ROADS & HIGHWAYS DEPARTMENT (RHD), MINISTRY OF COMMUNICATION (MOC)
PEOPLE'S REPUBLIC OF BANGLADESH

PREPARATORY SURVEY FOR
DHAKA-CHITTAGONG NATIONAL HIGHWAY NO.1
BRIDGE CONSTRUCTION AND REHABILITATION PROJECT

(Project name:

THE KANCHPUR, MEGHNA, GUMTI 2ND BRIDGES CONSTRUCTION AND EXISTING BRIDGES REHABILITATION PROJECT)

FINAL REPORT

VOLUME 1 : MAIN REPORT

March 2013

JAPAN INTERNATIONAL COOPERATION AGENCY

ORIENTAL CONSULTANTS CO., LTD.

KATAHIRA & ENGINEERS INTERNATIONAL

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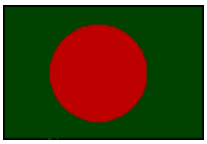
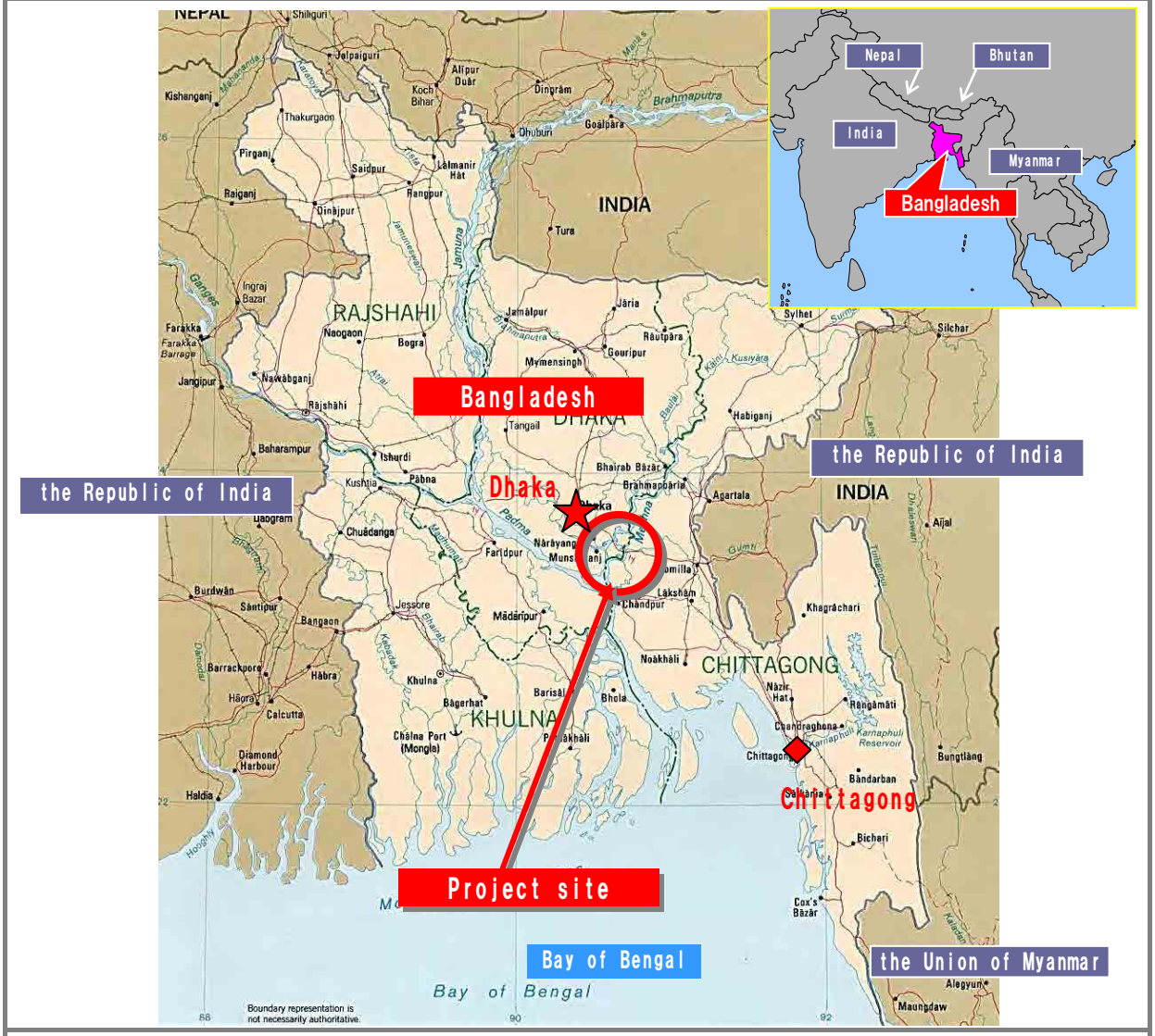
The exchange rates applied in this Study are:
USD 1.00 = BDT 81.7 = JPY 79.0 (December 2012)
*BDT: Bangladesh Taka



People's Republic of Bangladesh



■Area	144 thousand km^2 (About 0.4 times of Japan)
■Population	149.77 million (2012)
■Capital	Dhaka
■Ethnic	Bangalese
■Language	Bengali
■Religion	Muslim (89.7%), Hinduism (9.2%), Buddhism (0.7%), Christianity (0.3%)
■Major industry	Clothing goods, Sewing
■GDP	USD 684 (2010, Central Bank, Bangladesh)
■Economic growth	6.0% (2009, Ministry of Foreign Affairs)
■Price Escalation	6.5% (2009, Ministry of Foreign Affairs)

■Trade (2009, Central Bank, Bangladesh)

Export: USD 162 million

(Knitwear, Clothing goods)

Import: USD 214million

(Fiber, Petroleum products, Steel manufactures, Mechanical component)

■Currency	Bangladesh Taka
■Exchange rate	USD1.00 = BDT 69.18

(2010, Central Bank, Bangladesh)

■ODA Performance of GOJ (2009)

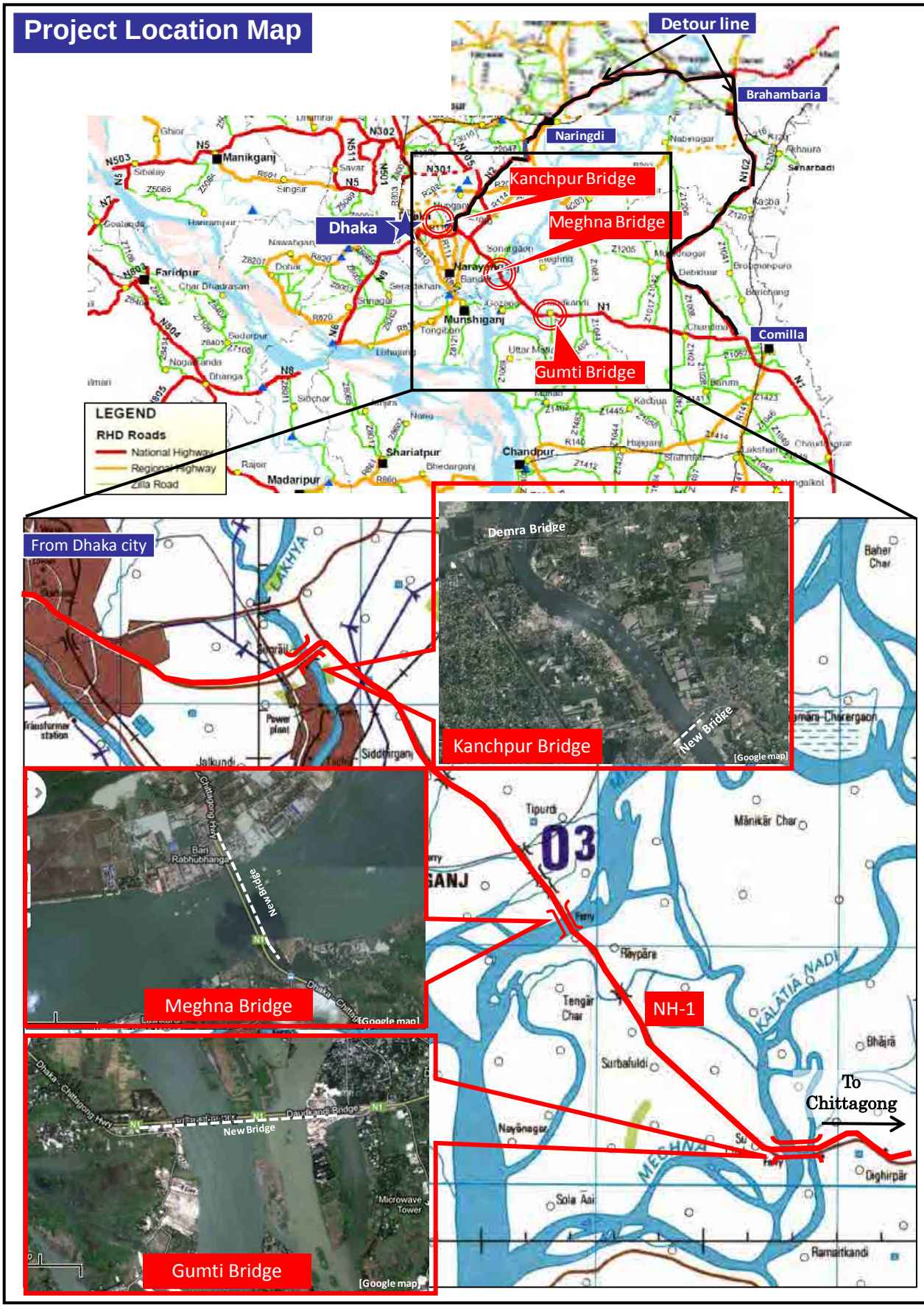
Government loans : 38.792 billion JPY

Grant aid: 2.765 billion JPY

Technical assistance: 2.503 billion JPY

Source: Ministry of Foreign Affairs (2011,10)

Project Location Map



Computer Graphics of completed 2nd Kanchpur Bridge (Dhaka side)

Computer Graphics of completed 2nd Meghna Bridge (Chittagong side)

Computer Graphics of completed 2nd Gumti Bridge (Dhaka side)

Outline of the Project

1. Country: People's Republic of Bangladesh

2. Project Name: The Kanchpur, Meghna, Gumti 2nd Bridges construction and existing bridges rehabilitation project

3. Execution Agency: Roads and Highways Department (RHD) under Ministry of Communication

4. Survey Objective:

The overall goal of the Project is to improve the traffic congestion problem on NH-1 by the construction of Kanchpur, Meghna and Gumti 2nd Bridges and the rehabilitation of existing Kanchpur, Meghna and Gumti Bridges. The outcome of the Survey will be referred to appraise the feasibility of the project as Japanese-ODA loan project.

5. Survey Contents:

Stage 1: Survey Project Background and Data Collection

(1) Review plan and methodology followed during site investigation
(2) Confirmation of the necessity and background of the project
(3) Review design standards followed in Bangladesh
(4) Confirmation of site situation

Stage 2: Survey Project Essential Contents

(5) Location of 2nd bridges, approach road alignment
(6) Rehabilitation plan for existing bridges
(7) Construction plan
(8) Environmental and social consideration
(9) Operation & maintenance administration
(10) Determination of essential contents of the project

Stage 3: Outline Design of Project Components

(11) Outline design
(12) Project implementation plan
(13) Project implementation framework
(14) Bill of Quantities and total cost estimate
(15) Project implementation method
(16) Economic and financial analysis

6. Conclusions and Recommendations:

(1) Conclusions

- The economic viability of the Project is secured at a highly feasibility level. Furthermore, if toll scheme is adopted for three bridges, the project will also be financially viable.
- The route alignment next and parallel to the existing bridge is selected as optimum route for 2nd bridges construction. The required numbers of lanes for 2nd bridges are proposed as 4-lanes. Moreover, 'Steel narrow box girder bridge' is evaluated as the most appropriate bridge type for 2nd bridges. The Steel Pipe Sheet Pile (SPSP) is evaluated as the most suitable foundation type for the construction of 2nd bridges and the rehabilitation of existing bridges.
- The construction of 2nd bridges together with the rehabilitation of existing bridges is to be simultaneously commenced on August, 2016 and their overall completion is scheduled on July, 2021.

(2) Recommendations

As the consequence of this survey, followings are recommended by study team.

a) Environmental and Social Consideration

- Environmental Management Plan (EMP) is prepared in this study. This EMP should be thoroughly implemented in preconstruction and construction stage.
- Resettlement Action Plan (RAP) is prepared in this study. This RAP should be thoroughly implemented without any delay of construction works.

b) Operation and Maintenance

- To establish an effective operation and maintenance, it is strongly recommended to raise 'Road Fund' in which all toll revenues will be considered as contributions to this Fund.
- It is strongly recommended to establish well-maintenance management so that the periodic and routine maintenance works of the bridges can be carried out at a regular interval. The periodic and routine inspection can be conducted safely and smoothly by Bridge Inspection Vehicle.

c) Weighbridge Installation

- To prevent damages in roads and bridges, it is recommended to control the overloading trucks strictly. It can be controlled by the installation of weighbridges at both sides of the bridges.

Preparatory Survey for Dhaka-Chittagong National Highway No.1 Bridge Construction and Rehabilitation Project (Project name: The Kanchpur, Meghna, Gumti 2nd Bridges Construction and Existing Bridges Rehabilitation Project)

EXECUTIVE SUMMARY

1. INTRODUCTION

1.1 Background of the Study

The economic development in Bangladesh maintains a GDP growth rate of around 6 % per annum in the 2000s. More specifically, the adjacent areas along Dhaka-Chittagong National Highway No.1 (NH-1), the lifeline of economy, contributes approximately one-third (32 %) of the nation's GDP and more than one-third (45 %) of the nation's industrial sector, while it reaches 33 % and 13 % of nation's service sector and agricultural sector, respectively. Such trend in economic development of Bangladesh directly impacts on the strong growth in both the number of passengers and freight traffic. Accordingly, the freight traffic has been increasing by 8 times over the last 30 years from 1975 to 2005 and at a rate of 6-7 % in recent years at the same pace as the GDP, and the amount of passenger transport has been increasing at about 6.5 times during the same period.

The traffic capacity on the main roads connecting the major cities and metropolitan areas in Dhaka cannot keep up with the year-after-year increase of traffic volume and eliminating bottlenecks of distribution routes has become a pressing issue. On the other hand, damage to roads and bridges is progressively increasing and has restrained traffic, becoming a major issue. Moreover, "Bangladesh National Building Code (BNBC)" has been implemented in 1993 and the earthquake standards have been raised in 2006; therefore the existing bridges no longer meet the earthquake-resistance standards. Accordingly, rehabilitation and retrofitting of the existing bridges have undoubtedly become a pressing issue.

Since 2008, Government of Bangladesh has been widening the all sections of NH-1 to 4-lanes except existing Kanchpur, Meghna and Gumti Bridges. This 4-lane project is one of the projects mostly needed to accommodate the growth in traffic demand over the next 20 years. However, for bridge sections, funds have not been raised, enlargement to meet the traffic capacity has not progressed, becoming a critical bottleneck to traffic.

Furthermore, the existing Kanchpur, Meghna and Gumti Bridges were constructed in 1977, 1991 and 1995 based on outdated design standards with the seismic acceleration coefficient

of 0.05; however the value has been increased to 0.15 in accordance with BNBC (2006). These three bridges are still further damaged by passing huge numbers of overloaded vehicles, and this situation is bound to go on.

In order to handle the situation, in June 2011, the Government of Bangladesh requested to JICA to undertake a Feasibility Study on 'the Kanchpur, Meghna and Gumti 2nd Bridges construction and existing Kanchpur, Meghna and Gumti Bridges rehabilitation project'. The details of the study area are shown in Project Location Map.

1.2 Objective of the Study

The overall objective of this project is to improve the traffic congestion problem on NH-1 by

a) Construction of 2nd Kanchpur, 2nd Meghna and 2nd Gumti Bridges

b) Rehabilitation of existing Kanchpur, Meghna and Gumti Bridges

In consideration with the above project objectives, the survey works are conducted and the necessary materials are prepared in order to appraise the feasibility of project as Japanese-ODA loan project.

2. NUMBER OF LANES REQUIRED FOR 2ND BRIDGES

For the assessment of lane numbers necessary for 2nd bridges, the traffic surveys (traffic count, OD interview, traffic movement count and traffic speed) were conducted in February, 2012 at Kanchpur, Meghna and Gumti Bridge sites. This provides primary traffic data for the analysis of the current traffic characteristics and a basis for the forecast traffic demand of the project. Average Daily Traffic (ADT) at Kanchpur Bridge site is counted at 34,453, while that at Meghna and Gumti Bridge sites is 27,578.

Regression analysis is made using existing traffic and socio-economic data (vehicle registration data and GDP of Bangladesh) to forecast future traffic demand. Additionally, the traffic demand forecast also considers the influence of traffics to NH-1 due to development of Dhaka-Chittagong double tracking railway and Chittagong port. The forecasted traffic volume at the project bridge sites is shown in Table 2.1.1 hereunder.

The total numbers of lanes required are determined in accordance with forecasted traffic volume and standard road capacity. It is found that at least 10 lanes will be required to cope with traffic volume forecasted in 2030. But, widening of NH-1 to more than10-lanes is not realistic. Rather GoB has a master plan to develop a toll road connecting Dhaka-Chittagong corridor as 8-lanes ahead of Kanchpur Bridge and 6-lanes beyond Gumti Bridge. Therefore, the required numbers of lanes for 2nd bridges are proposed as 4-lanes so as to concurrent with the GoB master plan. Moreover, the lane number of Dhaka-Chittagong expressway, an alternate route of NH-1, was proposed as 4 lanes in the FS study. Accordingly, in 2030, the

numbers of lanes for Dhaka-Chittagong corridor is expected to become 12 lanes in Kanchpur and 10-lanes in Meghna/Gumti.

Table 2.1.1 Proposed lane numbers for 2nd bridges

Survey location	Year 2012		Year 2021		Year 2030		No. of lanes		
	PCU/ day	Required lane no.	PCU/ day	Required lane no.	PCU/ day	Required lane no.	Adopted	Existing Bridge	2nd Bridge
Kanchpur Bridge	76,732	6	123,301	8	192,687	12	8	4	4
Meghna/Gumti Bridge	65,008	4	105,374	6	165,168	10	6	2	

3. SELECTION OF OPTIMUM ROUTE FOR 2ND BRIDGES

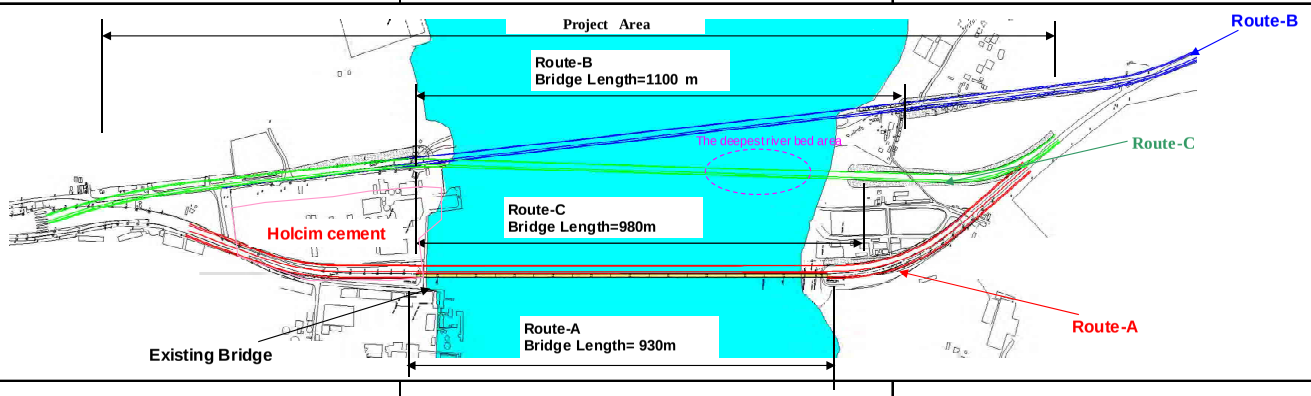
In order to select the optimum route alignment for 2nd bridges construction, the three feasible alternative routes of each bridge are taken into consideration. These route alternatives for respective bridges are briefly described in Table 3.1.1 and they are comprehensively analysed and evaluated by focussing some key items such as impact on socio-environment and natural environment, construction condition and project cost. For instance, the comprehensive evaluation on three alignment alternatives of 2nd Meghna Bridge is summarized in Table 3.1.2. It is found that 'Route A', upstream next and parallel to the existing bridge, has minimum resettlement issue and less impact on the natural environment. Therefore, 'Route A' is considered to be optimum route for 2nd bridge construction, even though this alignment might have some influence to Holcim Cement boundary. However, this issue has already been resolved by the understanding and agreement between RHD and Holcim Cement administration through a clarification letter memo no.5-187/1099-bridge.

On the other hand, the comprehensive evaluation, followed similar approach of 2nd Meghna Bridge, is also applied to optimize route selection for 2nd Kanchpur and 2nd Gumti Bridge construction. Accordingly, the 'Route A' which is downstream next and parallel to the existing bridge is set to as final alignment for 2nd bridges construction. Their detailed evaluations are cited elsewhere in the main report.

Table 3.1.1 Route Alternatives for 2nd Bridges

Bridge	Route alternatives	Location to existing bridge	Description of Route
2nd Kanchpur	**Route A**	**Downstream**	**Next to existing bridge**
	Route B	Downstream	Provides adequate distance from existing bridge
	Route C	Upstream	Next to existing bridge
2nd Meghna	**Route A**	**Upstream**	**Next to existing bridge** **Minimizes the influence on Holcim Cement boundary**
	Route B	Upstream	Provides distance of 250m upstream near the old ferry route
	Route C	Upstream	Provides distance of 250m upstream of shifted ferry route Minimize resettlement issue (Ctg. side) on Route B
2nd Gumti	**Route A**	**Downstream**	**Next to existing bridge**
	Route B	Downstream	Provides adequate distance from existing bridge
	Route C	Upstream	Next to existing bridge

Table 3.1.2 Optimum route selection for 2nd Meghna Bridge

Route alternatives		Route A		Route B		Route C	
Route image							
Route alignment		Next to existing bridge (upstream)		Secure distance of 250m upstream near old ferry route		Secure distance of 250m upstream of shifted ferry route Minimize resettlement issue (Ctg. side) on Alignment B	
① Convenient to road user		No specific problem	◎	No specific problem	◎	No specific problem	◎
Impact on Socio-environment	② Resettlement*	10 structure (5 houses, 5 shops)	◎	250 structure (90 houses, 150 shops, 10 stalls)	△	60 structure (10 houses, 50 shops)	△
	③ Public facility	No	◎	Mosque relocation	△	No	◎
	④ Land acquisition (area,landowner)	15m from Holcim Cement boundary (RHD agreed with Holcim Cememt)	◎	0 m2	◎	0 m2	◎
	⑤ Traffic safety for vessels	Negligible (Integrated foundation)	◎	Slight (two foundations are separated)	○	Slight (two foundations are separated)	○
	⑥ Economic activities (sand unloading, ferry terminal operation, factory etc)	5 shops Fishery	◎	150 shops 50 Sand loading/unloading workers Fishery	△	50 shops 30 Sand loading/inloading workers Fishery	△
Impact on natural environment	⑦ Ecosystem	Small plantation Some impacts on natural fauna and flora during construction	△	Many roadside trees are needed to be cut	△	Many roadside trees are needed to be cut	△
	⑧ Hydrological conditions	Slight (accelerate scouring if some foundations in main channel are conbined, but bank erosion will be little)	○	Slight (impact on new bridge pier is little, but scouring around existing bridge pier will be increased due to protection works)	○	Worst (Increased scouring around new bridge pier due to new route along deepest riverbed, and existing bridge needs protection)	△
	⑨ Noise / air pollution	Negligible impact because few houses remain along new access on Chittagong side	◎	Severe impact because many houses and a school remain along new access	△	Severe impact because many houses and school remain along new access	△
	⑩ River flow	Negligible (Integrated foundation)	◎	Slight (two foundations are separated)	○	Slight (two foundations are separated)	○
	⑪ Landscape	Negligible (two bridges are close)	◎	Slight (two bridges are separated ,loss of road side trees)	○	Slight (two bridges are separated ,loss of road side trees)	○
⑫ Obstacle Object (steel towers, water pipe, gas pipe)		No specific problem	◎	No specific problem	◎	No specific problem	◎
⑬ Construction condition		Construction period is the shortest Bridge Length: 930m Earthwork : 39,000m3	◎	Construction period is the longest Bridge Length: 1,100m Earthwork : 84,000m3	△	Construction period is shorter comparing to Route B Bridge Length: 980m Earthwork : 128,000m3	○
⑭ Project cost		Low	◎	High	△	High	△
Evaluation		◎		△		○	

Legend ◎ : Excellent, ○ : Good, △ : Poor

Note: *Number of structures within the proposed alignment were counted and rouded up based on the number of roofs identified through Google maps and site reconnaissance survey
From the census survey, the number of affected households along Route A is found to be 19 households, that means an average of 1.9 households/structure. Based on this assumption, the affected households under Route B and Route C would be 475 and 114 respectively. Therefore, Route A is the most feasible route due to least affected households, comparing to other plans.

4. SELECTION OF BRIDGE TYPE OF 2ND BRIDGES

The bridge types of 2nd bridges are studied and examined in accordance to several factors such as (1) type of foundation and their integrity with existing one, (2) applicable bridge types and (3) comprehensive evaluation of applicable bridge types.

4.1 Selection of Foundation Type

Two types of foundations are chosen as applicable foundation types for 2nd bridges and retrofitting of existing bridges, one is Steel Pipe Sheet Pile (SPSP) and other is Cast-in-place Concrete Pile. From numerical computation, it is found that the cast-in-place concrete pile foundation under severe riverbed scouring zone needs a huge plane section, a long period for construction, a huge construction cost and a cofferdam to construct pile cap, while the SPSP foundation is possible to be constructed with a smaller plane section, a shorter period and least cost and also needs no cofferdam because of cofferdam function of SPSP. Accordingly, the application of SPSP is proposed and decided to integrate the foundations of 2nd bridges and the existing bridges.

4.2 Applicable Bridge Types

The 2nd bridges will be in close vicinity of the existing bridges respectively, therefore the span configuration of 2nd bridge is required to be same as the existing bridge. In case of modification of span configuration of 2nd bridge, the span length of 2nd bridge should be expanded as a double or triple of one of the existing bridge by decreasing one or two piers and foundations. The existing Kanchpur Bridge has 8 spans with a longest span of 73.2m and shortest one of 42.7m, and most of span length of the existing Meghna and Gumti Bridges is 87.0m. Under restricting the condition of span configuration of the existing bridges, the applicable bridge types for respective 2nd bridges are listed in Table 4.2.1.

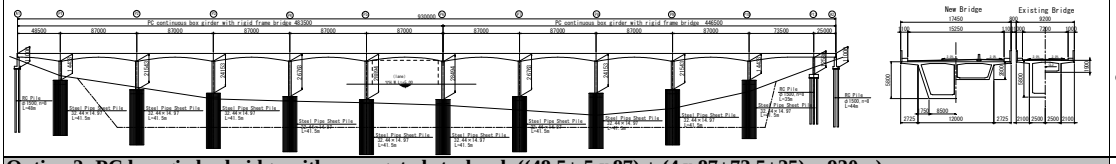
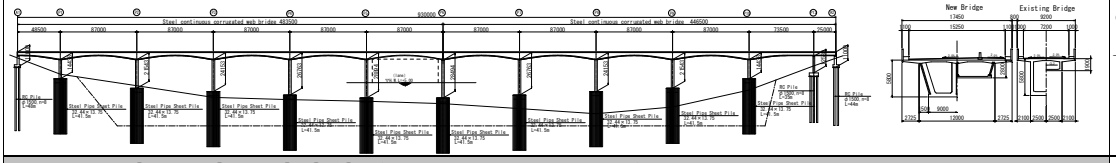
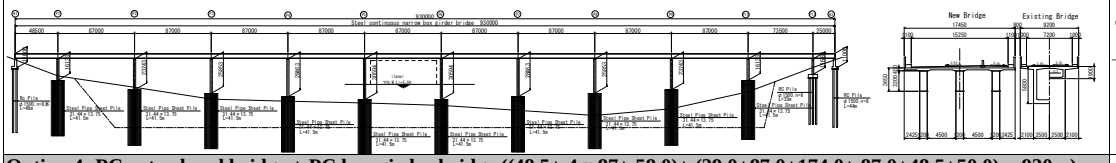
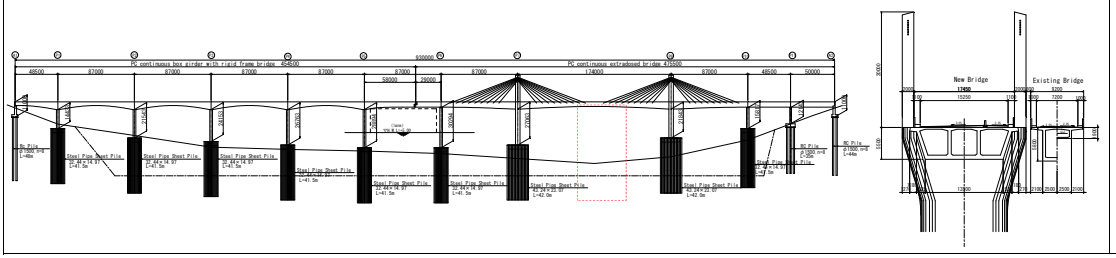
For instance, a comparison among the applicable bridge types (Option-1 to Option-4) for 2nd Meghna Bridge, considering with their cross section, side view, span configuration and selection criteria, is shown in Table 4.2.2.

Table 4.2.1 Applicable Bridge Types

Bridge type	Applicable span length (m)	2nd Bridges			Remarks
		Kanchpur	Meghna	Gumti	
PC T-beam	25 – 45	○	-	-	Same span configuration of existing bridges
PC box girder	45 - 100	○	○	○	Ditto
PC box girder with corrugated steel web	50 - 120	-	○	○	Ditto
Steel narrow box girder	50 - 120	○	○	○	Ditto
PC extradosed	150 - 240	○	○	○	In case of adopting double span length of existing bridges

Among the four options, Option-1 to Option-3 have span configuration same as existing bridge. But, in case of Option-2 and Option-3, Prestressed Concrete (PC) is changed to steel material so as to decrease the superstructure weight. The decreasing in superstructure weight leads advantages to the earthquake resistance. In case of Option-4, the span length is expanded to double of one of the existing bridge by decreasing one pier and foundation located under severe scouring zone.

Table 4.2.2 Applicable Bridge Types for 2nd Meghna Bridge

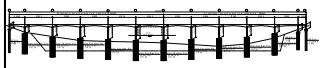
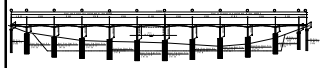
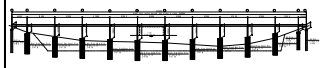
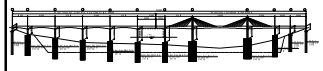
	Remarks
Option-1: PC box girder bridge ((48.5+ 5 x 87) + (4 x 87+73.5+25) = 930m) 	→Same span configuration as existing bridge
Option-2: PC box girder bridge with corrugated steel web ((48.5+ 5 x 87) + (4 x 87+73.5+25) = 930m) 	→Same span configuration as Option-1 →Superstructure weight is decreased compared to Option-1
Option -3: Steel narrow box girder bridge (48.5+ 9 x 87+73.5+25 = 930m) 	→Same span configuration as Option-1 →Superstructure weight is decreased compared to Option-2
Option-4: PC extradosed bridge + PC box girder bridge ((48.5+ 4 x 87+ 58.0)+ (29.0+87.0+174.0+ 87.0+48.5+50.0) = 930m) 	→ One pier is decreased compared to Option-1

4.3 Comprehensive Evaluation on Bridge Type for 2nd Bridges

In accordance with some major evaluation items, the comparison results for the 4-options of 2nd Meghna Bridge are shown in Table 4.3.1. The major items such as Structural performance, Constructability, Maintenance, Landscape, Environmental impact and Construction cost are chosen and each major item consists of some sub-items. Each major item is analysed by integrating the evaluation results of the sub-items. In accordance with these evaluation results, finally "Option-3 (Steel narrow box girder bridge)" is ranked as "1st order" by comprehensive comparison procedure, and it is proposed for the most appropriate bridge type of the 2nd Meghna Bridge. Same evaluation results are also obtained for 2nd Kanchpur and 2nd Gumti Bridges. Details of their comprehensive evaluation are shown elsewhere in the main report.

Specifically the selection of "Opton-3" is governed by some vital factors such as enough durability, advantageous to earthquake resistance, shorter construction period, less impact on environment, compared to other candidate bridges. Therefore, "Steel narrow box girder bridge" is proposed as the most appropriate bridge type for the construction of 2nd bridges.

Table 4.3.1 Evaluation Result of 2nd Meghna Bridge

Bridge type			Option-1			Option-2			Option-3			Option-4		
			PC box girder bridge			PC box girder bridge with corrugated steel web			Steel narrow box girder bridge			PC extradosed bridge + PC box girder bridge		
Bridge shape														
Strctural performance	Record of usage		Many	◎	◎	Moderate	○	○	Moderate	○	◎	Moderate	○	○
	Durability	Durability of floor slab	Enough (PC floor slab)	◎		Enough (PC floor slab)	◎		Enough (PC floor slab)	◎		Enough (PC floor slab)	◎	
	Earthquake resistance	Weight of superstraucture	Moderate	○		Slightly advantageous	○		Advantageous	◎		Moderate	○	
Constructability	Construction method	Difficulty level of constructuction	Normal	○	○	Slightly difficult	△	○	Normal	○	○	Slightly difficult	△	△
	Quality control	Difficulty level of quality control	Normal	○		Normal	○		Normal	○		Slightly difficult (Camber adjustemnt)	△	
	Construction period		4 years	○		4 years	○		3 years	◎		4 years	○	
Maintenance	Painting / Carbonation	Necessity of painting / Surface treatment	Painting once in 30 years	○	○	Painting once in 30 years	○	○	Painting once in 30 years	○	○	Painting once in 30 years	○	○
	Periodic maintenance	Intermidiate joint numbers	1 points	○		1 points	○		Nothing	◎		1 points	○	
		Pier with bearings	2 points	○		2 points	○		11 points	△		3 points	○	
	Cable	replacement of cable sheath	Not required	◎		Not required	◎		Not required	◎		Replacement once in 75 years	△	
Landscape	Aesthetic view		Slender arch shape	○	○	Slender arch shape	○	○	Straight	○	○	Monumental appearance	◎	◎
Environmental impact	River Hydrology	Depends on no. of bridge piers in riverbed	11 piers	○	○	11 piers	○	○	11 piers	○	○	10 piers	◎	◎
	Scouring	number of pier in main stream	5 piers	○		5 piers	○		5 piers	○		4 piers	◎	
	Noice/vibraton	No.and conditions of expansion joints	3 Points	○		3 Points	○		2 Points	◎		3 Points	○	
Construction cost			1.00	◎		1.00	◎		1.00	◎		1.17	△	
Evaluation			2			3			1			4		

Legend: ◎ Excellent, ○ Good, △ Poor

5. OUTLINE DESIGN

5.1 Approach Road

Design conditions for the approach road are as follows:

a) Design speed = 80 km/h

b) Lane width = 3.65 m

c) Outer shoulder width = 1.8 m,
Inner shoulder width = 0.3 m

The plan and the typical cross section of the approach road of 2nd Meghna Bridge, for instance, are shown in Figure 5.1.1 and its geometry is designed based on geometric design standard by RHD and land uses along the selected route of the project. The thickness of flexible pavement is determined based on the cumulative Equivalent Single Axle Load (ESAL) value computed from all heavy commercial vehicles. The calculated thickness of pavement layer components is schematically shown in Figure 5.1.1.

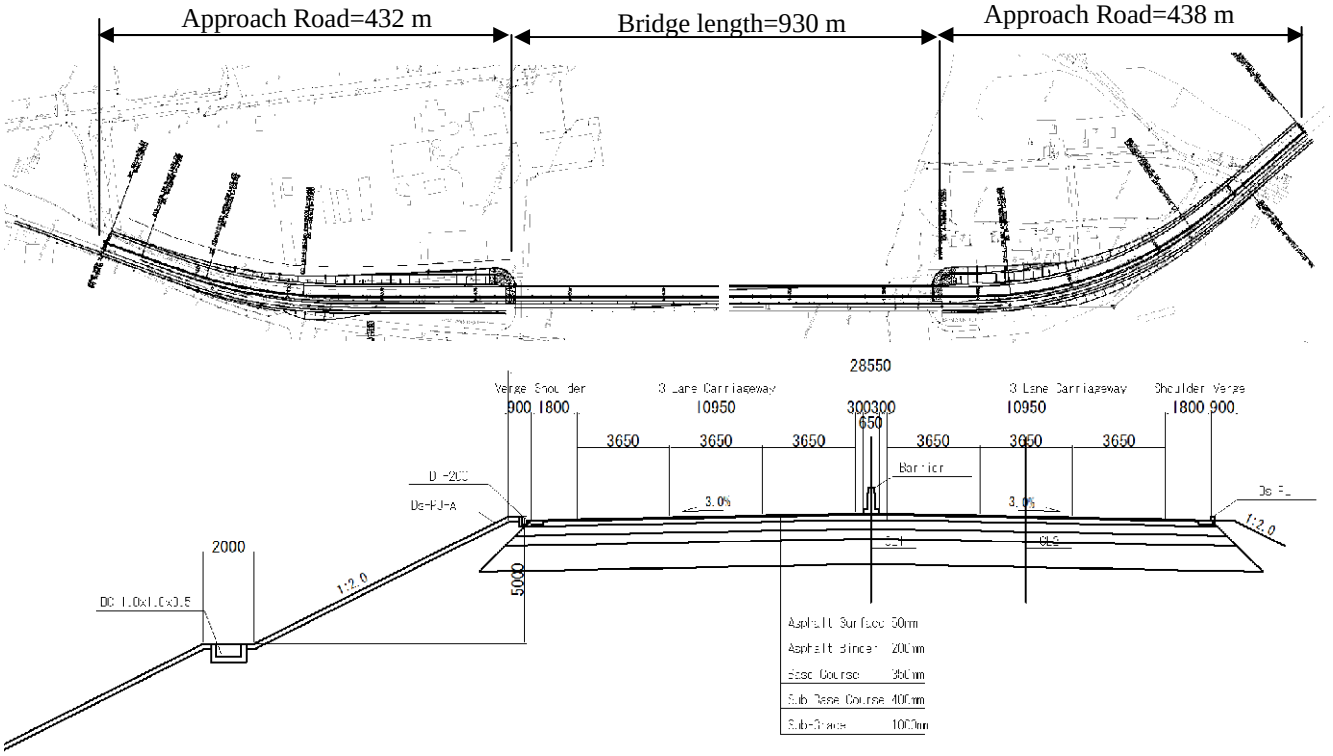


Figure 5.1.1 Plan and typical cross section of approach road (2nd Meghna Bridge)

5.2 2nd Bridges

The design conditions to be used for the 2nd bridges are listed as follows:

1) The type of 2nd bridges would be continuous “Steel Narrow Box Girder Bridge”. The steel box girders have been chosen for the superstructure; therefore the span allocation is kept the same as existing one. The same span allocation will ensure the same number of foundations

for the 2nd bridge and existing bridge. Therefore, it will be easier to unify the new foundations with those of adjacent existing bridge.

2) In accordance with the design scouring level, the type of foundation is determined. Accordingly, where the riverbed scouring level is medium to severe (RL= -14.90 m to -26.2 m), "Steel Pipe Sheet Pile (SPSP)" type foundation is found to be economical and additionally this SPSP will act as a scouring countermeasure. On the other hand, where the riverbed scouring is shallow level (RL= -0.7 m to - 4.6 m), the "Cast-in-place Concrete Pile" foundation is found to be cost effective.

The general outline of the design and the obtained outputs are summarized in Table 5.3.2. Consequently, the general view of 2nd Meghna Bridge, for instance, is shown in Figure 5.2.1.

5.3 Existing Bridges

The present conditions observed and investigated have been examined and the latest design criteria to be conformed to have also been considered. As a result, the existing Kanchpur, Meghna and Gumti Bridges have been determined to need to be retrofitted and rehabilitated in the manner described in Table 5.3.1.

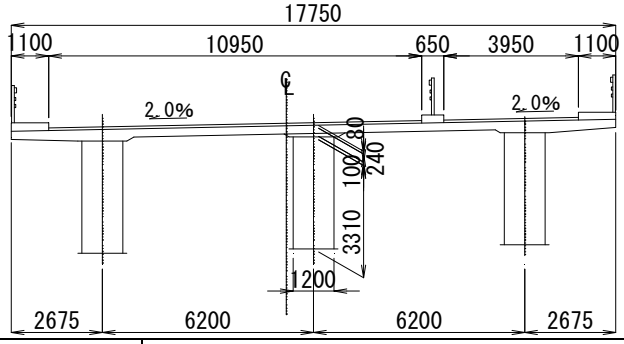
1) The rehabilitation works have been determined as the repair works for the expansion joints in three existing bridges and the repair works for the damaged hinges in existing Meghna Bridge and Gumti Bridge.

2) The repair works for the damaged hinges shall be connecting two cantilever girders to become monolithic, eliminating the hinge and expansion joint, at each hinge section. The retrofitting works comprises the works to renew the bridge structure to conform to the current bridge design standards and to cope with the current and future scouring conditions.

