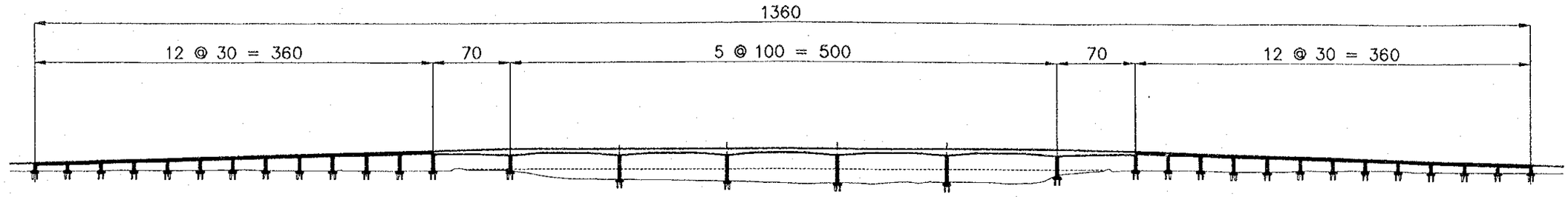
12.2.7 Selection of Recommended Structural Type for Main Bridge

To help better understanding the remaining alternatives for the main bridges are indicated below. Fig. 12.2.2 and Fig. 12.2.3 show the side views and the cross-sectional views respectively of the remaining three types for the main bridge, taking Rupsa Bridge as a sample.

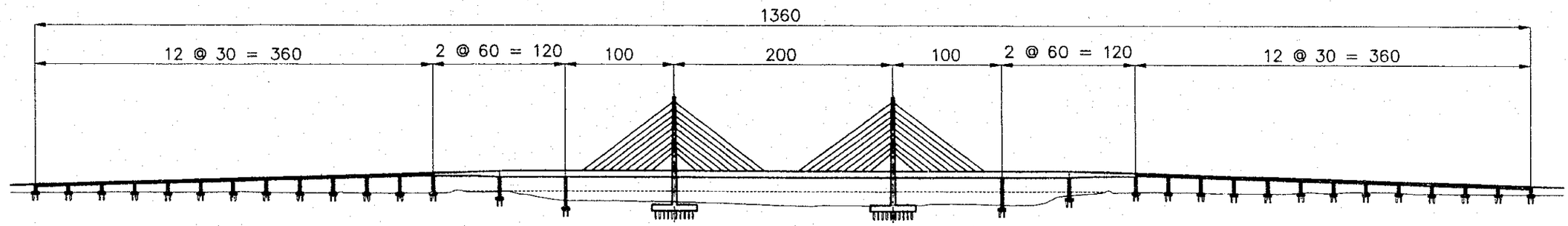
(1) Rupsa, Bhairab and Atai Bridge
(Required minimum span length = 100 meters)

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

PC BOX GIRDER



PC CABLE STAYED GIRDER



STEEL BOX GIRDER WITH STEEL DECK

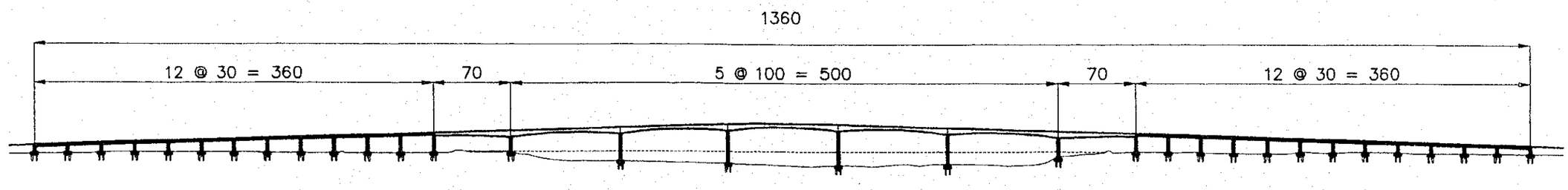
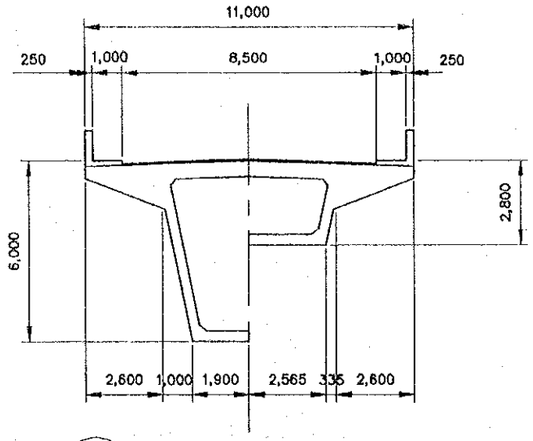
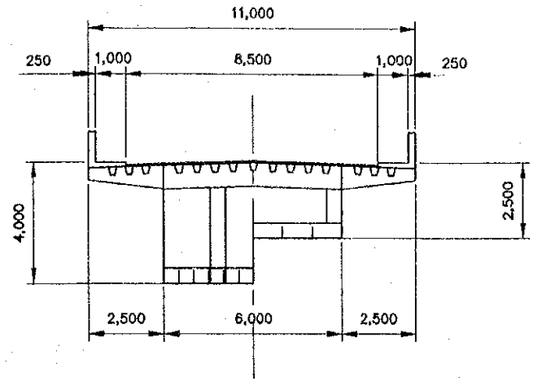


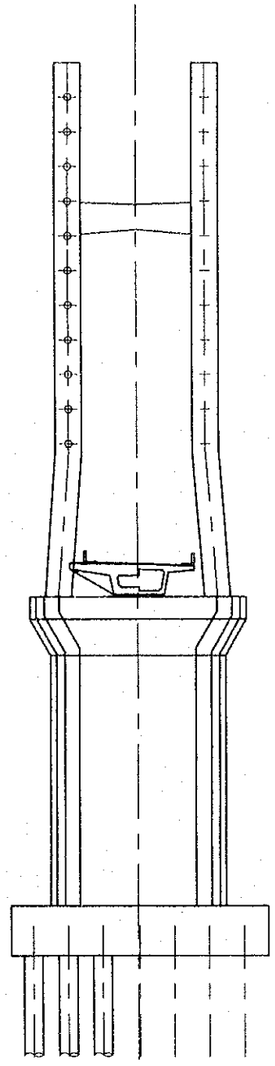
Fig. 12.2.2 Side views of Alternative Structural Types



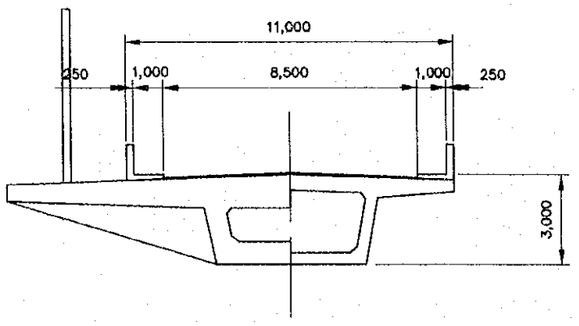
A PC BOX GIRDER



C STEEL BOX GIRDER



D ELEVATION



B PC CABLE STAYED GIRDER

Fig. 12.2.3 Cross-sectional Views of Alternative Structural Types

(2) Atherobaki Bridge

(Required minimum span length = 50 meters)

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

For clear understanding, some comments are added on the different idea of establishing the girder depth of Continuous Box Girder for 100 meters and 50 meters. Namely for a longer span than approximately 50 meters it is recommendable to give deeper web to the box girder on an intermediate pier and reduce it by tapering gradually up to the span center. By taking this method, saving of materials is enabled and thus the construction cost can be reduced. On the other hand for a shorter span, keeping a uniform girder depth is more advantageous in order to avoid troublesome work of varying forms for concreting instead of saving material.

