CHAPTER 7 FORMULATION OF TRANSPORT MASTER PLAN

7.1 Planning Parameters

(1) Scheme of Khulna Bypass

The scheme of Khulna Bypass is to be studied for route location and configuration of road itself from viewpoints of road planning and highway engineering in both the eastern and the western sides of the Rupsa river.

The scheme of Railway Extension to Mongla Port is assumed to connect existing railway to Mongla Port only to accommodate future cargo demand, and such future demand will be examined whether it enables to sustain railway operation in terms of its economical, financial and managerial viability.

The scheme of rail-cum-road bridge may be one of alternatives to enhance possibility of the extension plan by reducing construction costs.

(2) Cross Sectional Configuration

Khulna-Mongla Road is designated rural arterial road to connect regional/district centers such as Mongla International Port and Khulna the third largest city in Bangladesh, while Khulna Bypass proposed by Khulna Development Master Plan is designated urban arterial road to strengthen road network in Khulna city and its surroundings.

Rupsa Bridge which is located in the western side of the Rupsa river is to have one of expected roles and functions to be substituted for Rupsa Ferry, in which commuter traffic is found major users and non-motorized vehicles are also potentially dominant. Accordingly, the Bridge is regarded as a city bridge in urban area, namely cross sectional configuration comprising through traveled lanes with shoulder plus space for non-motorized vehicles and pedestrian.

(3) Navigation Clearance at River Crossing Points

Navigation clearance beneath the Bridge is appropriately reserved to provide space vertically and horizontally for letting design vessel pass safely even on high water level. It is also pointed out that navigation clearance is not only dependent on maximum vessel in the past but also related to managerial policy of the river such as future development along the river and salvaging allowance.

Navigation clearance of rivers in Bangladesh is controlled under jurisdiction of Bangladesh Inland Water Transport Authority (BIWTA).

The four rivers in the study area, namely Bhairab, Atai, Atherobaki and Rupsa have already had specified navigation clearances by the document which the BIWTA made to reply officially to the RHD's questionnaire.

Therefore, specified navigation clearances at each bridge crossing point are not planning parameters but precedent design criteria.

(4) Appropriate Slope of Approach Section

Grade on approach road is close relations to design speed and traffic capacity in terms of planning and scale of land acquisition area and social impacts in physical aspects. Greater grade may bring about lower in planning and smaller in physical constraints, and on the contrary flatter is higher in planning and bigger in physical.

Although all passenger cars can readily negotiate grades as steep as 5% without significant loss in speed below that normally maintained on level highway, 3% of maximum grade has been widely applied to bridges on National Highways in Bangladesh. Furthermore, salient features of road traffic in the study area are predominant non-motorized traffic, consisting of rickshaws and carts.

Under such circumstances, application of flatter grade is desirable yet practical from the aspect that trucks of quite an old vintage prevail and they also move slowly due to overloaded and shortage of horsepower among motorized vehicles.

(5) Adverse Social Impacts

Adverse social impacts will be brought more or less by road development in urban area, even though route selection should be made to minimize violation of existing community and public facilities. One of most serious issues is resettlement of affected inhabitants due to land acquisition, and loss of arable land, fishery and public disturbances during construction also bring adverse impacts to society.

It is sure, however, that road is most fundamental infrastructure as a means of communication, and road development enables to improve society in terms of accessibility, mobility and quality of life as well as to increase land productivity along roads significantly.

"Slope of Approach Section" and "Adverse Social Impacts" are in trade-off relationship. Flatter grade makes slope of approach section longer, and embankment on long approach road results in larger land acquisition to increase probability of occurrence of social problems. It is sure that rail-cum-road

bridge should require flatter grade in approach section and thus larger land should be acquired, taking into consideration difference of 3% in road from 1% in rail.

(6) River Morphology

Shifting of river bed, erosion of slope and embankment, scouring and sedimentation around structures in water are always taking place in the river. Such phenomena are observed in all the rivers to greater or lesser degree in case of no river training.

To cope with the phenomena and to make the Bridge sound and stable, some river training is indispensable where building dike, ground sill and revetment of slope are built in general. Simultaneously, inspection roads are constructed normally on the top of embankment to maintain dike.

There are several evidences and certain witness to envisage scale of river morphology in the study area. The most remarkable phenomenon occurs in the Atai river where shifting of river bed of more than 500 m far is taking place in the vicinity of merging point with the Bhairab river. Accordingly, the bridge crossing the Atai river will require longer main span as well as large scale river training.

7.2 Roles and Functions of Rupsa Bridge

The roles and functions of the Bridge have been deliberated for a long span of time, and they are categorized into four, namely i) Alleviate Traffic Congestion of Rupsa Ferry, ii) Strengthen Khulna - Mongla Road by Non-River Interruption, iii) Promote Khulna Bypass and iv) Stimulate Mongla Port to Induce Freight Demand.

However, it becomes clear and distinct that the Bridge should play roles and functions pertaining to them, considering circumstances of formulation of on-going Khulna Development Master Plan and progress of Paksey Bridge Construction Project.

7.3 Related Transport Facilities

Traffic demand forecasts are carried out, having assumptions that following transport facilities related to the Bridge are to be improved in order to sustain future traffic demand systematically and comprehensively. The location of these transport facilities is shown in Fig. 7.1.

(1) Khulna Bypass

Rupsa Bridge is designated to be a part of Khulna Bypass and to cross the Atai/Rupsa river on National Highway No. 7. An appropriate type and location of the Bridge will be selected in the course of the Study within the corridor covering Alignment-A & B studied by ADB, examining possibility of railway extension up to Mongla Port.

Table 7.1 summarizes the comparison of salient features and differences revealed in association with route location of which Khulna Bypass is located either in the eastern side of the river or in the western side.

(2) Railway Extension to Mongla Port

The Railway Extension to Mongla Port is planned in the Study to connect existing railway to Mongla Port only to accommodate future cargo demand by its own route.

Bangladesh Railways (BR) had studied the railway extension to Mongla Port in the past. The southern part of the extension was almost similar to Khulna-Mongla Road in the section between Rupsa East and Mongla Port, but its northern part was different from that of the MPADP. The eastern route (B) diverts Khulna City in order to evade a high clearance bridge at the Rupsa river, while the western route (A) goes in the suburbs of Khulna City. The railway extension is approximately 40 km in length, of which the land in 15 km long stretch was reported to have been acquired and owned by the BR.

(3) Multi Modal Terminal at Khulna Port Area

The cargo throughput of Mongla Port is expected to dramatically increase up to the year 2015. Although it is presumed that most of these container cargo would be transported by land transport means through the improved future land-transportation-networks in the hinterland of Mongla Port, the major portion of the inland transport of the port cargo would be still performed by inland water vessels. This is the most suitable transportation system for Mongla Port, which has lots of anchorage space with the limited number of jetty berths, and is also environmentally friendly means of transportation with the best energy efficiency. According to the possible increase of port cargo movement to/from Mongla Port by inland water, the necessary considerations should be given to the development of Multi Modal Terminal at Khulna Port area, which currently handles approximately a third to a quarter of cargo volume to/from Mongla Port by inland water.

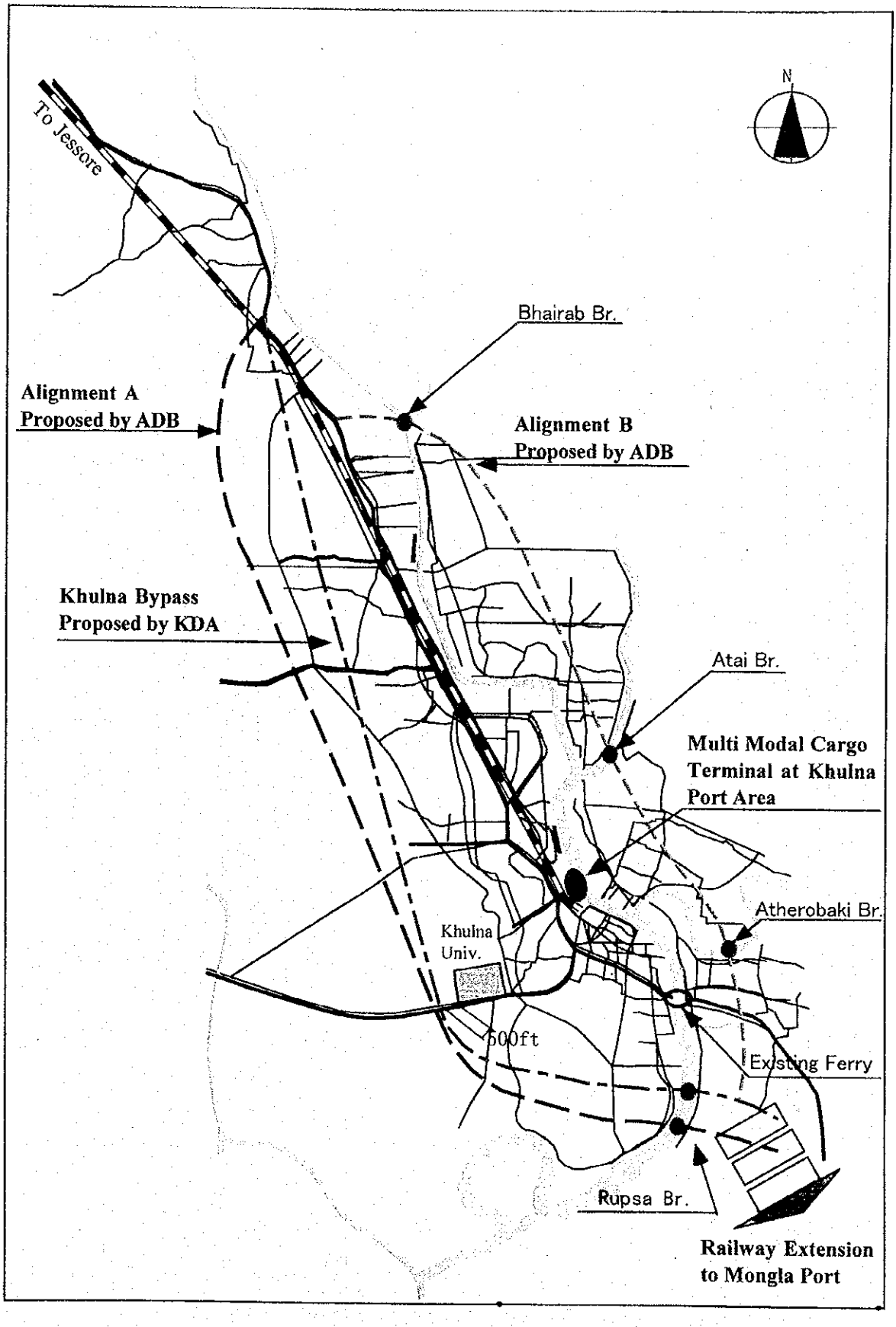


Fig. 7.1 Location of Bridges and Related Transport Facilities

Table 7.1 Comparison of Salient Features of Bridge and Approach Road on Alignment-A and B

Items	Alignment - A (in the western side of the Rupsa river)	Alignment - B (in the eastern side of the Rupsa river)
Outline of Bridge and Approach Road		
Road Length	10 km Between Khulna-Satkhira Road and Khulna-Mongla Road	20 km Between Cantonment in Siromoni on Khulna - Jessore Road and Khulna-Mongla Road
Bridge Length & Navigation Clearance	Rupsa Bridge : 1,385 m with H=76.22 m, V=18.3 m	Bhairab Brdige : 823 m with H=76.22 m, V=12.2 m Atai Bridge : 923 m with H=76.22 m, V=12.2 m Atherobaki Bridge : 488 m with H-30.48 m, V=7.62 m Total Bridge Length : 2,234 m
General Conditions of Land Use	1) Arable lands spread widely in the western side of the river and shrimp farms exist in the eastern side. 2) Affected villages will be limited.	1) Villages have been densely developed along the river and scattered villages are also found in arable lands. 2) Affected villages will be considerable due to passing through the suburbs.
1. Land Availability	1) **Very high** because the route is located in the periphery of urbanized area. 2) The northern part of the Bypass is planned by KDA and acknowledged by Ministry of Land.	1) **Uncertain** because the routes have to pass in the suburbs with scattered villages. No commitment is made.
2. Future Traffic Demand	1) **Very high** to accommodate traffic demand to/from Khulna and its surroundings as well as to let present traffic at Rupsa Ferry divert.	1) **Low** because the route will serve only through traffic bound for beyond Khulna and hardly contribute to alleviate traffic congestion at Rupsa Ferry.
3. Social Impacts	1) **Lesser degree** because loss of cultivated lands with certain productivity will be limited to road right-of way acquisition due to few resettlements.	1) **Considerable** because cultivated lands with certain productivity will be acquired for road right-of way acquisition and resettlements for affected inhabitants.
4. Construction Economy	1) **Smaller** because of one bridge of totaling 1,390 m in length including 590 m main spans just in case of 60ft navigation clearance with 3% grade. 2) One construction site will be able to make works more economical yet shorter.	1) **Bigger** because of three bridges of totaling 2,230 m in length including 870 m main spans even in case of 40 ft and 25 ft navigation clearance with 3% grade. 2) Three construction sites will make works inefficient yet longer.
5. River Morphology	1) **Sound** because the western bank of the Rupsa river is comparatively stable in spite of high current velocity. 2) A conventional river training is required.	1) **Changeable** because the Atai river moves considerably and the Atherobaki river meanders sharply. 2) Intensive river trainings will be required.

