CHAPTER 2 ROAD TRANSPORT CONDITIONS

2.1 Current Road Transport

(1) Modal Share in Transport Sector

Road transport plays important roles in transport sector in Bangladesh as progress has been made on road improvement through several Five Year Plans. Fig. 2.1.1 shows trends of modal share of transport sector in Bangladesh. Road transport has high growth of both passenger and freight movement shares in 1980s, while rail transport has decreased share in both passenger and freight during the same period.

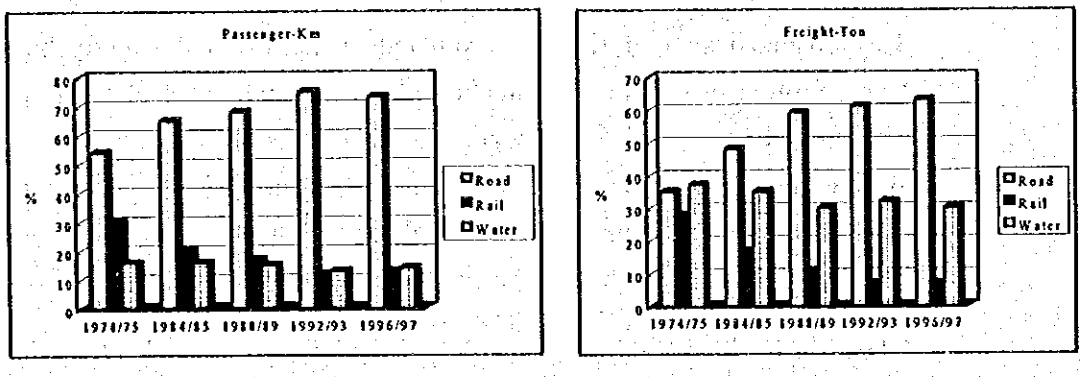


Fig. 2.1.1 Modal Share of Transport in Bangladesh

(2) Road Network

(a) Road Classification

The road network in Bangladesh is classified as national highways, regional highways, feeder roads (type A and B) and local roads. The definition of each highway and road is as follows:

- National highways connect the national capital with district headquarters, port cities and international highway.
- Regional highways connect different regions and district headquarters which are not connected by the national highways.
- Feeder road type A connects thana (lowest tier of administration) headquarters and important growth centers to the main arterial roads.
- Feeder road type B connects growth centers with other growth centers and thana headquarters.
- Local roads include municipal roads and rural roads.

The Roads and Highways Department (RHD), Ministry of Communications is responsible for construction, improvement and maintenance of national and regional highways and feeder road type A. Feeder roads type B and rural roads are built and maintained by the Local Government Engineering Department (LGED). Construction and maintenance of municipal and urban roads are charged with municipal bodies like city corporation and municipalities.

Area under the jurisdiction of RHD is divided into 7-Zones and 16-Circles for the present. The total length of road network under the RHD stands at 20,285 km. National Highway accounts for 14% or 2,862 km, Regional Highway for 8% or 1,565 km and Feeder Road-A for 78% or 15,860 km in Bangladesh. In addition to its road network, there is road length of 179,000 km that is under the LGED in collaboration with the local government bodies.

Road network administrated by RHD Khulna Circle is as shown in Fig. 2.1.2. Table 2.1.1 shows the road length under RHD. Road length in Khulna Circle occupied five (5) percents of that of whole county or 1,002 km, consisting of National Highway of 67 km (7%), Regional Highway of 125 km (12%) and Feeder Road-A of 810 km (81%). Khulna Circle has low percentage of road length, especially of National Highway.

Table 2.1.1 Road Length by Category and Circle under RHD in 1996/97

(Unit: km)

Circle	National Highway	Regional Highway	Feeder Road- A	Total
Dhaka	314 (23%)	66 (5%)	626+356*=982 (72%)	1,362 (100%)
Khulna	67 (7%)	125 (12%)	498+312*=810 (81%)	1,002 (100%)
Jessore	267 (20%)	228 (17%)	656+179*=835 (63%)	1,330 (100%)
Bangladesh	2,862 (14%)	1,565 (8%)	10,508+5,352*=15,860 (78%)	20,285 (100%)

Source: RHD

Note: Mark * shows new additional length as confirmed by divisional field Executive Engineers.

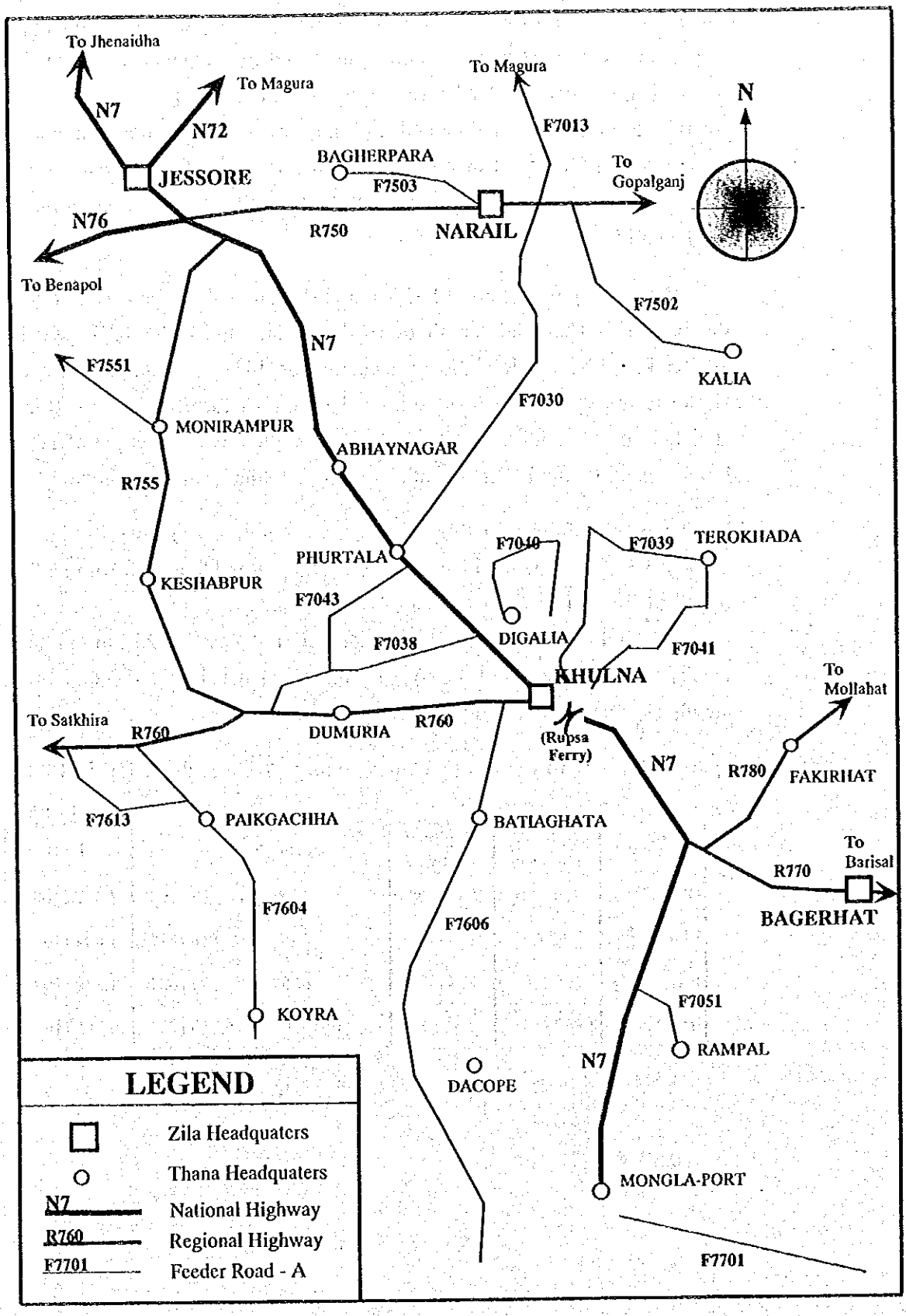


Fig. 2.1.2 Road Network in RHD Khulna Circle

(b) Road Conditions

Road network in Khulna Former District comprises 13 % in length of 6.71 m wide or more, and 78 % in length of 3.66 m wide or less. It means three fourth of road network are one (1) lane. And more than 87 % of road length in Khulna Former District is assumed to be paved or surface treated. Regarding the pavement conditions of roads in Khulna Zone, about 82% of the road length is considered to be in good or fair condition.

(3) Current Vehicle Ownership

Number of registered motorized vehicles in Bangladesh was about 508 thousand in 1996. The growth rate during 1990 - 96 was 6.8% per annum, while that of microbus was the highest as 46.3% per annum during the same period. In this connection, that of car and jeep, truck and motorcycle was 5.2%, 4.6% and 5.9% per annum, respectively. The level of ownership for total motorized vehicles in 1995 was 3.9 vehicle per 1,000 persons.

In 1996, the share of motorcycle was the highest 38.6%, followed by 25.5% for car and jeep, 15.6% for auto-rickshaw, 9.6% for truck and 8.1% for bus/minibus/microbus.

In Bangladesh, rickshaws as non-motorized vehicles exceed the motorized vehicles in number of registration. The number of registered rickshaws in the whole country was approximately 507 thousand in 1996. The growth rate during 1990 - 1996 was 5.8% per annum, and it was approximately one percent less than that of motorized vehicles. The number of registered rickshaws in Khulna Former District was about 29 thousand. The number of rickshaws per 1,000 persons in 1995 was 3.9 for the whole country and 4.6 for Khulna Former District, the level of Khulna was higher than that for the whole country.

(4) Outlook of Vehicle Ownership

The motorized vehicle ownership is forecasted by the method of regression analysis based on the trend data of registered vehicles and per capita GDP.

The correlation of number of registered vehicles and per capita GDP in Bangladesh becomes clearly high. Based on the results of regression analysis, number of vehicles by type in the year 2015 is estimated. The results are shown in Table 2.1.2. From the forecast results, level of vehicle ownership will increase from 4.1 vehicles/1000 persons in 1997/98 to 10.0 vehicles/1000 persons in 2014/2015.

Table 2.2.1 Forecast of Vehicle Ownership by Type

(unit:vehicle)

Year	Motorcycle	Autorickshaw	Car	Bus	Truck	All Vehicles
1989/90	125,000	30,200	92,650	25,000	37,200	310,050
1990/91	138,750	32,616	97,943	26,750	39,512	335,571
1991/92	150,171	36,796	101,806	28,820	40,752	358,345
1992/93	158,588	40,114	103,511	30,444	41,632	374,289
1993/94	165,360	43,863	106,634	32,335	42,723	390,915
1994/95	173,167	53,851	111,392	35,601	44,691	418,702
1995/96	182,035	68,039	119,020	38,156	48,175	455,425
1997/1998	236,000	99,000	141,000	51,000	57,000	584,000
1999/2000	267,000	121,000	155,000	58,000	63,000	664,000
2004/2005	414,000	222,000	221,000	95,000	90,000	1,041,000
2009/2010	506,000	286,000	263,000	117,000	107,000	1,279,000
2014/2015	614,000	360,000	312,000	144,000	127,000	1,558,000

Source: Forecasted figures are by JICA Study Team.

2.2 Road Traffic Conditions

(1) Traffic Volumes

The RHD conducted a traffic count survey in 1995 as the nation wide traffic census to reveal traffic situation on all roads under the RHD administration. Then, the RHD has been carrying out the survey every year for updating the data. Fig. 2.2.1 shows the current road traffic volumes (pcu/day) counted by RHD in traffic census and JICA Study Team in the Phase 1 study.

From the RHD survey results, the salient features of road traffic in the Study area are summarized as follows:

i) Traffic Volume of Motorized Vehicle

The highest traffic volume of 8,100 vehicles/day is observed in Khulna-Jessore road (National Highway No.7) in 1997/98. Other roads have traffic volume of more or less 3,500 vehicles/day. Traffic volumes on Khulna-Noapara and Noapara-Mongla sections are around 3,100 and 1,500 respectively.

ii) Traffic Volume of Non-motorized Vehicle

Traffic volume of non-motorized vehicle, such as bicycle and rickshaw is very high, and there are many survey stations in Khulna Circle jurisdiction that it exceeds that of motorized vehicle.

iii) Heavy Vehicle Ratio

High percentage of heavy vehicle ratio, more than 25% is observed in road sections of Khulna-Jessore and Khulna-Satkhira.

