4	30.6	30.9	33.4	33.5	32.8	31.4	30.6	32.6	33.0	30.6	29.1
2006	28.2	30.7	33.7	33.5	32.8	32.5	31.4	32.5	32.3	32.7	31.1	28.3
2007	26.8	28.7	32.3	32.3	33.1	32.0	30.6	32.0	31.5	32.2	31.0	28.4
2008	24.9	26.0	29.9	32.0	32.2	30.9	29.8	30.2	30.9	30.7	29.7	26.7
2009	26.6	29.0	31.7	32.0	32.5	32.0	30.2	30.6	31.5	31.2	29.9	26.2
2010	25.0	28.9	31.3	31.9	32.0	31.2	31.6	31.7	31.8	31.8	29.9	26.3
2011	25.0	28.8	30.5	31.2	31.5	30.6	31.2	30.4	30.7	31.2	28.8	25.1
2012	25.4	29.6	30.3	31.3	32.3	31.1	30.1	31.1	31.2	31.2	28.8	24.7
Average	26.1	29.2	31.3	32.2	32.6	31.5	30.9	31.3	31.6	31.9	30.2	27.2

Source: Bangladesh Meteorological Department, Dhaka

2) Topography and Geology

The area lies west of Chittagong Hills between Chittagong in the north and Cox's Bazar in the south. Chittagong coastal plain extends from Chittagong to the mouth of the Matamuhuri delta. It comprises gently sloping piedmont plains. From the Matamuhri delta to Cox's Bazar narrow floodplains extend adjoining the coastal beaches and dunes. The typical soil is silty sand or clayey sand and is shallow over the shale bedrock in some places.

4 bridges were selected; they include 2 relatively short bridges and 2 long bridges. Borings were conducted, 1 for each short bridge and 2 for each long one. At all the boring sites, silty/clayey sand is thickly deposited. Pile bearing strata exists at 30 to 55m below GL. At the long bridge sites, shale bedrock is encountered at 38 m below GL which is common to Chittagong area.

3) Water Resources

The section C has four bridges which are located over the Chankhali khal, Pouromati, Sangu and Mataamuhuri River. Surface water system of the project site is given below:

Chankhali khal

Chankhali khal is located Patiya paurashsva of Chittagong district. The main source of water flows in this khal is tidal water as result water of this khal is saline. Other source of water flows in this khal is rainfall during in the wet season. Both stream velocity and water levels remain high in the wet season, which drops down significantly in the dry season.

Pouromati khal

Pouromoti khal is located chandaish upazila in the Chittagong district. This khal get water during the monsoon season which drops down significantly in the dry season.

Sangu River

The Sangu River is a river in Myanmar and Bangladesh. Its source is in the North Arakan Hills of Myanmar, located at 21°13′N 92°37′E. The Arakan Hills form the boundary between Arakan and the Chittagong Hill Tracts. The length of Sangu River is 270 kilometers where has happened joar-vata. The Sangu drains off the waters of Patiya, Satkania, and Banshkhali Upazilas. It has a connection with the Karnafuli River through the Chand Khali River. The Sangu is a shallow river, but it becomes violent during rains and develops rapid currents. It is navigable up to 48.27 kilometres (29.99 mi) from the estuary.

Matamuhuri

This is a flashy river that originates in the Moyvar hills of Alikadam (Bandarban). It flows northwest through Alikadam and Lama upazilas of Bandarban and Chakaria of Cox's Bazar. The river discharges into Maheshkhali channel near Saflapur (Chakaria, Cox's Bazar). The length of the river is 148 km. Yanchha khal and Bamu khal are its important tributaries.

4) Land Resources

The region includes 6 physiographic unit namely piedmont plains, river floodplain, old tidal floodplain, Young tidal floodplain, Mangrove tidal floodplain and old beach ridges. Soils conditions are relatively uniform over most of the area, with grey, near neutral, silt loams and silty clay loams predominating. Acid sulphate soils occur on mangrove tidal floodplain. Organic matter status is low. Major cropping pattern in this region is Fallow-T.aus-T.aman, Fallow-B.aus-T.aman, Boro-Fallow-T.aman.

5) Land Use

The land types of the Patiya Paurashava are medium highland (60%) followed by medium low land (30%), low land (5%) and highland (25%). The highlands are not inundated by monsoon flooding but the other lands are inundated for 2-3 months in the monsoon up to maximum 120 cm depending on land types.

The agricultural land types of the Hashimpur union are medium low land (50%) followed by medium high land (30%) and highland (20%). The highlands are not inundated by monsoon flooding but the other lands are inundated for 2-3 months in the monsoon up to maximum 120 cm depending on land types.

The agricultural land types of the Dohazari union are medium low land (35%) followed by high land (30%), medium highland (20%) and low land (15%). The highlands are not inundated by monsoon flooding but the other lands are inundated for 3-4 months in the monsoon up to maximum 120 cm depending on land types.

The major land type of the Lakshyar Char union is medium highland (70%) followed by high land which indicates that the area is free from deep monsoon flooding and is suitable for T. aman cultivation in kharif-II season when both water and soils become salinity free. The high land is not inundated by monsoon flooding but if there is heavy rain fall the medium high land areas are inundates for 1-2 months at various depths not exceeding 90 cm.

Land Type of the Section C area is given in Table 11.1.20.

Table 11.1.20 Land Type of the Section C Area

Upazila	Union	Area (Ha)	Land Type (%)
Patyia	Patyia Paurashava	996	HL-05, MHL-60, MLL-30, LL-5
Chandanaish	Hashimpur	2,787	HL-20, MHL-30, MLL-50
	Dohazari	3,281	HL-20, MHL-30, MLL-50
Chakaria	Lakshyar Char	468	HL-34, MHL-43, MLL-23

Note: HL= Highland, MHL= Medium Highland, LL= Lowland, MLL= Medium Lowland
Source: www.landzoning.gov.bd (accessed in August 2015)

6) Demography

In accordance to the Census of Bangladesh (2011), Table 11.1.21 provides a snapshot of the key demographic indicators of the key unions within the project study area.

Table 11.1.21 Demography of the Project Area

Section	Upazila	Union	Total population	Total HHs	Average HH size	Literacy (%)
Section C	Patiya	Patiya Paurashava	55,323	10,613	5.4	64.4
	Chandanaish	Hashimpur	21,941	4,139	5.2	46.9
		Dohazari	40,147	7,601	5.3	49.3
	Chakaria	Kakhara	22,829	4,177	5.5	45.8

Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

7) Religion Profile

In the project area, the population primarily consists of Muslims with majority of the same from the Sunni sect. The following Table 11.1.22 indicates the various religious profile of the project study area.

Table 11.1.22 Religion Profile of Project Area

Section	Upazila	Union	Total Pop.	Muslim		Hindu		Christian		Buddhist		Others	
				Pop.	%	Pop.	%	Pop.	%	Pop.	%	Pop.	%
Section C	Patiya	Patiya Paurashava	55,323	5,642	98.5	85	1.5	0	0.0	0	0.0	0	0.0
	Chandanaish	Hashimpur	21,941	19,027	86.7	2,465	11.2	4	0.0	445	2.0	0	0.0
		Dohazari	40,147	33,445	83.3	6,192	15.4	1	0.0	508	1.3	1	0.0
	Chakaria	Kakhara	22,829	20,981	91.9	1,847	8.1	0	0.0	1	0.0	0	0.0

Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

8) Type of Structure and Tenancy

Table 11.1.23 and Table 11.1.24 show the type of housing structure and tenancy in the project area.

Table 11.1.23 Type of Structure in the Project Area

Section	Upazila	Union	Number of Households	Type of Structure (%)			
				Pucka	Semi-pucka	Kutcha	Jhupri
Section C	Patiya	Patiya paurashava	10,613	13.4	18.2	0.5	0.5
	Chandanaish	Hashimpur	4,139	1.4	3.3	92.6	2.7
		Dohazari	7,601	1.3	2.1	94.0	2.7
	Chakaria	Kakhara	4,177	4.1	14.1	5.7	15.7

Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

Table 11.1.24 Housing Tenancy in the Project Area

Section	Upazila	Union	Number of Households	Housing Tenancy (%)		
				Owned	Rented	Rent free
Section C	Patiya	Patiya paurashava	10,613	82.2	16.2	1.6
	Chandanaish	Hashimpur	4,139	94.1	5.3	0.6
		Dohazari	7,601	78.5	17.8	3.7
	Chakaria	Kakhara	4,177	97.7	1.0	1.2

Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

9) Drinking Water Facility

The following Table 11.1.25 indicates the source of drinking water facility of the project study area.

Table 11.1.25 Sources of Drinking Water and Electricity Facility of the Project Area

Section	Upazila	Union	Total Households	Source of Drinking Water (%)			Electricity Connection (%)
				Tap	Tube-well	Other	
Section C	Patiya	Patiya Paurashava	10,613	29.5	49.3	20.4	85.3
	Chandanaish	Hashimpur	4,139	0.4	94.2	5.4	72.5
		Dohazari	7,601	0.9	94.0	5.1	74.3
	Chakaria	Kakhara	4,177	0.3	93.4	6.3	45.9

Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

11.1.3 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 were enacted in 1997 to evaluate and review the Environmental Impact Assessments (EIA) of various projects and activities.

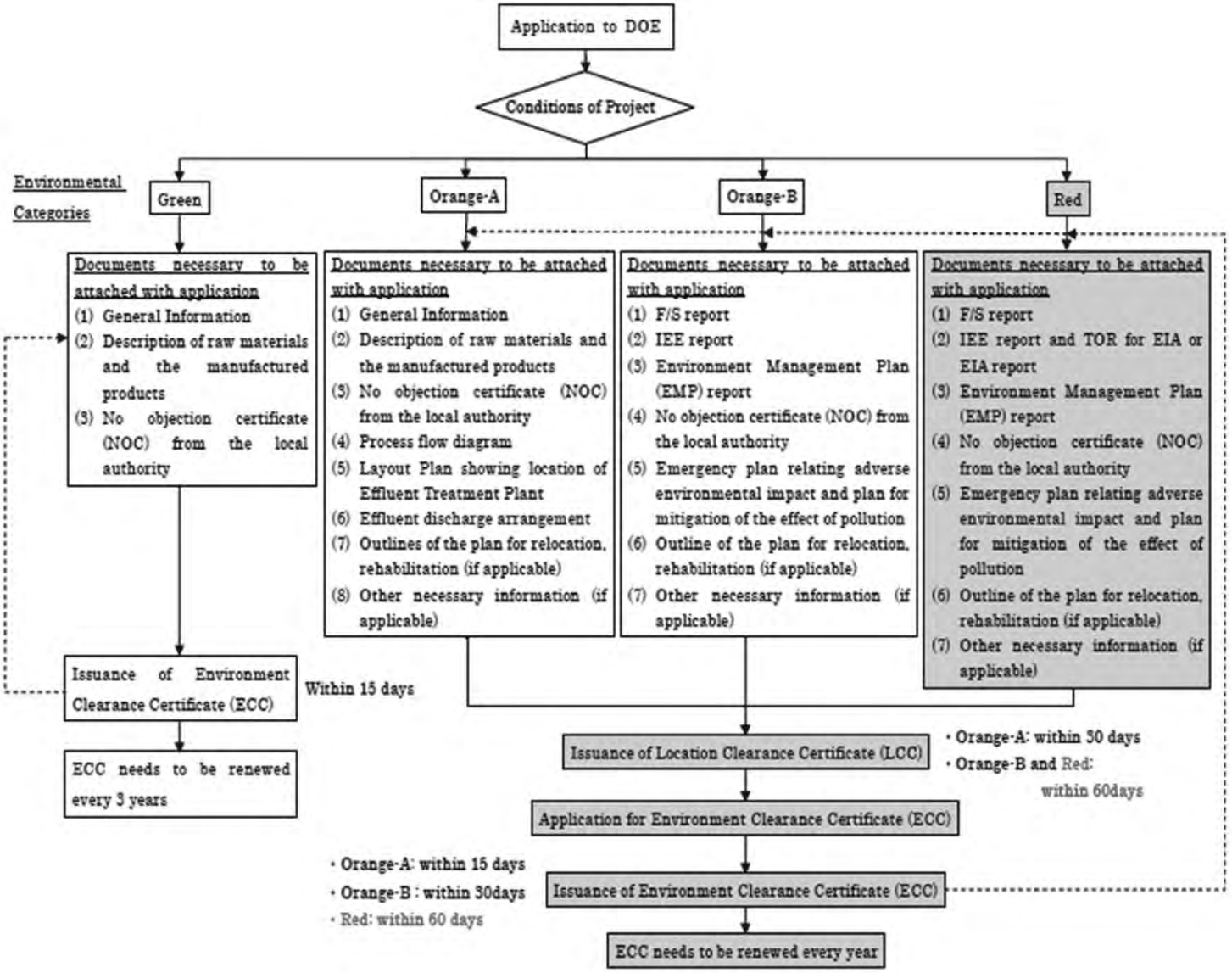
The Department of Environment (DoE) under the Ministry of Environment and Forest is the regulatory body which is responsible for enforcing the act and rules. Although the proponent is responsible for conducting an environmental impact assessment of the development proposal, the responsibility for reviewing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

In accordance with Schedule-1 of the Environmental Conservation Rules, the following provisions classify the environmental category of Cross Border 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 the “Red Category”

The Cross Border Project involves bridges both less than and over 100m, therefore, one EIA report which will include all bridges shall be prepared the same as Western Bangladesh Bridge Improvement Project (WBBIP). Being similar procedure followed in WBBIP, RHD obtained No Objection Certificate (NOC) for each bridge and submitted them with an application to DOE on 22nd November, 2015 requesting to issue an the Environmental Clearance Certificate (ECC) of the Cross-Broder Project. The necessary documents including EIA report submitted to DoE are presented in Figure 11.1.2.

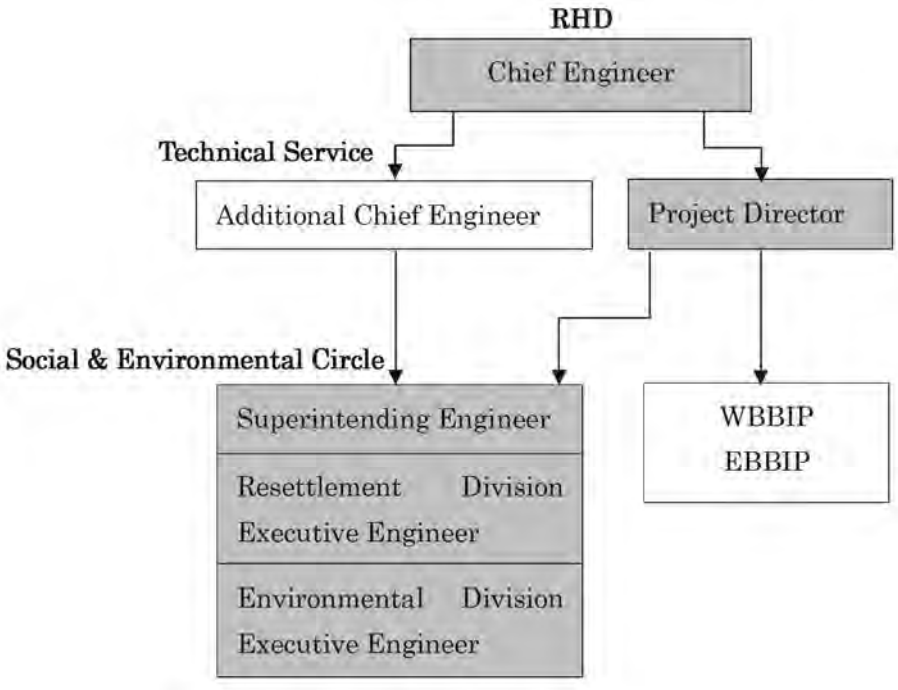
In addition, DoE has issued an ECC of the Project on 7th January, 2016. The obtained ECC is valid for one (1) year from the date of issuance and RHD is requested to apply for renewal to DOE's Head Office with a copy to Dhaka/Chittagong Region/ Khulna Divisional Offices of DOE at least 30 days ahead of expiry.



Source: JICA Survey Team

Figure 11.1.2 Procedure to obtain ECC

The following Figure 11.1.3 presents the Organogram of the Environmental and Social Considerations at RHD.



Source: JICA Survey Team

Figure 11.1.3 Organogram of RHD on Environmental and Social Considerations

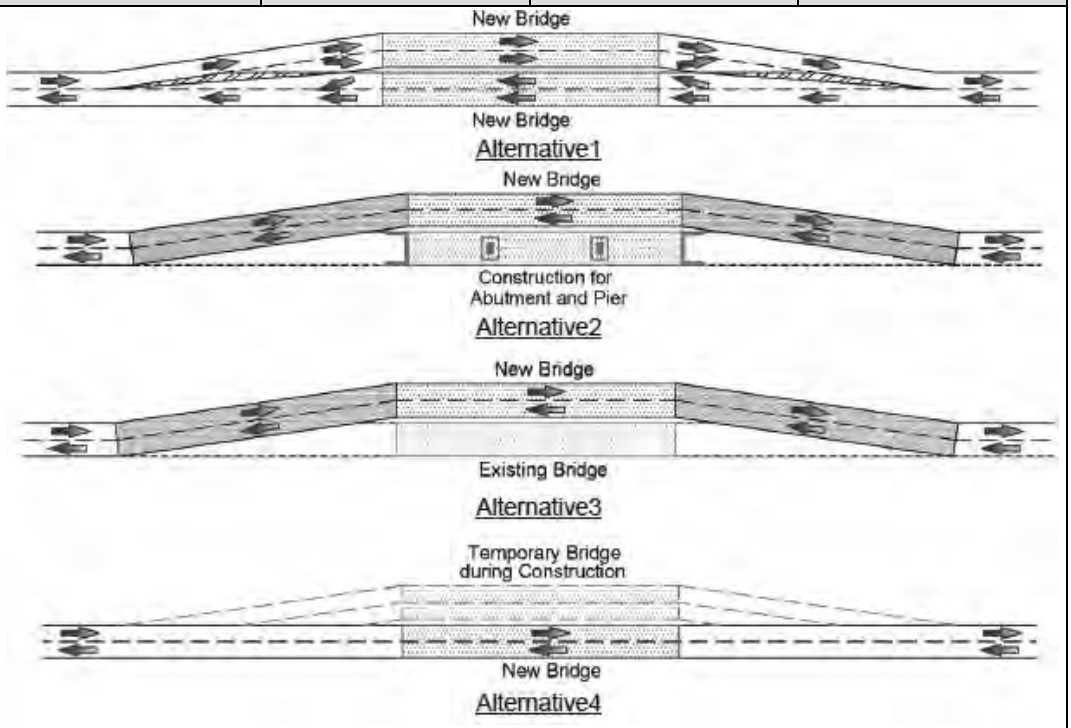
11.1.4 Alternatives

The location of new bridge shall be determined in consideration of impact to existing residences/shops, cost and so on. However, it shall be considered future widening project, additionally.

As a result of comparison (see Table 11.1.26), Alternative 4 (Replacement Existing Bridge) was selected for Section B from the viewpoint of the cheapest initial cost. Alternative 3 (New Bridge Construction next to Existing Bridge) was selected in consideration of easy future widening, in principle.

If “No Action Plan” is chosen, reliable road networks including sub-regional and international corridors will remain incomplete which will hinder the economic growth and livelihood.

Table 11.1.26 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	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 Section A & C** - Easy for future widening.	**Recommended for Section B** - The cheapest initial cost.

Source: JICA Survey Team

(1) Kalna Bridge

RHD operate ferry crossing at Madhumati River on National Highway N806 as a part of the Asian Highway. The ferry crossing is not operated in the night or weather is bad. Alternative routes, including bridge crossing locations, have been studied to construct an all-weather road and bridge over Madhumari River.

RHD had carried out the route study and prepared the crossing points where both ferry terminals were locating in preliminary design stage. The Study Team has reviewed their preliminary design taking into account the above river morphology, the existing ferry terminals, mosques, high-voltage lines and houses, proposed the following three alternatives and discussed.

- ALT-A: The river crossing location is approximately 500 m upstream from the RHD's original route.
- ALT-B: The river crossing location is approximately 300 m upstream from the RHD's original route.
- ALT-C: The river crossing location is approximately 700 m downstream from the RHD's original route.

After examination of the 3 alternatives, ALT-B was selected because the river course is most stable and the numbers of affected are fewest among them. It is supposed that this alternative would not affect to the high-voltage lines. However, considerations including relocations might be taken when the alternative affects them. Figure 11.1.4 and Table 11.1.27 are prepared to compare the advantage and disadvantage of the Alternatives.