Note : Lengths of road and bridge are estimated on the assumptions that the grade is 3% and the maximum embankment height is 5 m high.

7.4 Recommended Transport Master Plan

(1) Development Scenario

Following three (3) development scenarios are contemplated in association with potential traffic on the Bridge.

1) Scenario-1 : the Bridge with Railway Extension to Mongla Port

Land transport shall be enhanced to access to/egress from Mongla Port to accommodate long-trip cargo demand in this case, providing that the hinterland of Mongla Port will extend considerably to the North-western region. This traffic movement will support the possibility of railway extension plan to Mongla Port in case that long-trip cargoes such as Nepalese transit cargo become dominant in future. It will also examine the possibility of Khulna Bypass in the eastern side of the Rupsa river.

2) Scenario-2 : the Bridge with Multi Modal Terminal

Incremental container cargoes handled at jetties will be transported by land transport network in the hinterland of Mongla Port, and Multi Modal Terminal will become necessary at Khulna Port area to build inland links between railway, road and waterway.

This scheme is deliberated as a practical solution from managerial viewpoints of present railway because container base/bases at an arrival side is indispensable in the western inland area if container trains should run on the western zone from Mongla port. Simultaneously, it might become a good chance to renew the freight system by rail in the western zone, including the introduction of the airbrake and automatic coupling to the freight cars.

3) Scenario-3 : Only the Bridge

This case forms remarkable contrast with the former two scenarios regarding degree of traffic movement beyond Khulna, namely significantly low traffic movement beyond Khulna. On the contrary, local traffic will become dominant demand pertaining to the Bridge. This traffic movement will badly require Rupsa Bridge itself to cross the Rupsa river, and it will not support the possibility of railway extension plan to Mongla Port.

(2) Evaluation and Recommendations

Present Rupsa Ferry will become 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 Multi Modal Terminal at Khulna Port area in case of its realization

2) At most 478,000 tons/year cargo traffic demand for the year 2015 will be generated and attracted at Mongla Port through railway, if Railway is extended to Mongla Port. Although the possibility of the extension plan will be examined in the course of the Study on the basis of this demand forecast, it is as a matter of fact that this demand is a half of freight in present Khulna - Jessore section.

3) Traffic assignment of Case 1 supported by Development Scenario-2 is evaluated as the optimum alternative for the Study from the following aspects;
   a) Although it is presumed that most of these container cargo would be transported by land transport means through the improved future land transportation networks in the hinterland of Mongla Port, the major portion of the inland transport of the port cargo would be still performed by inland water vessels. This is the reason why it is the most suitable transportation system for Mongla Port and is also environmentally friendly means of transportation with the best energy efficiency.
   b) Although on-going Paksey Bridge will be completed and future land transportation network will be improved toward the north as the hinterland of Mongla Port such as North-Western Region and Nepal, Cargo Movement beyond Khulna subject to rail transport is estimated 478,000 tons/year at most, that is medium.

CHAPTER 8 PRELIMINARY ENGINEERING STUDY

8.1 Highway Design

(1) The Outline of Road Planning

1) Khulna Bypass

The Study comprises the Bridge and other related facilities. The related facilities are contemplated infrastructures such as road, railway and inland waterway to accommodate passengers and freight passing through the Rupsa Bridge.

The transport master plan is formulated to delineate Railway Extension to Mongla Port and Multi Modal Terminal at Khulna Port. They are close relationship to designated roles and functions of the Rupsa Bridge to strengthen the traffic network of Khulna City and its surroundings as well as to stimulate Mongla Port to induce freight demand.

Rupsa Bridge is to be located on Khulna Bypass and to cross the Atai/Rupsa river as shown in Fig.8.1.

There are four (4) possible bridges involved in the Study. Every bridge is named referring to river name at river crossing point, namely Rupsa Bridge on ADB's Alignment-A (the Western Route) and Bhairab Bridge/Atai Bridge/Atherobaki Bridge on ADB's Alignment-B (the Eastern Route).

Planning Parameters are studied for the deliberation upon major issues which have been encompassing the Bridge from technical, social, managerial, economical and financial viewpoints. These issues are deliberated in such ways of the scheme of rail-cum-road bridge in relation to the scheme of railway extension, cost difference in association with navigation clearance, degree of social impacts in different grade between road and railway and cross sectional configuration including lane for slow-moving vehicles.

The alternative study of bridge types is also made in the following Section 8.2.

2) Multi Modal Terminal

94% of the cargo throughput at Mongla Port is handled at either mooring buoys or anchorage areas. Major portion of the inland waterway transport of the port cargo will be performed by inland water vessels even though it is presumed that most of these container cargo would be transported by land transport means

through the improved future land transportation networks in the hinterland of Mongla Port. It is the reason why inland waterway is the most suitable transportation system for Mongla Port and is also environmentally friendly means of transportation with the best energy efficiency.

The Khulna Port is a river port under jurisdiction of BIWTA, and it extends north- and southwards along the Rupsa River with scattered facilities. BIWTA terminal is located at the center of Khulna City, and it is adjacent to the National Highway No.7, Roosevelt Jetty of Mongla Port Authority and Khulna Railway Station and its marshalling yard.

A Multi Modal Terminal is planned to be located in the area as shown in Fig.8.2 and the scheme is regarded as a re-development project of 80 ha in the vicinity of the existing BIWTA facilities, taking opportunity of strengthening road network by construction of the Rupsa Bridge as well as the south section of the Khulna Bypass.