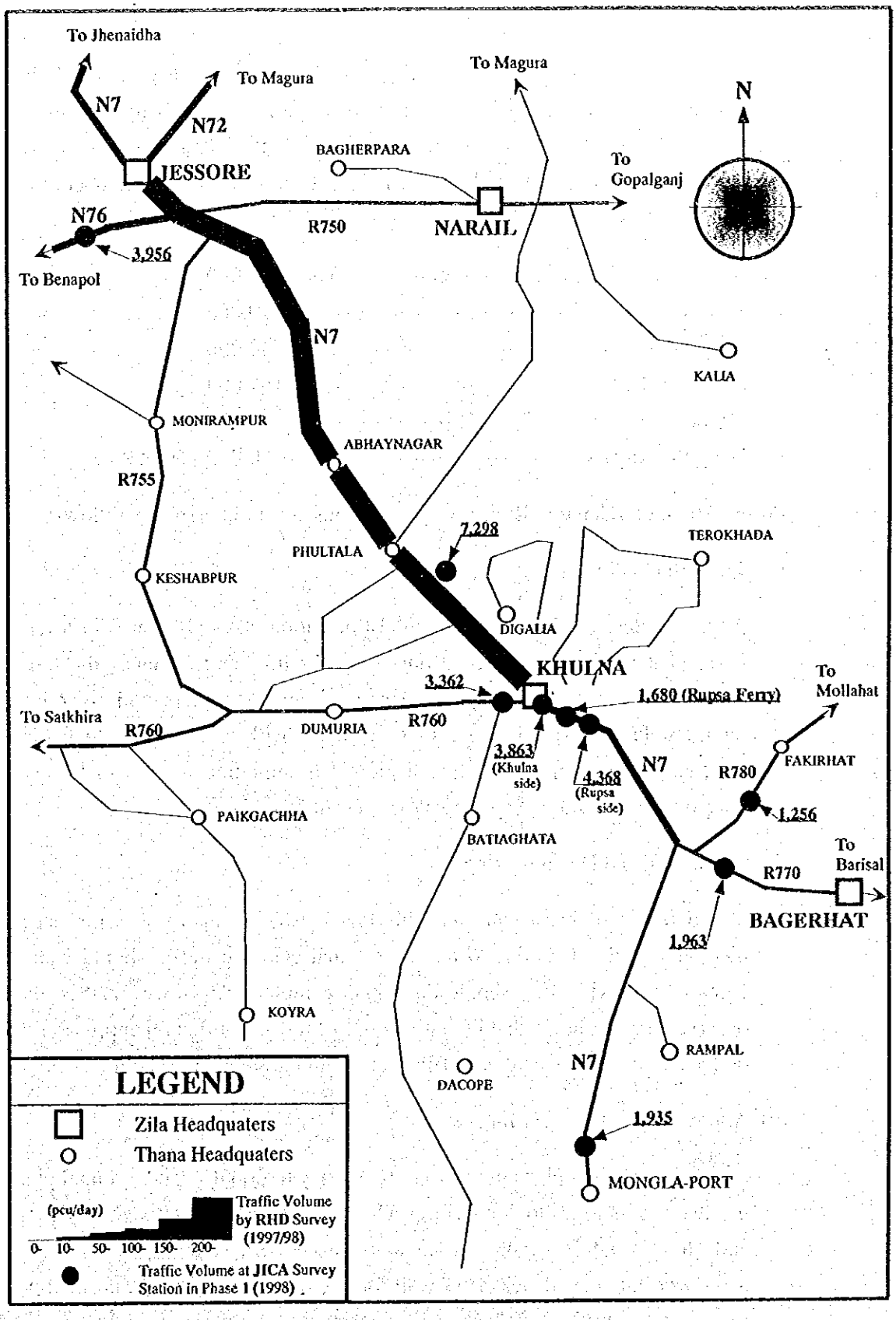


Fig. 2.2.1 Current Road Traffic Volume

(2) Situations of Rupsa Ferry

Rupsa ferry ghats exist on National Highway No.7 to form a part of Khulna-Mongla road, and they are located at the southern part of Khulna city crossing the 350 m wide Rupsa River. There are two ghats at both riversides to operate two ferry boats simultaneously, and five (5) ferry boats are always in operational conditions. Presently, Rupsa ferry transport is approximately as follows:

- Annual motorized vehicle transport Total 293,000
  - Trucks ---------- 70,000
  - Buses ---------- 40,000
  - Passenger Cars ---------- 167,000
  - Motorcycles ---------- 16,000
- Daily Passengers ---------- 50,000 - 60,000

Present situation related to Rupsa ferry operations are summarized as follows:

i) Tidal Fluctuation

Approximately three meters high tidal fluctuation takes place at Rupsa ferry. Ferry ghat is always inundated during spring tide, and it makes the traffic congestion worse. Furthermore, slope of approach piers and its related facilities face physical difficulties to cope with such high fluctuation, especially steep slope on approach piers. It sometimes causes to let over-loaded trucks or old vintage buses/cars get stuck on the way.

ii) Embarking and Disembarking

Mixed traffic of passengers and motorized vehicles share the same access piers and road. It is due to one access that entrance traffic should wait to embark until exit traffic should disembark completely. However, it is often observed at peak hours that both directions of traffic conflict on approach road or even on bridge, as neither traffic control nor enforcement is done.

iii) Approach Road and Terminal Plaza

There is a terminal plaza in the vicinity of ferry terminal. The terminal plaza has two access roads to connect to each ferry ghat respectively. Many shops and street venders occupy space along access roads and terminal plaza. Moreover, number of rickshaws wait for passengers at terminal plaza. Such mixed traffic situation makes traffic congestion worse during peak hours.

Photo-4 : Traffic Congestion at Rupsa Ferry

Two ghats in both sides exist at Rupsa Ferry to operate two ferries simultaneously during peak hours, transporting daily passengers of 50,000 - 60,000.
Motorized vehicles manage to pass among predominant non-motorized traffic, consisting of pedestrian, rickshaws and carts.

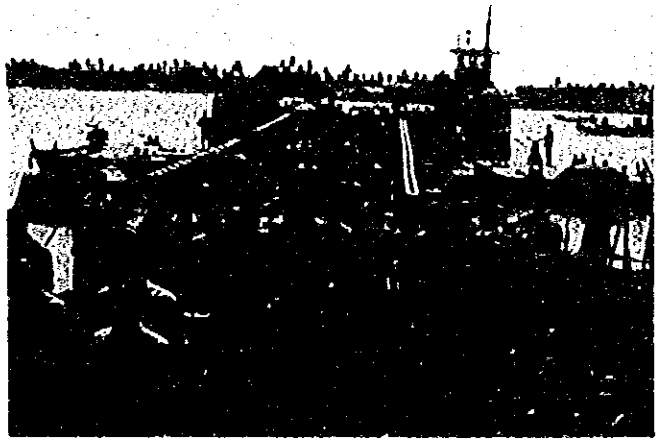


Photo-5 : Khulna Terminal at Rupsa Ferry

Very high non-motorized traffic exists at Khulna terminal, while high volumes of buses are found at Rupsa terminal.
Short trips are dominant in Khulna side and medium and long trips prevail in Rupsa side.

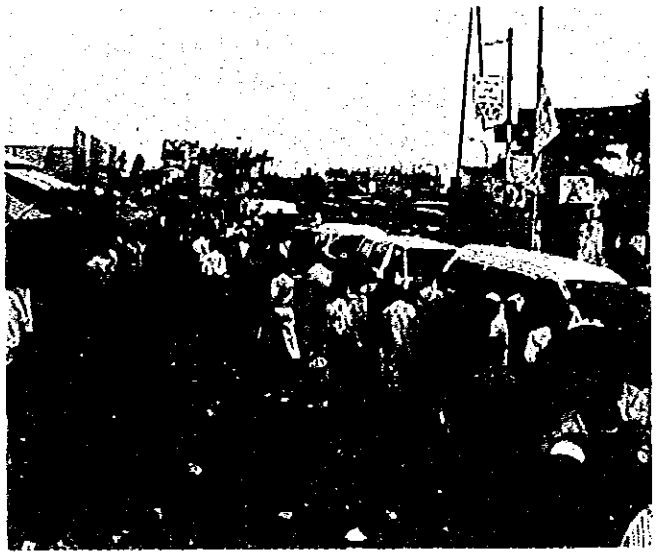


Photo-6 : Serious Traffic Congestion

Considerable number of passengers saturate traffic capacity to cause serious traffic congestion for motorized traffic.
It is often observed at peak hours that both directions of traffic conflict on approach road and access bridge.
The scheme of bridge construction is deemed a drastic measure to improve the situation.

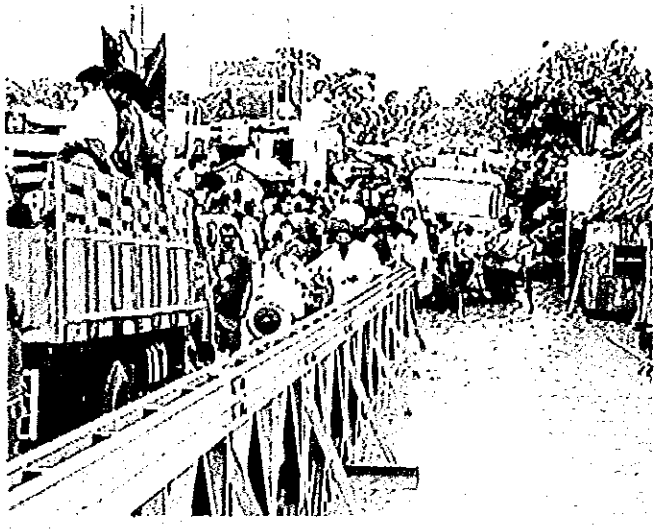


Fig. 2.2.2 Site Photographs

(3) Traffic Survey Results

Fig. 2.2.3 shows the results of traffic count survey in the project area.

Traffic movement at Rupsa Ferry is studied in implication with traffic count surveys of No. 1and No. 2 at both sides of the ferry. Fig. 2.2.4 shows difference of traffic movement in terms of volume and type of vehicle. Following features are found;

1) Very high non-motorized traffic exist at Khulna terminal, while high volume of buses are found at Rupsa terminal. Trip length of users may explain this change of modes, namely short trips are dominant in Khulna side and medium and long trips prevail in Rupsa side.

2) High portion of buses at Rupsa terminal decline to cross the Rupsa river or may be controlled because of congestion and wait for passengers in Rupsa side.

3) Passenger cars, motorcycles and trucks are observed quantitatively the same at three survey points, and they are of through traffic.

4) emarkable peak traffic in morning and evening are observed. It reveals commuters are to be main traffic.

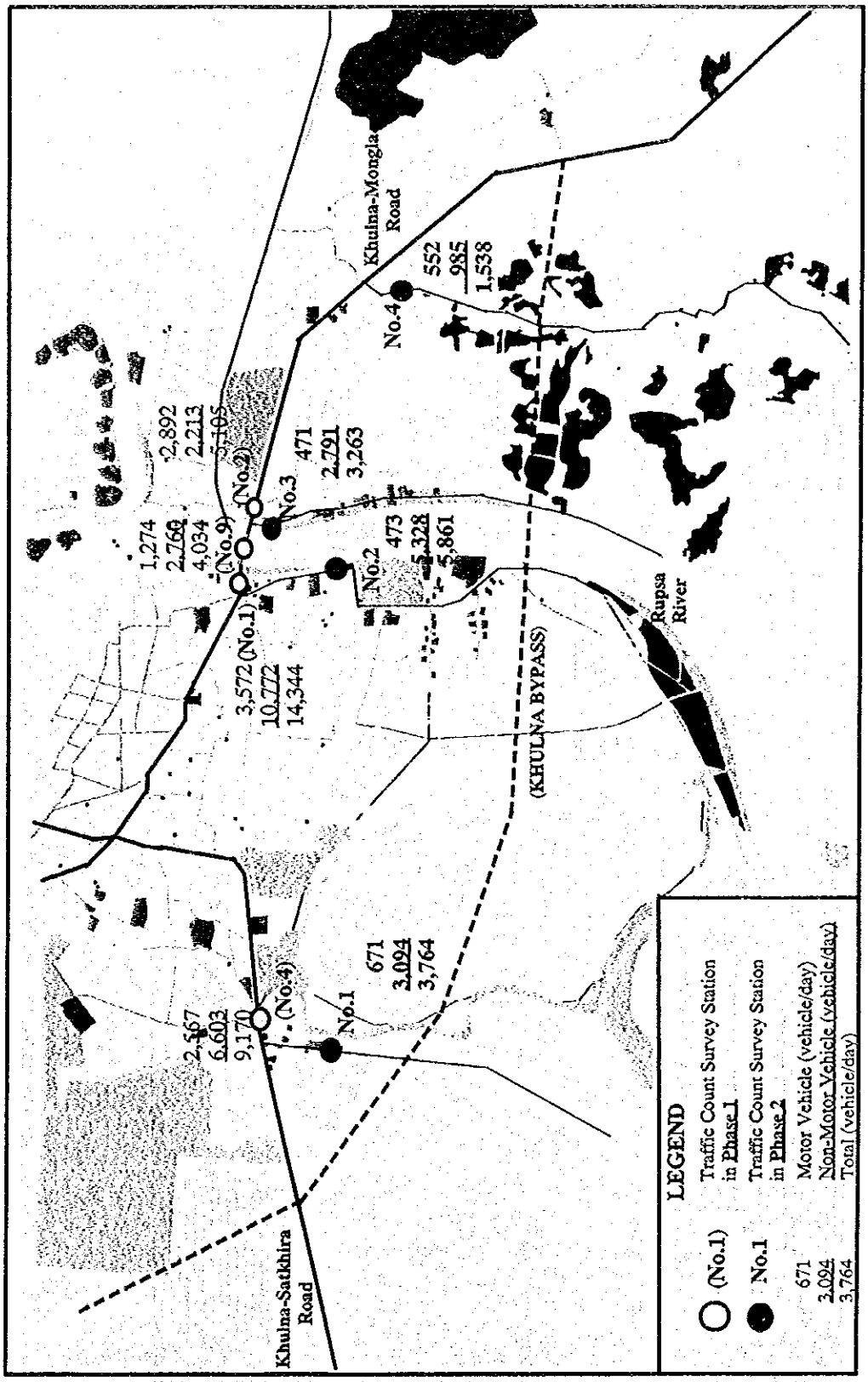
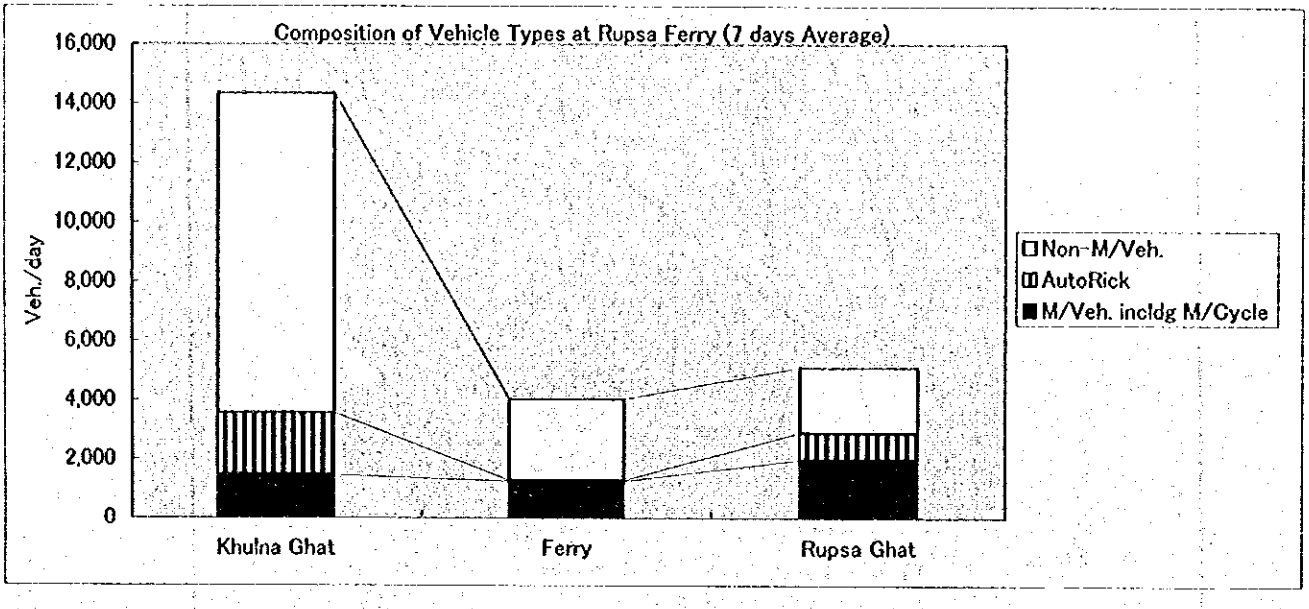