(3) Selection of optimum type

The alternatives selected during the preliminary selection been examined more in detail considering those factors especiallly essential as shown by the Table 12.2.3..

1) Continuous PC Box Girder Bridge

i) Construction Cost

Construction cost indices and construction period of the Main Bridge by type are given in the Table 12.2.4. Among others, this type is the cheapest.

Table 12.2.4 Construction Cost and Period of the Main Bridge by Type

	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

Note: Cost Index shows a proportion when construction cost of the main bridge for the Continuos PC Box Girder Bridge is 100. (Maintenance cost is not included.)

Table 12.2.3 Evaluation of Structural Candidates (Main Bridge)

		Structural Type	Construction Cost	Constructability	Construction Period	Aesthetic View	Maintenance	Technology Transfer	Drivability	Consideration on Aviation	Comprehensive Evaluation
Rupsa, Bhairab, Atai	1	Continuous PC Box Girder	Smallest	Highest	Middle	Ordinary	Best	Ordinary	Ordinary	No problem	**Note (1)**
	2	PC Cable Stayed Girder	Biggest	Higher	Longest	Excellent	Ordinary	Better	Cables obstructing better sight	Require consideration	**Note(2)**
	3	Continuous Box Girder with Steel Deck	Middle	Ordinary	Shortest	Ordinary	Requiring periodic maintenance	Better	Ordinary	No problem	**Note(3)**
Atherobaki	1	Continuous PC Box Girder	Smaller	Higher	Ordinary	Ordinary	Best	Ordinary	Ordinary	No problem	**Note(4)**
	2	Continuous Box Girder with Steel Deck	Bigger	Ordinary	Shorter	Ordinary	Requiring periodic maintenance	Better	Ordinary	No problem	**Note(5)**

Comprehensive Evaluation

Rupsa, Bhairab and Atai Bridge

Note(1); This type is superior in such essential aspects as construction cost, constructability and maintenance, and also has no problems in the construction period, aesthetics and other aspects. This is the type best recommended.

Note(2); This is superior in aesthetics and technology transfer but too much expensive.

Note(3); It is appreciated that the construction period is a little shorter than PC box girder, but costs more and requires periodical maintenance.

Atherobaki Bridge

Note(4); This is the type recommended to Atherobaki, for same reasons as those for Rupsa, Bhairab and Atai.

Note(5); This is evaluated same as Rupsa, Bhairab and Atai.

ii) Constructivity

The girder is extended from a pier top by balanced cantilevering to both sides, and thus will not obstruct navigation during the construction.

iii) Construction Period

The construction period is a little longer than the continuous box girder with steel deck, but much shorter than that of the cable stayed girder bridge as given also in the Table 12.2.4.

iv) Aesthetic

This type dose not have remarkable aesthetic characteristics, but has a kind of functional and stable beauty of the structure.

v) Maintenance

It is said to almost free of maintenance.

vi) Technology Transfer

As a similar type of bridges has been constructed, new technology transfer may not be expected.

vii) Drivability

There's no problem at all in driving cars on this type of bridge.

viii) Consideration on Aviation

There's no problem at all.

2) PC Cable Stayed Girder Bridge

i) Construction Cost

This type necessitates a pair of towers, and cables and their fittings that must be imported and expensive. Generally this is a type to be adopted where aesthetic viewpoint must be stressed and/or longer horizontal clearance must be kept beneath the bridge.

ii) Constructivity

The girder is extended from a pier top by balanced cantilevering and supporting with cables to both sides, and thus dose not obstruct navigation during the construction.

iii) Construction Period

The construction period is the longest among others.

iv) Aesthetic

The tower and diagonally extended cables form a geometric beauty and no doubt it becomes a landmark.

v) Maintenance

Most parts of the structure have same conditions as a PC continuous box girder

regarding the maintenance, but the cables have to be carefully protected and periodical inspection must be provided.

vi) Technology Transfer

This might be the first regular roadway cable stayed girder bridge in Bangladesh if this would be realized. It will surely contribute to technology transfer.

vii) Drivability

The different point from the other two types is the stiffness. Generally it is less rigid than other types and thus may obstruct drivability with a vibration of the bridge structure caused by wind. Wind tunnel test or other simulation tests may be required before detail design.

viii) Consideration on Aviation

As a rule tower height is approximately one fifth of the main span length, in other word it is assumed as 40 meters high in this case. When aviation is expected near the bridge or construction of a new airport is planned, the tower may obstruct it or at least some countermeasures must be taken on the tower.

3) Continuous Box Girder Bridge with Steel Deck

i) Construction Cost

Almost all steel elements must be imported, and the cost is in-between.

ii) Constructivity

The semi-assembled girder block is installed by a floating crane or a method making use of tidal difference. Navigation must be held up.

iii) Construction Period

The best characteristic of the type is its short construction period, only under such conditions that an appropriate season and time for the girder lifting-up are chosen, a large floating crane can be towed from other country, and also stopping the navigation is allowed.

vi) Aesthetic

Outline of the form is almost same as that of PC Continuous Box Girder Type. The difference is that a steel bridge may be painted in desirable colors. On the other hand, the painted color is inevitable to be faded by the ultraviolet of the sunshine after several years, and requires the maintenance.

iv) Maintenance

As explained before in 12.2.4, the remarkable shortcoming of the material is a countermeasure against the corrosion. The maintenance work necessitates cost and time periodically.

vi) Technology Transfer

There's no modern long span bridge of steel elements with welding technique in Bangladesh. It will surely contribute to technology transfer.

vii) Drivability

There's no problem at all.

viii) Consideration on Aviation

There's no problem at all.

(4) Best Recommended Structural Type

Through the comparison on the criteria made among candidates for the Main Bridge, these below are recommended as the optimum type for Rupsa, Bhairab/Atai and Atherobaki Bridges.

1) Rupsa, Bhairab/Atai Bridge
   Continuous PC Box Girder Bridge with Tapered Girder Depth

2) Atherobaki Bridge
   Continuous PC Box Girder Bridge with Uniform Girder Depth

12.2.8 Selection of Structural Type for Approach Bridge

(1) Introduction

Approach Bridge is a viaduct structure constructed on both sides of the Main Bridge, connecting with roadway embankments.

Usually this consists of short to medium span bridge structure ranging between approximately 20 to 40 meters.

The criteria in determining a suitable type for the Approach Bridge are described in 12.2.2, out of which important factors are the cost and the experience in constructing the type, because many numbers of the same structures are to be constructed continuously at the site.

(2) Selection of span length and type

No reason can be found for selecting a steel bridge due to the high cost.

Table 12.2.2 shows that PC simple/continuous T-girder, box girder and composite I girder may be adopted for the Approach Bridge.
Out of these types, composite PC I-girder bridge is a type which is frequently used in Bangladesh, and thus enough experience has been accumulated already.

The factor of the cost is given in such a way. The viaduct is to be built in relatively a high elevation, which signifies that the cost for the substructure is high, where a span length of the superstructure is assumed to be constant. On the other hand, where the elevation is assumed constant, then the longer the span is, the more expensive the superstructure is.