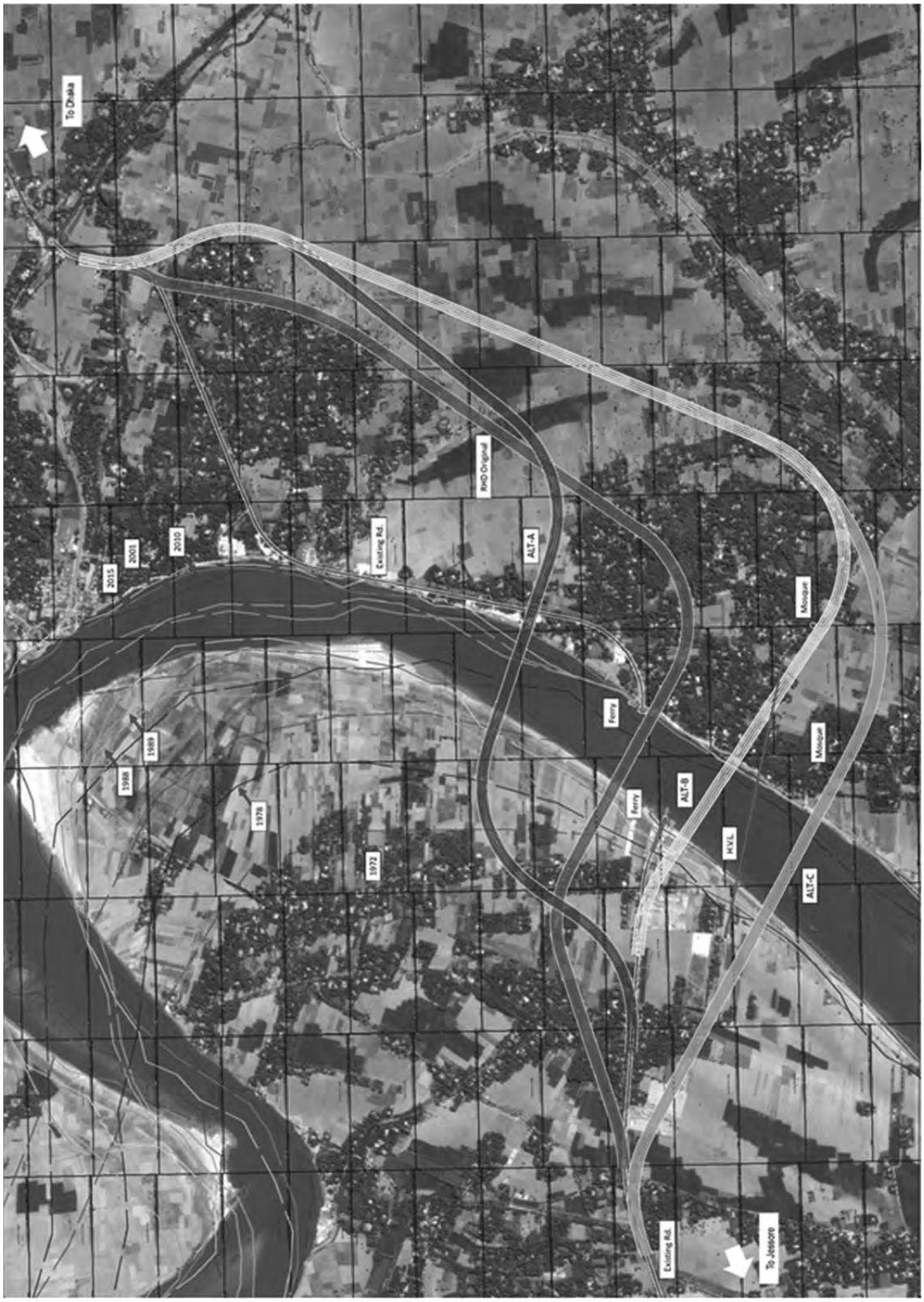
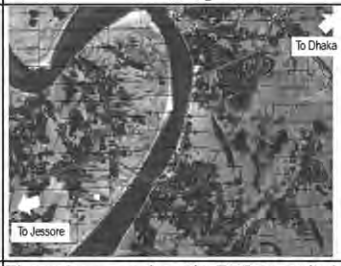
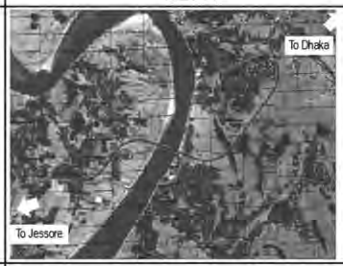
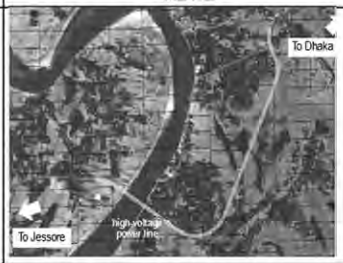
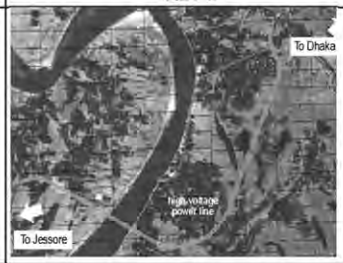


Figure 11.1.4 Alternative Routes for Kalna Bridge

Source: JICA Survey Team

Table 11.1.27 Route Comparison for Kalna Bridge

Alternative	RHD Original	ALT-A	ALT-B	ALT-C
Route Outline				
Route Summary	The route was analyzed by RHD for preliminary design. Bridge crosses over between both ferry terminals.	Bridge crosses over at approx. 500 m upstream from RHD Original Route.	Bridge crosses over at approx. 300 m downstream from RHD Original Route.	Bridge crosses over at approx. 700 m downstream from RHD Original Route.
Road Length (incl. bridge) [km]	4.66	4.35	4.77	5.89
Min. Horizontal Curve Radius [m]*1	400	440	440	440
No. of Horizontal Curves	7	5	4	4
River Crossing Angle (degree)	85.0	75.0	90.0	80.3
Deepest Depth of River Bed [m]	-10.0	-6.0	-3.5	-2.3
River Morphology	Almost stable since **Year 1989**.	Almost stable since **Year 2001**.	Almost stable since **Year 1978**	Almost stable since **Year 1978**
No. of Affected Buildings (Area)*2	86	33	41	44
Affected Area (ha)	17.46	16.19	17.89	22.34
Impact on Bridge Type	Slight impact on approach bridge due to transition curve	Slight impact on approach bridge due to transition curve	Slight impact on approach bridge due to transition curve	No impact
Constructability	Existing ferry terminal on western bank requires shifting to upstream and requires construction of temporary access road. And construction site crosses over the road.	Construction site crosses over existing NH.	Close to high-voltage power line and intersects in plane.	Close to high-voltage power line.
Road Construction Cost*3	1.1	1.0	1.1	1.4
Bridge Construction Cost*3	1.0	1.0	1.0	1.0
Evaluation			Recommendation	
	River banks are more stable than ALT-A. Social impacts are significant compared to 4 alternatives.	Some river training works may be required because the river crossing are located around the upstream limit of less river meanderings since 2001. Social impacts are assumed to be lowest among 4 alternatives, and road length is shortest.	River banks are most stable as well as ALT-C, and river crossing is almost perpendicular to the riverbank. Social impacts are assumed to be less. If sufficient vertical clearance is not secured under high-voltage power line, then it will be necessary to relocate.	River banks are most stable as well as ALT-B. River crossing is little bit under skew angle. Moreover, the road length is longest among 4 alternatives, thereby, cost increases by 40 % compared to ALT-A. Social impacts are almost same as ALT-B.
Remarks			Increase the number of affected buildings due to the widening of existing road between ALT-B and ALT-C on Jessore side.	Additional cost requires for relocation of Brick Field.

*1: Excl. the vicincity of intersection at ending point side. *2: 50% increasing based on Satellite Image (excl. RHD Original). *3: Comparison ratio based on ALT-A (1.0).

Source: JICA Survey Team

(2) Jhikorgacha Bridge

The Jhikorgacha Bridge is located on National Highway N706 as a part of the Asian Highway, but it is deteriorated. In WBBIP, it was planned to reconstruct the bridge with 4-lanes. However, the stake holders didn't agree with the proposed plan.

Further local stakeholder meeting has held in 2015 with following 4 alternatives.

- ALT-A: New bridge will be constructed upstream and the existing bridge will be replaced by a new one at the same location. (one-side widening which was denied in WBBIP)
- ALT-B: New bridges will be keeping the centerlines along that of existing bridge (both-sides widening which was proposed in WBBIP)
- ALT-C: New bridge will be constructed downstream near the railway bridge (Bypass option which was proposed in WBBIP)
- ALT-D: New bridge is constructed upstream far from the existing bridge (Bypass option which was proposed in 1st round meeting held in 6th July, 2015)

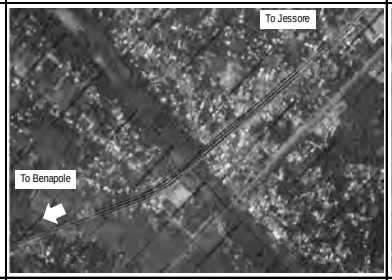
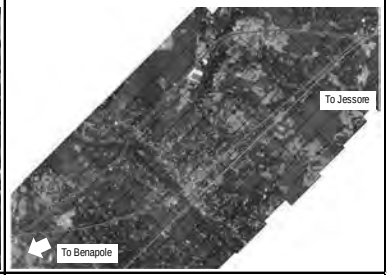
The comparison are shown in Figure 11.1.5 and Table 11.1.28.

The alternatives were introduced to the local stakeholders and above mentioned ALT-B was accepted by them on 1st September, 2015. The detail is presented in Annex-IV Minutes of SHM.

Source: JICA Survey Team

Figure 11.1.5 Alternative Routes for Jhikorgacha Bridge

Table 11.1.28 Route Comparison for Jhikorgacha Bridge

Alternaties	ALT-A	ALT-B	ALT-C	ALT-D
Route Outline				
Route Summary	New bridge is constructed at upstream side and existing bridge will be replaced by new one at same location. (one-side widening as same as WBBIP)	New bridge will be constructed keeping its centerline along that of existing bridge (both-sides widening). Existing bridge will be demolished.	New bridge is constructed at downstream near railway bridge (Bypass option)	New bridge is constructed at upstream far from the existing bridge (Bypass option as same as SH opinion)
Road Length (incl. bridge) [km]	0.98	0.84	1.70	6.14
Min. Horizontal Curve Radius [m]	440	270	440	440
No. of Horizontal Curves	3	2	4	6
No. of Affected Buildings*1	65	70	130	191
No. of Affected Households	28 (Based on detailed survey in WBBIP)	31*2 (Estimated by using the ratio of Alt-A)	63*2 (Estimated by using the ratio of Alt-A. However, household ratio of ALT-C is higher than the one of ALT-A.)	83*2 (Estimated by using the ratio of Alt-A. However, household ratio of ALT-D is higher than the one of ALT-A.)
Affected Area (ha)	2.63	2.21	4.79	18.13
Assumed Land Acqusition Area (ha)*3	0.39	0.24	4.19	17.53
Assumed Relocation Area (ha)*3	0.72	0.72	0.00	0.00
Traffic Situation	Traffic capacity doubles with 4 lanes.	Traffic capacity doubles with 4 lanes.	Traffic capacity is increased because traffic will be distributed by bypass.	Traffic capacity is increased because traffic will be distributed by bypass.
Constructability	Temporary bridge is unnecessary. However, existing bridge requires replacing by new one.	Temporary bridges are necessary and demolition of existing bridge with diversion of existing traffic is required before bridge construction.	The existing bridge will be kept untouched. However, new construction beside the existing railway bridge requires special precaution.	The existing bridge will be kept untouched. However, widening of the existing railway crossing requires special precaution.
Road Constuction Cost*4	1.2	1.0	2.0	7.3
Bridge Constuction Cost*4	1.0	1.0	1.0	1.0
Evaluation		Recommendation		
	Social impacts are smallest among 3 alternatives, however, road length is a little bit longer.	Social impacts are almost same as ALT-A and road length is shortest among 3 alternatives. It could be optimum of road widening and easiest for RHD to receive consensus from stakeholders. Because social impacts on bothside stakehoulders can be concluded/summarized in a harmony manner.	Traffic capacity is increased because traffic will be distributed by bypass. However, construction cost will be increased and social impacts will be significant.	Traffic capacity is increased because traffic will be distributed by bypass. However, construction cost will be increased and social impacts will be significant among 4 alternatives.
Remarks		Bridge construction cost increases and construction period is longer a bit because temporary bridges and several diversion of existing traffic are required. Min. horizontal curve radius is smaller so as to follow the existing alignment. However, it requires to reduce the design speed due to its location under developed area.		

*1: Based on Satellite Image. *2: The number of affected households was estimated by using the ratio between Buildings and Households of Alt-A. *3: In case of existing ROW is 30 m. *4: Comparison ratio based on ALT-B (1.0).

Source: JICA Survey Team

11.1.5 Scoping and TOR of EIA

A reconnaissance survey was carried out, taking the 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 11.1.29. The Terms of Reference (ToR) for the EIA is shown in Table 11.1.30.

Table 11.1.29 Predicted Scoping Matrix

No.	Items of Impact	Predicted Impact		Reason for Assessment
		Before/ During Construction Stage	Operation Stage	
Anti-Pollution Measures				
1	Air pollution	B-	C	Construction Stage: Air pollution will be caused due to vehicular emissions and dust blowing. Operation Stage: The impact is not clear at this moment.
2	Water pollution	B-	D	Construction Stage: Water pollution might be occur due to working activities. Operation Stage: The impacts in operation stage will be very small.
3	Soil pollution	B-	D	Construction Stage: Soil pollution may be caused due to spilling of oil/lubricants. Operation Stage: The impacts will be very small.
4	Waste	B-	D	Construction Stage: Camp sites and construction wastes may pollute the soil. Operation Stage: The impacts in operation stage will be almost nil.
5	Noise and vibration	B-	B-	Construction Stage: Noise level may increase. Operation Stage: It is assumed that increase of traffic will cause the noise level high.
6	Ground subsidence	D	D	Some groundwater will be pumped up, but no ground subsidence is expected.
7	Offensive odors	D	D	No offensive odor is anticipated at any stage of the project.
8	Global warming/Climate change	D	C	Construction Stage: Very small impact is anticipated. Operation Stage: Impact is not clear at this moment.
Natural Environment				
9	Topography and geology	D	D	The project is aiming at the improvement of existing bad conditions and impact due to the improvement might be very small both construction and operation stage.
10	Bottom sediment	D B-(Section B and Kalna Bridge)	D	Construction Stage: The impacts will to be very small in construction stage excepting Section B and Kalna Bridge. Operation Stage: Impact might be very small.
11	Biota and ecosystem	C	C	Impacts are not clear at this stage.
12	Hydrology	B-	C	Construction Stage: Some impacts due to the project are anticipated. Operation Stage: It is not clear whether there might be impact or not.

No.	Items of Impact	Predicted Impact		Reason for Assessment
		Before/ During Construction Stage	Operation Stage	
13	Water use	C	C	Impact to present water use is not clear in construction or operation stages.
14	Protected area	D C(Section B)	D	Before Construction Stage: There is no protected area near the project site except Section B: Forestry Protected Area. Operation Stage: Impact might be very small.
Social Environment				
15	Involuntary resettlement	B-	D	Before Construction Stage: Displacement is required, however it will not be significant. Operation Stage: All PAPs will be resettled, therefore, impact will not exist.
16	Local economies, such as employment, livelihood, etc.	B-/B+	C	Construction Stage: At several bridges sites livelihoods might be affected due to removal of shops and acquisition of land. On the other hand, some people will be offered jobs. Operation Stage: It is not clear at this stage.
17	Land use and utilization of local resources	D	D	Impact on land use will be almost nil.
18	Social institutions and local decision-making institutions and social service facilities	B-	D	Construction Stage: Some utilities, such as water pipes and power cables might be affected due to the new bridge construction. Operation Stage: No impact is assumed.
19	Poor	A-	A-	Construction Stage: Poor people living on RHD land might be affected. Operation Stage: They will become poorer if no countermeasures are taken.
20	Indigenous or ethnic minority people	D	D	No indigenous tribal people are affected.
21	Misdistribution of benefits and damages	D	D	No impact is anticipated, because the project bridges will be constructed adjacent to the existing bridges.
22	Local conflicts of interest	D	D	No impact is anticipated.
23	Gender	C	C	It is not clear at this stage
24	Children's right	C	C	It is not clear at this stage
25	Cultural heritage	D	D	No cultural and/or historical relics exist in the bridge sites.
26	Infectious diseases such as HIV/AIDS	B-	D	Construction Stage: Influx of workers may increase the possibility of infectious diseases. Operation Stage: The impacts might be very small.
27	Landscape	D	D	No impact is anticipated.
28	Working conditions	B-	D	Insufficient safety management may cause the accidents in construction stage. No impact in operation stage is anticipated.
29	Social consensus	A-	D	Construction Stage: The physical construction activities might be hampered without obtaining appropriate local consensus. Operation Stage: No impact is anticipated.

No.	Items of Impact	Predicted Impact		Reason for Assessment
		Before/ During Construction Stage	Operation Stage	
Others				
30	Accident	B-	D	Construction Stage: Inappropriate traffic control or increase of traffic may induce accidents. Operation Stage: The improvement will contribute to the safety of traffic because the old and damaged bridges will be replaced with new ones.

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

Source: JICA Survey Team

Table 11.1.30 ToR for EIA

Items of Impacts	Items to be Studied	Study Method
Air pollution	• Confirm the environmental standards in Bangladesh • Confirm the present level of pollution • Check on the location of neighboring residences, schools, hospitals located near the 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 countermeasures 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 in construction stage	• From similar and neighboring construction activity
Noise	• Confirm the environmental standards in Bangladesh • Confirm the distance from noise source to residential areas, hospitals, schools • Review the impacts while in construction stage	• From the latest standards • From the plan drawing prepared based on the topographic survey
Global warming/Climate change	• Confirm the present level of pollution • Review the impacts while in operation stage	• Sampling, testing and analysis through EIA activity • Assessment in accordance with other survey results
Topography and geology	• Confirm the mark of slope corruption adjoining the bridge.	• In accordance with site survey results
Bottom sediment	• Confirm the present situation of riverbed.	• In accordance with site survey results
Protected area	• Confirm if the project bridge locates within protected area or not.	• Confirm local DOE
Biota and ecosystem	• Confirm the species existing in/around the project bridge	• In accordance with site survey results

Items of Impacts	Items to be Studied	Study Method
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 if it is located within national protected area or not	• It is not located within national protected area
Involuntary resettlement	• Confirm the number of displaced persons/affected households at each bridge • Prepare RAP or ARP	• From related ordinance in Bangladesh • From census and socio-economic survey • RAP and ARP in accordance with JICA's guidelines
Local economy such as employment and livelihood	• Confirm the economic status and means of livelihood accompany with PAPs	• From socio-economic survey
Existing social infrastructures and services	• Survey the existing utilities and confirm if impacts arise 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
Gender	• Confirm woman headed household must be involved in SES, if there are any • Confirm the participation of women's groups in the stakeholder meetings	• From local SHM results • From socio-economic survey
Children's rights	• Confirm the present distance to the schools from the project bridges • Review the method of detour provided in construction stage	• From the plan drawing prepared based on the topographic survey • From working method statement
Infectious diseases such as HIV/AIDS	• Present distribution of HIV/AIDS sufferers	• Interview with local clinic
Working conditions	• Confirm the measures to provide worker's safety while in construction stage	• From working method statement
Social Consensus	• Obtain opinions from local residents and refer to the construction design/plan.	• Conduct local Stakeholder Meetings
Accidents	• Review the necessity of safety equipment/tools to prevent accidents while in construction stage	• From working method statement

Source: JICA Survey Team

11.1.6 Results of EIA Study

The result of EIA survey on item of impact in accordance with the scoping is presented in following Table 11.1.31.

Table 11.1.31 Result of EIA Survey

No.	Item of Impact	Outline of the Survey Result
Anti-Pollution Measures		
1	Air pollution	The monitoring parameters included Particulate Matter (SPM, PM_{10} and $PM_{2.5}$), Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2) and Carbon Monoxide (CO). All the parameters were monitored on 24-hourly basis during the duration of the study. Section A: Refer to Table 4-39: Ambient Air Quality in the Section A Area, EIA Report. The surveyed parameters are less than National Ambient Air Quality Standard (NAAQS) Section B: Refer to Table 4-40: Ambient Air Quality in the Section B Area, EIA Report. The surveyed parameters are less than National Ambient Air Quality Standard (NAAQS) Section C: Refer to Table 4-41: Ambient Air Quality in the Section C Area, EIA Report. The surveyed parameters are less than National Ambient Air Quality Standard (NAAQS) The impacts might be very small in operation stage.
2	Water pollution	The surface water sampling was based on the identification of major surface water bodies such as the River, Canal and *Chara*. The quality of surface water was compared with the standards for *Inland Surface Water*, Environment Conservation Rules (ECR), 1997-Schedule 3. The standards have been presented along with the monitoring results of surface for comparison. Section A: Refer to Table 4-51: Surface Water Quality of Section A, EIA Report. The quality of the surface water samples from the Madhumati River is of a level that can be utilized for fisheries, industrial process and cooling purpose and for irrigation. Section B: Refer to Table 4-52: Surface Water Quality of Section B, EIA Report. The quality of the surface water samples from different Khals and chara are of a level that can be utilized for fisheries, industrial process and cooling purpose and for irrigation with the exception of Heako khal, Johorful khal, Borobil khal, Noloa chara and Rupai chara. Dissolved oxygen and total coliform concentration exceed the standards in six samples. Section C: Refer to Table 4-53: Surface Water Quality of Section C, EIA Report. The quality of the surface water samples from different Khals and chara are of a level that can be utilized for fisheries, industrial process and cooling purpose and for irrigation with the exception of Chankhali khal in Patiya Bridge. 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. However, most of the wastes are well re-cycled to get reinforcing bar, road base material or compost. Impact is not assumed in operation stage.
5	Noise and vibration	The purpose of ambient noise level measurement was to determine sound intensity at the monitoring locations. These locations are chosen in such a way that a representative data could be recorded all over the block. The sound level is recorded in form of A-weighted equivalent continuous sound pressure level (Leq.) values with the use of A-weighting filters in the noise measuring instrument. Section A: Refer to Table 4-45: Noise Level recorded in the Section A Area, EIA Report. The surveyed data are less than Bangladesh Standards dB Section B: Refer to Table 4-46: Noise Level recorded in the Section B Area, EIA Report. In some residential and silent zones the ambient noise level exceed the stipulated Bangladesh standard due to these houses and Mosques are located near to the road and noise level in these points influenced by the traffic movement. Section C: Refer to Table 4-47: Noise Level recorded in the Section C Area, EIA Report. In some residential and silent zones the ambient noise level exceed the stipulated Bangladesh standard due to these houses and Mosques are located near to the road and noise level in these points influenced by the traffic movement. Some extent of impacts is assumed both in construction and operation stage.
6	Global warming/Climate change	The emission of CO_2 gas from vehicle is compared from the present traffic volume and estimated traffic volume in 2023: target year of the economic evaluation. The results are; Section A (68 km long): Increase in amount 23,300 ton/year. Section B (30 km long): Increase in amount 160 ton/year Section C (69km long): Increase in amount 8,900 ton/year The impacts due to construction equipment will be very small and mitigation measures are presented in Table 11.1.34.

No.	Item of Impact	Outline of the Survey Result
Natural Environment		
7	Topography and geology	Kalna Bridge: The embankment as the access roads to the bridge will be carried out and the height of embankment will be less than 10 meters at abutments and this height will not affect to the topography. And activity to change the present geological conditions is not assumed. Section B: The new bridge will be provided adjacent to the existing bridge. This will not affect to the topography. The cast-in-place RC pile will be applied to mitigate cut/embankment around foundations which will minimize the soil disturbance due to the project.
8	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. For this Project the cast-in place RC pile will be applied for pile foundation and temporary shoring of steel pile will be installed to mitigate the soil run-off. Impact might be very small at any stages.
9	Biota and ecosystem	IUCN, The World conservation Union, Bangladesh has divided the whole country into 25 Bio-ecological Zones in context of biological diversity. The survey area covers three distinct Bio-ecological zones; they are the Ganges Floodplain in section A, the Chittagong Hill and CHTS in section B and section C. These zones describe holistic ecological features of the country. The projects are in the vicinity of existing roads or cultivated fields and affected areas are minimized in before construction stage. Impact might be very small at any stages.
10	Hydrology	The impediment ration of river flow at new Kalna bridge is 3 % approximately. Furthermore, riverbed around piers which the scouring are assumed, have taken costs for the appropriate bed protection into account. Therefore, the potential impact against hydrology will be almost nil.
11	Water use	Bangladesh is the world's largest delta and also the land of many water bodies. Water dominates life, people and economy of Bangladesh. Water is the most important resource of Bangladesh and the basis of its agricultural productivity. Their own characteristics and use patterns are as follows. Section A: Madhumati river system is connected by large number of tributes which are flowing water from the surrounding water system and is also connected with small canals. There are some low agricultural lands which are seasonally flooded and use as fish culture. Section B: Different types of chara, khal are found in this area. Those are connected with Feni River which ultimately connected to Bay of Bengal. Those are used for agriculture purposes. Section C: The section C has four bridges which are located over the Chankhali khal, Pouromati, Sangu and Mataamuhuri River. Those are used for navigation, capture fisheries, agriculture and industrial purposes. Impact is not assumed in any stages.
12	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. Furthermore, B9(Kalapani-2), B12(Koila bazar) and B13(Balutila) are locating within the Reserved Forests which belong to Department of Forestry. Impact is not assumed in any stages because the project bridges are not located in the protected area. However, bridges of Section B are in the vicinity of Reserved Forest and NOC shall be obtained.
Social Environment		
13	Involuntary resettlement	30.3 ha of land will need to be acquired of which 24.7 ha in Section A, 2.8 ha in Section B and 2.7 ha in Section C. As a result, 149 households and 755 people will be displaced. Some impacts are identified in Chapter 11.2: Land Acquisition and Resettlement. Impact is not assumed in operation stage.

No.	Item of Impact	Outline of the Survey Result
14	Local economies, such as employment, livelihood, etc.	In total 477 households are going to lose their income as wage earners in the business and commercial enterprises affected by the project. In total 33,172 m^2 is going to be affected by this project. Some extent of impact is assumed, however it is not assumed in operation stage.
15	Social institutions and local decision-making institutions and social service facilities	There are 25 common property resources in three sections of the project and are getting affected. Out of these 6 in Section A 9 in Section B and 10 in Section C. The common properties are mostly government, schools 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.
16	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'. Based on the census socioeconomic survey (June - September 2015) indicating yearly income and expenditure of the project affected households it is found that about 3.66% households earn less than Tk 60,000 per year. Some impacts are assumed to the non-title peoples if assistance is not carried out to those who are residing within RHD land before construction stage. Impact will be very small in operation stage.
17	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.
18	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 small in each stage.
19	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 six and ten. The project will not cause commuting distance to school, therefore, impact is not assumed in any stages.
20	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.
21	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.
22	Working conditions	It is necessary to secure the safety of workers, pedestrians and vehicular traffics in construction stage.
23	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.