Table 5.3.1 Scope of the Rehabilitation and Retrofitting Works

Rehabilitation/Retrofitting works		Existing Bridge		
		Kanchpur	Meghna	Gumti
Repair of cracks/rebar exposures		○	○	○
Connecting girders (eliminating hinges/joints)		-	○	○
Center hinge rehabilitation		-	○	○
Expansion joint replacement		○	○	○
Steel brackets on the substructures		○	○	○
Fail-safe connection		○	-	-
Deck strengthening		○	-	-
Piers	RC-lining	○	○	○
	Diaphragm wall	○	-	-
Foundations	Pile cap integration	P1, P3, P5, P6	P1 to P10	P1 to P8
	Steel Pipe Sheet Pile (SPSP)	P1 to P6	P3 to P10	P1 to P8
	Cast-in-place concrete pile	-	P1, P2	-

Table 5.3.2 Outline of Design (2nd Meghna Bridge)

Bridge type				Continuous steel narrow box girder
Configuration of bridge superstructure				Bridge length= 930.0 m Girder length= 929.1 m Span= 47.4 m + 9@87.0 m + 73.5 m + 23.9 m
Number of lanes				4-lanes
Cross section				17.75 m (1.1 m (sidewalk) + 15.55 m (road) + 1.1 m (sidewalk)) 
Bridge components	Superstructure			3-box girders (1.2 m x 3.31 m) with PC floor slab(t=24 cm)
	Substructure	Abutment	Inverted T-type	Number: 2 Height: 8.0 m - 9.5 m
		Pier	Columnar type	Number: 11 Height: 9.9 m - 30.44 m
		Foundation	Abutment	Cast-in-place RC pile (φ1.5 m): A1&A2; n=6, L=48.0 m
			Pier	Cast-in-place RC pile (φ1.5 m): P1,P2&P12; n=6-12, L=35.0 m - 44.0m
				SPSP (φ1.0 m) P3-P10; 39.93 m x 14.97 m (including existing) L=42.65-44.15m
Loads	Live load			JRA B-type (only for floor slab system) AASHTO HS20-44 (for girder and substructure)
	Seismic load			$C_{sm} = \frac{1.2ZS}{T_m^{2/3}} \le 2.5Z$; where Z=0.15 and S=1.5
	Wind load			3.0 kN/m^2
	Thermal force			Temperature range: +10 ^{o}c to +50 °c
Construction Materials			Specification	
	Superstructure		Steel	Grade-SM490A (JIS) σ_u = 490 MPa, σ_y = 315 MPa
			PC steel bar	Grade-SWPR7BL (JIS) σ_u = 1,850 MPa, σ_y = 1,600 MPa
			Concrete (Precast)	JIS σ_c = 50 MPa
	Substructure		Concrete (cast-in-situ)	RHD σ_c = 25 MPa
			Rebar	Grade-60 (ASTM) σ_u : 620 MPa, σ_y : 420 MPa
			SPSP	SKY400 and SKY490 (JIS) σ_u = 400 MPa and 490 MPa σ_y = 235 MPa and 315 MPa

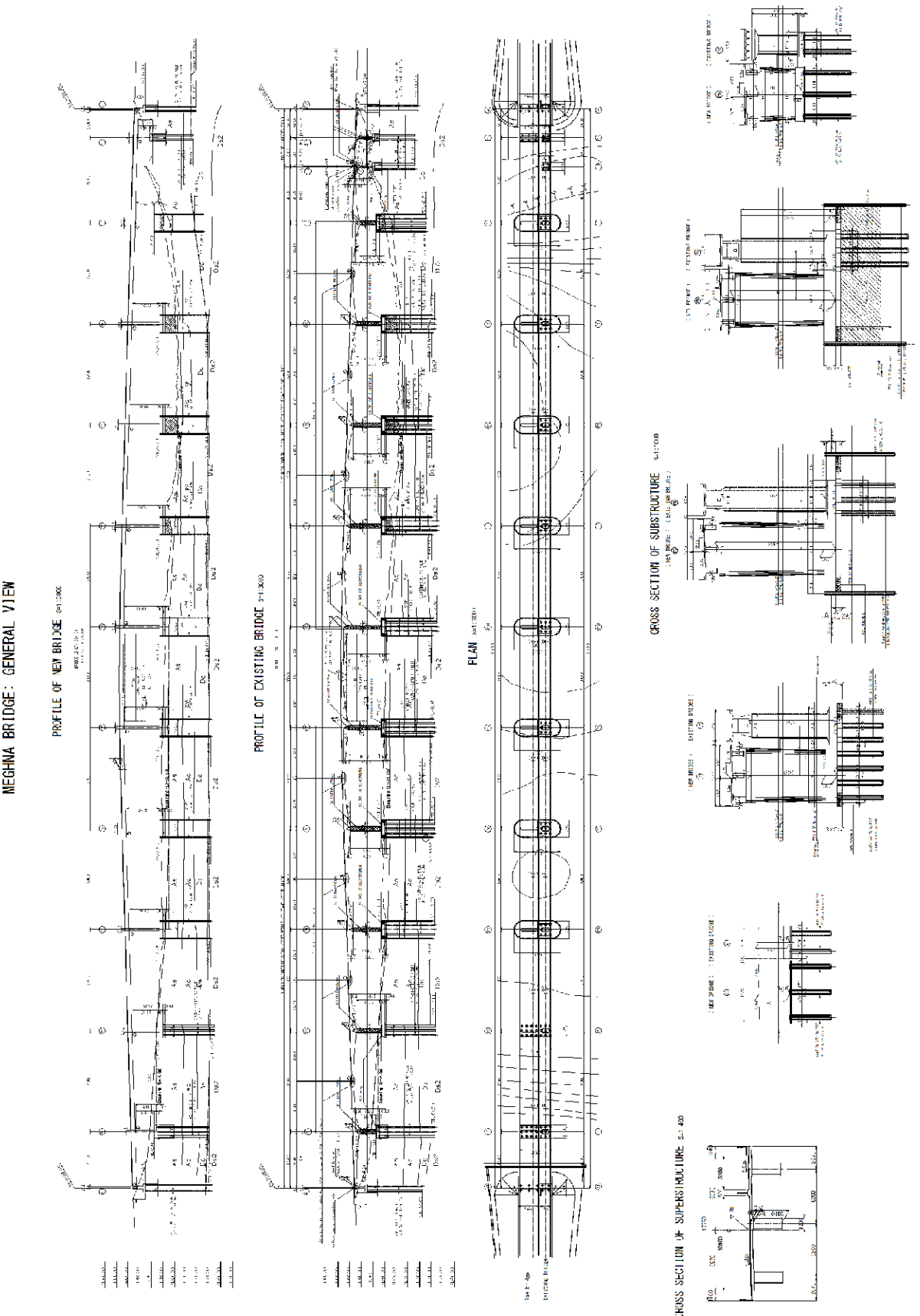
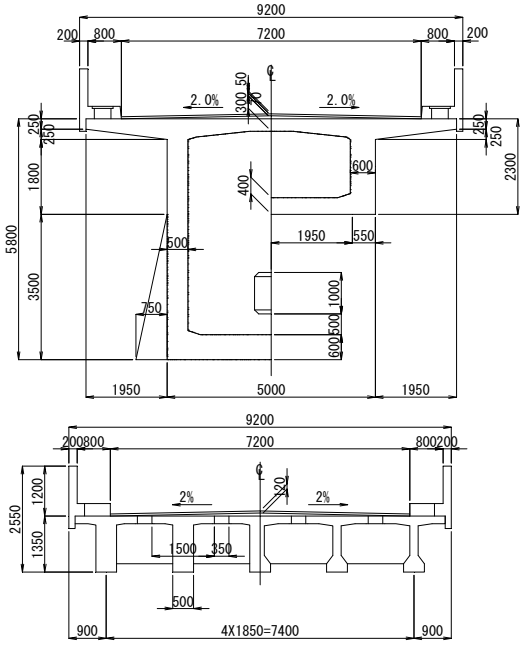


Figure 5.2.1 General view of Meghna Bridge

The general outline of the design and the obtained outputs are summarized in Table 5.3.3. Consequently, the general view of Existing Meghna Bridge, for instance, is shown in Figure 5.2.1.

Table 5.3.3 Outline of Design (Existing Meghna Bridge)

Bridge data			Length = 930 m : 48.5 + 9@87.0 + 73.5 + 25.0 m Width = 9.2 m
Bridge components	Superstructure		Pre-stressed concrete box girder, continuous rigid frame type (48.5 m + 9*87.0 m + 48.5 m) Pre-stressed concrete T girder, simply supported type (2*25.0 m) 
	Substructure	Abutment	Inverted T-type
		Pier	Columnar type
		Foundation	Abutment: Cast-in-place RC pile (φ1,500) Pier: Cast-in-place RC pile (φ1,500)
Loads	Live load		AASHTO HS20-44 (for girder and substructure)
	Seismic load		$C_{sm} = \frac{1.2ZS}{T_m^{2/3}} \leq 2.5Z$; where Z=0.15 and S=1.5
	Wind load		3.0 kN/m^2
	Thermal force		Temperature range: $26^{\circ}c \pm 17^{\circ}c$
Girder and deck	Repair of cracks/rebar exposures		P12 to A2
	Connecting girders (eliminating hinges/joints)		All except P5 to P6
Bridge accessories	Center hinge rehabilitation		P5 to P6
	Expansion joint replacement		A1, P5 to P6, A2
	Steel brackets		A1, A2
Pier	RC-lining		P1 to P12
Foundation	RC casting reinforcement		P1 to P10
	Steel pipe sheet piles		P3 to P10
	Bored RC piles		P1, P2

6. CONSTRUCTION PLAN AND COST ESTIMATE

The construction period of 2nd bridges construction and existing bridges rehabilitation will be 5.0 years (60 months) including mobilization and demobilization as shown in Figure 6.1.1. The project cost is estimated at JPY 88,464 million based on the price in July, 2012 as shown in Table 6.1.1.

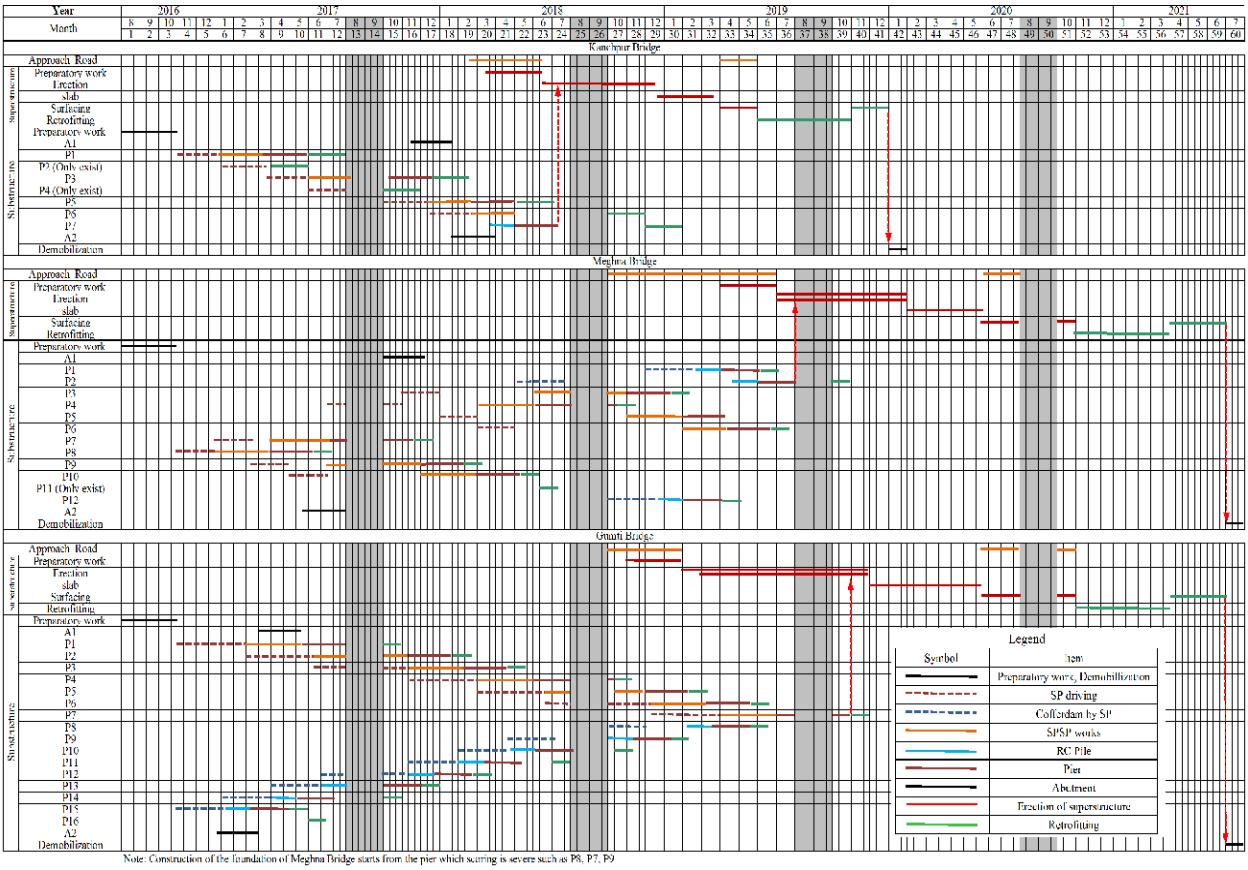


Figure 6.1.1 Construction Schedule

Table 6.1.1 Project Cost Estimates with Components

Cost components		Foreign currency (million JPY)	Local currency (million BDT)	Total (million JPY)
ELIGIBLE PORTION				
	Procurement/ Construction cost	36,999	24,120	60,299
	Consulting Services	3,324	2,678	5,911
	Total	40,322	26,798	66,209
NON ELIGIBLE PORTION				
	Land Acquisition	0	97	94
	Administration cost	0	6,864	6,630
	VAT	0	4,550	4,396
	Import Tax	0	11,490	11,100
	Total	0	23,001	22,219
INTEREST DURING CONSTRUCTION		36	0	36
Project Cost		40,358	49,800	88,464

7. OPERATION AND MAINTENANCE PLAN

Following three key points are strongly recommended to establish an effective operation and maintenance plan for roads and bridges.

- To establish 'Road Fund'. Vehicle Registration tax, additional earmarked tax on fuel and existing toll revenue can be considered as contributions to this Fund.
- To prevent damages in roads and bridges by strict control of overloading trucks. It can be controlled by the installation of weighbridges at both sides of the bridges.
- To ensure easy operation and proper maintenance of the 2nd bridges and the existing bridges, the Bridge Inspection Vehicle (BIV) is introduced through which the daily and periodic inspection can be easily conducted. The level of painting deterioration in steel girder, the present state of damage in expansion joints and hinges should necessarily be inspected by BIV and the corresponding countermeasures should be taken into action accordingly.

8. IMPLEMENTATION PLAN

The milestones for the implementation of project undertaken by Japanese ODA loan are planned as:

- E/N for the implementation of project is to be concluded end of January 2013 and L/A is to be concluded soon after E/N, within 3months after Loan pledge on March 2013
- Assumed 10 months for selection of D/D, Tender Assistance and Supervision consultant
- A period of Review of FS and D/D works including topography, geological survey and preparation of tender documents is 12 months
- Assumed 18 months for procurement of contractor
- The construction of 3 bridges together with rehabilitation of 3 existing bridges is to be simultaneously commenced August 2016
- Overall construction and rehabilitation is to be completed end of July 2021.
- A defect liability period is 24 months after completion of each work component and final defect liability period is to be expired on July 2023.

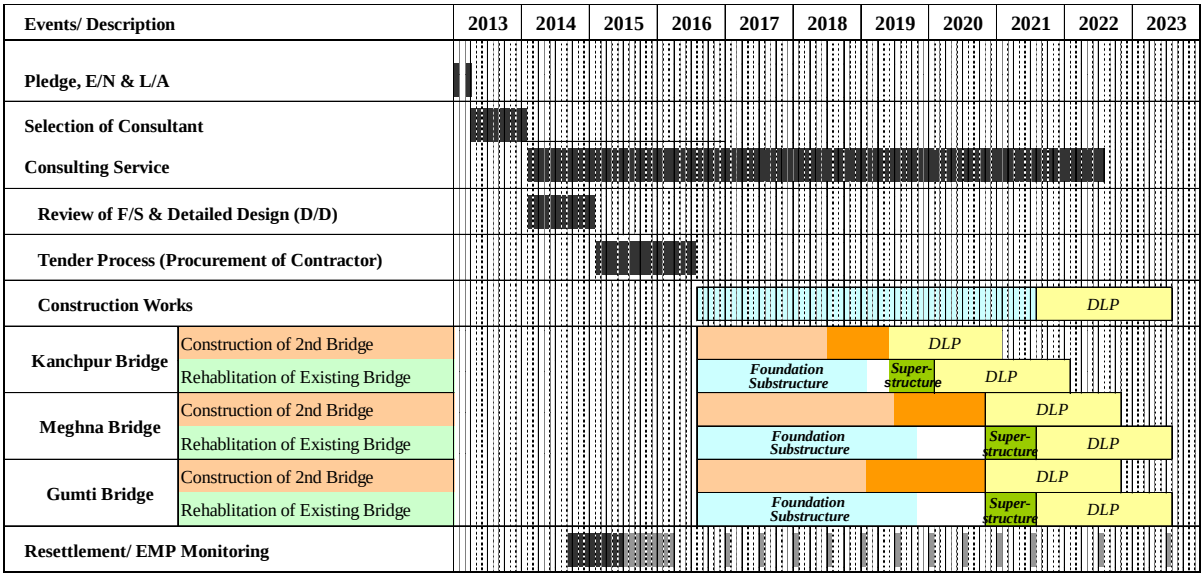


Figure 8.1.1: Project Implementation Plan

9. ECONOMIC AND FINANCIAL EVALUATION

9.1 Economic Evaluation

The Project is evaluated in terms of EIRR, BCR and NPV within the assumed evaluation period of 25 years. Evaluation of the economic viability is made through comparative analysis between EIRR and a social discount rate of 12.0 %. Comparing such a discount rate, it can be said that economic viability is secured at a highly feasibility level whether the road is improved or not improved.

Table 9.1.1 Economic Indicators of project three bridges

Indicator	Plan 1: Road to be Improved				Plan 2: Road not to be Improved			
	Kanchpur Bridge	Meghna Bridge	Gumti Bridge	All Bridges	Kanchpur Bridge	Meghna Bridge	Gumti Bridge	All Bridges
EIRR (%)	38.5 %	24.1 %	19.1 %	24.9 %	38.5 %	21.4 %	16.5 %	23.2 %
BCR	6.22	1.96	1.72	2.59	6.22	1.59	1.40	2.27
NPV (million BDT)	19,337	9,290	9,127	41,446	19,337	5,751	5,088	33,150

9.2 Financial Evaluation

In the financial analysis, two (2) cases of Plans 1 and 2 are not taken into consideration due to toll revenues of Plan 1 and 2 being the same. The financial analysis is computed with the following three (3) cases:

a) Case 1: Cost recovery analysis made by three (3) Bridges individually
b) Case 2: Cost recovery analysis of all three (3) Bridges using revenues of 2-bridge, namely Meghna and Gumti Bridges

c) Case 3: Cost recovery analysis of all three (3) Bridges using all revenues of all 3-bridge

The Project is evaluated in terms of FIRR and NPV within the assumed evaluation period of 25 years. Evaluation of the financial viability is made through comparative analysis between FIRR and a discount rate of 8.0% taking into consideration of 10 years treasury bound of Bangladesh. Comparing such a discount rate, it can be said the project is not financially viable except Kanchpur Bridge.

Table 9.2.1 Financial Indicators of project three bridges

Indicator	Case 1						Case 2		Case 3	
	Kanchpur Bridge		Meghna Bridge		Gumti Bridge		w/o Toll Scheme for Kanchpur Bridge		w/ Toll Scheme for Kanchpur Bridge	
	With Toll	W/O Toll	Plan 1	Plan 2	Plan 1	Plan 2	Plan 1	Plan 2	Plan 1	Plan 2
NPV (million BDT)	21,978	n/a	4,733	781.3	-1,297	-5,249	-3,883	-11,787	23,628	15,517
FIRR (%)	30.40%	n/a	10.20%	8.10%	7.4	5.40%	7.20%	5.10%	12.40%	11.30%
Cost Recovery After Opening (Years)	4	n/a	15	23	No	No	No	No	12	12

10. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

10.1 Environmental Impact Assessment

The EIA report was prepared on the basis of proposed engineering works, field investigations, stakeholder consultation, primary and secondary data collection, screening of all baseline environmental parameters, environmental quality baseline monitoring, and review of other similar project reports in Bangladesh. The study was taken up during March–August, 2012.

Locations of the 2nd bridges were studied in the views of feasibility such as social impact, environmental impact and cost etc. It is found that 'Route A', next and parallel to the existing bridge, has minimum resettlement issue and less impact on the natural environment.

The Project is classified as "Red" under regulation of Bangladesh and "A" according to the JICA Environmental Guidelines, and thus EIA is necessary to be conducted.

Several scoping has been set to find out possible ecological/environmental and social impact caused by the implementation of proposed project. The results of scoping are shown in Table 10.1.1. Impacts are rated in A, B, C and D, which are defined as follows;

A: Severe negative impact is predicted
B: Limited negative impacts can be predicted
C: Impact is unknown
D: Almost no negative impact is predicted

Table 10.1.1: Results of Scoping at three bridges

Sl. no.	Item	Kanchpur Bridge			Meghna Bridge			Gumti Bridge		
		Overall	Before / During Construction	During Operation	Overall	Before / During Construction	During Operation	Overall	Before / During Construction	During Operation
1	Involuntary resettlement	A	A	D	A	A	D	A	A	D
2	Local economics, such as employment, livelihood, etc.	A	A	D	A	A	D	A	A	D
3	Land use and utilization of local resources	B	B	D	B	B	D	D	D	D
4	Social institutions such as social infrastructure and local decision-making institutions	D	D	D	B	B	D	B	B	D
5	Existing social infrastructures and services	D	D	D	B	B	D	D	D	D
6	Poor, indigenous, or ethnic people	A	A	D	A	A	D			
7	Misdistribution of benefits and damages	B	B	B	B	B	B	A	A	D
8	Local conflicts of interest	B	B	B	B	B	B	B	B	B
9	Cultural heritage	D	D	D	D	D	D	B	B	B
10	Accident	B	B	B	B	B	B	D	D	D
11	Infectious diseases such as HIV/AIDS	B	B	C	B	B	C	B	B	B
12	Gender	B	B	C	B	B	C	B	B	C
13	Children's rights	B	B	C	B	B	C	B	B	C
14	Erosion and scouring	C	C	C	A	C	A	A	C	A
15	River transportation	B	B	B	B	B	B	B	B	B
16	Hydrology	B	B	B	B	B	B	B	B	B
17	Biota and Ecosystem	B	B	C	B	B	C	B	B	C
18	Global Warming	C	C	C	C	C	C	C	C	C
19	Air Pollution	B	B	C	B	B	C	B	B	C
20	Water Contamination	B	B	D	B	B	D	B	B	D
21	Soil Pollution	B	B	D	B	B	D	B	B	D
22	Waste	B	B	D	B	B	D	B	B	D
23	Noise and Vibration	B	B	C	B	B	C	B	B	C
24	Ground Subsidence	C	D	C	C	D	C	C	D	C
25	Offensive Odor	C	C	C	C	C	C	C	C	C
26	Bottom Sediment	C	C	D	C	C	D	C	C	D
27	Landscape	C	C	C	C	C	C	C	C	C

Source: EIA Report

The EIA report as per the TOR and specified terms and conditions in the DoE letter no. DoE/Clearance/5150/2012/31 7/2002/900 dated 23/05/2012, has been prepared for obtaining the Environmental Clearance Certificate (ECC) from the Government of Bangladesh (GoB). Accordingly, the EIA report was submitted to DoE on October 11, 2012 and approved by DoE on 12 November, 2012.

10.2 Consultation and Participation

Public consultations were held three times on 15th March 2012, 1st August 2012 and 1st September 2012. In the consultation, the local people did not mostly have any comment, opinion, suggestion and question relating to the environment.

10.3 Resettlement Action Plan

Construction of the 2nd bridges and rehabilitation of the existing bridges will require no land acquisition. All components of the project will be constructed on the RHD land. A total of 274 Project Affected Households (PAHs) or 972 peoples will be relocated due to the project interventions as shown in Table 10.3.1. Besides, two community properties will also be relocated from the project area. A total of 231 households and shop tenants will be displaced in Kanchpur Bridge, 19 in Meghna Bridge and 24 in Gumti Bridge. In addition to 274 households to be displaced, a total of 28 wage laborers will also lose their sources of livelihood due to the project of which 26 at Kanchpur Bridge and 2 at Gumti Bridge. These peoples and properties are located in RHD owned land and have not official land ownership. However, bridge wise impacts are shown in Table 10.3.1.

Table 10.3.1 Number of Affected Households

Type of loss		No of PAHs				No of people			
		Kanchpur	Meghna	Gumti	Total	Kanchpur	Meghna	Gumti	Total
Required for Displacement									
1	Residential house owners	100	1	6	107	412	3	19	434
2	Residential rentee	98	0	0	98	313	0	0	313
3	Shop owners	26	17	18	61	98	40	61	199
4	Shop tenants	4	1	0	5	12	4	0	16
5	Residential and shop owner	3	0	0	3	10	0	0	10
	Sub Total (1-5)	231	19	24	274	845	47	80	972
Not required for Displacement									
6	Pond/fish cultivator	1	0	0	1	5	0	0	5
7	Tree owners	0	1	0	1	0	6	0	6
8	Wage earners (Employees)	26	0	2	28	26	0	2	28
9	Community owned structures	1	1	0	2	1	1	0	2
	Sub Total (6-9)	28	2	2	32	32	7	2	41
Grand Total (1-9)		259	21	26	306	877	54	82	1,013

Source: RAP Report

Mitigation of above impacts will be undertaken through implementation of this Resettlement Action Plan (RAP), addressing the gaps between national legislation and the requirements of Development Partner (such as JICA)'s Policy on Involuntary Resettlement.

Resettlement Action Plan (RAP) report was prepared and submitted to RHD for obtaining the approval from the GoB side and accordingly MoC approved the RAP report on November 28, 2012.

Preparatory Survey for Dhaka-Chittagong National Highway No.1 Bridge Construction and Rehabilitation Project

(Project Name: The Kanchpur, Meghna, Gumti 2nd Bridges Construction And Existing Bridges Rehabilitation Project)

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AADT	Annual Average Daily Traffic
AASHTO	American Association of State Highway and Transport Officials
ACC	Accident Cost
ACEs	Additional Chief Engineers
ADB	Asian Development Bank
ADCP	Acoustic Doppler Current Profiler
ADT	Average Daily Traffic
AH	Affected Household
AIDS	Acquired Immunodeficiency Syndrome
AOGCMs	Atmosphere-Ocean General Circulation Model
APs	Affected Persons
AR4	Forth Assessment Report, IPCC
ASTM	American Society for Testing Material
BBA	Bangladesh Bridge Authority
BBS	Bangladesh Bureau of Statistics
B/C	Cost-Benefit
BCCSAP	Bangladesh Climate Change Strategy and Action Plan
BCM	Billion Cubic Meter
BCR	Benefit Cost Ratio
BDNAPA	Bangladesh National Adaptation Program of Action
BDT	Bangladesh Taka
BEPZA	Bangladesh Export Processing Zones Authority
BIWTA	Bangladesh Inland Water Transport Authority
BMD	Bangladesh Metrological Department
BMMS	Bridge Maintenance Management System
BNBC	Bangladesh National Building Code
BOD	Biochemical Oxygen Demand
BRTA	Bangladesh Road Transport Authority
BRTC	Bangladesh Road Transport Corporation
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
CBEs	Commercial and Business Enterprises
CG	Computer Graphics
CPD	Center for Policy Dialogue
CBR	California Bearing Ratio
CCC	Climate Change Cell
CEAM	Cumulative Effects Assessment and Management
CEGIS	Center for Environmental and Geographic Information Service
CH	Fat Clay
CL	Lean Clay
CMS	Central Monitoring and Management System

C&B	Construction and Building
COD	Chemical Oxygen Demand
COP	Conference of the Parties
CPRs	Common Property Resources
CS	Construction Supervision
DB	Dispute Board
DC	Deputy Commissioner
DCSC	Design and Construction Supervision Consultant
DD	Dry Density
D/D	Detail Design
DfID	Department for International Development
DOE	Department of Environment
DPs	Displaced Persons
DTCB	Dhaka Transport Co-ordination Board
E/N	Exchange of Note
EA	Executing Agency
ECC	Environmental Clearance Certificate
EDA	Elastic Dynamic Analysis
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMA	External Monitoring Agency
EMP	Environmental Management Planning
EPs	Entitled Persons
EPZ	Export Processing Zones
ESA	Equivalent Static Analysis
ESAL	Equivalent Single Axle Load
ESDI	Global Land Cover Facility Earth Science Data Interface
FAO	Food and Agriculture Organization
FC	Foreign Currency
FIRR	Financial Internal Rate of Return
FGD	Focus Group Discussion
FMU	Financial Management Unit
FS	Feasibility Study
FS	Fine sand
FY	Financial Year or Fiscal Year
GDP	Gross Domestic Product
GIS	Geographic Information Service
GoB	Government of Bangladesh
GoJ	Government of Japan
GPS	Global Positioning System
GRCs	Grievance Redress Committees
GWAVA	Global Water Availability Assessment
HDM	Highway Development and Management

HHs	Households
HIV	Human Immunodeficiency Virus
HNPS	Hard Non Plastic Silt
HPC	Hard Plastic Clay
HSMP	Health and Safety Management Plan
IA	Implementation Agency
IARC	International Agency for Research on Cancer
ICB	International Competitive Bidding
ICC	Impact Climate Change
ICT	Information and Communication Technology
IDB	Islamic Development Bank
IDC	Institutional Development Component
IM	Impact
IMF	International Monetary Fund
IOL	Inventory of Losses
IPCC	Intergovernmental Panel on Climate Change
IRC	Indian Road Congress
IWFM	Institute of Water and Flood Management
IWT	Inland Water Transport
JBIC	Japan Bank for International Cooperation
JDCF	Japan Debt Cancellation Fund
JICA	Japan International Cooperation Agency
JIS	Japan Industrial Standards
JPY	Japanese Yen
JRA	Japan Road Association
KFAED	Kuwait Fund for Arab Economic Development
kp	kilometer post
km	kilometer
LL	Liquid Limit
L/A	Loan Agreement
LGI	Local Government Institutions
LGED	Local Government Engineering Department
LRFD	Load and Resistance Factor Design
M	Month
MDD	Maximum Dry Density
MFF	Multi-tranche Financing Facility
MH	Elastic Silt
M.H.W.L	Mean High Water Level
MILTT	Ministry of Land, Infrastructure, Transport and Tourism
MOC	Ministry of Communication
MoEF	Ministry of Environment and Forest
MPC	Medium Plastic Clay
MSL	Mean Sea Level

NAPA	National Adaptation Program of Action
NGO	Non Governmental Organizations
NH-1	National Highway No.1
NH-2	National Highway No.2
NMV	Non- Motorized Vehicle
NPV	Net Present Value
OD	Origin Destination
ODA	Official Development Assistance
OM	Operation and Maintenance
OMC	Optimum Dry Density
PAHs	Project Affected Households
PAVC	Property Assessment and Valuation Committee
PD	Project Director
PC	Prestressed Concrete
PCU	Passenger Car Unit
Pf	Failure Pressure
PI	Plasticity Index
PIU	Project Implementation Unit
PL	Plastic Limit
PMBP	Padma Multipurpose Bridge Project
PMT	Pressuremeter test
Po	Earth Pressure at rest
PPP	Public Private Partnership
PQ	Pre-qualification
PRC	Prestressed Reinforced Concrete
PRECIS	Providing Regional Climates for Impacts Studies
PWD	Public Works Datum
PWRI	Public Work Research Institute of Japan
Py	Yield Pressure
Q-V	Quantity of traffic volume and Velocity
RAMS	RHD Road and Bridge Asset Management System
RAP	Resettlement Action Plan
RC	Reinforced Concrete
RHD	Roads and Highways Department
RL	Reduce Level
RMG	Ready Made Garments
ROW	Right of Way
RRC	Riprap Cost
RS	Response Spectrum
RTA	Road Traffic Accident
RTWs	River Training Works
RUC	Road Use Cost
RV	Replacement Value

SES	Socio-economic Survey
SEC	Social and Environmental Circle
S.H.W.L	Standard High Water Level
SMP	Safety Management Plan
SN	Standard Number
SPSP	Steel Pipe Sheet Pile
SPT	Standard Penetration Test
SRES	The Special Report on Emissions Scenarios
SST	Sea Surface Temperature
STA	Station
SWG	Sectoral Working Group
TA	Technical Assistance
TAR	Trans Asian Railway
tf	ton force
TOR	Terms of Reference
TTC	Travel Time Costs
UD	Undisturbed Sample
UK	United Kingdom
UNFCCC	United Nation Framework Convention on Climate Change
US$	United State Dollar
VAT	Value Added Tax
VFS	Very Fine sand
VHH	Vulnerable Households
VOC	Vehicle Operating Cost
W	With
WACC	Weighted average capital Cost
WARPO	Water Resources Planning Organization
WD	Wet Density
W/O	Without
WHO	World Health Organization
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific

CHAPTER 1

INTRODUCTION

1. INTRODUCTION

1.1 General

In Bangladesh, along with the economic development maintaining a GDP growth rate of around 6 % per annum in the 2000 s, the strong growth in both the number of passengers and amount of freight continues, as the amount of freight has increased by a factor of 8 over the last 30 years from 1975 to 2005 and at a rate of 6-7 % in recent years at the same pace as the GDP, and the amount of passenger transport has been increasing at about a factor of 6.5 during the same period. Although the country's main transportation modes are inland waterways, railways and roads, the tendency is in the concentration of both passenger and freight using roads. Bangladesh is aiming at the "economic growth to benefit the poor" based on the revised PRSP-II (2009). In this situation, road traffic management of basic infrastructure is considered as having a direct impact on economic growth and poverty reduction, and the National Land Transport Policy (2004) has made "the construction of new bridges to reduce the missing links of the main road network a more effective use of existing infrastructure". Taking this situation into account, the road network has been actively expanding, and the Bangladesh road network has extended to a total length of approximately 271,000 km.

However, the traffic capacity on the main roads connecting the major cities and metropolitan areas in Dhaka can not keep up with the year-after-year increase of traffic volume and eliminating bottlenecks of distribution routes has become a pressing issue. On the other hand, damage to roads and bridges is advancing and has restrained traffic, becoming a major issue. In particular, for trunk roads and local highways where there are no alternative roads, progression of bridge damage is a serious problem. In addition, the "Bangladesh National Building Code (BNBC)" has been implemented in 1993, and as Bangladesh earthquake standards have been raised (2006), existing bridges no longer meet the earthquake-resistance standards and repair and reinforcement have undoubtedly become a pressing issue.

Based on the Road Master Plan (2009), Bangladesh has specifically made the reinforcement of National Highway No.1 (NH-1) as one of the projects most needed to accommodate the growth in traffic demand over the next 20 years, and since 2008, the change to a four-lane in all sections has been carried out. However, for bridge sections, funds have not been raised, enlargement to meet the traffic capacity has not progressed, becoming a bottleneck to traffic, and existing bridges which no longer meet the earthquake standards are still further damaged by passing vehicles, and this situation is bound to go on. In the Bangladesh Climate Change Strategy and Action Plan (BCCSAP, 2008), guidelines have been established for bridge construction in river banks that is subject to erosion, and for seawall construction to suppress bank erosion.

Thus, in June 2011, the Government of Bangladesh has requested to JICA to undertake a study to repair and reinforce the existing Kanchpur, Meghna and Gumti Bridges on NH-1, and the construction of the 2nd Kanchpur, 2nd Meghna and 2nd Gumti Bridges. Kanchpur, Meghna and Gumti Bridges are important bridges located on the NH-1 connecting Dhaka and Chittagong which is the key corridor that supports the economy.

1.2 Project Background

1.2.1 Deterioration of Existing Bridges

The NH-1, namely, Dhaka-Chittagong Highway, is the lifeline for the economy of Bangladesh with a capacity of 25,000 Annual Average Daily Traffic (AADT). The NH-1 will be a part of the Asian Highway that connects with neighbouring countries. Along this highway, existing Kanchpur, Meghna and Gumti Bridges are major structures which cross Lakhya, Meghna and Gumti Rivers. These bridges, constructed in the year of 1977, 1991 and 1995 respectively, have been deteriorating for several years. If the existing Kanchpur, Meghna or Gumti Bridges become impassable, a very long detour will be made necessary, that is, traveling from Dhaka to Chittagong or Comilla, a detour of 70 km (Figure 1.4.1) would be necessary. Such an extensive detour is certain to create immeasurable economic losses. Consequently, to recover this economic loss, the three existing bridges need rehabilitation on an urgent basis.

(1) The deterioration of existing Kanchpur Bridge, Meghna Bridge and Gumti Bridge were only a result of normal aging except those of the expansion joints in all the bridges and the hinges in existing Meghna and Gumti Bridges. Existing Meghna and Gumti Bridges are multi span continuous prestressed concrete rigid frame bridges having, in the middle of each span between piers, hinges and expansion joints, where no bending moments occur. The hinges are fixed in the vertical direction to transmit the shearing forces between the cantilevers projecting from the piers whereas they are free in the horizontal direction to eliminate restraint forces due to creep, shrinkage and temperature in the structures. It has been observed that the hinges lost the proper function to transmit the shearing forces between the cantilevers, generating noises and unfavorable impact forces on the expansion joints when vehicles move from one cantilever to the other cantilever. The main reason for the damage is considered to

be heavily overloaded trucks. The essential parts such as the superstructures and substructures of the bridges were investigated and judged as sound even though some cracks due to aging are observed.

(2) The three existing bridges were designed and constructed in accordance with the outdated seismic design standard with the seismic acceleration coefficient of 0.05, however, the value has been increased to 0.15 in BNBC (2006)[1].

(3) The deepest river bed -20.70 m (PWD) was measured in the bathymetric survey conducted along the centerline of existing Meghna Bridge. Therefore, the local scouring at bridge piers is suspected to be in critical condition.

(4) The issues of damage to the expansion joints and hinges will be resolved by connecting the simply supported girders into a continuous girder at the hinged sections. And also the existing bridges may necessitate seismic retrofitting to withstand earthquake excitations in accordance with current codes under the scoured condition.

1.2.2 Substantial Shortage of Capacity for Present and Future Traffic Demand

Recently, the Government of Bangladesh (GoB) has planned to widen the NH-1 into 4-lanes in order to increase traffic capacity and remove traffic bottlenecks in the earthwork section. But, these are existing 2-lane bridges which are becoming a critical bottleneck for traffic movement on NH-1 in the bridge section.

In 2012, Average Daily Traffic (ADT) of the NH-1 is 75,000PCU, 65,000PCU at existing Kanchpur and Meghna/Gumti Bridges respectively. The magnitude of ADT has already exceeded its traffic volume capacity by more than 10 % and 60 % at Kanchpur and Meghna/Gumti Bridges respectively. In addition, due to the increasing traffic trend, the forecast traffic volume in 2025 will exceed by 100 % and 200 % the capacity at Kanchpur and Meghna/Gumti Bridges respectively.

It is obvious that the existing 2-lane bridges will fail to cope with the increased traffic volume of the NH-1 and cause serious traffic congestion. Therefore, the construction of new 2nd Kanchpur, 2nd Meghna and 2nd Gumti Bridges is becoming an essential issue.

1.3 Project Objectives

In accordance with the context of the preceding section, it can be concluded that the three existing bridges need to be retrofitted and three new 2nd bridges should be constructed to meet the increasing traffic demand of NH-1. So, the overall objective of this project consists of the rehabilitation of the three existing bridges and the construction of three new 2nd bridges.

[1] Bangladesh National Building Code (BNBC) was first published in 1993. Then, in 2006, the Building Construction Act 1952 was amended to include a new section 18A empowering the Government to promulgate the BNBC (1993) as a legally binding document (Gazette).

(1) Rehabilitation of existing Kanchpur, Meghna and Gumti Bridges so as to ensure smooth traffic flow over the bridges.

The three existing bridges are damaged due to heavily overloaded trucks, the scouring of Meghan Bridge piers is in progress, and also the three existing bridges designed in accordance with the outdated seismic design standard should be analyzed using the new seismic design standard of BNBC (2006). The contents of rehabilitation of the three existing bridges are examination of the above influence and retrofitting them to secure their reliability as bridge structures.

(2) Construction of new 2nd Kanchpur, 2nd Meghna and 2nd Gumti Bridges to accomodate the increasing traffic demand.

In the recommendation of the traffic demand forecast, 8-lanes are necessary for existing Kanchpur Bridge and 6-lanes for existing Meghna and Gumti Bridges. The existing Kanchpur Bridge will function as a 4-lane bridge, and also the existing Meghna and Gumti Bridges as 2-lane bridges after rehabilitation. Therefore, the new 2nd Kanchpur, 2nd Meghna and 2nd Gumti Bridges are designed as 4-lane bridges.

In consideration of the above project objectives, the survey work will be carried out in order to appraise Japanese ODA loan that will cover total project cost, project implementation framework, environmental and social considerations.

1.4 Survey Area

1.4.1 Location of Survey Area

The survey area covers existing Kanchpur, Meghna and Gumti Bridges on NH-1. The details of the study area are shown in Figure 1.4.1. The Dhaka-Chittagong corridor NH-1 passes through seven districts (Dhaka, Narayanganj, Munshiganj, Comilla, Feni, Chittagong, and Cox's Bazar). The importance of this corridor and its contribution to the national economy are explained in the following section.

1.4.2 Economic Condition of Dhaka-Chittagong Corridor NH-1

The economic condition of Dhaka-Chittagong corridor is expressed herein under by regional GDP growth of the areas adjacent to NH-1. The average regional GDP growth over the 10 years from 1995 to 2005 for the seven districts of Bangladesh along Dhaka-Chittagong corridor NH-1 is shown in Table 1.4.1. This table shows that the average GDP growth of the seven districts ranges between 4.3 %-6.6 % p.a. in which the regional GDP growth rate at Dhaka district is accelerated to maximum. Moreover, this table also shows that the overall GDP growth of the nation (whole Bangladesh) accelerated to 5.4 % p.a.

It can also be observed that greater Dhaka, Comilla and Chittagong regions together account for approximately one-third (32 %) of the nation's GDP and more than one-third (45 %) of

the nation's industrial sector, while it reaches 33 % and 13 % of the nation's service sector and agricultural sector, respectively. Therefore, the reduction of travel time between Dhaka and Chittagong, two of the most important cities in Bangladesh, will help to improve the overall economic environment of Bangladesh in addition to strengthening ties between the two cities.

Table 1.4.1 Trends in GDP Growth at Current Market Prices in Areas along NH-1

Areas	1995-96				2005-06				Average change p.a.
	Agricul-ture	Industry	Service	total	Agricul-ture	Indust-ry	Service	total	
Dhaka	62	2,348	3,304	5,714	82	4,103	5,311	9,496	6.6 %
Narayanganj	48	503	546	1,097	62	848	841	1,751	6.0 %
Munshiganj	74	78	173	325	70	134	262	466	4.3 %
Comilla	362	239	544	1,145	410	338	887	1,635	4.3 %
Feni	85	61	141	287	99	95	235	429	4.9 %
Chittagong	357	1,061	1,637	3,055	421	1,861	2,581	4,871	5.9 %
Cox's bazar	214	117	234	565	233	203	383	819	4.5 %
Bangladesh	9,355	9,717	19,321	38,393	11,014	16,674	31,356	59,044	5.4 %
Contribution to National economy	13 %	45 %	34 %	32 %	13 %	46 %	33 %	33 %	-

Unit: million US$

Source: Center for Policy Dialogue (CPD) report on Growth, Income, Inequality and Poverty (2008)

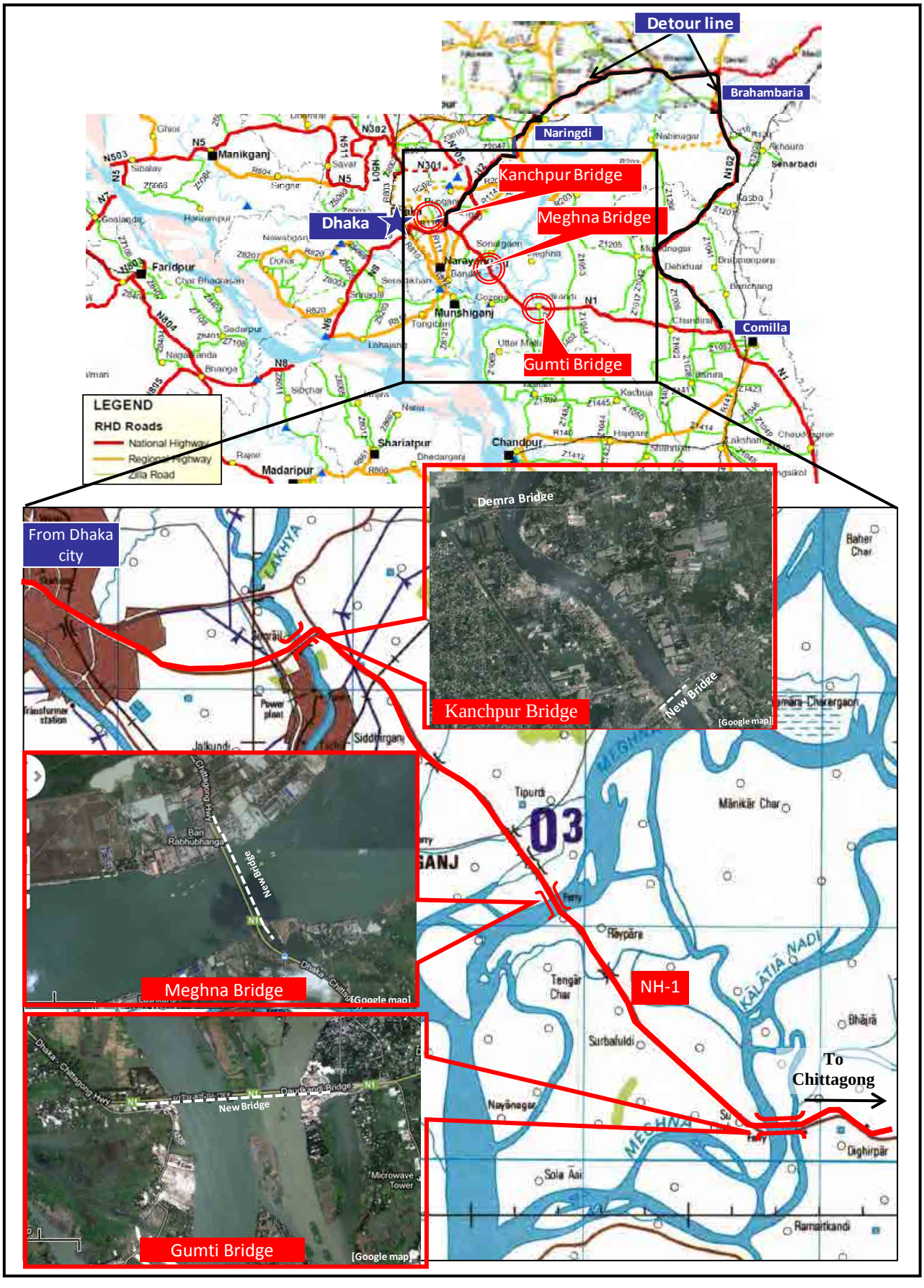


Figure 1.4.1 Project Location Map

1.5 Relevant Development Plans

1.5.1 Road Development Plans

(1) 8-laning of Jatrabari-Kanchpur Road

(Polder Road)

The main objective of the project is to widen the Jatrabari-Kanchpur portion of NH-1 to 8-lane for minimizing traffic congestion and to establish better road communication. The project is managed by RHD.

Length: 9 km

Project was commenced in January 2011, and is scheduled to be completed in the beginning of June 2013. The present construction progress is 10 %.

(2) 4-laning of Dhaka - Chittagong

Highway Project (Daudkandi -Chittagong Section)

The 4-laning highway project of NH-1 (Daudkandi - Chittagong) is a high priority for RHD. Under the project, a new 2-lane carriageway is planned to be constructed along the existing 2-lane to make it into a 4-lane highway in order to reduce the existing traffic congestion and to increase the road transport efficiency. The project road, having a length of 198 km, starts from Daudkandi, 28 km from Dhaka, and ends 226 km away at Chittagong. The construction of the project was started in 2006 and is scheduled to be completed by the end of 2013. The project has been divided into 10 packages / contracts, and the present progress is around 20 %.

(3) Construction of NH-1 between Dhaka and Chittagong with six (6) lanes

The above plan is described in the Sixth Five Year Plan (FY2011 - FY2015), however, the project is still in planning stage.