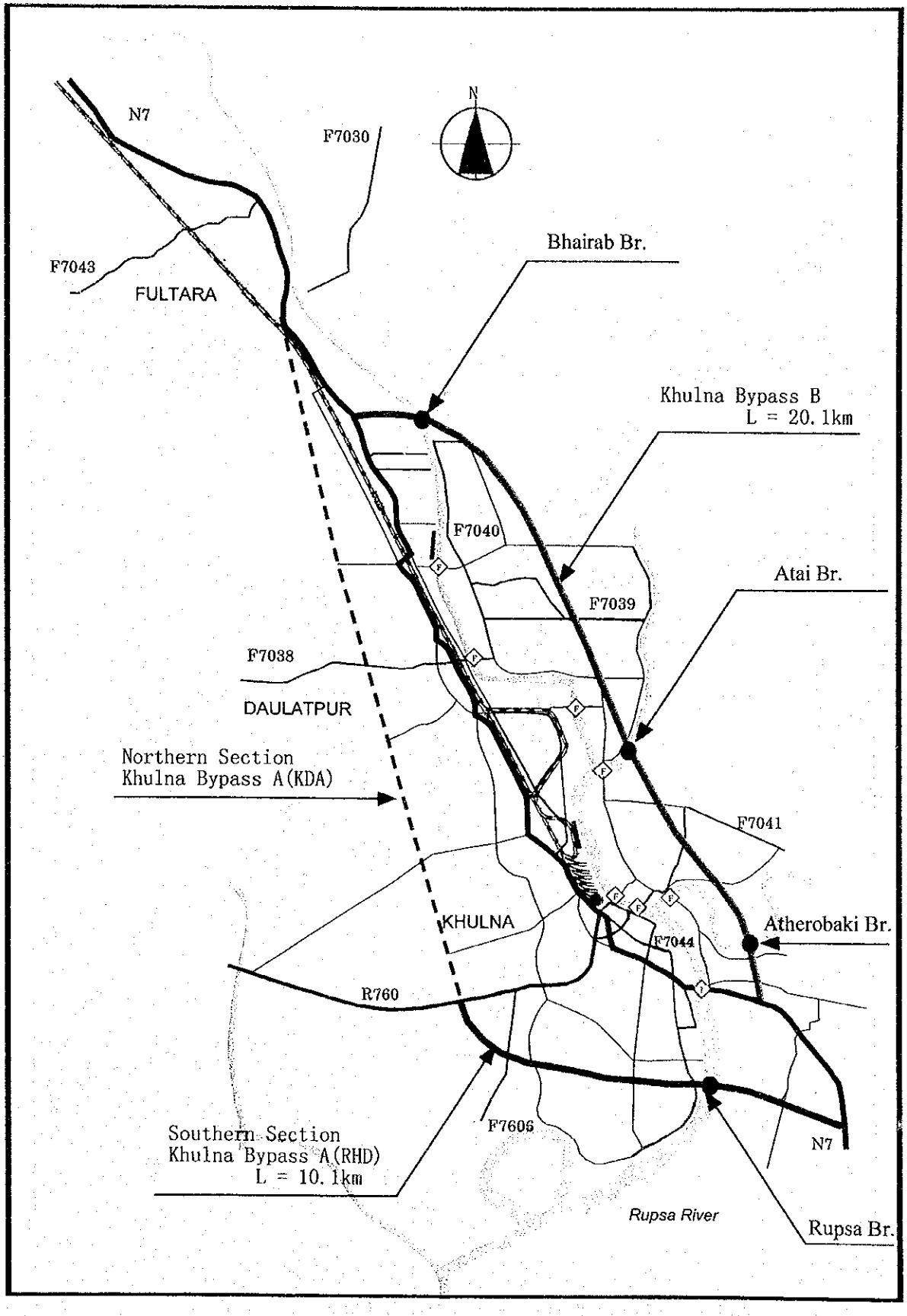


Fig. 8.1 Road Network Proposed by Khulna Master Plan

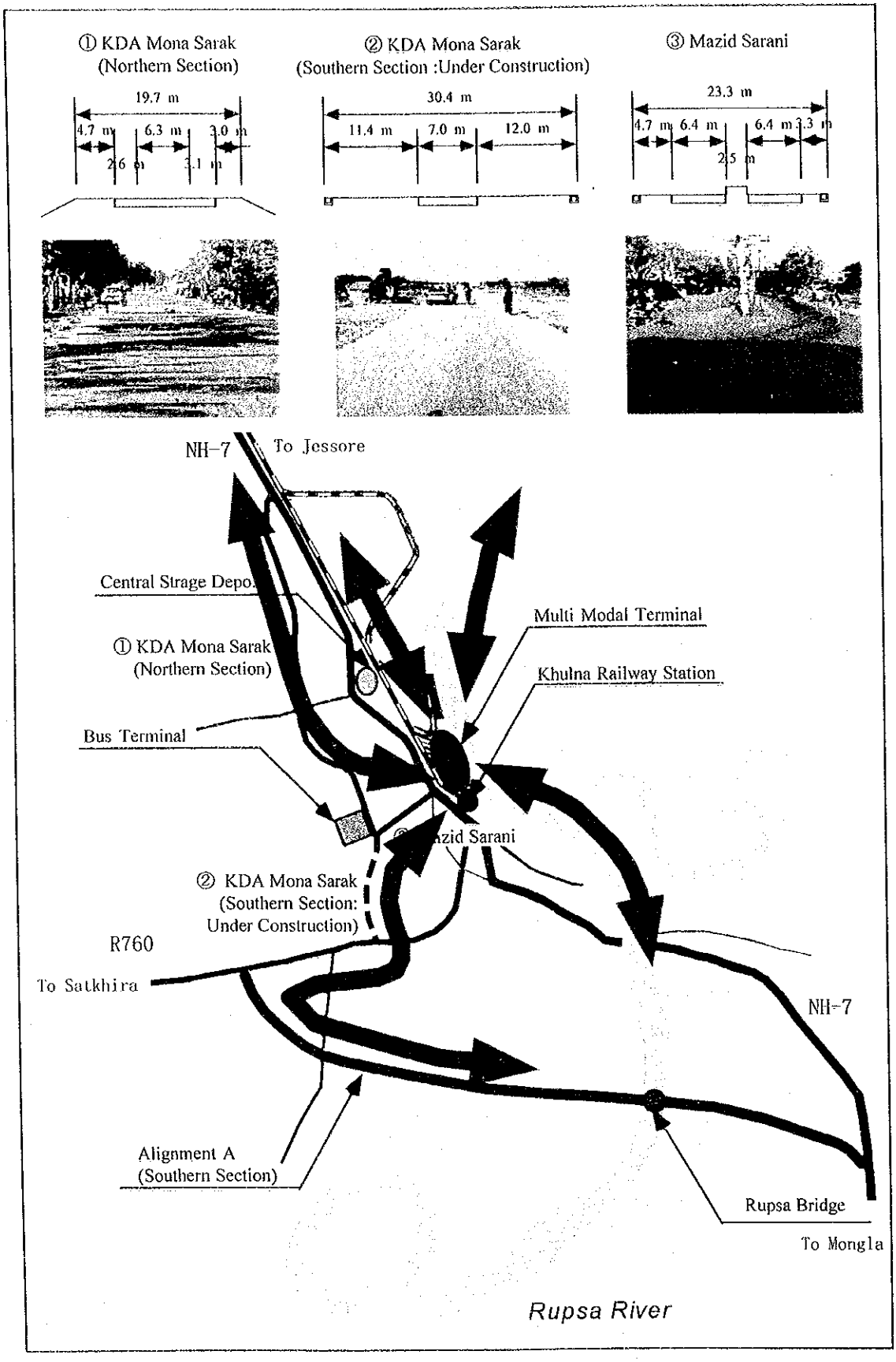


Fig. 8.2 Freight Transportation in Southern Khulna City

(2) Road Planning and Studied Road Sections

i) As shown in Fig. 8.1, KDA Master Plan proposes extension of 115 kilometers including the north section of Khulna Bypass A route 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 A route has a high priority and is expected to be commenced in 1998. The study has been conducted on the assumption that this is completed.

ii) The benefit estimate of road is worked out in such a manner that the case without the project (Case-0) is assumed as a base case, and then indices of difference of vehicle-hour and vehicle-km between Case-0 and Case-1, 3 are calculated from the results of distribution for the cases with the project, namely the south section of Khulna Bypass A route (Case-1: without railway extension) and the Khulna Bypass B route (Case-3: without railway extension).

iii) The case without the project signifies that none of the four bridges in the project is not yet realized while the road network in 2015 is completed, and therefore the Rupsa River is crossed only by ferry. The traffic distribution in 2015 will be calculated for the road network obtained by adding the road network plan proposed by Khulna Master Plan including the north section of the Khulna Bypass A route to the existing network.

iv) Meanwhile the case with the project means that the road network in 2015 and the bridges have been completed. Therefore where the Khulna Bypass takes A route, the object section is 10.1 kilometers of the south section under the jurisdiction of RHD between Cantonment in Siromony and Khulna-Satkhira Road. On the other hand, where B route is taken, then the object is 20.1 kilometers between Cantonment in Siromony and Khulna –Mongla Road. In either case, it is assumed in relation with the benefit estimate that the 17.6 kilometer of the north section under the jurisdiction of KDA will have been opened to traffic before the south section is opened.

v) Indicated below are the basic cases for the economic analysis;

① ALT 1-1: Traffic demand =CASE-1 (without railway extension) :
Section =Khulna Bypass, southern section of the west side :
Cross section =undivided 2-lane + sidewalk on both sides

② ALT 3-1: Traffic demand =CASE-3 (without railway) :
Section =Khulna Bypass, the east side :

Cross section =undivided 2-lane + sidewalk on both sides

(3) Alternatives for Road Planning

1) Approaches on Alternative Setting

i) Rupsa Bridge consist of the four bridges, is placed on the Khulna Bypass, are examined here only as road bridges on the east or west route.

ii) Undivided 2-lane was decided to be a basic idea of the roadway in the Study, as Judged from traffic demand forecast, shown in Fig. 8.3. Therefore, the basic cross section for each alternatives is taken as undivided 2-lane with sidewalk on both sides. 8.5 m is given to throughway for an undivided 2-lane, which enables a vehicle passing by a breakdown car stopping at a shoulder. Divided 4-lane also examined in order to compensate the uncertainty that the future demand forecast may have. The cross section is almost same scale of Paksey Bridge.

iii) The railway extension plan is studied so that it independently extends the railway from Khulna to Mongla Port. It is assumed that the railway bridges at four locations will be installed parallel to those of the road bridge, when the extension is considered.

iv) Maximum grade for the bridge portion is taken as 3.0% for the project. Japanese Road Design Standard specifies the maximum grade to be 5% for the design speed of 60km/h. If less grade such as 3% or 4% is taken, the bridge length will increase by 470m or 170m respectively compared with that of 5%, as shown in Fig.8.4. The reason for adopting the less grade of 3% is that the traffic characteristic in the Study Area is a traffic by a large number of vintage, over loading trucks. Maximum grade for rail-cum-road bridge is 1% considering relationship between traction power of locomotive and length of a freight train.

v) As development of the Multi Modal Terminal concerns to several departments of the Government, it is essential to regulate the situation in the aspects of the system and management. Accordingly only the scope of the works of the feasibility study is prepared just in case that the Multi Modal Terminal would carry out in the Phase II.

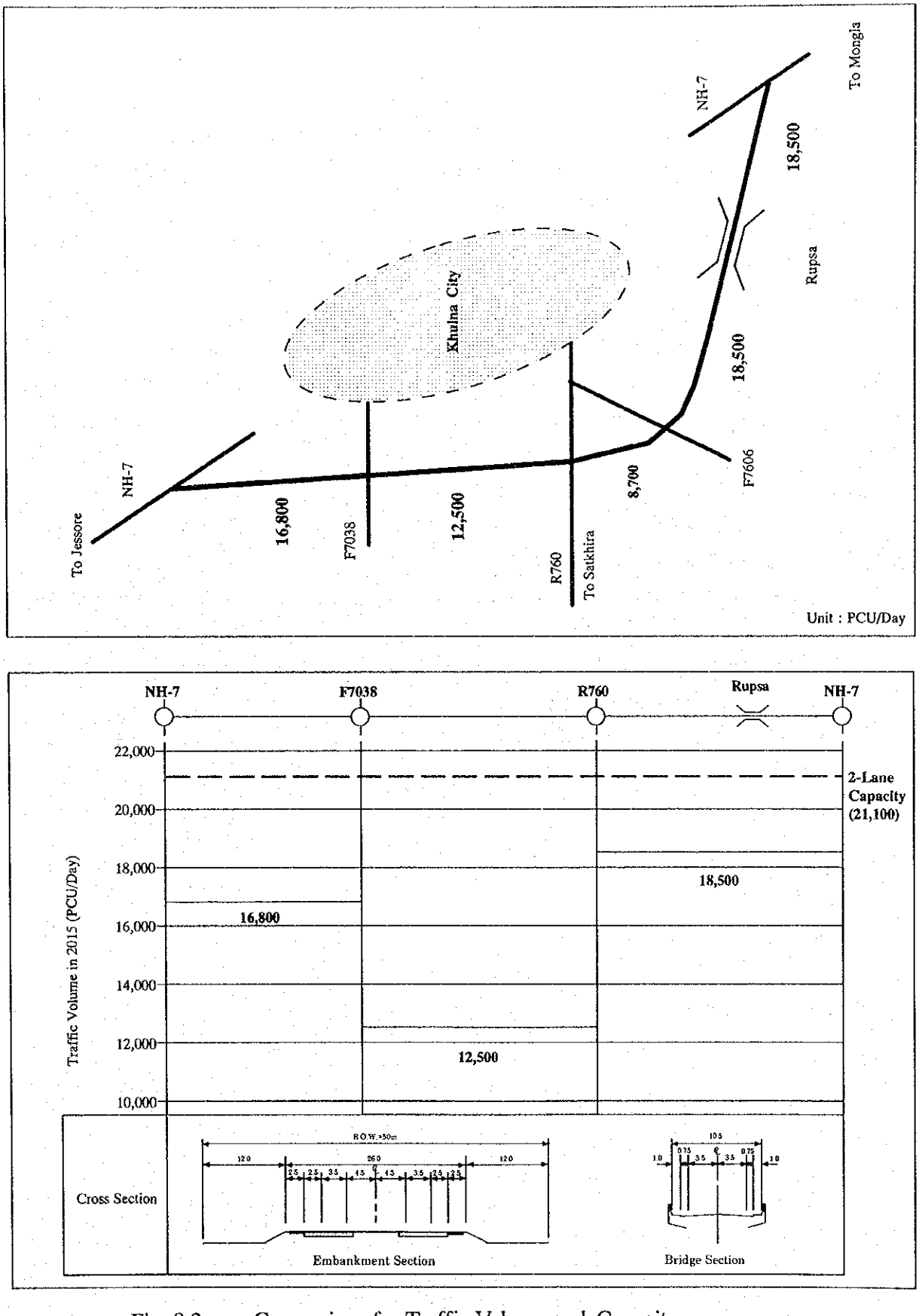


Fig. 8.3 Comparison for Traffic Volume and Capacity

2) Comparison for Rail-cum-Road Bridge

i) For the comparison of rail-cum-road bridge, it is assumed that the common structures between the rail and road part are to be built at once when the road bridge is constructed. Namely, the case is assumed that direct construction cost of railway is reduced, the cost for the common structures are borne by the road bridge.

ii) On the other hand, "the alternative of the rail-cum-road bridge only the main bridge (ALT 1-4)" and "the alternative of the rail-cum-road bridge through the whole length (ALT 1-6)", are compared with the alternative bridge (ALT 1-1) only for a roadway purpose on the assumption that they are used as roadway bridge initially until the railway facilities are completed, and then later are made use as rail-cum-road bridges. This aims at verifying the degree to which the road bridge will bear the burden of the initial investment from the aspect of investment efficiency.

iii) Fig. 8.4 shows the comparison of bridge length and direct construction cost among the alternatives taking Rupsa Bridge as an example. It is revealed that the costs of ALT 1-4 and ALT 1-6 are as high as 1.6 times and 3.8 times compared to that of ALT1-1.