Cheap cost of this kind of the viaduct is attained by an appropriate combination of span length and pier height. Fig. 12.2.4 shows the relation of costs for superstructure and substructure of the Approach Bridge, of which span length ranges between 20 and 30 meters. As the result, there's not much difference between the total costs for the span of 20, 30 and 40 meters, but it proves that the span length of 30 meters is the most economic alternative.

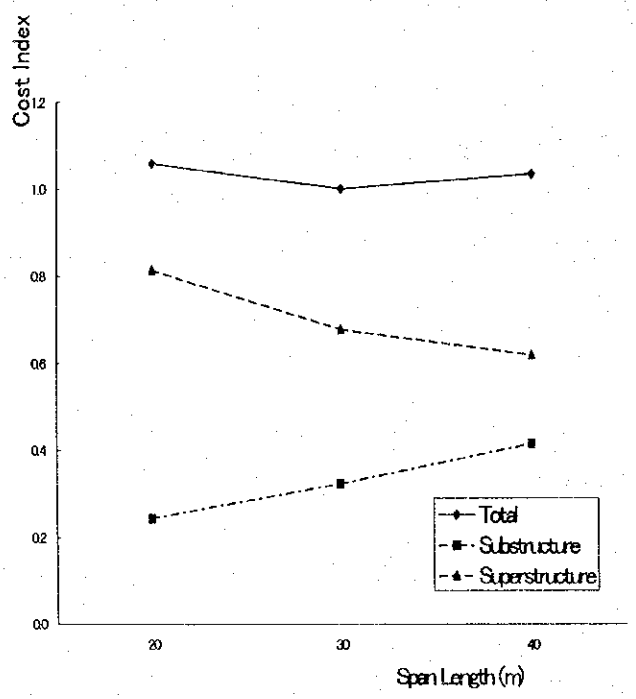


Fig. 12.2.4 Cost Comparison of Approach Bridge

Taking the cost and experience into account, a composite PC I-girder bridge with a span length of 30 meters has been selected as a structure for the Approach Bridge.

12.2.9 Selection of Substructure Type

A pier consists of a body portion and a foundation portion.
Types of the body and the foundation portions are selected as follows;

(1) Selection of pier type

Usually a pier is constructed of concrete, and there are such types of the pier body as shown in Table 12.2.5.

A wall type pier with/without cantilever is often used. Having cantilever or not will depend on the correlation between the bridge width and those of column and foundation. A wall type with an ellipse cross-section can reduce disturbing effect to the river flow. And thus this type was adopted for the Main Bridge.

The same may be used as a pier body for the Approach Bridge. But rectangular wall type was selected here, simply because there's no need of considering the effect of flow to these piers of approach portion.

(2) Selection of foundation type

Table 12.2.6 is a useful measuring device in selecting foundation types.

The types are commonly classified into three basic methods, they are driving piles, cast-in-situ piles and caisson foundation, and in addition there are some other special technique.

Dominating factors in deciding the type are soil conditions of the ground up to the bearing stratum, condition of the bearing stratum itself, depth of the stratum, magnitude of vertical and horizontal load and water depth.

The most significant here in this project is the fact that the bearing stratum exists so deep in the ground as approximately 50 meters deep.

According to the table, the methods of driving steel pile, cast-in-situ concrete pile by reverse circulation and open caisson may be selected for the depth in this project.

Out of these three candidates, cast-in-situ concrete pile by reverse circulation method was adopted taking the following facts into consideration. That is, steel piles must be purchased

from overseas and difficulty may happen if there are found very hard strata difficult to be penetrated, and also caisson method generally necessitates more cost and time.

The same method was selected for the foundation of the Approach Bridge for the reason similar to those of the Main Bridge, and also there's absolutely no reason for taking up neither steel pipes nor caisson.

Only the difference is that the piles of the Main Bridge are located offshore and thus are constructed in a cofferdam surrounded by steel pipe piles using a crane mounted on a barge.

Table 12.2.5 Types of Pier

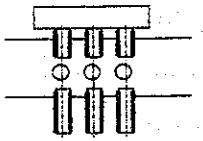
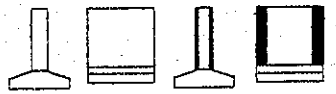
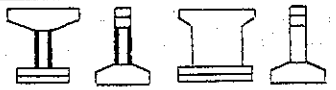
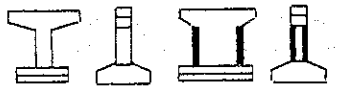
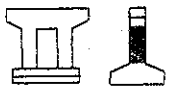
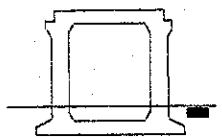
Type	Shape	Characteristics
Pile - Bent		• Pile heads are connected by a cross beam • Flexible in bridge axis direction • Not applicable to large scaled structures
Wall Type	(1) Rectangular column  (2) Ellipse shape column	• Generally applicable to common structures • To be installed parallel to river flow
Wall/Column Type With Cantilever	(3) Cylindrical column  (6) Rectangular column (4) Rectangular column  (7) Ellipse shape column	• To be installed parallel to river flow • (3) Cylindrical column: having an advantage where a river flow not in perpendicular to bridge
Rigid Frame Type (2-Columns)	(5) Two columns 	• To be installed parallel to river flow • Having tendency to disturb river flow and scour
Rigid Frame Type (Box)		• Possible to be constructed by the slender member