No.	Item of Impact	Outline of the Survey Result
Others		
24	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.

Source: JICA Survey Team

11.1.7 Assessment of Impacts

Various impacts of bridge construction during pre-construction, construction and operation stages are indicted in following Tables at section-wise basis.

(1) Section A

Table 11.1.32 Comparison of Scoping before/after EIA Study at Section A

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-	C	B-	D	During Construction Stage: Air pollution will be caused due to vehicular emissions and dust blowing.
2	Water pollution	B-	D	B-	D	During Construction Stage: Water pollution likely to be occurred due to the drainage from the sites.
3	Soil pollution	B-	D	B-	D	During Construction Stage: Soil pollution may be caused due to the spilling of oil or lubricants.
4	Waste	B-	D	B-	D	During Construction Stage: Waste from camp sites and construction sites may pollute the soil.
5	Noise and vibration	B-	B-	B-	B-	Noise level may increase during construction and operation stage.
6	Ground subsidence	D	D	D	D	During Construction Stage: No ground subsidence will be occurred because the project does not include large scale of pumping up or tunnel excavation.
7	Offensive odors	D	D	D	D	No offensive odor will be occurred in any stage.
8	Global warming/Climate change	D	C	D	D	It is assumed that impact will be limited and almost negligible.
Natural Environment						
9	Topography and geology	D	D	D	D	The project aims at improve the existing bridge and impact anticipated might be very small.

No.	Items of Impact	Predicted Impact		Assessed Impact		Reason of Assessment
		Before/ During Construction Stage	Operation Stage	Before/ During Construction Stage	Operation Stage	
10	Bottom sediment	B-	D	D	D	During Construction Stage: Impact is not assumed due to the noxious material or others. Operation Stage: No impact is 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	The project aims at improve the existing bridge and impact anticipated might be very small.
13	Water use	C	C	D	D	Impact to present water use due to the project implementation is assumed almost nil.
14	Protected area	D	D	D	D	There is no protected are in the vicinity of the site.
Social Environment						
15	Involuntary resettlement	B-	D	B-	D	Before Construction Stage: Displacement is required in this stage and some impacts are assumed. Operation Stage: Displacement must be completed and the impacts might be limited.
16	Local economies, such as employment, livelihood, etc.	B-/B+	C	B-	D	Before Construction Stage: At several bridges sites livelihoods may be affected due to the displacement of shops or acquisition of lands. Operation Stage: Impacts might be limited.
17	Land use and utilization of local resources	D	D	D	D	Impact to land use due to the land acquisition might be very small.
18	Social institutions and local decision-making institutions and social service facilities	B-	D	B-	D	Before Construction Stage: Some utilities might be affected due to the new bridge construction. Operation Stage: Impact will be nil.
19	Poor	A-	A-	B-	B-	Before Construction Stage: Poor people living on RHD land might be affected. Operation Stage: It is assumed that the impacts will remain
20	Indigenous or ethnic minority people	D	D	D	D	No indigenous tribal people is found at project site.
21	Misdistribution of benefits and damages	D	D	D	D	The new bridge will be provided adjacent to the existing one. Therefore, no impact is assumed.
22	Local conflicts of interest	D	D	D	D	No local conflict is assumed because the new bridge will be provided adjacent to the existing one.
23	Gender	C	C	D	D	Females have joined the SHM, it is assumed that negative impact to gender is limited.

No.	Items of Impact	Predicted Impact		Assessed Impact		Reason of Assessment
		Before/ During Construction Stage	Operation Stage	Before/ During Construction Stage	Operation Stage	
24	Children's right	C	C	D	D	No project activity which will hamper the legal rights of children is assumed.
25	Cultural heritage	D	D	D	D	No cultural and/or historical relics is found at project site.
26	Infectious diseases such as HIV/AIDS	B-	D	D-	D	Influx of worker may cause the possibility, however it may be very small in construction stage.
27	Landscape	D	D	D	D	No impact is assumed.
28	Working conditions	B-	D	B-	D	During Construction Stage: Insufficient safety management will cause the accidents. Operation Stage: Impact is assumed very small.
29	Social consensus	A-	D	B-	D	During Construction Stage: The physical construction activity might be hampered without obtaining appropriate local consensus.
Others						
30	Accident	B-	D	B-	B-	During Construction Stage: Inappropriate traffic control or contractor's vehicle may induce the accident. Operation Stage: Increase of traffic will cause the accident.

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

Source: JICA Survey Team

(2) Section B

Table 11.1.33 Comparison of Scoping before/after EIA Study at Section B

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-	C	B-	D	During Construction Stage: Air pollution will be caused due to vehicular emissions and dust blowing.
2	Water pollution	B-	D	B-	D	During Construction Stage: Water pollution likely to be occurred due to the drainage from the sites.
3	Soil pollution	B-	D	B-	D	During Construction Stage: Soil pollution may be caused due to the spilling of oil or lubricants.

No.	Items of Impact	Predicted Impact		Assessed Impact		Reason of Assessment
		Before/ During Construction Stage	Operation Stage	Before/ During Construction Stage	Operation Stage	
4	Waste	B-	D	B-	D	During Construction Stage: Waste from camp sites and construction sites may pollute the soil.
5	Noise and vibration	B-	B-	B-	B-	Noise level may increase during construction and operation stage.
6	Ground subsidence	D	D	D	D	During Construction Stage: No ground subsidence will be occurred because the project does not include large scale of pumping up or tunnel excavation.
7	Offensive odors	D	D	D	D	No offensive odor will be occurred in any stage.
8	Global warming/Climate change	D	C	D	D	It is assumed that impact will be limited and almost negligible.
Natural Environment						
9	Topography and geology	D	D	D	D	The project aims at improve the existing bridge and impact anticipated might be very small.
10	Bottom sediment	B-	D	D	D	During Construction Stage: Impact is not assumed due to the noxious material or others. Operation Stage: No impact is 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	The project aims at improve the existing bridge and impact anticipated might be very small.
13	Water use	C	C	D	D	Impact to present water use due to the project implementation is assumed almost nil.
14	Protected area	D	D	B-	D	B9, B12 and B13 are in the vicinity of the Reserved Forest.
Social Environment						
15	Involuntary resettlement	B-	D	B-	D	Before Construction Stage: Displacement is required in this stage and some impacts are assumed. Operation Stage: Displacement must be completed and the impacts might be limited.
16	Local economies, such as employment, livelihood, etc.	B-/B+	C	B-	D	Before Construction Stage: At several bridges sites livelihoods may be affected due to the displacement of shops or acquisition of lands. Operation Stage: Impacts might be limited.
17	Land use and utilization of local resources	D	D	D	D	Impact to land use due to the land acquisition might be very small.

No.	Items of Impact	Predicted Impact		Assessed Impact		Reason of Assessment
		Before/ During Construction Stage	Operation Stage	Before/ During Construction Stage	Operation Stage	
18	Social institutions and local decision-making institutions and social service facilities	B-	D	B-	D	Before Construction Stage: Some utilities might be affected due to the new bridge construction. Operation Stage: Impact will be nil.
19	Poor	A-	A-	B-	B-	Before Construction Stage: Poor people living on RHD land might be affected. Operation Stage: It is assumed that the impacts will remain
20	Indigenous or ethnic minority people	D	D	D	D	No indigenous tribal people are found at project site.
21	Misdistribution of benefits and damages	D	D	D	D	The new bridge will be provided adjacent to the existing one. Therefore, no impact is assumed.
22	Local conflicts of interest	D	D	D	D	No local conflict is assumed because the new bridge will be provided adjacent to the existing one.
23	Gender	C	C	D	D	Females have joined the SHM, it is assumed that negative impact to gender is limited.
24	Children's right	C	C	D	D	No project activity which will hamper the legal rights of children is assumed.
25	Cultural heritage	D	D	D	D	No cultural and/or historical relics is found at project site.
26	Infectious diseases such as HIV/AIDS	B-	D	D-	D	Influx of worker may cause the possibility, however it may be very small in construction stage.
27	Landscape	D	D	D	D	No impact is assumed.
28	Working conditions	B-	D	B-	D	During Construction Stage: Insufficient safety management will cause the accidents. Operation Stage: Impact is assumed very small.
29	Social consensus	A-	D	B-	D	During Construction Stage: The physical construction activity might be hampered without obtaining appropriate local consensus.
Others						
30	Accident	B-	D	B-	B-	During Construction Stage: Inappropriate traffic control or contractor's vehicle may induce the accident. Operation Stage: Increase of traffic will cause the accident.

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

Source: JICA Survey Team

(3) Section C

Table 11.1.34 Comparison of Scoping before/after EIA Study at Section C

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-	C	B-	D	During Construction Stage: Air pollution will be caused due to vehicular emissions and dust blowing.
2	Water pollution	B-	D	B-	D	During Construction Stage: Water pollution likely to be occurred due to the drainage from the sites.
3	Soil pollution	B-	D	B-	D	During Construction Stage: Soil pollution may be caused due to the spilling of oil or lubricants.
4	Waste	B-	D	B-	D	During Construction Stage: Waste from camp sites and construction sites may pollute the soil.
5	Noise and vibration	B-	B-	B-	B-	Noise level may increase during construction and operation stage.
6	Ground subsidence	D	D	D	D	During Construction Stage: No ground subsidence will be occurred because the project does not include large scale of pumping up or tunnel excavation.
7	Offensive odors	D	D	D	D	No offensive odor will be occurred in any stage.
8	Global warming/Climate change	D	C	D	D	It is assumed that impact will be limited and almost negligible.
Natural Environment						
9	Topography and geology	D	D	D	D	The project aims at improve the existing bridge and impact anticipated might be very small.
10	Bottom sediment	B-	D	D	D	During Construction Stage: Impact is not assumed due to the noxious material or others. Operation Stage: No impact is 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	The project aims at improve the existing bridge and impact anticipated might be very small.
13	Water use	C	C	D	D	Impact to present water use due to the project implementation is assumed almost nil.

No.	Items of Impact	Predicted Impact		Assessed Impact		Reason of Assessment
		Before/ During Construction Stage	Operation Stage	Before/ During Construction Stage	Operation Stage	
14	Protected area	D	D	D	D	There is no protected are in the vicinity of the site.
Social Environment						
15	Involuntary resettlement	B-	D	B-	D	Before Construction Stage: Displacement is required in this stage and some impacts are assumed. Operation Stage: Displacement must be completed and the impacts might be limited.
16	Local economies, such as employment, livelihood, etc.	B-/B+	C	B-	D	Before Construction Stage: At several bridges sites livelihoods may be affected due to the displacement of shops or acquisition of lands. Operation Stage: Impacts might be limited.
17	Land use and utilization of local resources	D	D	D	D	Impact to land use due to the land acquisition might be very small.
18	Social institutions and local decision-making institutions and social service facilities	B-	D	B-	D	Before Construction Stage: Some utilities might be affected due to the new bridge construction. Operation Stage: Impact will be nil.
19	Poor	A-	A-	B-	B-	Before Construction Stage: Poor people living on RHD land might be affected. Operation Stage: It is assumed that the impacts will remain
20	Indigenous or ethnic minority people	D	D	D	D	No indigenous tribal people is found at project site.
21	Misdistribution of benefits and damages	D	D	D	D	The new bridge will be provided adjacent to the existing one. Therefore, no impact is assumed.
22	Local conflicts of interest	D	D	D	D	No local conflict is assumed because the new bridge will be provided adjacent to the existing one.
23	Gender	C	C	D	D	Females have joined the SHM, it is assumed that negative impact to gender is limited.
24	Children's right	C	C	D	D	No project activity which will hamper the legal rights of children is assumed.
25	Cultural heritage	D	D	D	D	No cultural and/or historical relics is found at project site.
26	Infectious diseases such as HIV/AIDS	B-	D	D-	D	Influx of worker may cause the possibility, however it may be very small in construction stage.
27	Landscape	D	D	D	D	No impact is assumed.

No.	Items of Impact	Predicted Impact		Assessed Impact		Reason of Assessment
		Before/ During Construction Stage	Operation Stage	Before/ During Construction Stage	Operation Stage	
28	Working conditions	B-	D	B-	D	During Construction Stage: Insufficient safety management will cause the accidents. Operation Stage: Impact is assumed very small.
29	Social consensus	A-	D	B-	D	During Construction Stage: The physical construction activity might be hampered without obtaining appropriate local consensus.
Others						
30	Accident	B-	D	B-	B-	During Construction Stage: Inappropriate traffic control or contractor's vehicle may induce the accident. Operation Stage: Increase of traffic will cause the accident.

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
Source: JICA Survey Team

11.1.8 Mitigation Measures and their Costs

Table 11.1.35 presents the combined mitigation measures on anticipated adverse impacts in pre-construction/construction stage, and Table 11.1.36 presents in operation stage, respectively.

Table 11.1.35 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

Item of Impact	Mitigation Measures	Implementing Organization	Responsible organization
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 heavy equipment and other construction machinery within permissible limits. - Contractors are required to use low-noise equipped machinery whenever it is necessary.	Contractor	PIU
Protected Area	- B9, B12 and B13 are in the vicinity of Reserved Forest. When RHD will submit EIA Report to DOE, he shall obtain NOC from Department of Forest.	RHD	RHD
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 provide 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 11.1.36 Mitigation Measures in Operation Stage

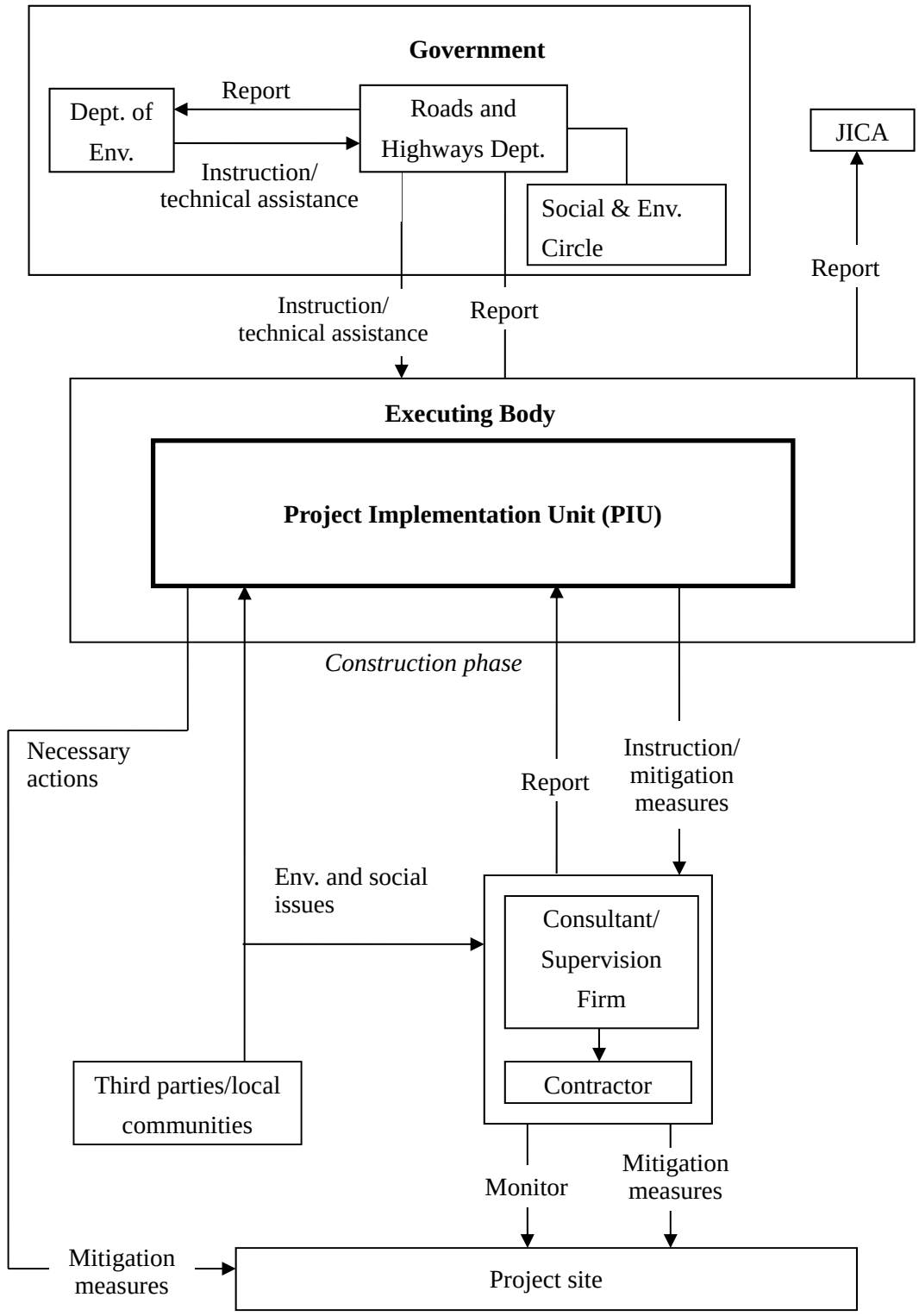
Item of Impact	Mitigation Measures	Implementing Organization	Responsible organization
Noise Level	- Monitoring and review the result by RHD. - Where noise level exceeds the environmental standards, provide hump/planting strip.	Local RHD	RHD
Poor	- Monitor by the External Monitoring Consultant	External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

Source: JICA Survey Team

11.1.9 Environmental Management Plan (EMP)

(1) Institutional Framework

The institutional framework for environmental management and monitoring is presented in Figure 11.1.6.



Source: JICA Survey Team

Figure 11.1.6 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-II Form of Monitoring.

Table 11.1.37 Environmental Monitoring Plan in Construction Stage

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

Source: JICA Survey Team

Table 11.1.38 Environmental Monitoring Plan in Operation Stage

No.	Environmental Indicator	Parameters/ Units	Means of Monitoring	Frequency	Implementing Organization	Responsible Organization
1	Noise Level	Monitor the (dB) caused traffics	Monitoring by tool	Once in a year	Local RHD	RHD
2	Poor	Comparison with the income before and after the resettlement	By the third party	Once in a year and twice.	External Monitoring Consultant	RHD
3	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 11.1.39 and Table 11.1.40. The detailed environmental management costs for three Sections [A (5 bridges), B (8 bridges and 7 box culverts), C (4 bridges)] are shown in Executive Summary of EIA main reports and Addendum No.1.

Table 11.1.39 Estimates for Environmental Monitoring Costs Borne by Contractor

	Description of items	Cost (thousand Tk)	Remarks	Cost borne by
A	Waste/Air/Water/Soil Quality	530	Personnel expense is involved in the Contract	Contractor
B	Dust Control	1,400	Personnel expense is involved in the Contract	Contractor
C	Noise Level	720	Personnel expense is involved in the Contract	Contractor
D	Water supply	725	Personnel expense is involved in the Contract	Contractor
E	Sanitation	330	Personnel expense is involved in the Contract	Contractor
F	Turf	1,200		Contractor
Total sum		4,905		

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

Table 11.1.40 Estimates for Environmental Monitoring Costs Borne by RHD

No	Description of items	Cost (million Tk)	Cost borne by
I	ARP Implementing Agency	9.50	RHD
II	External Monitoring	2.90	RHD
Total sum		12.40	

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

11.2 Land Acquisition and Resettlement

11.2.1 Necessity of Land Acquisition and Resettlement

All bridges that are to be replaced will be replaced with new bridges in locations adjacent to the existing bridges with new approach roads being constructed, and this is why new land acquisition and resettlement are required.

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.

The prepared ARP was submitted to RHD on 5th November, 2015 requesting to proceed for approval by MORTB. Accordingly, MORTB issued an ARP approval letter on 20th December, 2015.

For more information, the ARP Report, Annex-I: TOR for ARP Implementation, Annex-II: ARP Implementation Monitoring Format, Annex-III: TOR for External Monitoring Consultant, Annex-IV: Minutes of SHM, Annex-V: Section-wise Detail, Annex-VI: Survey Format of Census, Annex-VII: Survey Format of Inventory of Losses and Annex-VIII: Compensation Package, Entitlements and

Modes, and Addendum No.1 are attached separately. Addendum No.1 includes the resettlement cost budgeted for implementation of 7 box culverts under Section B.

11.2.2 Legal Framework of Land Acquisition and Resettlement

The current legislations governing land acquisition for Bangladesh are 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 an approved procedure and in addition to that pays an additional 50 percent (as premium) on the assessed value as the market price established by the Land Acquisition Officer (LAO) which still remains much below the replacement value. The 1994 amendment made provisions for payment of compensation for crops to tenant cultivators. The Ordinance, however, does not cover project-affected persons without titles or ownership records, such as informal settlers/squatters, occupiers, and informal tenants and lease-holders (without documents) and does not ensure replacement value of the property acquired. The act has no provision for resettlement assistance or 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 an 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 receipts or receipt for the 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, funded by ADB, has prepared a draft national policy on involuntary resettlement that is consistent with the general policy of the Government that the rights of those displaced by a 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, or ethnicity, but it is yet to be enacted.

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

11.2.3 Gap between JICA's Guidelines and related Ordinances in Bangladesh

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

Table 11.2.1 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 in this regard, 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 of 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 are no provisions for compensation to the non-titled residents in the Bangladesh ordinance, while JICA's Guidelines acknowledge all affected persons whether legally residing or not, are eligible for compensation.	Compensations are proposed even for non-titled affected people that will provide them with: - 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 pre-project levels.	Not specific for maintaining living standard of affected people the same or above pre-project levels.	There is no provision for maintaining living standard of affected people at the 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 at 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 waged 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 which are usually much lower than market price	There are no provisions in the Bangladesh ordinance, while JICA's Guidelines require that the replacement cost be provided for compensation.	The resettlement plan addresses all these issues and spells out a mechanism to fix the replacement cost by having an independent evaluator (committee) who will be responsible for deciding the replacement costs. Compensation based on full replacement cost shall be agreed with RHD.

No.	JICA's Guidelines (2010)	GOB's Acquisition and Requisition of Immovable Property Ordinance (ARIPO) of 1982	Gaps Between JICA's Guidelines and ARIPO	Proposed Gap Filling Measures
5	Compensation and other kinds of assistance must be provided prior to displacement	Payment is made at a predetermined time, regardless of whether it is before or after the construction starts	Compensation and other assistance are made regardless of whether it is before or after construction, while JICA Guidelines requires to pay compensation prior to relocation	The resettlement plan addresses all these issues and spells out a mechanism for all the compensation to be paid prior to possession of the acquired land and prior to displacement
6	For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public.	There is no provision for the formulation of a RAP or public hearings. The Deputy Commissioner contacts the land owner through the land Acquisition Officer (LO), and if the landowner has no objection, confirms the compensation amount etc. and proceeds.	There is no provision for preparation of resettlement action plan that describes all features of resettlement requirements and discloses them to the public.	The Abbreviated Resettlement Plan (ARP) prepared for this project with all features of resettlement requirements and mechanism of disclosure to the public is an 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 has 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 are all involved.	The ARP/resettlement plan for the project has been prepared following a consultation process which involved 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 consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people	There are 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 the local language and by following a participatory process with questions and explanations 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 are no provisions in Bangladesh ordinances, while JICA Guidelines recommend participation of affected people in planning, implementation and monitoring of the 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	If the AP have objections regarding the compensation amount, the AP should protest and entrust the matter to an Arbitrator. If the AP has to appeal against the Arbitrator's decision, then the AP should file a law suit in the court and wait for the decision.	The laws of Bangladesh states depend on the Arbitrator and court cases, while JICA's Guidelines recommend establishing an appropriate grievance redress mechanism for amicable settlement to minimize legal confrontation.	The resettlement plan prepared for this project has made a provision for setting up a 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 or 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 in the 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 an inventory of losses. Video filming has also been done for the affected properties.