Alternative	Studied Bridge				Direct Bridge Cost (M. Tk.)	Remarks
	Name	Main (m)	Approach (m)	Total (m)		
Road Bridge 2-Lane with Sidewalk No Slow-Track	Rupsa	640	720	1, 360	ALT 1-1 1, 341. 1 100%	3% of road grade Simple road bridge
Rail-cum-Road Br. 2-Lane with Sidewalk No Slow-Track	Rupsa	640	1, 140	1, 780	ALT 1-4 2, 126. 9 159%	3% of road grade and 1% of rail grade Rail-cum-road bridge
Rail-cum-Road Br. 2-Lane with Sidewalk Single Line	Rupsa	640	3, 180	3, 820	ALT 1-6 5, 131. 8 383%	1% of road grade and 1% of rail grade Rail-cum-road bridge

Note : 1) Direct construction cost of bridge covers costs between abutments and excluding 10% contingency.
2) In Road-cum-Railway Bridge, Direct construction cost of Approach Bridge for railway is not included.
3) 100 m span Continuous PC Box Girder with Cast In-situ Concrete Pile for Rupsa Bridge
4) 30 m span Composite PC I-Girder with Cast In-situ Concrete Pile for Approach Bridge

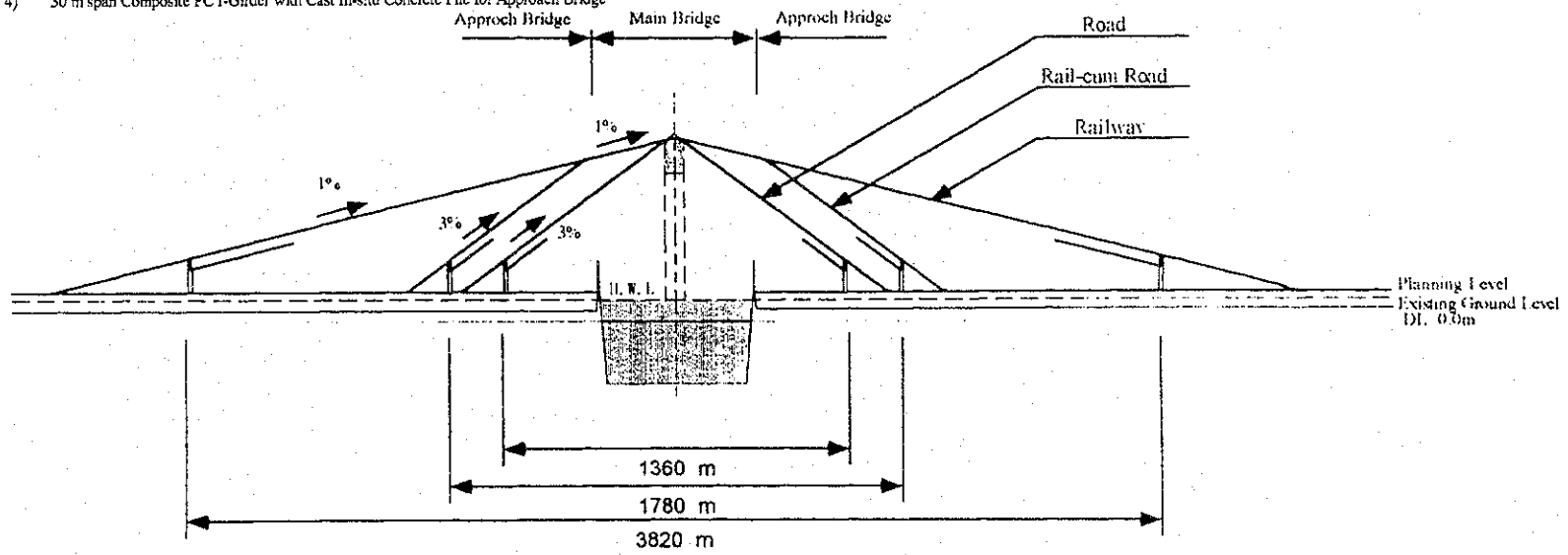


Fig. 8.4 Comparison of Length and Cost of Road Bridge and Rail-cum-Road Bridge

iv) Fig.8.5 indicates the comprehensive comparison. Examining the result, "the alternative of the rail-cum-road bridge through the whole length(ALT1-6)" is deleted from the alternatives for the study of road bridge hereinafter for the reasons described below;

- It is not reasonable that the vertical alignment of road should comply with considerably flatter grade of that of railway only to share the space of bridge to result in huge increase of bridge cost.
- There's a physical problem that the initial 4-lane road bridge has to be modified to a rail-cum-road bridge with a single track and 2-lane. It may be a seriously problem for RHD to have invested in such an inefficient manner.

3) Alternatives as Road Bridge

i) To cope with issues encompassing the Rupsa Bridge, the scheme of rail-cum-road bridge is examined, and the scheme of rail-cum-road bridge in a whole stretch (ALT 1-6) was set aside from alternative plan of road because of excessively high cost as well as reduction of lanes later on.

ii) It is possible that vertical alignment of main bridge is consistent with each other where large vertical curve radius usually exist. Therefore, alternative of rail-cum-road bridge is studied as "rail-cum-road bridge of only main bridge", and then road and railway have individual grades except main bridge.

iii) Both design speed and bridge length is closely connected with sight distance. If a design speed is assumed as 60km/h, 80km/h or 100km/h for the Rupsa Bridge, the vertical curve radius must be taken as 2000m, 4500m or 10000m respectively in order to secure the required sight distance. Keeping the grade to 3%, if the design speed is increased from 60 to 80km/h, or from 60 to 100km/h, the bridge length will increase by 55m or 210m respectively. The grade of 3% , which is flatter for road, has been already adopted with consideration of traffic characteristics. On the viewpoint of economy, design speed and vertical curve length are respectively applied 60km/h and 2000m for Road Bridge. Minimum vertical curve radius for rail-cum-road bridge is 3000m in accordance with the railway standard.

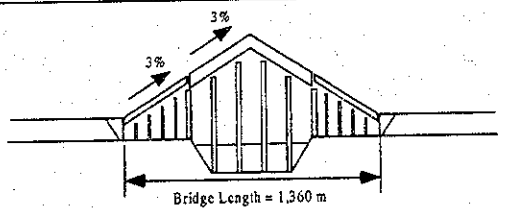
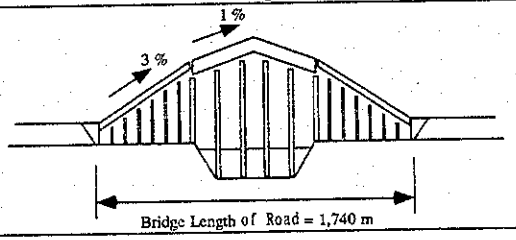
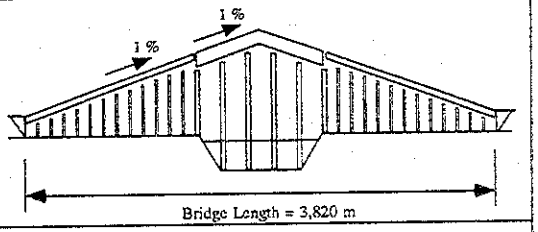
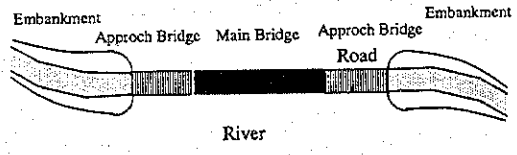
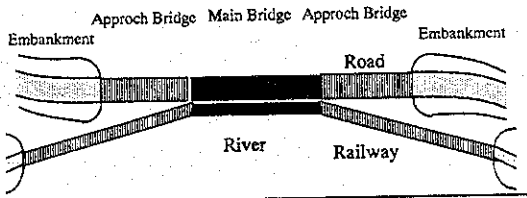
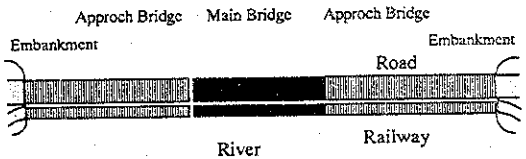
	Simple Road Bridge	Rail-cum-Road Bridge (Main Bridge)	Rail-cum-Road Bridge (Main + Approch Bridge)
Road Profile			
Plan			
Outline of Scheme	1) The scheme of Simple Road Bridge with 3% grade. 2) Total bridge length of 1,360 m with 640 m Main Br. & 720 m Approach Br. 3) Direct cost of bridge of 1,341 M. Tk. in case of ALT 1-1.	1) The scheme of Rail-cum-Road Bridge with only Main Bridge. 2) Total bridge length of 1,780 m with 640 m Main Br. & 1,140 m Approach Br. 3) 1.59 times as high as that of direct cost of bridge compared to ALT 1-1. 4) Slim chance in use of the space for railway on Main Bridge.	1) The scheme of Rail-cum-Road Bridge with Main plus Approach Bridges. 2) Total bridge length of 3,820 m with 640 m Main Br. & 3,180 m Approach Br. 3) 2.41 times as high as that of direct cost of bridge compared to ALT 1-1. 4) Excessively flat grade of 1% applied due to railway.
Return on Investment	High IRR is expected due to no excessive cost.	IRR still remains acceptable just in case earlier realization of railway extension.	IRR becomes marginal level due to excessive cost.
Road User's Benefits	Reasonable in all aspects even in case of toll bridge.	Not acceptable if toll should cover additional cost for railway space.	Unreasonable for excessively long bridge even though railway be extended.
Land Use along Road	Good in land use because of the shortest approach bridge section.	Fair in land use in spite of railway occupation taken place in one side.	Very poor because of long approach bridge and parallel railway.
Social Impacts	Shortest stretch of community disruption by viaduct and embankment.	Impairment of development impacts brought by road because of unfavorable elevated railway.	Longer stretch of community disruption by parallel and elevated railway.
Evaluation	**Superior.** Fulfillment of expected roles and functions of Rupsa Bridge.	Further study on the possibility of railway extension to Mongla Port is necessary.	**Inferior.** It is not acceptable that the grade of road becomes excessively flat due to railway and it results in very high construction cost.

Fig. 8.5 Comprehensive Comparison of Road Bridge and Rail-cum-Road Bridge

i) The slow-moving lanes are basically provided on both sides for the use by auto rickshaws and motorbikes. In case it is on only one side on bridge, consideration is given so that these slow moving vehicles can be distributed to both lanes through box culverts installed in the embankment behind the abutments in the embankment.

ii) At all locations of the four bridges, some improvements of the river protection, mainly bank protection on upstream and downstream, may be required. A road for maintenance purpose will be built on top of the banks, and a clearance for the roads are secured.

4) Alternatives for locations of Khulna Bypass

i) There should be a discussion on the matter of navigation clearances for each river, and so two routes are examined. If the east route is taken, then Khulna city is bypassed by bridging the three rivers, Bhairab, Atai and Atherobaki and if the west route is taken then only Rupsa Bridge.

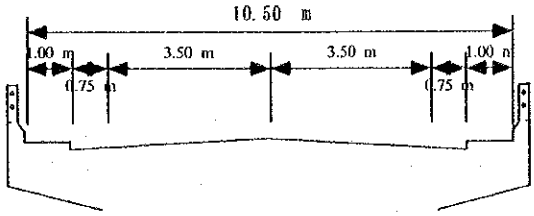
ii) In case of the west route, length of Rupsa Bridge is only 1,360 m, while those of Bhairab, Atai, Atherobaki are1,040m, 1,040m and 570m respectively. Total of these three on the east route is 2,650 m, and is as high as 1.9 times compared to that of the west route.

5) Alternative Cross Sections

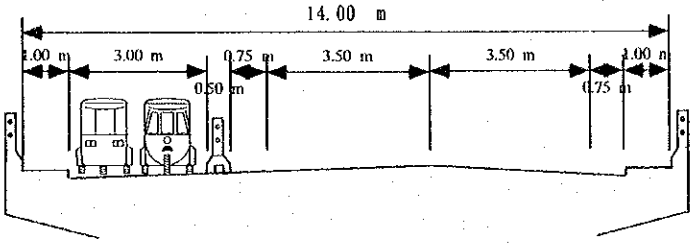
i) Traffic demand forecast warrants undivided 2-lane of Khulna Bypass for the Study. Although a large number of slow-moving vehicles such as motorbikes and auto-rickshaws are predicted to pass the four bridges because they are located in Khulna City, and commuters will become major users. Therefore, cross sectional configuration may contain undivided 2-lane with sidewalks and additional lane for slow-moving vehicles. Divided 4-lane also examined in order to cope with uncertainty of future traffic.

ii) As for rail-cum-road bridge, the scheme of rail-cum-road bridge only on main bridge is also involved.

iii) The cross sections of five alternatives are shown in Fig.8.6, which consist of undivided 2-lane with sidewalks, undivided 2-lane with sidewalks & slow-track (one side), undivided 2-lane with sidewalks & slow-track (both sides), undivided 2-lane with sidewalks & railway single truck, and divided 4-lane with sidewalks. The width of each alternative is 10.5m, 14.0m, 15.5m, 16.5m and 18.0m respectively.