(4) Dhaka – Chittagong Expressway (PPP) Project

(ADB TA loan)

NH-1 is considered to be the most important highway and lifeline of commerce in Bangladesh. Considering the above facts, the Government of Bangladesh has committed to a program for the feasibility studies and detailed design for a new access controlled expressway with 4-lanes between Dhaka and Chittagong planned as PPP. In 2006 a feasibility study & conceptual design of the project was conducted, however, the new study will be carried out again as a feasibility study and detailed design by September 2015, at the moment selection of a consultant is on-going.

1.5.2 Relevant Development Plans

(1) Padma Multi-purpose Bridge Project

Another big budget project "Construction of Padma multi-purpose bridge project" is now under consideration by GoB. In the feasibility stage from 2003 to 2005, JICA assisted in carrying out survey works. After that, project implementation is still under planning stage.

(2) Development of Export Processing Zones (EPZ)

In order to stimulate rapid growth of the country, particularly through industrialization, the GoB has adopted an 'Open Door Policy' to attract foreign investment in Bangladesh. The Bangladesh Export Processing Zones Authority (BEPZA) is the official organ of the government to promote, attract and facilitate foreign investment in all of the Export Processing Zones (EPZs) of the country. Of the eight EPZ's (existing or planned) nationwide, five are located along the Dhaka-Chittagong Corridor, namely;

- Chittagong EPZ (Prime sector: Heavy industry, fishing reels, garments and electronics)
- Dhaka EPZ (Prime sector: RMG, IT, shoes, electronics)
- Comilla EPZ (Prime sector: Textiles, garments, electrical goods)
- Adamjee EPZ (Prime sector: Knitting, Ready Made Garments (RMG), electronics, footwear)
- Karnaphuli EPZ (Prime sector: Knitting, RMG, electronics, footwear)

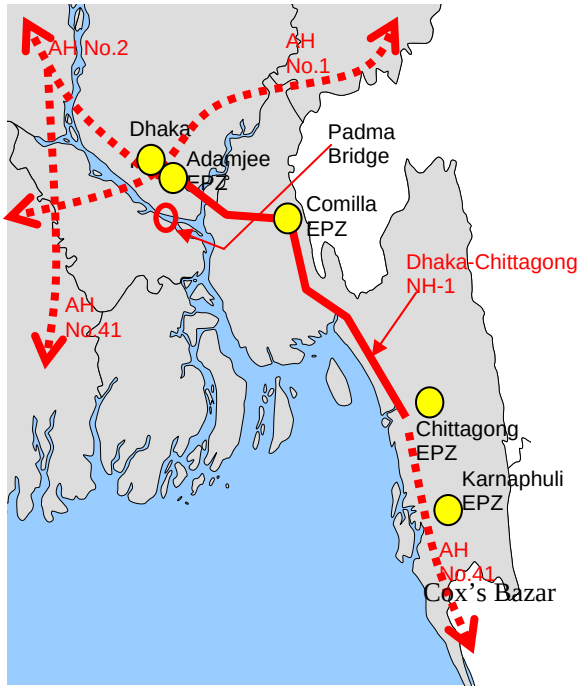


Figure 1.5.1 Five EPZs along NH-1

Among them, Chittagong EPZ is the largest one, which accommodates numerous Japanese firms among others, where a total of 147 industries are in operation whilst 19 industries are not yet in operation (under implementation). Accordingly, the cumulative performance of Chittagong EPZ along with the other seven EPZs of Bangladesh is summarized in Table 1.5.1. It reveals from the record up to July 2012 that a total of 341,344 workers, a cumulative number, are employed in the 8 EPZs. The cumulative EPZ investment of US$ 2,478.9 million and EPZ exports of US$ 30,078.75 million were recorded up to July 2012. Among them, the Chittagong EPZ, the Dhaka EPZ and the Comilla EZP contributed the major part. The Chittagong EPZ accounts for 51 % of the cumulative amount of exports from all EPZ's. This is followed by the Dhaka EPZ, the corresponding figures of which are 42 % and 35 % with respect to EPZ exports and investments respectively. Therefore, the upgrading of Dhaka-Chittagong corridor is indispensable for allowing the companies operating in the EPZ's to continue to carry out their activities efficiently.

Table 1.5.1 EPZs Cumulative Performance (up to July, 2012)

EPZ	Prime sectors	Employment (no.)	Investment (million US$)	Exports (million US$)
Chittagong	Heavy industry, fishing reels, garments and electronics	176,993	968.42 (39 %)	15,272.73 (51 %)
Dhaka	RMG, IT, shoes, electronics	84,503	866.06 (35 %)	12,729.37 (42 %)
Comilla	Textiles, garments, electrical goods	12,820	157.23	726.67
Mongla	Light engineering, RMG, electronics, agro products	1,522	5.36	134.95
Uttra	Domestic consumption goods, RMG, agro products, light engineering.	8,530	23.85	26.65
Ishwardi	RMG, electronics, plastic goods, light engineering.	7,958	68.03	87.86
Adamjee	Knitting, RMG, electronics, footwear	21,381	168.95	580.41
Karnaphuli	Knitting, RMG, electronics, footwear	27637	221.00	520.11
Total	-	341,344	2,478.9	30,078.75

Source: BEPZs Home Page: http://www.epzbangladesh.org.bd

(3) Development of Deep Sea Port in Cox's Bazar

The Bangladesh Government is considering the establishment of a deep water sea port on Sonadia Island, in Cox's Bazar. Construction of a deep sea port is needed to cater to the growing exports and imports of Bangladesh, as the existing Chittagong Port is already facing congestion, while mother vessels avoid it for poor navigability. With construction of a deep sea port, the Bangladesh's coast will turn into a top global cargo hub, working as a hinterland for a stretch of land including southern China, eastern India, landlocked Nepal and Bhutan and part of Myanmar.

A Feasibility Study (FS) was conducted using GoB fund and accordingly, a FS report was submitted to the Ministry of Shipping in 2009 for the construction of a deep-water sea port. The proposed port would have 58 jetties, with a total length of 11 kilometres. The scope of works includes construction of port and jetties, additional channel, specific places for import and export, road and rail communication, linking with internal river ports, transit area, township, helipad, safe places during disasters and construction of gas and power plants. The GoB has established this as a priority project to develop the entire region as a business hub. The port, which will be constructed at a cost of US$ 8.2 billion in three phases, will play a major role in keeping the country's economy vibrant;

- Phase 1: Nine jetty-berths will be constructed at a cost of US$ 2.2 billion and relevant construction is expected to be completed in the middle of 2020.
- Phase 2: Construction of twenty two berths for the container terminal and thirteen berths for the cargo terminal will be carried out from 2020 to 2031.
- Phase 3: Construction of sixty eight berths for the container terminal and forty six berths for the cargo terminal will be carried out from 2031 to 2050.

The Phase 1 will be financed by Private-Public-Partnership (PPP) funds. Funds will be raised through bonds and equity from share markets and lending from foreign donors. As much as thirty per cent of the expenditure will be met by Chittagong Port Authority.

Recently six foreign firms have been shortlisted for being appointed as consultants for the proposed deep sea port. The Terms of Reference (TOR) for the appointment of a consulting firm to prepare the detailed design and drawing of deep sea port has been finalized. The Final TOR is expected to be handed over to consultants in November, 2012 and accordingly, consultant will be recruited.

(4) Development of Double Tracking Dhaka-Chittagong Trunk Railway

About 200 km out of the 320 km railway line from Dhaka to Chittagong (Figure 1.5.2) is still only single track and therefore, a constraint to increase the number of trains in this corridor. Within those 200 km, of single track, the 3.7 km. single track section from Bhairab Bazar to Ashuganj has a rail-bridge named 'Bhairab Bridge' constructed on Meghna River, which is beyond the scope of double tracking. The Bangladesh Government's Sixth Five-Year Plan, 2011-2015 assigns high priority to increasing the capacity of the Dhaka-Chittagong corridor by completing double tracking on the entire corridor, which is important to increase the market share of the railway. Enhancing the capacity of the entire corridor will also allow operating additional trains for sub-regional trade through Chittagong Port with Bhutan, India and Nepal; a part of the Trans Asian Railway (TAR) network.

Figure 1.5.2 Dhaka-Chittagong Railway Network

The Dhaka-Chittagong Trunk Railway, which will be upgraded to double tracking, has three sections;

- Section1: Double tracking of 64 km Tongi-Bhairab Bazar (ADB-loans 2316/2845)
- Section2: Double tracking of 71 km Akhaura-Laksam (TA-loan 2688-BAN by ADB)
- Section 3: Double tracking of 61 km Laksam-Chinki Astana(JICA-ODA loan)

Among the three sections, Section 1defined as 'Double tracking of 64 km Tongi-Bhairab Bazar section' is financed by ADB-loans 2316/2845. This project is under construction and scheduled to be completed in 2015.

At the time of processing of the Mutitranche Financing Facility (MFF) by ADB for Section 1, Akhaura-Laksam section was supposed to be financed by World Bank. Due to delays in project preparation, reform process and lapse of the credit for project design, the World Bank has not renewed its financial support to this project. The GoB has therefore requested ADB to finance double tracking of the 71 km Akhaura-Laksam section. Given the urgency to address the remaining line capacity bottlenecks in the Dhaka-Chittagong corridor, the scarcity of remaining funds and the focus on other key infrastructure investments under the ongoing MFF, a project loan will be processed for approval in 2014. Section 2 will be high priority due to preparation of the detailed design and bid documents under TA-loan 2688-BAN.

Section 3 defined as 'Double tracking of 61 km Laksam-Chinki Astana section' is financed by JICA-ODA loan (FY2005-2007). The Yen loan amounts to 12,916 million yen. This project is scheduled for November 2007-July 2015 (93 months) and the project completion period includes the defect liability period.

CHAPTER 2

SITE SURVEY RESULTS

2. SITE SURVEY RESULTS

2.1 Survey Items

(1) Ambient natural condition survey

Table 2.1.1 shows the relation among the design, Environmental Impact Assessment (EIA) and Impact Climate Change (ICC) on the site survey. The site survey results are used for the analysis and design base data.

Table 2.1.1 Ambient natural condition survey and design relationship

Survey Item	Design			EIA	Impact Climate Change
	Road	2nd bridge	Existing bridge		
Weather condition					
Temperature		○	○	○	○
Rain fall		○	○	○	○
Hydraulic and Hydrological survey					
Discharge		○			
River profile		○			
Riverbed material geological survey		○			
River current velocity		○			
Topographic					
Topographic	○	○		○	
Geological					
Boring					
SPT		○			
Soil strata profile		○			
Pressure meter test		○			
Soil test					
Density		○			
Grain size		○			
Moisture content		○			
Atterberg limit		○			
Unconfirmed compression		○			
Direct sheer		○			
CBR	○				

Source: JICA study team ○ means usage

(2) Traffic survey and River traffic survey

Conducted traffic survey and river traffic survey items are shown below. Traffic survey results are used road design, while river traffic survey results are used for preparation of EIA and ICC.

- Traffic survey
  - ✓ Classified traffic count
  - ✓ OD survey
  - ✓ Traffic movement count
  - ✓ Traffic speed
- River traffic survey

(3) Detailed Inspection of Structures

Conducted detailed inspection survey items are shown below. The survey results are used to conduct design for rehabilitation of existing bridges.

- Visual Inspection
- Dimension measuring
- Schmidt hummer test
- Rebar direction

(4) Baseline survey

Conducted baseline survey items are shown below. The survey results are used to calculate project operation and effect indicators, for preparation of EMP.

- Average daily traffic
- Traffic speed
- Accident rate
- Air quality
- Water quality
- Ground water
- Soil pollution
- Bottom sediment

2.2 Natural Condition

2.2.1 Meteorological Condition

(1) Meteorological Survey

In order to design the three bridges, it is necessary to collect and correlate the basic meteorological data such as Rainfall, Humidity and Wind Speed and Direction data.

1) Rainfall

According to monthly rainfall data from 2000 to 2009, average annual rainfall is about 2,100 – 2,200 mm/yr at Dhaka and Comilla Stations. Normally, the rainy season starts from May and ends in October. There is especially heavy rainfall, which is about 400 mm/month, in June and July in comparison to the other months. Dry season lasts from November to April.

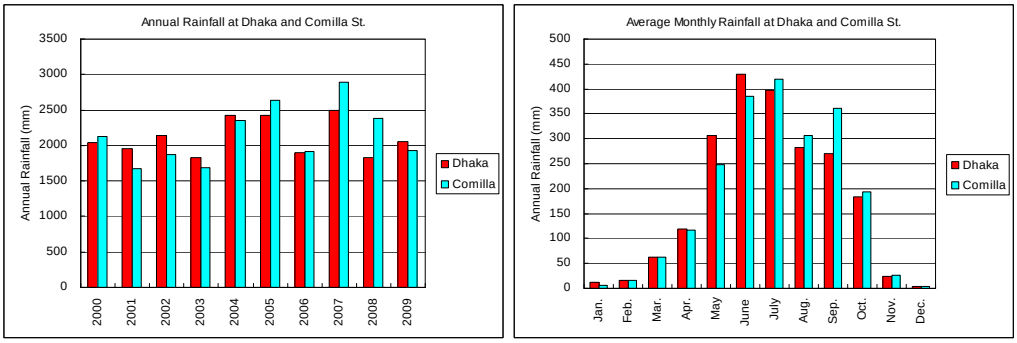


Figure 2.2.1 Annual Rainfall and Monthly Rainfall at Dhaka and Comilla Met. Station

2) Temperature

The monthly maximum, minimum and average temperature data at Dhaka and Comilla station are shown in the following figure, which are based on data collected from Bangladesh Meteorological Department (BMD) for the year 1999-2008. It can be observed that the monthly average temperatures through the year at the two stations are around 19 to 29 ℃.

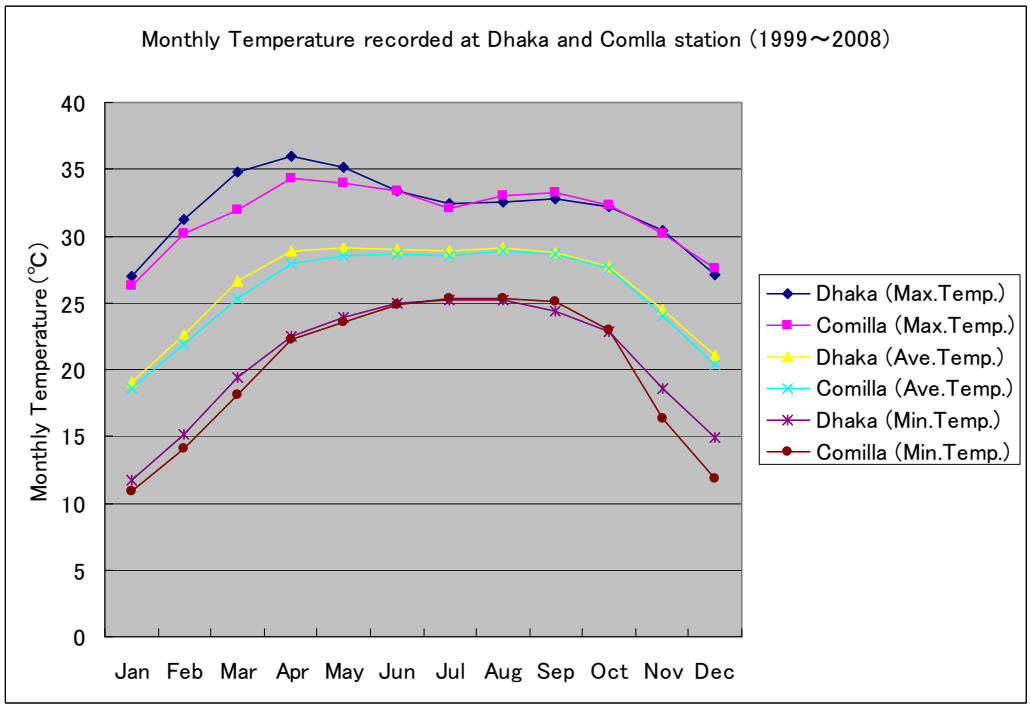


Figure 2.2.2 Monthly Temperature Data

2.2.2 Hydraulic Survey and Hydrological Condition

(1) Existing Hydraulic and Hydrological Data

1) Existing Kanchpur Bridge

No relevant information on sounding surveys conducted for riverbed erosion and change of riverbank data are available for either before or after construction of the existing Kanchpur Bridge.

2) Existing Meghna Bridge

According to the bathymetric survey result, the average scouring depth at riverbed level is -12.4 m, while the maximum scouring depth measured near bridge piers is -20.7 m (PWD). Therefore, the scouring of riverbed near bridge piers is in a critical condition, compared with the condition of the riverbed when the bridge was constructed. Accordingly, the severe scouring problem could threaten the stability of the bridge and endanger the transport system in the future if proper and sustainable remedial measures are not taken immediately.

Further, the existing Meghna Bridge was designed following outdated design standards. Accordingly, seismic retrofitting to withstand earthquake excitations as per current design codes and constraining the riverbed scouring to a tolerable limit are becoming a challenging job for rehabilitation and reconstruction of the existing Meghna Bridge. Specifically, as a

countermeasure for the latter one, the concept of combined foundations that connect the foundation of the existing and new bridges can be applied to reduce the scouring tendency in the near future.

At the time of bridge construction, the elevation of Meghna riverbed at the lowest part was -7.0 m PWD. But after that, due to severe scouring effect, the riverbed elevation changed to -19.5 m PWD in 2010.

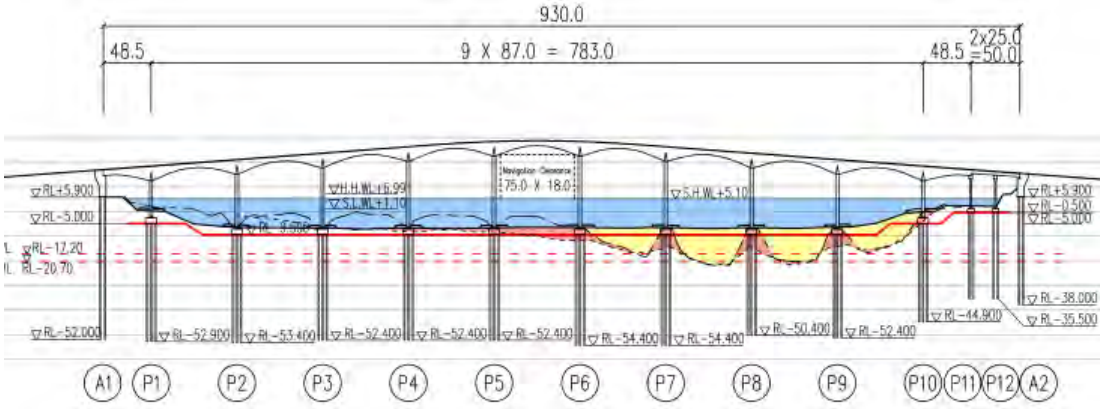


Figure 2.2.3 Longitudinal Profile of Existing Meghna Bridge (1995)

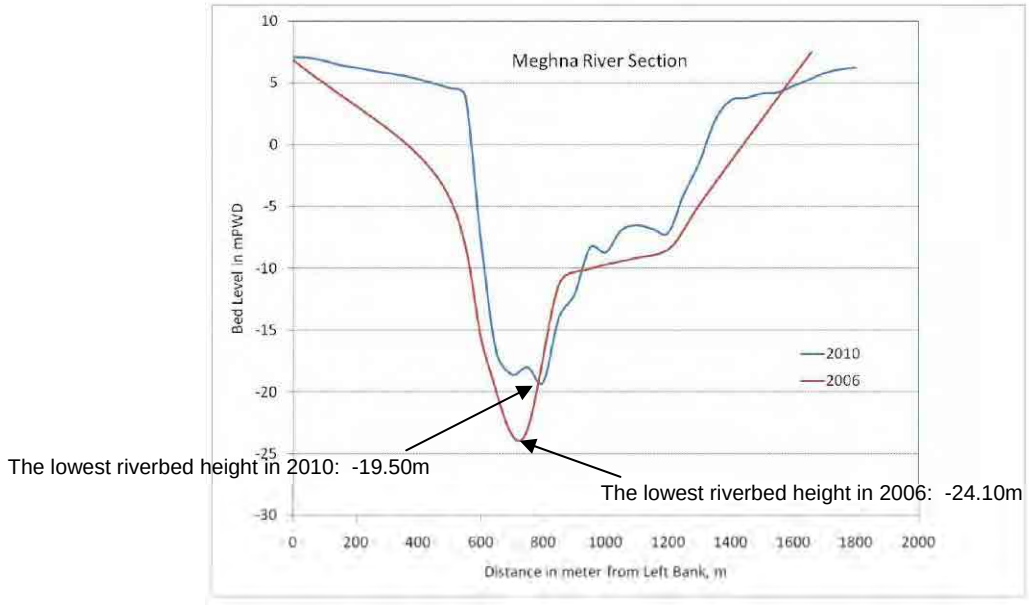


Figure 2.2.4 Change in Riverbed Cross-Section at Existing Meghna Bridge Site (Sounding survey result in 2006, 2010)

3) Existing Gumti Bridge

At the time of bridge construction, the elevation of Gumti riverbed at the lowest part was -6.0 m. The riverbed level remained unchanged until 1999. But after that, due to severe scouring effect, the riverbed elevation changed to -7.6 m in 2006, -11.1 m in 2010.

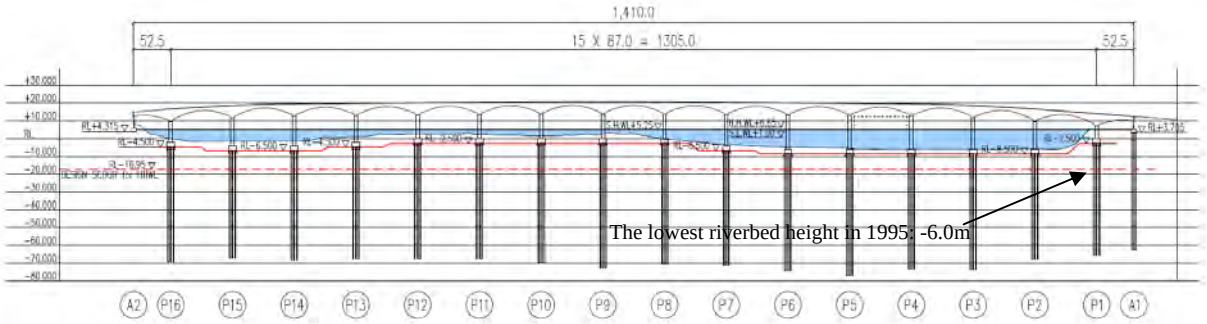


Figure 2.2.5 Longitudinal Profile of Existing Gumti Bridge (1995)

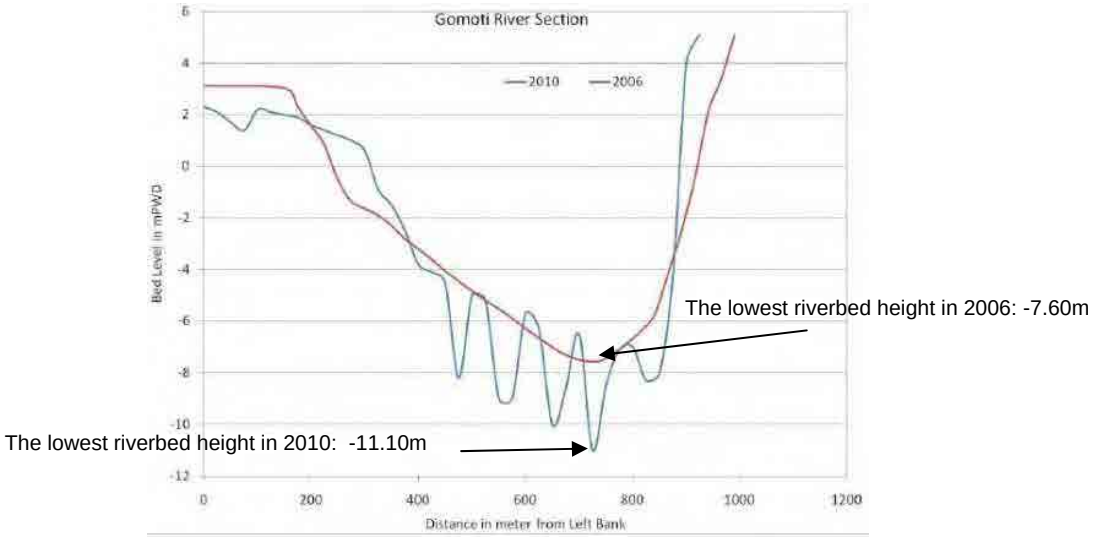


Figure 2.2.6 Change in Riverbed Cross-Section at Existing Gumti Bridge Site (Sounding survey result in 2006, 2010)

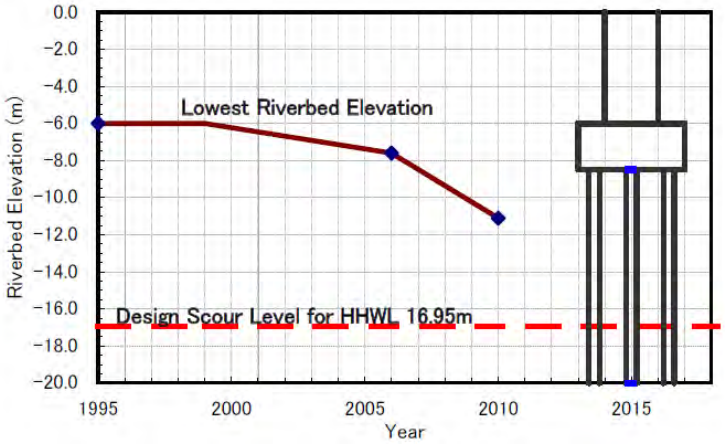


Figure 2.2.7 Change in Riverbed Level along Bridge Pile Foundation

4) Causes of scouring

The riverbed inclinations in Bangladesh are generally very flat in lower basin as 1/100,000 in average. The riverbed sand average diameter is quite fine as 0.1 mm to 0.2 mm without silt and clay. The riverbed sand has no adhesion and very fine so that the riverbed can be easily eroded and the sand will floated in the river flow. And the scoured hole is not stable in the water repose angle 30 degrees such as in Japan, in some cases the angle of repose is very small as 2 to 3 degrees. The angle of repose in Japan case is average 30 degrees.

Additionally the climate is sorted as tropical monsoon and the catchment area is quite large, when it rains strongly and long so that the flooding time is quite long because of the small riverbed inclination. The scoured hole in the river is easy to spread caused by the whirl in the river flow. This is one of the causes of scouring around the Meghna bridge piers. This phenomenon is typical in Meghna River.[1] Furthermore, the cause of scouring around Meghna Bridge is briefly explained in Chapter 5 Section 5.4.3.

(2) Hydraulic and Hydrological Data Surveyed

1) Overall

In order to predict the water flow during the flood season and resultant scour around existing and new bridge piers, it is necessary to collect and correlate the hydraulic and hydrological properties of the Lakhya River (Kanchpur Bridge), Meghna River and Gumti River. Some of the properties will be directly used in the numerical model as input data or is needed for developing the model. Regarding these input data, some existing hydrological data has been collected from Bangladesh Water Development Board (BWDB).

2) Hydraulic data

Secondary hydraulic data around the three bridges are collected in order to develop a numerical model, which will be set as boundary conditions. Collected data from BWDB are shown in Table 2.2.1 and Table 2.2.2. Locations of Observation Stations are shown in Figure 2.2.8.

Annual maximum discharge and annual maximum and minimum water levels are calculated in Table 2.2.3 to Table 2.2.5 for the bridge design.

[1] "river technological consideration for bridge planning in the developing country" Junji YOKOKURA Gyozo SUGA Thesis in Japan Association of Civil Engineering.

Table 2.2.1 Discharge and Water Level Data List around Kanchpur Bridge

Item	Station Name	Station Number	River Name	Location (Dist:Thana:Union:Mouza)	Data Available (Year)	Observation Period	
						From	To
Tidal Water Level	Kalagachia	71	Dhaleswari	Munshiganj, Munshiganj Sadar, Paurashava,	44	1968	2011
	Kalatia (Outfall)	70	Dhaleswari	Dhaka, Keraniganj, Kalatia, Nutan Char	44	1968	2011
	Demra	179	Lakhya	Narayanganj, Rupganj, Tarabo, Taraba	44	1968	2011
Non Tidai Discharge	Demra	7.5	Balu	Narayanganj, Rupganj, Kayet Para, Pubgaon	16	1994	2009
	Demra	179	Lakhya	Narayanganj, Rupganj, Tarabo, Taraba	24	1986	2009

Table 2.2.2 Discharge and Water Level Data List around Meghna Bridge and Gumti Bridge

Item	Station Name	Station Number	River Name	Location (Dist:Thana:Union:Mouza)	Data Available (Year)	Observation Period	
						From	To
Tidal Water Level	Bhairb Bazar	273	Upper Meghna	Kishoreganj, Bhairab, Paurashava,	44	1968	2011
	Narsingdi	274	Upper Meghna	Narsingdi, Narsingdi Sadar, Hajipur, Char Hajipur	44	1968	2011
	Meghna Ferry Ghat	275.5	Upper Meghna	Munshiganj, Gazaria, Baluakandi, Bara Baliakandi	44	1968	2011
	Satnal	276	Upper Meghna	Chandpur, Matlab, Satnal, Char Chariani	44	1968	2011
	Daudkandi	115	Gumti-Burinadi	Comilla, Daudkandi, Dakshin Daudkandi	44	1968	2011
Non Tidal Discharge	Jibanpur(Gumti Br.)	114	Gumti-Burinadi	Comilla,Debidwar,Debidwar,Binoypar	30	1996	2011
Tidai Discharge	Bhairab Bazar	273	Surma-Meghna	Kishoreganj, Bhairab, Paurashava,	28	1981	2011

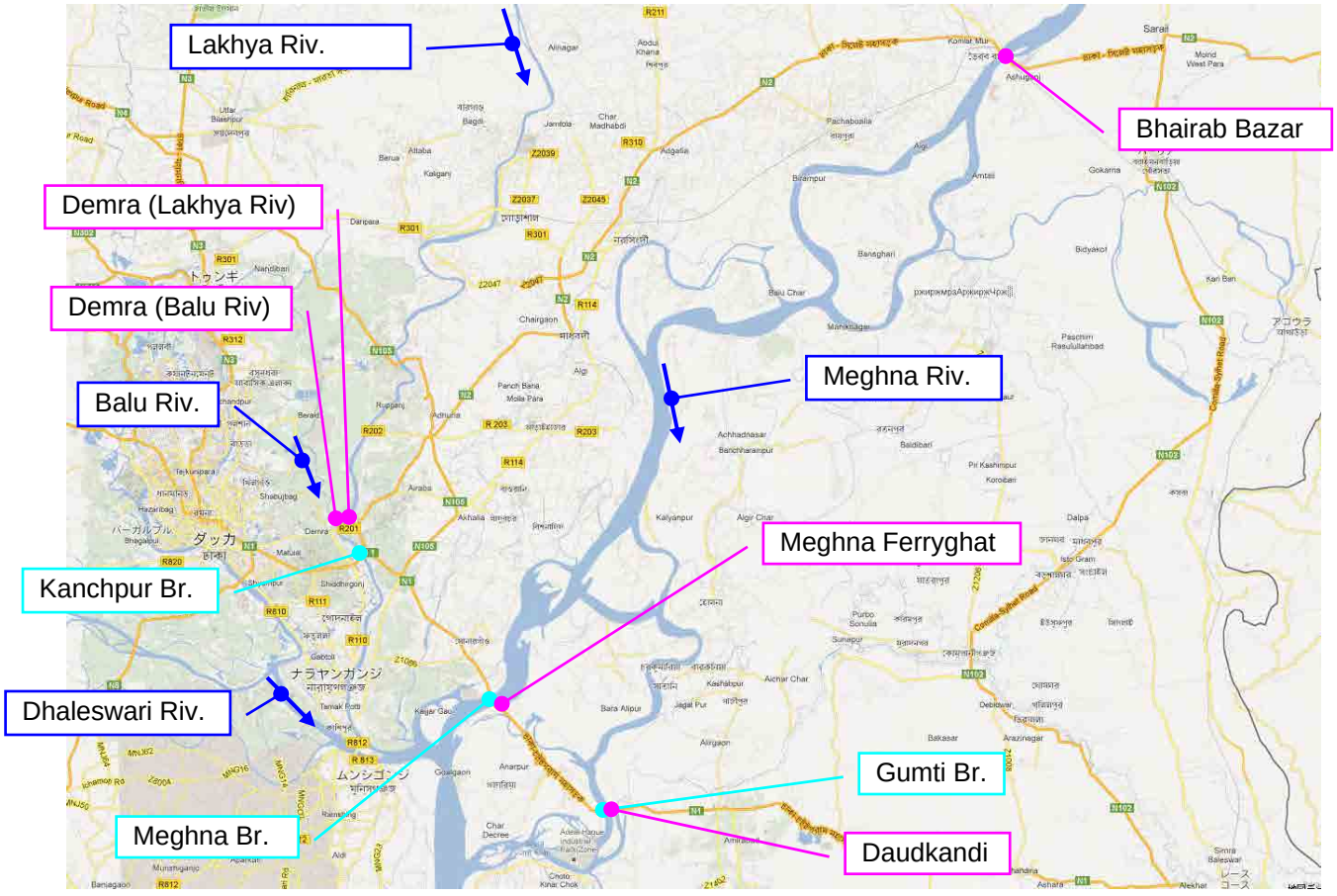


Figure 2.2.8 Water Discharge and Water Level Station Location Map

Table 2.2.3 Annual Maximum Discharge Observed by BWDB (unit: m^3/s)

	Observed Discharge [m3/s]		
River	Meghna	Lahkya	Balu
Station	Bhairab Bazar	Demra	Demra
Maximum	19,900	2,742	744
Minimum	7,375	657	88
Mean	12,936	1,784	389

Source: Edited BWDB observation data by JICA Study Team

Table 2.2.4 Annual Highest Water Level Observed by BWDB (unit: PWD.m)

River	Meghna	Meghna-Gumti	Lahkya
Station	Meghna Ferryghat	Daudkandi	Demra
Maximum	6.76	6.77	7.11
Minimum	3.50	4.40	5.07
Mean	5.50	5.55	5.82

Source: Edited BWDB observation data by JICA Study Team

Table 2.2.5 Annual Lowest Water Level Observed by BWDB (unit: PWD.m)

River	Meghna	Meghna-Gumti	Lahkya
Station	Meghna Ferryghat	Daudkandi	Demra
Maximum	1.61	3.14	1.56
Minimum	0.20	0.22	0.48
Mean	0.85	1.09	0.86

Source: BWDB observation data edited by JICA Study Team

3) River Profile Data

River cross section profile data have been collected from BWDB and former reports (JPZ consultants) in order to determine the historical changes of Meghna and Lakhya riverbed profiles.

(a) Cross section profile by BWDB Survey

Cross-sectional data that are collected from BWDB are listed in Table 2.2.6, and Cross sectional lines are shown in Figure 2.2.9. BWDB has surveyed the river cross sections at about 2-3 years intervals along the measurement line since the 1960's. But there are some limitations observed in BWDB's data to study the historical river deformation.

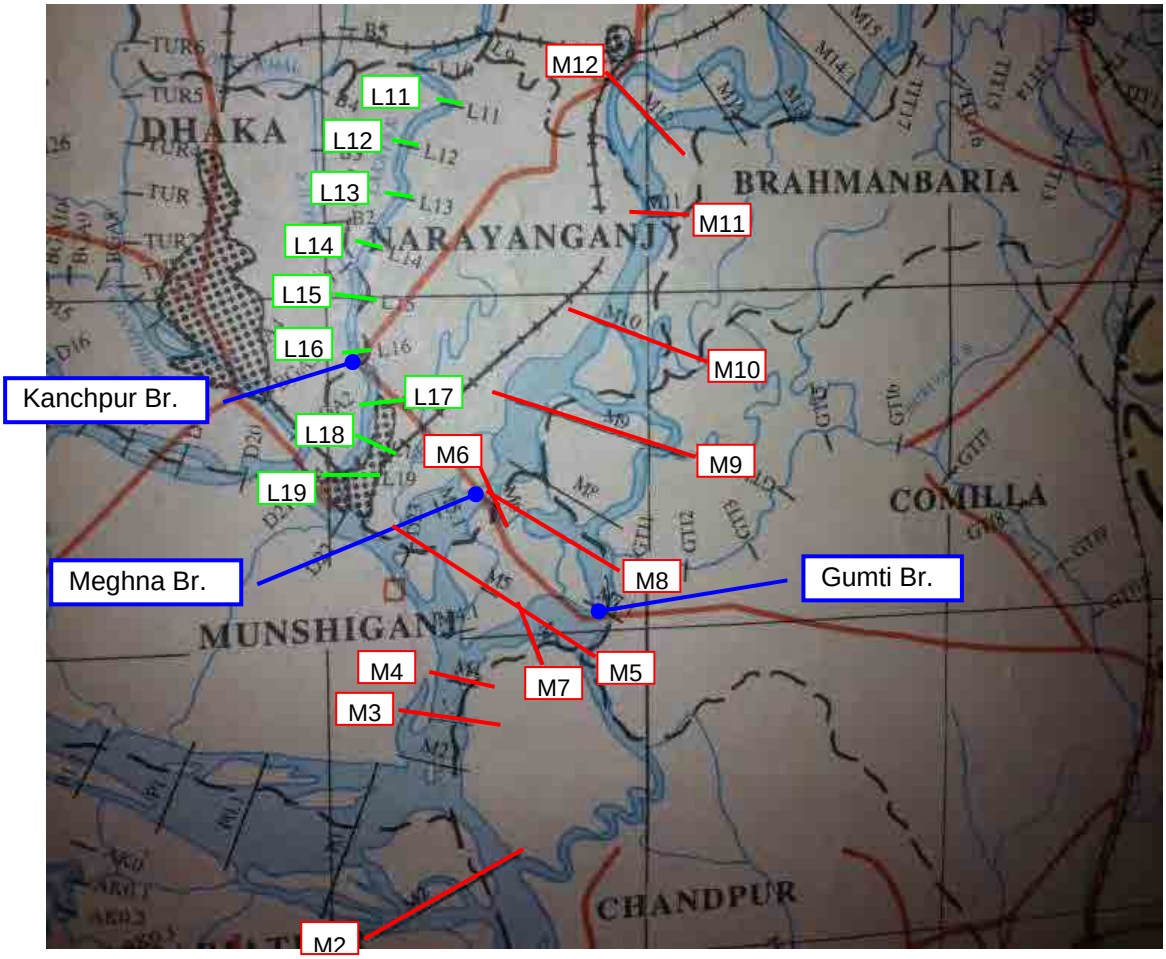
1. There are no measurement lines near the three bridges, and these lines are at a minimum of 6 km intervals along longitudinal direction. Therefore, it is difficult to discuss the meandering behavior of the river around the bridges

2. It seems that BWDB's survey line does not coincide with the line surveyed every year. Especially for Meghna River, the river channel has widely varied due to major floods. Therefore, it is difficult to compare the cross sections of Meghna River surveyed every year.

However, BWDB's cross section data are useful to check and understand the historical change of longitudinal river profile. In Figure 2.2.10, the longitudinal riverbed height seems to be almost stable for 40 years.

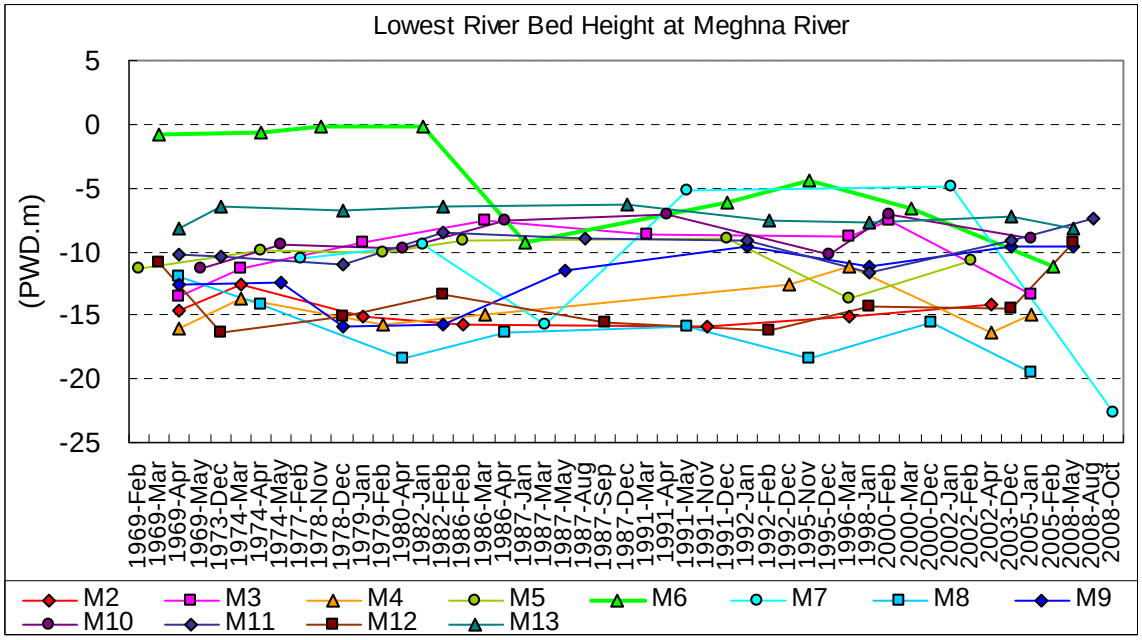
Table 2.2.6 Cross Section Survey Data List (BWDB Survey)

River name	Bridge name	Data Station	Data Period
Lakhya River	Kanchpur	L11 to L19 (9 Lines)	Now (latest), Oldest, about 5 year interval periods.
Meghna River	Gumti	M2 to M12 (13 Lines)	



Source: BWDB

Figure 2.2.9 Location Map for Cross Section Survey by BWDB



Source: Edited BWDB observation data by JICA Study Team

Figure 2.2.10 Historical Change of Lowest Riverbed Height of Cross Section at Meghna River

4) Interview Survey

Interview surveys around the three bridges have already been conducted in order to determine information regarding past major flood water levels and river flow conditions around existing piers.

The field survey result will be used to increase the level of accuracy of the numerical model and to analyze the characteristics of these rivers during the peak flow in rainy season. These will be helpful to detect scouring around bridge piers also.

Table 2.2.7 Interview Survey Overview

Bridge site	Interview data	Interview Points
Kanchpur Bridge	25/Jan/2012	4
Meghna Bridge	14/Mar/2012	5
Gumti Bridge	25/Jan/2012	4

Table 2.2.8 Interview Result around Meghna Bridge

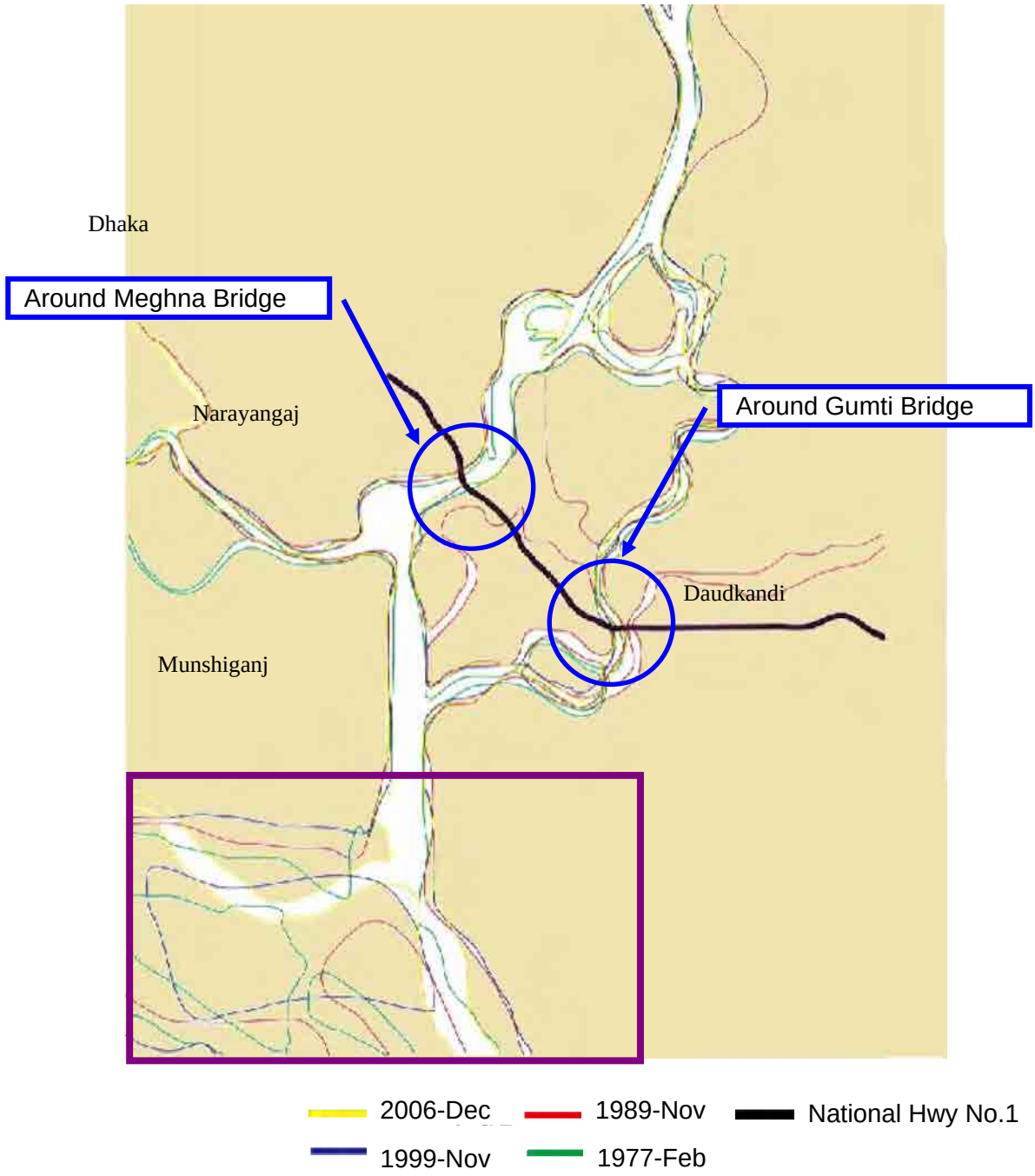
Question		Interview Point.1	Interview Point.2	Interview Point.3	Interview Point.4	Interview Point.5
		Right side of the river (dhaka side)		Right side, upstream	Left side of the river (chittagon side)	
Q1	Have you ever seen the flood around Meghna bridge in rainy season? When those flood has occurred? How much height is those highest flood level?	1998 is up to 30cm above ground at the location of that tree.	1998 is up to 30cm above ground at the location of that tree. 1988 is up to the ground at the location of that car.	1988 is up to 80cm above ground at the location of that tree.	1988 1998 (most highest).	1998 is up to the ground at the location of that bamboo.
Q2	How often does the river overflow to the land?	1960 1962 1974 1980 1987 1998(most highest).	1988, 1998 (most highest)	1988 (most highest), 1998 2004	No flood at here.	1988 1998 (most highest)
Q3	Was there historical changes about the river around this Meghna bridge? (ex. bank erosion, shoreline Scenery, sand bar rising and falling, land use along river)	-	The sand bar upstream of the bridge, have already collected by the digging contractor 7-8 years ago, and now lost.	Bank erosion of this side is progressing every year. The sand bar upstream of the bridge, have already collected by the digging contractor 7-8 years ago, and now lost. (same as Interview 2.) Cement plant embankments look over there, which was completed in 2008.	-	-
Q4	If know, please teach the river flow condition around piers in summer season (flood) to us. (ex. Eddy or Whirlpool around pier, Waves from pier to shoreline)	-	-	-	I have seen several times the eddy at the downstream of the pier during the flood.	I have seen several times the eddy at the downstream of the pier during the flood.
Q5	Sediment unload area works in rainy season?	-	-	-	-	-

5) Land Sat Data Survey

Land sat data has already been collected from the concerned homepage in order to fully understand the historical changes of the river stream line/belt. These data were downloaded from the Global Land Cover Facility Earth Science Data Interface (ESDI) homepage.