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
12	Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), 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 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.
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. Attempts 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 the 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.	The 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 a project that entails land acquisition or involuntary resettlement of fewer than 200 people, an 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 to be fewer than 200 at each project bridge.

Source: JICA Survey Team

11.2.4 Census and Socio-economic Survey

(1) Methodology

The census and a socio-economic survey was carried out through June and July 2015 to provide requisite details on the Project Affected Units (PAUs) to further assess the magnitude of likely impacts and to identify measures for mitigation of adverse impacts. The survey included (i) full census and socioeconomic survey with structured questionnaire and inventory of losses (Annex- VI and VII), (ii) surveys for valuation of lost assets through structured questionnaire; (iii) Video filming of the affected properties and (iv) Community based public consultation etc. The survey identified the households, commercial and business enterprises, land owners/occupiers, sharecroppers, tree losers, squatters, tenants and community properties on project right of way.

The socioeconomic survey collected a wide range of data, for example, demography, age/sex distribution, education, occupation, income/poverty data, types of businesses, types and ownership status of affected structures and other assets.

(2) The Project Area

The selected 24 bridges are identified in in three sections i.e. Section A, Section B, and Section C and located in different parts of the country. A total of 5 bridges are located in Section A and covers Dhaka –Kolkata (India) road in south west region of the country, 8 bridges in Section B, Ramgarh – Baraiyarhat road in the southeast region of the country and 4 bridges in Section C, Chittagong – Cox's Bazar roads are in the south east region of Bangladesh. Distribution of sub-project wise number of bridges and project affected units are shown in the Table11.2.2.

Table 11.2.2 Sub-project Wise Number of Bridges and Project Affected Units

Serial No.	Bridge ID	Number of Residence lose Households (PAHs)	Number of Residence lose People (PAPs)	Affected Residence, Residence/Commerce (category 1)	Affected Agriculture/Others (category 2)
Section A					
Jhikotgacha	N-706_14b	30	164	0	4,512
Garakola	N-805_24a	6	36	0	148
Tularampur	R750_25a	5	14	0	1,339
Hawai khali	Z7503_5a	0	0	1,373	1,679
Kalna	New bridge	39	183	6,554	231,677
	Sub-total	80	397	7,927 m^2	239,355 m^2
Section B					
B2,B3[14]	R-151_4a/4c	13	78	1,206	5,392
B9	R-151_14a	0	0	0	3,567
B12	R-151_16a	5	29	269	1,761
B13	R-151_16c	0	0	0	3,115
B16	R-152_Sa	8	57	648	2,825
B18	R-152_7a	1	5	70	4,271

[14] B2 and B3 are combined as sub-project because they are same village.

Serial No.	Bridge ID	Number of Residence lose Households (PAHs)	Number of Residence lose People (PAPs)	Affected Residence, Residence/Commerce (category 1)	Affected Agriculture/Others (category 2)
B25	R-152_14a	7	43	769	4,366
	Sub-total	34	212	2,962 m^2	25,297 m^2
Section C					
C8	N-1_257a	3	10	422	5,604
C12	N-1_272a	1	9	149	14,223
C13	N-1_279a	20	67	1,061	3,948
C26	N-1_328a	11	60	1,545	410
	Sub-Total	35	146	3,177 m^2	24,185 m^2

Source: JICA Survey Team

The total of 149 households are identified within the Corridor of Impact (COI) and 755 people have to be displaced, accordingly. Out of the total 302,903 m^2 of affected area, 14,066 m^2 residential or residential/commercial properties. In total 477 households are going to lose their income as wage earners in the business and commercial enterprises affected by the project. In total 33,172 m^2 is going to be affected by this project.

(3) Profile of Affected Households

Number of affected households and gender is presented Table 11.2.3 and number of affected male and female population by section is presented in Table 11.2.4, respectively. Out of 683 affected households, 656 (96.05 %) are male and 27 (3.95) are female.

Table 11.2.3 Affected Household Heads by Section and Gender

SEX	Affected Household Heads by Section			Total	Percentage
	Section A	Section B	Section C		
Male	396 (97.3%)	133 (95.0%)	127 (93.4%)	656	96.05
Female	11 (2.70%)	7 (5.00%)	9 (6.62%)	27	3.95
Total	407 (100%)	140 (100%)	136 (100%)	683	100.00

Source: Census & Socioeconomic survey, June 2014

Table 11.2.4 presents that out of the total affected population, 2,205 (55.52%) are male and 1,752 (44.28%) are female.

Table 11.2.4 Number of Male and Female Population by Section

Section	Total HH	Population				Total Population
		Male	Percentage (%)	Female	Percentage (%)	
Section A	407	1,340	56.76	1,021	43.24	2,361
Section B	140	475	55.82	376	44.18	851
Section C	136	390	52.35	355	47.65	745
Total	683	2,205	55.72	1,752	44.28	3,957

Source: Census & Socioeconomic survey, June 2014

Table 11.2.5 presents that 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, in another word whose income is less than Tk 60,000/year 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 3.66% households earn less than Tk 60,000/year.

Table 11.2.5 Poverty Level and Annual income of head of the households by Section

Section	Section A		Section B		Section C		Total	
Income	No	%	No	%	No	%	No	%
less than 15,000	0	0.00	0	0.00	0	0.00	0	0
15,001-30,000	4	0.98	0	0.00	0	0.00	4	0.59
30,001-45,000	2	0.49	0	0.00	3	2.21	5	0.73
45,001-60,000	9	2.21	3	2.14	4	2.94	16	2.34
60,001-75,000	6	1.47	3	2.14	3	2.21	12	1.76
75,001-90,000	11	2.70	1	0.71	0	0.00	12	1.76
90,001-105,000	12	2.95	0	0.00	1	0.74	13	1.90
105,001-120,000	33	8.11	16	11.43	24	17.65	73	10.69
120,001-135,000	6	1.47	0	0.00	0	0.00	6	0.88
135,001-150.000	10	2.46	2	1.43	6	4.41	18	2.64
150,001-165,000	2	0.49	0	0.00	0	0.00	2	0.29
165,001-180,000	30	7.37	17	12.14	15	11.03	62	9.08
180,001-195,000	2	0.49	0	0.00	0	0.00	2	0.29
more than 195,001	280	68.80	98	70.00	80	58.82	458	67.06
Total	407	100.00	140	100.00	136	100.00	683	100.00

Source: Census & Socioeconomic survey June 2015

11.2.5 Eligibility Policy and Entitlement Matrix

All APs will be entitled to compensation and resettlement assistance based on the severity (significance) of the 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 to be 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 disclosure of entitlements and consultation meeting with the stakeholders which were held on 21st of August at Kalna and 1st of September at Jhikorgacha for Section A, from 23rd to 25th of August for Section B and on 26th of August for Section C to those staying on public/private lands. The absence of legal title will not bar APs from compensation and/or assistance, as specified in the Entitlement Matrix (Table 11.2.6).

The Entitlement Matrix has been prepared based on results of the census and socioeconomic survey (SES) conducted from 8th July for Section A, from 16th June for Section B and from 17th August for

Section C, respectively. 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 for the lost assets, and various resettlement benefits. Cash compensation under law (CCL) for lost assets (land, trees, structures and 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 the ARP Implementing Agency.

The Entitlement Matrix has unanimously agreed with PAPs at 2nd round SHM and it is going to be endorsed by RHD and approved by MORTB.

Table 11.2.6 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, ponds, 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 %for agricultural, fish ponds, ditches, etc. and @ BDT 200 % 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 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

Item No.	Type of loss	Entitled Persons (Beneficiaries)	Entitlement (Compensation Package)	Implementation issues/Guidelines
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 3 years 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 trees, 2 timber type and 1 medicinal tree) free of cost will be distributed among the households losing trees.
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 @ 12.50% of the replacement value of main structure iii. Reconstruction grant @ 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. 5000.00 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
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. 500 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. 3,000 for affected poor, 5000 for 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

Item No.	Type of loss	Entitled Persons (Beneficiaries)	Entitlement (Compensation Package)	Implementation issues/Guidelines
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, June 2015

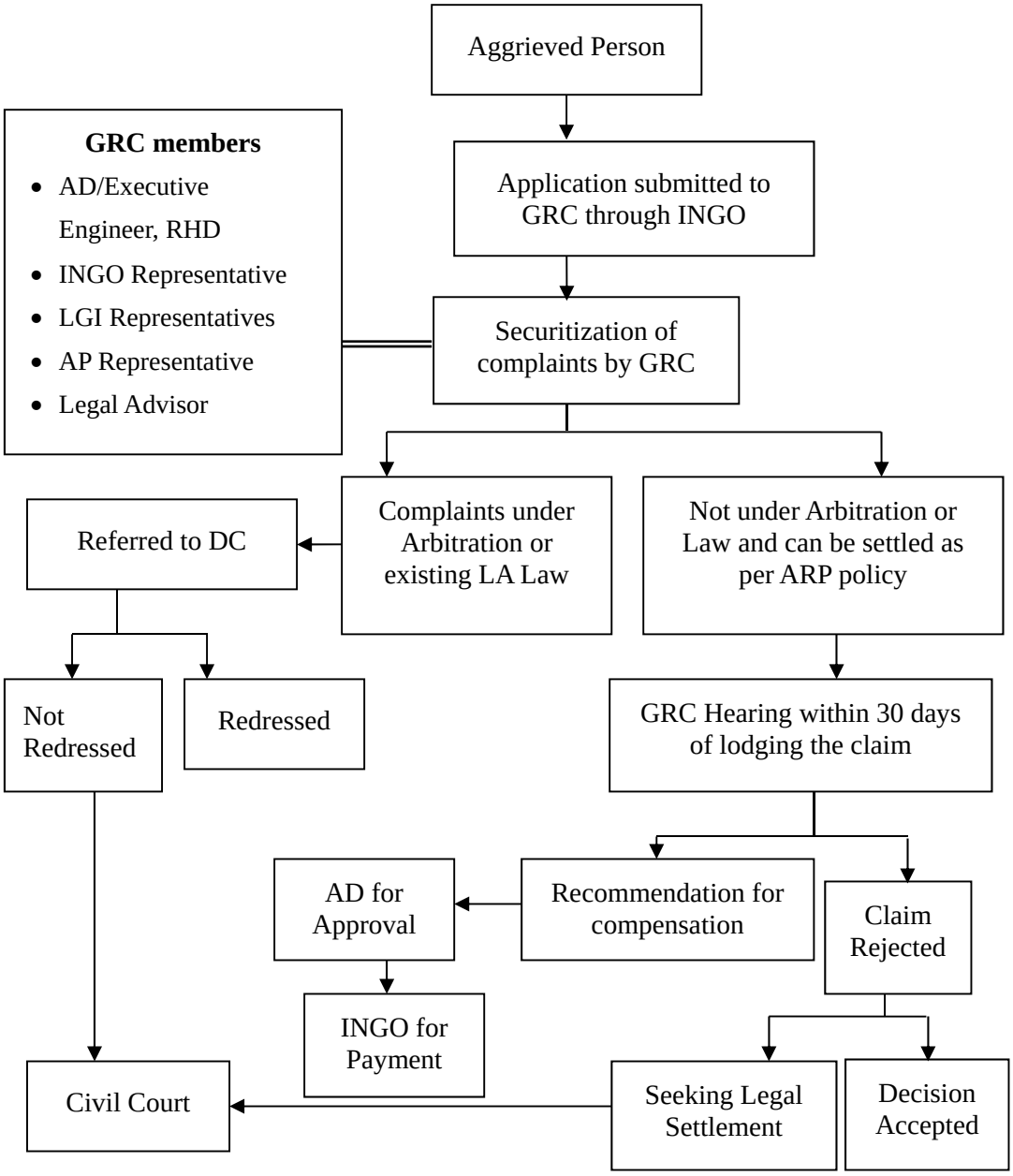
11.2.6 Grievance Redress Committee

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 be 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 to 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 a 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 11.2.1.



Source: JICA Survey Team

Figure 11.2.1 Grievance Redress Mechanism

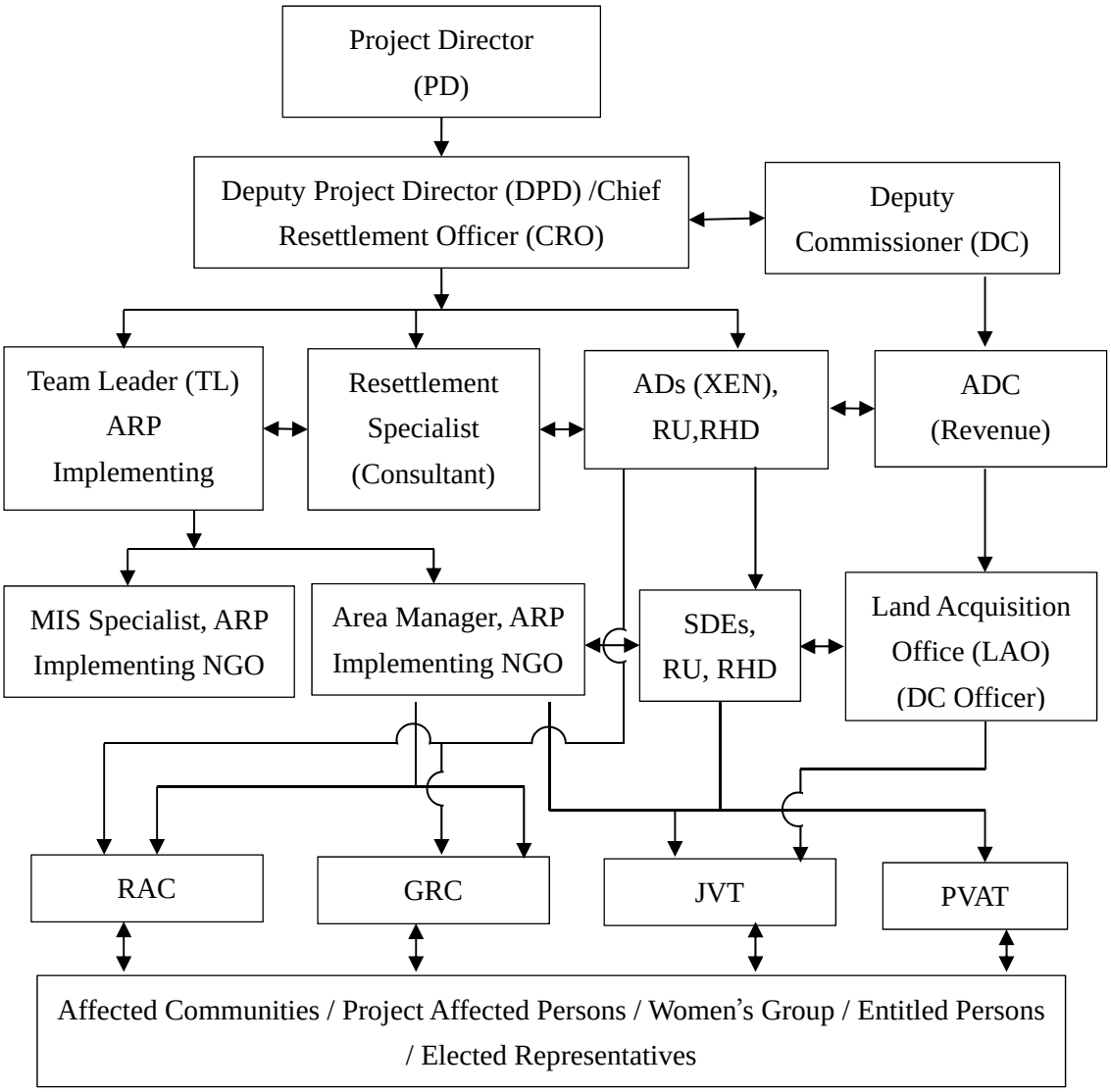
11.2.7 Implementation Organization

(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 an 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 the Joint Verification survey by JVT for both title and non-title holders.
- To assist the APs in preparing a 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 the union based resettlement advisory committee (RAC) to involve the local communities and APs in the implementation process.
- To prepare payment debit vouchers and other documents and disburse account payee checks to the APs.

The implementation organizations and hierarchy involved in the implementation process are shown in Figure 11.2.2.



Source: JICA Survey Team

Figure 11.2.2 ARP implementation Organogram

(2) Women's Groups in Resettlement Process

In accordance with the result of the focus group discussions (FGD) which targeting female participation, 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 focus 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 the implementing NGO will identify the needs of female APs for income restoration approaches and implementation of the income restoration component of the ARP. Thus, women have been and will be consulted during the whole process of Resettlement.

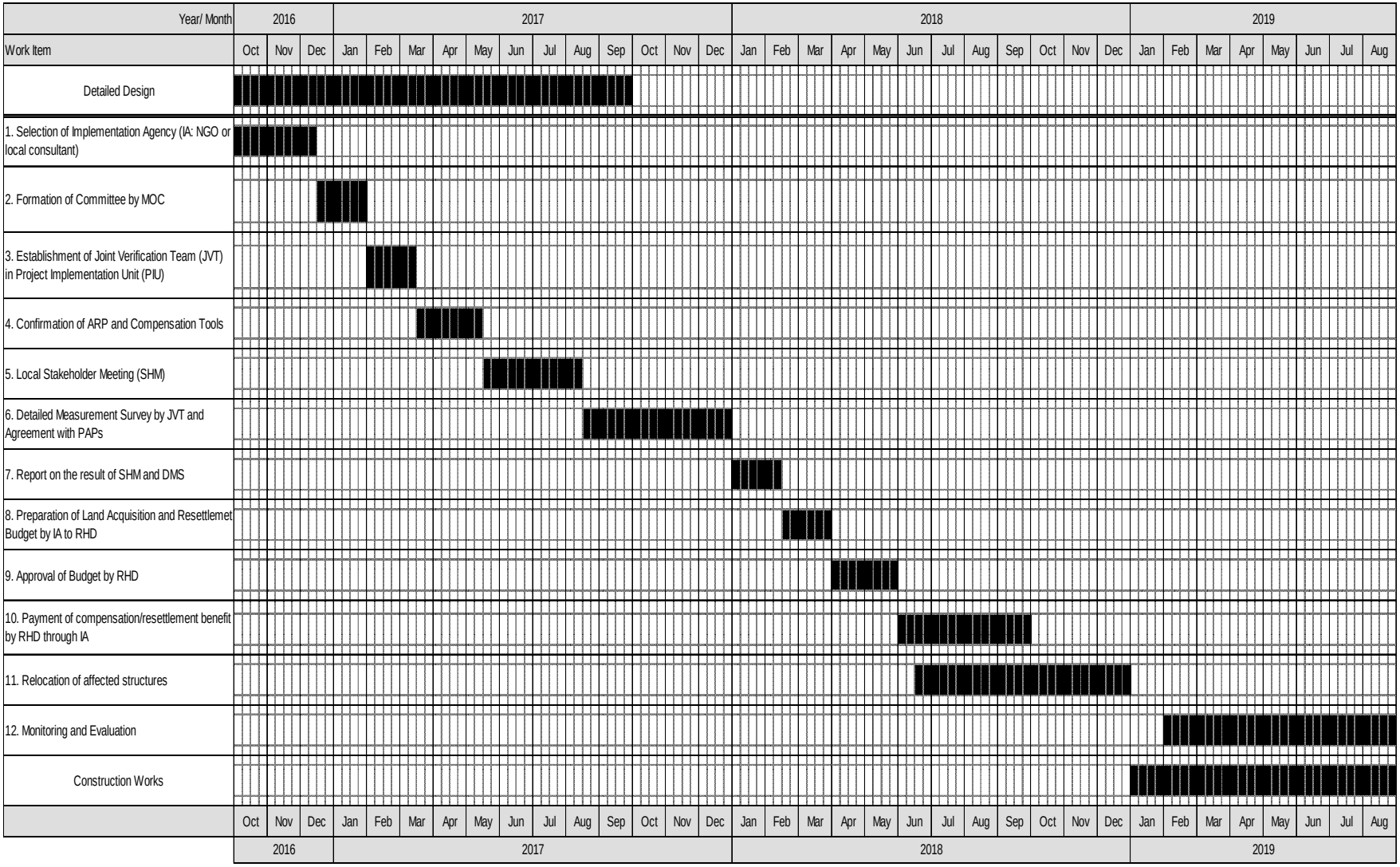
(3) Appointment of Implementing Non-Government Organization (INGO)

The Consultant will appoint an experienced NGO through the standard procurement system in consultation with RHD. This NGO will be appointed for implementation of the ARP on the field level in coordination with DC, RHD and National Resettlement Consultant (NRS) in accordance with the TOR for ARP-IA.

11.2.8 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 January 2019 to December 2020 is devised below.



Source: JICA Survey Team

Figure 11.2.3 Implementation Schedule

11.2.9 Resettlement and Compensation Costs & Budget

The total estimated budget for implementation of the Abbreviated Resettlement Plan is BDT 1,720,661,525 which is shown in Table 11.2.7. It is to be noted that the estimated budget includes 20% increase of land price and land related costs. The reason behind this consideration is that the land and land related costs can spiral up with the implementation of the Project. This consideration is also cited in the section of "Special Consideration for Land Acquisition Budget" under Executive Summary of ARP. The detailed resettlement costs are shown in ARP and its Addendum No.1 which are approved by MORTB.

In addition to the above mentioned cost, it is necessary to consider 32,355,000 (BDT) at Benapole and 7,470,000 (BDT) at Ramgarh for the installation of 'Axle Load Control Stations'.

Other costs have been estimated at current market price for the year 2015 with necessary supplements for replacement cost, physical assets and businesses with assessed replacement cost for the same year, and additional assistance for loss of income and vulnerabilities as per the resettlement policy framework. This budget is indicative of outlays for different expenditure categories assessed by census and IOL. The budget will be updated and adjusted once the land acquisition boundaries are finalized and the Government adopts a price of land and other assets based on the recommendations of the PVAC prior to implementation.

Table 11.2.7 Summary of Land Acquisition and Resettlement Cost

(unit: BDT)

Sl. No.	Head of Budget	Section A	Section B	Section C	Total
1. Compensation Cost for Lost Properties					
a1	Price of Residential/Commercial Land	80,826,672	11,916,054	36,956,489	129,699,215
a2	Price of Agriculture/Others land	244,314,740	71,917,861	194,889,211	511,121,812
a	***Price of Land***	**325,141,412**	**83,833,917**	**231,845,699**	**640,821,028**
b	Stamp duty and registration fee (10.5%)	34,139,848	8,802,561	24,343,798	67,286,208
c1	Price of primary Structure	258,825,222	108,356,838	185,181,866	552,363,926
c2	Price of secondary Structure	914,836	281,403	558,578	1,754,817
c	***Price of Structure***	**259,740,058**	**108,638,241**	**185,740,444**	**554,118,743**
d	Price of Trees	87,032,448	51,528,420	15,802,128	154,362,996
Sub-Total of 1		**706,053,766**	**252,803,139**	**457,732,070**	**1,416,588,975**
2. Resettlement Benefits		90,934,607	36,959,657	52,397,319	180,291,584
3. Social Development Fund for Livelihood Restoration and Training		117,000	58,500	72,000	247,500
4. Operation Cost for External Monitoring		1,150,000	750,000	1,000,000	2,900,000
5. Contingency for unforeseen issues @ 5% of Total Budget (Item 1-2)		39,849,419	14,488,140	25,506,469	79,844,028
6. Administration Cost of DC on Compensation (Item a, b and c) @3%		18,570,640	8,960,900	13,257,898	40,789,438
Total Estimated Budget		**856,675,432**	**314,020,336**	**549,965,757**	**1,720,661,525**

Source: ARP September, 2015

11.2.10 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 11.2.8 shows the potential monitoring indicators which will be reported. And, Table 11.2.9 shows the format for ARP implementation monitoring which will be filled by RU quarterly.