Fig. 2.2.3 Results of Traffic Count Survey

Veh./day

Location		Motorized Vehicles		Non-Motorized Vehicles	Total
		Motorized incldg M/Cycle	Auto Rickshaw		
No. 1	Khulna Ghat	1,453	2,120	10,772	14,344
No. 9	Ferry	1,245	29	2,760	4,034
No. 2	Rupsa Ghat	1,964	928	2,213	5,105



veh./day

Location		M/Cycle	AutoRick	P/cars	Buses	Trucks	Total
No.1	Khulna Ghat	541	2120	344	200	368	3,572
No.9	Ferry	406	29	247	198	393	1,274
No.2	Rupsa Ghat	373	928	285	861	444	2,892

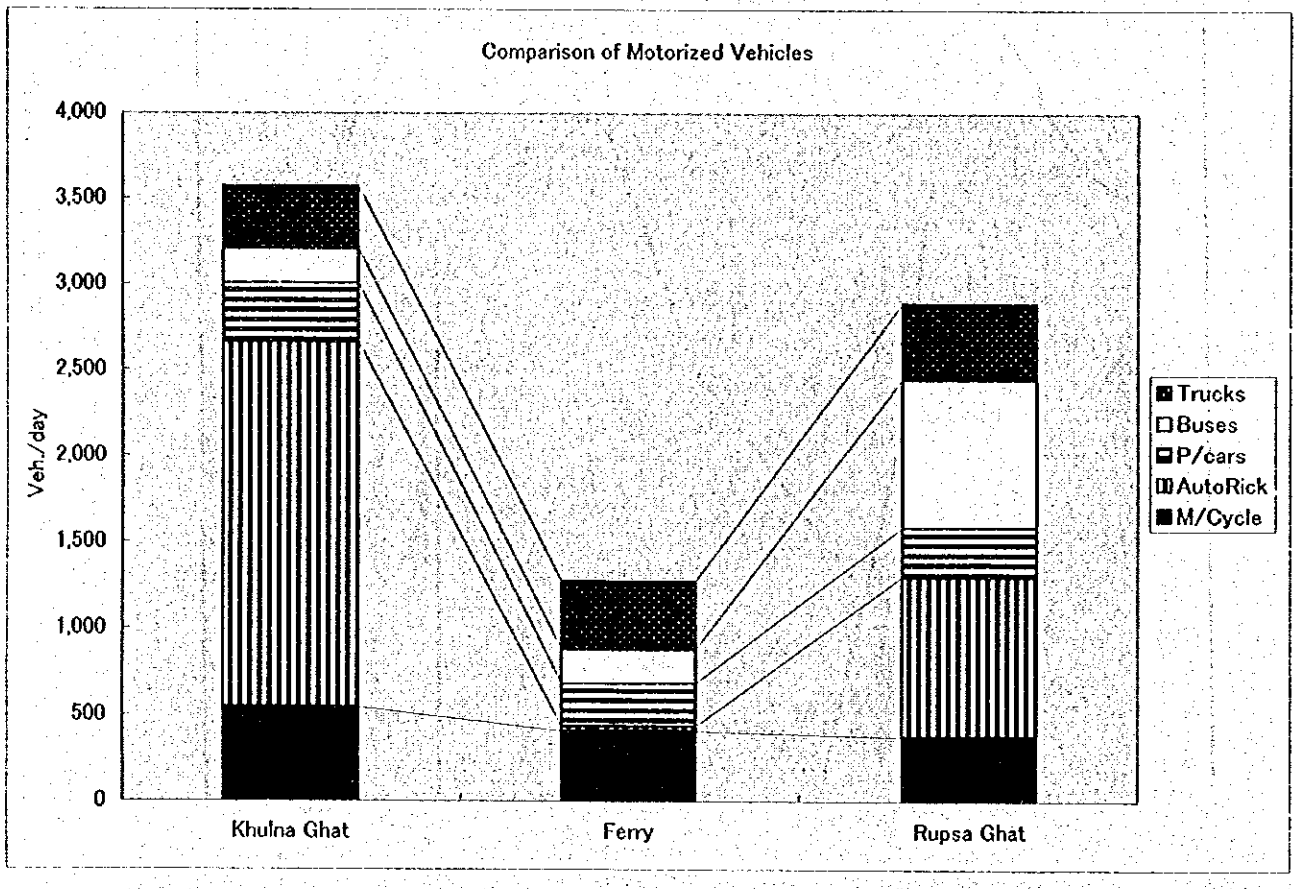


Fig. 2.2.4 Salient Features of Traffic Movement at Rupsa Ferry

2.3 Outline of Road Transport Sector in Fifth Five-year Plan

In terms of share of GDP, the Transport Sector is forecasted to grow from 11.27 percent in 1996/97 to 11.54 percent by 2001/02, representing an annual growth rate of 7.51 percent. For transport, the main objective of the 5FYP is to develop a balanced and integrated transport network.

In broad terms, the network development strategy is as follows:

- Development efforts will concentrate on five strategic transport corridor: Dhaka-Chittagong; Dhaka-Northwest; Dhaka-Khulna; Dhaka-Sylhet; and Khulna-Northwest. Along these corridors, the majority of investment will focus on the development of bridges, and upgrading of ferry and roads.
- The rural transport system will be developed by integrating inland water transport with the road system.
- The framework of transport development will be broadened by incorporating the urban transport dimension, starting with improvements in the greater Dhaka area.
- Railway investments will be selected on the basis of consistency with the Railway Recovery Program (i.e., profitable investments).
- The two seaports will continue to be developed to address capacity, efficiency and operational constraints.
- Greater participation by the private sector will be encouraged, both for transport operations and investment in transport infrastructure.

In 1996/97 prices, an amount of Taka 121,755.50 million has been allocated for public sector outlay in the transport sector during the 5FYP. This allocation represents 14.20 percent of total public sector outlay, compared with 16.50 percent for the Fourth FYP. The sub-sectoral breakdown of the 5FYP transport allocation is set out below:

Sub-Sector	Taka (million)	percent
Roads	64,905.50	53 %
Jamuna Bridge	11,800.00	10 %
Railway	24,000.00	20 %
Water Transport	13,550.00	11 %
Air Transport	7,500.00	6 %
Total	121,755.50	100 %

2.4 Traffic Demand Forecast

2.4.1 Approach and Methodology

The procedure used for traffic demand forecast through the Phase 1 and Phase 2 is shown in Fig. 2.4.1. The outlines of main items at each step are described as follows:

(Phase 1)

(a) Zoning

Zoning is done with Khulna and Mongla areas as the center of study areas. Khulna area was split into four zones, and Khulna and Bagerhat zilas was divided upon the thana boundaries, whereas other districts were combined into zilas appropriate to the direction of the future trunk road. The number of zones established thus was finally 27.

(b) Making Present Origin and Destination (OD) Tables

The present OD tables by vehicle type were constructed based on the data obtained from traffic survey (traffic count survey and roadside interview survey) in the Phase 1. The accuracy of OD tables has been checked in terms of implementation of traffic flow simulation on the present road network.

(c) Future Total Traffic Demand (Control Total)

In general, traffic demand increases in accordance with GDP and population growth, domestic and international trade as well as expansion of agriculture and industrial production. Actually, traffic demand (passengers, freight) in Bangladesh is basically increasing until now, and it is the growth rate in passenger and freight transport that exceeds the rate of GDP growth.

The study in Phase 1 applied the forecast results for total traffic demand (control total) derived within the national transport plan formulated by "Bangladesh Integrated Transport System Study (hereinafter referred to as "BITSS")" issued by Planning Commission in June 1998 as priority planning Figs. (see Table 2.4.1). Accordingly, this study applied future increases between 1997/98 and 2014/15 of 2.54 times for passenger demand, and 2.75 for freight demand.

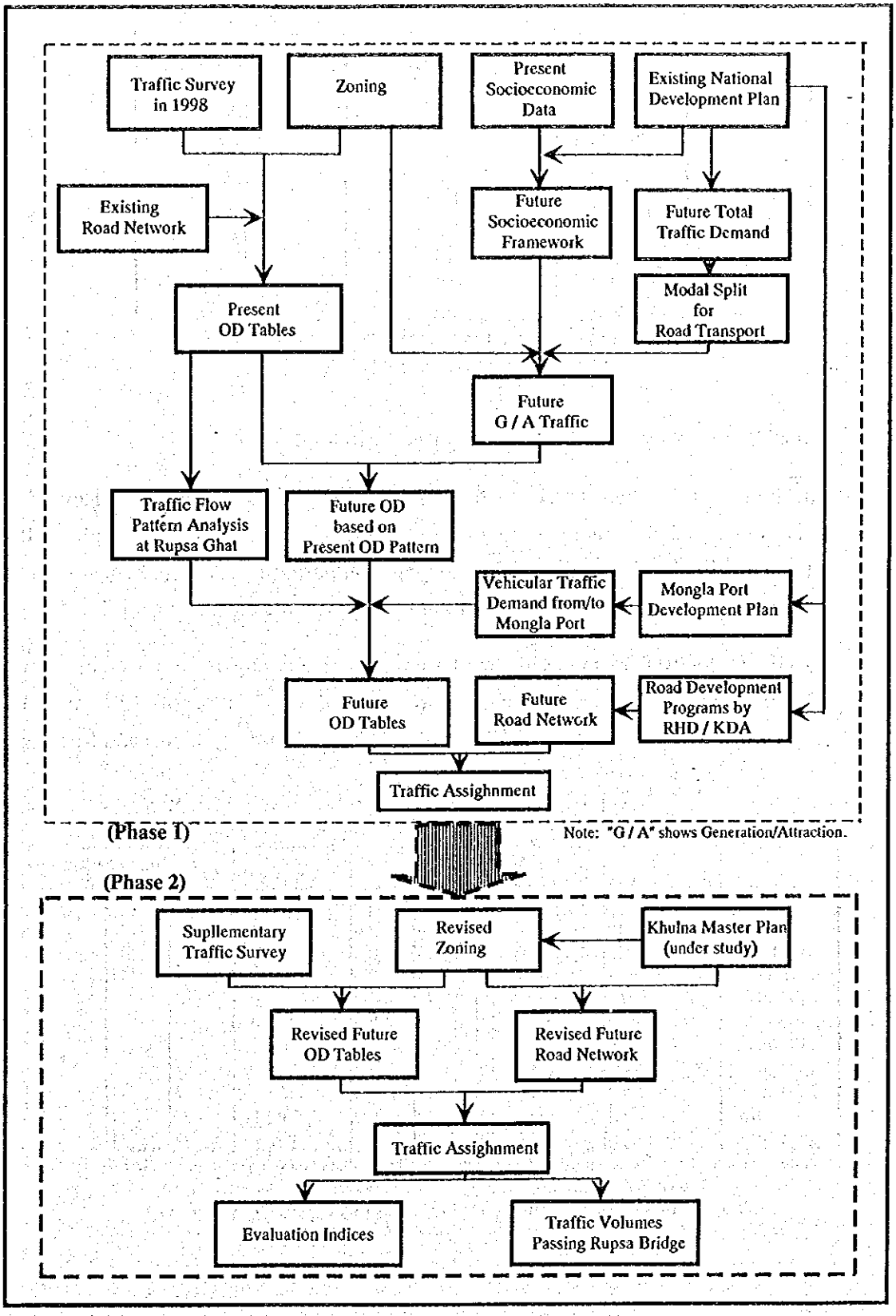


Fig. 2.4.1 Process of Traffic Demand Forecast

Table 2.4.1 Future National Transport Demand

Year	Passenger (billion passenger-Km)	Freight (billion ton-Km)
1974/75	17	2.6
1984/85	35	4.8
1988/89	57	6.3
1992/93	66	9.0
1996/97	72	10.2
1997/98	77	10.9
1999/2000	89	13
2004/2005	116	17
2009/2010	150	23
2014/2015	196	30

Note : 1) Values for passenger-Km and ton-Km in 1997/98 are estimated by the Study Team.

Source : BITSS

(d) Modal Share Analysis for Different Transport Modes

The future modal share has been forecasted in the BITSS as shown in Table 2.4.2. It is considered that increase in road transport of passengers and freight will be guaranteed by the shared use of the Jamuna Multipurpose Bridge, the construction of Dhaka Eastern Bypass and road bridges at Paksey, Khulna and Ashuganji.

Based on the BITSS forecasts, road transport of passengers and freight between 1997/98 and 2014/15 was expected to increase by factors of 2.81 and 3.14, respectively, mirrored by a proportional increase in passenger vehicles and trucks.

Table 2.4.2 Estimates of Modal Share of Transport

Year	Passenger					Freight				
		Modal Distribution					Modal Distribution			
	Passenger-Km (billion)	Road (%)	Rail (%)	Watert (%)	Total (%)	Ton-Km (billion)	Road (%)	Rail (%)	Watert (%)	Total (%)
1974/75	17	54	30	16	100	2.6	35	28	37	100
1984/85	35	65	20	16	100	4.8	48	17	35	100
1988/89	57	68	17	15	100	6.3	59	11	30	100
1992/93	66	75	12	13	100	9.0	61	7	32	100
1996/97	72	73	13	14	100	10.2	63	7	30	100
1997/98	77(1.00)	-	-	-	100	11(1.00)	-	-	-	100
1999/2000	89(1.15)	76	10	13	100	13(1.19)	65	10	25	100
2004/2005	116(1.50)	79	10	11	100	17(1.56)	68	11	21	100
2009/2010	150(1.94)	80	10	10	100	23(2.11)	70	11	19	100
2014/2015	196(2.54)	82	10	8	100	30(2.75)	72	11	17	100

Note : 1) Data relate to Mechanized transport only and data relating to road transport refers to Bus, Truck, Car and other four wheelers.

2) Values for passenger-Km and ton-Km in 1997/98 are estimated by the Study Team.