Table12.2.6 Selection of Foundation Types

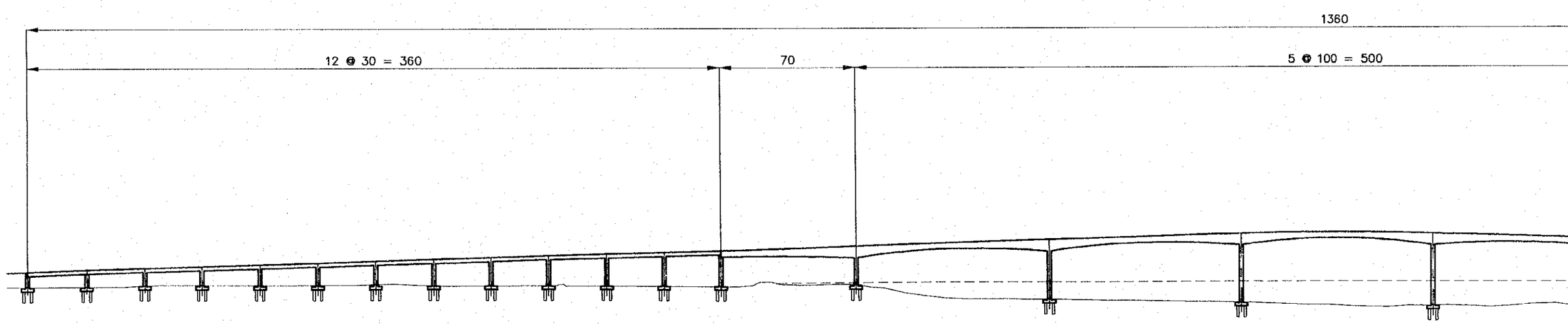
Conditions \ Foundation Type				Spread Footing	Driving Pile: Reinforced concrete pile (RC pile)	Driving Pile: Prestressed concrete pile (PC pile)	Driving Pile: Steel pipe pile	Cast in situ Conorete pile: All casing method	Cast in situ Conorete pile: Reverse circulation method	Cast in situ Conorete pile: Earth Drill Method	Caisson: Pneumatic caisson	Caisson: Open caisson	Steel pipe pile method	Cast-in-situ-slurry wall method
Ground conditions	Existance of very soft layer in the middle			×	○	○	○	○	○	○	○	○	○	○
	Conditions up to bearing strarum	Existance of gravel layer in the middle	Diameter of gravel : less than φ 5cm	○	△	△	◎	○	◎	○	○	◎	○	○
			Diameter of gravel : φ 5cm - φ 10cm	○	×	△	△	○	◎	△	○	◎	△	○
			Diameter of gravel : φ 10cm - φ 50cm	○	×	×	×	△	×	×	○	△	×	△
	Conditions of the bearing strarum	Depth up to bearing strarum	less than 5m	○	×	×	×	×	×	×	×	×	×	×
			5m - 15m	△	○	○	◎	○	△	○	○	◎	△	△
			15m - 25m	×	△	○	◎	○	◎	○	○	◎	○	○
			25m - 40m	×	×	○	◎	○	◎	△	○	◎	○	○
			40m - 60m	×	×	△	◎	△	◎	×	△	◎	◎	◎
			more than 60m	×	×	×	△	×	△	×	×	△	△	△
		Soil condition of bearing stratum	Cohehive soil (20≦N)	○	○	○	◎	○	◎	○	○	◎	○	○
			Sandy or gravel (30≦N)	○	○	○	◎	○	◎	○	○	◎	○	○
		Bearing stratum level inclines ($30^\circ < \theta$)		○	×	△	◎	○	△	△	○	△	△	△
	Conditions of ground water	Ground water level is near ground surface		△	○	○	◎	○	◎	△	○	◎	○	○
		Resurgent water is large		△	○	○	◎	○	◎	△	○	◎	○	△
		Artestian head water exits (h > 2m)		×	○	○	◎	×	×	×	△	△	○	×
		Velocity of ground water is more than 3m/min		×	○	○	◎	×	×	×	○	△	○	×
Structural feature	Magnitute of load	Vertical load is low (span < 20m)		○	○	○	◎	○	◎	○	×	△	×	×
		Vertical load is medium (span 20m - 50m)		○	△	○	◎	○	◎	○	○	◎	○	○
		Vertical load is large (span > 50m)		○	×	△	◎	○	◎	△	○	◎	○	○
		Horizontal load is comparatively low againt vertical load		○	○	○	◎	○	◎	○	△	△	△	△
		Horizontal load is comparatively large againt vertical load		○	×	△	◎	○	◎	○	○	○	○	○
	Support system	Bearing pile		-	○	○	◎	○	◎	○	-	-	-	-
		Friction pile		-	○	○	◎	○	◎	○	-	-	-	-
Construction condition	Construction over water	Water depth is less than 5m		○	○	○	◎	△	◎	△	△	△	○	×
		Water depth is more than 5m		×	△	△	◎	△	◎	×	△	△	○	×
	Working space is narrow			○	△	△	△	△	△	△	△	△	×	△
	Inclined pile construction			-	△	○	◎	△	×	×	-	-	-	-
	Environment	Required measures for vibration and noise		△	○	×	×	△	◎	○	○	◎	×	○
		Influence to adjusment structures		○	○	×	△	○	◎	○	△	△	△	○

○ : Suitable　　△ : Applicable　　× : Not suitable

12.2.10 Recommended Bridges

The recommended bridges through the procedure so far are shown in Fig. 12.2.5 to 12.2.8.

RUPSA BRIDGE



RUPSA BRIDGE

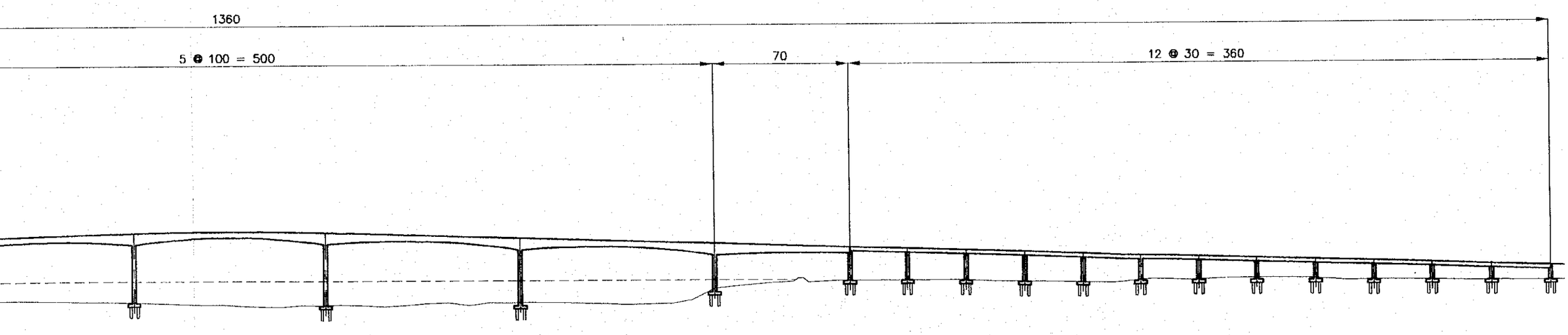
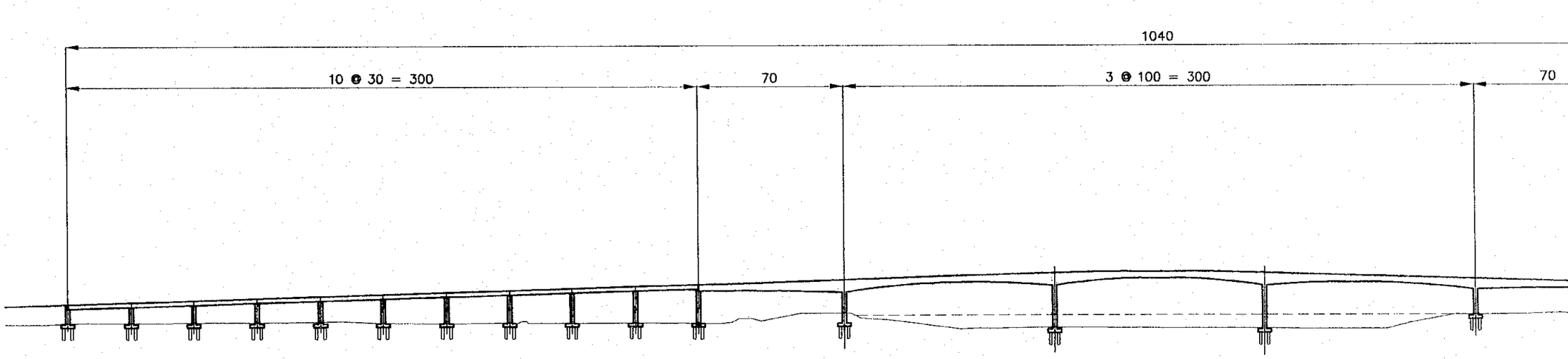