Table 11.2.8 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						

Component	Total (unit)	Completed (unit)	Cumulative Achievement Total (unit)	Progress During Reporting Month (%)		Status & Remarks
				Target (%)	Achievement (%)	
Social Development Activities						
Grant for loss of wages						
Loss of business grant						
Business restoration grant						
Payment for indirect impact						
LIRP activities						

Source: ARP September, 2015

Table 11.2.9 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? 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, 2015

(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 Annex-III TOR for External Monitoring Consultant.

11.2.11 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 the Second Phase SHMs for eligibility of receiving resettlement benefits for the non-titled affected peoples.

(1) Meeting Phase I

In the initial stage of the project in June to August 2015, 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 11.2.10.

Table 11.2.10 Stakeholders Meetings in Phase I

Sl. No.	Dates of stakeholder Meetings	Type of Participants & Methodology	Issues Discussed	Outcome of the discussion
1	During conducting survey in June in Section B, June, July and August in Section A and in August in Section C.	A total of 35 stakeholders meetings were held in 34 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. Women groups were consulted separately	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, including women group should be employed during construction of the new bridge irrespective of gender; f. Construction of new bridge by widening on both side is appreciated ; g. Proposed Bridge location should avoid the densely populated areas, especially the market area; 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, 2015

	
Heako Bazar Bridge	Anandobabur Pool,60
Section B	Section B
	
Jhikorgacha Bridge	Jhikorgacha Bridge
Section A	Section A
	
Patiya Bridge	Patiya Bridge
Section C	Section C

Source: ARP September, 2015

Figure 11.2.4 Photos of SHM

(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 34 stakeholders consultation meetings (Section A 5, Section B 25 and Section C 4) were held for the period from July through September 2015 covering affected communities in all bridge locations. Stakeholders were informed about the meeting time and location ahead of time through personal contact and over telephone. Local people were also called by announcing in person and well as instantly through using hand microphone.

Process of land acquisition, DC's payment procedure, donor's policy on involuntary resettlement, entitlements of the affected PAUs and vulnerable people, cut-off-date for listing property and probable resettlement benefits, etc. were discussed in the meetings.

The ARP design, compensation, relocation options, benefits and adverse social impacts were discussed with the affected persons and their community. Stakeholders were asked for their views on the project overall as well as more specific discussion about their perception on land acquisition process, compensation process, relocation requirements, and views on alternative options. Women and other vulnerable groups were also consulted concerning the specific project impacts and their livelihood aspects. Detail stakeholder meeting in each bridge location is presented in Annex-IV.

The inputs from the stakeholders meetings have been used to develop measures and principles for mitigation of loss on APs. A summary of consultation meetings with affected people and other stakeholders are described in Table 11.2.11.

Table 11.2.11 Stakeholders Meetings in Phase II

Sl. No.	Dates of holding Meetings	Type of Participants & Methodology	Issues Discussed	Outcome of the discussion
1	During conducting survey from July through September 2015 in all the sections (A, B and C)	A total of 34 stakeholders meetings were held in 34 bridge locations. People attended the meeting including farmer, homestead 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. Women groups were consulted separately	Issue based discussion was held on community people's perception, attitude, needs and aspiration from the project. Following issues were discussed along with their raised issues: - Impact (positive and negative) of the project & mitigation measures against negative impact, - Policy of compensation and resettlement grants for land, crops, houses 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 for indirect EPs and notice under section 3 is for land owners. - Training and cash grant for vulnerable households, etc. - Gender issues, especially the scope of work for women in project civil work.	a. Entitlements of the affected people and cut-off-date for listing of the lost properties are known to the people b. Land price should be fixed on open market rate and compensation should be paid at their door step before displacement; c. Proper compensation for land, crops, 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. Women of many locations showed interest to work during project implementation. g. Facilities for using river water will be kept undisturbed for the community h. Training on some income generating activities should be provided to the poor. i. People know their right and responsibilities at the initial stage of the project by FGD, consultation, information campaign, etc.

Source: ARP September, 2015

12. PRELIMINARY COST ESTIMATES

12.1 Introduction

In this chapter, the civil cost is estimated for Project bridges under Section A, B and C which are selected in Chapter 3 for preliminary design. In addition, the preliminary design of Ramgarh-Baraiyarhat road section under Section B is carried out, which can be referenced when further road improvement plan will be undertaken. And in Chapter14 “Implementation Plan”, the project cost for the finally selected bridges under JICA-ODA loan is summarized. In this Chapter, the financial plan with funding schedule for eligible portion by GOJ and non-eligible portion by GOB are shown as well.

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

12.1.1 General Conditions of Cost Estimation

(1) Term of Cost Estimation

The unit rates of material, equipment, labor and other costs adopted for this cost estimation are based on November 2015.

(2) Exchange rate

The exchange rate adopted for this cost estimate is the prevailing average rate of exchange in November 2015 (adopted by JICA as a General Guideline of Appraisal for FY 2015) as shown hereunder:

US$ 1 = Yen 120.2
US$ 1 = BDT 77.8
BDT 1 = Yen 1.55

(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 by its unit price which is derived from basic unit rates of major items. The basic unit rate excludes contractor’s overhead, profit, Value Added Tax (VAT), income tax, physical contingency and price escalation etc. The quantities of each bridge/road component are calculated in accordance with

preliminary design carried out for each bridge location and for some standard bridge structural designs.

2) Consulting Services

The consulting services are determined on the basis of man-months (national and international levels) required to implement the project and TOR prepared for consulting services. The man-months are determined based on expected manpower required for the project implementation stage (D/D, tender assistance and C/S). The consulting service cost is shown elsewhere in Chapter 14.

3) Physical Contingency

The physical contingencies are set at 5.0 % for the civil work on the basis of only the preliminary design having been conducted, and 5.0 % for the consultant service cost.

4) Price Escalation

The price escalations shall follow the JICA guideline for loan calculation, and are set at 6.1 % for local currency and 1.8 % for foreign currency in accordance with other ODA-loan projects in Bangladesh.

(4) Non-eligible portion covered by GOB

1) Land Acquisitions and Resettlement Cost

GOB must cover the following costs at the preconstruction stage.

Resettlement of Houses and Public/ Private Structures
Relocation of Utilities
Land acquisition cost
Administration Cost

The administration cost incurred for establishment of the organization under RHD is set at 5.0% of the sum of construction cost and consultant service costs.

2) Value Added Tax (VAT)

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.

3) Import Tax (IT)

An average import tax is estimated as 30.0 % which will be utilized for the products to be imported into Bangladesh.

4) Interest during Construction

The interest during construction calculated by JICA guideline shall be non-eligible as a GOB portion.

12.2 Civil Work Cost

12.2.1 Unit Rate of Major Items

In order to derive the unit rate of major items for the Project, a unit rate analysis is carried out on the basis of regulations followed for a similar project, WBBIP as well as RHD's regulation (Schedule of Rates-2011). The labor, material, equipment rental and other costs to formulate the unit rates of major items are determined from current market price in Bangladesh. Moreover, the unit rates of steel works, particularly steel arch section of Kalna main bridge, are determined from international market research.

Table 12.2.1 Basic Unit Rate of Major Items for Civil Works

Item no.	Description	Unit	Total unit cost	Rate		
				Local	Foreign ratio	Foreign
			(BDT)	(BDT)		(USD)
Bridge Superstructure						
1	Bituminous Wearing Course (62mm)	sq.m	1,106	656	41%	5.78
2	Concrete, Class A3-2 (Side walk, Railing)	cu.m	12,625	6,699	47%	76.17
3	Concrete, Class A3-4 (footpath)	cu.m	11,406	5,559	51%	75.15
4	Concrete, Class A2-2 (Deck slab)	cu.m	17,590	11,314	36%	80.67
5	Concrete, Class A4 (precast formwork)	cu.m	11,114	5,229	53%	75.64
6	High yield deformed reinforcing bars (fy=400MPa)	ton	86,067	49,031	43%	476.04
7	Concrete, Class A2-2 (Diaphragm, Cross beam)	cu.m	17,590	11,314	36%	80.67
8	Concrete, Class A1 (PC girder)	cu.m	21,913	16,178	26%	73.72
9	Pre-stressing strands for PC girder	ton	305,209	78,946	74%	2,908.26
10	Steel works (SM400, SM490Y, SBHS500)	ton	385,578	35,053	91%	4,505.46
12	Steel cable works	ton	2,026,148	184,195	91%	23,675.49
11	H.T.Bolt	ton	296,313	26,938	91%	3,462.40
12	Erection of Arch	ton	195,938	17,813	91%	2,289.52
13	Elastomeric bearing for PCG	each	564,845	54,237	90%	6,563.09
14	Elastomeric bearing for Nielsen Arch	each	13,515,391	1,228,672	91%	157,926.98
15	Expansion joint	m	98,445	11,897	88%	1,112.44
16	Expansion joint for main bridge (Kalna)	m	739,249	32,388	96%	9,085.61
17	Bridge draining	m	2,785	2,785	0%	0.00
Bridge Substructure including Foundation						
18	Excavation and Backfill	cu.m	639.00	331	48%	3.96
19	Sand backfill for structure	cu.m	1,729	1,729	0%	0.00
20	Concrete, Class A2-2 (Abutment)	cu.m	17,590	11,314	36%	80.67
21	Concrete, Class A2-1 (Pier head, column)	cu.m	17,699	11,402	36%	80.94
22	Concrete, Class A2-2 (Pile cap)	cu.m	17,590	11,314	36%	80.67
23	Drilling of pile (Dia 1.2m)	lm	6,731	3,547	47%	40.93
24	Bored pile A3-1 (Dia 1.2m)	cu.m	13,609	7,742	43%	75.41
25	Loading test (Dia 1.2m)	L.S	3,894,602	2,686,203	31%	15,532.11
26	Drilling of pile (Dia 1.5m)	lm	8,414	4,434	47%	51.16
27	Bored pile A3-1 (Dia 1.5m)	cu.m	21,264	13,495	37%	99.86
28	Loading test (Dia 1.5m)	L.S	3,894,602	2,686,203	31%	15,532.11
29	Cofferdam by sheet pile	m2	8,754	2,020	77%	86.55
30	Temporary access bridge	m	750,000	750,000	0%	0.00

Item no.	Description	Unit	Total unit cost	Rate		
				Local	Foreign ratio	Foreign
			(BDT)	(BDT)		(USD)
Approach road/Access road (Kalna)						
31	Embankment fill	cu.m	470	411	12%	0.75
32	Sub-base	cu.m	7,220	7,220	0%	0.00
33	Aggregate base	cu.m	7,703	7,626	1%	0.99
34	Bituminous binder course	cu.m	18,562	14,660	21%	50.15
35	Bituminous wearing course	cu.m	18,234	14,036	23%	53.96
36	Soft soil treatment	cu.m	3,210	3,210	0%	0.00
37	Median	m	5,142	5,142	0%	0.00
38	Lane marking	m	102	102	0%	0.00
39	Street lighting _2-faces	each	50,083	50,083	0%	0.00
40	Street lighting _1-faces	each	56,991	56,991	0%	0.00
41	Guard rail	m	6,073	6,073	0%	0.00
42	Site cleaning	sq.m	35	35	0%	0.00
43	Sodding/embankment works	sq.m	282	282	0%	0.00
44	Scarify/remove Pavement	sq.m	68	0%	0%	0.00
45	Cement treated base course (t=15 cm)	sq.m	9,724	9,724	0%	0.00
46	Cement concrete pavement (t=25 cm)	cu.m	16,281	16,281	0%	0.00
Miscellaneous						
47	Box culvert (B3.0*H3.0)	lm	118,683	118,683	0%	0.00
48	Box culvert (B5.1*H6.0)	lm	403,522	403,522	0%	0.00
49	Box culvert (B2.0*H2.0)	lm	52,748	52,748	0%	0.00
50	Box culvert extension (B3.7*H3.7)	lm	180,530	180,530	0%	0.00
51	Box culvert extension (B4.3*H4.3)	lm	243,828	243,828	0%	0.00
52	Retaining wall (h=5m) for Kalna	lm	222,050	222,050	0%	0.00
53	Pile supported retaining wall (8-5m)	lm	715,643	715,643	0%	0.00
54	Retaining wall (h=5-3m)	lm	177,640	177,640	0%	0.00
55	Retaining wall (h=3-1m)	lm	88,820	88,820	0%	0.00
River training works						
56	Sand filled Geo-bag	each	386	386	0%	0.00
57	Gabion works	cu.m	10,000	10,000	0%	0.00
58	Riprap works	cu.m	3,000	3000	0%	0.00
59	Granular filter	cu.m	236	235.97	0%	0.00
60	Geotextile fabric	sq.m	1,000	1000	0%	0.00

Source: JICA Survey Team

12.2.2 Unit Price of Bridge Components

The bridge components are set as four major components which are listed as follows. The unit prices of bridge components are determined on the basis of the rate analysis carried out for standard PC-I girder bridges (17 types as shown in Table 12.2.2) and the obtained prices are applied for target bridges of the Project to estimate their civil cost as well.

i. Abutment
ii. Superstructure
iii. Pier
iv. Cast-in Place RC Pile

Table 12.2.2 Standard PC-I Girder Bridges taken into Consideration for Price Analysis

Sl. no.	Span (m)	Bridge width (m)	Sl. no.	Span (m)	Bridge width (m)
1	1 span (30),	W=11.3	10	3 span (30+30+30),	W=10.4
2	1 span (35),	W=11.3	11	3 span (35+35+35),	W=10.4
3	1 span (25),	W=13.4	12	3 span (40+40+40),	W=10.4
4	1 span (30),	W=13.4	13	3 span (45+45+45),	W=10.4
5	1 span (35),	W=13.4	14	3 span (30+30+30),	W=11.3
6	1 span (40),	W=11.3	15	3 span (35+35+35),	W=11.3
7	2 span (25+25),	W=11.3	16	3 span (40+40+40),	W=11.3
8	2 span (30+30),	W=11.3	17	3 span (45+45+45),	W=11.3
9	2 span (25+25),	W=13.4			
Total: 17 types of PC-I bridges					

The unit prices of above components are broken down into local currency (BDT) and foreign currency (USD). The obtained unit prices are summarized in Table 12.2.3. And the Contractor's overhead and profit (15%) is added to the total of each bridge component.

Table 12.2.3 Unit Prices for Bridge Components

PC-I girder Bridges (W=11.3m) excluding Kalna					
No.	Bridge Component	Unit	Currency	Unit price	Remarks
1	Superstructure	m^2	Local (BDT)	23,990	A function of new bridge area (length*width)
			Foreign (USD)	515	
2	Abutment	nos.	Local (BDT)	3,630,406	A function of bridge width. Standard abutment height is assumed as 5 m.
			Foreign (USD)	27,731	
3	Pier	nos.	Local (BDT)	4,505,325	A function of bridge width. Standard pier height is assumed as 10 m. If pier height more than 10m, unit cost is increased proportionally with pier height and 1.5 times maximum.
			Foreign (USD)	36,778	
4	Cast-in-Place RC pile	m	Local (BDT)	27,586	A function of pile nos. and total pile length for each bridge location
			Foreign (USD)	258	
5	Temporary bridge	m	Local (BDT)	266,025	A function of new bridge length
	Existing bridge demolition		Local (BDT)	85,128	
6.	Contractor's overhead and profit	%	Local (BDT)	15 % of total	Practice of WBBIP
			Foreign (USD)		

Source: JICA Survey Team

12.2.3 Civil Cost of Project Bridges/Culverts

(1) PC-I girder bridges (excluding Kalna)

Based on the unit prices of 4 bridge components, the civil cost of project bridges excluding Kalna under Section A, B and C is calculated and their breakdown according to structural components is shown in Table 12.2.4. Moreover, the civil cost of project bridges including approach roads is broken down into local currency (BDT) and foreign currency (USD). The combined cost in BDT is also shown in Table 12.2.5 for bridges.

(2) RC Box Culverts

As is mentioned in Chapter 4, Seven (7) Bridges under Section B are appraised to include under Project scope, which will converted into RC Box Culverts in place of existing bridges at the same location. Their civil cost mainly includes construction of box culvert and approach road, demolition of existing bridge, and construction of traffic diversion measure by temporary road and bridge. Their cost is also broken down into local currency (BDT) and foreign currency (USD) as shown in Table 12.2.6.

Table 12.2.4 Break Down of Civil Cost for PC-I Bridges (Excluding Kalna)

Exchange Rate 1 USD=77.80 BDT		New Bridge Inventory				Superstructure		Abutment		Pier		Pile		Temporary Br. & Demolish Existing Br.		Overhead and Others (15%)		Bridge Civil cost (Inc. Overhead)		
Sl. No	Bridge Name	Total Length (m)	Width (m)	Abut. Pile Length (m)	Pier Pile Length (m)	Local (BDT)	Foreign (USD)	Local (BDT)	Foreign (USD)	Local (BDT)	Foreign (USD)	Local (BDT)	Foreign (USD)	Local (BDT)	Foreign (USD)	Local (TK)	Foreign (USD)	Local (BDT)	Foreign (USD)	Comb. Total (BDT)
Section A (Excluding Kalna)																				
A1	Jhikorgacha Bridge	125	28.4	42	38	85,164,105	1,826,516	18,248,412	139,390	33,969,355	277,302	135,471,721.83	961,255.94	10,641,000	-	42,524,189	480,670	326,018,783	3,685,134	612,722,218
A2	Tularampur Bridge	100	20.8	39	30	49,898,968	1,070,184	13,365,034.24	102,088.71	16,585,976.08	135,396.35	54,290,044.31	508,384.02	8,512,800	-	21,397,923	272,408	164,050,747	2,088,461	326,533,018
A3	Hawai Khali Bridge	35	22.6	43		18,976,002	406,979	14,521,624	110,923.31	-	-	37,958,892.77	355,455.49	2,979,480	-	11,165,400	131,004	85,601,398	1,004,361	163,740,688
A5	Garakola Bridge	110	10.4	39	29	27,444,433	588,601	6,682,517.12	51,044.35	8,292,988.04	67,698.17	26,813,985.30	251,092.11	-	-	10,385,088	143,765	79,619,012	1,102,201	165,370,268
Section B																				
B2	Telipool Bridge	25	13.40	36	-	8,036,613	172,361	8,610,166.29	65,768.69	-	-	19,862,211.33	185,994.15	8,778,825	-	6,793,172	63,619	52,080,988	487,743	90,027,381
B3	Lakshmi Chara Bridge	40	13.40	59	-	12,858,580	275,778	8,610,166.29	65,768.69	-	-	32,551,957.46	304,823.75	14,046,120	-	10,210,024	96,956	78,276,848	743,326	136,107,628
B9	Kalapani Bridge-2	35	13.40	10	-	11,251,258	241,306	8,610,166.29	65,768.69	-	-	5,517,280.93	51,665.04	12,290,355	-	5,650,359	53,811	43,319,419	412,551	75,415,855
B12	Koilabazar Bridge	55	13.40	10	10	17,680,548	379,195	8,610,166.29	65,768.69	5,342,598	43,613	7,724,193.30	72,331.06	19,313,415	-	8,800,638	84,136	67,471,559	645,044	117,655,998
B13	Balutila Bridge	30	13.40	10	-	9,643,935	206,834	8,610,166.29	65,768.69	-	-	5,517,280.93	51,665.04	10,534,590	-	5,145,896	48,640	39,451,868	372,907	68,464,070
B16	Heako Bridge	25	13.40	38	-	8,036,613	172,361	8,610,166.29	65,768.69	-	-	20,965,667.52	196,327.16	8,778,825	-	6,958,691	65,169	53,349,962	499,626	92,220,850
B18	Chikon Chara Bridge	30	13.40	13	-	9,643,935	206,834	8,610,166.29	65,768.69	-	-	7,172,465.20	67,164.56	10,534,590	-	5,394,174	50,965	41,355,330	390,732	71,754,274
B25	East Baganbazar Bridge	50	13.40	20	20	16,073,225	344,723	8,610,166.29	65,768.69	5,342,598	43,613	15,448,386.59	144,662.12	-	-	6,821,156	89,815	52,295,533	688,582	105,867,198
Section C																				
C8	Patiya Bridge	55	22.60	50	46	29,819,432	639,538	14,521,624	110,923	9,010,650	73,557	59,365,942.77	555,915.86	4,682,040	-	17,609,953	206,990	135,009,642	1,586,924	258,472,310
C12	Mazar Point Bridge	60	22.60	34	29	32,530,289	697,678	14,521,624	110,923	9,010,650	73,557	39,614,077.05	370,955.01	5,107,680	-	15,117,648	187,967	115,901,968	1,441,080	228,017,957
C13	Sangu Bridge	215	20.80	37	27	107,282,782	2,300,896	13,365,034	102,089	50,587,227.04	412,958.86	116,636,948.58	800,810.82	18,302,520	-	45,926,177	542,513	396,639,473	4,159,267	720,230,459
C26	Mathamuhuri Bridge	310	20.80	29	21	154,686,802	3,317,571	13,365,034	102,089	62,197,410.30	507,736.30	112,957,390.87	746,604.07	26,389,680	-	55,439,448	701,100	466,599,037	5,375,100	884,781,781

Source: JICA Survey Team

Table 12.2.5 Civil Cost of PC-I Bridges with Approach Road (Excluding Kalna Bridge)

Exchange Rate 1 USD=77.8 BDT		New Bridge Inventory		Base Civil Cost							
				Bridge Civil Cost			Road Civil Cost		Civil Cost (Bridge+Road)		Section Total (BDT)
Sl. No.	Bridge Name	Total Length (m)	Width (m)	Local (BDT)	Foreign (USD)	Comb. Total (BDT)	Local (BDT)	Foreign (USD)	Local (BDT)	Foreign (USD)	
Section A (Excluding Kalna)											
A1	Jhikorgacha Bridge	125	28.4	326,018,783	3,685,134	612,722,218	133,022,464	137,433	459,041,247	3,822,567	2,045,861,011
A2	Tularampur Bridge	100	20.8	164,050,747	2,088,461	326,533,018	178,964,541	238,428	343,015,287	2,326,889	
A3	Hawai Khali Bridge	35	22.6	85,601,398	1,004,361	163,740,688	225,127,271	245,578	310,728,669	1,249,939	
A5	Garakola Bridge	110	10.4	79,619,012	1,102,201	165,370,268	174,571,329	224,438	254,190,340	1,326,639	
Section B (Excluding Box Culverts)											
B2	Telipool Bridge	25	13.40	52,080,988	487,743	90,027,381	125,601,708	38,594	177,682,695	526,336	1,213,313,184
B3	Lakshmi Chara Bridge	40	13.40	78,276,848	743,326	136,107,628	47,592,099	35,621	125,868,947	778,947	
B9	Kalapani Bridge-2	35	13.40	43,319,419	412,551	75,415,855	27,865,768	37,318	71,185,187	449,869	
B12	Koilabazar Bridge	55	13.40	67,471,559	645,044	117,655,998	26,980,071	29,003	94,451,630	674,047	
B13	Balutila Bridge	30	13.40	39,451,868	372,907	68,464,070	71,266,990	37,070	110,718,858	409,977	
B16	Heako Bridge	25	13.40	53,349,962	499,626	92,220,850	25,697,851	36,311	79,047,813	535,937	
B18	Chikon Chara Bridge	30	13.40	41,355,330	390,732	71,754,274	77,363,335	40,651	118,718,666	431,383	
B25	East Baganbazar Bridge	50	13.40	52,295,533	688,582	105,867,198	30,254,600	43,344	82,550,133	731,926	
Section C											
C8	Patiya Bridge	55	22.60	135,009,642	1,586,924	258,472,310	157,713,287	205,699	292,722,929	1,792,623	2,888,986,727
C12	Mazar Point Bridge	60	22.60	115,901,968	1,441,080	228,017,957	178,102,455	233,458	294,004,424	1,674,538	
C13	Sangu Bridge	215	20.80	396,639,473	4,159,267	720,230,459	222,017,012	247,740	618,656,484	4,407,007	
C26	Mathamuhuri Bridge	310	20.80	466,599,037	5,375,100	884,781,781	168,105,629	232,715	634,704,666	5,607,815	

Source: JICA Survey Team

Table 12.2.6 Civil Cost of Box Culverts under Section B

							Base Civil Cost										
		Culvert Inventory					Box section		Approach Road		Temporary Bridge & Bridge Demolition		Overhead		Culvert_Civil Cost		
Sl. No	Bridge Name	Culvert Type	Vent No.	Section (m×m)	Total Length (m)	Approach total (m)	Local (BDT)	Foreign (USD)	Local (BDT)	Foreign (USD)	Local (BDT)	Foreign (USD)	Local (BDT)	Foreign (USD)	Local (BDT)	Foreign (USD)	Equivalent (BDT)
B14	Fulchari	Box	2	B3.0×H3.0	16	200	3,797,856	-	56,924,003	39,198.87	17,571,478	-	11,744,001	5,880	90,037,338	45,079	93,544,460
B15	Heaku Bazar	Box	1	B3.0×H3.0	16	200	1,898,928	-	56,924,003	39,198.87	17,333,120	-	11,423,408	5,880	87,579,458	45,079	91,086,581
B19	Chikon Chara	Box	2	B3.0×H3.0	16	200	3,797,856	-	56,924,003	39,198.87	17,336,525	-	11,708,758	5,880	89,767,141	45,079	93,274,264
B20	Banglabazar	Box	1	B3.0×H3.0	16	200	1,898,928	-	56,924,003	39,198.87	17,346,740	-	11,425,451	5,880	87,595,122	45,079	91,102,245
B22	Borobil	Box	1	B2.0×H2.0	16	200	843,968	-	56,924,003	39,198.87	17,565,519	-	11,300,024	5,880	86,633,514	45,079	90,140,636
B23	Gadar Dokan	Box	2	B3.0×H3.0	16	200	3,797,856	-	56,924,003	39,198.87	17,395,263	-	11,717,568	5,880	89,834,690	45,079	93,341,813
B24	Bagan Bazar	Box	1	B3.0×H3.0	16	200	1,898,928	-	56,924,003	39,198.87	17,832,821	-	11,498,363	5,880	88,154,115	45,079	91,661,238
														Grand Total	**619,601,377**	**315,551**	**644,151,237**

Source: JICA Survey Team

(3) Kalna Bridge (PC-I + Steel)

As is already explained in Chapter 8, the main bridge of Kalna will be constructed with steel arch whereas the approach bridges are planned both sides with PC-I girder. The design quantities of each section are summarized in Table 8.3.4 (Chapter 8). The unit rates of major items (Table 12.2.1) are multiplied with design quantities so as to obtain their civil cost estimates. The summary of estimated costs for superstructure, abutment, pier, RC pile foundation, access road on both sides and river training is shown in Table 12.2.7.