Source : BITSS

(e) Future Traffic Volume by Zone

Forecasting of future traffic volumes in the various zones was carried out using the control total as well as socioeconomic indicators. Indicators used in this study included zonal population for forecasting passenger traffic volumes by zone, and freight traffic demand done by BITSS on the zila level.

(f) Traffic Patterns Analysis at the Rupsa Ferry Ghat

Latent demand for the Rupsa Ferry is presently indicated by much shuttle service to the Rupsa Ferry ghat. It is predicted that traffic flow pattern will greatly change in the future with the construction of a bridge nearby. The latent traffic demand for Rupsa River crossing that will arise upon the construction of the bridge can be forecasted on the basis of Origin-Destination studies of the existing situation. The estimated results are shown in Table 2.4.3.

Table 2.4.3 Latent Traffic Demand for Rupsa River Crossing

	Khulna from Rupsa		Rupsa from Khulna	
	1998	2015	1998	2015
Autorickshaw	455	1,373	352	1,062
Bus	296	847	260	745

Source: Study Team

(g) Vehicular Traffic Volumes Arising from Mongla Port Freight Handling

About two (2) million ton cargo (including Nepalese cargo) handled at the jetty of Mongla Port, separately forecasted in Phase 1, was applied in the forecasting of vehicular traffic volumes generating from the harbor freight handling. Vehicular traffic volumes were as follows:

	(1998)	(2015)	
Trucks	120	140	(trips/day)
20-foot Trailers	0	600	
40-foot Trailers	0	360	
Passenger Vehicles	60	550	
Total	180	1,650	

Moreover, the vehicular traffic volumes in the case of the railway extension from Khulna to Mongla Port were examined in Phase 1. In the case, it was forecasted that

a part of long-distance freight transport demand (for example, freight transport demand to Nepal) would be mainly diverted to rail transport.

(h) Future OD Table Forecasting

Based on the above-mentioned information, future OD tables were estimated in accordance with the following procedure:

(i) Future OD projections were in principal done by the application of Present Pattern Method.

(ii) OD traffic volume estimates prepared by the Present Pattern Method were adjusted by applying future traffic flow patterns forecasted for the Rupsa Ferry ghat area.

(iii) Further, OD traffics generating from the handling of freight at Mongla Port were added to the above OD.

(i) Establishment of Future Road Network

The future road network was consisted of the national highways, feeder roads including urban roads and the roads of whose future construction was certain. Two alternative routes for the Khulna Bypass, route A and B, as well as its access links were added to the network.

(j) Traffic Assignment

The future OD traffic volumes were assigned upon the future road network.

(Phase 2)

The future OD tables are subdivided into more detailed traffic zones in the study area, and the future traffic is assigned on more detailed road network than that of Phase 1 to examine necessary improvement of connecting roads.

(k) Revised Zoning

According to the above-mentioned purpose, the zoning in the Phase 1 is looked again based on the information for land use and road network plan in the KDA Master Plan Study area (under study), taking the results of supplementary traffic survey into consideration.

(l) Revised Future OD Tables

The future OD tables forecasted in the Phase 1 are subdivided in accordance with the revised zoning. At that time, ratios for zone subdivision are calculated by the area-wise population estimated in the KDA Master Plan Study.

(m) Revised Future Road Network

Future road network is revised based on the proposed road network in the KDA Master Plan Study, especially access roads to Khulna Bypass.

(n) Traffic Assignment

Revised future OD traffic volumes are assigned upon the revised future road network.

(o) Evaluation Indices, Traffic Volumes Passing Rupsa Bridge

Evaluation indices and traffic volumes using Rupsa Bridge are calculated based on the results of traffic assignment.

2.4.2 Revised Future OD Tables

(1) Revised Zoning

In principle, the zoning in Phase 2 maintained the traffic zone boundary established in Phase 1, and the relative zones that are mainly included in Khulna city are subdivided. The subdivisions are revised based on the information on land use, area population and road network plan in the KDA Master Plan Study area. As a result, four traffic zones in Khulna city were subdivided into 11 traffic zones in the Phase 2. Additionally, traffic zone No. 14 in the Phase 1 is divided into east (Zone 21) and west (Zone 22) sides by the Rupsa River, taking condition of access link to the Khulna Bypass into consideration.

(2) Future OD Tables

The future OD tables forecasted in the Phase 1 are subdivided in accordance with the revised traffic zoning. At that time, the ratios of zone subdivision are calculated by using the area population estimated in the KDA Master Plan Study, and then revised future OD table is made based on the new traffic zoning.

2.4.3 Traffic Assignment

As in Phase 1, the calculation for simulation of traffic assignment is carried out using the software "STRADA (System for Traffic Demand Analysis)", supplied by JICA.

(1) Future Road Network

Future road network established for traffic assignment in Phase 1 is basically maintained, and it in Phase 2 is mainly revised with the focus on road network in the KDA Master Plan Study area, especially access links to Khulna Bypass route (Route A) selected in Phase 1.

(2) Link Specifications

The distance and lane number for each link consisting of road network is specified using RHD road inventory data, and data from the road improvement program as well as road development plan for the KDA Master Plan Study area. Moreover, for each link, the traffic variables of capacity (Q) and speed (V) are arranged in a Q - V pattern as shown in Table 2.4.4.

Table 2.4.4 Q- V Pattern

Q - V Code	Capacity (pcu/day)	Max. Velocity	No. of Lanes	Remarks
1	22,200	60	2	Low class of National Highways & high class of Regional Highways as inter-city roads
2	16,400	60	2	Low class of Regional Highways as inter-city roads
3	12,900	60	2	Other inter-city
4	7,800	40	2	Urban roads

(3) Traffic Assignment

Traffic assignment is implemented by the "Equilibrium Assignment Method (EAM)" available in the JICA STRADA program. The EAM is based on the total system optimization, and loads the OD trips to the road network so as to minimize the total travel time in the network.

Fig. 2.4.2 shows the future traffic flow in and around Khulna city corporation area based on the results of simulation for traffic assignment.

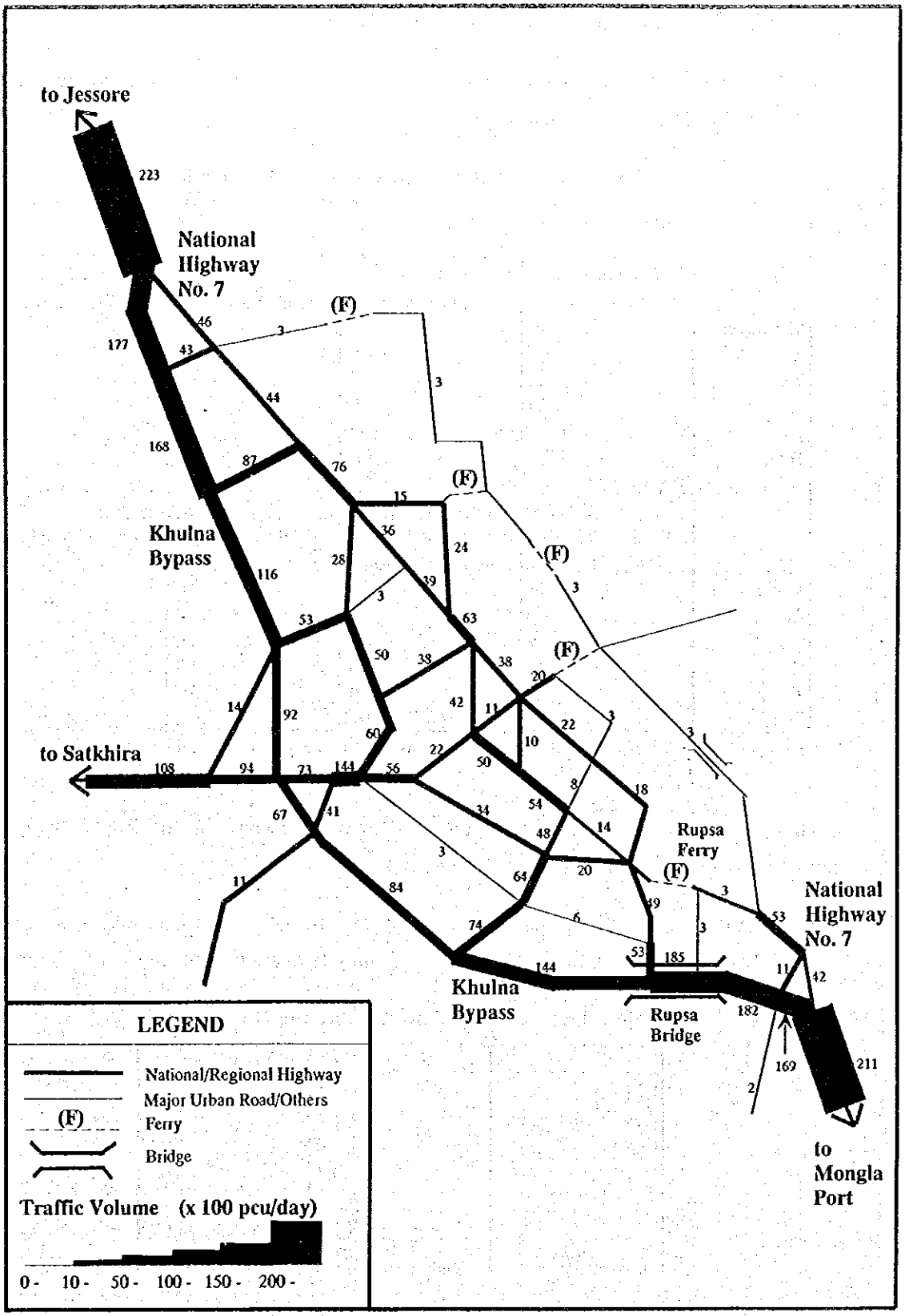


Fig. 2.4.2 Future Traffic Flow

(4) Evaluation Indices, Traffic Volumes Passing Rupsa Bridge

Table 2.4.5 shows evaluation indices (e.g. total vehicle-km and vehicle-hour) calculated from the assignment results.

Table 2.4.5 Total Vehicle-km and Vehicle-hour

Total pcu-km & pcu-hour				
	(a) Without Project		(b) With Project	
	Total pcu-km (x 1000 pcu-km/day)	Total pcu-hour (x 1000 pcu-hour/day)	Total pcu-km (x 1000 pcu-km/day)	Total pcu-hour (x 1000 pcu-hour/day)
Motorcycle	84	4	73	2
Autorickshaw	414	23	349	9
Car	308	12	272	7
Bus	1,421	75	1,199	29
Truck	1,512	60	1,304	32
Total	3,739	174	3,197	79
Total vehicle-km & vehicle-hour				
	(a) Without Project		(b) With Project	
	Total vehicle-km (x 1000 vehicle-km/day)	Total vehicle-hour (x 1000 vehicle-hour/day)	Total vehicle-km (x 1000 vehicle-km/day)	Total vehicle-hour (x 1000 vehicle-hour/day)
Motorcycle	280	13	243	7
Autorickshaw	414	23	349	9
Car	308	12	272	7
Bus	568	30	480	12
Truck	756	30	652	16
Total	2,326	108	1,996	51

Note: "With Project" and "Without Project" represent the cases with and without the southern section of Khulana Bypass, respectively.

Then, based on the assignment results, traffic volumes passing the Rupsa Bridge is analyzed, and its result is shown in Table 2.4.6.

The traffic demand passing the Rupsa Bridge is forecasted as about 11,100 vehicles/day (about 18,500 pcus/day), and its average trip length is 53.8 km.

Table 2.4.6 Traffic Volumes Passing Rupsa Bridge

	pcu/day	vehicle/day
Motorcycle	349	1,163
Autorickshaw	2,466	2,466
Car	1,097	1,097
Bus	9,016	3,606
Truck	5,524	2,762
Total	18,452	11,094
Average Trip	53.8 Km	

2.5 Necessity for Implementing the Project

2.5.1 Necessity from Regional Development Perspective

Rupsa Bridge is planned to be located on National Highway No. 7 and to cross over the Atai/Rupsa River. This river severs the Southwestern region of Bangladesh and disrupts regionally the Khulna Division with 12.7 million population as well as locally the Khulna Former District with 5.3 million people as shown in Fig. 2.5.1.

National Highway No. 7 is the backbone of north-south arterial road network to connect Mongla Port to its hinterland such as Khulna, Jessore, the North-western Region of Bangladesh and even for Nepalese Transit Cargo, and it also sustains socio-economic activities and development along the road.

2.5.2 Necessity from City Planning Viewpoint

As shown in Fig. 2.5.2, KDA Master Plan proposes a road extension of 115 kilometers including the north section of Khulna Bypass in addition to the existing 100 kilometers section, totaling 215 kilometers. Accordingly it is expected that the road development will be implemented continually until 2015. In particular the Northern Section Khulna Bypass is given a high priority by the KDA and is expected to be completed by 2005, while the Southern Section of Khulna Bypass is planned to be developed by the RHD. The JICA Study is focussed on the Southern Section of Khulna Bypass in conjunction with Rupsa Bridge.