Figure 2.2.11 which is made of 4 Land Sat Images, shows that the course of Meghna River is morphing year by year and accordingly, the channel width changes depending on river discharge. As of the selected section bounded by '□', it seems that the river profile of 1989 is very much wider than that of other years because this picture is taken at the time of the flood season (Discharge at Bhairab Bazar is 15,500 m^3/s).

Especially around Meghna Bridge and Gumti Bridge bounded by 'O', it seems that the stream line shows almost the same profile, compared to shore line shown by red line. Therefore, it is supposed that the river shore line around Meghna Bridge and Gumti Bridge is stable with respect to the morphological view point.



Source: Edited Landsat data by JICA Study Team

Figure 2.2.11 Change of Shore Line of Meghna River around Meghna and Gumti Bridges

6) Riverbed material and geological survey

The diameter of riverbed materials is important in order to predict the scouring around piers. The former survey result by JICA in 1997[2] around Meghna Bridge represents that most of the bed materials are a formation of fine sand and silt and the size of D50 is about 0.1 to 0.2 mm, which has an average value of 0.167 mm.

(3) Topographic Survey (on the river)

A topographic survey has been carried out to determine the riverbed profile and to develop numerical models for each river. Survey lines are decided from the hydraulic point of view, which are also close to past survey lines so that a comparative study can be easily carried out. The survey lines at Meghna Bridge and Gumti Bridge are set along the past survey lines to compare with the historical change of river profile.

There are no survey results/ survey records for Kanchpur Bridge, therefore, the survey lines have been selected at 200 m intervals upstream and downstream of the existing bridges.

- River Bathymetric Survey (under the river flow)
- Using Echo- Sounding device (Figure 2.2.12)
- River Topographic Survey (on the land)

(GPS)

Echo-sounding device -Echotrac DF3200 MKII

Odom Hydrographical Systems Inc.)

Figure 2.2.12 Bathymetric Survey Device.

[2] Basic Design Study Report on The Project For Protection Works For Meghna Bridge In The People's Republic of Bangladesh, Feb 1998, JICA, Pacific Consultants International , Nippon Koei Co.,Ltd.

(4) River Current Velocity Survey

In order to protect the existing bridges and new bridges from scouring around the piers, it is necessary to predict current velocity in the design flood event. A river current velocity survey was held to collect the basic hydrological data of the river, and data measured will be used to check the numerical analysis.

The river current velocity survey was carried out from July 30th 2012 by ADCP device which can measure river current velocity, flow direction and total discharge measurement along the cross section of the river.

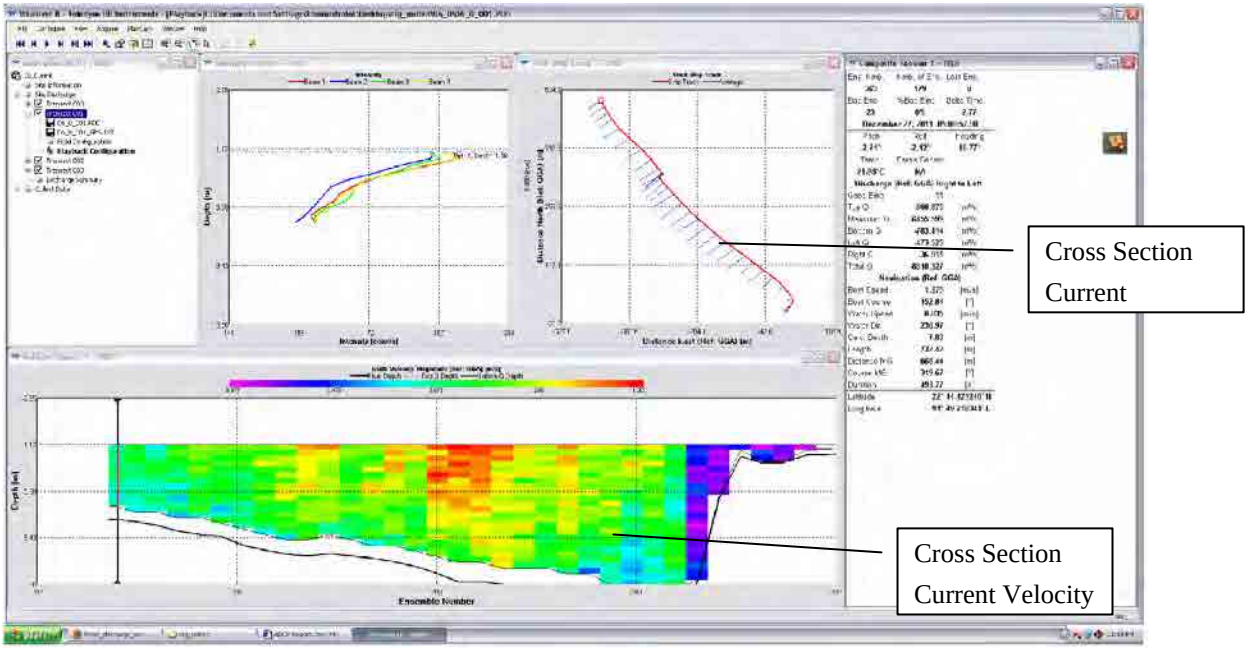


Figure 2.2.13 ADCP Software Main Window

Total discharge, average flow area and average velocity near the three bridges by ADCP survey are shown in Table 2.2.9.

In this result, discharge at Meghna Bridge is about 10 times more than the discharge at Gumti Bridge. Both river flows originated from one channel upstream of the bridges, and after Bhairab Bazar, station, both river channels are separated. Hence it seems that the discharge at Bhairab Bazar mostly flows along the Main Meghna River through Meghna Bridge.

Table 2.2.9 Measurement Result at Three Bridges

	Unit	Kanchpur	Meghna	Gumti
Water Level	M.S.L	3.96	3.72	3.69
Total Discharge	m^3/s	1248.4	11637.0	1063.5
Average Flow Area	m^2	2267.5	13245.9	7416.0
Average Velocity	m/s	0.554	0.892	0.143

2.2.3 Topographic Survey

(1) General

1) Work Components

A topographic Survey was carried out in the area planned for the existing and new bridges, which are composed of the 3 sub-components listed below;

- ◆ Plane Table Survey in existing bridge approaches and in area planned for new bridge approaches,
- ◆ Longitudinal Survey in existing bridge approaches and in area planned for new bridge approaches,
- ◆ Cross Section Survey in existing bridge approaches and in area planned for new bridge approaches,

2) Survey Areas

Plane table survey areas are schematically shown in the following maps for Kanchpur Bridge, Meghna Bridge and Gumti Bridge.

Figure 2.2.14 Kanchpur Bridge (Dhaka side) Plane Table Survey Area

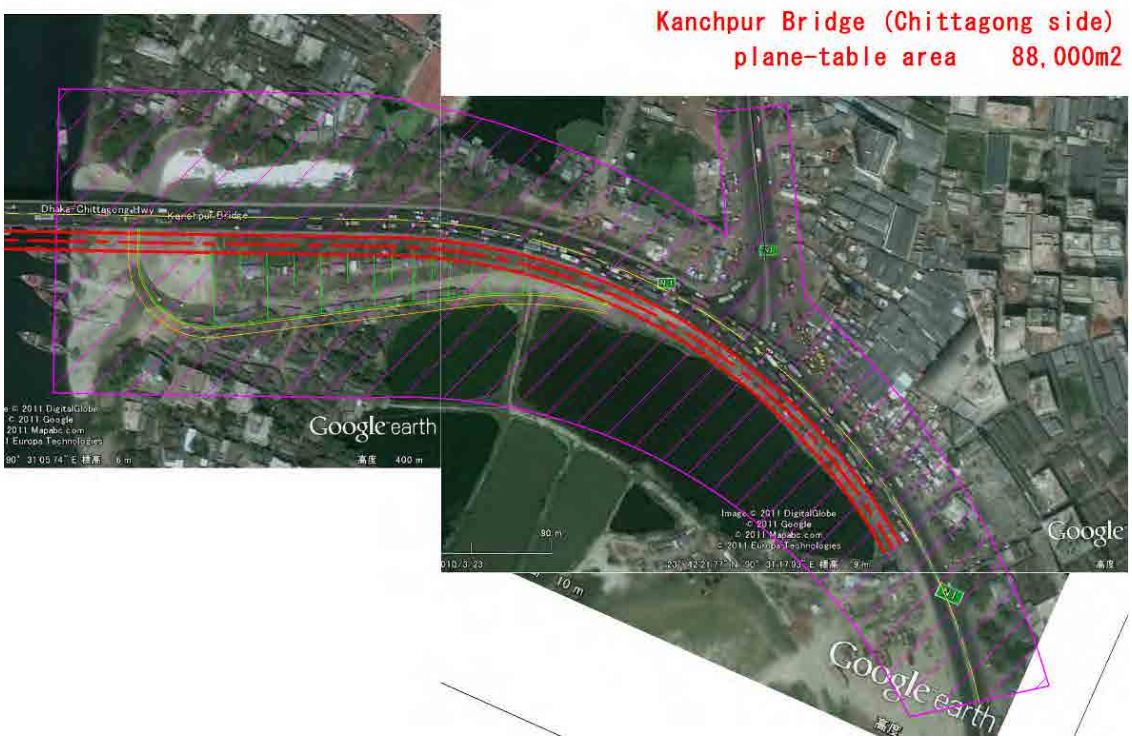


Figure 2.2.15 Kanchpur Bridge (Chittagong side) Plane Table Survey Area

Meghna Bridge plane table area 284,000m^2

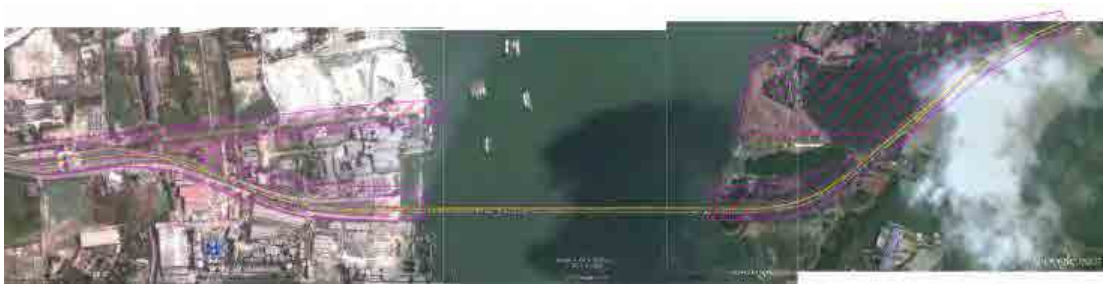


Figure 2.2.16 Meghna Bridge Plane Table Survey Area

Gumti Bridge (Dhaka side)

plane-table area 47,000m2

Figure 2.2.17 Gumti Bridge (Dhaka side) Plane Table Survey Area

Gumti Bridge (Chittagong side)

plane-table area 43,000m2

Figure 2.2.18 Gumti Bridge (Chittagong side) Plane Table Survey Area

(2) Survey Results

Detailed survey results are shown in the Appendix 2.

2.2.4 Geological Condition

(1) Existing Data

Basically, the Meghna and Gumti Rivers are turbulent in nature while the Lakhya River is less turbulent. Furthermore, the river valley is still developing and changes its formation level to some extent. Moreover, it is connected with many old stream channels and less turbulent tributaries that forms the flood plain.

The three bridge sites are on a formation of alluvial soil. The riverbed material type is micro-sand which has uniform grain size with lower uniformity coefficient value. Accordingly, the angle of repose, an indication of scouring range, should be studied carefully.

The geological condition around the bridge site is soft-ground, which is composed of loose sandy soil as well as loose silty soil.

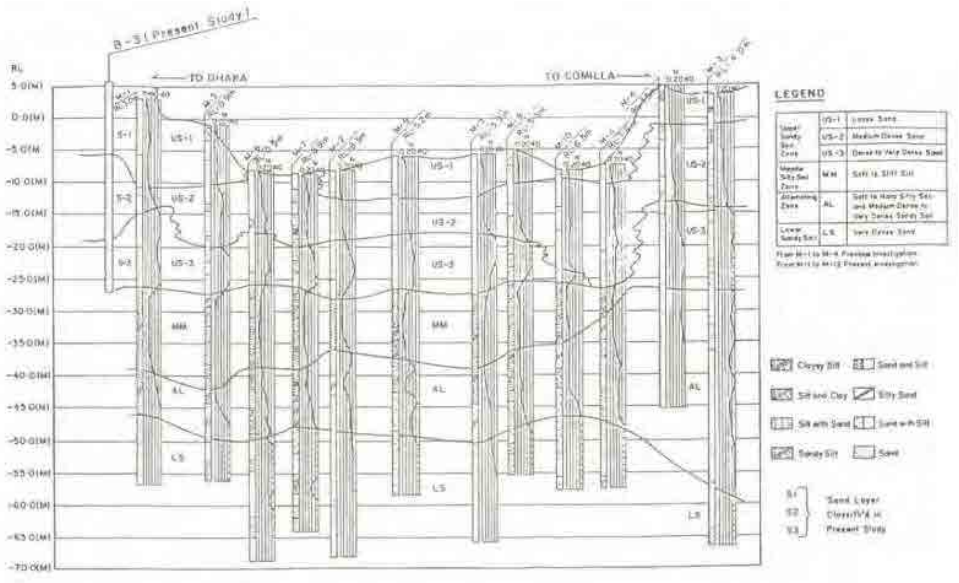


Figure 2.2.19 Geological Profile at Existing Meghna Bridge Site

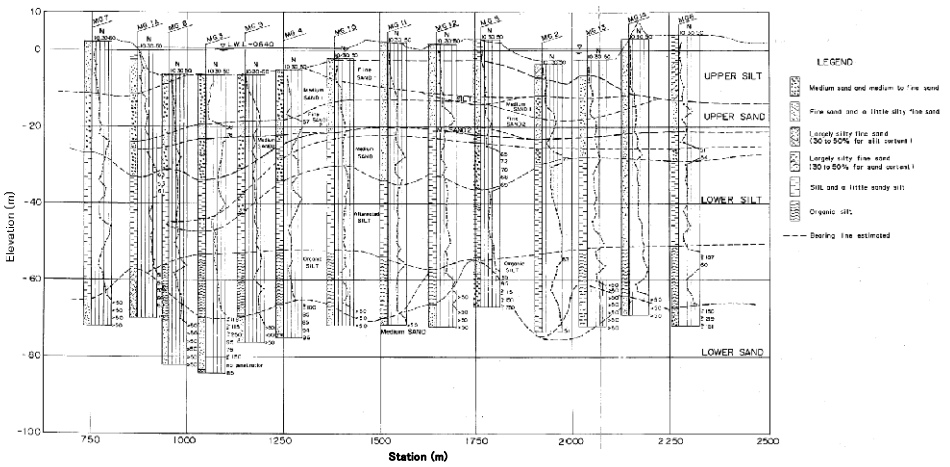


Figure 2.2.20 Geological Profile at Existing Gumti Bridge Site

(2) Geological Data Surveyed

1) General

(a) Work Components

Geological survey works are composed of 6 sub-components and are listed below;

- SPT
- Disturbed soil samplings
- Laboratory test (density test, grain size analysis test, moisture content test and Atterberg limit test)
- Undisturbed soil sampling
- Unconfined compression test
- Pressure meter test

(b) Survey Locations

Geological survey borehole locations were planned 15 m downstream from the center of each existing pier and abutment in Kanchpur Bridge assuming the adjacent location of the new bridge; approx. 255 m upstream from the center of each existing pier and abutment in Meghna Bridge assuming the approach roads are within the RHD's property and 12 m downstream from the center of each existing pier and abutment in Gumti Bridge assuming the adjacent location of the new bridge. These locations are shown in appendix 3.

2) Geological Survey Field Work

Field work for borehole drilling including Standard Penetration Test (SPT) and disturbed soil samplings for each 1.0 m depth were carried out from the 31 st January to 28 th March, 2012.

3) Field Investigation Results

(a) Boring Logs

Boring logs are shown in appendix 3 on Kanchpur Bridge, Meghna Bridge and Gumti Bridge.

(b) Soil Strata Profile

Soil strata profiles assumed from the boring logs are shown in Figure 2.2.21 to Figure 2.2.23 on Kanchpur Bridge, Meghna Bridge and Gumti Bridge.

(c) Pressure meter test results

Pressure meter test results are shown in appendix 3 on Kanchpur Bridge, Meghna Bridge and Gumti Bridge.

Summary of the test data is shown in Table 2.2.13 and Figure 2.2.24 to Figure 2.2.26. On Kanchpur Bridge, the total test number is 7. In the MPC, 2 PMT have been conducted. In the HPC, 4 PMT have been conducted. In the HNPS, 1PMT has been conducted. The depth of testing was 14 to 35 m.

On Meghna Bridge, the total test number is 8. In the VFS, 3PMT have been conducted. In the FS, 5 PMT have been conducted. The depth of testing was 13 to 20 m.

On Gumti Bridge, the total test number is 7. In the SS, 4 PMT have been conducted. In the FS, 3 PMT have been conducted. The depth of testing was 10 to 19 m.

All PMT were carried out by the 1 cycle load procedure.

The pressure-radius displacement curve ideal lines except for 3 places (P6D14, P7D17, and D24 on Kanchpur Bridge), see Figure 2.2.24. Because, from an initial load, the inclination of the line rises gradually and then between Po and Py the line is almost straight. After Py, the inclination of the line drops down gradually. The rest of the 3 test curves are composed of 2 lines. That is two linear parts are apparent.

None of the results reach to the Pf point, and the values of creep are in convergence. In the elastic range, the value is small. It is approximately 1 mm.

Po values correspond to the static earth pressure. The depths of the test locations are in a range of 10 to 20 m, and the Po value is distributed in the range of 2 to 4 kg/cm^2. But, the Po value (27 kg/cm^2) at P2 Kanchpur Bridge is higher than the static earth pressure (7 kg/cm^2 is calculated from the 35 m depth), see Figure 2.2.25.

Py values are distributed in a range of 3 to 11 kg/cm^2, but the Py value at P2 on Kanchpur Bridge shows a high value (35 kg/cm^2).

E moduli of this PMT are distributed from 18 to 265 kg/cm^2. No clear difference is found between soil types. The average of all PMT data is 124 kg/ cm^2. N-value is said to be related to E modulus. A value of 7N is used to convert E modulus, but in these tests, 6N corresponds to the E modulus, see Figure 2.2.26. Therefore, E modulus of this test is proper for the next design.

Table 2.2.10 The results of pressure tests for Kanchpur Bridge

Point	Depth(m)	Em (kg/cm^2)	Em (KN/m^2)	N value	Standard value (700 N) KN/m^2
P2 1	23	146.923	14398	18	12600
P2 2	35	84.963	8326.	50	35000
P2 3	20	38.379	3761.	12	8400
P6 1	14	61.382	6015.	37	25900
P6 2	21	136.053	13333	35	24500
P7 1	17	18.783	1840.	20	14000
P72	24	65.695	6438.	50	35000

The results of pressure tests at Kanchpur are lower than the standard values. The horizontal reaction of soil is weak.

Table 2.2.11 The results of pressure tests for Meghna bridge

Point	Depth(m)	Em (kg/cm^2)	Em (KN/m^2)	N value	Standard value (700 N) KN/m^2
A1 1	10	21.196	2077.	11	7700
A1 2	16	130.607	12799.	9	6300
A1 3	20	53.379	5231.	11	7700
P4 1	10	151.821	14878.	18	12600
P4 2	13	130.607	12799.	24	16800
P4 3	18	217.332	21298.	22	15400
P11 1	10	15.769	1545.	13	9100
P11 2	15	72.276	7083.	26	18200

The results of pressure tests at Meghna are lower than the standard values in the shallow depth but higher in deep areas. The horizontal reaction of the soil is stronger in the deep areas.

Table 2.2.12 The results of pressure tests for Gumti Bridge

Point	Depth(m)	Em (kg/cm^2)	Em (KN/m^2)	N value	Standard value (700 N) KN/m^2
p-1 1	15	187.809	18475	25	17500
P 1 2	19	253.211	24814	17	11900
P8 1	13	243.200	23833	21	14700
P8 2	18	266.718	26138	17	11900
P 13 1	10	178.328	17476.144	11	7700
P 13 2	14	109.364	10717.672	13	9100
P 13 3	19	130.607	12799.486	21	14700

The results of pressure tests at Gumti are higher than the standard values. The horizontal reaction is good.

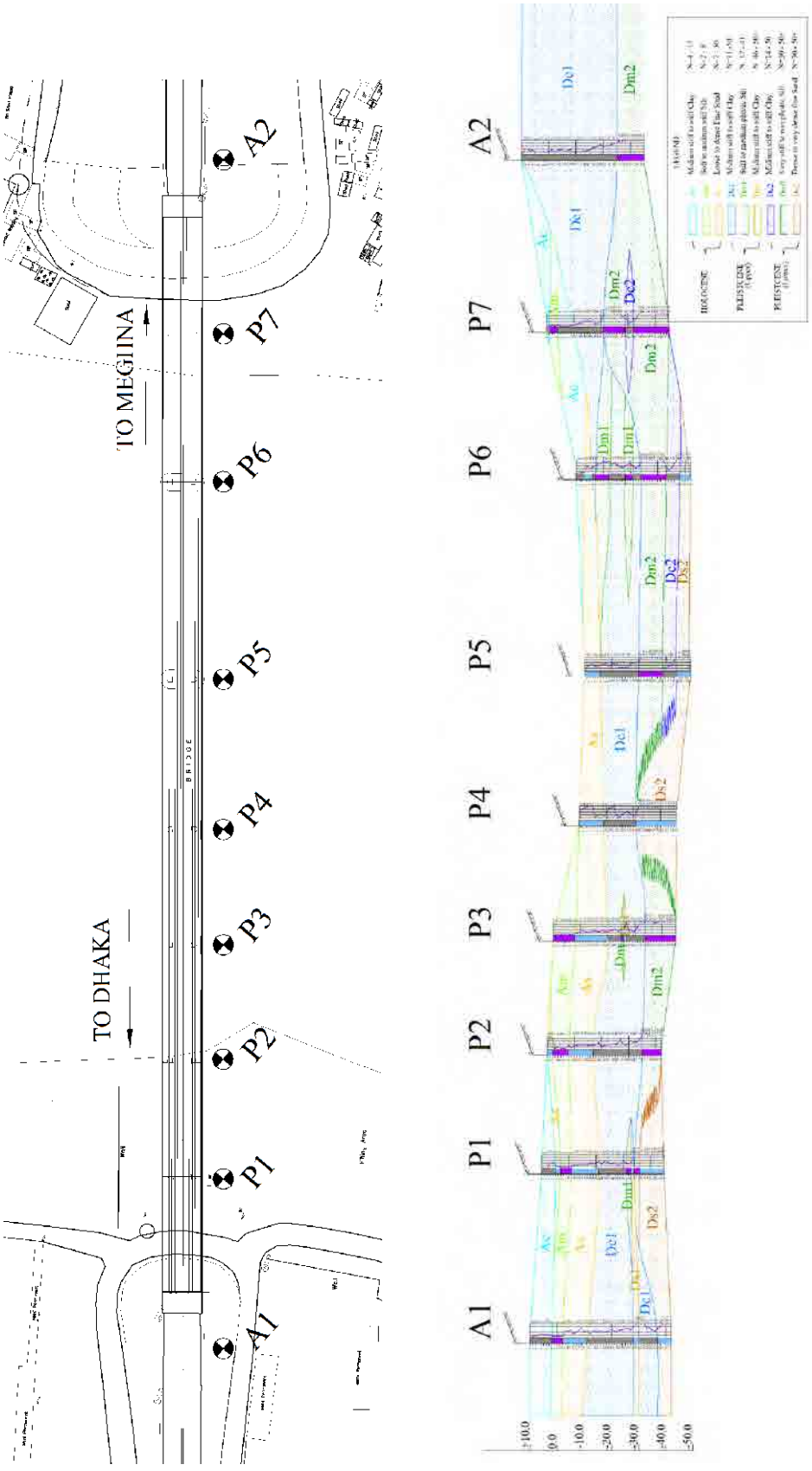


Figure 2.2.21 Soil Strata Profile at Kanchpur

Source: JICA Study Team

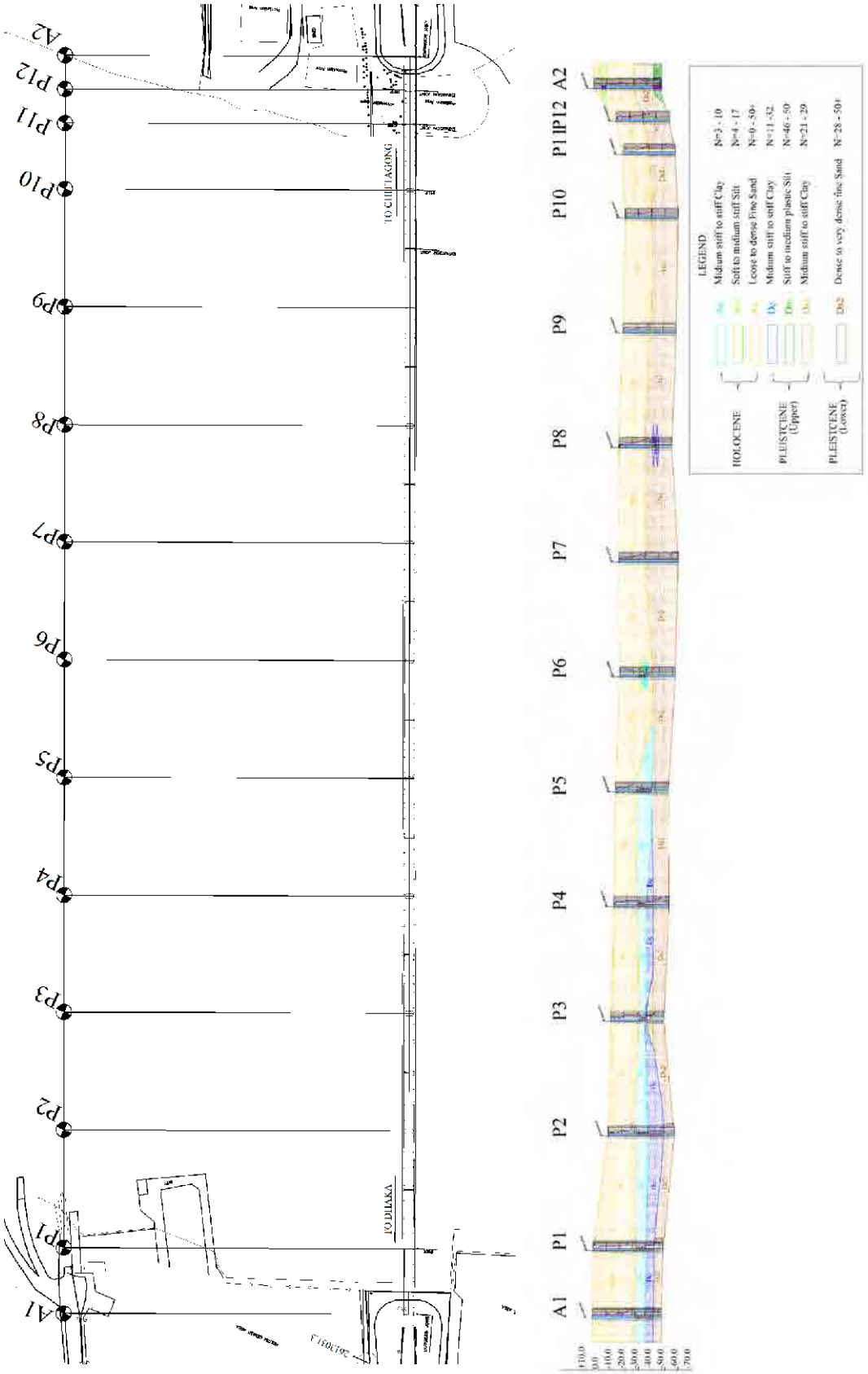


Figure 2.2.22 Soil Strata Profile at Meghna Bridge

Source: JICA Study Team

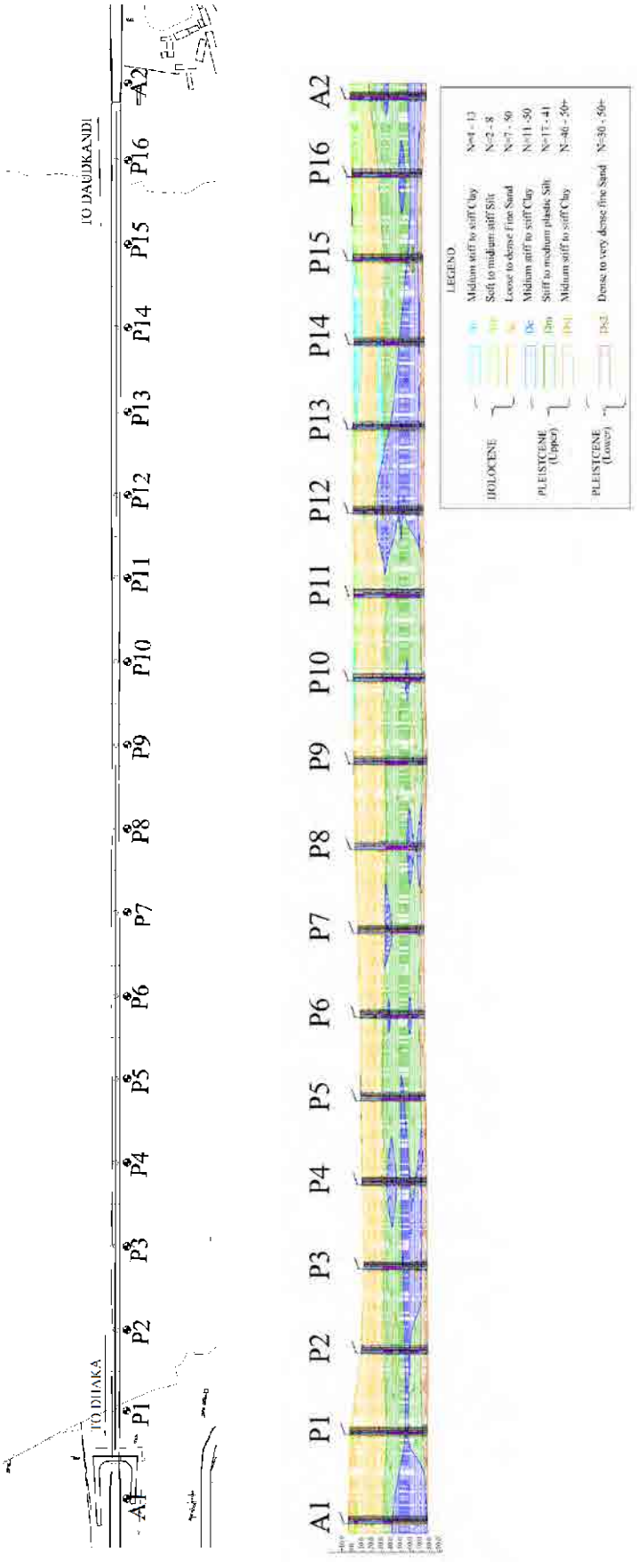


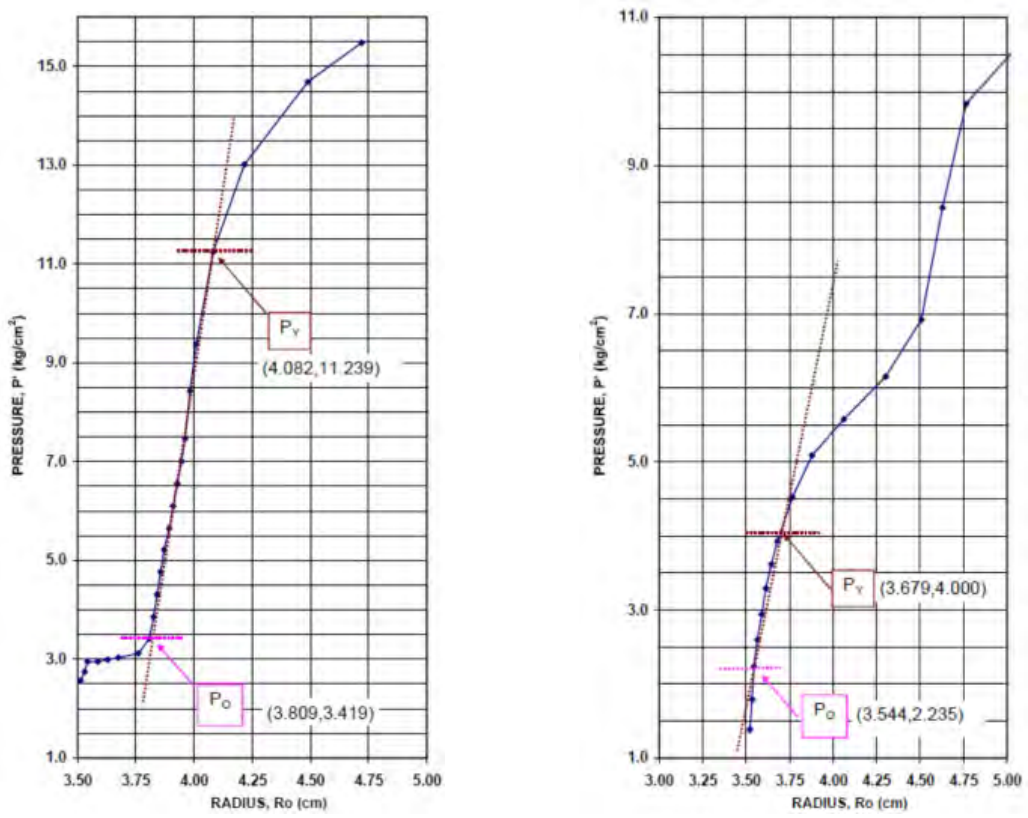
Figure 2.2.23 Soil Strata Profile at Gumi Bridge

Source: JICA Study Team

Table 2.2.13 Summary of Pressure Meter Test Data Results

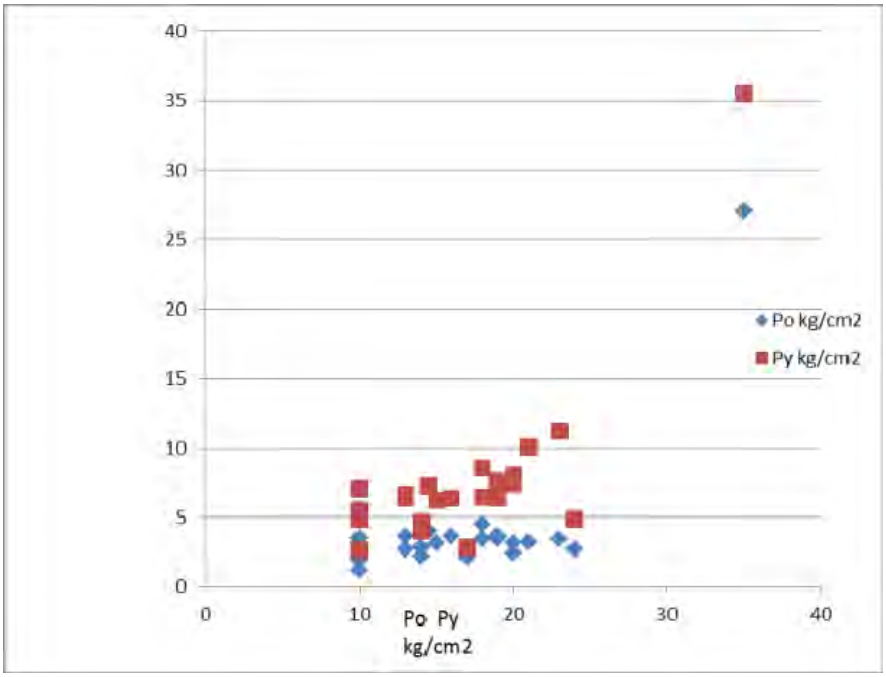
LOCATION		SOIL TYPE	N-VALUE	DEPTH	Po	Py	Pf	Km	Em	Rm	N×7	
				m	kg/cm2	kg/cm2	kg/cm2	kg/cm3	kg/cm2	cm	kg/cm2	
KANCHPUR	P2 br	MEDIUM PLASTIC CLAY	12	20	2.436	8.026		6.988	38.379	4.225	84	
	P2 br	MEDIUM PLASTIC CLAY	18	23	3.419	11.239		28.645	146.923	3.946	126	
	P2 br	HARD PLASTIC CLAY	50	35	27.026	35.469		14.786	84.953	4.420	350	*
	P6 br	HARD PLASTIC CLAY	37	14	2.235	4.000		13.074	61.382	3.612	259	*
	P6 br	HARD PLASTIC CLAY	35	21	3.198	10.059		25.989	136.053	4.027	245	
	P7 br	HARD PLASTIC CLAY	20	17	2.118	2.823		4.006	18.783	3.607	140	*
	P7 br	HARD NON PLASTIC SILT	50	24	2.692	4.843		13.877	65.695	3.642	350	*
MEGHNA	A1 br	VERY FINE SAND	11	10	1.226	2.625		3.721	21.196	4.382	77	
	A1 br	VERY FINE SAND	9	16	3.670	6.382		27.394	130.607	3.668	63	
	A1 br	VERY FINE SAND	11	20	3.170	7.427		10.860	53.379	3.781	77	
	P4 br	FINE SAND	18	10	3.174	7.000		30.608	151.621	3.811	126	
	P4 br	FINE SAND	24	13	3.670	6.382		27.394	130.607	3.668	168	
	P4 br	FINE SAND	32	18	4.51	8.513		45.489	217.322	3.675	224	
	P11 br	FINE SAND	13	10	3.493	4.859		7.0780	35.769	3.888	91	
	P11 br	FINE SAND	26	14.5	4.000	7.280		14.199	72.276	3.916	182	
MEGHNA GUMUTI	P1br	SANDY SILT	25	15	3.137	6.215		39.462	187.809	3.661	175	
	P1br	SANDY SILT	17	19	3.483	7.587		54.000	253.211	3.607	119	
	P8 br	FINE SAND	21	13	2.737	6.657		51.579	243.200	3.627	147	
	P8 br	SANDY SILT	17	18	3.420	6.438		56.943	265.718	3.590	119	
	P13 br	FINE SAND	11	10	2.018	5.501		36.663	178.328	3.742	77	
	P13 br	FINE SAND	13	14	2.832	4.666		22.642	109.364	3.716	91	
	P13 br	SANDY SILT	21	19	3.670	6.382		27.394	130.607	3.668	147	
				MPC	5.855	19.265		35.633	185.302	8.171	210	
				HPC	34.577	52.351		57.855	301.171	15.666	994	
				HNS	2.692	4.843		13.877	65.695	3.642	350	
				VFS	8.066	16.434		41.975	205.182	11.831	217	
				FS	26.434	50.858		235.652	1138.487	30.043	1,106	
				SS	13.71	26.62		177.80	837.35	14.53	560	
				TOTAL	91.334	170.373		562.791	2733.182	83.879	3437	
				AVERAGE	4.2	7.7		25.6	124.2	3.8	156.2	

Source: JICA Study Team



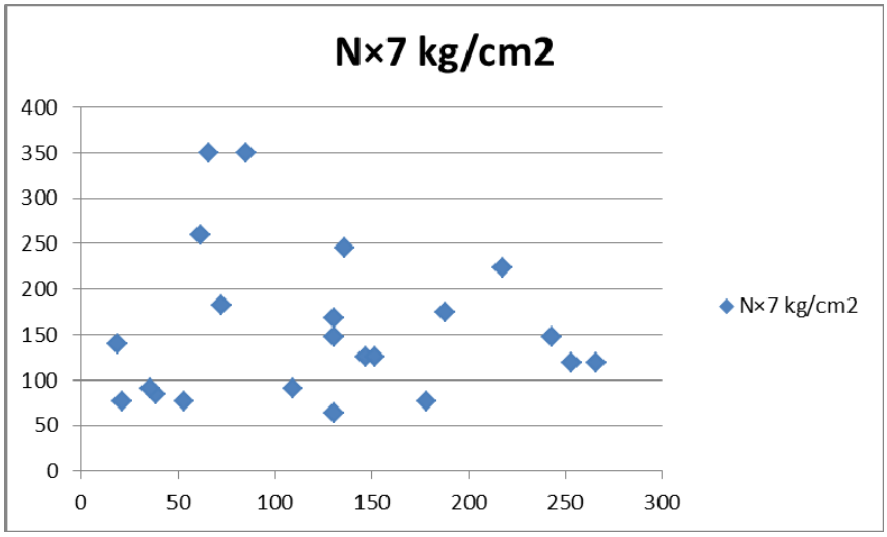
Source: JICA Study Team

Figure 2.2.24 The Pressure-Radius Displacement Curve



Source: JICA Study Team

Figure 2.2.25 The Relation between Po and Py



Source: JICA Study Team

Figure 2.2.26 The Relation between N Value and Elastic Modulus

4) Laboratory test results

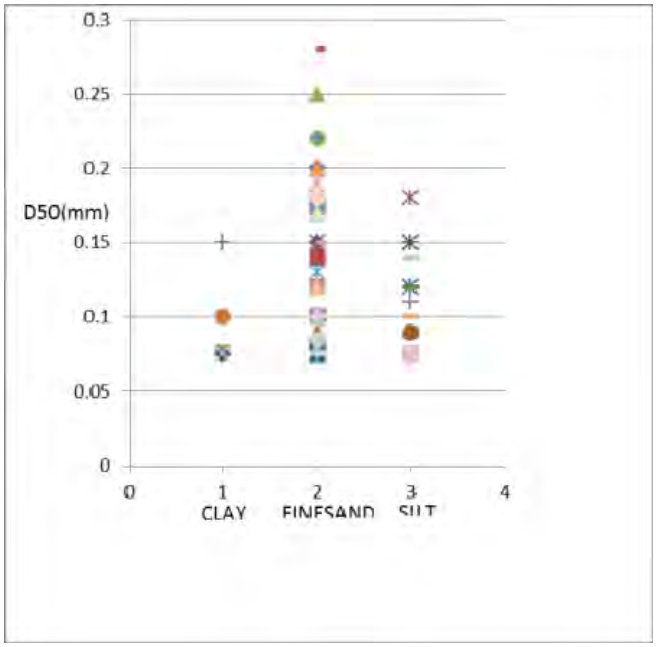
Details of the laboratory test results regarding 1) to 4) are shown in appendix 3 for Kanchpur Bridge, Meghna Bridge and Gumti Bridge.