ALT 1-1 / 3-1



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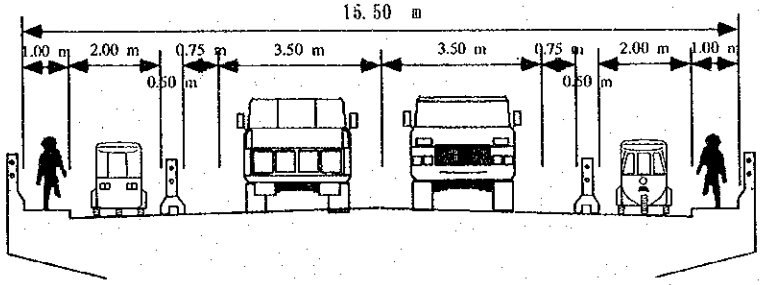

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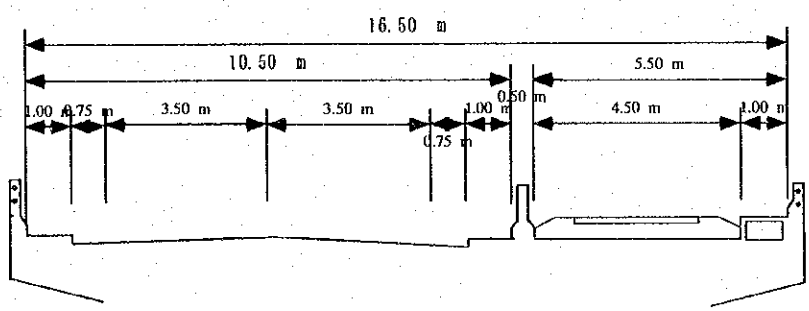

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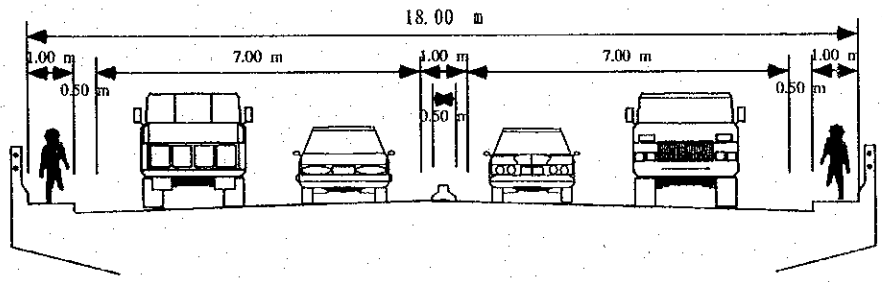


ALT 1-5 / 3-5

Fig. 8.6 Cross Sectional Configuration of Bridge

8.2 Setting of Bridge Alternatives and Selection

Although the Study is still at a master plan level with limited data and information, the bridge engineering study aims at selecting suitable type of bridge and structures as far as it may be practical, giving basis for cost estimates and summarizing technical data and information for succeeding engineering study.

(1) Main Bridge

Rupsa, Bhairab and Atai Bridge having the required minimum span length of 100 m, and Atherobaki Bridge of 50 m are separately examined.

i) Factors of selecting structural types

As the Main Bridges cross over the rivers, and are comparatively of a long span, the selection was made based on such factors as 1) navigational requirements, 2) topography and geology, 3) river conditions, 4) aesthetics, 5) constructability (degree of ease on construction), 6) construction cost, 7) construction period, 8) maintenance, 9) aviation requirements and 10) technology transfer/new technology.

ii) Preliminary selection

Shown below are the types picked up, which are frequently applied to the span length.

Required minimum span length=100 m

PC Bridge

Continuous Box Girder Bridge, Truss Bridge, Arch Bridge, Cable Stayed Girder Bridge, and Extradosed Bridge

Steel Bridge

Continuous Girder Bridge with Steel Deck, Continuous Truss Bridge, Langer Arch Bridge, Lohse Arch Bridge, Trussed Langer Bridge, Nielsen Bridge, Arch Bridge, Cable Stayed Girder Bridge, and Suspension Bridge

Required minimum span length=50 m

PC Bridge

Simple Box Girder Bridge, Continuous Box Girder Bridge, and Truss Bridge

Steel Bridge

Simple Box Girder Bridge, Simple Composite Box Girder Bridge, Continuous Plate Girder Bridge, Continuous Box Girder Bridge, Continuous Girder Bridge with Steel Deck, Rigid Frame Bridge, Simple Truss Bridge, Continuous Truss Bridge, Langer Arch Bridge, and Arch Bridge

Out of all the possible alternatives above, the following types were selected, based on the factors previously described.

Required minimum span length=100 m

1) Continuous PC Box Girder (Tapered Girder Depth)
2) PC Cable Stayed Girder
3) Continuous box girder with steel deck

Required minimum span length=50 m

1) Continuous PC Box Girder (Uniform Girder Depth)
2) Continuous Steel Box Girder with Steel Deck

iii) Selection of the optimum type

The alternatives selected during the preliminary selection been examined more in detail considering those factors especially essential.

Taking Rupsa Bridge as a sample, the construction cost index and period were worked out as shown in Table 8.1;

Table 8.1 Comparison of Cost and Construction Period

	Continuous PC Box Girder	Cable-Stayed PC Girder	Continuous Box Girder with Steel Deck
Cost Index	100	159	114
Construction Period(month)	36	42	33

iv) Comprehensive evaluation

Required minimum span length=100 m

1) Continuous PC Box Girder (Tapered Girder Depth);

A reasonable construction period is taken, but this type is selected as the

best suitable judging comprehensively from viewpoints of the construction economy, maintenance, experiences in Bangladesh and availability of the materials.

2) PC Cable Stayed Girder

Once this type is realized, it will be the first of the type in Bangladesh, desirable in light of technology transfer, remarkably aesthetic and may be a landmark in Khulna. But on the contrary, it generally costs 1.6 times as expensive as the PC continuous box girder bridge under the circumstances of bridge site, as any of the locations of the project is too small in the scale for the type of the bridge.

3) Continuous Box Girder with Steel Deck

The remarkable shortcoming of steel is the characteristic of having corrosion and then deteriorating the strength, thus huge amount must be spent to repaint and false work over the navigation route. It was turn out by the study that they are not only tidal rivers but also have high salinity increasing year by year. This type necessitates construction cost a little more than PC continuous box girder type because the materials and fabricated structural elements must be imported. On the other hand, while the foundations and piers are constructed at site, the steel elements for superstructure may be fabricated at the shop. And also girders may be installed at once in a pre-assembled large block by utilizing a floating crane on the pier tops, thus time is saved for erection of the superstructure. In case that construction time is the factor much more significant than economy and maintenance, this may be adopted.

Required minimum span length=50 m

1) Continuous PC Box Girder (Uniform Girder Depth)
2) Continuous Steel Box Girder with Steel Deck

Both of these are adopted for the same reasons as 1) and 3) respectively.

(2) Approach Bridge

Factors dominating selection of the Approach Bridge are construction economy and constructability including the experience achieved in this country, somewhat different from those for the Main Bridge.

PC composite I-girder was chosen as the type for the Approach Bridge, which is

commonly used in Bangladesh.

360 m is an Approach Bridge length on one side of the river Rupsa, which is the longest, 120 m of the Atherobaki. When the Approach Bridge length is divided by a number of short span lengths, many piers are required. On the contrary, in order to reduce the number of piers long spans must be crossed over, and consequently the superstructure costs much.

Generally to say, longer span length is preferable when bearing strata are situated and tall piers are necessary. But to the contrary where substructures dose not cost much, short spans and less number of piers will reduce the cost.

Cost indices of a superstructure and substructure was calculated as a trial for a span of 20, 30 and 40 m in order to compare the costs.

The span of 30 m is found the cheapest in the total of the superstructure and substructure cost. Accordingly the Approach Bridge is to be divided by 30 m span.

(3) Substructure

1) Body of pier

i) Main Bridge

As the piers of the Main Bridges are located in a river, wall types with an ellipse cross section are chosen considering expected scouring of the riverbed.

ii) Approach Bridge

Wall types with a rectangular cross section, commonly used in Bangladesh, are adopted for the Approach for there's no influence from water flow.

2) Foundation

The investigation reveals that the bearing strata are as deep as 40 through 50 meters. Driving piles, concrete cast-in-situ piles and caisson are typical foundations.

Driving steel pipe piles, cast-in-situ piles by reverse circulation method and caisson may be methods applicable to the deep foundation.

The concrete cast-in-situ pile method was adopted among these three because the steel piles have problem of availability, and the caisson necessitates a long period as well as high cost in general.

The method can be applied both onshore and offshore, and therefore is to be used to the Main and Approach Bridge.

CHAPTER 9 INITIAL ENVIRONMENTAL AND INITIAL SOCIAL IMPACT EXAMINATION

9.1 Objectives and Methodology

Actual conditions of each environment item were surveyed for planning the Bridge construction including roads, along with Initial Environmental Examination (IEE) and Initial Social Impact Examination (ISIE). For establishing the social baseline of the study area, hundred percent household survey was conducted on the road alignment by interviewing through the use of survey sheet and the collected data were analyzed.

9.2 Natural and Social Conditions of the Study Area

1) The city area of Khulna is situated on narrow and slightly high natural levee, formed in south-north direction along the both sides of the River. In general, the ground of natural levee is good on sandy soil. However, the back swamp outside such levee is located on soft ground and development in east-west direction of the town is hindered making a boundary due to this back swamp which is between the natual levee and the back swamp.
2) The road alignments A and B are crossing along the above boundary, which is mostly paddy field but in some places they go across private houses and their land.
3) Most of people in these private houses group into small communities called" homestead". These lands of homestead are raised by about 1 m above farmlands to get protected from flooding. Usually they have a pond for livelihood in an average area of 200-300 m^2, surrounded by woods and the family and relatives are living together in small houses. The woods are mostly fruit trees and timber trees, as source of fuel along with dung of domestic animals. These homesteads are either located intermittently or adjoined.
4) Literacy of aged 7 years old and above is 43.6% in Khulna District, higher than that of national average and it is believed being improved remarkably recently by NGO's activities.

9.3 Impacts and Countermeasures for Implementing the Project

1) Impacts on Social Environment

The most important problems for both Alignment A and B lie with dividing these homesteads from neighboring communities. However, moving to adjacent farmlands seems relatively easy as the land holding rate shows nearly 90% with less tenant farmers and non-land holding farmers. Meantime, the construction of the roads will make big merits. The reasons are that the income of these families through agricultural products shares only 3% on the Alignment A South Section and that only 18% on the Alignment B, indicating that they are of the typical periurban (urban-neighboring) societies. It is also judged by the facts that there are few shops along the proposed alignment and most of residents should go to cities/towns for shopping. The people on the Alignment B go and return by the use of small boats as exist everywhere from the upper stream to down stream. The outline of each Alignment is as follows:

① Alignment A

This Alignment is near to Khulna City and is convenient for daily life. It crosses on some 89% of agricultural land, mainly paddy fields including culture ponds. 30% of this low land is submerged during rainy season. The farmers in this area raise three crops a year and Aman rice species is particularly suited to such deep-water conditions. However, they can have only small harvest as most of them are not full-time farmers and due to poor land conditions. The household nos. to be affected is 25 – 135 persons – on the South Section (total 174 households with 886 persons) on this Alignment. Excluded in these figures are 1 rice mill. 1 mosque and 2 schools in addition to private houses. Average family size is 5.8 persons, and 58% of the Project Affected Persons (PAPs) are original inhabitants, and ratio between men and women is 1.67. Many are single laborers travel from their villages to Khulna for work but still more than 50% of PAPs have work place within 2km. Housewives are involved in housework and farm works. Average annual income of one family is US$1,600 (converted) which is higher than the national average. Food expense share 70% of the income.