2.5.3 Technical Requirement against Congested Rupsa Ferry

Present Rupsa Ferry will become a serious traffic bottleneck to sustain Mongla Port and future development at the port area if no bridge exists to cross the Rupsa River. Khulna Bypass located in the western side of the Rupsa River has advantages in the aspects of;

a) To alleviate traffic congestion at Rupsa Ferry as well as to serve majority of present ferry users.

b) To keep consistence with the proposed route of Khulna Development Master Plan and to strengthen road network in Khulna City.

c) To strengthen not only north-south road network but also the east-westward road link of Satkhira - Khulna - Mollahat/Gopalganj

d) To provide good access to the central business district (CBD) in Khulna in case of its realization

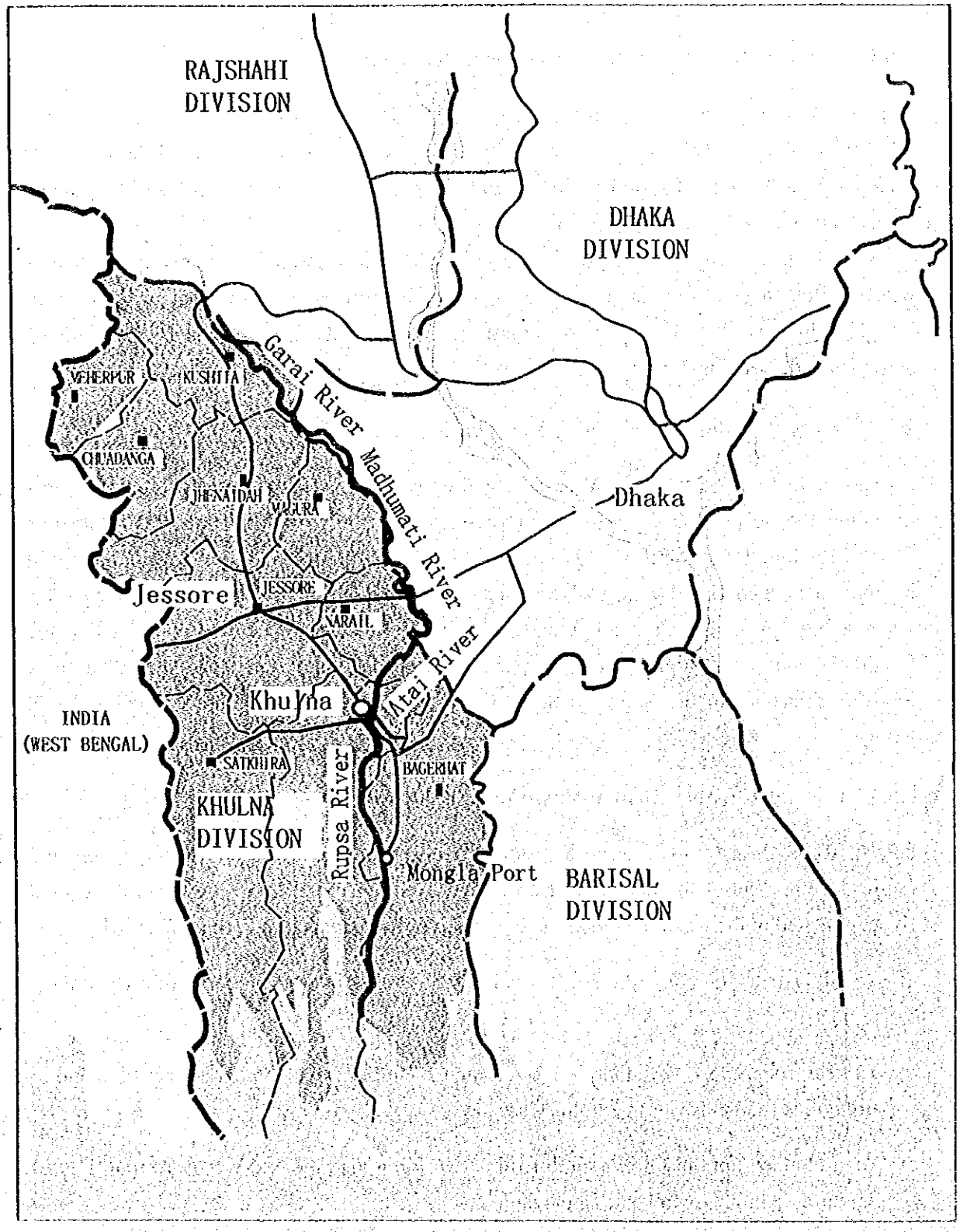


Fig. 2.5.1 Rupsa Bridge and its Location in Khulna Division

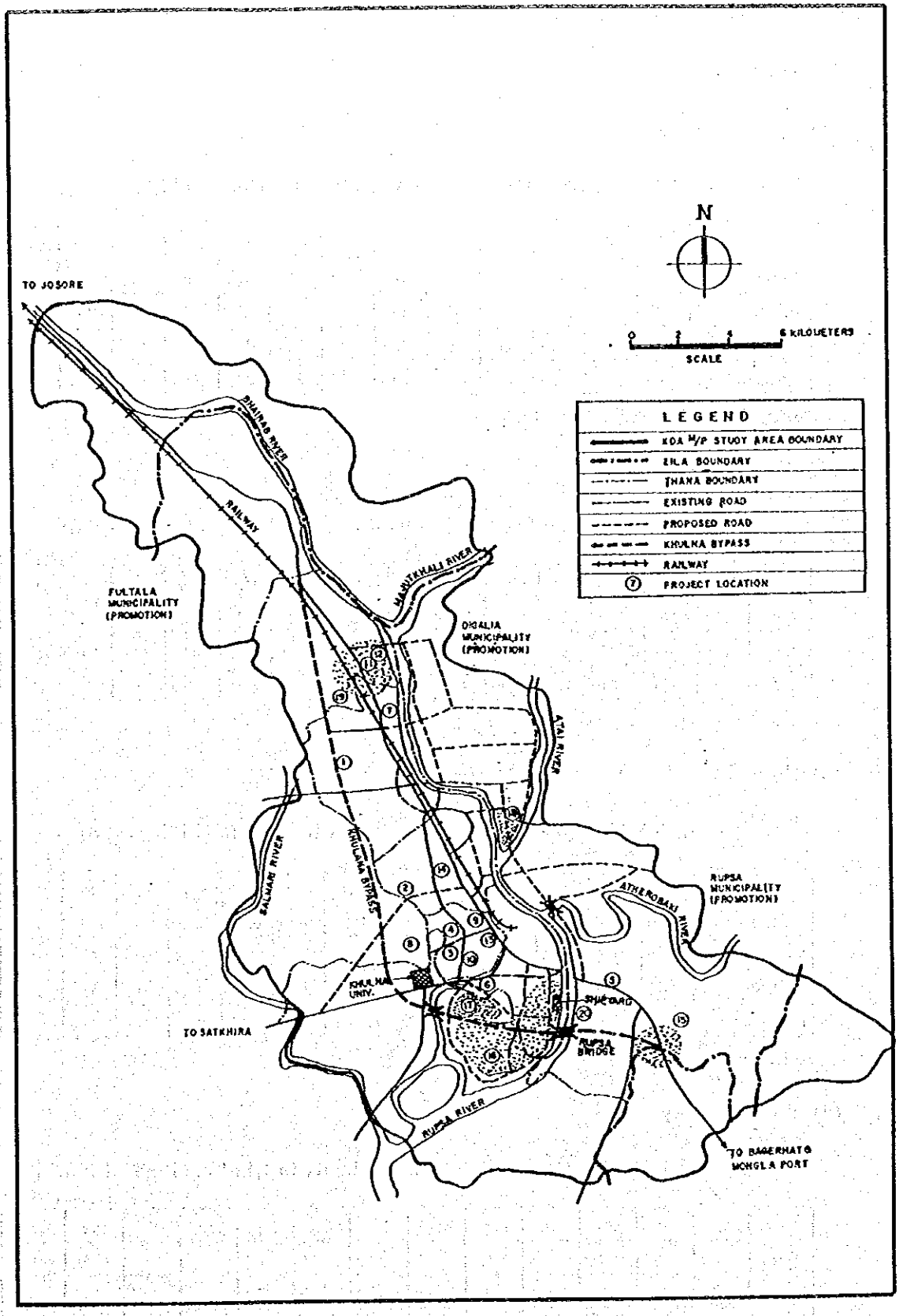


Fig. 2.5.2 Project Location in KDA Master Plan

CHAPTER 3 NATURAL CONDITIONS

3.1 Meteorology

(1) Temperature

Table 3.1.1 Mean Monthly Temperature in Khulna (1988 - 1998)

(°C)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Extreme Max	30.5	33.7	37.7	39.4	40.0	37.2	35.5	35.6	39.1	36.4	34.2	30.4	40.0
Mean Max	29.0	32.3	36.3	37.6	37.3	36.3	35.0	34.6	35.9	34.9	32.8	29.5	
Mean Min.	7.6	10.6	14.8	18.6	20.9	22.8	24.2	24.1	23.6	20.5	14.6	10.2	
Extreme Min.	6.8	9.0	12.8	15.8	19.4	20.8	22.2	22.3	22.2	18.4	11.9	8.0	6.8

Source: Provincial Meteorology Office - Khulna

(2) Precipitation

Table 3.1.2 Mean Monthly Precipitation in Khulna (1969 - 1998)

(mm/month)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	11.1	34.7	54.9	76.1	183.9	345.2	322.1	321.1	240.2	127.1	31.0	7.1	1754.5
Max	70.0	203.0	220.0	347.0	373.0	783.0	792.0	633.0	843.0	330.0	162.0	65.0	2762.0 (1974)
Min	0.0	0.0	0.0	0.0	30.0	63.0	48.0	80.0	39.0	17.0	0.0	0.0	475.0 (1971)

Source : Provincial Meteorology Office – Khulna

(3) Humidity

Table 3.1.3 Mean Monthly Humidity in Khulna (1988 - 1998)

(percent)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Extreme Max	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mean Max	100.0	100.0	99.8	99.3	99.8	100.0	99.8	99.8	99.8	99.9	99.7	100.0	99.8
Mean Min	26.9	29.7	23.6	27.5	43.2	53.1	57.1	60.8	57.5	45.5	38.0	33.2	41.3
Extreme Min	9.0	22.0	13.0	20.0	27.0	30.0	26.0	51.0	41.0	39.0	31.0	28.0	28.1

Source: Provincial Meteorology Office - Khulna

(4) Wind Velocity

Table 3.1.4 Mean Monthly Wind Velocity in Khulna (1988 - 1998)

(m/s at 10 m from ground)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	6.7	6.2	7.9	12.8	9.3	8.9	8.0	7.7	8.2	5.7	7.1	7.9	
Max	15.9	9.3	13.9	23.1	12.8	18.0	10.3	11.3	33.4	9.3	18.5	18.5	33.4
Min	4.1	4.1	4.6	6.2	6.2	5.1	4.6	5.1	3.1	2.1	2.1	3.1	2.1

Source : Provincial Meteorology Office - Khulna

The strongest wind of 44.4m/s (160 km/hr) was recorded by the cyclone of November 29, 1988.

3.2 Rupsa River

The Rupsa River is greatly influenced by the tide of the Bay of Bengal. Therefore, its water level fluctuates not only between dry and rainy seasons but also in hours everyday. The water system of the Rupsa River has little influence from the neighboring major systems such as of the Ganges and the Gorai/Madhumati Rivers. In reality, no flood was observed at the Rupsa River even when a great flood was recorded at the other rivers in 1998.

Fig. 3.2.1 show the monthly fluctuations of HWL (High Water Level) and LWL (Low Water Level) at Khulna station, located 4 km upstream form the proposed bridge location, as an average over a period from 1970 to 1998.

Fig. 3.2.2 shows the hourly fluctuations of water level and flow velocity within a day on July 29, 1999.

The design HWLs and LWLs against various return periods are estimated by frequency analysis as presented in Table 3.2.1.

Table 3.2.1 Design High and Low Water Levels

(m PWD)

Return Period	Khulna		Chalna		Rupsa Bridge	
Year	HWL	LWL	HWL	LWL	HWL	LWL
100	3.68	-1.06	4.24	-2.25	3.77	-1.26
50	3.58	-0.99	4.10	-2.04	3.67	-1.17
20	3.42	-0.90	3.92	-1.76	3.50	-1.04
10	3.32	-0.83	3.77	-1.56	3.40	-0.95
5	3.20	-0.74	3.61	-1.36	3.27	-0.84

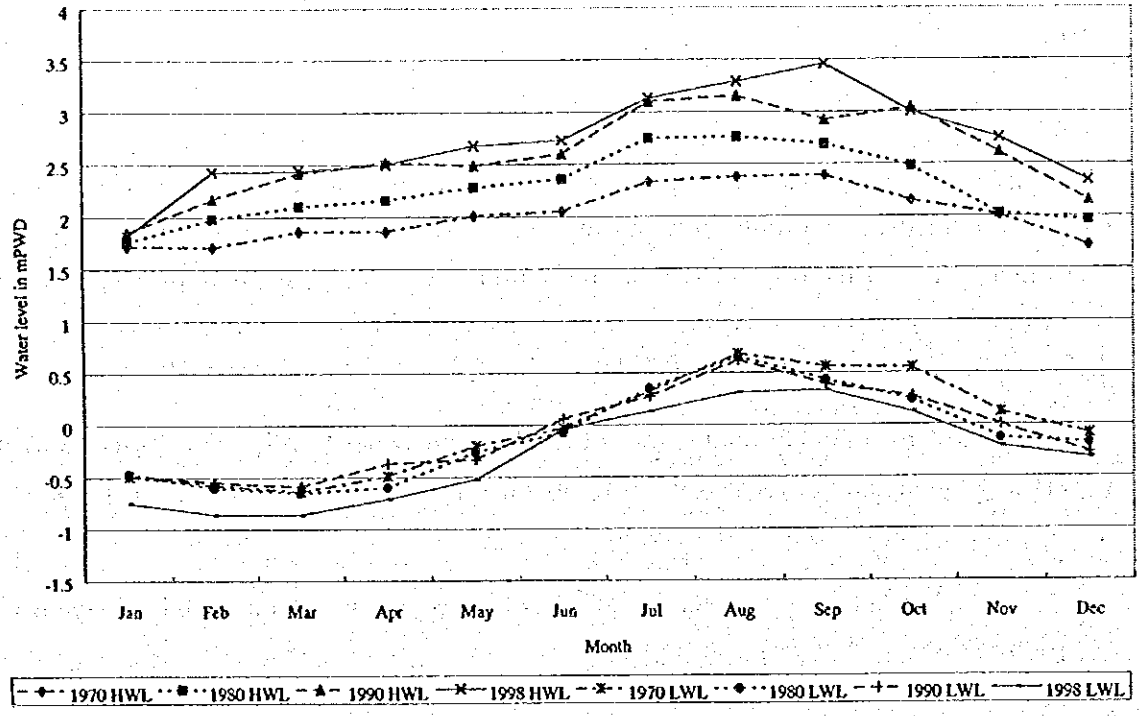


Fig. 3.2.1 Monthly HWL & LWL at Khulna Station

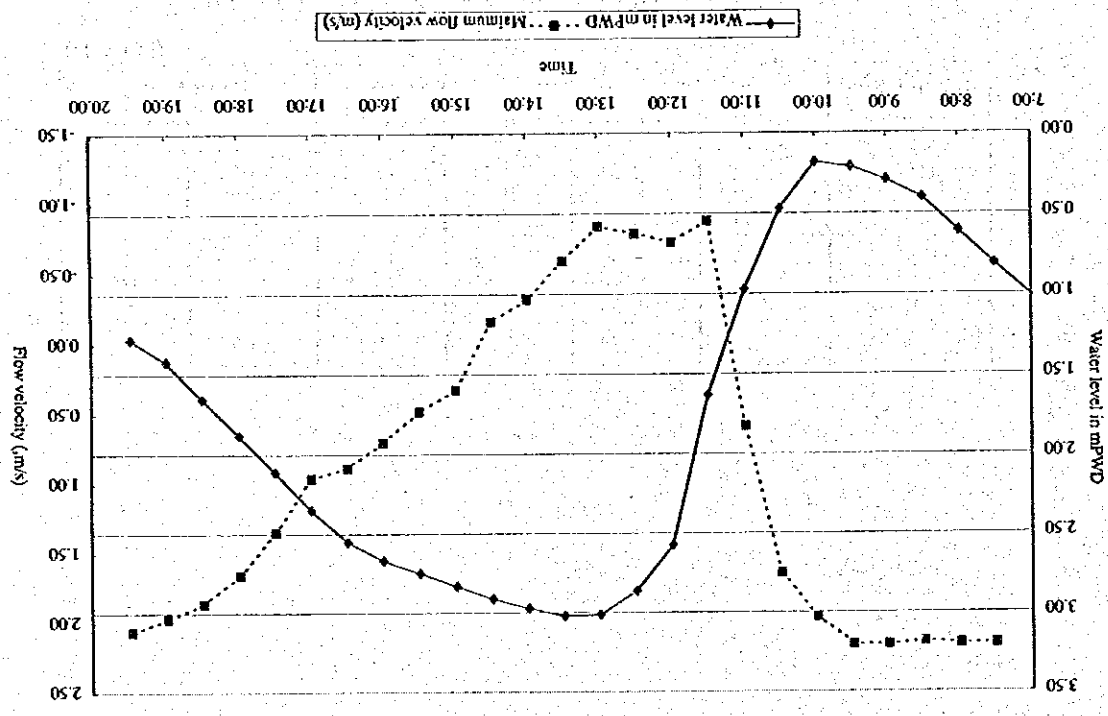


Fig. 3.2.2 Hourly Change in Water Level and Flow Velocity at Proposed Bridge Site