Table 12.2.7 Break Down of Civil Cost for Kalna (Bridge and Access Road)

Exchange Rate 1 USD = 77.80 BDT	Approach Bridge (A1 side) 6-span		Main Bridge		Approach Bridge (A2 side) 6-span		Total	
	270 m		150 m		270 m		690 m	
	Cost(BDT)	Cost(USD)	Cost(BDT)	Cost(USD)	Cost(BDT)	Cost(USD)	Cost(BDT)	Cost(USD)
Bridge Section 21.90m								
Abutment	11,970,742	75,955			11,970,742	75,955	23,941,483	151,910
Pier	90,196,377	719,873	84,172,016	643,893	85,059,686	680,659	259,428,079	2,044,425
Superstructure	136,869,617	1,618,648	141,056,566	14,390,268	136,869,617	1,618,648	414,795,799	17,627,565
Pile	393,839,761	1,646,853	90,053,800	980,308	395,987,187	1,625,307	879,880,748	4,252,468
Contractor Overhead+Profit 15%	94,931,474	609,199	47,292,357	2,402,170	94,483,085	600,086	236,706,916	3,611,455
Total cost	727,807,970	4,670,529	362,574,740	18,416,639	724,370,316	4,600,656	1,814,753,026	27,687,823
a. Combined cost (BDT)	1,091,175,093		1,795,389,249		1,082,301,327		**3,968,865,669**	
Access Road	Length= 4,238m							
Earth Work							393,835,421	650,125
Pavement Work							746,104,568	1,080,285
Soft Soil Treatment 100m							40,125,000	-
Box Culvert							35,130,168	-
Retaining Wall							6,661,502	-
Miscellaneous							82,232,738	-
Contractor Overhead+Pro 15%							195613409.5	259,561
							1,499,702,806	1,989,971
b. Combined cost (BDT)							**1,654,522,576**	
River Training Works								
Sand filled Geo-bag							54,817,914	-
Gabion works							16,427,000	-
Riprap works							6,078,300	-
Granular filter							155,953	-
Geotextile fabric							4,405,800	-
Contractor Overhead+Pro 15%							12,282,745	-
c. Combined cost (BDT)							**94,167,711**	
Grand Total (BDT) Bridge+Road+River Training a+b+c							**5,717,555,957**	

Source: JICA Survey Team

13. PROJECT IMPLEMENTATION PLAN

13.1 Introduction

The target project is selected based on multi criteria and listed in Chapter 4. In this chapter, the contract package including project cost, the implementation organization and the implementation schedule are proposed in order to implement the project effectively and successfully.

13.2 Project Cost

13.2.1 Civil Work Cost

The civil work cost is shown in Table 12.2.5 and 12.2.6.

13.2.2 Land Acquisition and Resettlement Cost

The land acquisition and resettlement cost are shown in Table 11.2.7.

13.2.3 Contract Package

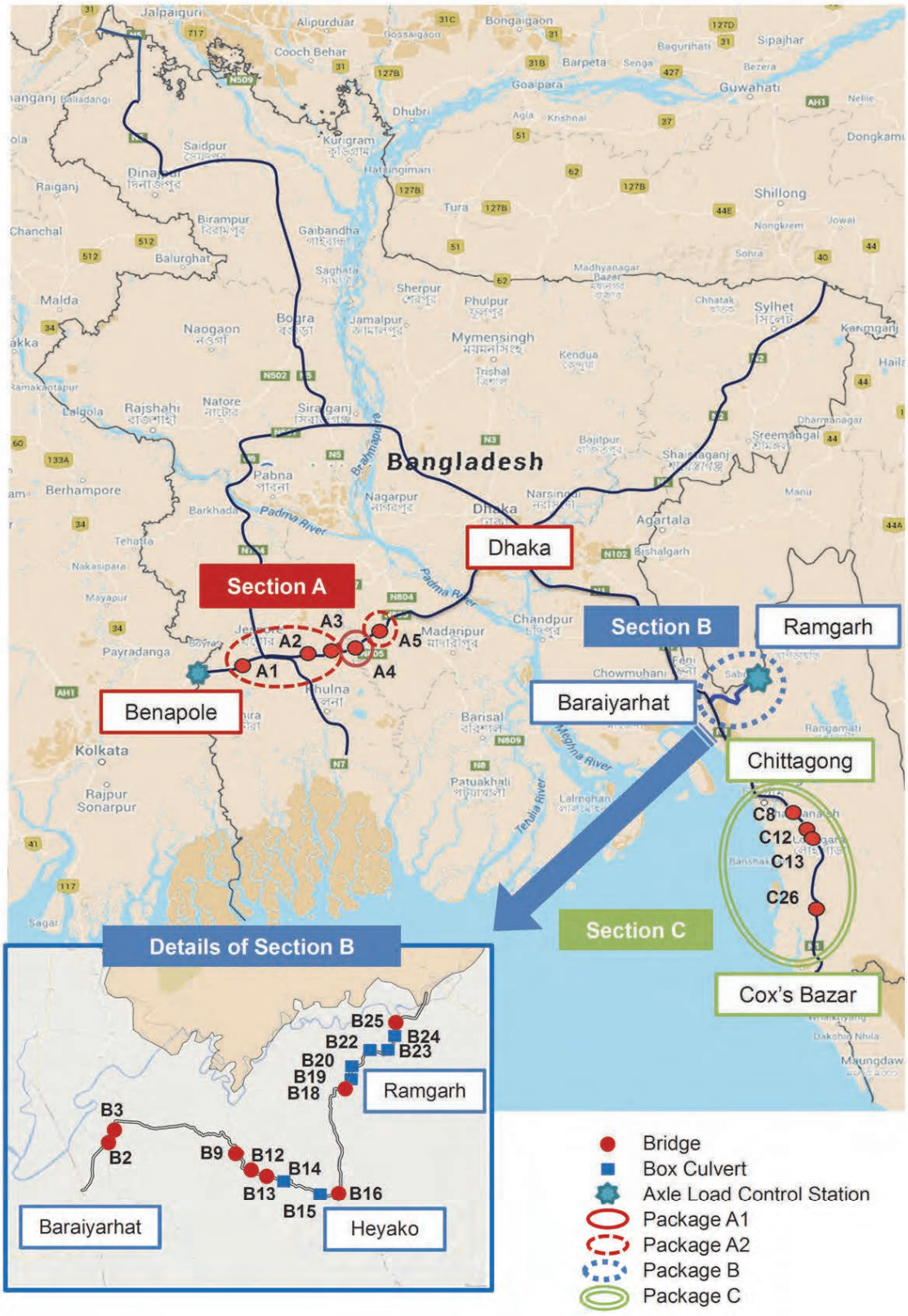
It is recommended that the project should be implemented with 4 contract packages in order to control smoothly under RHD.

The list of the target project with contract package is shown in Table 13.2.1. In addition, the location of the target bridges and contract packages is shown in Figure 13.2.1.

Table 13.2.1 List of Target Projects

Package	Name	Project Contents
A1	Kalna Bridge (4-lane)	-PC-I: L=540m -Nielsen Lohse Bridge: L=150m -Road: Approximately 4,000m -Tollgate -Vehicle for Operation and Maintenance
A2	Jhikorgacha Bridge	PC-I: L=125m
	Tularampur Bridge	PC-I: L=100m
	Hawai khali Bridge	PC-I: L=35m
	Garakola Bridge	PC-I: L=110m
	Axle Load Scale at Benapole	No. : 2 for both way traffics
B	Telipool Bridge	PC-I: L=25m
	Lakshmi Chara Bridge	PC-I: L=40m
	Kalapani Bridge-2	PC-I: L=35m
	Koilabazar Bridge	PC-I: L=55m
	Balutila Bridge	PC-I: L=30m
	Heako Bridge	PC-I: L=25m
	Chikon Chara Bridge	PC-I: L=30m
	East Baganbazar Bridge	PC-I: L=50m
	Box Culverts	No.: 7
	Axle Load Scale at Ramgarh	No. : 2 for both way traffics
C	Patiya Bridge	PC-I: L=55m
	Mazar Point Bridge	PC-I: L=60m
	Sangu Bridge	PC-I: L=215m
	Mathamuhuri Bridge	PC-I: L=310m

Source: JICA Survey Team



Source: JICA Survey Team

Figure 13.2.1 Location of the Target Bridges and Contract Packages

13.2.4 Project Cost

The project cost is shown in Table 13.2.2.

Table 13.2.2 The Project Cost

Breakdown of Cost	Foreign Currency Portion (million JPY)			Local Currency Portion (million JPY)			Total (million JPY)		
	Total	JICA Portion	Others	Total	JICA Portion	Others	Total	JICA Portion	Others
A1	4,112	4,112	0	5,313	5,313	0	9,425	9,425	0
A2	1,147	1,147	0	2,146	2,146	0	3,294	3,294	0
B	644	644	0	2,359	2,359	0	3,003	3,003	0
C	1,621	1,621	0	2,882	2,882	0	4,503	4,503	0
Dispute Board	24	24	0	0	0	0	24	24	0
Civil Works Sub Total	7,547	7,547	0	12,702	12,702	0	20,249	20,249	0
Price Escalation	595	595	0	3,671	3,671	0	4,266	4,266	0
Physical Contingency	407	407	0	819	819	0	1,226	1,226	0
Consulting Services	1,452	1,452	0	1,505	1,505	0	2,957	2,957	0
Land Acquisition	0	0	0	3,327	0	3,327	3,327	0	3,327
Administration Cost	0	0	0	1,601	0	1,601	1,601	0	1,601
VAT (Contractor & Consultant)	0	0	0	1,389	0	1,389	1,389	0	1,389
Import Tax	0	0	0	2,565	0	2,565	2,565	0	2,565
Corporate Tax	0	0	0	0	0	0	0	0	0
Income Tax (Contractor)	0	0	0	1,287	0	1,287	1,287	0	1,287
Income Tax (Consultant)	0	0	0	296	0	296	296	0	296
Interest during Construction	14	0	14	0	0	0	14	0	14
Total	10,015	10,001	14	29,162	18,697	10,465	39,177	28,698	10,478

Source: JICA Survey Team

13.3 Implementation Organization

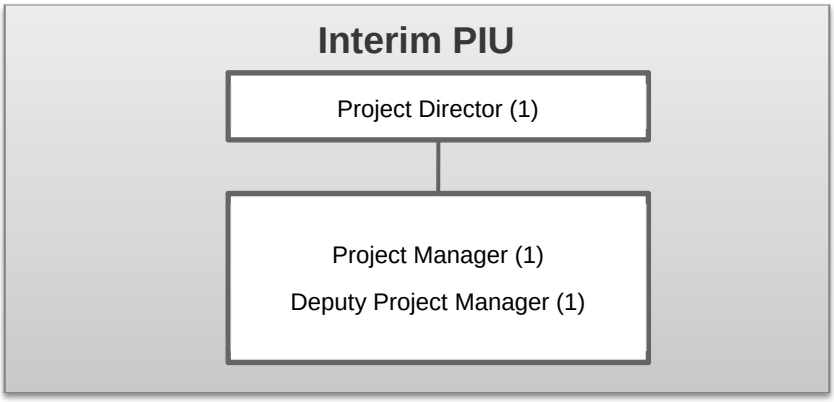
The project organization will be organized so that the GOB can implement the Project smoothly and effectively as well as coordinate with project stakeholders.

It is recommended that the Project Implementation Unit (PIU) for the Project will be organized under the Chief Engineer (CE) of RHD. PIU is divided into the following two stages.

- Interim PIU
- PIU

13.3.1 Interim PIU

Interim PIU was established for conducting formulation of the project, preparation of DPP (Development Project Proposal) and the consultant selection activity as JICA's counterpart in September 2015. The organization diagram of the interim PIU is shown in Figure 13.3.1.



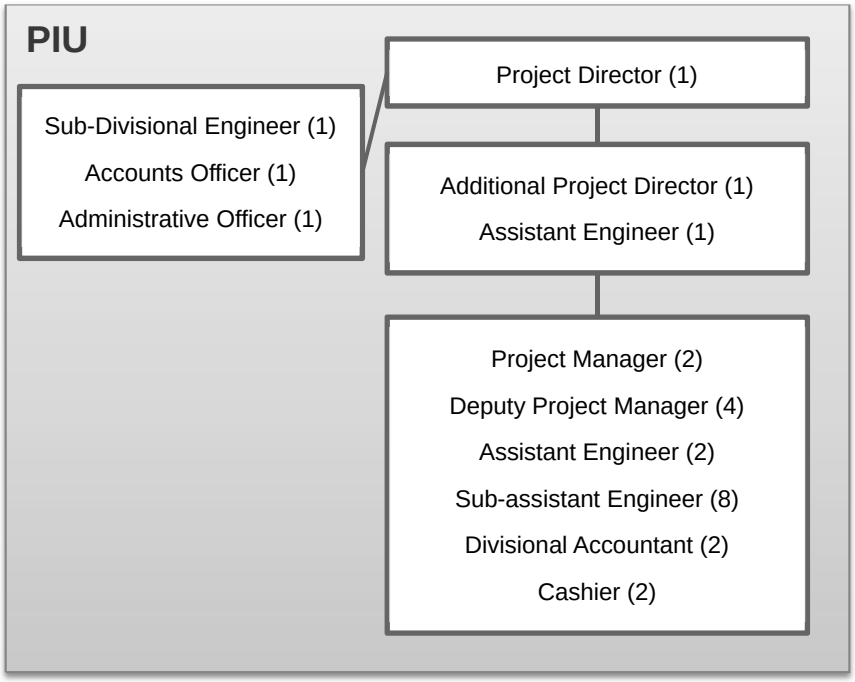
Note: (): No of post
3 staff in total

Source: JICA Survey Team

Figure 13.3.1 Organization Diagram of Interim PIU

13.3.2 PIU

PIU is organized after DPP is officially approved. The organization diagram of the PIU is shown in Figure 13.3.2.



Note: ( ): No of post
26 staff in total
In addition to above, supporting staff will be outsourced.

Source: JICA Survey Team

Figure 13.3.2 Organization Diagram of Interim PIU

13.4 Implementation Schedule

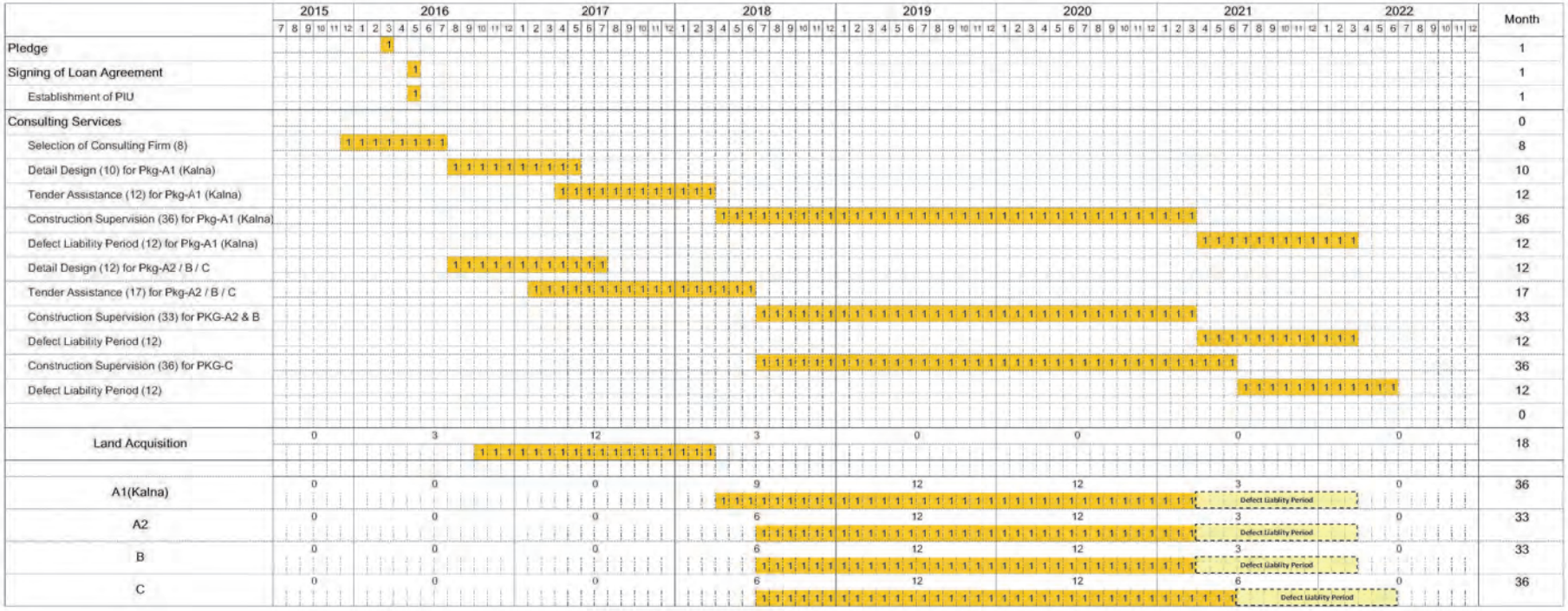
T The implementation plan is established based on the month/year for the milestones of key events of the Project. The plan includes the stage of detailed design, tender procedure, and construction work. The construction period was estimated as 3 years for A1 (Kalna Bridge) and C package and 2.75 years (33 months) for A2 and B package.

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

- A loan agreement (L/A) is expected to be signed in May 2016.
- 8 months will be required for the selection of a consultant for the detailed design, tender assistance, and construction supervision.
- The period of detailed design will be 10 months for Package A1 and 12 months for Package A2 / B / C.
- 12 months for Package A1 and 17 months for Package A2 / B / C will be required for the procurement of a contractor.
- The construction period will be 36 months for Package A1 / C and 33 months for Package A2 / B.

The total implementation period is from signing of L/A (expected in May 2016) to completion of construction (in June2021).

The implementation schedule for the Project is shown in Figure 13.4.1.



Source: JICA Survey Team

Figure 13.4.1 Implementation Schedule

14. ASSESSMENT OF PROJECT VIABILITY AND EFFECTS

14.1 Project Operation and Effect Indicator

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.

14.1.1 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. The indicators are set for Section A, B and C, but only “average travel time” is set for Section A and B. Selected operation and effect indicators are summarized at Table 14.1.1.

Table 14.1.1 Selection of Operation and Effect Indicators

Indicator			Baseline	2 years after project completion
Operation Indicators	(1) Traffic volume	Total traffic volume (pcu/day)	2015	2023
		Freight vehicle traffic volume (pcu/day)		
		Passenger vehicle traffic volume (pcu/day)		
	(2) Transit transportation	Transit freight vehicle transportation (vehicle/day)		
		Transit passenger vehicle transportation (vehicle/day)		
Effect Indicators	(3) Average travel time	Average travel time (for Section A, hour)		
	(4) Travel Cost saving	Travel cost accruing from detour when bridge collapsed (mil. BDT/year)		
	(5) Improvement of detour days	Detour days caused by flooding (day)		
	(6) Improvement of unserviceability rate	Unserviceability rate by collapse of bridge (%)		

Source: JICA Survey Team

(1) Freight and Passenger Vehicle Traffic Volume

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 survey, and traffic volume in both directions after 2 year of project completion was calculated in Chapter 6 based on the traffic forecast model.

(2) Transit Freight and Passenger Vehicle Transportation

It is expected that the roads on the target sections of the Project will contribute the cross border transportation in Southern Asia. As mentioned in 3.2.4, BBIN-MVA initiative is accelerating and it is expected that trucks and buses will pass through the cross border. The numbers of freight and passenger transportation for transit can be indicators that show how much the target routes are utilized for cross border transportation.

(3) Average Travel Time

The Project, especially Section A, will contribute to the improvement of the access between Dhaka and West Bengal of India. The improvement of Section A by building and improving bridges on the route of Section A will enables cross border transportation between Bangladesh and West Bengal of India in the shorter route, cooperating with the construction of Padma bridge and widening of AH1. As a result, average travel time between Dhaka and Benapole can be an indicator to recognize the improvement of access. The average travel time in 2015 is set along the most frequent route between Dhaka and Benapole (Dhaka- Daulatdia ferry – Jessore – Benapole).

Furthermore, average travel time between Ramgarh and AH41 for Section B can also be an indicator, considering the future plan that a land port at Ramgarh will make it possible to access over the border to the North East India. As Section B is selected as one of the priority projects of BBIN, it is expected that Bangladesh will have improved the roads of Section B by 2023. The improvement of bridges conducted by this Project will improve the access through Section B, cooperating with the improvement conducted by Bangladesh. The travel time in 2015 is gained by actual travel on Section B, and then the time is examined by comparing with the time estimated by a model considering damage level of bridges and waiting time caused by narrow width for travel way on the bridges. On the other hand, the travel time in 2023 is estimated based on the design speed for the roads.

In the Section C, the target bridges of this Project are small in number of bridges in this section comparing the length of this section. Furthermore, the target bridges provide enough width for bilateral traffic, which does not cause queue of traffic at bridge. Therefore, average travel time cannot be an appropriate indicator for Section C and Section C is not included in the target of this indicator.