Fig. 12.2.5 Recommended Type for Rupsa Bridge

BHAIRAB BRIDGE



BHAIRAB BRIDGE

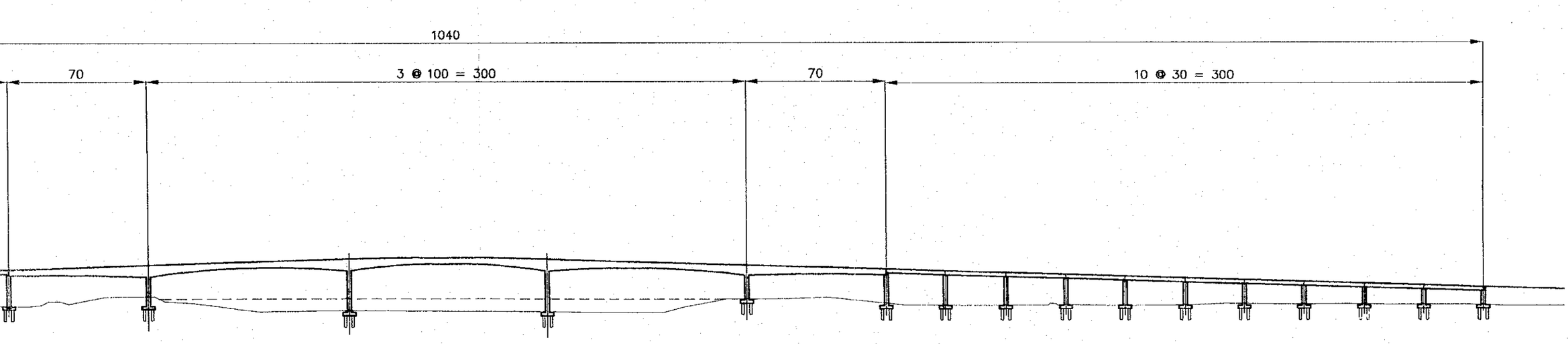
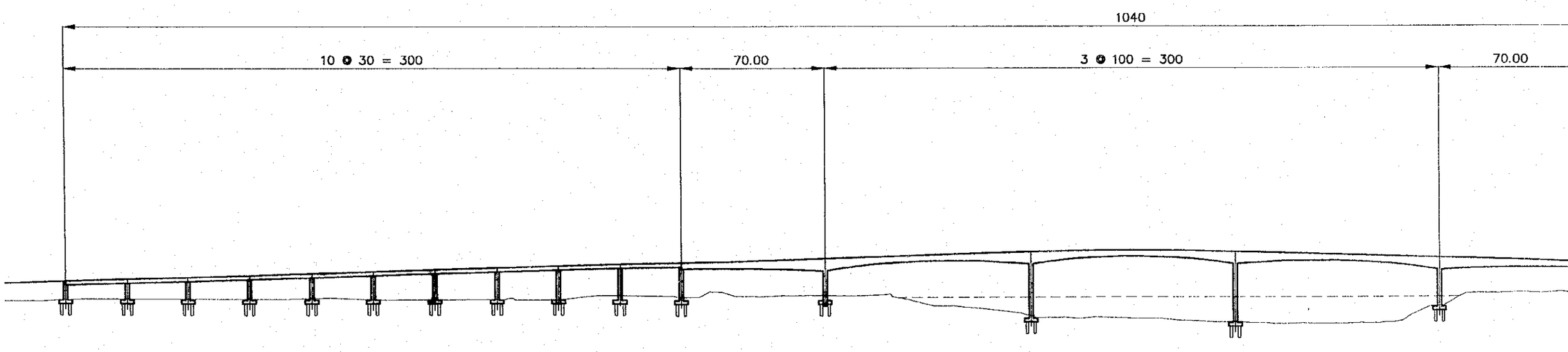


Fig. 12.2.6 Recommended Type for Bhairab Bridge

ATAI BRIDGE



ATAI BRIDGE

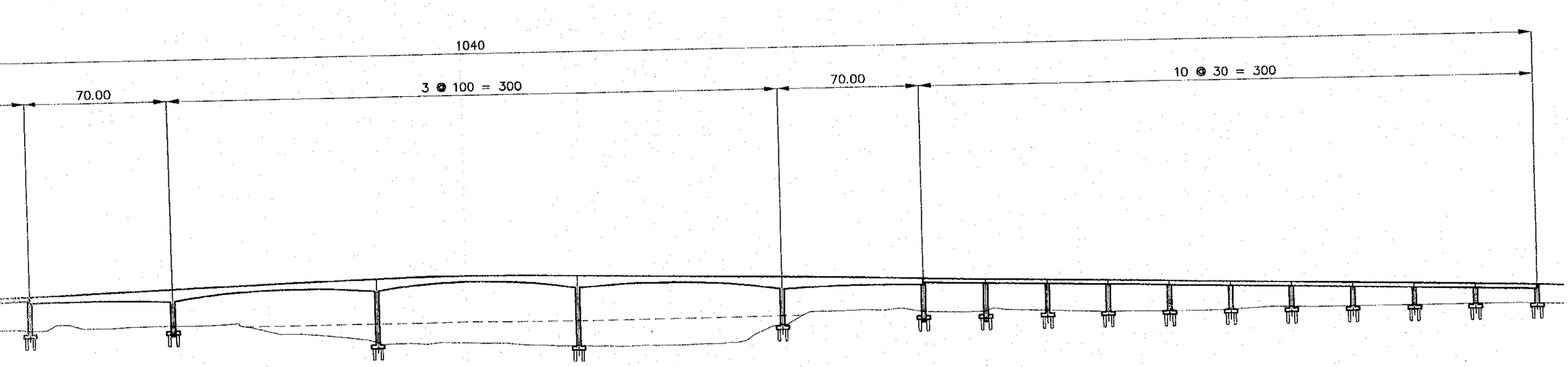


Fig. 12.2.7 Recommended Type for Atai Bridge

ATHEROBAKI BRIDGE

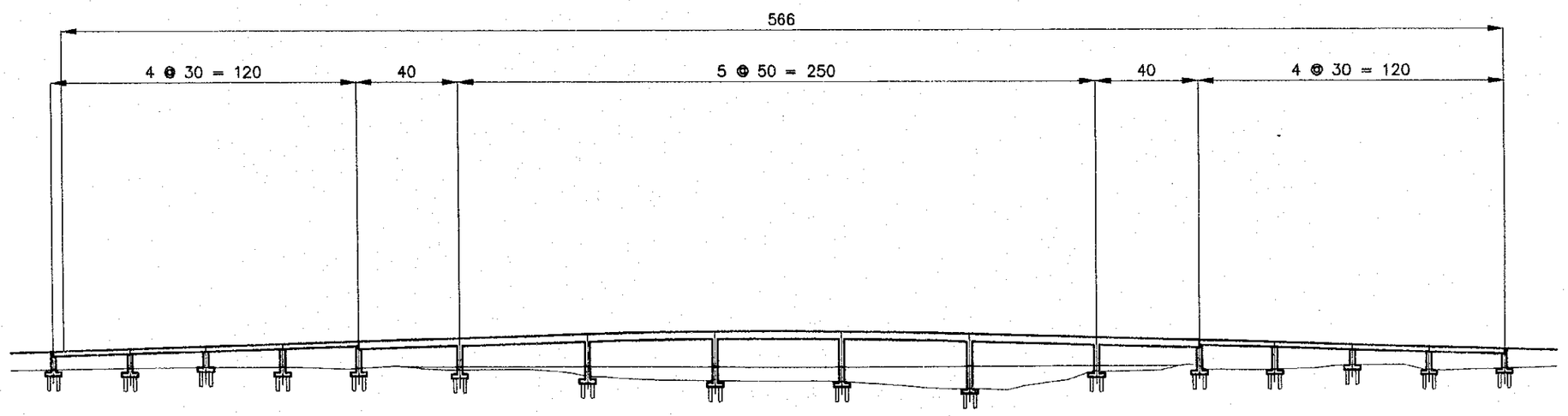


Fig. 12.2.8 Recommended Types for Atherobaki Bridge

12.2.11 Construction Planning

(1) Construction of substructure of the Main Bridge

The types of the foundation and pier recommended are cast-in-situ concrete piles by reverse circulation method and wall type pier with an ellipse cross-section.
Most of the foundations and piers are located in the river. Therefore the construction will have to be carried out in the offshore. The work is mostly conducted by a crane mounted on a barge. The procedures of constructing the substructure are as follows;

1) Installation of cofferdam (Fig.12.2.9-1)
   - Steel pipe piles are driven by the crane to form a cofferdam.