- Density test

WD, DD tests at A2 ((UD1, depth 4.5 m), (UD2, depth 6.0 m)) at Kanchpur are conducted. The result is WD=2.1 gm/cc, DD=1.88 gm/cc at UD1. And the other result is WD=2.19 gm/cc, DD=2.01 gm/cc at UD2. The result at UD2 is a little larger than the value for clay.

- Grain size analysis test

The summary of the Grain size analysis tests is shown in Table 2.2.14. The number of tests was 78. The result shows that the clay soil type is composed of 40 % sand. And fine sand soil type is composed of 80 % sand. Grain size distribution for the D50 index is nearly 0.1 mm, and if anything, not proportional but uniform, see Figure 2.2.27.



Source: JICA Study Team

Figure 2.2.27 Grain Size of Each Soil Type

Table 2.2.14 Summary of Grain Size Analysis Test Data Results

LOCATION		SOIL TYPE	DEPTH	SAND	CLAY	D50	SILTFACTOR
			m	%	%	mm	
KANCHPUR	P1 br	clay	5	40	60	0.075	0.48
	P1 br	silt	8	54	46	0.08	0.5
	P1 br	silt	10	46	54	0.075	0.48
	P1 br	fine sand	17	80	20	0.15	0.68
	P1 br	fine sand	43	86	14	0.12	0.61
	P5 br	fine sand	2	70	30	0.09	0.53
	P5 br	fine sand	6	82	18	0.15	0.68
	P5 br	clay	33	48	52	0.075	0.48
	P5 br	fine sand	37	74	26	0.12	0.61
	P7 br	silt	26	60	40	0.085	0.51
	P7 br	silt	28	22	78	0.075	0.48
	P7 br	silt	39	66	34	0.09	0.53
	P7 br	silt	42	44	56	0.075	0.48
MEGHNA	P1 br	FINE SAND	5	80	20	0.1	0.56
	P1 br	FINE SAND	10	75	25	0.1	0.56
	P1 br	FINE SAND	18	85	15	0.18	0.75
	P1 br	FINE SAND	22	90	10	0.2	0.79
	P1 br	FINE SAND	26	82	18	0.1	0.56
	P1 br	FINE SAND	31	88	12	0.12	0.61
	P1 br	FINE SAND	47	72	28	0.15	0.68
	P1 br	FINE SAND	51	82	18	0.18	0.75
	P4 br	CLAY	8	68	32	0.1	0.56
	P4 br	CLAY	18	84	16	0.15	0.68
	P4 br	CLAY	19	44	56	0.075	0.48
	P4 br	CLAY	28	54	46	0.08	0.5
	P4 br	FINE SAND	31	82	18	0.15	0.68
	P4 br	FINE SAND	40	86	14	0.175	0.74
	P6 br	FINE SAND	7	84	16	0.14	0.66
	P6 br	FINE SAND	11	90	10	0.18	0.75
	P6 br	SILT	15	88	12	0.18	0.75
	P6 br	FINE SAND	18	85	15	0.22	0.83
	P6 br	CLAY	20	60	40	0.11	0.58
	P6 br	FINE SAND	22	82	18	0.17	0.73
	P6 br	FINE SAND	24	82	18	0.17	0.73
	P6 br	FINE SAND	28	80	20	0.18	0.75
	P6 br	FINE SAND	34	74	26	0.14	0.66
	P6 br	FINE SAND	41	98	2	0.25	0.88
	P11 br	FINE SAND	6	88	12	0.18	0.75
	P11 br	FINE SAND	11	90	10	0.13	0.63
	P11 br	FINE SAND	18	88	12	0.18	0.75
	P11 br	FINE SAND	24	90	10	0.22	0.83
	P11 br	FINE SAND	31	97	3	0.28	0.93
	A2 br	FINE SAND	10	84	16	0.12	0.61
	A2 br	FINE SAND	19	85	15	0.17	0.73
	A2 br	FINE SAND	22	82	18	0.12	0.61
	A2 br	FINE SAND	29	90	10	0.2	0.79
	A2 br	FINE SAND	37	88	12	0.17	0.73
	A2 br	SILT	50	40	60	0.075	0.48
MEGHNA GUMUTI	A1br	FINE SAND	2	75	25	0.095	0.54
	A1br	SILT	6	85	15	0.1	0.560
	A1br	SILT	7	34	66	0.075	0.48
	A1br	FINE SAND	17	80	20	0.12	0.61
	A1br	FINE SAND	22	70	30	0.1	0.56
	A1br	FINE SAND	27	76	24	0.12	0.61
	A1br	SILT	36	30	70	0.075	0.48
	A1br	SILT	37	30	70	0.075	0.48
	P3 br	FINE SAND	4	94	6	0.17	0.73
	P3 br	FINE SAND	14	80	20	0.15	0.68
	P3 br	SILT	20	78	22	0.14	0.66
	P3 br	SILT	21	28	72	0.075	0.48
	P3 br	SILT	39	45	55	0.075	0.48
	P3 br	FINE SAND	61	78	22	0.12	0.61
	P7 br	FINE SAND	2	88	12	0.1	0.56
	P7 br	FINE SAND	8	92	8	0.19	0.77
	P7 br	FINE SAND	17	67	33	0.085	0.51
	P7 br	FINE SAND	26	50	50	0.075	0.48
	P7 br	FINE SAND	64	78	22	0.095	0.54
	P12br	FINE SAND	3	48	56	0.075	0.48
	P12br	FINE SAND	7	86	14	0.1	0.56
	P12br	SILT	11	44	56	0.075	0.48
	P12br	FINE SAND	14	90	10	0.17	0.73
	P12br	CLAY	25	50	50	0.075	0.48
	P12br	FINE SAND	31	54	46	0.08	0.5
	P12br	FINE SAND	68	82	18	0.18	0.75
	P16br	FINE SAND	11	78	22	0.1	0.56
	P16br	FINE SAND	20	74	26	0.1	0.56
	P16br	FINE SAND	67	38	62	0.075	0.48
	P16br	FINE SAND	68	80	20	0.1	0.56
			CLAY	56	44	0.093	0.530
		AVERAGE	SILT	47	53	0.084	0.489
			FINESAND	81	19	0.144	0.667
						0.13	

Source: JICA Study Team

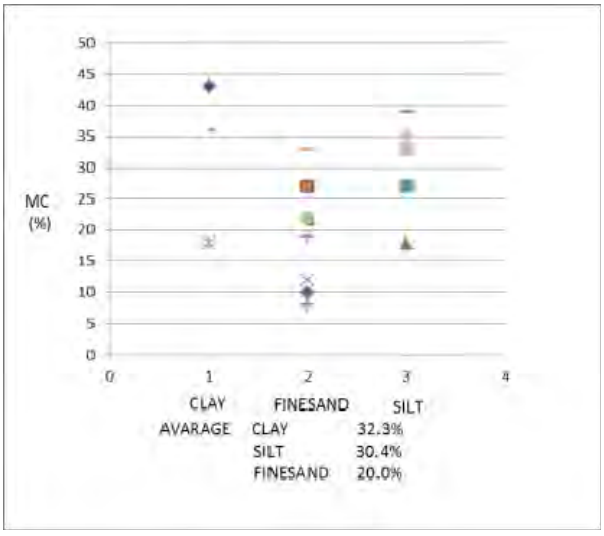
◆ Moisture content test

The summary of the moisture content tests is shown in Table 2.2.15. The number of tests is 17. Moisture content of the clay is in the range of 18 to 43 %. And the silt is 18 to 39 %. Fine sand is 8 to 33 %. The order of the Moisture content is clay > silt > fine sand. The moisture content of the fine sand is near to OMC (18 %), see Figure 2.2.28.

Table 2.2.15 Summary of Moisture Content Test Data Results

LOCATION		SOIL TYPE	DEPTH	MC
			m	%
KANCHPUR	P1 br	CLAY	1	43
	P5 br	FINE SAND	6	27
	P7 br	SILT	2	18
MEGHNA	P1 br	FINE SAND	1	27
	P4 br	FINE SAND	2	8
	P6 br	FINE SAND	2	21
	P6 br	SILT	16	39
	P11 br	FINE SAND	2	10
	A2 br	SILT	7	27
MEGHNA GUMUTI	A1 br	FINE SAND	2	12
	A1 br	CLAY	63	18
	P3 br	FINE SAND	2	22
	P7 br	FINE SAND	2	19
	P7 br	CLAY	30	36
	P12 br	FINE SAND	2	33
	P16 br	SILT	3	35
	P16 br	SILT	36	33
			CLAY	32.3
			SILT	30.4
			FINESAND	20.0

Source: JICA Study Team



Source: JICA Study Team

Figure 2.2.28 Moisture Content of Each Soil Type.

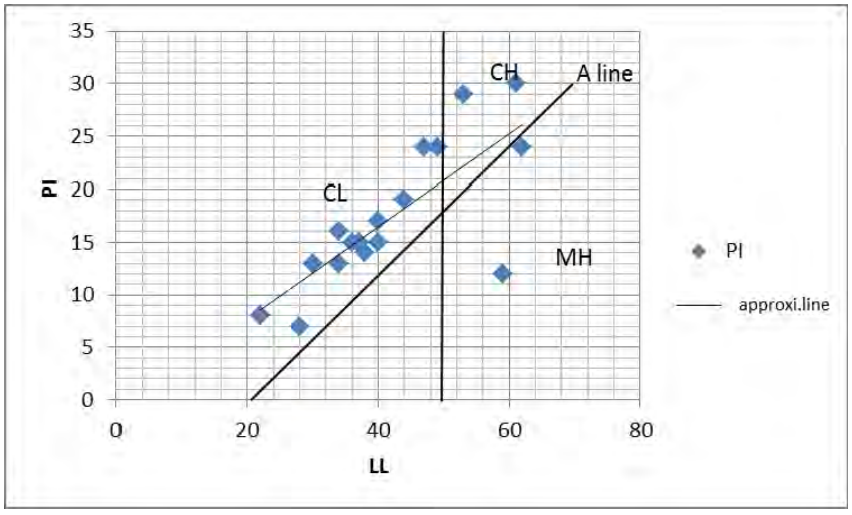
◆ Atterberg limit test

The summary of the Atterberg limit tests is shown in Table 2.2.16. The number of tests is 18. Average value is LL 42, PL 25, and PI 17. Soil of P1, P7 at Kanchpur Bridge is classified to be MH through A-line of IP-LL figures. Soil of P5 at Kanchpur Bridge and P3 on Gumti Bridge are classified to be CH. The others are CL, see Figure 2.2.29. In general, classification CL is good to poor for bearing capacity, CH, MH are poor or bad.

Table 2.2.16 Summary of Atterberg Limit Test Data Results

LOCATION		SOIL TYPE	DEPTH	LL	PL	PI	CLASSIFICATION
			m				
KANCHPUR	P1 br	CLAY	3	59	47	12	MH
	P1 br	CLAY	28	49	25	24	CL
	P5 br	CLAY	7	44	25	19	CL
	P5 br	CLAY	14	53	24	29	CH
	P7 br	CLAY	5	62	38	24	MH
	P7 br	CLAY	11	34	18	16	CL
	P7 br	CLAY	18	47	23	24	CL
MEGHNA	P1 br	CLAY	33	37	22	15	CL
	P4 br	CLAY	19	38	24	14	CL
	P6 br	CLAY	19	22	14	8	CL
	A2 br	SILT	46	28	21	7	CL
MEGHNA GUMUTI	A1 br	CLAY	46	30	17	13	CL
	A1 br	CLAY	56	40	25	15	CL
	P3 br	CLAY	42	61	31	30	CH
	P3 br	CLAY	51	36	21	15	CL
	P7 br	CLAY	28	37	22	15	CL
	P12 br	CLAY	26	40	23	17	CL
	P16 br	CLAY	26	34	21	13	CL
			AVERAGE	42	25	17	

Source: JICA Study Team

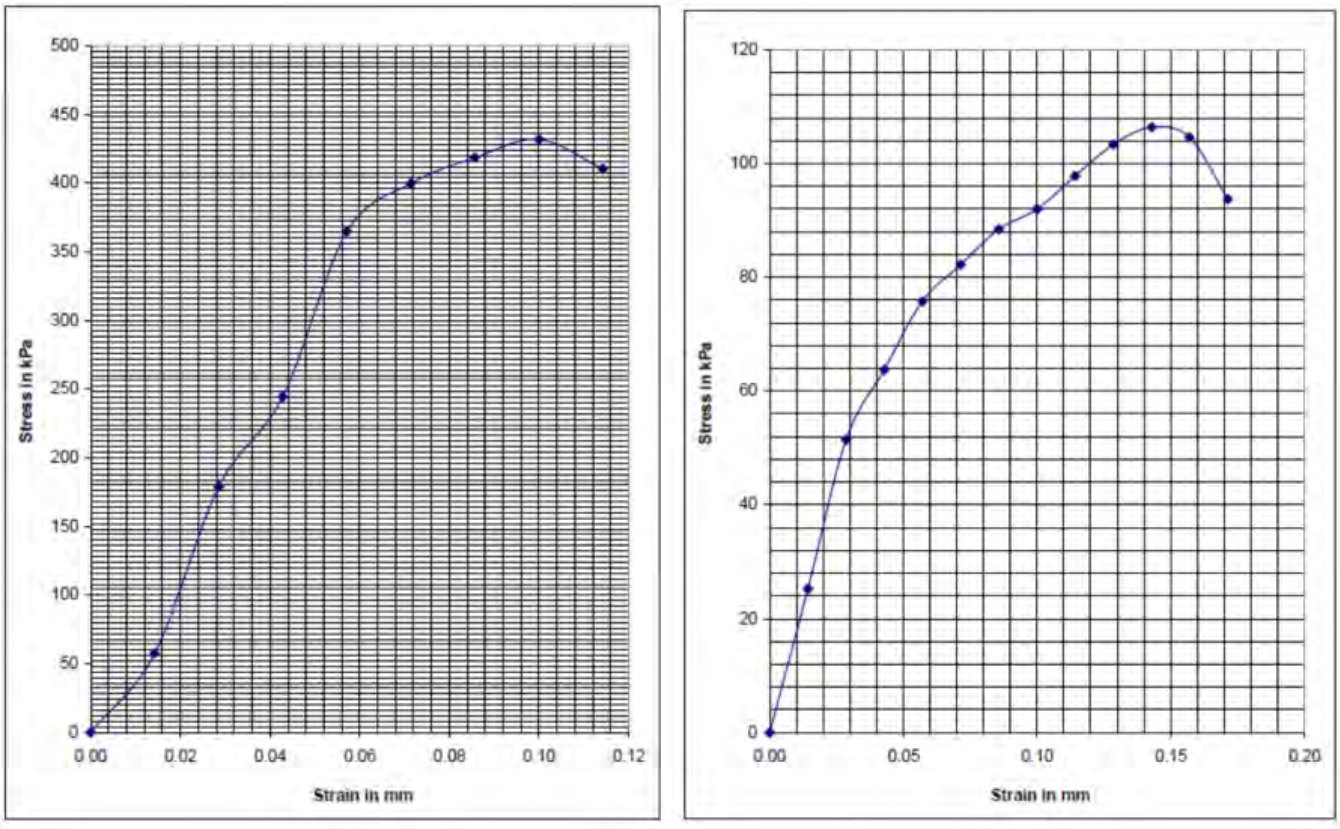


Source: JICA Study Team

Figure 2.2.29 Consistency Graph of LL-PI

- Unconfined compression test

Unconfined compression tests were executed at A2 (depth 4.5 m, 6.0 m) at Kanchpur Bridge. Soil type of the two samples was clay. The strengths measured in the tests were 440 kpa and 106 kpa. Both values show a maximum load stress at the point. And the strains were 10 % and 14 %. Stress-strain curves (see Figure 2.2.30) show the narrow elastic region and show the modulus of deformation depends on strain. Comparing the unconfined tests with in-situ pressure meter tests, the unconfined test curve is different from the para-elastic curve of the pressure meter test because the level of strain in the unconfined test is larger than the level of TMT (5 %).



Source: JICA Study Team

Figure 2.2.30 Stress Strain Curve of Unconfined Compression Tests

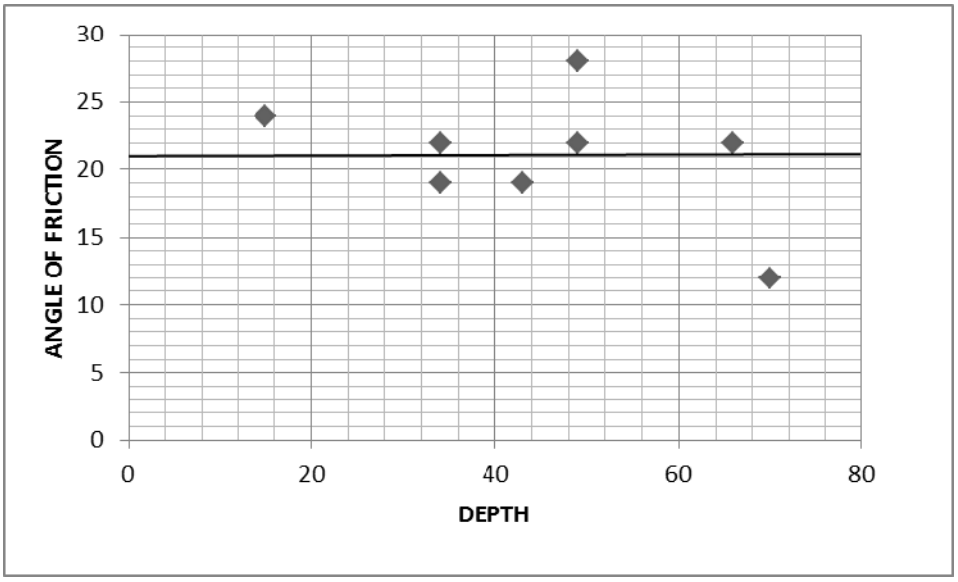
◆ Direct shear test

The summary of direct shear tests is shown in Table 2.2.17. The total number of tests is 8. Soil types are silt and fine sand. The result of the tests is that the range of the angle of internal friction is 12 to 28 degrees. Average is 21 degrees, see Figure 2.2.31. The angle of internal friction is low for the wet sand with small grain size. Because uniform dry sand is about 30 degrees generally, the angle of internal friction (φ=12 degrees) of the sample at p16 (depth=70 m) on Gumti Bridge is especially small.

Table 2.2.17 Summary of Direct Shear Test Data Results

LOCATION		SOIL TYPE	DEPTH	COHESION	ANGLE OF FRICTION
			m	kPa	Degree
KANCHPUR	P1br	FINE SAND	49	0	22
	P7 br	SILT	43	0	19
MEGHNA	P1 br	FINE SAND	49	0	28
	P6 br	FINE SAND	34	0	22
	A2 br	FINE SAND	34	0	19
MEGHNA GUMUTI	A1br	FINE SAND	15	0	24
	P7br	FINE SAND	66	0	22
	P16 br	FINE SAND	70	0	12
				AVERAGE	21

Source: JICA Study Team



Source: JICA Study Team

Figure 2.2.31 Distribution of Friction of Angle

2.2.5 CBR Test

(1) Test Location

There are two test locations for each of the two bridges. These two locations were selected with one on each side of the existing approach roads. Therefore, a total of six CBR tests have been conducted during the survey stage.

(2) Type of test

Three tests were conducted at each point. Each test was executed on the condition of the compaction ratio and different moisture contents. This is referred to as the three point CBR test.

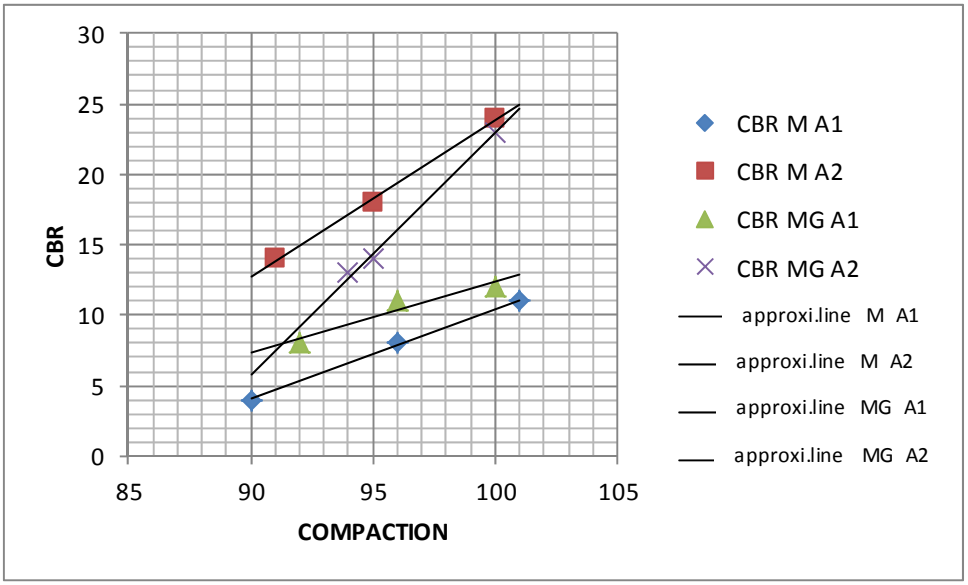
(3) Results of test

The summary of the CBR tests is shown in Table 2.2.18 and Figure 2.2.32. The result of the soil analysis shows MDD is 1.3 t/m^3, OMC is 29 % at A1 at Meghna Bridge. The value of MDD is small, but OMC is high. As a result, the value of CBR (8) is relatively low. If the ratio of compaction is low, CBR becomes about 4. Therefore, the soil needs to be compacted sufficiently. On the other hand, the result of fine sand shows MDD is 1.6 t/m^3, OMC is 18 % at A2 at Meghna Bridge. Both values are good, and CBR (18) is evaluated as good. The results of the soil analysis show MDD is 1.8 t/m^3, OMC is 15 % at A1 at Gumti Bridge. The value of OMC is lower, but the value of CBR (11) is an average numerical value. The results of the fine sand show MDD is 1.6 t/m^3, and OMC is 17 %. Those are average numerical values. The value of CBR (14) is a good numerical value. Both the results of CBR tests show linear lines which link 3 points, and there is no special CBR change when the compaction ratio decreases. The CBR test on Kanchpur was not good, because the soil type is clay. Clay is not compacted sufficiently. And the stress and penetration displacement curve doesn't show the linear line clearly. The value shows 6.9 MN/m^2 under at 2.5 mm displacement. So, the soil is not firm for the basement. It has to be solidified by the improvement of the soil.

Table 2.2.18 Summary of CBR Test Results

LOCATION		SOIL TYPE	MDD	OMC	D-DENSITY	COMPACTION	CBR 1	D-DENSITY	COMPACTION	CBR 2	D-DENSITY	COMPACTION	CBR 3
			kg/m3	%	kg/m3	%	%	kg/m3	%	%	kg/m3	%	%
Kanchpur	TP-A1 D1	CLAY					0			0			0
	TP-A2 D1	CLAY					0			0			0
MEGHNA	TP-A1 D1	SOIL	1338	29	1203	90	4	1282	96	8	1348	101	11
	TP-A2 D1	FINE SAND	1595	18	1458	91	14	1509	95	18	1597	100	24
MEGHNA GUMUTI	TP-A1 D1	SOIL	1795	15	1652	92	8	1720	96	11	1803	100	12
	TP-A2 D1	FINE SAND	1602	17	1510	94	13	1527	95	14	1601	100	23
	MDD:MAXIMUM-DRY-DENSITY												
	OMC:OPTIMUM-MOISTURE-CONTENT												

Source: JICA Study Team



Source: JICA Study Team

Figure 2.2.32 The Relation between the Compaction and CBR

2.3 Traffic Surveys, Analysis

2.3.1 Traffic Survey

(1) Outline of Survey

Traffic surveys were conducted in February 2012 at Kanchpur Bridge, Meghna Bridge and Gumti Bridge, for the purpose of traffic demand forecasts on NH-1.

Table 2.3.1 Types of Survey

Name of the Survey	Survey Period	Survey hours	Number of locations
Manual Classified Counts	7 days (Whole Week) [26/2/2012~3/3/2012]	24 hours	4
	1 day (Weekday) [28/2/2012]	24 hours	3
OD Interview Survey	1 day (Weekday) [28/2/2012]	12 hours	7
Traffic Movement Count Survey	1 day (Weekday) [27/2/2012]	16 hours	1
Traffic speed survey	2 day (Weekday, Weekend) [28/2/2012, 3/3/2012]	16 hours	-

Source: JICA Study Team

(2) Locations of the Surveys

The traffic surveys were conducted on NH-1 and the road connected to NH-1. In order to avoid traffic congestion during the traffic survey, the survey locations shown in Figure 2.3.1 were selected.

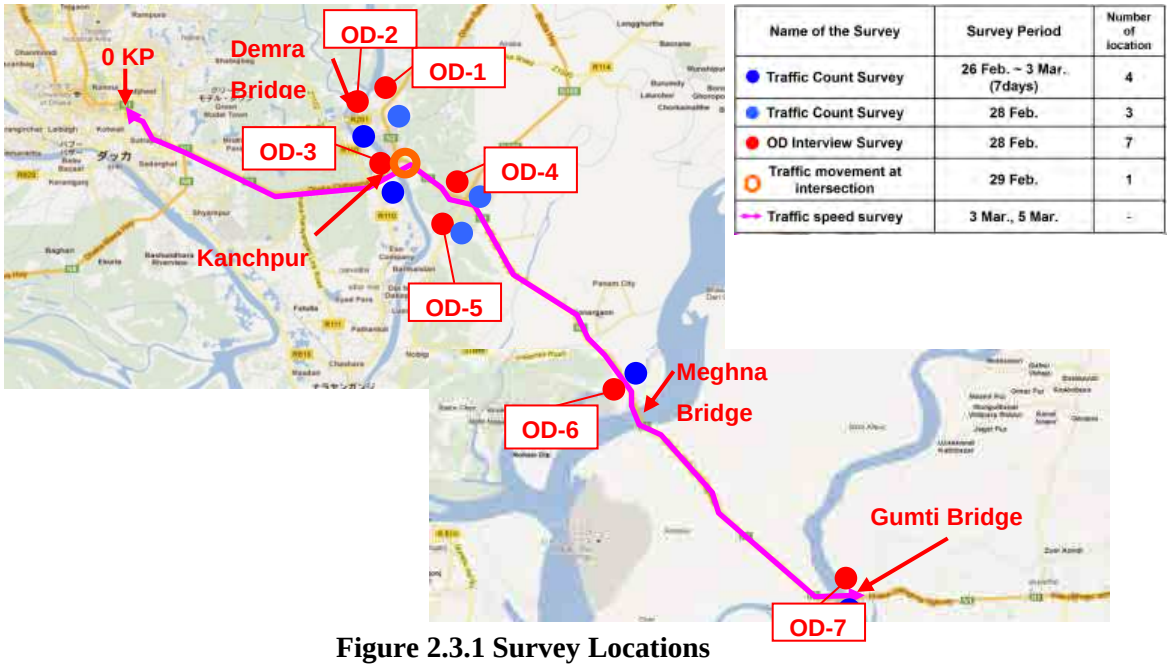


Figure 2.3.1 Survey Locations

(3) Manual Classified Counts

The purpose of the classified traffic survey is to count the Average Daily Traffic (ADT) passing over Kanchpur Bridge, Meghna Bridge and Gumti Bridge on NH-1. There were 7 survey locations selected, which are shown in the survey location map (Figure 2.3.1). The manual traffic volume survey has been counted for both directions.

Table 2.3.2 Classifications of Vehicles

Motorized Vehicle	Non-Motorized Vehicle
Heavy Truck	Bicycle
Medium Truck	Cycle Rickshaw
Small Truck	Cart
Large Bus	
Medium bus	
Microbus	
Utility	
Car/Taxi	
Baby-taxi/Tempo	
Motor Cycle	

Source: JICA Study Team

(4) OD Interview Survey

The Origin–Destination (OD) survey, which was conducted on NH-1 and the road connected to No.1 as show in Figure 2.3.1 has been carried out to predict the travel patterns of goods and passenger traffic This survey was conducted for 12 hours of one working day at 7 locations which are shown in Figure 2.3.1. These locations are selected in order to determine the traffic pattern traveling on the existing corridor.

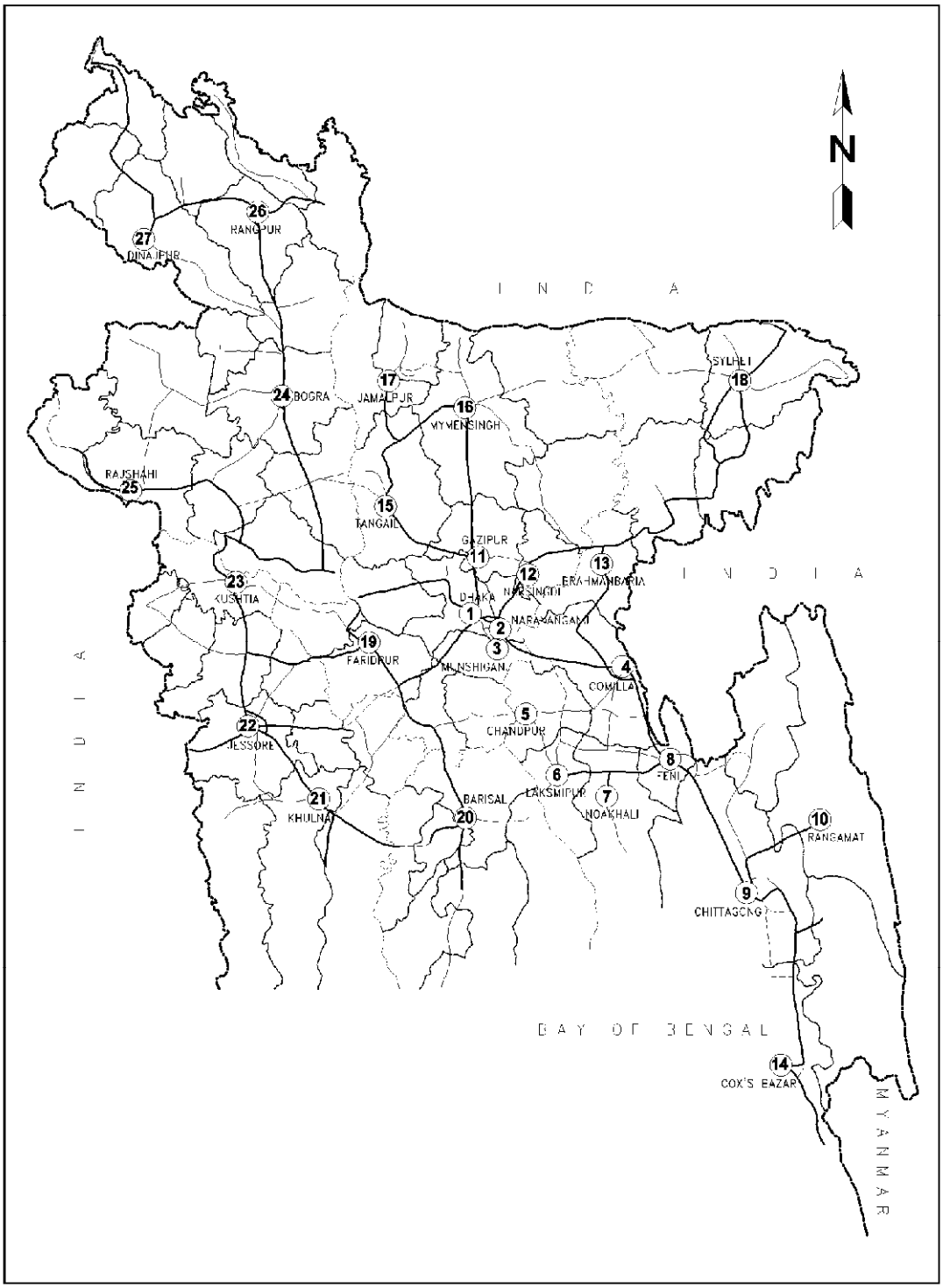
The road side interview method was adopted for conducting the OD survey. Various samples of vehicles were stopped randomly with the help of traffic police. The OD survey zones of NH-1 were assumed to be the same as the OD zone decided for Dhaka-Chittagong access controlled road. In this study appropriate coding was followed for zones, types of vehicles and commodities transported by the vehicles. The pertinent information on travel characteristics was collected during the interviews, which are listed as follows;

Origin and Destination of trips.

- Frequency of trip
- Trip purpose
- Trip length
- Number of passengers in the vehicle

For Goods Vehicles,

- Commodity type
- Load in Tonnes



Source: "Consultancy Services for Feasibility Study and Conceptual Design of Dhaka-Chittagong Expressway (PPP) project"

Figure 2.3.2 Adopted Zones of OD Survey

Table 2.3.3 Adopted Zones of O-D Survey

ZONE	name of the zone	description of zones
1	Dhaka	dhaka city
		keraniganj
		nawabganj
2	narayanganj	saver
		tongi
		sonargone
		rupganj
3	munshiganj	serajdikhan
		gozaria
		tongibari
		lohajanj
4	commilla	chandina
		daudkhandi
		barura
		chuddagram
		laksham
		debiduar
		companiganj
		burichang
		muradnagar
		homna
5	chandpur	hajiganj
		shahrasti
		matlab
		kachua
		faridganj
		hamichar
6	lakshmipur	roypur
		ramgati
7	noakhali	chowmohani
		sonagazi
		senbagh
		daganbhuiyam
		companiganj
8	feni	chhagalnaiya
		parshuram
9	chattagong	mirsaraiy
		sitakundo
		chittagong city
		hathazari
		fatikchhari
		kapati
		anowara
		satkania
		banshkhali
		rangunioa
		patiya
		boalkhali
10	chaittagonj hill	rangamati
		khagrachari
		bandarban
11	gazipur	pubail
		kapasia
		kaliakoir
		sreepur
		kaligonj
12	narsingdi	raipur
		shibpur
		araihazar
		palashi
		belabo
		manohardi
		ashuganj
13	brahmanbaria	banchharampur
		sarail
		ashuganj
		nabinagar
		kashba
		akhaura
		kashba
14	cox's bazar	teknaf
		chakaria
		ramu
15	tangail	mirjapur
		khalihati
		ghatail
		bhuapur
		delduar
16	maymensingh	basail
		madhupur
		netrokona
		kishirgangj
		gafargaow
		trishal
		bhaluka
		haluaghat
		phulbaria
		purbadhala
		kalmakanda
		dharmapasha
		mohanganj
		atpara
		madan
		nandail
		kendua
		karimganj
17	jamalpur	bajitpur
		bhairab
		nikli
		sherpur
		nakla
		nalitabari
		melandhaha
		sarishabari
		jhenaigati
18	sylhet	hobigonj
		moulabibazar
		sunamganj
		beanibazar
		zakiganj
		barlekha
		fenchuganj
		golapganj
		balaganj
		kaniaghat
		tamabil
		chunarughat
		bahubai
		nabiganj
		ajmiriganj
		kulaura
		shimangal
		kamalganj
		biswanath
		chhatak
		dirai
		jagannathpur
19	Faridpur	madaripur
		shariatpur
		gopalgonj
		kalkini
		rajoir
		naria
		bhederganj
		goshirghat
		kotalipara
		tungipara
		mollarhat
		rajbari
		bhanga
		goalanda
		pangsha
20	barishal	jhalokati
		pirojpur
		patuakhali
		bhandaria
		rajapur
		patharghata
		barguna
		kuakata
21	khulna	bagarhat
		rupsha
		dacop
		mongla
		morelganj
		sarankhola
22	jessore	benapole
		satkhira
		jhenaidha
		magura
		narail
23	kushtia	kumarkhali
		meherpur
		chudanga
		bheramara
		mirpur
		mujibnagar
24	bogra	pabna
		sirajgonj
		joypurhat
		panchbibi
		sherpur
		kazipur
25	rajshahi	naogaou
		nawabganj
		bholahat
		shapahar
		raninagar
		badalgachi
		mohadevpur
		shantahar
		natore
		tanor
		bagmara
26	rangpur	nimatpur
		charghat
		lalmonirhat
		burimari
		khurigram
		gaibandha
		palashbari
		bhurungamari
		nilpharamari
		saidpur
		roumari
		jaldhaka
27	dinajpur	dimla
		birampur
		fulbari
		hili
		haripur
		thakurgaon
		panchagarh
		tentulia
		banglabandh
		ranisonkail
		haripur
		burimari
28	india	kolkhata
		agortala

Source: "Consultancy Services for Feasibility Study and Conceptual Design of Dhaka-Chittagong Expressway (PPP) project"

(5) Traffic Movement Count Survey

The objective of the Traffic Movement Count Survey is to obtain information regarding directional movement at Kanchpur intersection. The survey was conducted for 16 hours including the morning and evening peak hours.

(6) Traffic Speed Survey

The purpose of the Traffic Speed Survey is to determine the average speed of the traffic moving on NH-1. The survey was conducted from 0 kilometer post (kP) of NH-1 to Gumti toll gate.

2.3.2 Results of the Survey

(1) The passenger car units (PCUs)

The Passenger Car Units (PCUs) recommended by RHD for all types of vehicles is adopted for the traffic analysis. The adopted values are shown in Table 2.3.4.

Table 2.3.4 Adopted Values of Passenger Car Units (PCUs)

Vehicle Type		PCU Equivalency		
		RHD Standard	HCM	remarks
Motorized Vehicle	Heavy Truck	3.00	1.5*	Upgrade < 2 %
	Medium Truck	3.00		
	Small Truck	3.00		
	Large Bus	3.00		
	Mini Bus	3.00		
	Micro Bus	3.00		
	Utility	1.00	1.2*	Upgrade < 2 %
	Car	1.00	1.00	
	Auto Rickshaw	0.75	-	
	Motor Cycle	0.75	-	
Non-Motorized Vehicle	Bicycle	0.50	-	
	Cycle Rickshaw	2.00	-	
	Animal / Push Cart	4.00	-	

Source: JICA Study Team

(2) Average Daily Traffic (ADT)

Classified Manual Traffic Volume Surveys were conducted for 24 hours (6:00 a.m. to 6.00 a.m.) and the results obtained are expressed in terms of Average Daily Traffic (ADT). Table 2.3.5 and Table 2.3.6 show calculated ADT values.

Table 2.3.5 ADT Values of Motorized and Non-Motorized Vehicles (in number of Vehicles)

		Motoraized Vehicles										Non-Motorized Vehicles					
No	Location	1 Heavy Truck	2 Medium Truck	3 Small Truck	4 Large Bus	5 Mini bus	6 Microbus	7 Utility	8 Car/Taxi	9 Baby-taxi/ Tempo	10 Motor Cycle	11 Bicycle	12 Cycle Rickshaw	13 Cart	Total Motor	Total Non-M	Grand Total
1	Demra	2,107	1,468	1,245	1,002	745	1,464	1,488	1,832	2,360	770	119	367	-	14,480	486	14,966
2	Kanchpur	4,974	3,417	2,349	4,958	3,766	2,559	2,690	3,237	5,472	1,031	178	581	8	34,453	767	35,220
3	*Meghna, Meghna-Gumti*	3,337	4,944	1,797	4,138	1,986	2,929	2,740	2,937	2,509	260	-	-	-	27,578	-	27,578
4	*N-2:Sylhet Road*	3,755	1,487	1,243	2,645	1,966	1,704	1,938	1,855	4,201	1,049	220	1,698	-	21,843	1,918	23,761
5	*Modonpur to Bandar road*	760	627	587	19	217	307	235	368	1,879	324	116	1,369	-	5,323	1,485	6,808
6	*Modonpur to Arihazar road*	4,603	1,295	1,088	1,068	897	1,145	463	784	6,127	461	185	3,683	-	17,931	3,868	21,799

Source: JICA Study Team

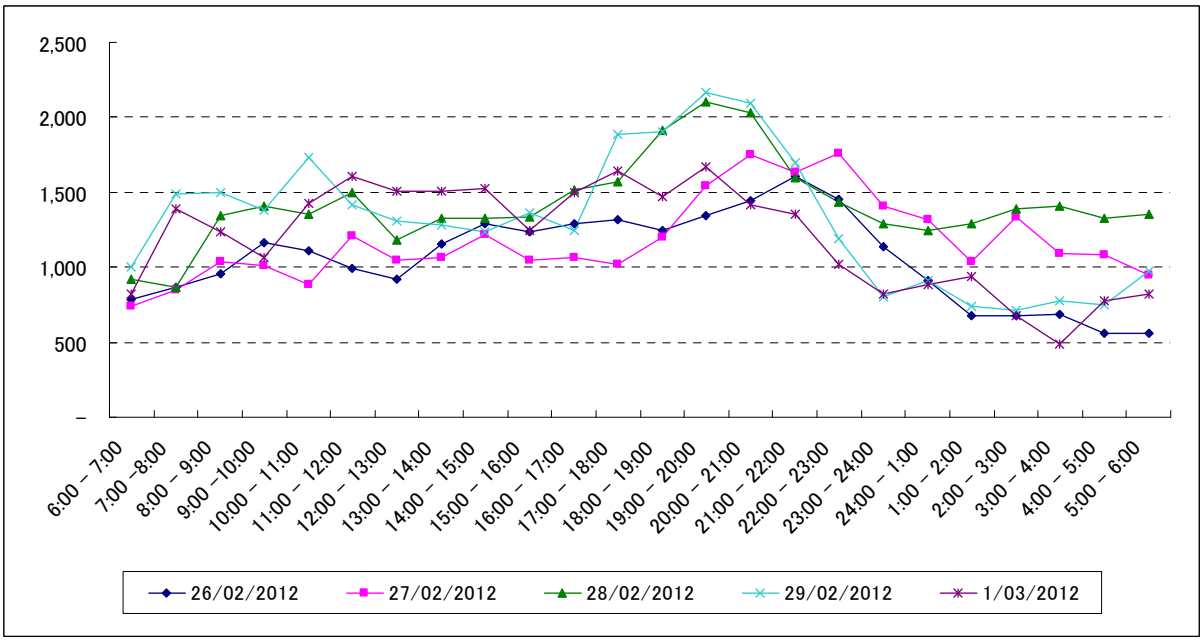
Table 2.3.6 ADT Values of Motorized and Non-Motorized Vehicles (in PCU)

No	Location	Motoraized Vehicles										Non-Motorized Vehicles			Total Motor	Total Non-M	Grand Total
		1	2	3	4	5	6	7	8	9	10	11	12	13			
		Heavy Truck	Medium Truck	Small Truck	Large Bus	Mini bus	Microbus	Utility	Car/Taxi	Baby-taxi/ Tempo	Motor Cycle	Bicycle	Cycle Rickshaw	Cart			
	PCU Equivalency	3.00	3.00	3.00	3.00	3.00	3.00	1.00	1.00	0.75	0.75	0.50	2.00	3.00			
1	Demra	6,320	4,403	3,736	3,007	2,234	4,391	1,488	1,832	1,770	577	60	735	-	29,759	794	30,553
2	Kanchpur	14,921	10,252	7,046	14,875	11,297	7,676	2,690	3,237	4,104	773	89	1,163	23	76,872	1,275	78,147
3	*Meghna, Meghna-Gumti*	10,012	14,831	5,392	12,413	5,958	8,786	2,740	2,937	1,882	195	-	-	-	65,147	-	65,147
4	*N-2:Sylhet Road*	11,265	4,461	3,729	7,935	5,898	5,112	1,938	1,855	3,151	787	110	3,396	-	46,131	3,506	49,637
5	*Modonpur to Bandar road*	2,280	1,881	1,761	57	651	921	235	368	1,409	243	58	2,738	-	9,806	2,796	12,602
6	*Modonpur to Arihazar road*	13,809	3,885	3,264	3,204	2,691	3,435	463	784	4,595	346	93	7,366	-	36,476	7,459	43,935

Source: JICA Study Team

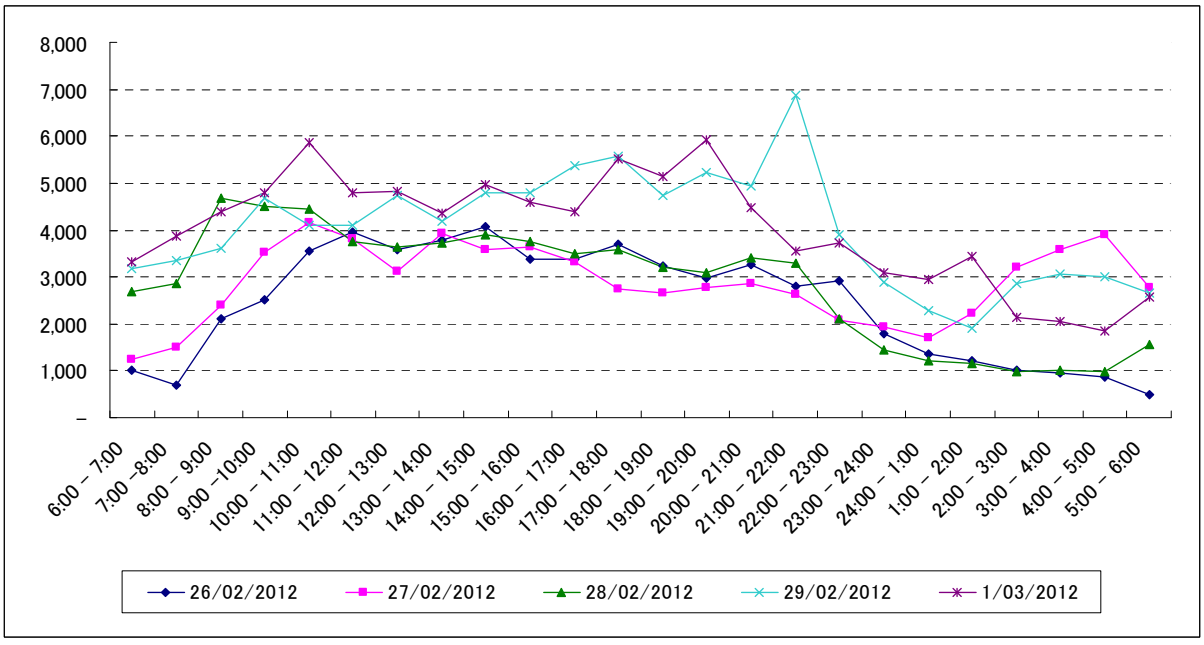
(3) Hourly Variation of Traffic

Hourly variation of traffic was studied for 24 hours and accordingly the results obtained are shown in Figure 2.3.3 to Figure 2.3.5.