② Alignment B

Agricultural land including culture ponds occupies 76% of the Project Area, which shows larger housing area than the Alignment A. The land is rather high and submersion rate is 10% making it possible for use other than paddy fields. PAPs

are 297 households with 1,685 persons, more than that of Alignment A. Excluded are 4 brick factories, 2 rice mills, 5 mosques, 6 schools, 2 shops and 1 hospital. Average family size is 5.7 persons and 62% of the PAPs are original inhabitants. The ratio between men and women is1.25, slightly less than the Alignment A. More than 50% of PAPs have work place within 1km. Average annual income of one family is US$1,500, which is higher than the national average. Food expense shares 62% of the income.

③ Railway Alignment

The big difference with the road alignment is that the high embankment for rail bridge approach is longer (more than about 700 m/bridge) and hence impact is upon Community Split and Traffic will be larger than the roads alignment. It will be necessary to design underpass taking into account the traffic of small boats in rainy season. Choice for alignment in rail design is limited than the roads. In case of railway, more households will be required to be relocated.

2) Impacts on Natural Environment

① Soil Erosion

The sites after taking soil for embankment material will become ponds and puddles. Therefore, excavation plan shall be made carefully considering best utilization of such lands.

② Hydrological Situation

Khulna City is included in the area affected by the ebb and flow of the tide. Complicated flow regime is seen in rainy and cyclone season and large erosion was reported on the Atai River.

③ Ecosystem

Sundarbans Mangrove Reserved Forests as developed from the down stream of Mongla Port through the seashore of the Bay of Bengal are source of valuable woods, which are designated as the World's Heritage. But there are no natural forests near Khulna City. In this sense, the woods in homesteads play important role. There is no wildlife as designated by the Wildlife Protection Law and those as extinct species. No waterfowl and migratory birds are confirmed in broad Swamp (Bil Dakatia), which was artificially made in the West Side of the Alignment A. Freshwater dolphin as broadly inhabit in the Padma River and other domestic rivers are also seen in the Rupsa River and capturing is prohibited. But the numbers are drastically decreased by the water pollution and poaching. The Ministry of Environment and Forestry presumes that 25 or 30 dolphins are inhabiting in the region up to the down

stream of Mongla Port.

④ Water Pollution

There are sewerage systems in Khulna City but much sewage flows into rivers and the contamination is reaching the upper limit of the standard value. Therefore, the fishery catch in the rivers is decreasing.

3) Mitigation

① Social Environment

More precise baseline survey should be conducted at the time of Feasibility Study and further detailed land acquisition plan and countermeasures for PAPs should be prepared. In this case, tenant farmers (5%), shops and nurseries should be taken into account for supplementing their income. The opinion of Hindus (some 5%) as one of the minority ethnic group should also be taken into consideration. In case of Alignment B, which is similar to Alignment A, income supplement may be considered for small ferry boat operators on three rivers where the alignment crosses additionally. The unbalanced ratio between men and women on the Alignment and other problems such as women laborers should also be made clear. For this purpose, NGO, universities and other general citizens in addition to central/local governments officers should be consulted during the study as participatory approach. Particularly, NGO's role is important in it.

② Natural Environment

The Alignments will go across largely agricultural lands (including nurseries) and will have no serious impact upon natural environment but major consideration should be taken into account for pollution to be caused by the construction upon the lands and rivers. Productive agricultural lands should be avoided as much as possible in selecting the Alignment and the sites after taking soil should be utilized as nursery ponds. Tree planting along the roadsides should be encouraged. Change in flow regime and erosion is not reported on the Alignment A but careful consideration should be given.

4) Environment Impacts and Countermeasures in the Site Proposed for Multi Modal Terminal (MMT)

The proposed site from the railway terminal up to the Roosevelt Jetty in the north is largely occupied by the Bangladesh Railway (BR) and the remainder is the lot for Mongla Port. The site faces with the west bank of the Bhairab River. More than half of the BR's lots are unused at present, and there are no houses except squatters. Therefore, only slight impact on natural and social environments are expected. But

much impact is foreseen upon the adjacent roads reaching MMT to be caused by increased traffic. In this case, KCC City Bypass through Majid Saran Road will be used for large vehicles. At the junction of the National Highway with KDA Avenue and Majid Saran Road, grade separation and new traffic signals will be required. Traffic congestion will be much mitigated with these countermeasures but currently heavy congestion is seen at this junction with uncontrolled traffic. For air pollution, NO_2 has already shown 199.36 Mg/m^3, which is above the regulated value for industrial and commercial areas. Smooth traffic flow should be secured and exhaust gas be mitigated.

9.4 Policy, Laws and Organization for Environment, and Land Acquisition and Compensation

1) Policy and Laws for Environment

The fundamental requirements for environmental protection are as stipulated in the Environment Conservation Act (1995) and the Environment Conservation Rule (1997) enacted based thereupon. These Act and Rule are centered by protection from pollution but residents participation during the course of a project is not stipulated. These activities are managed by the Department of Environment (DOE), the Ministry of Environment and Forestry, but the total staff of DOE is only 173 and there are no responsible departments in RHD and other ministries. DOE has 4 divisional offices in Dhaka, Chittagong, Khulna and Rajshahi in addition to its headquarters in Dhaka. The Rule stipulates that bridges over 100 m. and national highway projects belong to the 4th category called"Red Category". For this Project, environment clearance application should be submitted to Khulna Office. In such application, F/S Report and IEE Report should be attached.

2) Procedures for Land Acquisition and Compensation

The concept of PAPs is known in general as used for Jamuna Bridge Project which was completed through the co-finance of international lending institutions. Legally, however, the Acquisition and Requisition of Immovable Property Ordinance (1982) is still applied. Therefore, PAPs should move at their own responsibility once compensation money is received under the present Ordinance, except that donors in case of foreign assisted projects do not require such consideration. Procedures commence with submission of application to the Regional Deputy Commissioner (DC) after the Ministry of Communication approved a land acquisition plan including compensation items as applied by RHD. DC shall be responsible up to

the time when such land is delivered. Land cost should originally be decided based upon the data kept at the Land Registry Office, however, costs largely below market value are declared for countermeasures of personal tax.. It usually makes problem for the balance with the value decided by the Land Evaluation Committee in land expropriation. One of the cases was that RHD raises funds and paid the difference through NGO. In general, it takes 6 months through 1 year for obtaining approval of land delivery after application.

9.5 Social Cost

(1) Direct Social Cost for Road Construction

The following social costs, as detailed in Table 9.1, are estimated for the Alignments A and B.

1) Land acquisition costs – lands for farming, housing, commerce, shrimp and fish nursery ponds, and others, 2) Compensation of property – house, factory, school, mosque, and shop, trees, 3) Compensation for crops – cultivation, woods as fuel, 4) Compensation for income – shop, ferry, tenant farmer, day laborer, 5) Cost for moving, 6) Costs for relocation sites.

(2) Direct Social Cost for Railway Construction

Average width of railway is assumed as 30m, and while the section running parallel to the road from Khulna east to Mongla Port (25,100m) is 15m. Land acquisition and compensation costs for the Railway A Alignment (52,400m) and B Alignment (51,500m) were calculated using unit rates of the Road Alignment. And the results are shown in Table 9.1.

Table 9.1 Social Cost

Unit: Million Taka

No.	Alignment	Land Acquisition					Compensation Cost								Toatal	No.
		Agri.	Home	Farming Pond	Other	Sub. T	Struct.	Trees	Pond	Crops	Moving	Income	Reloc.	Sub. T		Affected Homes
1	Alignment A South Section	61.8	9.4	0.8	1.2	73.20	6.6	0.8	5.6	1.7	0.1	4.7	0.2	19.70	92.90	25
2	Alignment B	72.3	68.6	3.5	23.2	167.60	71.4	8.1	4.9	18.7	1.5	1.5	1.5	107.60	275.20	297
3	Rail Alignment A					198.70								97.09	295.79	
4	Rail Alignment B					205.08								131.65	336.73	

Note 1: The width of Road ROW and Rail ROW are assumed 50m and 30m respectively.
Note 2: Excluding the river widths, the length of road alignment are 9.320m for A-South, 17,540m for A-North, and 19,100m for Alignment B. The length of rail alignment are 20,400m for Rail A, 19,500 for Rail B. Meantime, 30m wide section between Khulna-Mongla is 6,900m in length and 15m wide section is 25,100m in length. Thus, the total length of Rail A is 52,400m and that of Rail B is 51,500m.
Note 3: For calculation purpose, the width of ROW is assumed 50m for road and 30m/15m for rail uniformity including structures/high embankment.
Note 4: The costs are calculated proportionally based on the actual survey results obtained on Alignment A and Alignment B.

Reference

5	Alignment A North Section	87.6	32.3	2.0	16.2	138.1	28.7	1.7	13.5	2.2	0.7	1.5	0.8	49.1	187.2	149
6	Alignment A	149.0	41.7	2.8	17.4	210.9	35.3	2.5	19.1	3.9	0.8	6.2	1.0	68.8	279.7	174

9.6 Preliminary Evaluation

(1) Social Environment

In case of the road, some 89% for Alignment A and 76% for Alignment B will cross farmlands. On these Alignments, communities of families and relatives called homestead are living which will be affected by a serious problem of family split. Careful attention is required as the original inhabitant rate shows as high as 60%. On Alignment A, 25 private houses with 135 persons will be affected and 297 private houses with 1,685 persons will be affected on Alignment B. Their land holding rate including farm lands shows around 90%, meantime, their income from farming is only 2% on Alignment A and 18% on Alignment B forming periurban(urban-neighboring) societies. Therefore, negative impact upon social environment through land acquisition seems small. Men travel to town for work and women are engaged in housework and farming. Careful attention will also be required for sharecroppers (tenant farmers), people with no lands, and Hindus as a minority ethnic group, although they are in small numbers.

For the railway Alignment, Right-of-Way (ROW) width is 30 m., which is narrower than 50 m. of roads. However, the high embankment sections will be longer than roads and will have a impact on Community Split and Traffic. and PAPs will be increased further based on the selection of alignment.

(2) Natural Environment

Remarkable impact upon natural environment has not been recognized around the Alignments. But careful consideration is necessary to minimize the felling of trees of homesteads and for sites after taking soil for embankment. Some pollution during and after construction cannot be avoided but such measures as planting trees along the roads will be necessary to keep it to the minimum.

(3) Care and Dialogue with Residents and PAPs

Early realization of the Project will bring about great merits to regional activation. But it will take 6 months through 1 year to acquire the land after the detailed plan and the applications of acquisition are made. Therefore, the cooperation of residents and PAPs is indispensable and dialogue including NGO should be made at an early stage without sticking to the existing laws and rules.

(4) In view of the foregoing, it should be necessary to formulate environment assessment, resettlement plan, and environment management plan at each suitable stage.

CHAPTER 10 ALTERNATIVE PLANS

10.1 Railway Extension to Mongla Port

(1) Planning Approach for Alternative Plans

The scheme of Railway Extension to Mongla Port is planned in the Study to connect existing railway to Mongla Port only to accommodate future cargo demand by its own route.

Bangladesh Railway (BR) had studied the rail transportation to Mongla Port in the past. Two routes were studied in the northern part to bypass Khulna, namely the eastern route (B) and the western route (A), and the route in the southern part ran almost parallel to existing Khulna - Mongla Road.

In the Study, the preliminary engineering study is conducted along these two route on the assumption that the scheme of Railway Extension to Mongla Port is assumed to connect existing railway to Mongla Port by its own route and to run parallel to Khulna Bypass only at river crossing points in the northern part.

Financial analysis is required to examine a rational investment scheme as BR pursues Railway Recovery Program (RRP) under ADB program loan since 1993 and it necessitates to ensure that a new investment should have clear commercial justification. On the other hand, although most possible benefit from railway extension is balance of transport costs between road and rail, economic analysis is hardly conducted because the transport cost of cargo to final destination through rail transport is too ambiguous and financial analysis would be pessimistic.

The scheme of rail-cum-road bridge is studied in the stretch where railway is planned to run parallel to Khulna Bypass at river crossing points in the northern part.