2) Reverse Circulation Drill (RCD) Piles (Fig.12.2.9-2)
   - Holes are drilled through a standpipe.
   - Cage of reinforcing bars is inserted into the drilled hole while cofferdam is still filled with water.
   - Concrete is poured through a tremie pipe to form the cast-in-situ concrete piles.

3) Excavation inside the cofferdam (Fig.12.2.9-3)
   - The earth at the bottom of the cofferdam is removed.

4) Placing concrete (Fig. 12.2.9-4)

   - Concrete is placed underwater through a tremie pipe to establish a firm base and to seal the bottom.

5) Pumping up water (Fig. 12.2.9-5)

As the water inside is pumped up, steel shoring and bracing are installed layer by layer so as to resist the water pressure outside the cofferdam.

6) Construction of pier body (Fig.12.2.8-6)

   - Concrete is poured to form the pier body inside the dry cofferdam
   - The cofferdam is removed after completion of constructing the substructure.

(2) Construction of superstructure of the Main Bridge

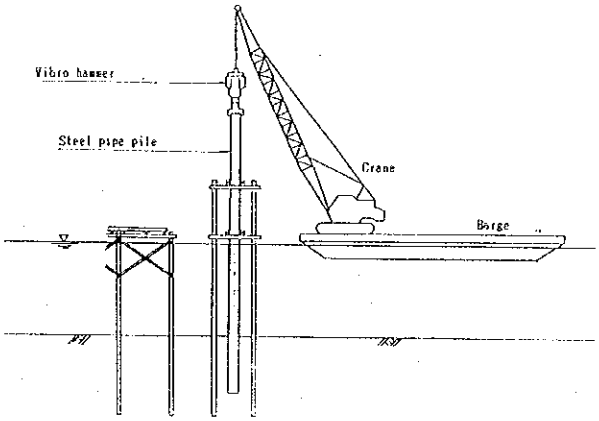
The Main Bridge is a continuous PC box girder bridge supported on foundations of cast-in-situ concrete piles by a reverse circulation method. This type of bridge has been experienced and, needless to say, how to construct it is well known here already. The outline of procedures in constructing the superstructure are described.

1) Construction of the girder on the pier top (Fig.12.2.10-1)

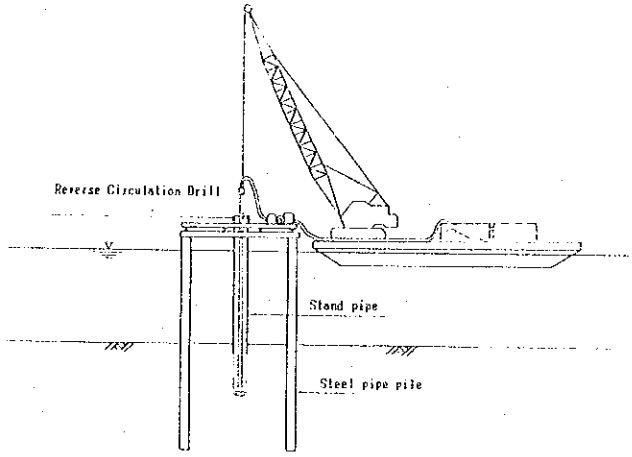
- A portion of the PC box girder is constructed on top of the pier supported by steel bracket firmly fixed to the pier body.

2) Installation and operation of the travelling wagon (Fig. 12.2.10-2,3)

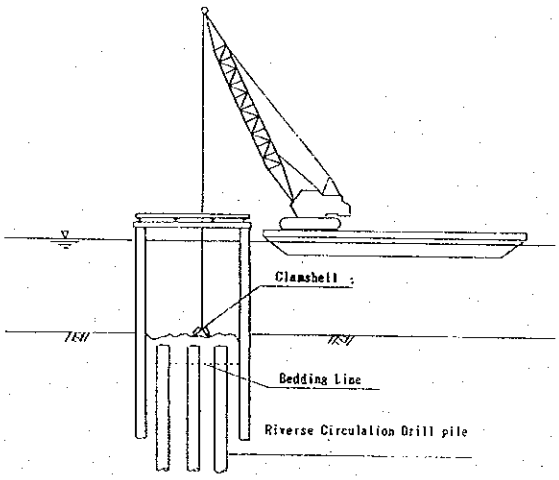
- On the both edges of the cantilevered girder, travelling wagons are assembled and anchored.
- Suspended by the wagon, forms are established, rebars are assembled and concrete is place.
- After the concrete has an expected strength and the forms are removed, then each wagon is driven towards the span center.
- This operation is repeated symmetrically until both ends of the box girders meet together at the center.



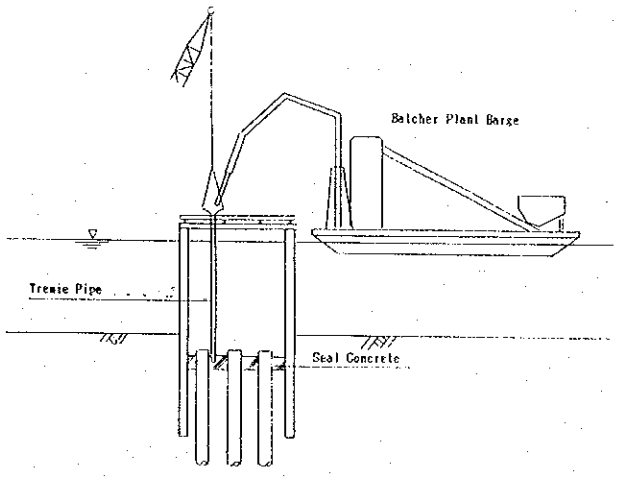
1) Installation of cofferdam



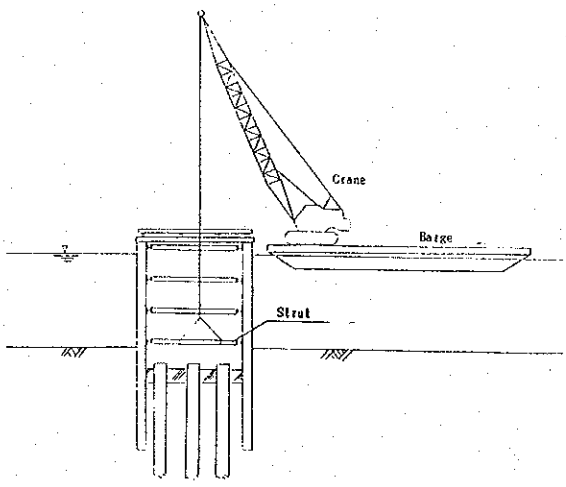
2) Reverse Circulation Drill (RCD) Piles