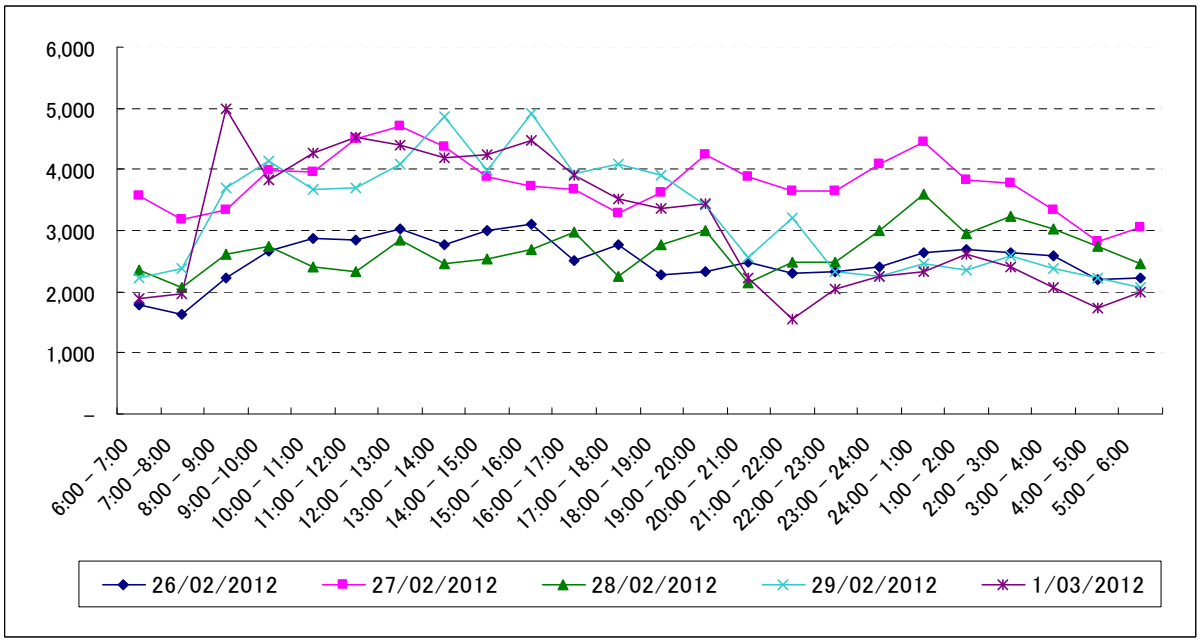
Source: JICA Study Team

Figure 2.3.3 Hourly Variation of Traffic Data - Demra



Source: JICA Study Team

Figure 2.3.4 Hourly Variation of Traffic Data - Kanchpur

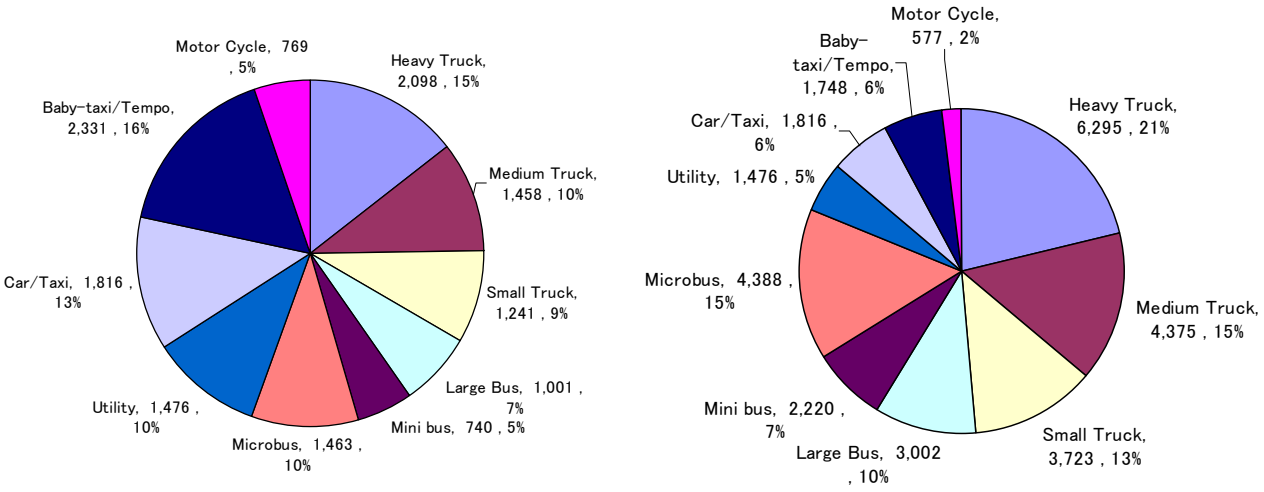


Source: JICA Study Team

Figure 2.3.5 Hourly Variation of Traffic Data - Meghna, Gumti

(4) Composition of Traffic

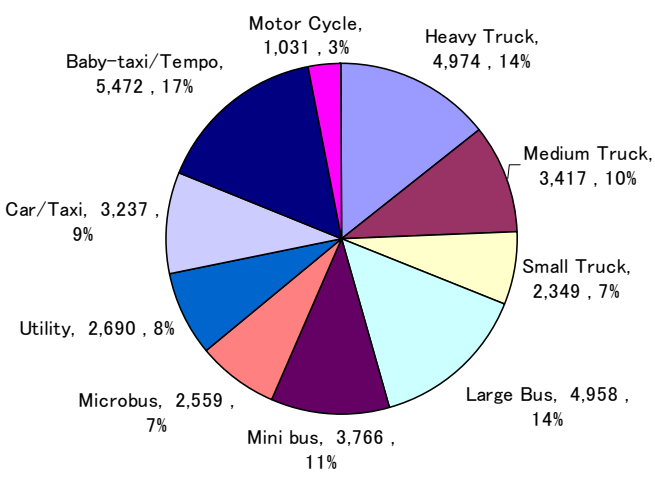
The traffic composition along with the percentage of vehicles of each category is expressed herein in terms of the numbers counted and PCU. Accordingly, the computed results are compared in Figure 2.3.6 to Figure 2.3.8. It shows that the large type vehicles (Heavy Truck, Medium Truck, Small Truck, Large Bus, Mini Bus, and Microbus) make up more than 50 % of the traffic at Kanchpur Meghna, and Gumti. On the other hand, considering the PCU factor, the large type vehicles are more than 80 % of the traffic at Demra, Kanchpur and Meghna and Gumti.



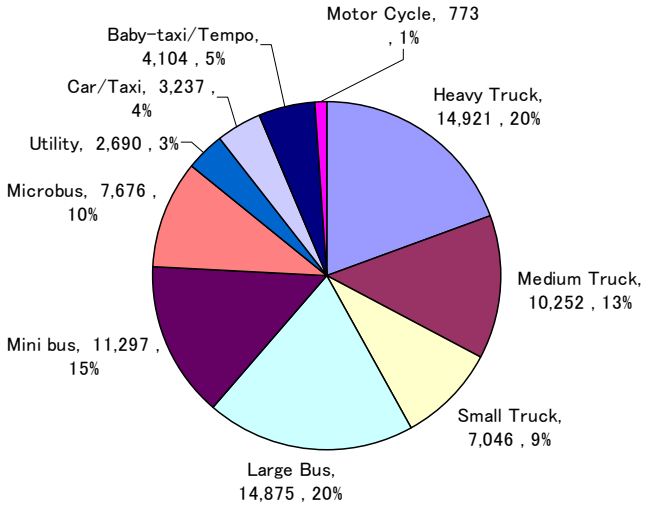
(In number of Vehicles) (In PCU)

Source: JICA Study Team

Figure 2.3.6 Composition of Traffic at Demra



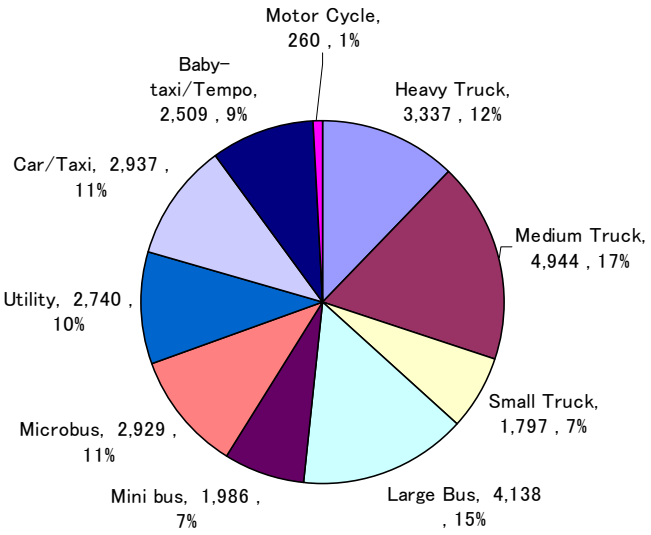
(In number of Vehicles)



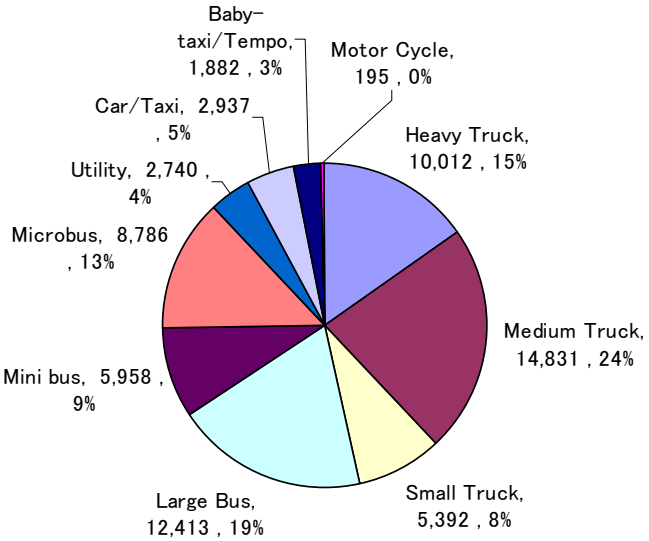
(In PCU)

Source: JICA Study Team

Figure 2.3.7 Composition of Traffic at Kanchpur



(In number of Vehicles)



(In PCU)

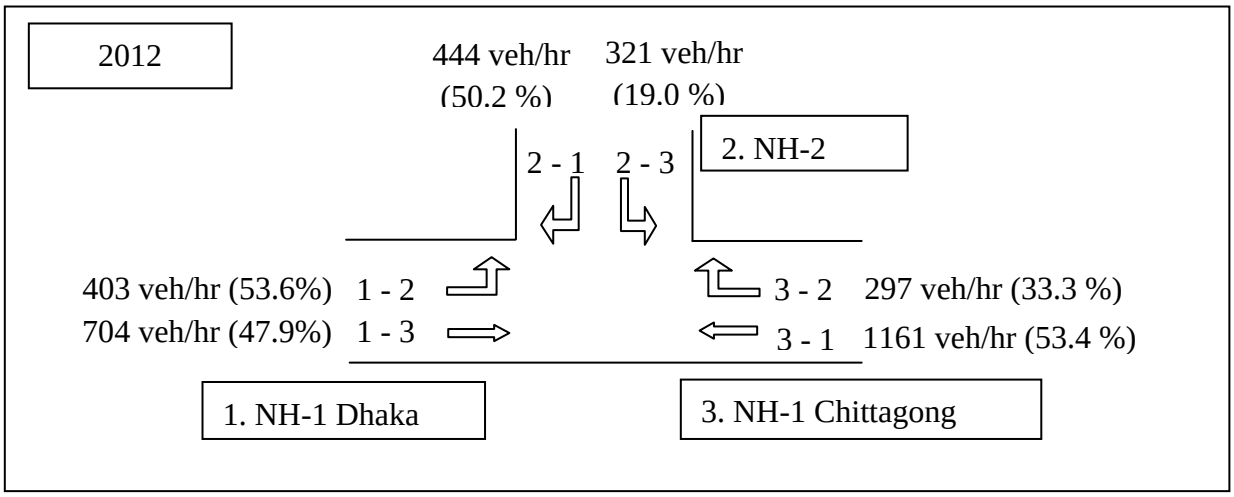
Source: JICA Study Team

Figure 2.3.8 Composition of Traffic at Meghna, Gumti

(5) Traffic Movement Count Survey

The analysis of the traffic movement count survey has been used for studying the requirement of improvement of intersections such as at grade intersections, u-loops and fly-overs etc.

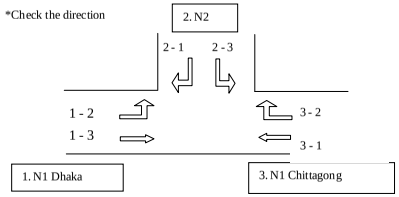
Summary of peak hour flow is reported in Figure 2.3.9. Result of traffic movement count survey is shown in Table 2.3.7.



Note: ( ) shows percent heavy vehicles
Source: JICA Study Team

Figure 2.3.9 Peak Hour Volume Flow

Table 2.3.7 Traffic Volume of Traffic Movement Count Survey



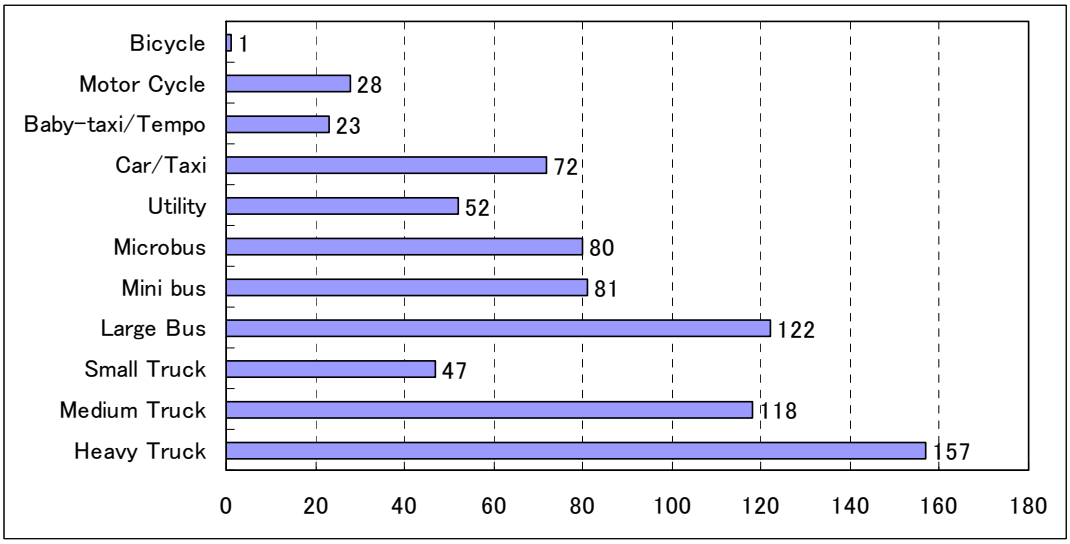
	1-2			1-3			2-1			2-3			3-2			3-1		
	Total	Heavy vehicle	Heavy ratio	Total	Heavy vehicle	Heavy ratio	Total	Heavy vehicle	Heavy ratio	Total	Heavy vehicle	Heavy ratio	Total	Heavy vehicle	Heavy ratio	Total	Heavy vehicle	Heavy ratio
6:00 - 7:00	235	97	41.3%	347	174	50.1%	231	108	46.8%	77	20	26.0%	86	47	54.7%	1161	620	53.4%
7:00 -8:00	237	164	69.2%	399	221	55.4%	167	99	59.3%	100	39	39.0%	137	54	39.4%	1062	543	51.1%
8:00 - 9:00	353	187	53.0%	480	225	46.9%	288	142	49.3%	88	18	20.5%	150	63	42.0%	1071	572	53.4%
9:00 -10:00	355	195	54.9%	428	209	48.8%	293	145	49.5%	101	20	19.8%	120	33	27.5%	933	486	52.1%
10:00 - 11:00	397	187	47.1%	485	248	51.1%	382	164	42.9%	167	33	19.8%	146	42	28.8%	936	434	46.4%
11:00 - 12:00	342	164	48.0%	475	225	47.4%	352	168	47.7%	219	29	13.2%	173	59	34.1%	818	362	44.3%
12:00 - 13:00	379	170	44.9%	506	270	53.4%	345	152	44.1%	244	33	13.5%	193	60	31.1%	922	374	40.6%
13:00 - 14:00	380	174	45.8%	519	251	48.4%	377	167	44.3%	223	31	13.9%	187	55	29.4%	795	350	44.0%
14:00 - 15:00	340	158	46.5%	471	248	52.7%	329	156	47.4%	245	58	23.7%	151	45	29.8%	727	356	49.0%
15:00 - 16:00	325	164	50.5%	528	288	54.5%	328	167	50.9%	275	63	22.9%	177	46	26.0%	666	310	46.5%
16:00 - 17:00	310	176	56.8%	646	313	48.5%	318	193	60.7%	321	61	19.0%	203	62	30.5%	623	297	47.7%
17:00 - 18:00	316	160	50.6%	627	293	46.7%	324	158	48.8%	256	40	15.6%	232	60	25.9%	775	396	51.1%
18:00 - 19:00	339	161	47.5%	688	324	47.1%	444	223	50.2%	229	60	26.2%	297	99	33.3%	714	434	60.8%
19:00 - 20:00	403	216	53.6%	704	337	47.9%	411	220	53.5%	253	28	11.1%	261	55	21.1%	605	333	55.0%
20:00 - 21:00	285	175	61.4%	491	268	54.6%	283	180	63.6%	282	31	11.0%	185	59	31.9%	642	388	60.4%
21:00 - 22:00	222	141	63.5%	321	180	56.1%	273	172	63.0%	211	23	10.9%	150	55	36.7%	440	266	60.5%
Total	5218	2689		8115	4074		5145	2614		3291	587		2848	894		12890	6521	

Source: JICA Study Team

(6) Analysis of Origin – Destination (O-D)

1) Attributes of respondent's transport mode

Figure 2.3.10 shows the composition of the respondent's transport mode from the OD Interview Survey. In term of the number of respondents, "Heavy truck" occupies the largest portion with 157 persons. However, it does not indicate the modal share of traffic, since the numbers are based on respondents, not vehicular traffic.

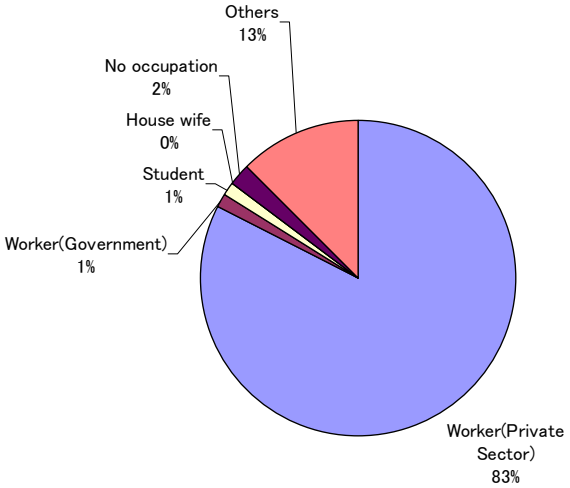


Source: JICA Study Team

Figure 2.3.10 Composition of Vehicle Type

2) Attributes of respondent's occupation

Figure 2.3.11 shows the composition of the respondent's occupation for the OD Interview Survey. In term of the number of respondents, "Worker (private sector)" occupies the largest portion with 83 %.

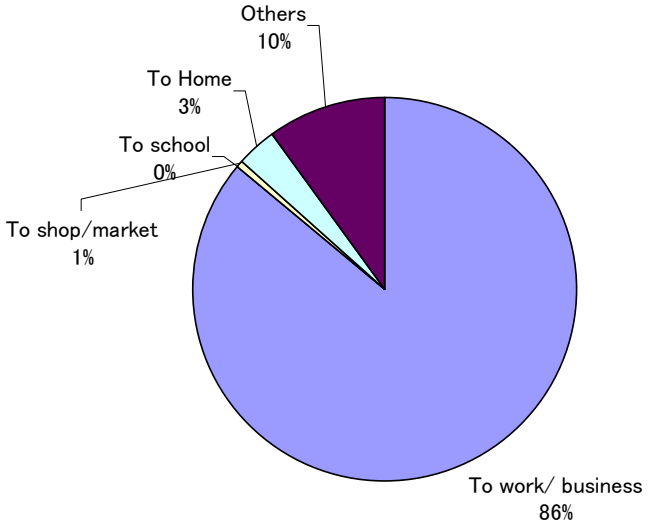


Source: JICA Study Team

Figure 2.3.11 Composition of Occupations

3) Attributes of respondent's trip purpose

Figure 2.3.12 shows the composition of the respondent's trip purpose for the OD Interview Survey. In term of the number of respondents, "To work/business" occupies the largest portion with 86 %.

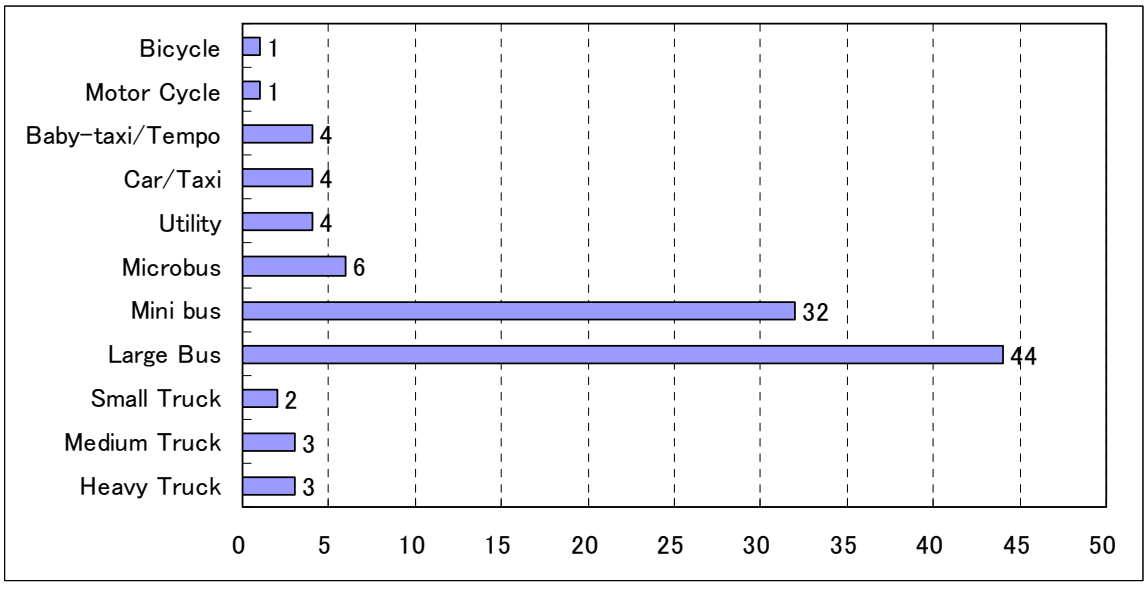


Source: JICA Study Team

Figure 2.3.12 Composition of Trip Purposes

4) Number of passengers

Figure 2.3.13 shows the average number of passengers by vehicle.



Source: JICA Study Team

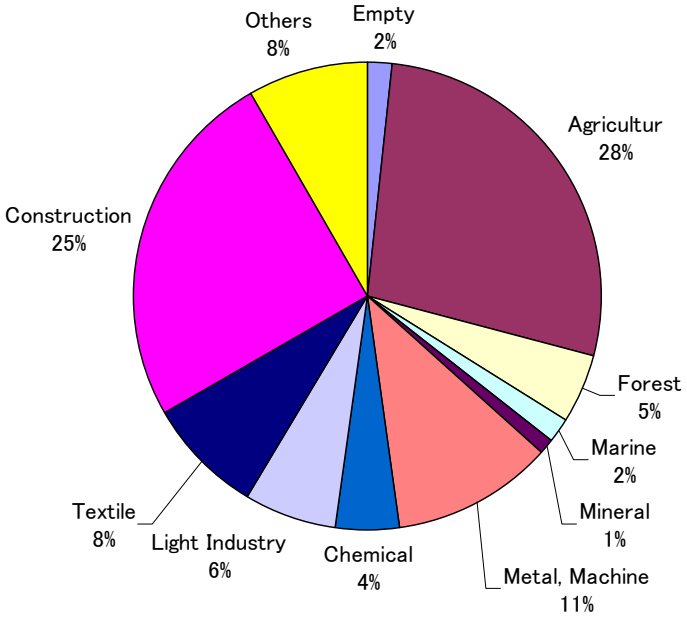
Figure 2.3.13 Number of Passengers

5) Commodity Analysis

Each commodity was assigned a particular code as shown in Table 2.3.8. Eleven groups for classification of commodities were formed and percentages of composition of commodities were detected. Typical compositions of commodities are shown in Figure 2.3.14. It can be seen that Agriculture and Construction are substantial.

Table 2.3.8 Commodity Classification Groups

Code No.	Commodity Type
1	Empty
2	Agricultur
3	Forest
4	Marine
5	Mineral
6	Metal, Machine
7	Chemical
8	Light Industry
9	Textile
10	Construction
11	Others



Source: JICA Study Team

Figure 2.3.14 Typical Composition of Commodities

6) Major movements of traffic

Figure 2.3.16 to Figure 2.3.22 present the major OD characteristics of truck (Heavy Truck, Medium Truck, Small Truck), bus (Large Bus, Mini Bus, Microbus), and passenger car (Utility, Car/Taxi, Baby-taxi/Tempo) traffic between districts.

As trend of trip distance, the trip distance of passenger car tends to be short and the trip distance of truck and bus tend to be long. Regarding bus and track, high share of trip destination is occupied in Chittagong, Comilla and Sylhet area. In particular, the trip of Chittagong and Comilla destination counted for a higher proportion of trip through the Meghna and Gumti Bridge. Therefore, trips of Chittagong and Comilla are assumed to be influenced by development of Dhaka-Chittagong railway and Chittagong seaport.

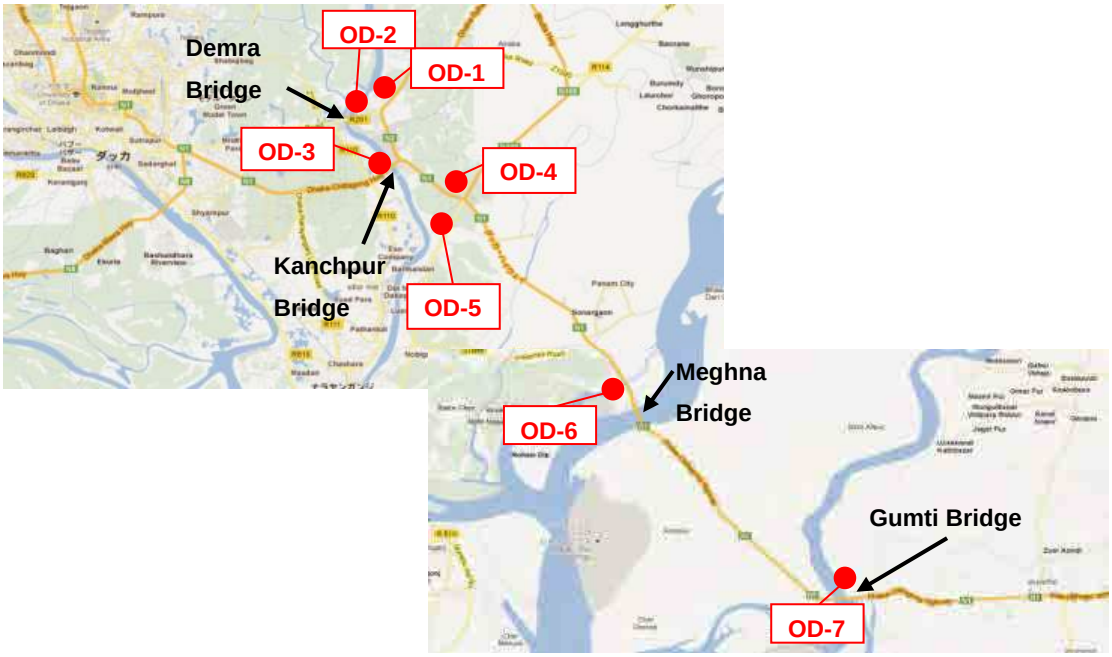
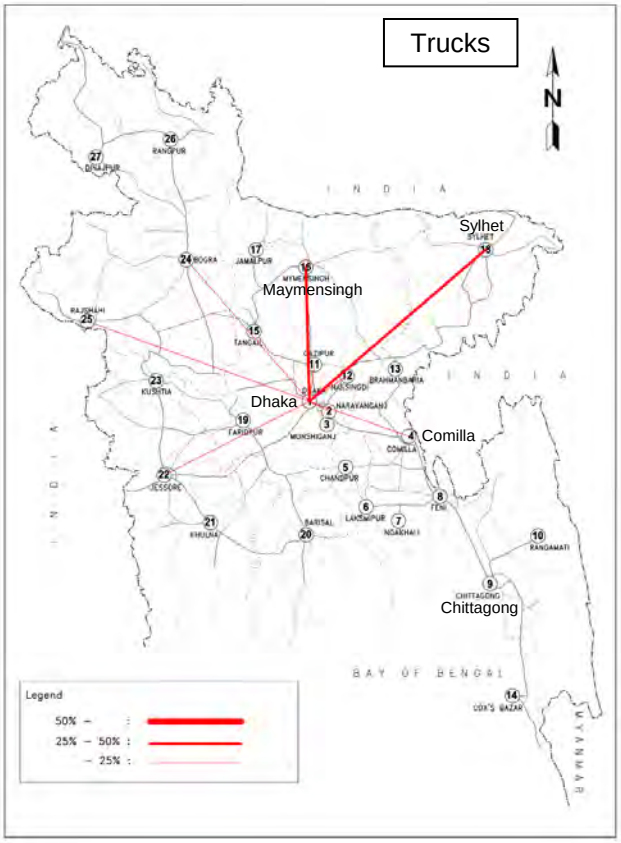
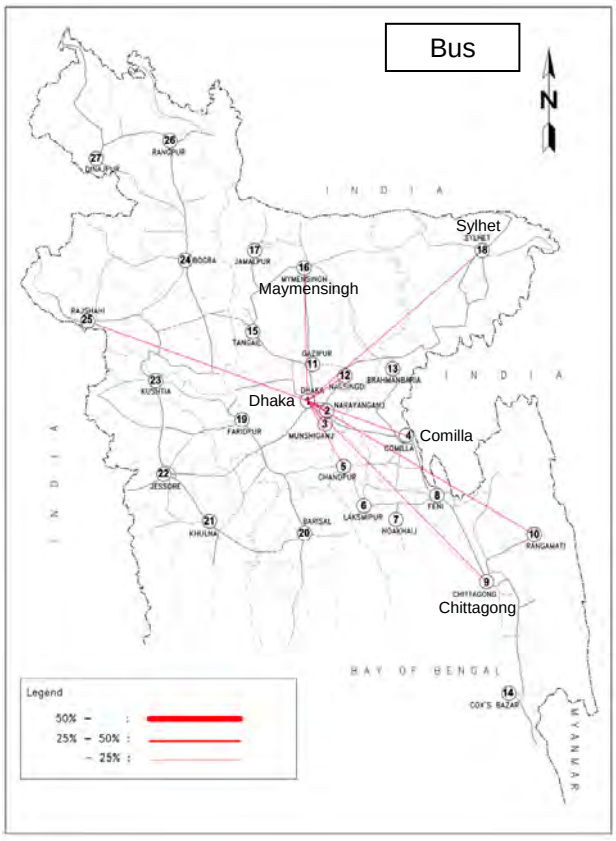
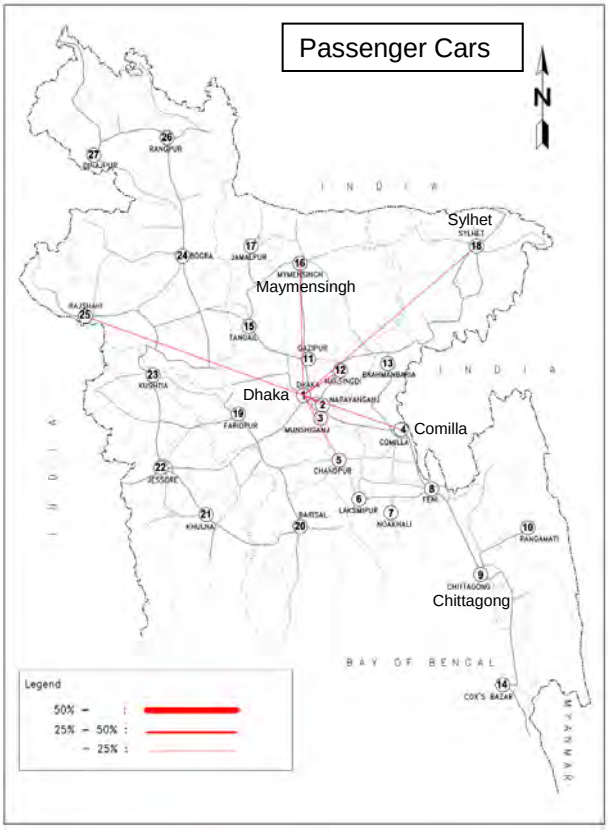


Figure 2.3.15 Locations of OD Survey



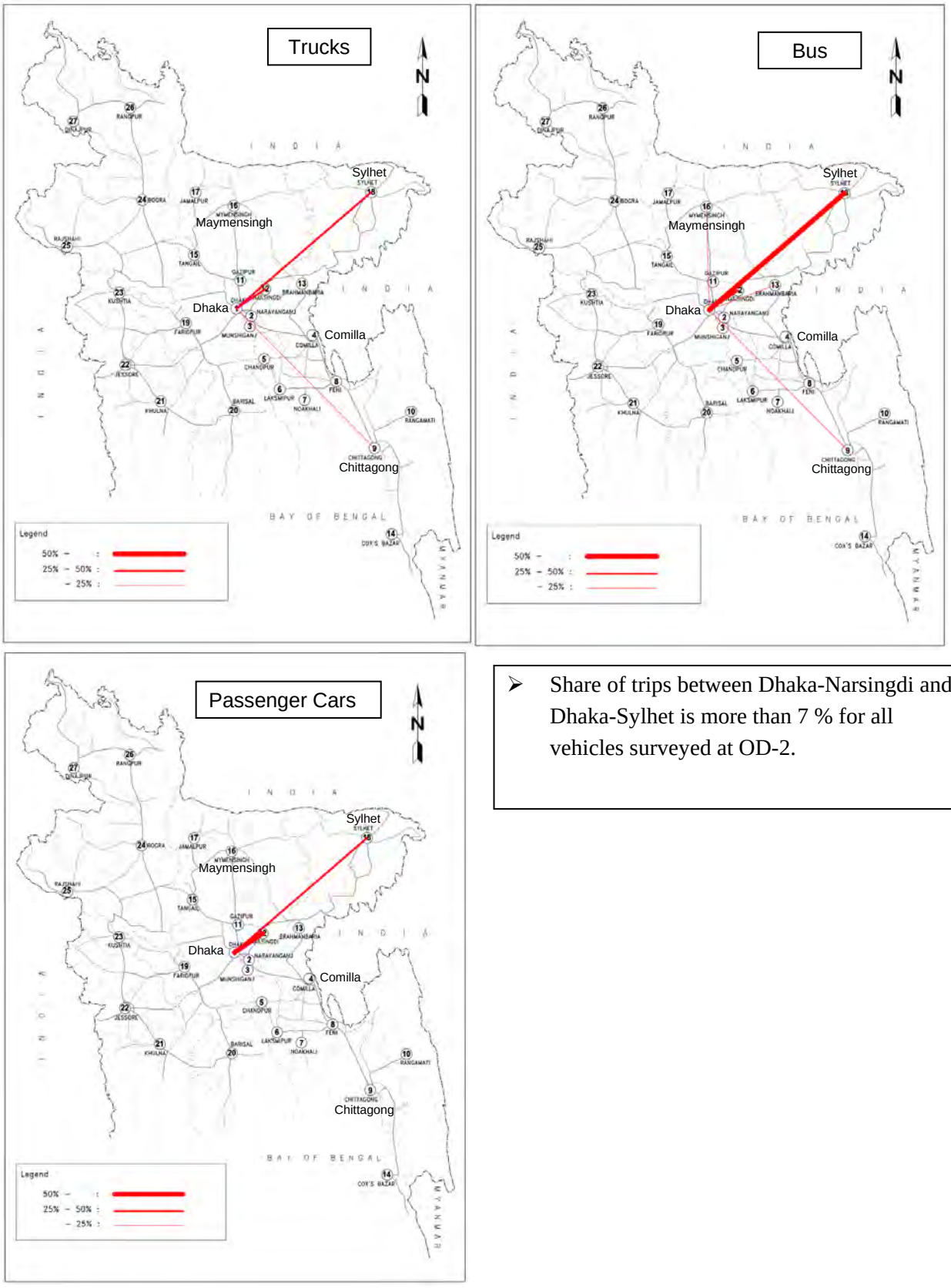




- Share of trips between Dhaka-Maymensingh and Dhaka-Sylhet is more than 50 % for trucks surveyed at OD-1.
- Each share of trips between Dhaka-Commilla, Dhaka-Brahmanbaria, Dhaka-Maymensingh and Dhaka-Sylhet is more than 10% for buses surveyed at OD-1.
- Each share of trips between Dhaka-Comilla, Dhaka-Brahmanbaria, Dhaka-Maymensingh and Dhaka-Sylhet is more than 10 % for passenger cars surveyed at OD-1.

Source: JICA Study Team

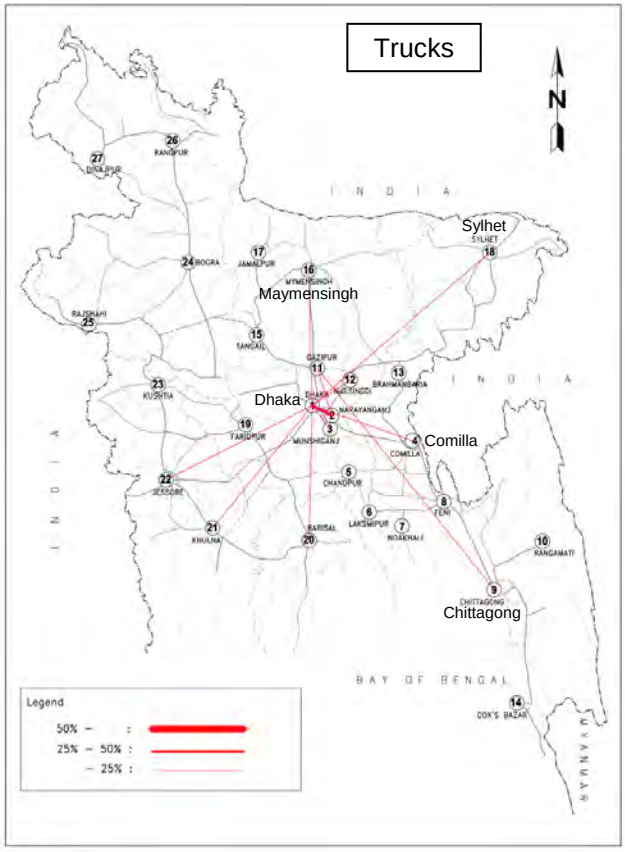
Figure 2.3.16 Desire Line Diagram at OD-1

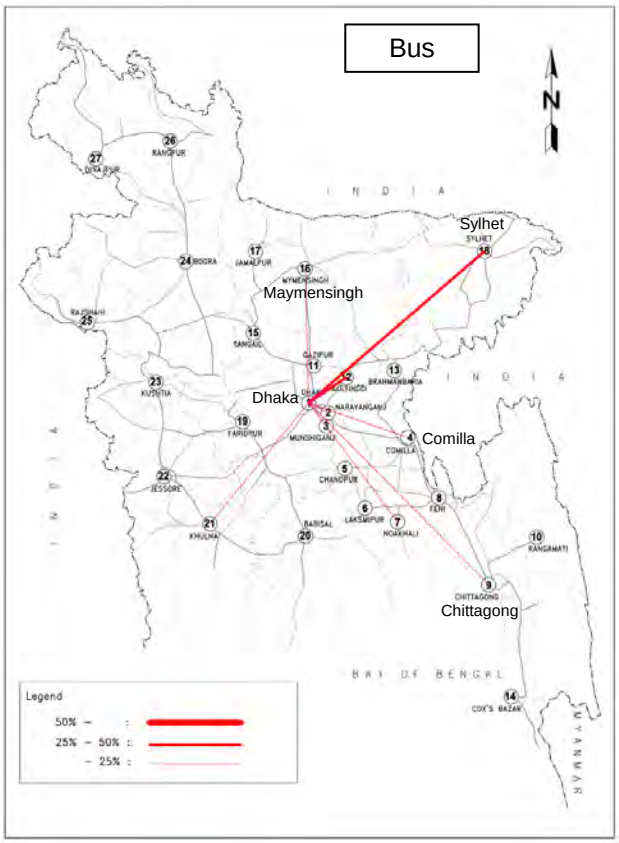


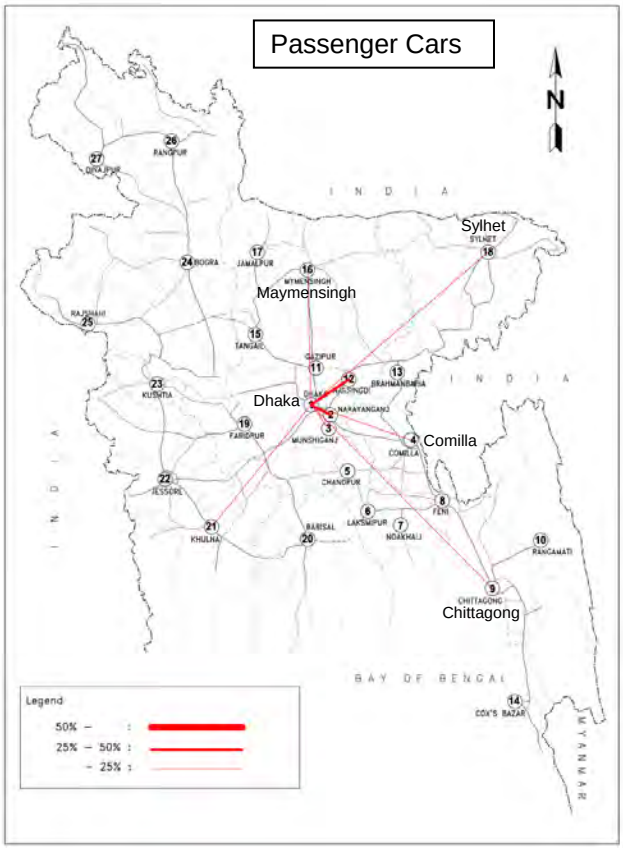
- Share of trips between Dhaka-Narsingdi and Dhaka-Sylhet is more than 7 % for all vehicles surveyed at OD-2.