3.3 Geology and Subsoil Condition

3.3.1 Geology

Khulna area is composed of tidal deltaic deposit along active and abandoned stream channels.

The terrain is flat and the geology is characterized with six major features namely natural levees, flood plain, old meanders, bar, tidal marsh and back swamp. Level tracts are submerged during spring tides.

3.3.2 Subsoil Condition

Fig. 3.3.1 shows the typical subsoil profile of the project route crossing the Rupsa River.

In general, the soils are categorized within silty clay to fine sand and form normal stratification although slight falls are observed at rivers and channels. Consistency appears soft at surface and gradually becomes dense as deepening.

The soils are broadly classified into the following three layers.

From surface:

(1) Soft Silty Clay or Clayey Silt

Depth : up to 5 - 15 m
SPT : 0 - 5
Nature : soft, plastic with trace of decomposed organic matter

(2) Loose to Dense Silty Fine Sand

Depth : up to 40 - 55 m
SPT : 10 - 50
Nature : non-plastic with tract of mica and clayey silt from place to place

(3) Very Dense Silty Fine Sand

Depth : below 40 - 55 m
SPT : over 60
Nature : non-plastic, very dense with trace of mica

Note) SPT means the value by Standard Penetration Test.

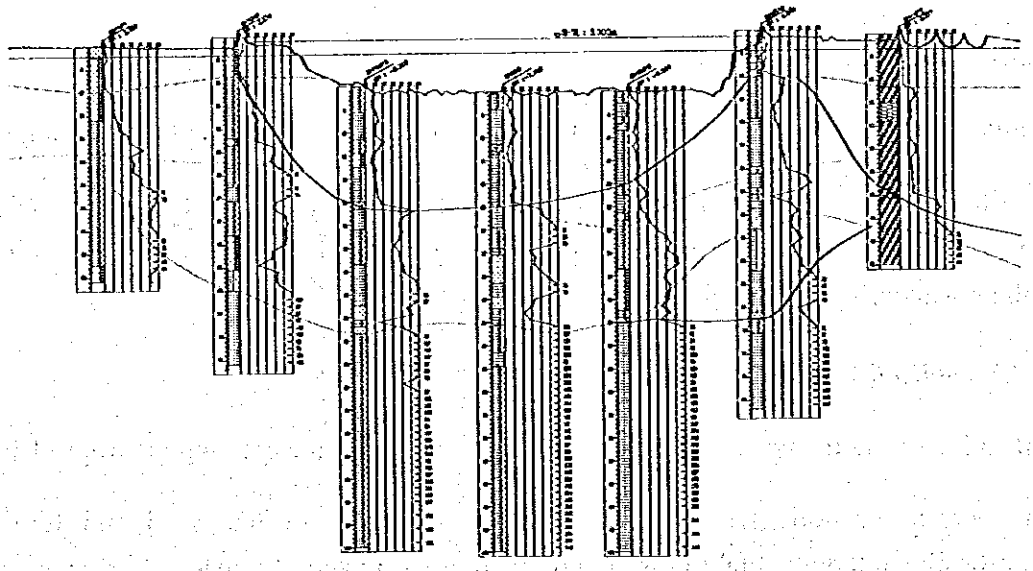


Fig. 3.3.1 Subsoil Profile across the Rupsa River

CHAPTER 4 SELECTION OF ALTERNATIVE PLANS

4.1 Selection of Route Alternatives

(1) Route Alternatives

Three alternative routes are contemplated to fulfill expected roles and functions as shown in Fig. 4.1.1.

Alternative-1: Urban Structure Scheme

The Urban Structure Scheme is planned to pass mostly undeveloped area where it is assumed to be the southern boundary of urbanization of Khulna city, thus bringing considerable development impacts to induce future urban structure in south-west direction as well as minimizing adverse social impacts.

Alternative-2: Mobility Scheme

The Mobility Scheme is planned to bypass presently congested roads and intersections in the downtown and it may enable the SSKB to provide good mobility to mainly medium to long trip traffic from the periphery of built-up area in Khulna City, which are not only through traffic of Khulna but also bypass traffic of origin/destination in Khulna. The location of river crossing is planned on the south of Khulna Shipyard.

Alternative-3: Accessibility Scheme

The Accessibility Scheme is planned to pass on the north of Khulna Shipyard where densely inhabited land use is found, and it is only for comparison purpose because the route could not help bringing serious adverse effects to inhabitants. However, it will be able to accommodate mainly short to medium trip traffic generated from and attracted to the built-up area of Khulna or its Central Business District.

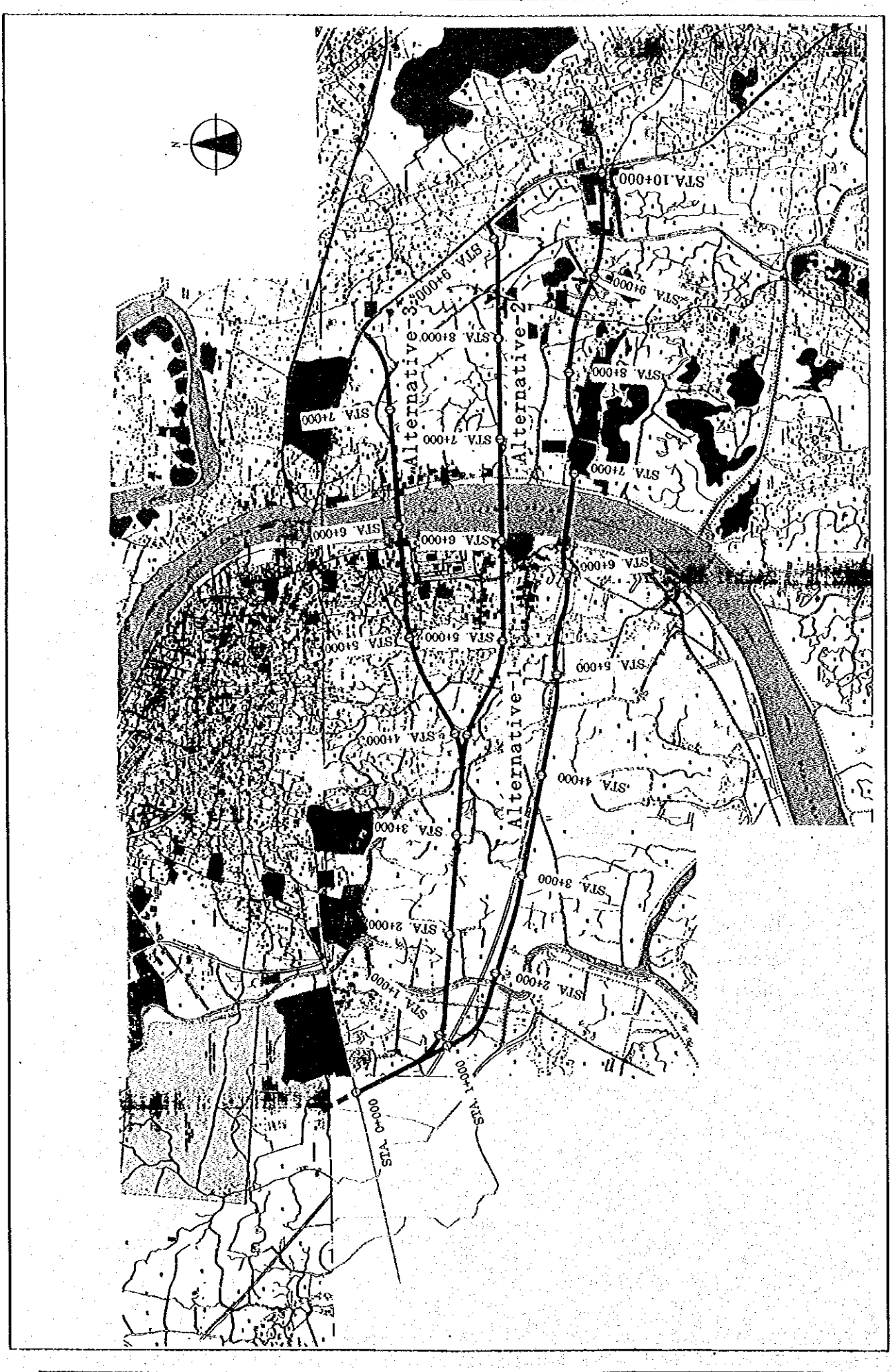


Fig. 4.1.1 Location of Each Route Alternative

(2) Evaluation on Route Alternative

Table 4.1.1 summarizes the comparison of salient features and differences revealed in association with route alternatives of which route location will bring about impacts physically, technically, socially and economically.

The comprehensive evaluation reveals the superiority of Alternative-1 quantitatively and qualitatively. The followings are summarized as its superiority.

(1) Rupsa Bridge has a complicated background and a number of relevant studies undertaken over a long span of time. Although it is very sure that substantial needs and social desire exist for the bridge over the Rupsa river locally as well as regionally, the Government of Bangladesh has firm intention to realize the project without any delay. The recommended plan has high land availability and least adverse social impacts so as to meet such requirement.

(2) Congested intersections at downtown of Khulna city as well as present Rupsa Ferry on National Highway No. 7 become serious traffic bottleneck to sustain Mongla Port and future development at the port area, and Rupsa Bridge is designated to be a part of Khulna Bypass to facilitate solving such situation. The recommended plan has primary functions to bypass such traffic bottleneck and simultaneously to bring benefits to congested downtown of Khulna city to avert through traffic.

(3) Considerable volume of local traffic at present Rupsa Ferry may be forced to make detour. However, the recommended plan has advantages that the following countermeasures are expected practically to cope with such situations so as to meet origin and destination of traffic.

1) to transfer existing facilities to KCC to accommodate non-motorized traffic.

2) to build bus terminals at present ferry terminals and to provide circumferential bus services between two terminals through Rupsa Bridge.

3) to improve existing crossing roads including dike roads at both sides of the Rupsa River to formulate a road network to collect/distribute local motorized traffic.

4) to provide Rupsa Bridge with sidewalks as well as staircases and slope for bicycle at pier-abutments to connect dike roads.

Table 4.1.1 Comparison of Salient Features of Each Alternative Route

Items	Alternative-1 : Urban Structure Scheme	Alternative-2 : Mobility Scheme	Alternative-3 : Accessibility Scheme
Outline of Alternative Route			
Road Length	10.034 km BP : 150 m from Weather Office on Satkhira Road EP : 4.8 km from Ferry Terminal at Rupsa East	9.234 km BP : 150 m from Weather Office on Satkhira Road EP : 3.6 km from Ferry Terminal at Rupsa East	7.758 km BP : 150 m from Weather Office on Satkhira Road EP : 1.8 km from Ferry Terminal at Rupsa East
River Crossing Point	2.6 km South from Rupsa Ferry	2.0 km South from Rupsa Ferry	1.0 km South from Rupsa Ferry
Land Area Affected (sq.m) in case of 36m ROW	363,600	338,400	295,200
Project Cost Estimates (Million Taka) 1) Construction Cost 2) Land Acquisition & Compensation 3) ES & SS Services 4) Total	 3,568.30 203.6 196.3 3,968.10	 3,479.30 255.4 191.4 3,926.10	 3,373.40 325.1 185.5 3,884.00
No. of Households Affected No. of Persons Affected	51 241	114 523	325 1,557
General Conditions of Land Use	1) Open spaces such as agriculture land, fishery ponds and shrimp farms spread widely. 2) Homesteads or residential area of single hut structure are scattered in local area.	1) Open spaces such as agriculture land, fishery ponds and shrimp farms spread widely except both sides of the Rupsa River. 2) Homesteads or residential area of bamboo houses are grouped in several areas.	1) Open spaces are limited and developed areas spread widely. 2) Densely inhabitated areas exist in the built-up area with semi-permanent structure houses.
1. Land Availability	1) **High** because the route is located in the periphery of urbanized area. 2) No difficult property or structure to be acquired is found.	1) **Uncertain** because the route will run to pass on the periphery of built-up area where scattered residential areas and homesteads exist.	1) **Poor** because the route will run to pass in the built-up area where residential areas and cluster of homesteads exist, and will violate public facilities such as primary school and mosque.
2. Social Impacts	1) **Lesser degree** because loss of cultivated lands will be limited to road right-of way acquisition and no resettlement plan will be required due to a few affected persons.	1) **Some Extent** because a number of affected persons may require to be relocated in groups due to no land availability to relocate within their own lot.	1) **Considerable** because a lot of affected persons may require to be relocated in groups due to no land availability to relocate within their own lot.
3. Construction Economy	1) **Medium** because road length is longer and land acquisition is wider but land price is cheaper and affected structures are less. 2) Less affected persons and structures make project implementation economical yet shorter.	1) **Medium** because costs of land acquisition and property compensation in developed area will increase project cost. 2) A resettlement plan will require time-consumed process, and it will result in less economy.	1) **Low** because road length is the shortest even though costs of land acquisition and property compensation in developed area will increase project cost. Site development for resettlement may increase the cost. 2) A resettlement plan will require time-consumed process, and it will result in less economy.
4. Development Impact	1) **Very high** to induce new urban development as well as to accommodate medium to long trip traffic in Khulna and its surroundings.	1) **High** because the road will bring considerable impacts to undeveloped areas along the route.	1) **Low** because the road will bring considerable impacts to limited undeveloped areas along the route.
Evaluation	**Superior** because it is practical yet implementable.	**Marginal** because it can achieve designated roles and functions of Khulna Bypass.	**Inferior** because it is far from practical yet implementable due to serious adverse social impacts.