(2) Base Case for Railway Extension Plan

The base case (ALT R-1) for railway extension plan is the eastern route (B) in the northern part and the route in the southern part parallel to existing Khulna - Mongla Road, which is recommended by BR.

478,000 tons/year cargo traffic demand for the year 2015 is projected to be generated and attracted at Mongla Port through railway, if Railway is extended to Mongla Port. Such potential rail cargo at Mongla Port is deemed long-haul freight traffic handled at the jetty, mainly comprising North-western Region and

Nepalese Transit Cargo.

For the purpose of financial analysis, freight revenue is assumed that tariff between Mongla Port and Rajshahi is regarded as transport cost of jetty cargo for the north-western region and tariff between Mongla Port and the border is for Nepalese transit cargo.

Construction costs for railway extension are estimated comprising minimum civil works such as fill, bridge, ballast, sleeper, rail and signaling. On the other hand, operation and maintenance costs are estimated on the assumption that 5 locomotives and 700 wagons are purchased.

10.2 Alternative Plans from Major Issues Encompassing the Rupsa Bridge

(1) Route Location and Navigation Clearance

Navigation clearance beneath the Bridge is appropriately reserved to provide space vertically and horizontally for letting design vessel pass safely even on high water level. Four river crossing points have already had specified navigation clearances, and vertical clearance for Rupsa Bridge is the highest of 60 ft (18.30 m) among them. It is no doubt that higher vertical clearance results in increase of bridge cost, but it is necessary to study it totally, considering difference between one bridge on the Western Route and three bridges on the Eastern Route. Table 10.1 presents the comparison of studied four bridges in term of bridge length and cost. It is a matter of fact that totaling of three bridges become longer in bridge length and more expensive in cost, and the bridge cost of the eastern route is 92% higher than that of the western route.

Although the main bridge is located in the river and thus no social impact is found, the approach bridge is located beyond dikes and it requires to acquire land. Land acquisition may bring many social impacts such as property compensation and relocation of affected persons. Table 10.1 shows the cost comparison of land acquisition and property compensation as well as potentially affected number of houses. Such social costs of the eastern route are estimated approximately three (3) times as high as that of the western route. Moreover, number of potentially affected houses become more than ten (10) times due to ribbon development along the river.

Table 10.1 Comparison of Studied 4 Bridges

Route	Studied Bridge				Alternatives and its Brdige Cost (M. Tk.)				
	Name	Main (m)	Approach (m)	Total (m)	2-Lane with Sidewalk No Slow-Track Road	2-Lane with Sidewalk One Side Road	2-Lane with Sidewalk Both Sides Road	2-Lane with Sidewalk No Slow-Track Rail-cum	4-Lane with Sidewalk No Slow-Track Road
Western Route					ALT 1-1	ALT 1-2	ALT 1-3	ALT 1-4	ALT 1-5
(A Route)	Rupsa	640	720	1,360	1,341.1	1,718.1	1,874.4	2,127.0	2,180.2
					100%	128%	140%	159%	163%
Eastern Route					ALT 3-1	ALT 3-2	ALT 3-3	ALT 3-4	ALT 3-5
(B Route)	Bhairab	440	600	1,040	1,059.4	1,358.5	1,482.0	1,644.8	1,724.6
	Atai	440	600	1,040	1,059.4	1,358.5	1,482.0	1,644.8	1,724.6
	Atherobaki	330	240	570	462.2	590.2	643.1	722.0	747.0
	Total	1,210	1,440	2,650	2,581.0	3,307.2	3,607.1	4,011.7	4,196.2
					192%				

Note :

1) Direct construction cost of bridge covers costs between abutments and excluding 10% contingency.
2) In Road-cum-Railway Bridge, Direct construction cost of Approach Bridge for railway is not included.
3) 100 m span Continuous PC Box Girder with Cast In-situ Concrete Pile for Rupsa/Bhairab/Atai Bridge
4) 50 m span Continuous PC Box Girder with Cast In-situ Concrete Pile for Atherobaki Bridge
5) 30 m span Composite PC I-Girder with Cast In-situ Concrete Pile for Approach Bridge

(2) Bridge Types such as Road, Rail and Rail-cum-Road

In the Study, the scheme of Railway Extension to Mongla Port is assumed to run parallel to Khulna Bypass only at river crossing points in the northern part, namely Rupsa on the western route and Bhairab/Atai/Atherobaki on the eastern route. Table 10.2 presents the comparison of studied four bridges in term of bridge length and cost. It is estimated that the bridge cost might jump to 3.8 times in case that the scheme rail-cum-road in the whole bridge section should be adopted.

(3) Cross Sectional Configuration

Typical cross section for four bridges is planned basically to be undivided 2-lane road with sidewalks at both sides. However, it is pointed out the necessity that additional track for slow-moving vehicles accommodates commuters and secures traffic safety as well as smooth traffic flow. Divided 4-lane road is also studied just in case of future increase of traffic beyond projection. In addition to these alternative plans, the scheme of rail-cum-road on main bridge is studied.

Table 10.1 shows the comparison of bridge cost among five alternatives. As an example of the western route, compared to the base case of ALT 1-1, ALT 1-2 (plus slow-track at one side) increases 28%, ALT 1-3 (plus slow-tracks at both sides) increases 40%, ALT 1-4 (plus space of rail-cum) increases 59% and ALT 1-4 (4-lane) increases 63%.

Table 10.2 Comparison among Road Br., Rail Br. and Rail-cum-Road Br.

Alternative	Studied Bridge				Direct Bridge Cost (M. Tk.)	Remarks
	Name	Main (m)	Approach (m)	Total (m)		
Road Bridge 2-Lane with Sidewalk No Slow-Track	Rupsa	640	720	1,360	ALT 1-1 1,341.1 100%	3% of road grade Simple road bridge
Rail Bridge Single Line	Rupsa	640	3,180	3,820	ALT R-3 1,990.2 148%	1% of rail grade Simple rail bridge
Rail-cum-Road Br. 2-Lane with Sidewalk Single Line	Rupsa	640	3,180	3,820	ALT 1-6 5,131.8 383%	1% of road grade and 1% of rail grade Rail-cum-road bridge

Note :

1) Direct construction cost of bridge covers costs between abutments and excluding 10% contingency.
2) 100 m span Continuous PC Box Girder with Cast In-situ Concrete Pile for Rupsa Bridge
3) 30 m span Composite PC I-Girder with Cast In-situ Concrete Pile for Approach Bridge

(1) Alternative Plans for Economic and Financial Analysis

Benefits are brought by savings of transport costs stemmed from traffic demand forecast on each alternative route, and they are estimated the same as among alternative plans on each route. Therefore, variation of project cost by each alternative plans can be covered by sensitivity analysis. The followings are the base case for each alternative route.

With Project Case

ALT 1-1 : Demand Forecast = Case-1, Cost Estimate = The Southern Section of Khulna Bypass (Undivided 2-lane with Sidewalks)

ALT 3-1 : Demand Forecast = Case-3, Cost Estimate = The Eastern Route of Khulna Bypass (Undivided 2-lane with Sidewalks)

Without Project Case (Demand Forecast : Case 0)

Standing on the assumption that studied 4 bridges would not exist in the future road network for the year 2015, vehicular traffic might still cross the Rupsa river by ferry. However, all roads proposed by Khulna Master Plan including the northern section of Khulna Bypass are taken into consideration traffic assignment on future road network.

A financial analysis is conducted assuming Rupsa Bridge levying toll.
Only ALT 1-1 is analyzed because the Study is still at a master plan level and amount of toll revenue is estimated the same among each alternative plans.

Since amount of freight revenue is estimated the same in both railway routes, sensitivity analysis can cover other alternatives.

ALT R-1 : Demand Forecast = 478,000 tons/year at the year 2015
Cost Estimate = The Eastern Route of Khulna-Mongla Railway Extension

Table 10.3 are summarized alternative plans from major issues encompassing the Rupsa Bridge.

Table 10.3 Alternative Plans from Major Issues Encompassing the Rupsa Bridge

Alternatives		Outline of Alternative Plan					Demand Forecast
		Route	Bridge	Cross Section	Slow-Track	Rail-cum	
1	ALT 1-1	Western Route (A Route)	Rupsa	2-Lane with Sidewalk	×	×	CASE-1
2	ALT 1-2			2-Lane with Sidewalk	One Side	×	
3	ALT 1-3			2-Lane with Sidewalk	Both Sides	×	
4	ALT 1-4			2-Lane with Sidewalk	×	○	
5	ALT 1-5			4-Lane with Sidewalk	×	×	
6	ALT 3-1	Eastern Route (B Route)	Bhairab/Atai/Atherobaki	2-Lane with Sidewalk	×	×	CASE-3
7	ALT 3-2			2-Lane with Sidewalk	One Side	×	
8	ALT 3-3			2-Lane with Sidewalk	Both Sides	×	
9	ALT 3-4			2-Lane with Sidewalk	×	○	
10	ALT 3-5			4-Lane with Sidewalk	×	×	
11	ALT R-1	Eastern Route (B Route)	Bhairab/Atai/Atherobaki & 6 Br.	Sigle Line	NA	×	478,000 t/yr
12	ALT R-2			Sigle Line	NA	○	
13	ALT R-3	Western Route (A Route)	Rupsa & 6 Br.	Sigle Line	NA	×	
14	ALT R-4			Sigle Line	NA	○	

CHAPTER 11 COMPREHENSIVE EVALUATIONS

11.1 Evaluation on Alternative Plans for Railway Extension to Mongla Port

1) The Asian Development Bank (ADB) as a sole donor in the railway subsector has adopted a long term perspective to Bangladesh Railway (BR) over 30 years. The objectives and scope of such assisting programs are consistent with the macroeconomic rationale, and aims at (i) significant deficit reduction, (ii) termination of open-ended subsides, (iii) labor rationalization, (iv) institutional reforms, and (v) adoption of a rational investment program.
   BR's financial condition has improved in recent years but is still weak. The on-going Railway Recovery Program (RRP) have emphasized recent substantial achievements such as reduction of debt from 1.2 billion Tk. in 1995/96 to 0.8 billion Tk. in 1996/97, and BR has taken action to control capital expenditures and to ensure that investment is targeted in areas which have a clear commercial justification.
2) The scheme of railway extension to Mongla Port opening until Year 2015 has negative financial internal rate of return (FIRR) at all alternative plans as shown in Table 11.1. The sensitivity analysis also reveals that freight revenue could not collect debts even if purchasing costs of five locomotives and 700 wagons are set aside from project cost.
3) Based on the Railway Recovery Program (RRP) agreed upon between the Government and ADB, by which Bangladesh Railway is obliged to act commercially, it is difficult to envisage a new rail line between Mongla and Khulna.
4) However, the scheme of rail-cum road bridge is to be studied as an alternative plan of road bridge because it never deny the possibility of railway extension beyond Year 2015.

Table 11.1 Results of Financial Analysis and its Sensitivity Analysis

Alternative	Outline of Scheme			Internal Rate of Return (IRR)	
	Route	Bridges	Rail-cum	Total Investment	w/o Loco & wagon
ALT R-1	Eastern R. (B Route)	Bhairab/Atai/Atherobaki & 6 br.	×	-40.0%	-18.4%
ALT R-2			○	-39.2%	-5.4%
ALT R-3	Western R. (A Route)	Rupsa & 6 br.	×	-39.7%	-15.2%
ALT R-4			○	-39.4%	-8.9%

Notes :

1) Construction costs comprise fill, bridge, ballast, sleeper, rail and signaling.
2) O & M costs are estimated on the assumption that 5 locos & 700 wagons are purchased.
3) The scheme of rail-cum-road bridge is to share the portion of main bridge only.