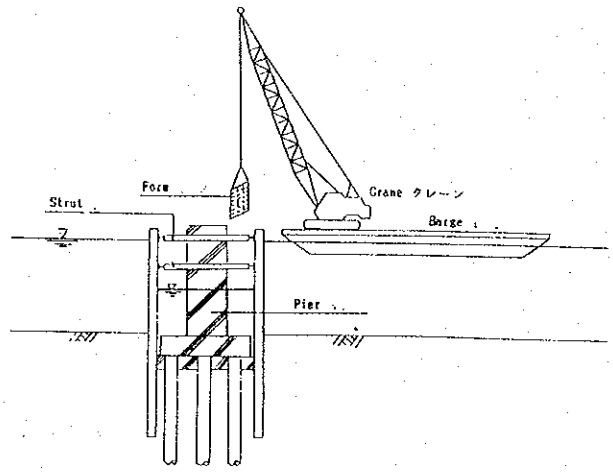
3) Excavation inside the cofferdam



4) Placing concrete

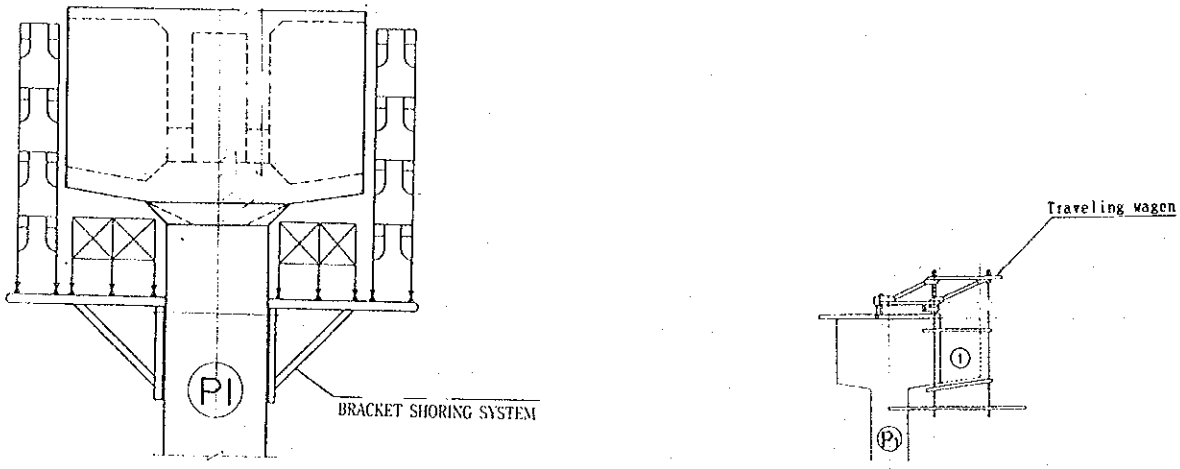


5) Pumping up water

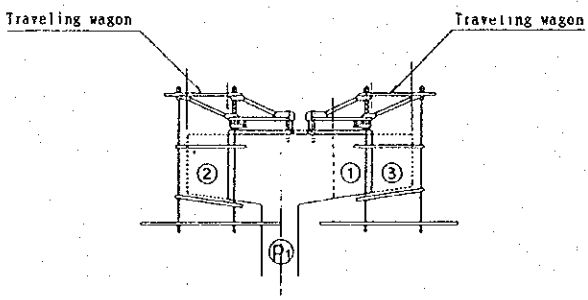


6) Construction of pier body

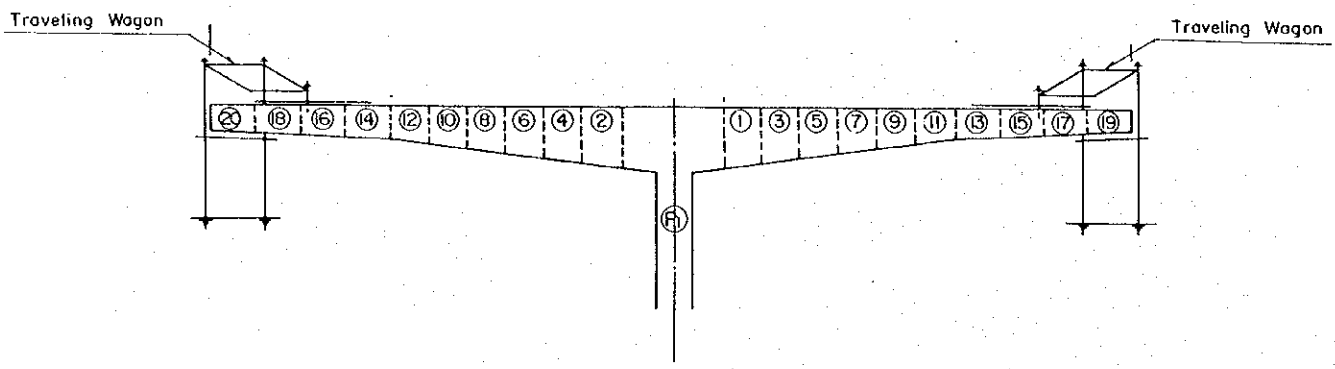
Fig. 12.2.9 Construction Procedure of Substructure



1) Construction of the girder on the pier top



2) Installation of the travelling wagon



3) Operation of the travelling wagon

Fig. 12.2.10 Construction Procedure of Superstructure

(3) Construction of the Approach Bridge

The Approach Bridge selected here is of a familiar structure type that has been adopted frequently in Bangladesh.

The foundation piles are installed by reverse circulation method, and the concrete bodies of the wall type piers are built in a common way.

The PC I-girders are prefabricated in a yard or a temporary mill prepared nearby, and transported to the site. The girders are lifted up and installed on the right position, and then concrete deck slab is placed on them so that the girders and the deck may work together as one body.

(4) Securing access road for bridge construction

In order to construct the Approach Bridge in the way described above, materials and construction mercenaries have to be conveyed to the point where they are utilized. Major works for the Main Bridge may be carried out from the river, but some will have to be done by land.

Access roads must be developed between the approach road and the river bank for the above purpose.

12.2.12 Hydraulic Design

When a bridge structure and its associated embankments encroach upon the flow of a river in flood, there is a risk to the structure, the embankments and the surrounding land. It is not economical, however, to build a bridge to clear a wide floodplain because the bridge works cost more than earth embankments.

There are two major problems on a hydraulic design of a bridge, namely scouring of the riverbed and erosion of banks.

(1) Scouring

Scour is the erosive effect of water flow on the riverbed. Bridge works may alter the existing scour pattern by restricting the free flow of the stream and/or causing local changes to the current.
There are two types of scour, general scour and local scour.
In order to protect the riverbed against scouring, first of all it must be predicted correctly as much as possible, and then a proper countermeasures must be established.

1) General scour

General scour is caused by reduction in the channel width at the bridge works, where a rise in water level occurs on the upstream side of a bridge.

There are many relationships that can be used to predict general scour. All of them assume a fairly simple river channel shape. At complex locations, particularly near the junction of two streams, these methods are known to be inaccurate.

The area-velocity method and the competent velocity method are principal methods for predicting general scour.

2) Local scour

Local scour occurs at the base of piers and abutments where they divert the general flow.

In addition to the general scour, there will be local scour of the riverbed at the bridge site caused by turbulent flow around obstacles such as piers, unless the bed is armored. The localized turbulence also removes bed materials from critical area wherever the flow of water is diverted downwards or sideways around the ends of wing walls and abutments.

Given a shape of pier nose, breadth of pier and water depth, then depth of a scour can be predicted.