Source: JICA Study Team

Figure 2.3.17 Desire Line Diagram at OD-2



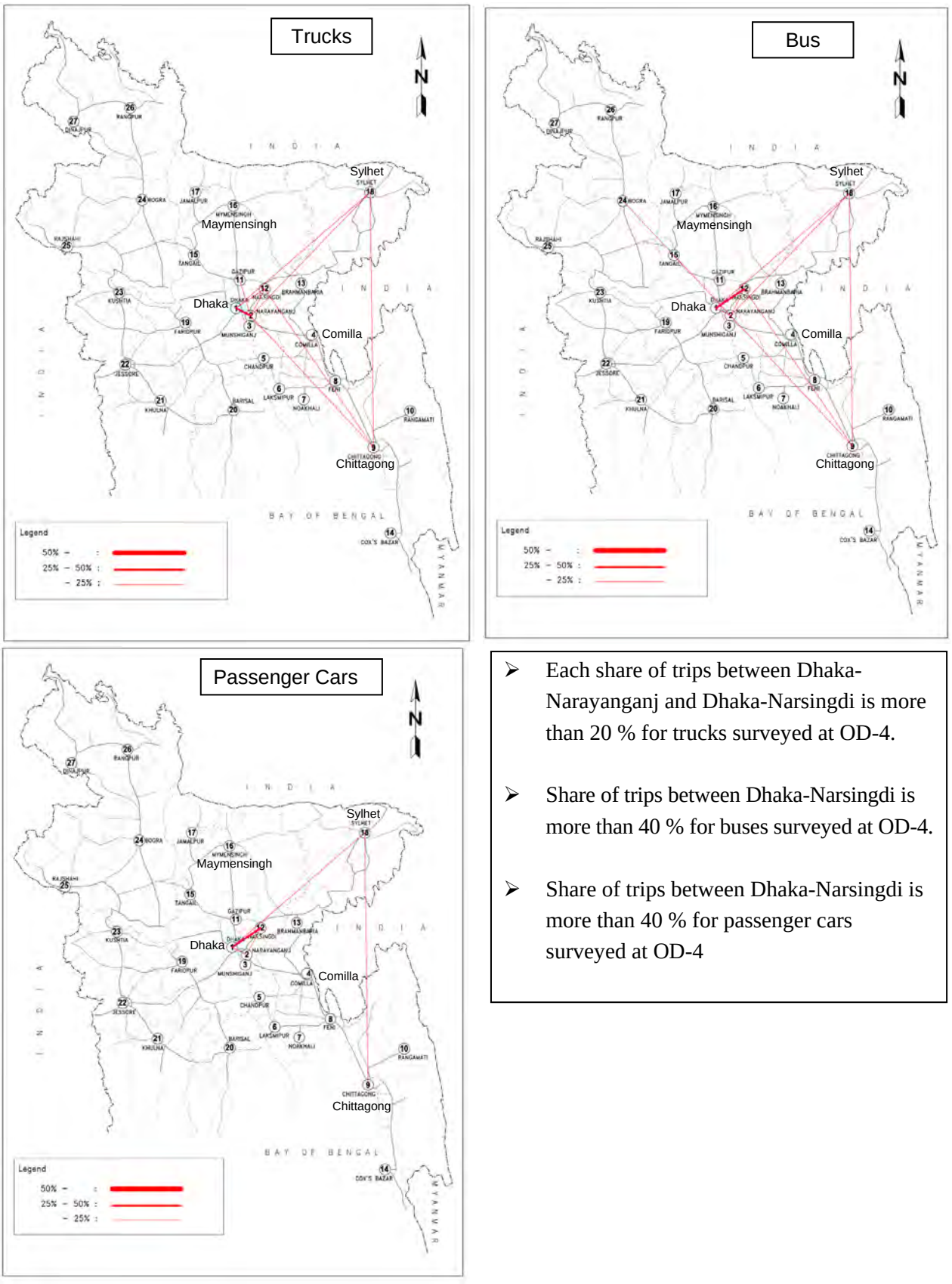




- Each share of trips between Dhaka-Narayanganj, Dhaka-Chittagong, Dhaka-Narsingdi and Dhaka-Sylhet is more than 10 % for trucks surveyed at OD-3.
- Each share of trips between Dhaka-Narayanganj and Dhaka-Sylhet is more than 30 % for buses surveyed at OD-3.
- Each share of trips between Dhaka - Narayanganj, Dhaka-Munshiganj, Dhaka-Chandpur, Dhaka-Maymensingh and Dhaka-Sylhet is more than 10 % for passenger cars surveyed at OD-3.

Source: JICA Study Team

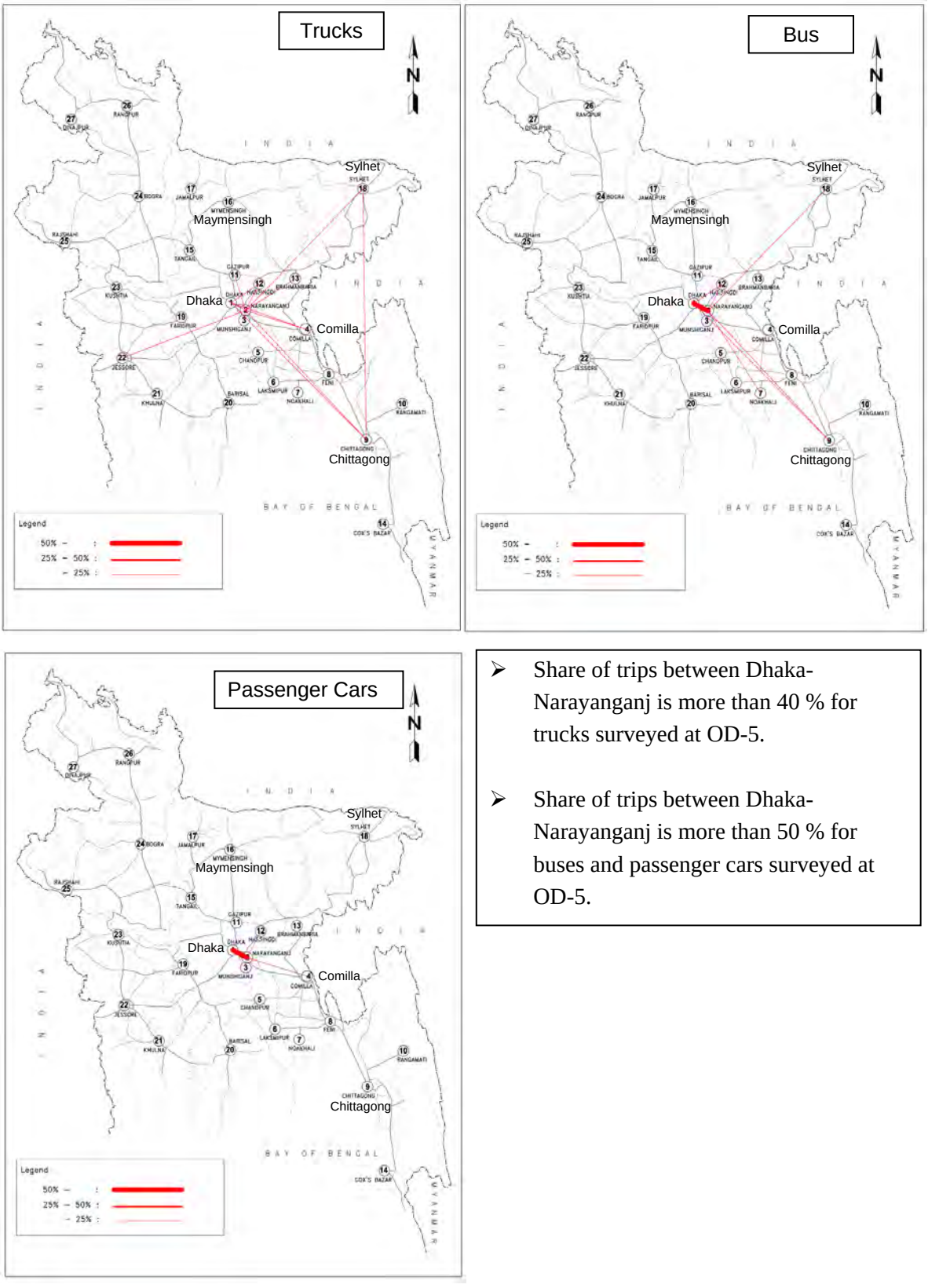
Figure 2.3.18 Desire Line Diagram at OD-3



- Each share of trips between Dhaka-Narayanganj and Dhaka-Narsingdi is more than 20 % for trucks surveyed at OD-4.
- Share of trips between Dhaka-Narsingdi is more than 40 % for buses surveyed at OD-4.
- Share of trips between Dhaka-Narsingdi is more than 40 % for passenger cars surveyed at OD-4

Source: JICA Study Team

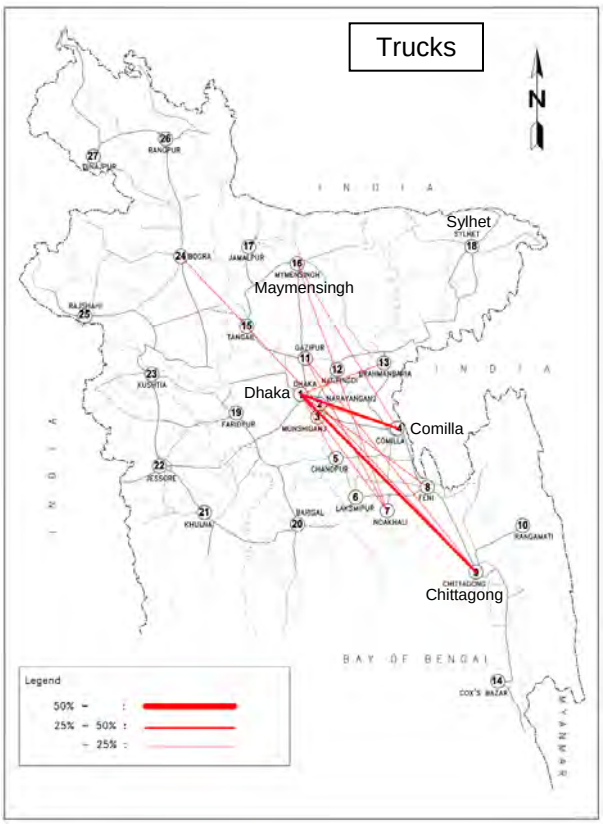
Figure 2.3.19 Desire Line Diagram at OD-4

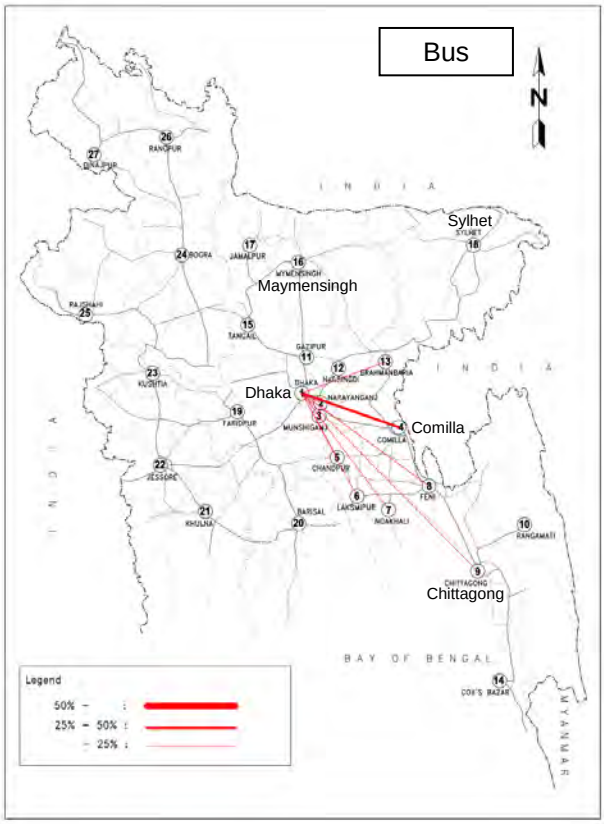


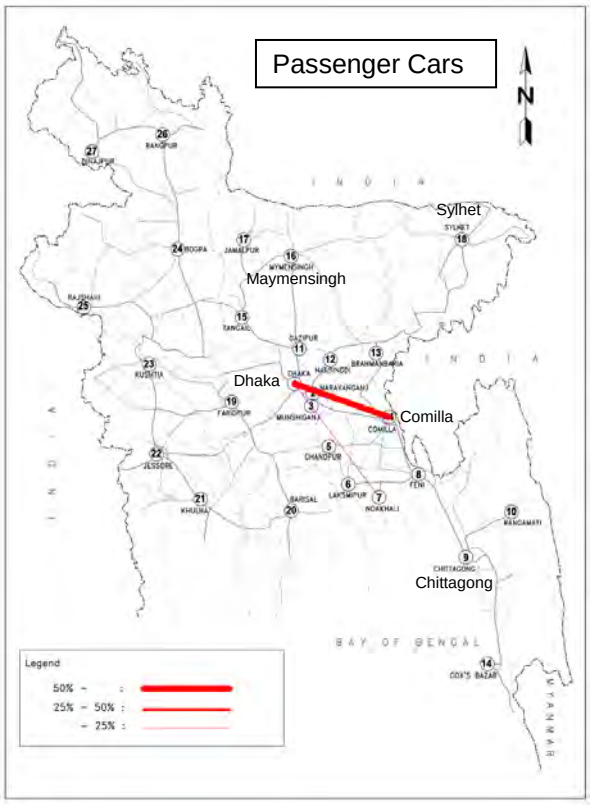
- Share of trips between Dhaka-Narayanganj is more than 40 % for trucks surveyed at OD-5.
- Share of trips between Dhaka-Narayanganj is more than 50 % for buses and passenger cars surveyed at OD-5.

Source: JICA Study Team

Figure 2.3.20 Desire Line Diagram at OD-5



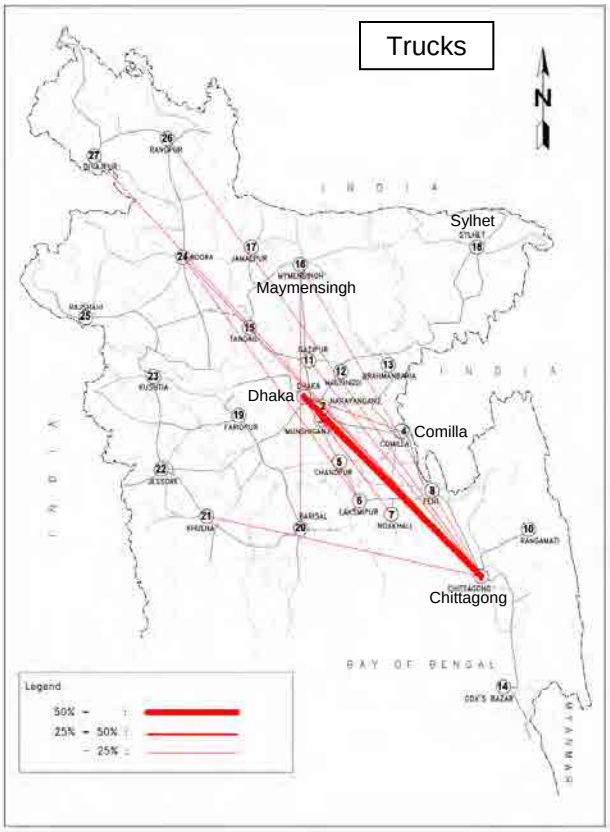


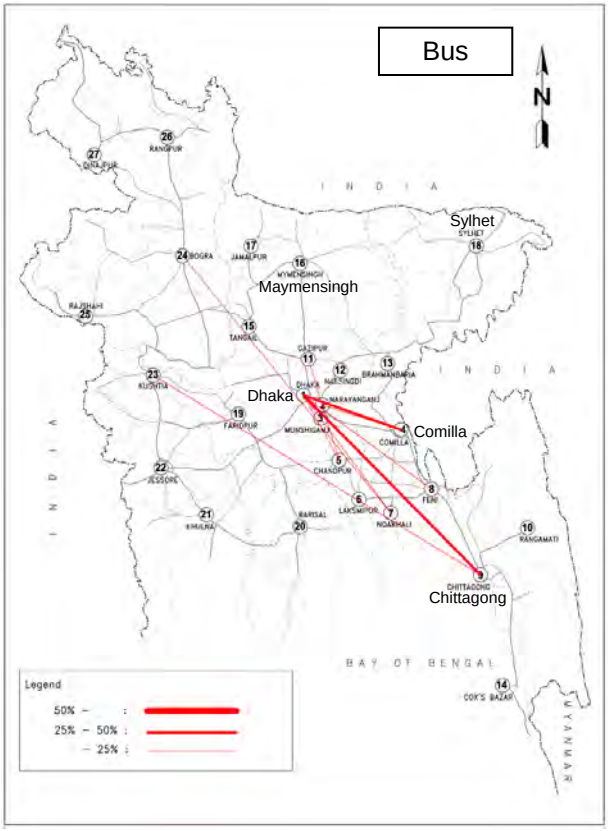


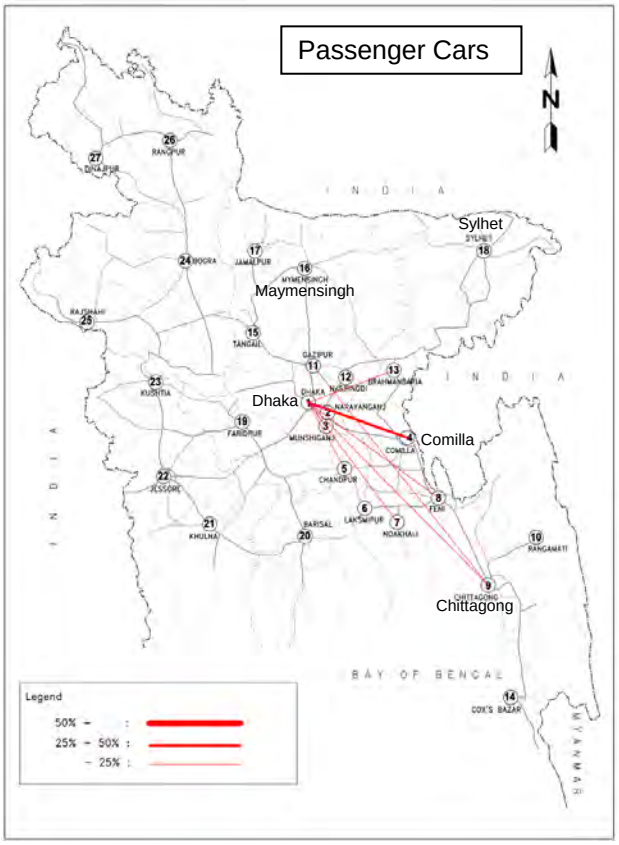
- Share of trips between Dhaka-Comilla is more than 30 % for trucks at OD-6.
- Share of trips between Dhaka-Chittagong is approximately 30 % for trucks surveyed at OD-6.
- Share of trips between Dhaka-Comilla is more than 40 % for buses surveyed at OD-6.
- Share of trips between Dhaka-Comilla is more than 80 % for passenger cars surveyed at OD-6.

Source: JICA Study Team

Figure 2.3.21 Desire Line Diagram at OD-6







- Share of trips between Dhaka-Chittagong is more than 50 % for trucks surveyed at OD-7.
- Share of trips between Dhaka-Comilla is approximately 40 % for buses surveyed at OD-7.
- Share of trips between Dhaka-Chittagong is more than 40 % for buses surveyed at OD-7.
- Share of trips between Dhaka-Comilla is more than 40 % for passenger cars surveyed at OD-7.
- Share of trips between Dhaka-Noakhali, Dhaka-Feni and Dhaka-Chittagong is more than 10 % for passenger cars

Source: JICA Study Team

Figure 2.3.22 Desire Line Diagram at OD-7

(7) Traffic Speed Survey

Table 2.3.9 shows the result of the traffic speed survey. The average speeds between Kanchpur Bridge and Gumti Bridge are 38 km/h in weekdays and 42 km/h in holidays.

Table 2.3.9 Result of Traffic Speed Survey

Location	KP (kilometer-post)	2012/3/3				2012/6/3				
		Outbound	Outbound	Outbound	average	Outbound	Outbound	Outbound	Outbound	average
N-1 (0 KP)	0 KP									
Kanchpure bridge (Dhaka side)	12KP	32.72	14.40	17.14	21.42	14.69	15.32	18.46	32.73	20.30
Meghna Bridge Toll Gate	26.5KP	45.79	37.80	48.33	43.97	43.50	43.50	36.25	48.33	42.90
Meghna-Gumti Bridge Toll Gate	41.0KP	33.22	32.22	48.33	37.92	41.49	48.33	51.17	34.80	43.95
average speed 0kp to 41kp		37.24	28.14	37.93	34.44	33.23	35.72	35.29	38.62	35.71
average speed katchpur to Meghnagumuti		39.51	35.01	48.33	40.95	42.50	45.92	43.71	41.57	43.42
Location	KP	Inboud	Inboud	Inboud	average	Inboud	Inboud	Inboud	Inboud	average
Meghna-Gumti Bridge Toll Gate	0 KP									
Meghna Bridge Toll Gate	14.5KP	20.23	43.50	36.25	33.33	45.79	39.59	41.43	41.43	42.06
Kanchpure bridge (Dhaka side)	29.0KP	27.19	43.50	37.82	36.17	39.54	31.07	48.33	36.25	38.80
N-1 (0 KP)	41.0KP	16.36	18.00	18.46	17.61	15.32	15.32	18.46	16.74	16.46
average speed 0kp to 41kp		21.26	35.00	30.84	29.03	33.55	28.66	36.07	31.47	32.44
average speed Meghnagumuti to kanchpur		23.71	43.50	37.04	34.75	42.67	35.33	44.88	38.84	40.43
Total average speed 0kp to 41kp		29.25	31.57	34.39	31.74	33.39	32.19	35.68	35.05	34.08
Total average speed Meghnagumuti to kanchpur		31.61	39.26	42.68	37.85	42.58	40.62	44.30	40.20	41.93

Source: JICA Study Team

2.4 Present River Traffic Condition

Several factors such as flood level and the change of tidal water level, riverbed scouring and ferry traffic congestion are considered in order to get to know the present river traffic condition.

The present river traffic condition is important to lay out the construction plan successfully and to ensure their safety while river traffic navigates through the construction working sites.

2.4.1 River Traffic Categories Observed

Observation fully covers all present river traffic categories passing under the existing bridges and river traffic condition also.

2.4.2 Observation Methods

(1) Observation day, observation time

This survey is conducted on the days excluding the beginning of the week and weekend. The observation time includes working hours between 7: 00- 18: 00.

(2) Observation locations

The river traffics were observed around the following three bridge sites;

- Kanchpur Bridge
- Meghna Bridge
- Gumti Bridge

(3) Survey area

The survey areas are marked in Figure 2.4.1 through Figure 2.4.3 for each bridge. The influence boundary shown in the figures represents the influence line expected from the implementation of construction. This influence line generally ranges within 200 m. In addition, another 50 meters is added to the influence boundary in order to increase the safety level. Furthermore, the direction of vessels marked in Figure 2.4.1 through Figure 2.4.3 has also been observed during the survey time.

- Plant/Ship size
- Estimated water depth
- Crane length and angle
- Anchor rode angle

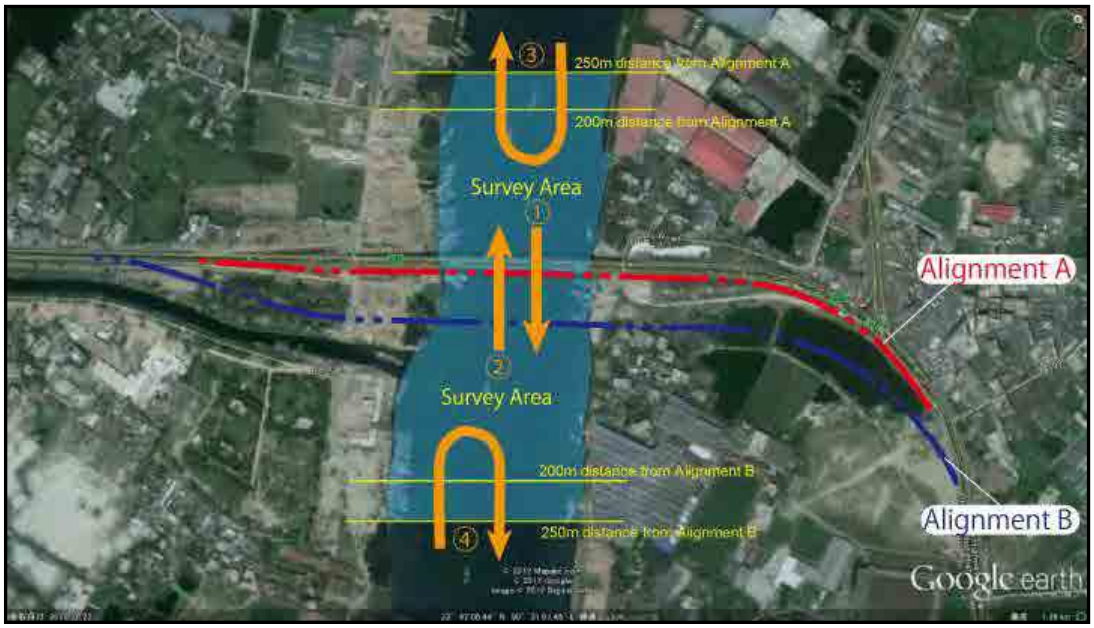


Figure 2.4.1 Survey Area (Kanchpur Bridge)

Figure 2.4.2 Survey Area (Meghna Bridge)

Figure 2.4.3 Survey Area (Gumti Bridge)

(4) Ship classification

Vessels are categorized as ferry, ship, boats carrying people and ships carrying goods. In addition, the length of the hull is classified into three types;

Less than 30 meters,

30 meters to 55 meters,

More than 55 meters

(5) Study results

The observation has been conducted in April, 2012 and the results are formulated accordingly.

1) Kanchpur Bridge (Lahkya River)

Table 2.4.1, Figure 2.4.4 and Figure 2.4.5 show the number of ships passing through and approaching towards Kanchpur Bridge. It is observed that 399 (392 for cargo ships, 7 for passenger ships) ships passed through the Kanchpur Bridge in the time between 7:00 to 18:00. Of which, 258 ships with less than 30 m, 137 ships with 30 to 55 m, 4 ships with more than 55 m, and ships with less than 30 m has been counted as 65 % of the total.

Investigation was conducted at every 30 minute interval and accordingly the observation results are plotted in Figure 2.4.4. The numbers of ships ranging between 7 to 28 and

averaging of 18.1 ships pass through the Kanchpur Bridge at every 30 minutes interval. That means, at every 2 minutes interval, one ship passes through the Kanchpur Bridge.

Figure 2.4.4 also shows that 55 ships passed at the time between 13:00 to 14:00. Of which, 5 ships approached and departed back from the observation range without passing Kanchpur Bridge. No fishing boat was observed near Kanchpur Bridge site.

Table 2.4.1 Number of Ships (Kanchpur Bridge)

Direction	1+2						1+2
Passenger/Cargo	Passenger			Cargo			Total
Size of ship	<30m	30～55m	55m<	<30m	30～55m	55m<	(all)
7:00 ～ 7:30				1	9		10
7:30 ～ 8:00				17	6		23
8:00 ～ 8:30				10	7		17
8:30 ～ 9:00				6	1		7
9:00 ～ 9:30				10	1	1	12
9:30 ～ 10:00				13	8	2	23
10:00 ～ 10:30				8	3		11
10:30 ～ 11:00				8	6		14
11:00 ～ 11:30				10	2		12
11:30 ～ 12:00				10			10
12:00 ～ 12:30				12	11		23
12:30 ～ 13:00	3			6	13	1	23
13:00 ～ 13:30				13	15		28
13:30 ～ 14:00	1			13	13		27
14:00 ～ 14:30				13	7		20
14:30 ～ 15:00				12	3		15
15:00 ～ 15:30				17	4		21
15:30 ～ 16:00				9	6		15
16:00 ～ 16:30				8	5		15
16:30 ～ 17:00				12	12		24
17:00 ～ 17:30				24	2		26
17:30 ～ 18:00	1			19	3		23
Total	7			251	137	4	399
Percentage	1.8%			62.9%	34.3%	1.0%	100.0%

Direction	3+4						3+4
Passenger/Cargo	Passenger			Cargo			Total
Size of ship	<30m	30～55m	55m<	<30m	30～55m	55m<	(all)
7:00 ～ 7:30							
7:30 ～ 8:00							
8:00 ～ 8:30							
8:30 ～ 9:00							
9:00 ～ 9:30					1		1
9:30 ～ 10:00							
10:00 ～ 10:30							
10:30 ～ 11:00							
11:00 ～ 11:30							
11:30 ～ 12:00							
12:00 ～ 12:30							
12:30 ～ 13:00					1		1
13:00 ～ 13:30							
13:30 ～ 14:00							
14:00 ～ 14:30							
14:30 ～ 15:00					1		1
15:00 ～ 15:30							
15:30 ～ 16:00							
16:00 ～ 16:30							
16:30 ～ 17:00				1			1
17:00 ～ 17:30				1			1
17:30 ～ 18:00							
Total				2	3		5
Percentage				40.0%	60.0%		100.0%

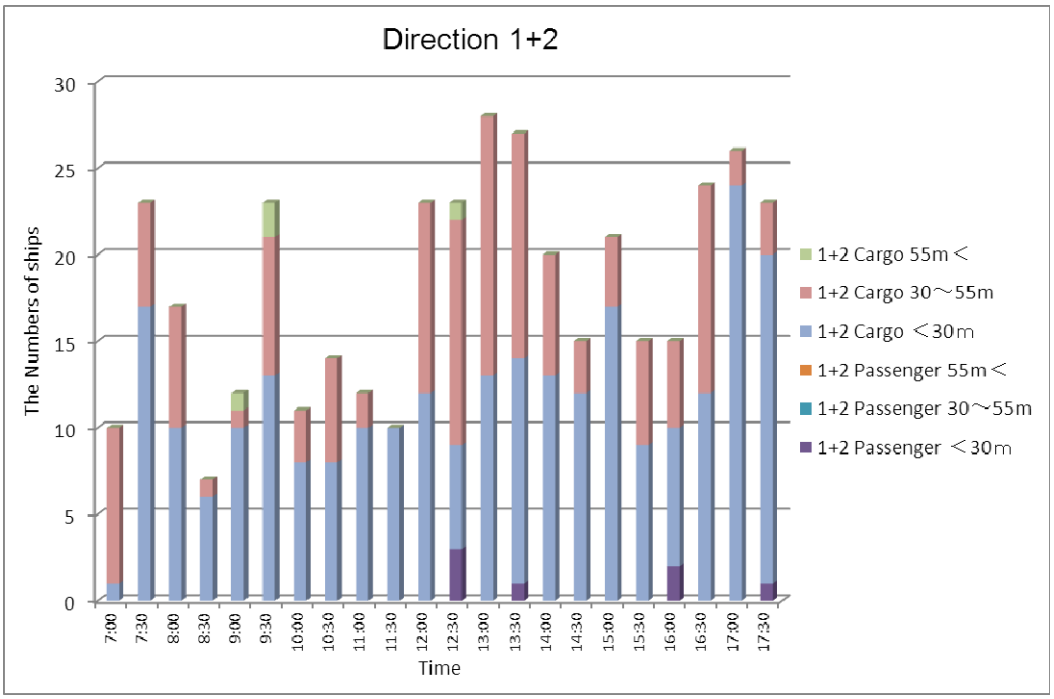


Figure 2.4.4 Numbers of Ships Passed under Kanchpur Bridge

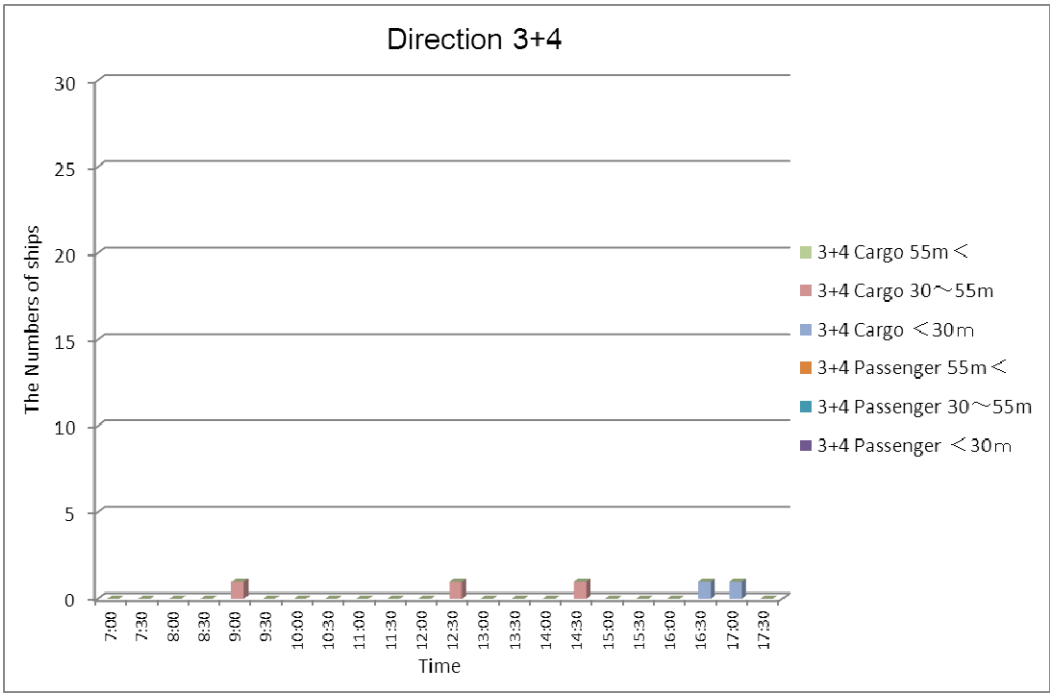


Figure 2.4.5 Numbers of Ships Approached by Kanchpur Bridge

2) Meghna Bridge (Meghna River)

Table 2.4.2, Figure 2.4.6 and Figure 2.4.7 show the number of ships passing through and approaching towards the Meghna Bridge. 611(581 for cargo ships, 30 for passenger ships) ships passed through the Meghna Bridge at the time between 7:00 to 18:00. Of which, 362 ships with less than 30 m, 249 ships with 30 to 55 m, no ship with more than 55 m, and ships with less than 30 m have been counted as 60 % of the total.

It was observed that there were many ships with more than 55 m moored in the right bank of the river but did not sail on the day of observation.

The observations which were conducted at every 30 minutes interval are plotted in Figure 2.4.6. It shows that the numbers of ships ranging between 17 to 38 and averaging of 27.8 ships pass through the Meghna Bridge at every 30 minutes interval. That means, one ship passes through the underneath of Meghna Bridge at every minute interval.

Figure 2.4.6 also shows that 71 ships passed at the time between 7:00 to 8:00. Of which, 29 ships approached and departed back from the observation range without passing Meghna Bridge. Many of passenger boats were moving to and fro near 'Old Ferry Ghat'. Moreover, in the observation site, 2 to 5 boats were observed at every one hour as fishing near Meghna Bridge site.

Table 2.4.2 Number of Ships (Meghna Bridge)

Direction	1+2						1+2
Passenger/Cargo	Passenger			Cargo			Total
Size of ship	<30m	30～55m	55m<	<30m	30～55m	55m<	(all)
7:00 ～ 7:30	8			10	15		33
7:30 ～ 8:00	4			19	15		38
8:00 ～ 8:30	4			26	8		38
8:30 ～ 9:00	1			10	13		24
9:00 ～ 9:30	1			13	15		29
9:30 ～ 10:00	5			11	10		26
10:00 ～ 10:30				15	13		28
10:30 ～ 11:00				20	2		22
11:00 ～ 11:30	1			18	12		31
11:30 ～ 12:00				15	6		21
12:00 ～ 12:30				15	6		21
12:30 ～ 13:00				17	4		21
13:00 ～ 13:30				14	3		17
13:30 ～ 14:00	1			17	12		30
14:00 ～ 14:30				16	16		32
14:30 ～ 15:00	1			20	12		33
15:00 ～ 15:30	1			10	12		23
15:30 ～ 16:00	1			16	13		30
16:00 ～ 16:30	1			16	19		36
16:30 ～ 17:00	1			11	16		28
17:00 ～ 17:30				11	14		25
17:30 ～ 18:00				12	13		25
Total	30			332	249		611
Percentage	4.9%			54.3%	40.8%		100.0%

Direction	3+4						3+4
Passenger/Cargo	Passenger			Cargo			Total
Size of ship	<30m	30～55m	55m<	<30m	30～55m	55m<	(all)
7:00 ～ 7:30	1						1
7:30 ～ 8:00	2				1		3
8:00 ～ 8:30	1						1
8:30 ～ 9:00	1						1
9:00 ～ 9:30	1				1		2
9:30 ～ 10:00	2				1		3
10:00 ～ 10:30							0
10:30 ～ 11:00	1			1	1		3
11:00 ～ 11:30	1						1
11:30 ～ 12:00	2				1		3
12:00 ～ 12:30							0
12:30 ～ 13:00	1						1
13:00 ～ 13:30	1						1
13:30 ～ 14:00	1						1
14:00 ～ 14:30	2						2
14:30 ～ 15:00							0
15:00 ～ 15:30	1						1
15:30 ～ 16:00	1						1
16:00 ～ 16:30	2						2
16:30 ～ 17:00							0
17:00 ～ 17:30	1						1
17:30 ～ 18:00	1						1
Total	23			1	5		29
Percentage	79.3%			3.4%	17.2%		100.0%

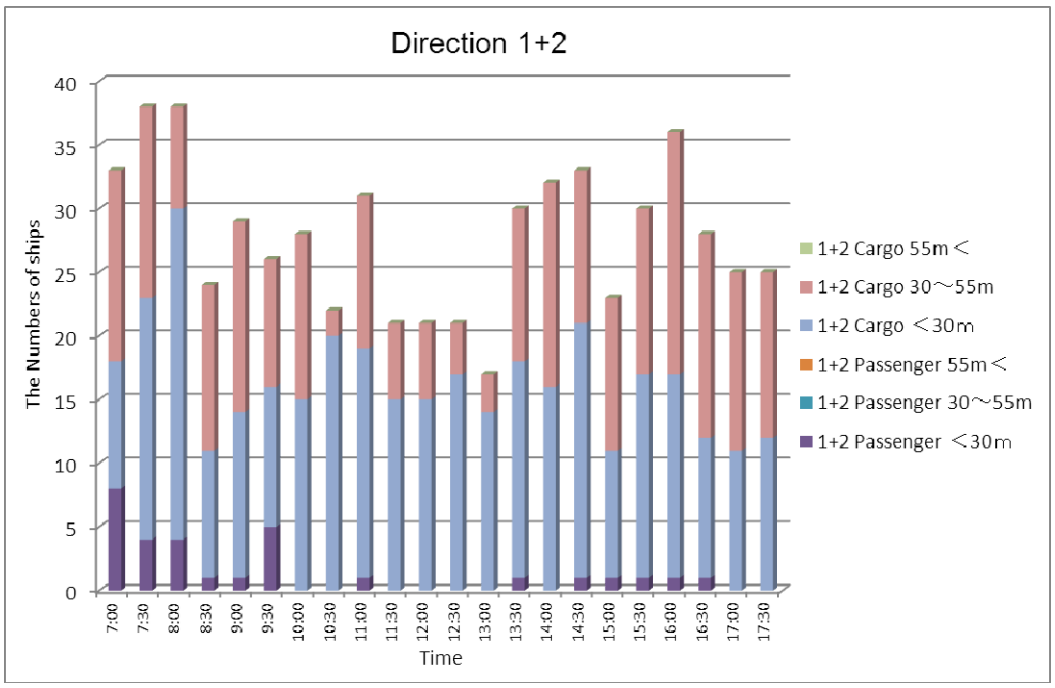


Figure 2.4.6 Numbers of Ships Passed through Meghna Bridge

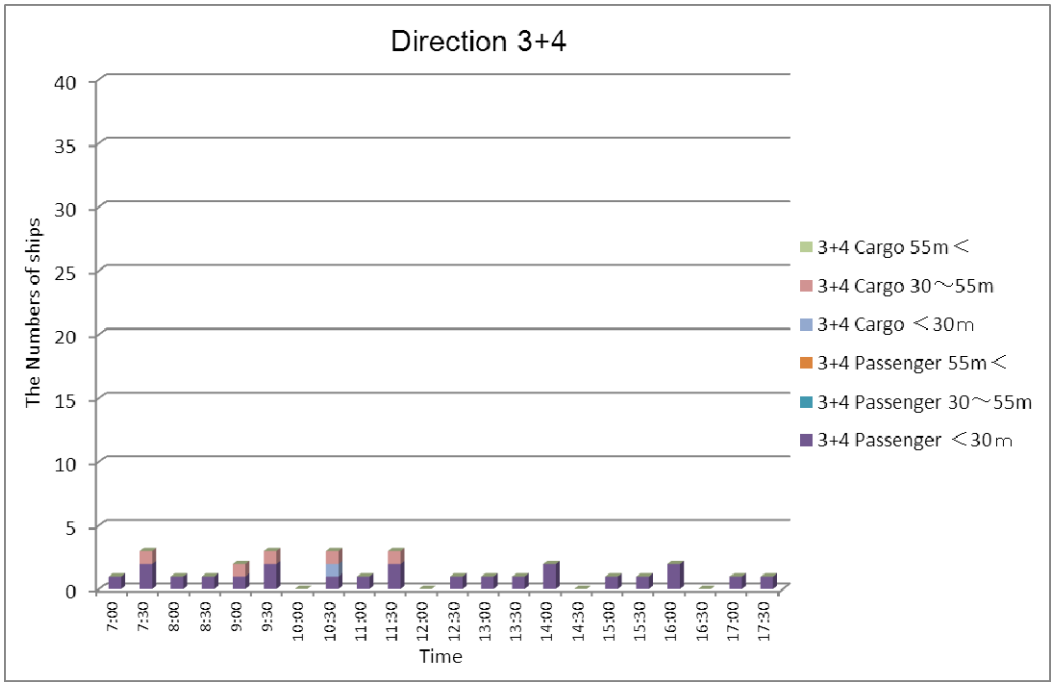


Figure 2.4.7 Numbers of Ships Approached towards Meghna Bridge

3) Gumti Bridge (Gumti River)

(a) Dhaka side

Table 2.4.3 Figure 2.4.8, and Figure 2.4.9 show the number of ships passing through and approaching the Gumti Bridge (Dhaka side). 174 (all for cargo ships) ships passed through the Gumti Bridge at the time between 7:00 to 18:00. Of which, 128 ships with less 30 m, 46 ships with 30 to 55 m, no ship with more than 55 m, and ships with less than 30 m have been counted as 74 % of the total.

The observations which were conducted at every 30 minutes interval are plotted in Figure 2.4.8. It shows that the numbers of ships ranging between 0 to 20 and averaging of 8 ships pass through the Gumti Bridge at every 30 minutes interval. That means, one ship passes through the underneath of Gumti Bridge (Dhaka side) at every 4 minutes interval.

Figure 2.4.8 also shows that 28 ships passed at the time between 11:00 to 12:00. Of which, 116 ships approached and departed back from the observation range without passing the Gumti Bridge (Dhaka side). Moreover, in the observation site, 2 to 8 boats were observed at every one hour as fishing near Gumti Bridge site.