11.2 Evaluation on Alternative Plans for Issues encompassed the Rupsa Bridge

1) In order to deliberate upon major issues which have been encompassing the Bridge from technical, social, managerial, economical and financial viewpoints, following planning approach are set forth.
   i) The scheme of rail-cum-road bridge in a whole (ALT 1-6/3-6) stretch was not included in the alternative study of road bridge because it was pointed out inferiority as a road bridge through preliminary engineering study and consequent comprehensive evaluation. Accordingly, totaling ten alternative plans for road bridge were set, multiplying two route locations and five cross sectional configurations.
   ii) The selection of route location of Khulna Bypass was discussed in the Interim Report, and it recommended the western route, evaluating them from the qualitative viewpoints of planning parameters such as land availability, future traffic demand, social aspects, construction economy and river morphology.
   Table 11.2 presents additionally quantitative comparison of each route location, and it reveals that the western route is superior to the eastern route at almost all aspects, especially economic indices.
   Therefore, the comparison and evaluation of cross sectional configurations are to be made only for the western route.

Table 11.2 Construction Costs and Indices of Economic Analysis of Alternative Plans

Alternative		Route Location	Direct Construction Cost (M. Tk.)			Economic Analysis			Social Costs (M. Tk.)			Affected Houses
			Bridge	Others	Total	IRR	B/C	N. P. V	Land	Comp.	Total	
1	ALT 1-1	Western Route (A Route)	1,341.1	1,186.8	2527.9	30.5%	3.01	M. Tk. 3,711	73.2	19.7	92.9	25
2	ALT 1-2		1,718.1	1,195.4	2,913.5	27.7%	2.62	M. Tk. 3,432				
3	ALT 1-3		1,874.4	1,191.5	3,065.9	26.7%	2.49	M. Tk. 3,323				
4	ALT 1-4		2,126.9	1,168.6	3,295.5	25.4%	2.32	M. Tk. 3,162				
5	ALT 1-5		2,180.2	1,351.0	3,531.2	24.1%	2.17	M. Tk. 2,988				
6	ALT 3-1	Eastern Route (B Route)	2,581.0	1,467.7	4,048.7	13.2%	1.09	M. Tk. 282	167.6	107.6	275.2	297
7	ALT 3-2		3,307.2	1,541.9	4,849.1	10.9%	0.92	-M. Tk. 295				
8	ALT 3-3		3,607.1	1,511.0	5,118.1	10.2%	0.87	-M. Tk. 491				
9	ALT 3-4		4,011.7	1,462.5	5,474.2	9.4%	0.82	-M. Tk. 751				
10	ALT 3-5		4,196.2	1,818.8	6,014.9	8.2%	0.75	-M. Tk. 1,138				

Note :

1) Direct construction cost of bridge covers costs between abutments and excluding 10% contingency.
2) In Road-cum-Railway Bridge, Direct construction cost of Approach Bridge for railway is not included.
3) 100 m span Continuous PC Box Girder with Cast In-situ Concrete Pile for Rupsa/Bhairab/Atai Bridge
4) 50 m span Continuous PC Box Girder with Cast In-situ Concrete Pile for Atherobaki Bridge
5) 30 m span Composite PC I-Girder with Cast In-situ Concrete Pile for Approach Bridge
6) 12% per annum discount rate applied to B/C and Net Present Value (N.P.V)

2) The evaluation criteria for cross sectional configuration are return on investment to compare costs and benefits, requirements of traffic features to accommodate not only quantitative aspects but also quality of traffic and future development to secure flexibility in future. Fig. 11.1 shows the comparison of each alternative plan and evaluates them comprehensively.

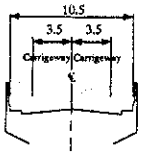
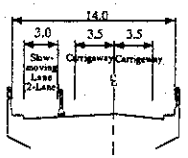
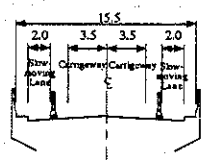
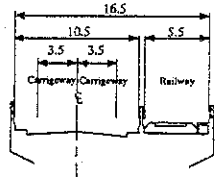
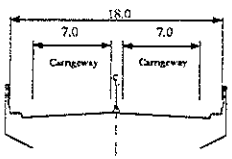
Alternative		ALT 1-1	ALT 1-2	ALT 1-3	ALT 1-4	ALT 1-5
Major Element of Cross Section	Carrigeway	2 - Lane with Sidewalks	2 - Lane with Sidewalks	2 - Lane with Sidewalks	2 - Lane with Sidewalks	4 - Lane with Sidewalks
	Slow-moving Lane	—	2-Lane Two ways (One Side)	2-Lane Two ways (Both Sides)	—	—
	Railway	—	—	—	Single Track	—
Typical Cross Section						
Type of Bridge Structure		Continuous PC Box Girder (Main) + Composite PC I-Girder + Cast In-situ Concrete Pile with Reverse Circulation Method				
Outline of Scheme		1) The basic configuration of 2-lane bridge section. 2) Only for movements of vehicular traffic and pedestrian. 3) Possibility of traffic congestion due to mixed traffic of slow-moving vehicles.	1) Provision of space for slow-moving vehicles. 2) Necessity of traffic management at both abutments. 3) Small number of slow-moving vehicles expected.	1) Provision of sufficient space for slow-moving vehicles. 2) Complete separation of slow-moving vehicles. 3) Alternative 4-lane scheme applicable in future.	1) Provision of space for railway only on Main Bridge. 2) Very limited usage of the space before realization of railway. 3) Imbalance of loading and cross sectional configuration.	1) The basic configuration of 4-lane bridge section. 2) Only for movements of vehicular traffic and pedestrian. 3) Mixed traffic of slow-moving vehicles allowed.
Direct Construction Cost (Million Taka)	Bridge	1,341.1 (100%)	1,718.1 (128%)	1,874.4 (140%)	2,127.0 (159%)	2,180.2 (163%)
	Road	1,186.8 (100%)	1,195.4 (101%)	1,191.5 (100%)	1,168.5 (98%)	1,351.0 (114%)
	Toal	2,527.9 (100%)	2,913.5 (115%)	3,065.9 (121%)	3,295.5 (130%)	3,531.2 (140%)
Economic Analysis	B/C	3.01	2.62	2.49	2.32	2.17
	IRR	30.5%	27.7%	26.7%	25.4%	24.1%
Requirements of Traffic Features		1) Unfavorable for both through traffic and slow-moving vehicles. 2) Unsuitable for traffic on urban road.	1) Practical solution for local traffic feature. 2) Anxiety of increase of traffic in future.	1) Desirable solution for local traffic feature. 2) High traffic safety anticipated.	The same as ALT 1-1.	1) No anxiety of increase of traffic in future. 2) High traffic safety anticipated.
Future Development		No room for modification and adjustment.	The same as ALT 1-1.	Possible 4-lane arrangement in future.	No room for modification and adjustment because of provision of space only on Main Bridge.	No need for modification and adjustment.
Comprehensive Evaluation		This scheme is of regional highway and has only advantage in construction economy. **Fair**	This scheme is practical solution in case of low motorization and also has advantage in construction economy. **Good**	This scheme has advantages in the aspects of local traffic requirements and future development. **Superior**	Additional cost for railway makes IRR lower, and it is hardly deemed due investment. **Inferior**	Uncertain future traffic demand could not justify this scheme. **Poor**

Fig. 11.1 Comparison and Evaluation of Alternative Plans

3) ALT 1-3 is selected as the most recommendable alternative plan for Rupsa Bridge form the following reasons;

i) Rupsa Bridge is located in the urbanized area of Khulna and major users are expected local commuters although major benefits are brought from transport cost savings of heavy trucks and long distance buses on regional and arterial road. It is necessary to deliberate transport means for citizens such as auto-rickshaws and motorcycles, and accordingly separated lanes for slow-moving vehicles accommodate commuters as well as contribute traffic safety and steady flow of traffic.

ii) Number of auto-rickshaws and trucks of quite an old vintage with overloaded or shortage of horsepower make it justify to adopt flatter 3% grade in approach section because mixed traffic of slow-moving vehicles causes present traffic congestion taken place on National Highway No. 7. It is desirable that separated slow-moving vehicles enhance traffic safety as well as smooth traffic flow.

iii) This scheme has remarkable advantage to expand 2-lane carriageway up to 4-lane just in case that traffic demand might increase beyond forecasted one. Total width of carriageway is 13.5 m wide including 2 lanes for slow-moving vehicles, and it is still practical to modify it divided 4-lane with lane width of 3 m wide.

Fig. 11.2 shows the study approach and proposal for the scope of work for Phase II based on the comprehensive evaluation.

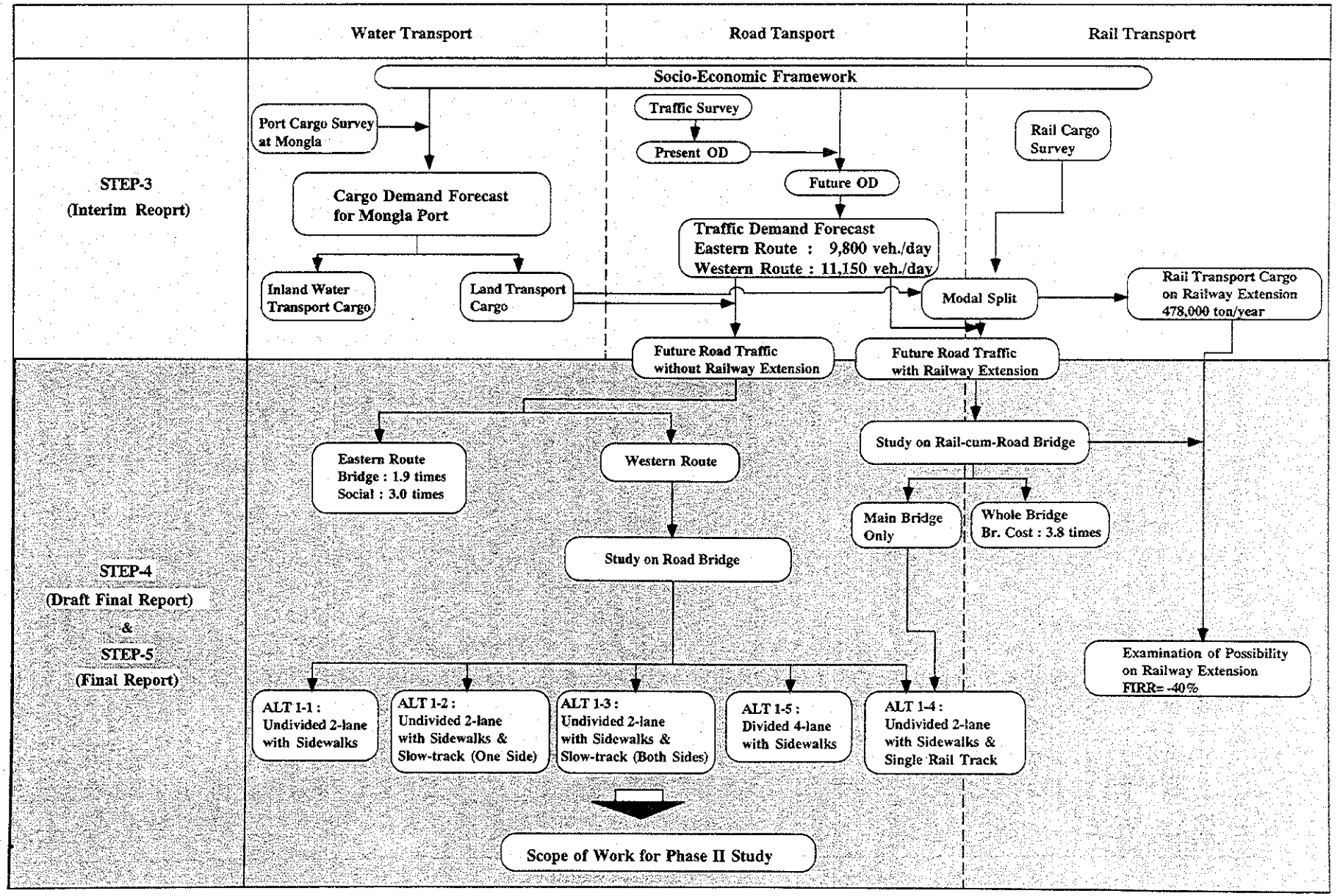


Fig. 11.2 Study Approach and Proposal for the Scope of Work for Phase II

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