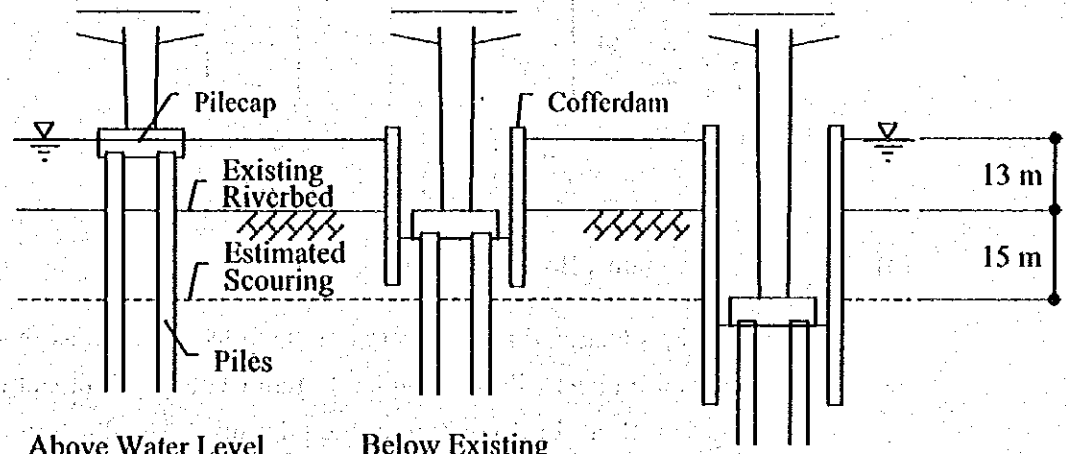
4.2 Selection of Bridge Structure Types

4.2.1 Rupsa River Main Bridge

4.2.1.1 Substructure

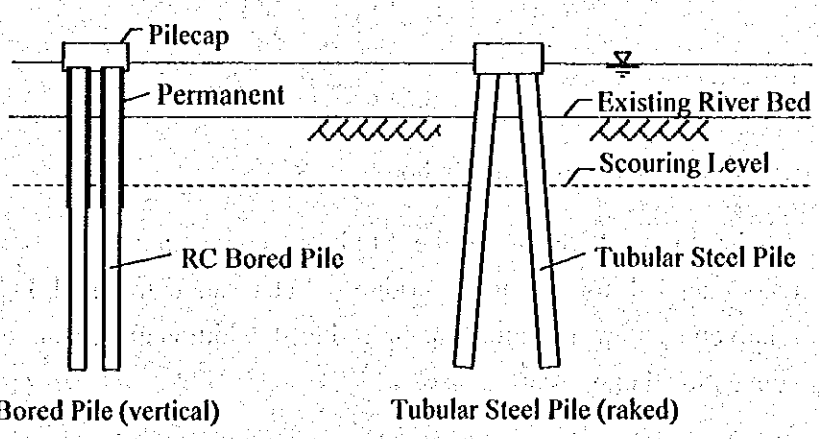
(1) Pier Foundation

- Pile foundation is required from the soft ground condition and the possibility of future river bed scouring
- Three types of pier, where position of pile cap differs, are compared as shown below. The pile cap position above water level (pile-bent type) is adopted for safety and economy of construction as well as for less scouring possibility.

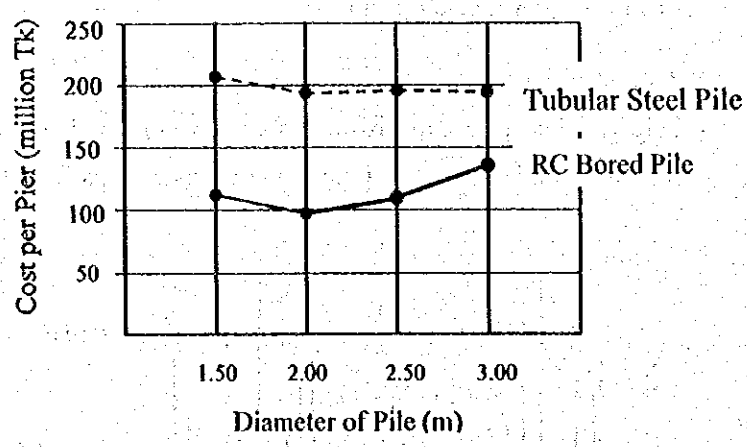


(2) Pile Type and Size

- The bearing strata lie about 50m deep. For such a depth, RC bored pile is the most suitable and which is commonly used in Bangladesh. Tubular steel pile is also a possible option.

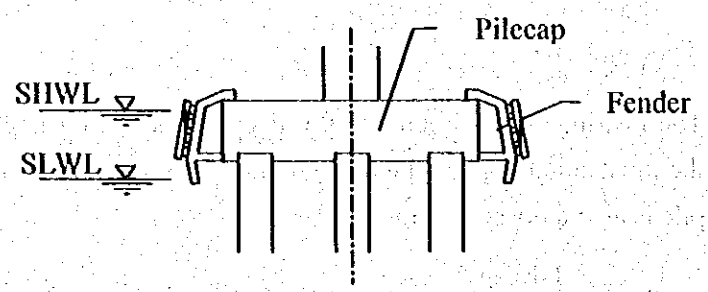


- The above two types of piles are economically compared for the diameters ranging from 1.5 to 3.0 m under constant superimposed load. From the cost comparison as shown in the figure below, the RC bored pile of 2.00 m in diameter is the most economical but the diameter needs as deep as 100 m of construction to ensure geotechnical capacity. Therefore, in design, the diameter of 2.50 m, for which requires a less construction depth of 75 m, is finally decided for more reliable construction though it is a little costlier.



(3) Pier Protection against Boat Collision

- A physical protection directly located on the pilecaps (such as fender made of concrete and timber) will be provided to relieve collision impact of vessels to the piers as well as for decoration of the pilecaps. The illustration below is a type of fender in design.



4.2.1.2 Superstructure

(1) Girder Type and Construction Method

- At the Phase 1 Stage of the Study, a conventional PC box-girder was recommended for the main bridge. Later, an extradosed PC box-girder, relatively a new technique, is introduced additionally as an option to the conventional one.

- Conventional PC box-girder usually holds prestressing tendons inside the box section, but the new type holds them outside the box section diagonally by pylons like cable-stayed bridge. These exposed cables enable the prestressed section more efficient by increasing eccentricity to the prestressing force.

- The merit of the extradosed over the conventional is that it can reduce the girder depth, which allows to lower the superelevation and thus save the overall bridge length.

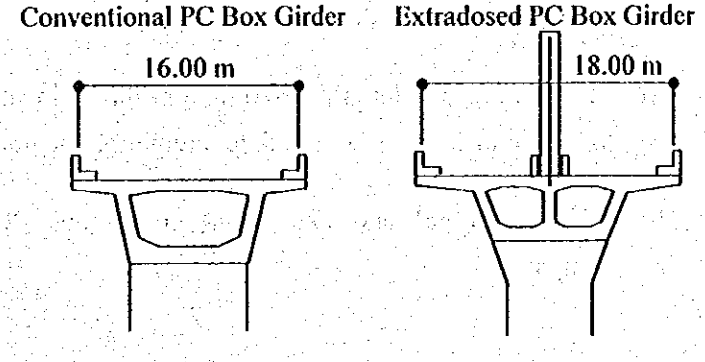
- Balanced cantilever segmental technique will be the most suitable method for erecting either type of PC box-girder bridges. This allows the navigation beneath the bridge even during the erection.

- Cast-in-place segmental method is preferred to precasting method for the rather small construction volume of the main bridge. The precast segment method requires vast yards and facilities within a certain reach of the site. This kind of capital investment will meet the demand to save total cost only for such long bridges as Jamuna (4800 m) and Paksey (1786 m), but will not in the Rupsa main bridge (640 m).

(2) Cross-sectional Design of PC Girders

- A single cell box cross-section with inclined webs is recommended for a conventional PC box-girder. Because, the single cell is the most efficient and the lightest cross-section compared with a multi-cell box. Also, the inclined webs give an esthetic view.

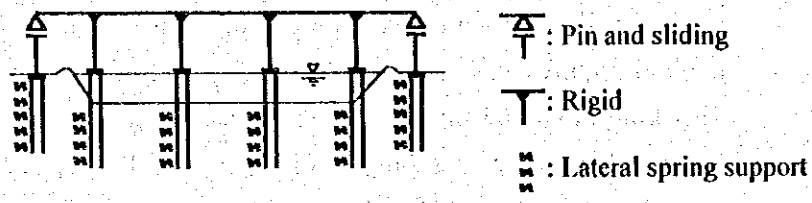
- However, an extradosed PC girder requires a double-cell box section, which has an additional web in the middle, resulting from a wider deck required in order to anchor the outer diagonal cables.



(3) Longitudinal Design of Girder and Supporting Details

- Continuous span arrangement is recommended. Reduction of number of expansion joints will not only improve rider comfort and economize the maintenance cost, but also the continuous beam is suitable to the aforesaid balanced cantilever segmental construction method.

- A rigid frame structure as illustrated below is designed for its structural advantages. Such as (1) the structural stability is high due to the structural indeterminacy. (2) the rigid connection of pier and girder is suitable for the balanced cantilever erection method, and (3) the more the members are constrained at joints, the more economical in initial and future maintenance costs.



- Notwithstanding the advantages, there is a problem that has to be verified by structural analysis on the rigid frame. That is, due to thermal expansion and/or shrinkage contraction, the frame will behave accordingly and the pier column has forces such as horizontal forces and bending moments which proportion the substructures. As the main bridge is planned high in elevation from the river bed to have slender and flexible piers for the substructures, the rigid frame structure is well suited. The structural analysis resulted in reasonable number and diameter of piles for the intermediate piers, they consist of six piles of 2.50 m in diameter for a pier.

(4) Selection of Superstructure Type and Span Length

- Herein the conclusions described so far are arranged:

  a) The main bridge length is 640 m, and the main spans have to be 100 m or longer in order to accommodate navigation clearance.

  b) A conventional and extradosed continuous PC box-girder types are compared.

c) Either type of the PC girders will be constructed by a cast-in-place balanced cantilevered erection method.

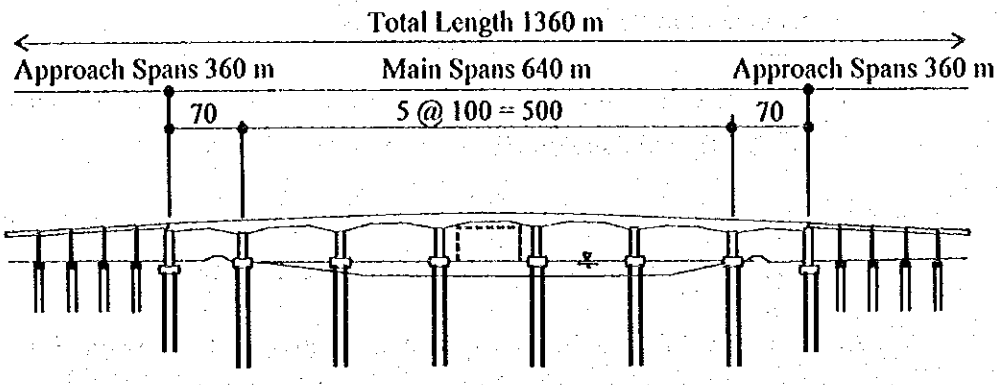
d) A single cell with inclined webs forms a cross-section of the conventional PC girder, and double-cell for the extradosed girder.

e) All the piers except the end piers are fixed rigidly to the superstructure, thus the super- and substructure form a rigid frame structure.

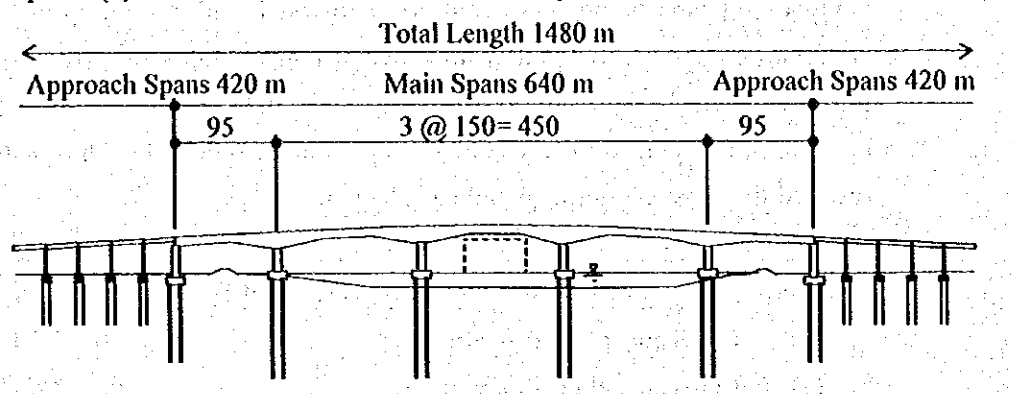
- According to the conclusions mentioned above, the following four options were established, studied and compared. From maintenance and navigational aspects, no significant problem was found in all the four options. As regards construction practicality, actual constructions of extradosed type bridge are very limited and no experience in Bangladesh so that the type may be unfamiliar depending on contractors. Furthermore, the Option (1) was resulted the most economical and so selected.