(4) Travel Cost Accruing from Detour when Bridge Collapsed

Most of the target bridges include the risk of 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 generate loss of time and value (cost of movement for people and materials). Therefore, the “travel cost from detour when bridge collapsed” was selected as an 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 basically selected using roads of municipal level or higher to ensure a practical route.

(5) Detour Days Caused by Flooding

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 as the standard, a baseline detour period of 60 days was assumed for existing low bridges.

(6) Unserviceability Rate by Collapse of Bridge

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.

14.1.2 Project Operation and Effect Indicators

The calculated operation and effect indicators for each bridge are shown in Table 14.1.4. As for average travel time, section 14.1.3 will examine its details, normal case (the case with Padma bridge for Section A) are shown in the table. Among them, project operation indicators for Bridge A1 and A4 are summarized in Table 14.1.2, and project effect indicators for Bridge A1 and A4 are summarized in Table 14.1.3

Table 14.1.2 Project Operation Indicator for Bridge A1 and A4

No.	Bridge Name	Traffic Volume (pcu/day)						Transit Transportation (vehicle/day)			
		Total		Freight Vehicle		Passenger Vehicle		Freight Vehicle		Passenger Vehicle	
		2015	2023	2015	2023	2015	2023	2015	2023	2015	2023
A1	Jhikorgacha Bridge	8,857	19,958	5,142	15,620	3,715	4,338	0	761	0	9
A4	Kalna Bridge	2,088	22,199	1,569	17,043	519	5,156	0	761	0	9

Table 14.1.3 Project Effect Indicator for Bridge A1 and A4

No.	Bridge Name	Travel Cost Accruing from Detour when Bridge Collapsed (mil. BDT/year)		Detour Days Caused by Flooding (day)		Unserviceability rate by Collapse of Bridge (%)	
		2015	2023	2015	2023	2015	2023
A1	Jhikorgacha Bridge	1,964	0	60	0	44	0
A4	Kalna Bridge	NA	0	NA	0	NA	0

Table 14.1.4 Project Operation and Effect Indicator

No.	Bridge Name	Traffic Volume (pcu/day)						Transit Transportation (vehicle/day)				Travel Cost Accruing from Detour when Bridge Collapsed (mil. BDT/year)		Detour Days Caused by Flooding (day)		Unserviceability rate by Collapse of Bridge (%)	
		Total		Freight Vehicle		Passenger Vehicle		Freight Vehicle		Passenger Vehicle							
		2015	2023	2015	2023	2015	2023	2015	2023	2015	2023	2015	2023	2015	2023	2015	2023
A1	Jhikorgacha Bridge	8,857	19,958	5,142	15,620	3,715	4,338	0	761	0	9	1,964	0	60	0	44	0
A2	Tularampur Bridge	2,875	23,863	1,491	17,669	1,384	6,194	0	761	0	9	4	0	0	0	54	0
A3	Hawai khali Bridge	2,088	22,199	1,569	17,043	519	5,156	0	761	0	9	295	0	0	0	26	0
A4	Kalna Bridge	2,088	22,199	1,569	17,043	519	5,156	0	761	0	9	NA	0	NA	0	NA	0
A5	Garakola Bridge	2,088	24,156	1,569	17,566	519	6,590	0	761	0	9	7	0	60	0	1	0
B2	Telipool Bridge	3,192	4,571	2,031	2,967	1,161	1,604	0	360	0	0	354	0	0	0	51	0
B3	Lakshmi chara Bridge	3,192	4,571	2,031	2,967	1,161	1,604	0	360	0	0	354	0	0	0	51	0
B9	Kalapani Bridge-2	3,192	4,571	2,031	2,967	1,161	1,604	0	360	0	0	58	0	60	0	23	0
B12	Koilabazar Bridge	3,192	4,571	2,031	2,967	1,161	1,604	0	360	0	0	252	0	0	0	20	0
B13	Balutila Bridge	3,192	4,571	2,031	2,967	1,161	1,604	0	360	0	0	252	0	0	0	20	0
B16	Heako Bridge	1,906	2,393	936	1,092	970	1,301	0	360	0	0	641	0	0	0	51	0
B18	Chikon Chara Bridge	1,906	2,393	936	1,092	970	1,301	0	360	0	0	138	0	0	0	11	0
B25	East baganbazar Bridge	1,906	2,393	936	1,092	970	1,301	0	360	0	0	641	0	60	0	51	0
C8	Patiya Bridge	17,060	24,114	6,468	9,449	10,592	14,665	0	0	0	0	49	0	0	0	25	0
C12	Mazar Point Bridge	12,989	18,489	5,727	8,367	7,262	10,122	0	0	0	0	201	0	0	0	51	0
C13	Sangu Bridge	12,989	18,489	5,727	8,367	7,262	10,122	0	0	0	0	2,050	0	0	0	63	0
C26	Mathamuhuri Bridge	12,955	18,417	5,484	8,013	7,471	10,404	0	0	0	0	978	0	0	0	63	0

Average Travel Time (Unit: hour)

Section	A			B		
Interval	I	II	III	IV	V	VI
2015	8.40	7.16	1.24	1.17	0.71	0.46
2023	3.29	2.77	0.52	0.78	0.42	0.36

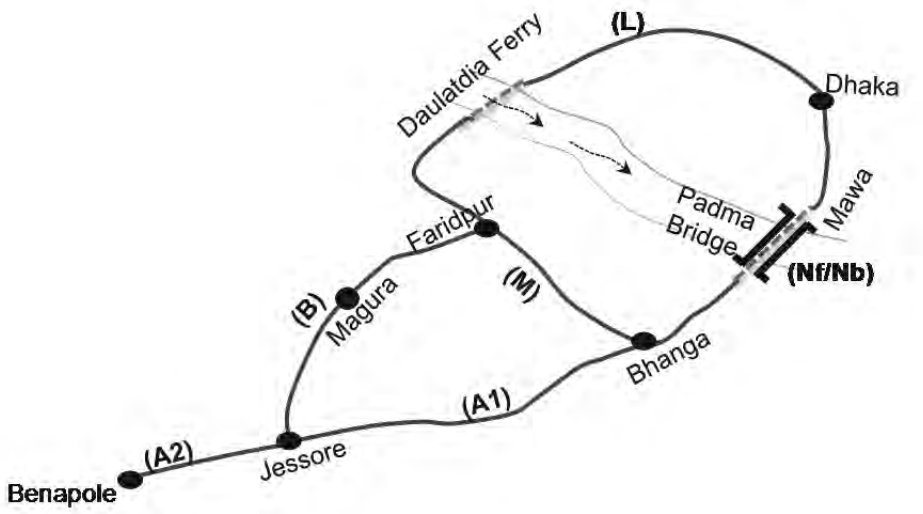
Section A Interval I: Dhaka – Benapole, II: Dhaka – Jessore, III: Jessore – Benapole
Section B Interval IV: Baraiyarhat– Ramgarh Bazar, V: Baraiyarhat– Heyako, VI: Heyako – Ramgarh Bazar
Source: JICA Survey Team

14.1.3 Review on Travel Time as an Effect Indicator

Travel time is set as an effect indicator targeting on whole Section A and B. The amount in 2015 (baseline) and in 2023 (project evaluation) for Section A and B is set along the following methodology.

(1) Travel time for Section A

Travel time in 2015, an indicator as baseline, is estimated based on the OD survey and traffic count survey conducted in this survey. Most of the traffic between Dhaka and Benapole is utilizing Daulatdia ferry and then select the route to Benapole through N7 (Magura) and Jessore (see Figure 14.1.1). This route is the fastest route and takes 8.4 hours between Dhaka and Benapole.



Note: At the construction site of Padma bridge, Nf means the case with ferry, and Nb means the case with bridge.

Figure 14.1.1 Target Intervals for Travel Time Estimation for Section A

The travel times for the other routes which can be selected for the travel between Dhaka and Benapole are also estimated and compared as shown in Table 14.1.5. All the other routes take more than 8.4 hours. As Padma bridge has not been constructed as of 2015, the route traveling to Jessor and Benapole through Mawa and Kalna ferry is not selected.

Table 14.1.5 Travel Time between Dhaka and Benapole in 2015

(Unit: hour)

	A2	A1	B	M	L	Nf	Nb	Total
The fastest route	1.24	-	3.02	-	4.14	-	-	8.40
Route through Daulatdia ferry	1.24	4.54	-	1.01	4.14	-	-	10.93
Route through Mawa ferry	1.24	4.54	-	-	-	3.99	-	9.77

Source: JICA Survey Team

<Case that Padma bridge will have been constructed by 2023>

In this case, travel time between Dhaka and Benapole is estimated under the assumption that Padma bridge will have been constructed and that all improvement of bridges and roads on Section A will have been completed by 2023. The results and its travel time (3.29 hours) are shown in Table 14.1.6.

Table 14.1.6 Travel Time between Dhaka and Benapole in 2023 (with Padma Bridge)

(Unit: hour)

	A2	A1	B	M	L	Nf	Nb	Total
The fastest route	0.52	1.26	-	-	-	-	1.51	3.29

Source: JICA Survey Team

<Case that Padma bridge will not have been constructed by 2023>

The construction of Padma bridge is constructed by the other scheme than this Project, and is out of the scope of this Project. Although Padma bridge is currently under construction, an indicator for the case that Padma bridge will not have been constructed by 2023 with some unexpected reasons is set in the following.

In the case that Padma bridge is not constructed, an alternative route is selected by comparing travel time along possible routes shown in Figure 14.1.1, and JICA Survey Team proposes that the estimated travel time is utilized as an indicator for the project evaluation for this case.

The travel time for each interval is estimated by the model set for demand forecast, and the results of alternative routes between Dhaka and Benapole in the case without Padma bridge are shown in Table 14.1.7. Even in the case without Padma bridge, the shortest route becomes the route using Mawa ferry and constructed Kalna bridge through Section A. It is estimated that travel time on the route takes 6.18 hour, which is smaller than current travel time, 8.40 hour. Even if Padma bridge would not be constructed, improvement of bridges on Section A conducted by this Project can contribute to the reduction of travel time between Dhaka and Benapole.

Table 14.1.7 Travel Time between Dhaka and Benapole in 2023 (without Padma Bridge)

(Unit: hour)

	A2	A1	B	M	L	Nf	Nb	Total
Route through Daulatdia ferry	0.52	1.26	-	1.04	4.26	-	-	7.08
Route through Mawa ferry	0.52	1.26	-	-	-	4.40	-	6.18

Source: JICA Survey Team

(2) Review on Travel Time for Section B

As of 2015, bridges on Section B are in a bad condition and do not secure enough width for transportation. As a result, if a vehicle traveling on Section B encounters an oncoming vehicle at a bridge, the vehicle has to wait until the oncoming vehicle pass the bridge. Considering this situation, JICA Survey Team reviews the travel time of Section B in 2015, considering the expected waiting time.

The waiting time in the travel time of Section B is estimated utilizing queuing theory. Waiting time at all the 26 bridges on Section B are estimated based on traffic amount of oncoming vehicle gained by current traffic survey, length of the bridges and expected speed set based on damage level of each bridge. In addition to the result, average speed by interval is set and then travel time for Section B is estimated as shown in Table 14.1.8.

Table 14.1.8 Comparison between Actual and Estimated Travel Time in 2015 (Section B)

	Length	Average travel speed	Travel time	Waiting Time	Estimated Travel Time	Actual Travel Time
Intervals	(km)	(km/h)	(min)	(min)	(min)	(min)
Baraiyarhat-Heyako	19.95	35.00	34.20	6.85	41.05	42.88
Heyako- Ramgarh Bazar	17.77	40.00	26.65	2.23	28.88	27.35
Total	37.72	37.19	60.85	9.09	69.93	70.23

Source: JICA Survey Team

As this table shows, the estimated travel time and actual time is quite close, and the travel time for Section B can be expected to be about 70 minutes. According to the estimated time, it can be assumed that the travel time currently includes about 9 minutes for waiting time on average.

Section B is nominated as one of the priority sections of BBIN, which is planned to be improved by 2020. Therefore, in addition to the improvement of bridges conducted by this Project, the improvement of roads and bridges on whole Section B will be completed by 2023. As a result, it can be expected that the waiting time, 9 minutes which is caused under current condition, will be cleared and average travel speed will also be improved to design speed, 50 km/hour. But, as the interval (Baraiyarhat-Heyako) is in a relatively rolling ground condition in comparing with the interval (Heyako- Ramgarh Bazar), the average speed in the interval (Baraiyarhat-Heyako) is assumed to be 47 km/hour, based on the actual travel time which indicated 3 km/h difference between average speed at the interval (Heyako- Ramgarh Bazar) and that at the interval (Baraiyarhat-Heyako). Based on these assumptions, the total travel time in 2023 is estimated about 47 minutes as shown in Table 14.1.9. The results indicate that about 23 minutes will be reduced in the travel time between in 2015 and in 2023.

Table 14.1.9 Estimated Travel Time in 2023 (Section B)

	Length	Average travel speed	Travel time	Waiting Time	Estimated Travel Time
Intevals	(km)	(km/h)	(min)	(min)	(min)
Baraiyarhat-Heyako	19.95	47.00	25.46	0.00	25.46
Heyako- Ramgarh Bazar	17.77	50.00	21.32	0.00	21.32
Total	37.72	48.38	46.78	0.00	46.78

Source: JICA Survey Team

14.2 Financial and Economic Evaluation

14.2.1 General

In this section, the financial and economic feasibility of construction of the selected bridges is evaluated in terms of the national economy. The financial analysis of the Project is performed through comparisons of financial benefit gained by the toll of the bridge from passengers with financial cost of the project. 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.

It is planned that only A4 (Kalna bridge) collects toll from passengers in the Project. Therefore, an evaluation target of the financial analysis is A4 (Kalna bridge), and evaluation targets of the economic analysis is all 17 bridges (A1-5, B2, 3, 9, 12, 13, 16, 18, 25 and C8, 12, 13, 26).

The traffic demand forecast of each bridge was made in Chapter 6, the preliminary design study was carried out in Chapter 7 and Chapter 8, and the cost estimate of each bridge was made in Chapter 12. Based on these studies, the financial and economic evaluation of each bridge project shall be carried out in this section.

In order to determine a procedure for this analysis, the corresponding procedures developed for the "Eastern Bangladesh Bridge Improvement Project"[15] and "Preparatory Survey on Western Bangladesh Bridges Improvement Project"[16] were reviewed. Due to the similar nature of the Project, it was decided that the similar procedure would be adopted

14.2.2 Basic Assumptions and Conditions

(1) Basic Concept of Benefit

1) Financial Evaluation

Financial benefit of the Project can be gained by the toll from passengers at Kalna Bridge. In Bangladesh, the toll rates at bridges are set based on the Toll Policy, 2014, issued by Roads Division of Ministry of Communications (currently Ministry of Road Transport and Bridges). The toll rate is determined along with the following factors:

i. Road Classification
ii. Vehicle Class
iii. Length class of bridge

A base toll rate, which is applied to the road class of Important Highways, is 400 BDT for Medium Truck.

The toll rate varies according to the length class of bridge, and the bridge length relevant to the Kalna Bridge (690 meters) falls in the length class of 501-750 meters. This eventually reduces the base toll rate to 75%.

[15] JBIC "Special Assistance for the Project Formulation (SAPROF) for Eastern Bangladesh Bridge Improvement Project" December 2007
[16] JICA "Preparatory Survey on Western Bangladesh Bridges Improvement Project" April 2015

Finally, toll rates of different vehicle classes are defined according to the below schedule:

Road Classification	Length Class of Bridge	Vehicle Class and weighting factor	Type of Vehicle	Toll Rate (BDT/vehicle)
Important Highways (Base toll rate is Tk.400)	501m<L< 750m (75% of base toll)	A : 250%	Trailer truck	750
		B : 200%	Heavy truck	600
		C :100% (Base rate)	Medium truck	300
		D : 90%	Large bus	270
		E : 75%	Mini truck	225
		F : 60%	Vehicles for Agricultural Works	180
		G : 50%	Minibus/Coaster	150
		H : 40%	Microbus	120
		I : 40%	Four wheel drive vehicles	120
		J : 25%	Sedan car	75
		K : 10%	3/4 wheel motorized vehicle	30
		L : 5%	Motor cycle	15
		M : 2.5%	Rickshaw van Rickshaw Bicycle Push cart	7.5->Rounded to 10 (Article 7.5 of Toll Policy)

Source: JICA Survey Team referring Toll Policy, 2014

Annual financial benefit is estimated by multiplying the annual traffic at Kalna Bridge by these rates along the type of vehicle.

2) Economic Evaluation

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 in normal cases. The difference between VOC/TTC in regular routes and detour routes will be considered a benefit.

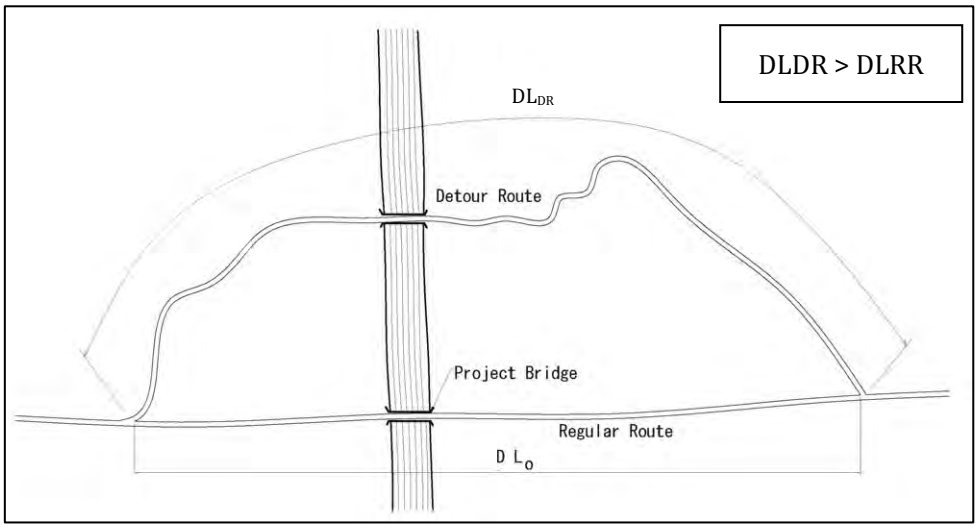


Figure 14.2.1 Travel Distance of Regular Route vs Detour Route in Normal Case

For Section A, as traffic network model of western Bangladesh area for demand forecast is established, specific detour route for economic analysis is not identified. The difference of total VOC/TTC amount between with case and without case are estimated using the model.

For Section B, it is expected that trucks are mainly directing to Chittagong and that other types of vehicles are mainly directing to Dhaka. Therefore, regular route and detour route are separately set for trucks and for other types of vehicles, considering the road network around Section B. Detour routes for Section B and Section C are shown in the following figures.

: Regular route for trucks, : Regular route for other types of vehicle,

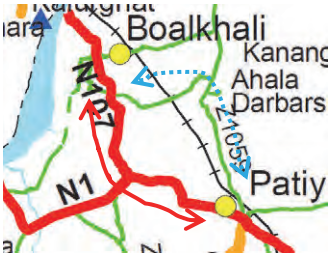
: Detour route for trucks, : Detour route for other types of vehicle

Figure 14.2.2 Detour Route for B2, 3, 9, 12 and 13

: Regular route for trucks, : Regular route for other types of vehicle,

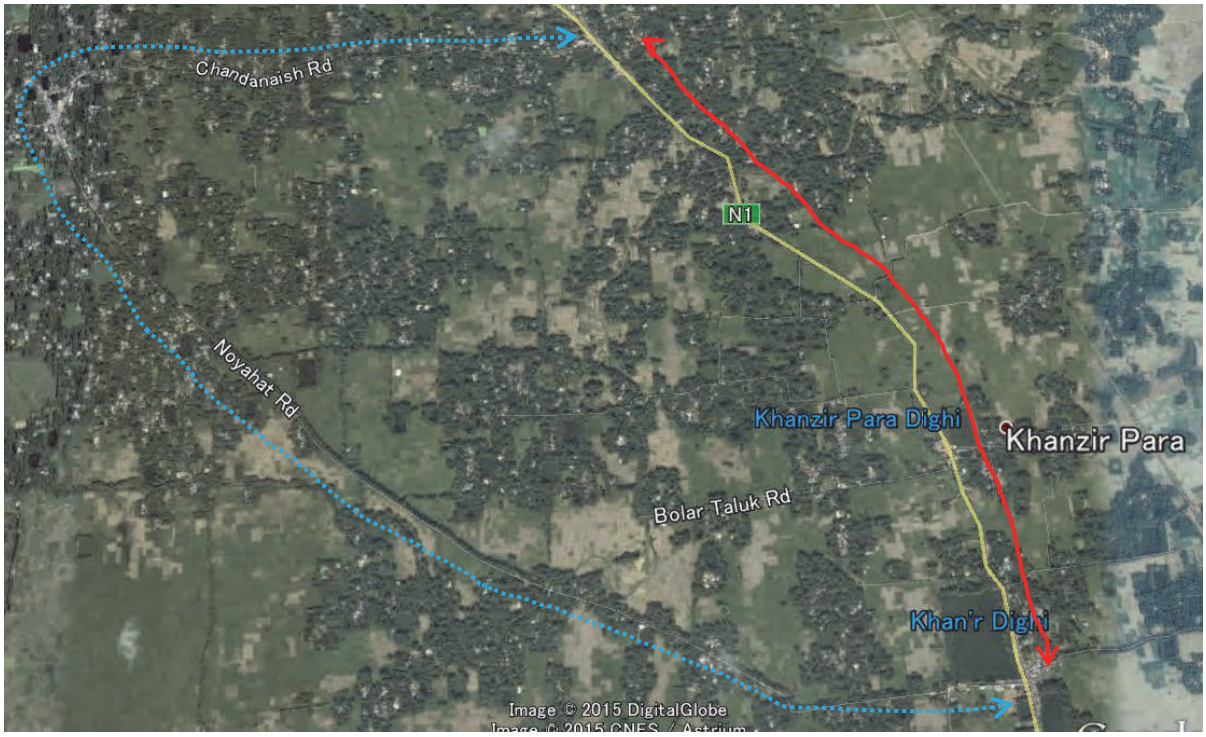
: Detour route for trucks, : Detour route for other types of vehicle

Figure 14.2.3 Detour Route for B16, 18 and 25



: Regular route, : Detour route

Figure 14.2.4 Detour Route for C8



: Regular route, : Detour route

Figure 14.2.5 Detour Route for C12

Figure 14.2.6 Detour Route for C13 and 25

(2) Implementation Schedule

As described in Chapter 13, the Project is proposed to be implemented with the following schedule:

2016 - 2017	Detailed design
2018	Procurement of contractors
2019 - 2021	Construction of bridges
2022	Opening to traffic

(3) Project Life

The economic life of the project is assumed to be 25 years (2022 - 2046), 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) Hurdle Rate

1) Financial Evaluation

The hurdle rate for financial evaluation (opportunity cost of capital) is set at 10.36 %. The rate is set referring annual coupon rate of 20 years Bangladesh Government Treasury Bond issued on October 2015. JICA Survey Team sets this rate as an opportunity cost of capital of the Project for financial analysis.

2) Economic Evaluation

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

14.2.3 Cost Estimate

(1) Financial Evaluation

Following items are considered as a financial cost of the Project: construction cost, equipment cost, consulting cost, security service cost, land acquisition and compensation cost, administration cost, VAT, import duty, physical contingency and operating/maintenance cost. Price inflation was not taken into account for either construction cost or operation/maintenance cost. All cost is estimated as of 2015.

(2) Economic Evaluation

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

- 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 is not used in the economic analysis.
- Construction and operation/maintenance costs: These costs are set up for each bridge based on the project implementation schedule.

14.2.4 Benefit Measurement for Economic Evaluation

(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)

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

- Permanent bridges
- Temporary bridges
- New bridges

In this survey, B12 and B13 are classified as temporary bridges. A4 is classified as a new bridge. Other bridges are classified as permanent bridges.