Table 2.4.3 Number of Ships (Gumti Bridge: Dhaka side)

Direction	1+2						1+2
Passenger/Cargo	Passenger			Cargo			Total
Size of ship	＜30m	30～55m	55m＜	＜30m	30～55m	55m＜	(all)
7:00 ～ 7:30				3			3
7:30 ～ 8:00				8	1		9
8:00 ～ 8:30				8	2		10
8:30 ～ 9:00				4			4
9:00 ～ 9:30				5	2		7
9:30 ～ 10:00				11	4		15
10:00 ～ 10:30				12	2		14
10:30 ～ 11:00				7	6		13
11:00 ～ 11:30				7	1		8
11:30 ～ 12:00				15	5		20
12:00 ～ 12:30							
12:30 ～ 13:00				4			4
13:00 ～ 13:30				16	2		18
13:30 ～ 14:00							0
14:00 ～ 14:30				4			4
14:30 ～ 15:00				1	5		6
15:00 ～ 15:30				4	6		10
15:30 ～ 16:00				2	4		6
16:00 ～ 16:30				3			3
16:30 ～ 17:00				6	3		9
17:00 ～ 17:30				5	1		6
17:30 ～ 18:00				3	2		5
Total				128	46		174
Percentage				73.6%	26.4%		100.0%

Direction	9+10						9+10
Passenger/Cargo	Passenger			Cargo			Total
Size of ship	＜30m	30～55m	55m＜	＜30m	30～55m	55m＜	(all)
7:00 ～ 7:30	1			9			10
7:30 ～ 8:00	1			4			5
8:00 ～ 8:30	4			5			9
8:30 ～ 9:00	2						2
9:00 ～ 9:30	2			2	2		6
9:30 ～ 10:00	6						6
10:00 ～ 10:30	4			1			5
10:30 ～ 11:00	4						4
11:00 ～ 11:30	5			3			8
11:30 ～ 12:00	7			1	3		11
12:00 ～ 12:30	2						2
12:30 ～ 13:00							
13:00 ～ 13:30	5			3			8
13:30 ～ 14:00							
14:00 ～ 14:30	3			4			7
14:30 ～ 15:00	3			2			5
15:00 ～ 15:30	4			2			6
15:30 ～ 16:00	3			1			4
16:00 ～ 16:30	3			3			6
16:30 ～ 17:00	2			1			3
17:00 ～ 17:30	1			6			7
17:30 ～ 18:00	1				1		2
Total	63			47	6		116
Percentage	54.3%			40.5%	5.2%		100.0%

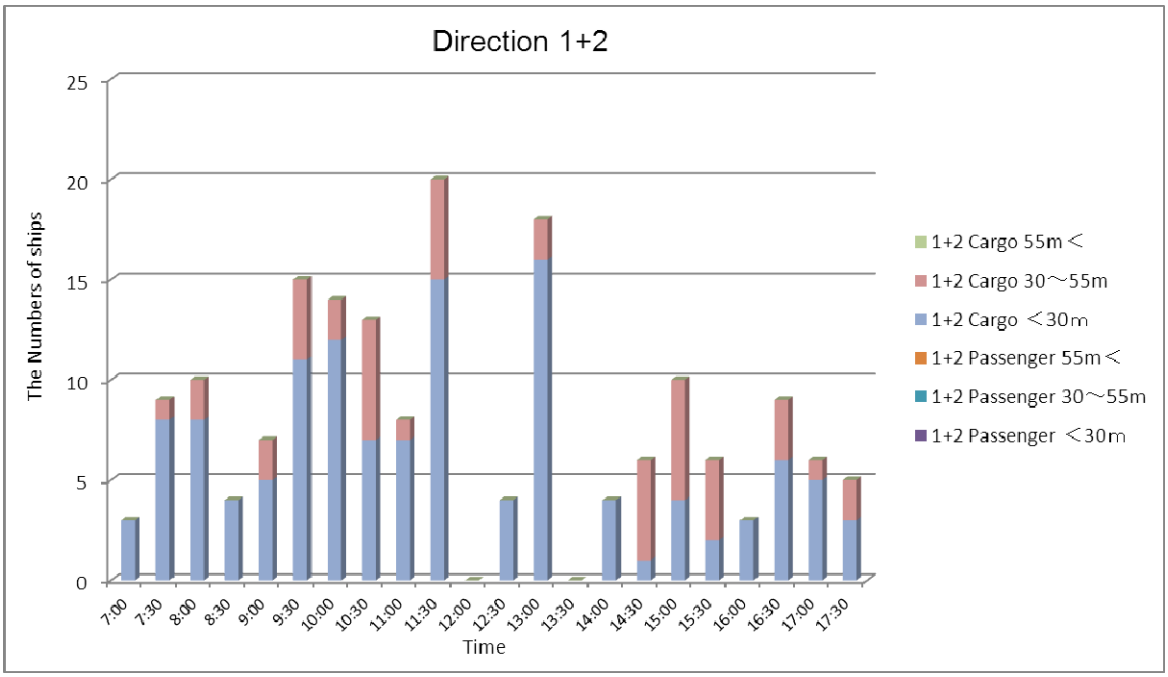


Figure 2.4.8 Numbers of Ships Passed under Gumti Bridge (Dhaka Side)

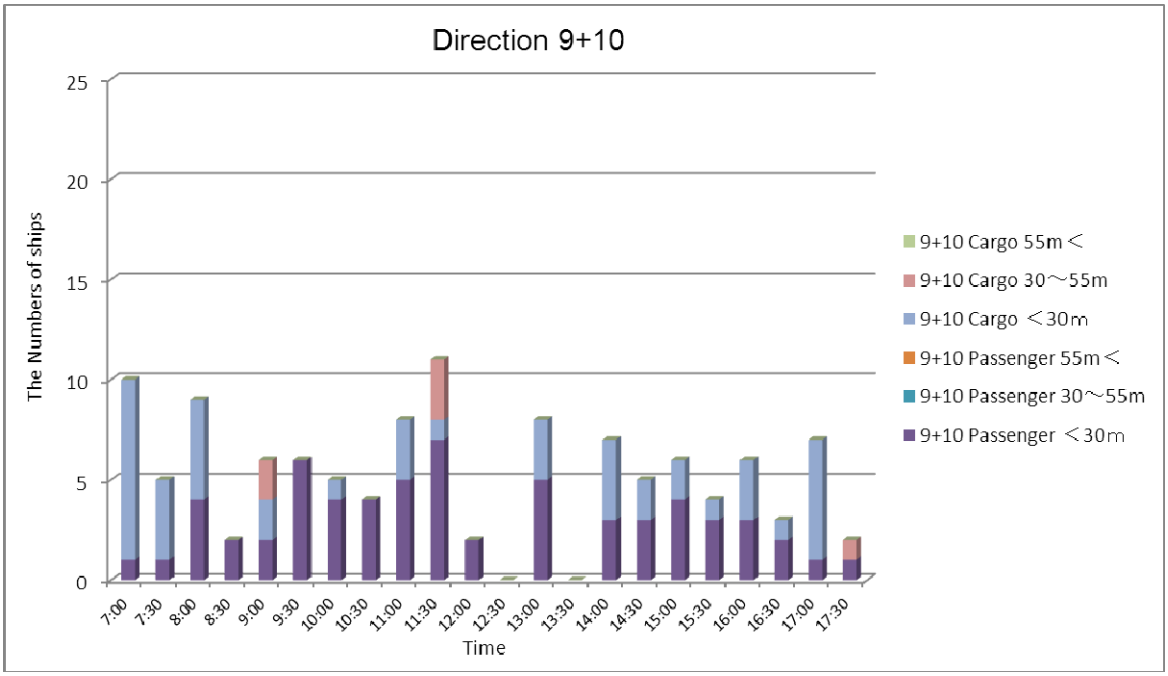


Figure 2.4.9 Numbers of Ships Approached towards Gumti Bridge (Dhaka side)

(b) Chittagong side

Table 2.4.4, Figure 2.4.10 and Figure 2.4.11 show the number of ships passing through and approaching the Gumti Bridge (Chittagong side). 457 (391 for cargo ships, 66 for passenger ships) ships passed through the Gumti Bridge at the time between 7:00 to 18:00. Of which, 427 ships with less 30 m, 30 ships with 30 to 55 m, no ship with more than 55 m, and ships with less than 30 m have been counted as 93 % of the total.

The observations which were conducted at every 30 minutes interval are plotted in Figure 2.4.10. It shows that the numbers of ships ranging between 12 to 30 and averaging of 21 ships pass through the Gumti Bridge at every 30 minutes interval. That means, one ship passes through the underneath of Gumti Bridge (Chittagong side) at every 3 minutes interval.

Figure 2.4.10 also shows that 57 ships passed at the time between 14:00 to 15:00. Of which, 105 ships approached and departed back from the observation range without passing the Gumti Bridge (Chittagong side). Moreover, in the observation site, 1 to 3 boats were observed at every one hour as fishing near Gumti Bridge site.

Table 2.4.4 Number of Ships (Gumti Bridge: Chittagong side)

Direction	5+6+7+8						5+6+7+8
Passenger/Cargo	Passenger			Cargo			Total
Size of ship	＜30m	30～55m	55m＜	＜30m	30～55m	55m＜	(all)
7:00 ～ 7:30	1			17	3		21
7:30 ～ 8:00	2			14			16
8:00 ～ 8:30	2			13	2		17
8:30 ～ 9:00	3			18			21
9:00 ～ 9:30	2			13			15
9:30 ～ 10:00	6			15	1		22
10:00 ～ 10:30	6			14	1		21
10:30 ～ 11:00	5			12	2		19
11:00 ～ 11:30	3			16			19
11:30 ～ 12:00	3			15	1		19
12:00 ～ 12:30	2			12	1		15
12:30 ～ 13:00	3			13	1		17
13:00 ～ 13:30	3			24	2		29
13:30 ～ 14:00	4			20	1		25
14:00 ～ 14:30	9			17	1		27
14:30 ～ 15:00	4			24	2		30
15:00 ～ 15:30	2			17	2		21
15:30 ～ 16:00	2			15	6		23
16:00 ～ 16:30	3			17			20
16:30 ～ 17:00	1			23	2		26
17:00 ～ 17:30				10	2		12
17:30 ～ 18:00				22			22
Total	66			361	30		457
Percentage	14.4%			79.0%	6.6%		100.0%

Direction	3+4+11+12						3+4+11+12
Passenger/Cargo	Passenger			Cargo			Total
Size of ship	＜30m	30～55m	55m＜	＜30m	30～55m	55m＜	(all)
7:00 ～ 7:30				1			1
7:30 ～ 8:00				9			9
8:00 ～ 8:30				1	3		4
8:30 ～ 9:00				2			2
9:00 ～ 9:30				9			9
9:30 ～ 10:00				8	5		13
10:00 ～ 10:30				10	4		14
10:30 ～ 11:00				3			3
11:00 ～ 11:30				4			4
11:30 ～ 12:00				4			4
12:00 ～ 12:30				3			3
12:30 ～ 13:00				3			3
13:00 ～ 13:30				3			3
13:30 ～ 14:00				2			2
14:00 ～ 14:30				3	1		4
14:30 ～ 15:00				1	1		2
15:00 ～ 15:30				3	2		5
15:30 ～ 16:00				4			4
16:00 ～ 16:30				7	2		9
16:30 ～ 17:00				1			1
17:00 ～ 17:30				2	2		4
17:30 ～ 18:00				1	1		2
Total				84	21		105
Percentage				80.0%	20.0%		100.0%

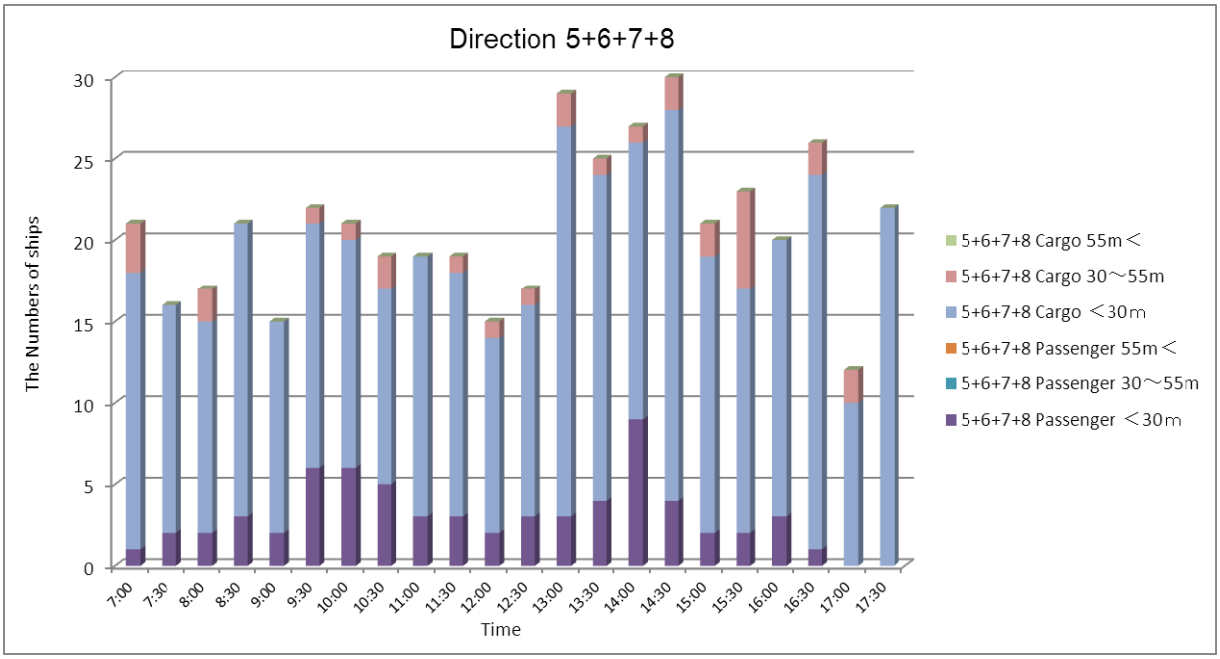


Figure 2.4.10 Numbers of Ships Passed under Gumti Bridge (Chittagong side)

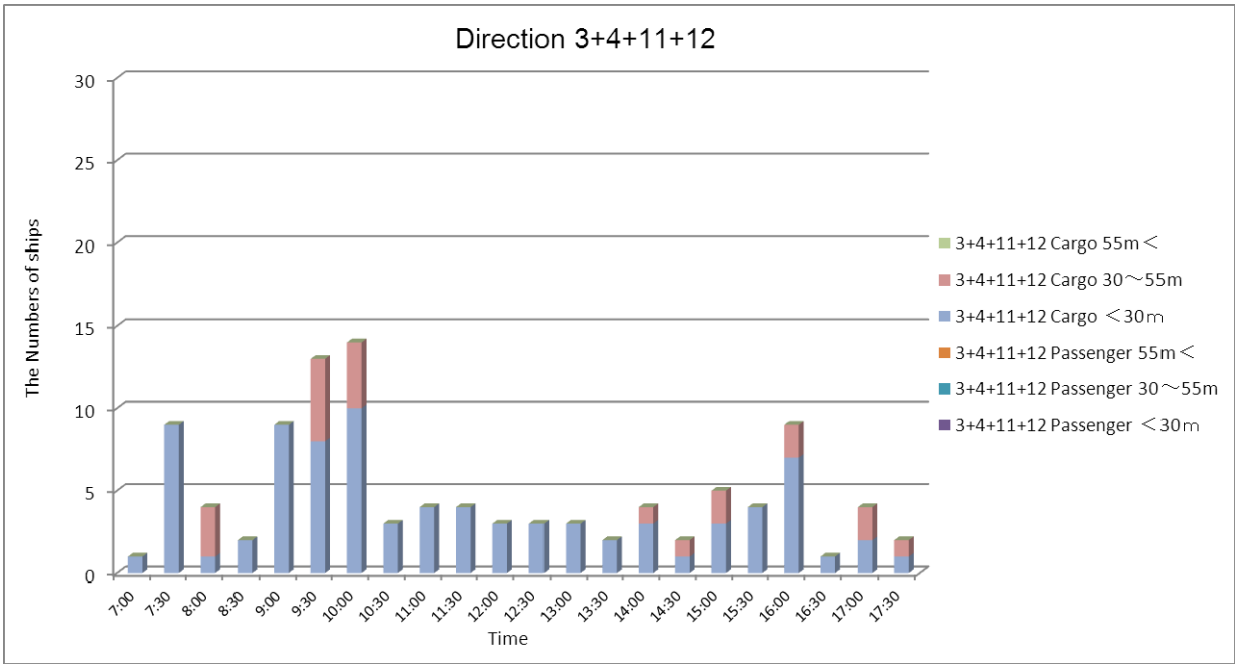


Figure 2.4.11 Numbers of Ships Approached by Gumti Bridge (Chittagong side)

2.5 Detailed Inspection of Structures

2.5.1 Visual Inspection

(1) Objective

The objective of the visual survey is to determine the present condition of the existing bridges and to develop a rehabilitation plan. The visual inspection was conducted for three bridges; Kanchpur, Meghna and Gumti.

(2) Method of Survey

A short distant visual inspection was conducted in accessible areas of the structure such as abutments, lower part of piers and expansion joints.

A distant visual inspection was conducted for non-accessible areas of the structure such as superstructures, and upper parts of piers.

(3) Survey Items

Survey items are identified as followings;

1) Cracks

In general damages caused by repeated vehicle traffic first emerge undersurface of bridge concrete decks. Cracks progress from those running in perpendicular direction to the bridge axis to those running in bridge axis direction. Also, cracks gradually progress to small cracks like crocodile cracks.

2) Isolated lime (Free lime), corrosion

Cracks emerging bottom of concrete decks will progress and penetrate concrete decks, causing water leakage into concrete decks. The leakage water dissolves the lime components and accumulates limes underneath of the concrete decks. If water leakage is running long time, the rusting occurs on the outer surface of steel bars. Accordingly, the trace of steel bar corrosion will propagate towards the surface of the concrete decks.

3) Peeling concrete decks

Salt components brought by concrete neutralization or from outside of the structure, cause corrosion to steel bars. Swelling of steel bars caused by corrosion then causes concrete peeling, creeping and spelling to concrete decks.

4) Exposure of steel bars

If the state of concrete damages is very serious, the steel bars are expected to be exposed to open air. To confirm this state of damage, following survey items were conducted. Moreover, the damage diagnosis criteria are defined in Table 2.5.2 through Table 2.5.5.

Table 2.5.1 Survey Items

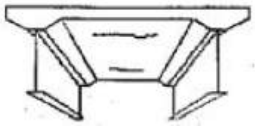
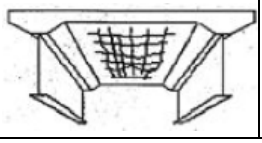
Survey Items	Damage level	Survey Location	Distant Visual Inspection	Proximity Visual Inspection	Remarks
Cracks, water leakage, isolated lime	a-e	Beams Cross Beams Substructure	○	○	Shown in Table 2.5.2
Cracks, water leakage, isolated lime	a-e	Slab around pier	○	○	Shown in Table 2.5.3
Exposure of reinforcement	Exist or not exist	Beams Cross Beams Slabs Substructure	○		Shown in Table 2.5.4
Uneven road surface	Exist or not exist	Road		○	Shown in Table 2.5.5

Table 2.5.2 Damage Level

Crack width	Condition	Damage Level
No crack	-	a
Less than 0.2 mm	-	b
More than 0.2 mm	Crack only	c
	Water leakage only	d
	Small amount of isolated lime	d
	Much isolated lime	e

The water leakage initiates from the crack of 0.2 mm width. The damage level is examined by crack width, water leakage.

Table 2.5.3 Cracks in Concrete Slab

Condition	Drawing	Damage level
No cracks or crack widths are less than 0.2 mm and crack intervals are over 1.0 m. Water leakage through cracks and isolated lime are not confirmed.		a
Crack width less than 0.2 mm occurs in one direction. These crack intervals are more than 0.5 m. Water leakage through cracks and isolated lime are not confirmed.		b
Crack width is about 0.2 mm and confined within a grid. But water leakage through cracks and isolated lime are not confirmed. Or Crack widths are about 0.2 mm and confined to one direction. But water leakage through cracks and isolated lime are confirmed.		c
Crack widths are about 0.2 mm and confined within a grid. Water leakage through cracks and isolated lime are confirmed. Or There exist many cracks with widths more than 0.2 mm and concrete chips are spalling off. But water leakage through cracks and isolated lime are not confirmed.		d
Many concrete chips are spalling off and water leakage through cracks and isolated lime are confirmed.		e

The damage level in accordance with rebar exposure is defined in Table 2.5.4.

Table 2.5.4 Damage Level and Rebar Exposure

Rebar exposure	Area	Condition	Damage
No damage	-	-	No
Existence of damage	Small	Corrosion in rebar	No
		Decrease in rebar cross section	No
	Large	Corrosion in rebar	No
		Decrease in rebar cross section	Exist

Generally, the rebar exposure is the final stage of concrete damage. This time the rehabilitation work will cover the damaged area so that the widely and severely corroded case should be identified.

Table 2.5.5 Unevenness of Road Surface

Condition	Damage
Uneven less than 20 mm	No
Uneven more than 20 mm	Exist

The unevenness of expansion joints or pavement surface should be identified from above mentioned criteria.

(4) Result of Visual Survey

1) Kanchpur Bridge

(a) Substructure

After careful investigation of the substructures of Kanchpur Bridge, no cracks were found in the existing bridge piers. There were several cracks observed in both abutments A1 and A2, each crack exceeding 0.2 mm. Water leakage through the crack in A1 was also observed. The state of these cracks are designated as Damage d for A1 and c for A2

A rebar exposure was found in both Pier 2 and Pier 3.

(b) Beams and Cross beams

There were no cracks observed in the beams or cross beams. Moreover, there was no noticeable damage observed in the rebar embedded in the beams and cross beams. The state is Damage a.

(c) Slab

There were no cracks observed in the slab. The state is Damage a.

(d) Uneven road surface

Unevenness on the road surface was observed, especially in the expansion joints. The relative vertical displacement was found to be more than 20 mm.

2) Meghna Bridge

(a) Substructure

After extensive investigation on the substructures of Meghna Bridge, the cracks with width more than 0.2 mm were found in Piers 1, 3, 6, 8, 9, 10, 11 and Abutment 2. So, their state is Damage c. The state of other piers is Damage a.

Small clear cover in the concrete were found in Piers 3, 4, 5, 6, 7, 8, 9 and 12, but there was no noticeable damage observed in the embedded rebar.

(b) Beams and Cross beams

There were no cracks observed in any of the sections. The state is Damage a. Moreover, in the section between Pier 12 and Abutment 2, slightly corroded rebar was observed.

(c) Slab

Crack with a width over 0.2 mm and partly isolated lime were observed in the slab between Pier 12 and Abutment 2. Their state is designated as Damage d. No crack was detected in other areas, so their state is Damage a.

(d) Uneven road surface

Unevenness on the road surface was observed, especially in the expansion joints. When a heavy loaded truck was passing over an expansion joint, the relative vertical displacement of the two faces of the expansion joint was noticed and its magnitude exceeds 20 mm.

3) Gumti Bridge

(a) Substructure

The state is Damage a except for the following.

A crack with a width less than 0.2 mm, stated as Damage b, was found in Pier 1. Cracks with a width more than 0.2 mm were found in Piers 2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 14, 15 and 16, all these being Damage c except Pier14 and 16 which are Damage d.

Water leakages were found in Piers 14 and 16. Beyond the concrete damage, there was no noticeable damage observed in the embedded rebar.

Small clear cover in the concrete was found in Piers 1, 2, 3, 4, 6, 7, 8, 9, 10, 12, 13, 14, 15 and 16 but there was no noticeable damage observed in the embedded rebar.

(b) Beams and Cross beams

The state is Damage a except for the following.

There were cracks with a width more than 0.2 mm and water leakage observed in the sections around Piers 5, 6, 7 and 10. Those areas can be evaluated as damage d according to Table 2.5.1.

(c) Slab

No cracks were observed, therefore the state is Damage a.

(d) Unevenness on road surface

Unevenness on the road surface was observed, especially in the expansion joints. While a heavy loaded truck was passing over an expansion joint, the relative vertical displacement of the two faces of the expansion joint noticed and its magnitude exceeds 20 mm.

4) Summary of the observed damages

The damages of the three bridges have been observerd as follows;

Table 2.5.6 Observation of the Damages (Structures)

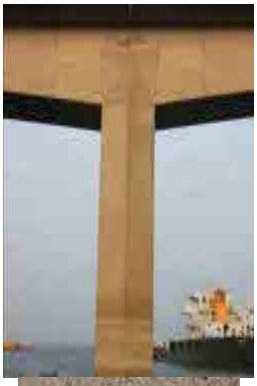
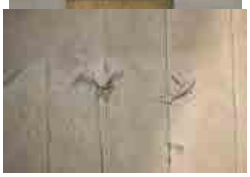
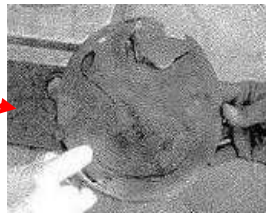
	Kanchpur	**Meghna**	**Gumti**
Sub-structure	A crack over 0.2 mm width in both A1 and A2 with water leakage in A1. Rebar exposures in P2 and 3. Abutment1  Crack and water leakage	Cracks over 0.2 mm width in P3, 6, 8, 9, 10, 11 and A2. Small indents in P3, 4, 5, 6, 7, 8, 9 and 12. No rebar deteriorations. Pier 3  	A crack under 0.2 mm width in P1. Cracks over 0.2 mm width in P2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 14, 15 and 16. Water leakage in P 14 and 16. Small indents in P1, 2, 3, 4, 6, 7, 8, 8, 10, 12, 13, 14, 15 and 16. No rebar deterioration. Pier 14  
Damage level	d	a	d
Girders & Cross beams	No visible cracks.	Rebar exposures between P12 and A2. P12-A2 	Cracks over 0.2 mm width with water leakage around P5 to P7 and P10. P5-P6 
Damage level	a	a	d
Deck slab	No visible cracks.	A crack over 0.2 mm width with small isolated lime between P12 and A2.	No visible cracks.
Damage level	a	a	a
State	The deterioration level is same as usual aging		
Causes of Deterioration	Aging		

Table 2.5.7 Observation of the Damages (Accessories)

	Kanchpur	Meghna	Gumti
Expansion joint			
Damage	Exist	Exist	Exist
Hinge		 	
Damage	N/A	Exist	Exist
State	Serious	Serious	Serious
Possible causes of damages	Overloaded trucks Insufficient maintenance		

2.5.2 Kanchpur Bridge Survey

(1) Dimension measuring

No physical dimensions or as-built drawings are available for the existing Kanchpur Bridge, therefore, all geometric properties of the existing bridge have been measured using measuring tools along with a Total Station where applicable. Total Station is widely used for measuring any bounded area. The geometric information collected during the survey stage is presented as a general drawing as shown in Appendix 5.

(2) Schmidt hammer test

The Schmidt hammer test was conducted for bridge piers no. P1-P5 and pier no.P7 in order to predict the concrete strength. But, being similar to P5, the Schmidt hammer test was not conducted for pier no. P6. For each pier, there are 16 points targeted within a grid net.

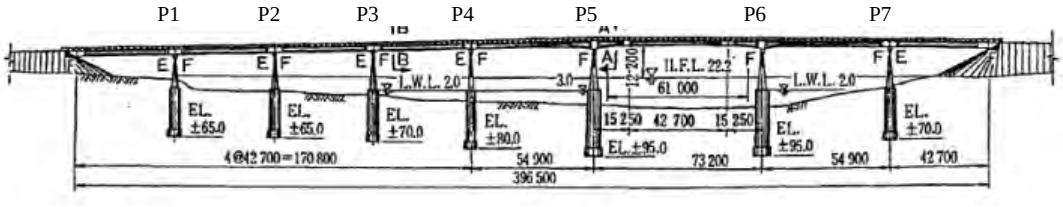


Figure 2.5.1 Kanchpur Bridge Profile

Table 2.5.8 Schmidt Hammer Tests Result

PIER No: #P1 (UPSTREAM)

44	42	44	46
46	42	44	52
40	42	46	42
42	40	46	54

PIER No: #P1 (DOWN STREAM)

45	38	48	50
46	48	50	47
40	43	40	50
46	44	50	40

PIER No: #P2 (UPSTREAM)

44	46	46	46
44	46	40	48
44	42	40	42
50	54	48	40

PIER No: #P2 (DOWN STREAM)

50	52	46	50
40	50	48	50
42	44	42	42
40	50	42	42

PIER No: #P3 (UPSTREAM)

42	36	36	38
44	45	50	36
48	38	32	35
44	40	35	38

PIER No: #P3 (DOWN STREAM)

50	44	37	40
38	40	40	38
38	40	40	42
40	38	36	40

PIER No: #P4 (UPSTREAM)

40	39	38	36
38	42	40	40
38	39	44	36
36	32	40	42

PIER No: #P4 (DOWN STREAM)

42	36	34	34
36	36	38	36
38	36	34	40
40	38	38	36

PIER No: #P5 (UPSTREAM)

PIER No: #P5 (DOWN STREAM)

40	44	38	50
42	44	42	42
44	42	40	46
48	46	40	44

PIER No: #P7 (UPSTREAM)

46	44	40	46
44	42	42	44
50	48	50	50
46	46	45	48

PIER No: #P7 (DOWN STREAM)

44	42	44	44
46	42	48	48
42	46	42	47
48	48	40	46

Unit: Mpa

Source: JICA Study Team

According to the report (1978) on Kanchpur Bridge published by the Journal of "Concrete Engineering", the concrete compression stiffness is designed as 211 kg/cm^2. But as per the Schmidt Hummer Test results,

the concrete stiffness is found to be higher than 211 kg/cm^2. Therefore, for safety consideration, the design concrete compression stiffness is set at 211 kg/cm^2.

(3) Reinforcement survey

1) Overall

The reinforcement pitch was detected by using electromagnetic radar waves, whereas the bar diameter along with concrete cover was determined by the chipping method.

2) Overview of the equipment for Rebar detection

The device radiates electromagnetic waves through a concrete surface and catches reflected waves from embedded objects that have different electrical characteristics than concrete. Object location and depth are then recorded and displayed as simple image data. A detector with higher resolution that can easily sense embedded rebar may be required. For rebar detection, the Consultant will use the GSSI manufactured structure scanner SIR-3000 (2.6 GMHz antenna).

3) Survey method

It is a cumbersome job to conduct a reinforcement survey for all bridge piers. Therefore, in order to reduce the work volume, all bridge piers are grouped as follows;

Group A: P1, P2, P3 → P2 selected

Group B: P4, P7 → P7 selected

Group C: P5, P6 → P5 selected

The combination of piers is set as group A for supporting 42.7 m length girders, group B for supporting 42.7 m and 54.9 m length girders and group C for supporting 54.9 m and 73.2 m length girders.

From each group, only a single pier was selected and tested by electromagnetic radar wave. This test was conducted on the locations shown in the following Table 2.5.9. The remaining piers were tested only at the lower part of each pier (location shown in Table 2.5.10) in order to confirm the survey results.

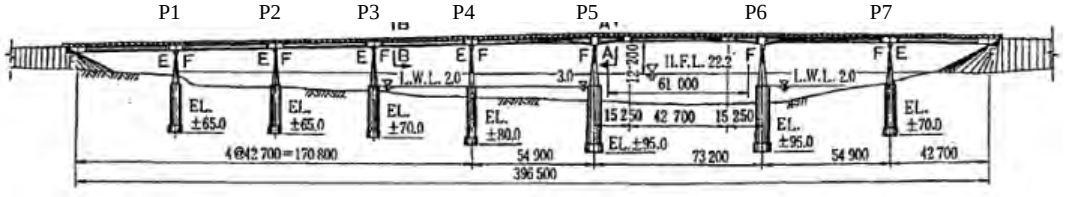
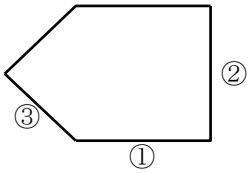


Figure 2.5.2 Kanchpur Bridge Longitudinal Profile

Table 2.5.9 Survey Location (Piers No. P2, P5, P7)

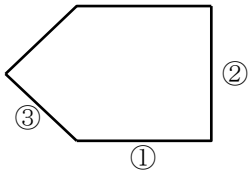
Item	Height	Plane
Electromagnetic wave rebar survey	Top of the pile cap above 1.5m (approx.)	①②③
	1.5 m from top of the pier	①②③
Concrete chipping	Top of pile cap above 1.5m (approx.)	①
	1.5 m from top of the pier	①②③



Pier cross section

Table 2.5.10 Survey Location (Piers No. P1, P3, P4, P6)

Item	Height	Plane
Electromagnetic wave rebar survey	Top of the pile cap above 1.5m (approx.)	①②③



Pier cross section

4) Survey results

The survey results obtained are expressed in terms of reinforcement diameter, concrete cover and reinforcement spacing, which are listed in Table 2.5.11.

Table 2.5.11 Survey Results on Reinforcement Arrangement

Item	Reinforcement	Diameter	Cover (mm)		Spacing (mm)	
			max	min	max	min
Group A (P1,P2,P3)	Longitudinal	D29	73	49	190	70
	Hoop	D16	55	30	390	180
Group B (P4,P7)	Longitudinal	D29	65	55	190	80
	Hoop	D16	45	36	400	230
Group C (P5,P6)	Longitudinal	D29	124	68	240	70
	Hoop	D16	106	52	370	220

Source: JICA Study Team

From the above observation it can be assumed;

1. The longitudinal reinforcement, D29, is arranged at 150 mm spacing.

2. The hoop reinforcement, D16, is arranged at 300 mm spacing.

3. The minimum cover to the hoop rebar is 35 mm.

2.6 Baseline Survey

2.6.1 Average Daily Traffic (ADT)

Table 2.6.1 shows Average Daily Traffic (ADT) at Kanchpur and Meghna and Gumti Bridges. The details of ADT results are shown in Appendix 4.

Table 2.6.1 ADT Values (2012)

Location		Motorized Vehicles	Non-Motorized Vehicles	Total
Kanchpur	(Number of Vehicles)	34,453	767	35,220
	(PCU)	76,872	1,275	78,147
Meghna, Gumti	(Number of Vehicles)	27,578	-	27,578
	(PCU)	65,147	-	65,147

Source: JICA Study Team

2.6.2 Traffic Speed

Table 2.6.2 shows the result of the traffic speed survey. The average speeds between Kanchpur and Gumti Bridges are measured as 38 km/hr in weekdays and 42 km/hr in holidays. The details of traffic speed survey results are shown in Appendix 4.

Table 2.6.2 Traffic Speed (2012)

Location	Week day	Holliday
Kanchpur - Gumti	37.9 km/hr	41.9 km/hr

Source: JICA Study Team

2.6.3 Accident rate

The number of accidents that occurred between Kanchpur and Gumti Bridges is shown in Table 2.6.3.

Target area;

“1 km ahead of Kanchpur Bridge (11.8 KP)” to“1 km beyond Gumti Bridge (42.2 KP)”

Table 2.6.3 Number of Accidents

	Fatal Accident No.	Non-Fatal Accident No.	Total Accident No.
1998-2006	98	34	132
	12(annual average)	4(annual average)	16(annual average)
2007-2008	26	6	32
2009-2010	11	1	12

Source: Accident Research Institute data edited by JICA Study Team

As the applicable traffic volume is not available for 2009, the traffic volume at 2009 is projected by the growth rate used for this project. The number of accidents is divided by total travel distance. An accident rate is found to be 4.1 accidents / 10million vehicle kilometers which is calculated based on the following.

- Accident rate: accident number / (traffic volume * travel distance * 365 days)
- Accident number: 12 accidents
- Traffic volume (2012): 31,016 vehicles/day (average traffic volume of Kanchpur and Meghna, Gumti)
- Traffic volume (2009): 26,257 vehicles/day (calculated from 2012 to 2009 by growth rate of this project)
- Travel distance: 30.4 km (from 11.8 KP to 42.2 KP)

2.6.4 Air Quality

Ambient air quality was monitored alongside the road at the three bridges. Table 2.6.4 represents the ambient air quality results and Figure 2.6.1 shows their monitoring points.

Table 2.6.4 Results of Ambient Air Quality Analysis

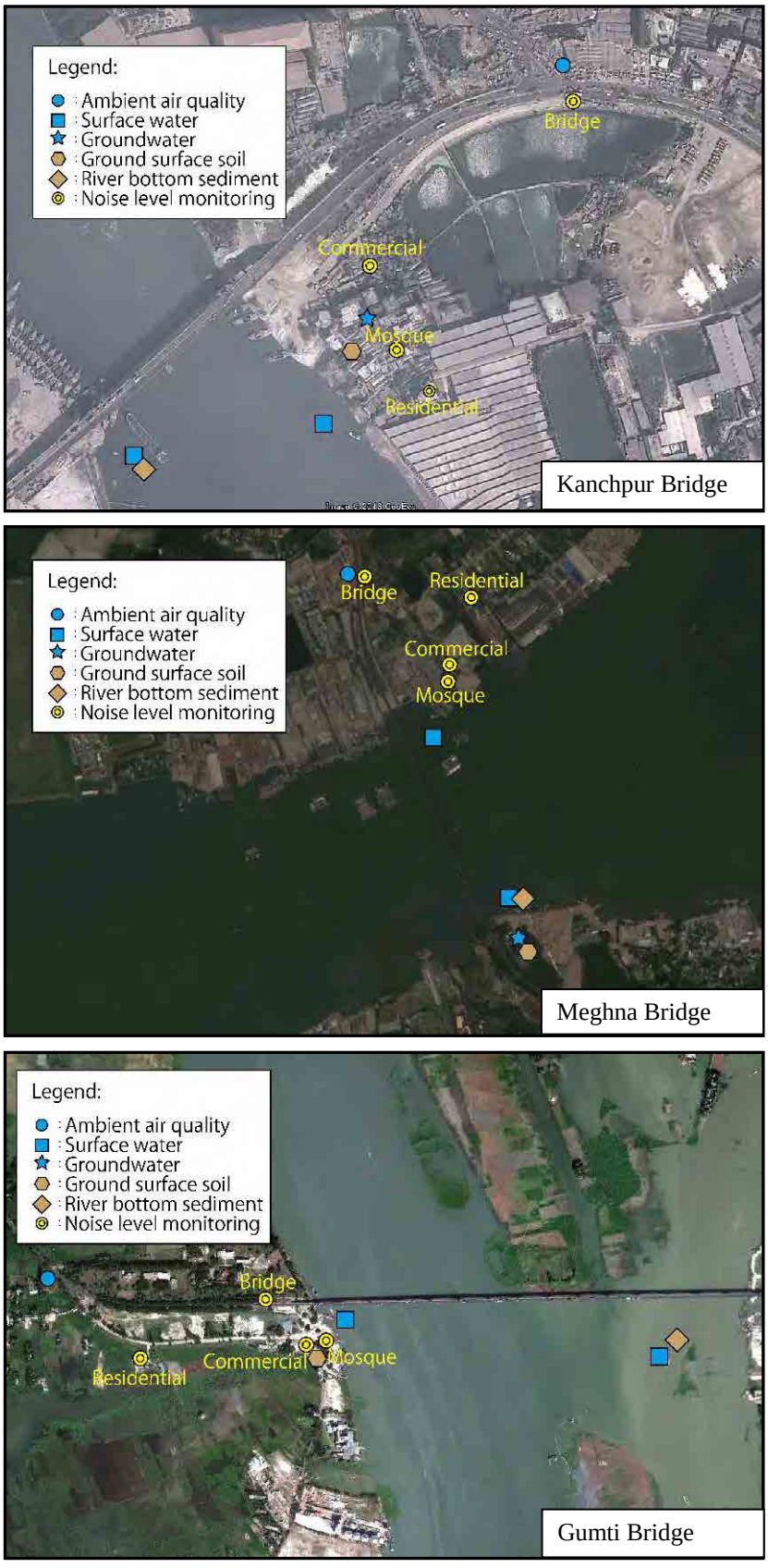
Unit: μ g/m^3

	Kanchpur		Meghna		Gumti				Environmental Conservation Rules, 1997 (Bangladesh)			
Season	Dry	Wet	Dry	Wet	Dry	Wet			Industrial area	Commercial and mix areas	Residential and rural areas	Sensitive area
Sampling date	8/5/2012	16/7/2012	8/5/2012	16/7/2012	9/5/2012	17/7/2012	Japanese Standard	WHO				
SPM	714	1,013	1,041	1,530	339	607	100	-	500	400	200	100
PM2.5	94	160	144	197	61	86	-	10	65			
PM10	193	270	317	510	131	170	-	20	150			
SO2	96	191	60	110	55	80	110	20	120	100	80	30
NO2	70	160	56	90	50	74	80	40	100	100	80	30
Pb	0.63	0.55	0.38	0.33	0.27	0.25	-	-	0.5			

: Exceeding Standards

Note: Standard applied is as industrial area for Kanchpur and Meghna sites. Gumti Bridge site is categorized as commercial area based on the surrounding condition of economic activities

Source: JICA Study Team



Note: location of groundwater sampling is not indicated in this figure because no designated well location traced near Gumti Bridge.

Figure 2.6.1 Locations of Ground Water Sampling

2.6.5 Surface Water Quality

The sampling points for surface water quality assessment are shown in Figure 2.6.1 and the results of the surface water test are shown in Table 2.6.5.

- high concentration of Total Coliform probably due to discharge of human waste into the river without treatment
- high concentration of COD and BOD which indicates many raw materials including the above waste are being discharged into the river before oxidization/decomposition and the resulting very low dissolved oxygen concentration makes it difficult for fish to survive
- high concentration of Ammonia Nitrogen probably from human waste
- high concentration of oil and greases as untreated effluents from factories

Due to its high Total Coliform concentration, Lahkya River water is not suitable for any use. As for water qualities in the Meghna and Gumti Rivers, they are similar but are much better than Lahkya River since Total Coliform concentration and COD/BOD are somewhat tolerable for uses other than drinking water in Bangladesh Standards.

Table 2.6.5 Results of Surface Water Analysis

River water	Lahkya				Meghna				Gumti				Environmental Conservation Rule 1997 (Bangladesh)					
Lacation	Upstream of Kanchpur Bridge		Downstream of Kanchpur Bridge		Upstream of Meghna Bridge		Downstream of Meghna Bridge		Upstream of Gumti Bridge		Downstream of Gumti Bridge		Source of drinking water after disinfection	Recreation purpose	Source of water after conventional treatment	Fishery	Industry use	Irrigation use
Season	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet						
Date	05/05/2012	16/07/2012	05/05/2012	16/07/2012	05/05/2012	16/07/2012	05/05/2012	16/07/2012	05/05/2012	16/07/2012	05/05/2012	16/07/2012						
pH 〔-〕	7.0	8.2	7.0	8.4	6.7	7.2	6.7	7.1	6.7	7.3	6.6	7.1	6.5 -8.5	6.5 -8.5	6.5 -8.5	6.5 -8.5	6.5 -8.5	6.5 -8.5
Turbidity 〔NTU〕	85	158	12	123	35	10	28	6	12	8	53	3	-	-	-	-	-	-
DO 〔mg/ℓ〕	0.3	3.2	0.1	4.1	4.2	6.3	4.7	6.7	4.4	5.8	4.4	6.7	>6	>5	>6	>5	>5	>5
Total Coliform 〔n/100mℓ〕	10,000>	>10,000	10,000>	>10,000	200	8	520	21	540	10>	1040	10>	50>	200>	5,000 >	-	5,000 >	1,000 >
TDS 〔mg/ℓ〕	468	2305	570	1810	85	72	76	54	72	47	108	87	-	-	-	-	-	-
TSS 〔mg/ℓ〕	153	248	16	123	29	13	28	11	25	9	40	12	-	-	-	-	-	-
COD 〔mg/ℓ〕	59	84	47	128	8	6	7	8	8	6	8	5	-	-	-	-	-	-
BOD5 〔mg/ℓ〕	20	12	10	19	3	1	3	1	1	1	3	1	2>	3>	6>	6>	10>	10>
NH4-N 〔mg/ℓ〕	9.6	3.5	9.5	1.2	0.3	0.1	0.5	0.1	0.27	0.1>	0.3	0.1	-	-	-	-	-	-
Oil and grease 〔mg/ℓ〕	4.7	2.8	5.1	3.9	3.8	0.8	4.1	0.7	6.2	0.1	5.3	0.1	0.01	-	-	-	-	-

: Exceeding Standards

Source : JICA Study Team

2.6.6 Groundwater

The groundwater is necessary for daily life as drinking water in most areas where pipeline water is not available. At the project site, wells are dug through ground surface and used for drinking by local people.

Table 2.6.6 Results of Groundwater Analyses

Unit: mg/L

Location	Kanchpur	Meghna	Gumti	Bangladesh Standard for Drinking Water(ECR'97)	WHO Guideline values,2004 (Drinking Water)
Date of sampling	5/5/2012	5/5/2012	5/5/2012	5/5/2012	5/5/2012
pH※1	6.7	6.8	6.8	6.5-8.5	6.5-8.5
EC ※2	824	553	646	-	(2,000 by EPA)
Turbidity※3	24.7	28.7	43.1	10>	5>
Chloride	75	27	23	150-600	250>
Total hardness	248	238	222	200-500	500>
Iron	2.0	2.5	3.6	0.3-1.0	0.3>
Manganese	0.053	0.840	1.156	0.1>	0.4>
Arsenic	0.052	0.075	0.079	0.05>	0.01>

: Exceeding Standards
Source: JICA Study Team
※1：Unit Dimensionless
※2：Unit μS/m
※3：Unit NTU

Locations of groundwater sampling were shown in Figure 2.6.1. As shown in the above table, the concentrations of Turbidity, Iron, Manganese and Arsenic in groundwater near the three bridges do not always satisfy drinking water standards of Bangladesh or WHO. Arsenic is classified by IARC[3] in Group 1 (carcinogenic to humans).

2.6.7 Soil pollution

Surface soils on the ground around the three bridges were sampled as shown in Figure 2.6.1 and analyzed accordingly. Because Bangladesh does not have any standard for soil pollution, the standards in Canada, the United States and Japan are used here for evaluation. The results of the primary survey satisfied all of the three standards and it can be said that there is no soil pollution in the project site.

[3] International Agency for Research on Cancer

Table 2.6.7 Results of Surface Soil Analysis

Unit: mg/kg dry soil

	Location			Guidelines[4]		
	Kanchpur	Meghna	Gumti	CCME[5]	US EPA[6]	Japan[7]
Arsenic As	1.8	2.4	2.7	-	-	150
Cadmium Cd	0.10	0.07	0.09	0.822	850	150
Chromium Cr	18	25	28	87	850	-
Lead Pb	3.6	3.6	9.2	600	400	150
Mercury Hg	0	0	0	50	510	15
Ignition loss	2,200	2,800	2,700	-	-	-

Source: JICA Study Team

2.6.8 Riverbed sediment

Riverbed sediments were sampled at the location where many vessels are being moored as shown in Figure 2.6.1, and were analyzed for the three rivers. The results are summarized in Table 2.6.8 and international guidelines are taken since there is no standard for sediment pollution in Bangladesh. As shown in the table, contamination by heavy metals, arsenic, Cadmium, Chromium, Lead and Mercury are within guidelines and considered as not polluted. The organics content is also acceptable.

Table 2.6.8 Results of Sediment Analysis

Unit: mg/kg dry soil

	Location			Guidelines, criteria or classification
	Kanchpur	Meghna	Gumti	US EPA[6] Guide-line[8]
Arsenic As	2.1	0.9	4.2	33
Cadmium Cd	0.8	<0.002	0.1	4.98
Chromium Cr	9	6	20	111
Lead Pb	3.6	3.6	9.2	128
Mercury Hg	0	0	0	1.06
Loss on ignition (Organics content)	6,700	2,000	4,300	-

Source: JICA Study Team

[4] Soil Environment Center,1999 and Commercial Law Instiute,1999
[5] CCME- The Canadian Council of Ministers of the Environment have adopted these guideline numbers as the Canadian Soil Quality Guidelines for the Protection of Environment and Human Health- Industrial Land Use (1999)
[6] US EPA- The United States Environmental Protection Agency (USEPA), adopted these guideline numbers as their Risk Based Screening Levels for Industrial Land Use, 1996
[7] Soil Contamination Countermeasures Act (Act No. 53 of 2002)
[8] Consensus-based freshwater sediment quality guidelines, US EPA, 2000