Option	Girder Type	Number of Spans	Span Length (m)
(1)	Conventional PC Box-girder	7	70 + 5@100 + 70
(2)	Conventional PC Box-girder	5	95 + 3@150 + 95
(3)	Extradosed PC Box-girder	5	95 + 3@150 + 95
(4)	Extradosed PC Box-girder	4	120 + 2@200 +120

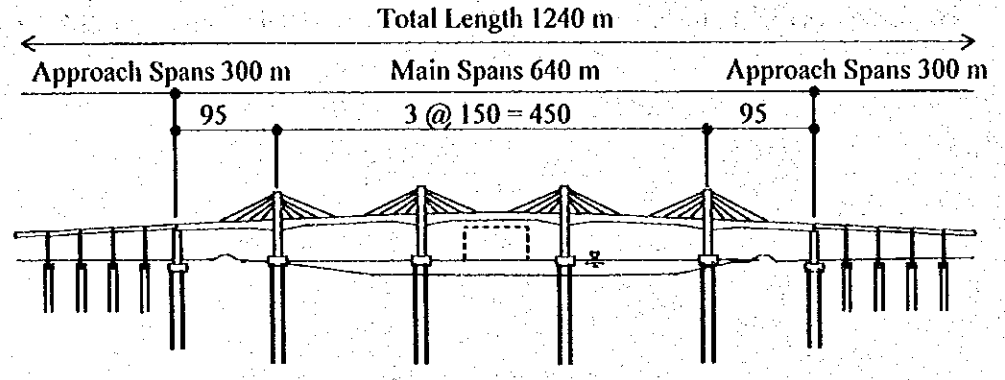
Option (1) : Conventional PC Box Girder 7 Spans



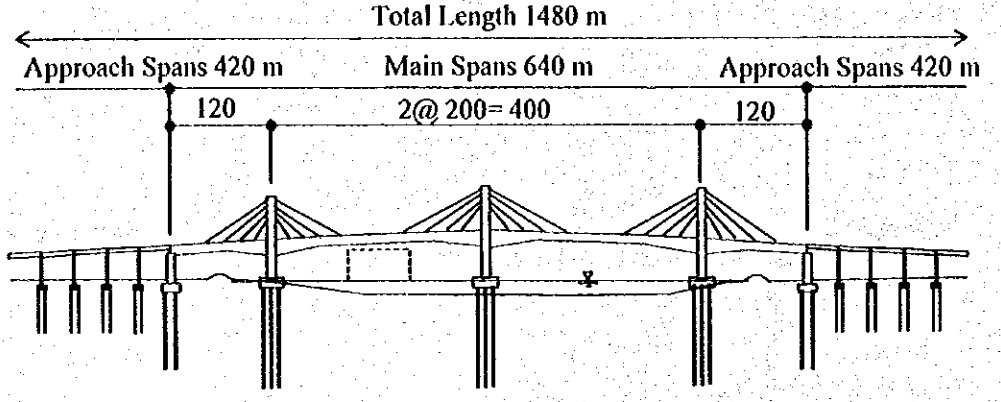
Option (2) : Conventional PC Box Girder 5 Spans



Option (3) : Extradosed PC Box Girder 5 Spans



Option (4) : Extradosed PC Box Girder 4 Spans



4.2.2 Rupsa River Approach Bridges

(1) Pier Type

- Multiple (four) column type is the most suitable for the approach bridges, because of its rigid frame action in transverse direction against the lateral wind load and its flexibility in longitudinal direction to the thermal expansion and/or shrinkage contraction of girders.

(2) Abutment Type

- As the surface soils up-to about 10 m in depth are soft, the height of embankment at abutments is limited to 5 m.
- The closed abutment together with parallel wing walls is adopted, because of its rigidity and satisfactory performance so far on the soft ground of Bangladesh.

(3) Pile Type and Size

- The depth of bearing strata varies from 25 to 55 m. For this range of depth, RC bored pile is adopted as the standard pile for the approach and canal bridges for its economy and wide practicability in depth. For such advantage, the pile is widely used in Bangladesh.
- A diameter of 0.90 m is designed according to the size of bridges.

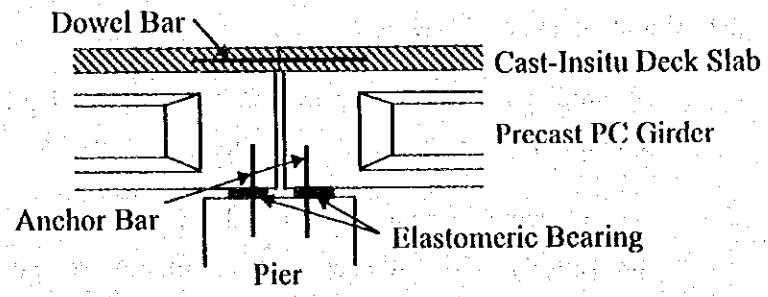
(4) Standard Precast PC Girder and Span Length

- PC girder is selected in preference to RC girder, because the RC girder will result in short span and clumsy appearance for having too many piers.
- In design of PC girder, the AASHTO's standard section of precast girder is applied to promote standardization of design and construction practice which will help in reduction of bridge costs.
- Through the cost comparison for different span length ranging from 20 to 35 m, the span length of 30 m is found to be the most economical and so the approach bridges are designed on this basis.
- Following the general practice for this type of bridge, cast insitu RC deck slab composite with precast PC girders is selected for the approach bridges. The

deck slab is designed to have a thickness of 0.20 m assuming a girders spacing of 2.40 m.

(5) Deck Continuity Design

- Deck continuity design is adopted to eliminate expansion joints. As shown in the following detail, all the connections between girders and piers and between deck slabs are assumed pinned.



- As all the spans in a 360 m long approach bridge are connected, expansion joint will be placed only on either boundary pier between the main bridge and the approach bridges.

- Like the main bridge, the safety of piers against the horizontal forces due to thermal expansion and/or shrinkage contraction of girders, was verified by the frame analysis of entire bridge structures.

4.2.3 Canal Bridges and Culverts

(1) Design High Water Level and Required Clearance

- Because the canals are interconnected, the water level remains same everywhere within the canal system. Based on the site survey including interviewing the local people, the following design SHWLs (standard high water levels) are established:

West bank of the Rupsa river:	1.90 m PWD
East bank of the Rupsa river:	1.60 m PWD

- Regarding the requirement of freeboard, following three different classes are established based on the canal water traffic survey:

Water Traffic	Freeboard provided (m)	Structures falling under category
No navigation	0.30	4 Culverts
Small boat	1.80	5 Culverts & Molonghata bridge
Boat with sail	3.50 (*1)	Hatia bridge

Note *1: Same freeboard as that of the existing Gallamari bridge located at upstream of the Hatia canal.

(2) Bridge over Hatia Canal

- For the bank to bank distance of 71 m, a 90 m long bridge is provided having three spans of standard 30 m PC girders.
- 0.90 m in diameter of RC bored piles same in size as that of the approach bridges are used. For the depth of water rather deep about 7 m, the pier is designed with the pile cap above water level which does not require cofferdam.
- For the skew angle (84 degree) of the bridge to the canal, the pile rows of piers are kept parallel to the flow of water to minimize the width of obstruction. However, the abutment and the pier head are kept perpendicular to the bridge axis for simplicity both in design and construction.

(3) Bridge over Molonghata Canal

- For the bank to bank distance of 33 m, a 30 m long bridge is provided with a single span of standard 30 m PC girders. The channel is constricted by 3 m, but no hydrological problem will occur because the flow is regulated by sluice gate of size much less than the opening provided.

(4) Culvert Design

- In total nine sites are selected for box culverts. Out of these three are skew by 70 to 80 degree angle.
- The width of culverts covers the full width of road embankment. The invert level is placed at least 0.30 m below the lowest bed level. Wherever the normal road level goes above the deck of culvert, fill is allowed on deck or otherwise the road level is raised to accommodate base and surfacing course on deck.

4.3 Major Facilities of Selected Route and Bridges

The Southern Section of Khulna Bypass is of 10,039m long, comprising following components:

(1) Rupsa River Bridge: L = 1360m, W =16.0m

1) Main Bridge
   - Superstructure: 7-span rigid frame PC box girder 70m + 5@100m + 70m = 640m
   - Substructure: RC bored piles, diameter 2.50 m and pile-caps on water level

2) Approach Bridges
   - Superstructure: standard PC girder composite with RC deck slab, 2 x 12 @30m = 720m
   - Substructure: RC bored piles, diameter 0.90 m

3) River Revetment: 50m wide x 150m long on the east bank

4) Pier Protection: at piers of main bridge in the water against scouring

(2) Approach Road: L = 8679 m (west section L = 5880 m, east section L = 2799 m)

1) Typical Cross Section

Roadway width	: 21.50 m
Through travel way	: 2 x 6.00 m
	(through travel lane 3.50 m, slow-moving lane 2.50 m)
Median	: 5.50 m (include inner shoulder)
Inner shoulder	: 1.00 m
Outer shoulder	: 2.00 m (use for sidewalk)

2) Canal Bridges
   - Hatia bridge: L = 3 x 30 m = 90 m, W = 2 x 9.00 m
   - Molonghata bridge: L = 1 x 30 m = 30 m, W = 2 x 9.00 m
   - Superstructure: standard PC girder composite with RC deck slab
   - Substructure: RC bored piles, diameter 0.90 m

3) Box Culvert

No.	Station	Name of Canal	Angle (degree)	Length (m)	Opening		
					Height (m)	Width (m)	Number of Cells
1	3+219	Alutala	90	23.000	1.500	4.000	2
2	3+760	Aralia	70	24.476	2.000	7.500	3
3	4+660	Narikal Baria	90	23.000	4.750	19.000	4
4	5+436	Karate	90	23.000	2.000	4.000	2
5	5+643	Laurir	70	24.476	3.500	14.000	4
6	5+882	Moyur	90	23.000	4.000	13.500	3
7	6+266	Khetra	80	23.355	4.000	12.000	3
8	6+496	Moriyutsure	90	23.000	2.000	12.500	5
9	9+860	Besar	90	23.000	4.000	12.000	3

4.4 Related Facilities

The following facilities are to be constructed related to the Southern Section of Khulna Bypass:

1) At-grade Intersection: six (6) locations

2) Toll Plaza (barrier type gate) for through travel lanes: five (5) booths
for slow-moving lanes: four (4) booths

3) Bus Bay: two (2) points

4) Staircase with Bicycle Slope: both sides and both ends of the Rupsa river main bridge

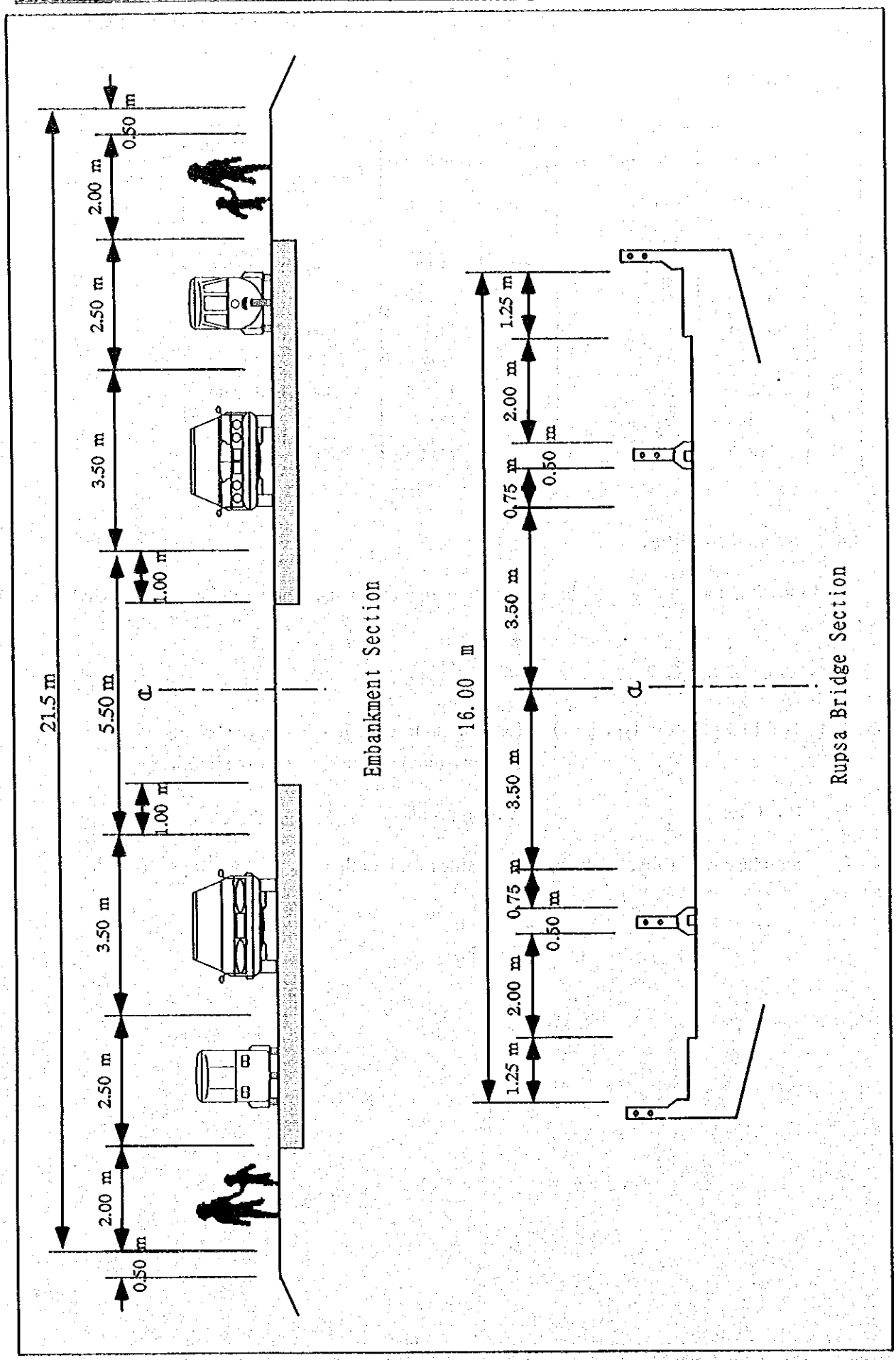


Fig 4.3.1 Typical Cross Sections of Embankment and Rupsa Bridge