(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 survey was taken from the RHD Road user Cost Annual report with some modifications made by considering the consumer price index (CPI) between 2004 and 2015. The VOC by road roughness (IRI) in 2015 is presented in Table 14.2.1.

Table 14.2.1 Vehicle Operating Cost by Road Roughness (as of 2015 Prices)

(BDT/vehicle/km)

	Good	Fair	Bad	V. Bad
IRI	4	6	8	10
Car	19.76	20.95	22.13	23.55
Utility	19.63	21.31	23.70	27.05
Microbus	24.08	26.01	28.30	31.29
Minibus	24.17	25.44	26.67	28.09
Large Bus	29.09	31.63	34.41	38.27
Small Truck	20.27	21.92	23.47	25.12
Medium Truck	27.35	29.64	32.08	34.73
Heavy Truck	30.17	32.69	37.52	40.62
Auto Rickshaw	4.92	5.17	5.47	5.81
Motor Cycle	2.76	2.84	2.88	2.90

Note: Estimated based on "RHD Road User Cost Annual Report by FY 2004/05" and CPI between 2004 and 2015

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

Table 14.2.2 IRR by Road Condition

Condition	IRI
Good	4
Fair	6
Bad	8
Very bad	10

Source: JICA Survey Team

Table 14.2.3 CPI Index and Growth Index

	2004/05	2014/15	Growth Index 2015/2004	Annual Growth Rate during 2004-2015 (%)
CPI	96.71	204.69	2.12	7.8%

Source: IMF World Economic Outlook, 2015

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). The TTC used in this survey was taken from the RHD Road user Cost Annual report with some modifications made by considering the gross domestic product (GDP) per capita (current price) between 2004 and 2015. Table 14.2.4 shows TTC by vehicle type.

Table 14.2.4 Travel Time Cost (TTC) by Vehicle Type (as of 2015 Prices)

Vehicle Category	TTC per passenger (BDT/hr)	Average Occupancy (Person / Veh)	TTC per Vehicle (BDT/hr)
Car	98.6	3.2	314.5
Utility	98.6	3.2	314.5
Microbus	79.4	8.00	635.4
All Bus	56.1	37.12	2,084.0
Light Truck	-	-	303.7
Medium Truck	-	-	334.5
Heavy Truck	-	-	334.5
Auto Rickshaw	52.3	3.7	195.2
Motor Cycle	73.1	1.1	76.9

Note: Estimated based on "RHD Road User Cost Annual Report by FY 2004/05" and GDP per capita between 2004 and 2015, "Average Occupancy" is shown in "RHD Road User Cost Annual Report by FY 2004/05".

Table 14.2.5 GDP per capita (current price) and Growth Index

	2004/05	2014/15	Growth Index 2015/2004	Annual Growth Rate during 2004-2015(%)
GDP per capita (BDT)	30,388	96,826	3.19	12.3%

Source: IMF World Economic Outlook, 2015

(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"[17].

[17] 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.

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

Permanent bridges

In Japan, a reliability function for bridges, R(t), has been obtained through statistical analysis on bridge life, as shown in Figure 14.2.7(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:

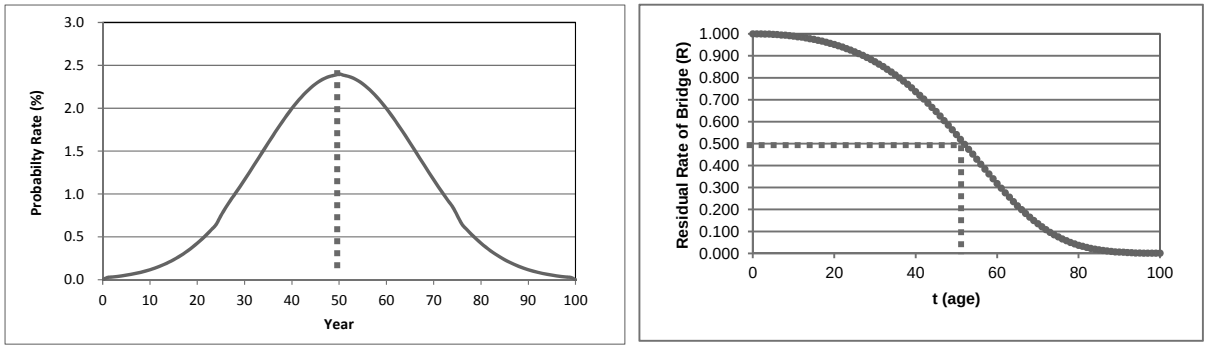
$$f(t) = dF(t)/dt = 1 - dR(t)/dt$$

The reliability function R(t) can be expressed as shown in Figure 14.2.7(a) while the "Residuals Rate of Unserviceability" f(t) can be expressed as shown in Figure 14.2.7(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:

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



(a) Probability Rate of Unserviceability of Existing Bridge (b) Residuals Rate of Unserviceability

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

Figure 14.2.7 Relation between Probability and its Cumulative of Unserviceability and Timing of New Bridge Construction by Bridge Age

The probability of unserveiceability for a bridge which starts its service at age a years in year y can be gained through the following formula.

$$U_a(y) = \int_a^y \frac{f(t)}{1 - F(a)} dt$$

As seen in Figure 14.2.7, the probability of unserviceability of existing bridges drastically increases so that probability of unserviceability for a bridge of age 50 years is calculated as shown in Table 14.2.6, in comparison with original probability densities.

Table 14.2.6 Probability Rate of Unserviceability (bridge age 50 years old)

Year	Probability Rate of Existing Bridge[1] (%)	Adjusted Probability Rate Bridge age 50 yrs. old[2] (%)	Cumulative Adjusted Probability Rate for Bridge age 50 yrs. old (without project) (%)
51	2.3846	4.8862	4.8862
52	2.3718	4.8599	9.7461
53	2.3506	4.8166	14.8527
54	2.3213	4.7565	19.3192
55	2.2842	4.6804	23.9996
56	2.2396	4.5890	28.5886
57	2.1880	4.4833	33.0719
58	2.1299	4.3643	37.4362
59	2.0660	4.2333	41.6692
60	1.9968	4.0915	45.7607
61	1.9230	3.9403	49.7010
62	1.8453	3.7812	53.4822
63	1.7644	3.6154	57.0976
64	1.6811	3.4446	60.5422
65	1.5959	3.2701	63.8123
66	1.5096	3.0933	66.9056
67	1.4229	2.9156	69.8212
68	1.3364	2.7383	72.5595
69	1.2506	2.5625	75.1220
70	1.1661	2.3895	77.5115
71	1.0835	2.2201	79.7316
72	1.0031	2.0554	81.7870
73	0.9254	1.8961	83.6831
74	0.8506	1.7429	85.4260
75	0.7790	1.5962	87.0222

Notes:
1) Values of probability rate of unserviceability under 'Original Probability Density' are obtained from bridge age 50 in Figure 14.2.7(a)
2) Values of probability rate of unserviceability of 'Bridge Age 50' are obtained from bridge age 50 in Figure 14.2.7(b)

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

Temporary bridges

In Bangladesh, temporary bridges are sometimes utilized for main routes. The temporary bridges, whose structure is "Bailey with Steel Deck" for B12 and B13, can normally serve for 5-7 years. On the other hand, bailey bridges are repaired (or reconstructed) in relatively short period and serve again. Therefore, JICA Survey Team made following assumptions for economic analysis based on the other examples.

- Bailey bridges needs to be repaired (or reconstructed) once in 5 years.
- It takes 4 months for procurement, preparation and repair of a bailey bridge. During the period, traffic will take detour route.
- The cost for the repair is assumed to be 70% of construction cost of Bailey bridge. Economic construction cost of Bailey bridge is 0.3 million BDT/m.
- As structure of Bailey bridge is steel deck, its operation and maintenance cost is higher than permanent bridges. 20% of the construction cost of the Bailey bridge is necessary as operation and maintenance cost every year.

3) Benefit Estimation Method by Case

In this survey, there are following 5 kinds of method for financial and economic analysis.

a. Financial analysis for a new bridge (A4)
b. Economic analysis for a new bridge (A4)
c. Economic analysis for permanent bridges in Section A (A1-3, 5)
d. Economic analysis for permanent bridges in Section B and C (B2, 3, 9,16, 18, 25, C8, 12,13,26)
e. Economic analysis for temporary bridges in Section B (B12, 13)

In the following, benefit estimation methods by case are summarized.

a. Financial analysis for a new bridge (A4)

Cost of this analysis is using financial cost of A4, Kalna Bridge. Benefit of this analysis is estimated by utilizing toll rate defined by JICA Survey Team and traffic amount estimated by demand forecast model. Furthermore, it can be expected that the toll rate will cause some decrease in traffic to avoid the payment of the toll by passengers. Therefore, JICA Survey Team assumes that the traffic at the first year of its in-service period becomes 80% of the traffic which is forecasted by demand forecast model and that the traffic at the 25^{th} years of its in-service period becomes 90% of the traffic which is forecasted by demand forecast model. In the meantime, the rate gradually changes.

b. Economic analysis for a new bridge (A4)

Cost of this analysis is using economic cost of A4, Kalna Bridge. Benefit of this analysis is gained by utilizing VOC and TTC savings. As mentioned before, unit road user cost is set by JICA Survey

Team. VOC saving amount (vehicle*kilometer) and TTC saving amount (vehicle*hour) is estimated by gaining the difference of these amounts between with case (the bridge is in service) and without case (the bridge is not in service) from demand forecast model. In addition, JICA Survey Team assumes that IRI of the route in the demand forecast model is 6 (Fair).

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

$$B_{xc} = \sum_{\mathrm{i}} \mathrm{VOC_i} \times \mathrm{DVOC_{xi}}$$

$$B_{xt} = \sum_{\mathrm{i}} TTC_i \times \mathrm{DTTC_{xi}}$$

where:

B_{xc} : *VOC savings at year x*
B_{xt} : *TTC savings at year x*
VOC_i : *Vehicle operating cost of vehicle type i (BDT/km)*
$DVOC_{xi}$: *VOC saving amount of vehicle type i at year x (vehicle*km)*
TTC_i : *Travel time cost of vehicle type i (BDT/hour)*
$DTTC_{xi}$: *TTC saving amount of vehicle type i at year x (vehicle*hour)*

c. Economic analysis for permanent bridges in Section A (A1-3, 5)

Cost of this analysis is using economic cost of A1-3 and 5. Benefit of this analysis is gained by utilizing VOC and TTC savings considering probability model for bridges to be unusable. As mentioned before, unit road user cost and probability model for bridges to be unusable (permanent bridges) are set by JICA Survey Team. VOC saving amount (vehicle*kilometer) and TTC saving amount (vehicle*hour) is estimated by gaining the difference of these amounts between with case (the bridge is in service) and without case (the bridge is not in service) from demand forecast model. In addition, JICA Survey Team assumes that IRI of the route in the demand forecast model is 6 (Fair).

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

$$B_{xc} = \sum_{\mathrm{i}} \mathrm{U_a(x)} \times \mathrm{VOC_i} \times \mathrm{DVOC_{xi}}$$

$$B_{xt} = \sum_{\mathrm{i}} \mathrm{U_a(x)} \times TTC_i \times \mathrm{DTTC_{xi}}$$

where:

B_{xc} : *VOC savings at year x*
B_{xt} : *TTC savings at year x*
$U_a(x)$: *Probability of bridge unusable for a permanent bridge which starts its service at age a years in year x for without project case*
VOC_i : *Vehicle operating cost of vehicle type i (BDT/km)*

$DVOC_{xi}$: *VOC saving amount of vehicle type i at year x (vehicle*km)*
TTC_i : *Travel time cost of vehicle type i (BDT/hour)*
$DTTC_{xi}$: *TTC saving amount of vehicle type i at year x (vehicle*hour)*

d. Economic analysis for permanent bridges in Section B and C (B2, 3, 9,16, 18, 25, C8, 12,13,26)

Cost of this analysis is using economic cost of B2, 3, 9, 16, 18, 25, and C8, 12, 13, 26. Benefit of this analysis is gained by utilizing VOC and TTC savings considering probability model for bridges to be unusable. Detour route for each bridge is set by JICA Survey Team. In addition, JICA Survey Team assumes that IRI of the route in the demand forecast model is 4 (Good) for National Highway (N1) and 6 (Fair) for the other roads.

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

$$B_{xc} = \sum_{\mathrm{i}} \mathrm{U_a(x)} \times AADT_{xi} \times (\mathrm{DL_0} \times \mathrm{VOC_{0i}} - \mathrm{DL_w} \times \mathrm{VOC_{wi}})$$

$$B_{xt} = \sum_{\mathrm{i}} \mathrm{U_a(x)} \times AADT_{xi} \times (\frac{DL_0}{V_{0i}} - \frac{DL_w}{V_{wi}}) \times TTC_i$$

where:

B_{xc} : *VOC savings at year x for a bridge of age a year old*
B_{xt} : *TTC savings at year x for a bridge of age a year old*
$U_a(x)$: *Probability of bridge unusable for a permanent bridge which starts its service at age a years in year x for without project case*
$AADT_{xi}$: *Average Annual 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 (BDT/km)*
VOC_{wi} : *Vehicle operating cost of vehicle type i along regular route (BDT/km)*
TTC_i : *Travel time cost of vehicle type i (BDT/hour)*
V_{0i} : *Vehicle operating speed of vehicle type i along detour route (km/hour)*
V_{wi} : *Vehicle operating speed of vehicle type i along regular route (km/hour)*

e. Economic analysis for temporary bridges in Section B (B12, 13)

Cost of this analysis is using economic cost of B12 and 13. Benefit of this analysis is gained by utilizing VOC and TTC savings considering probability model for bridges to be unusable. Furthermore, expected additional cost for repair of Bailey bridge and additional operation and maintenance cost for Bailey bridge are counted as benefit in this analysis. As mentioned before, unit road user cost and probability model for bridges to be unusable (temporary bridges) are set by JICA Survey Team.

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

$$B_{xc} = \sum_{\mathrm{i}} \mathrm{U} \times AADT_{xi} \times (\mathrm{DL_0} \times \mathrm{VOC_{0i}} - \mathrm{DL_w} \times \mathrm{VOC_{wi}})$$

$$B_{xt} = \sum_{\mathrm{i}} \mathrm{U} \times AADT_{xi} \times (\frac{DL_0}{V_{0i}} - \frac{DL_w}{V_{wi}}) \times TTC_i$$

where:

B_{xc} : *VOC savings at year x for a bridge of age a year old*
B_{xt} : *TTC savings at year x for a bridge of age a year old*
U : *Probability of bridge unusable for a temporary bridge for without project case*
$AADT_{xi}$: *Average Annual 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 (BDT/km)*
VOC_{wi} : *Vehicle operating cost of vehicle type i along regular route (BDT/km)*
TTC_i : *Travel time cost of vehicle type i (BDT/hour)*
V_{0i} : *Vehicle operating speed of vehicle type i along detour route (km/hour)*
V_{wi} : *Vehicle operating speed of vehicle type i along regular route (km/hour)*

14.2.5 Results of Economic Evaluation

Results of financial and economic evaluation are shown in Table 14.2.7. According to the results, it can be said that all bridge project are economically feasible. On the other hand, financial evaluation of A4 (Kalna bridge) is not feasible, because FIRR of A4, 8.7%, is lower than hurdle rate, 10.36%.

Table 14.2.7 Results of Financial and Economic Evaluation

No.	Structure Name	Bridge Type	Year of Construction	Economic Internal Rate of Return (EIRR) (%)	Financial Internal Rate of Return (FIRR) (%)
A1	Jhikorgacha Bridge	RCC Girder Bridge	1968	53.5	-
A2	Tularampur Bridge	RCC Girder Bridge	1964	53.3	-
A3	Hawai khali Bridge	RCC Girder Bridge	1976	50.4	-
A4	Kalna Bridge	-	-	33.8	8.7
A5	Garakola Bridge	PC Girder Bridge	2004	27.8	-
B2	Telipool Bridge	Steel Beam & RCC Slab	1965	26.1	-
B3	Lakshmi chara Bridge	Steel Beam & RCC Slab	1965	27.8	-
B9	Kalapani Bridge-2	RCC Girder Bridge	1978	28.9	-
B12	Koilabazar Bridge	Bailey with Steel Deck	1994	12.1	-
B13	Balutila Bridge	Bailey with Steel Deck	1991	12.0	-
B16	Heako Bridge	RCC Girder Bridge	1965	45.3	-
B18	Chikon Chara Bridge	RCC Girder Bridge	1986	28.6	-
B25	East baganbazar Bridge	Steel Beam & RCC Slab	1965	42.5	-
C8	Patiya Bridge	RCC Girder Bridge	1977	17.3	-
C12	Mazar Point Bridge	RCC Girder Bridge	1965	27.7	-
C13	Sangu Bridge	RCC Girder Bridge	1960	51.5	-
C26	Mathamuhuri Bridge	RCC Girder Bridge	1960	41.8	-

Source: JICA Survey Team

Furthermore, the results of economic evaluation by package and all are summarized in the following table.

Table 14.2.8 Results of Economic Evaluation by Package and All

Package	A1	A2	B	C	All
Economic Internal Rate of Return (EIRR) (%)	33.8	49.8	30.7	41.8	39.7

Source: JICA Survey Team

15. CONCLUSION AND RECOMMENDATION

15.1 Conclusion

The conclusion of the Preparatory Survey is as follows:

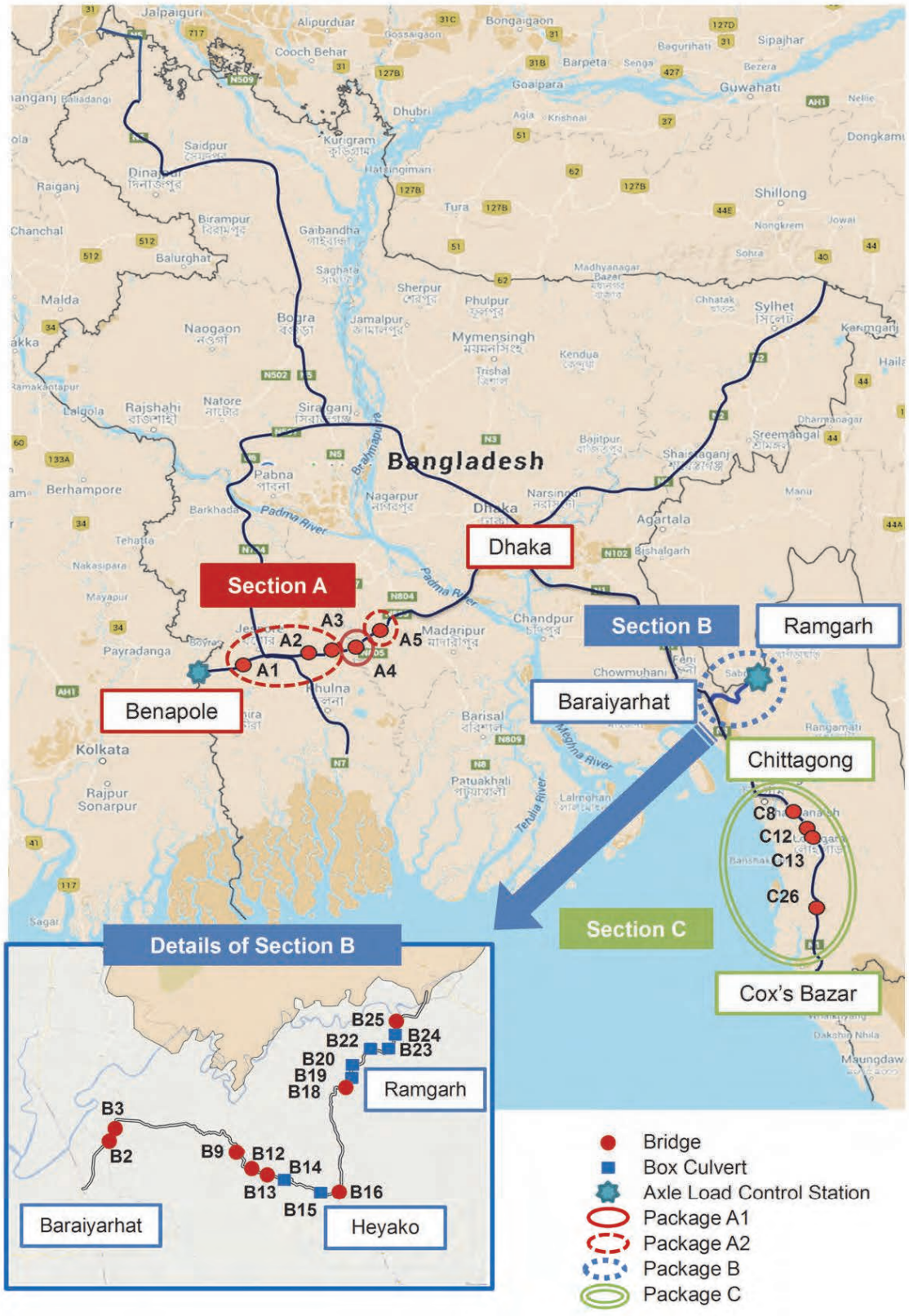
- The project is technically and economically feasible and environmentally sound.
- Hence, it is justified to implement the Project for national and people's benefits.
- The Project is comprised of 17 bridges construction including approach road, box-Culverts construction and axle load installation.
- Two types of bridges are constructed in the Project, namely, PC-I girder bridge, Nielsen Lohse bridge.
- Special steel, namely, SBHS (Steels for Bridge High Performance Structure) is applied for a part of Nielsen Lohse Bridge.

A summary of the project is shown in Table 15.1.1 and Figure 15.1.1.

Table 15.1.1 Summary of the Project

Package	Name	Project Contents
A1	Kalna Bridge (4-lane)	-PC-I: L=540m -Nielsen Lohse Bridge: L=150m -Road: Approximately 4,000m -Tollgate -Vehicle for Operation and Maintenance
A2	Jhikorgacha Bridge	PC-I: L=125m
	Tularampur Bridge	PC-I: L=100m
	Hawai khali Bridge	PC-I: L=35m
	Garakola Bridge	PC-I: L=110m
	Axle Load Scale at Benapole	No. : 2 for both way traffics
B	Telipool Bridge	PC-I: L=25m
	Lakshmi Chara Bridge	PC-I: L=40m
	Kalapani Bridge-2	PC-I: L=35m
	Koilabazar Bridge	PC-I: L=55m
	Balutila Bridge	PC-I: L=30m
	Heako Bridge	PC-I: L=25m
	Chikon Chara Bridge	PC-I: L=30m
	East Baganbazar Bridge	PC-I: L=50m
	Box Culverts	No.: 7
	Axle Load Scale at Ramgarh	No. : 2 for both way traffics
C	Patiya Bridge	PC-I: L=55m
	Mazar Point Bridge	PC-I: L=60m
	Sangu Bridge	PC-I: L=215m
	Mathamuhuri Bridge	PC-I: L=310m

Source: JICA Survey Team



Source: JICA Survey Team

Figure 15.1.1 Location Map of the Project

15.2 Recommendation

Recommendations for further studies and tasks are as follows:

- Safety measures such as providing road marking, road hump, guardrails, etc. shall be considered in the detailed design.
- Detailed surveys for public utilities such as waterworks, telephone lines, power lines, etc. shall be conducted in the detailed design. The bridge and road design shall be conducted in consideration of that information.
- RHD shall undertake the tasks for the EIA and ARP during the entire project period in order to implement the Project successfully.
- Technical cooperation project of bridge maintenance under JICA is ongoing and will be updated operation and maintenance manual in 2016. It is recommended that the project bridge should be maintained according to the manual.
- SBHS (Steels for Bridge High Performance Structure) is applied for Nielsen Lohse Bridge, especially at the corner part which is subjected to high stress concentration and needs special care for joining. The more detail use of SBHS shall be studied in the detailed design.