3) Countermeasures to scour

The following two countermeasures are proposed;

i) First of all, expected depth of scouring is calculated. Then the strength of piles are verified under such conditions that the piles are not embedded any more and exposed to the water.
ii) If the strength is not enough, then the piles are reinforced so as to bear it.
iii) In addition, the riverbed is protected by rip rap.

Rip rap riverbed protection consists of a carpet of loose stones, which prevents the eater current from eroding the soft bed material. The stone elements must be heavy enough to resist being washed away by maximum water velocities during a flood, and they should no be installed in a manner which reduces the area of waterway designed to accommodate general scour.

(2) Erosion

As mentioned before in this chapter the Main Bridge is a portion of the bridge crossing the river, and consequently is planned based on the conditions that the river keeps the situation as it was assumed. The conditions are in other words that the river stays for good in the same location, alignment, depth, velocity and so on. In order to realize and keep the conditions, the riverbanks must be protected in a proper manner after studies from various aspects.

There are several kinds of protection methods of the bank protection as below, among which the most suitable must be chosen.

1) Rip rap
2) Gabions and reno mattresses
3) Filter blankets
4) Piled wall
5) Vegetation
6) Slab concrete and stone pitching

12.3 Project Cost Estimates

12.3.1 General

Each project cost as a financial cost is estimated based on the results of preliminary engineering design, quantity take-off of each work item, and the studies on construction planning and method as described in the preceding subsections.
The basic premises in estimating preliminary cost are as follows:

1) All the construction work will be executed by constructor(s) to be selected by international competitive bidding provided that it shall exempt foreign personnel from tax, duties and other charges on equipment, machinery and other materials brought into and out of Bangladesh for the construction work.
2) The unit cost of each cost component is determined based on the economic conditions prevailing in December 1998 (USD $1 .0 = 48.3 Taka).
3) Engineering services cost is assumed to be 3% of construction cost.
4) Supervisory service cost is assumed to be 4% of construction cost.

12.3.2 Construction Cost

(1) Basis of Unit Cost of Construction Works

The unit cost of each construction work is estimated in principle based on labor costs, material costs, equipment costs prevailing in Khulna.

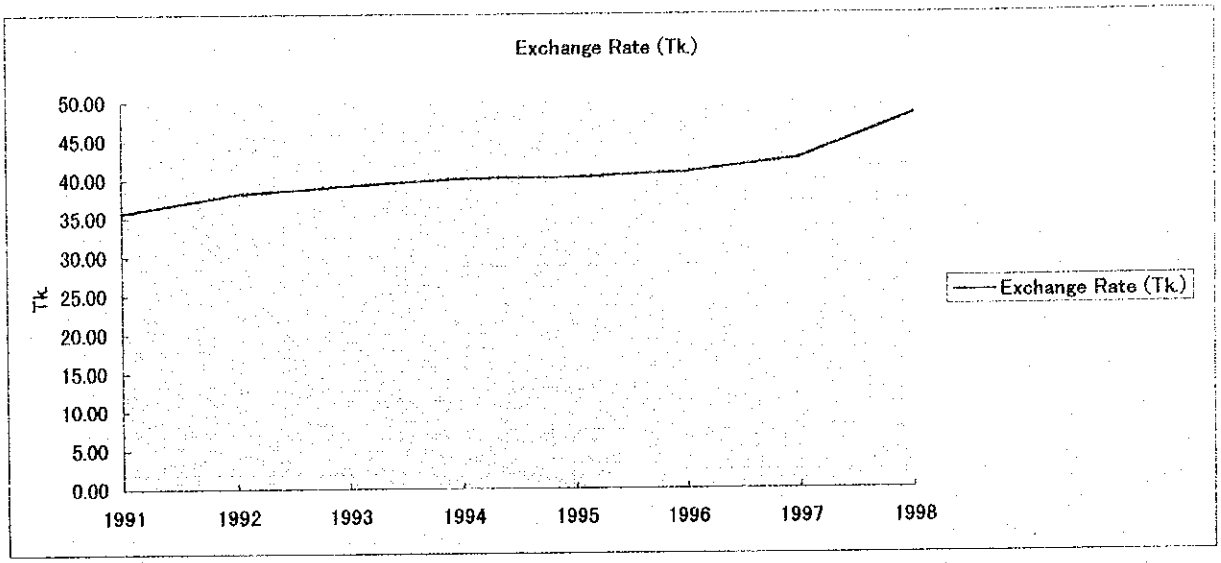
The unit costs are analyzed and compared with similar work items of approved agency's estimate, and they are adjusted as required to obtain more realistic ones.

Table 12.3.1 shows trend of exchange rates against US dollar for eight (8) years, and averaged devaluation of 4.4% per annum is found for the Study.

Table 12.3.2 shows key macroeconomic indicators in Bangladesh. Annual average of inflation based on Consumer Price Index (CPI) is found 4.9% and it is applied to the Study.

Table 12.3.1 Trends of Foreign Exchange Rate against US$

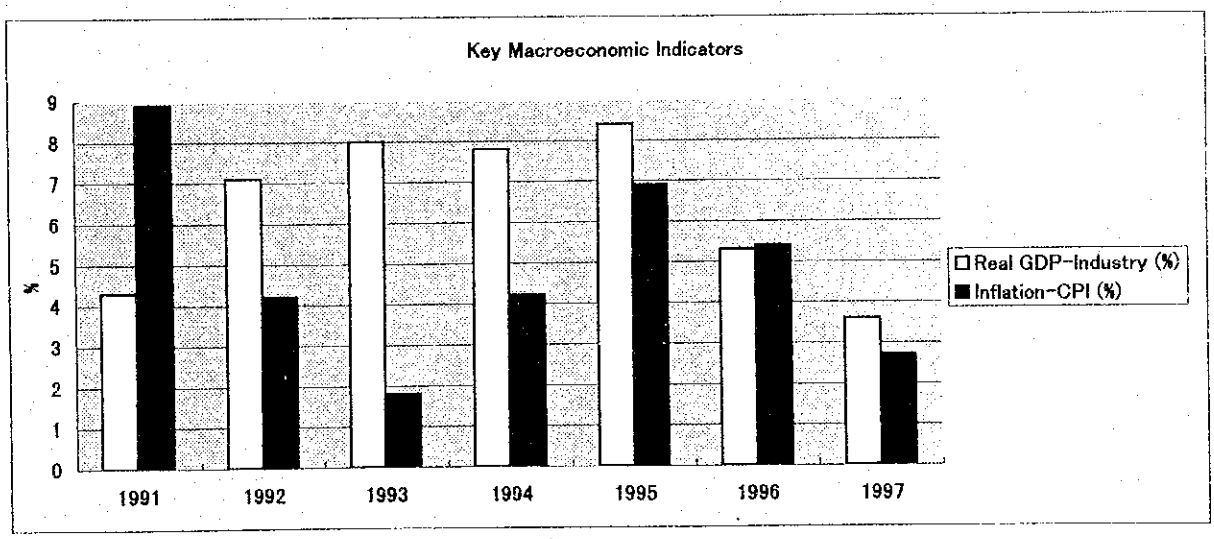
Year	1991	1992	1993	1994	1995	1996	1997	1998	Ave. Devaluation
Exchange Rate (Tk.)	35.68	38.15	39.14	40.01	40.20	40.84	42.63	48.30	4.4%



Source : Country Economic Review (ADB), October 1997
The Rate in 1998 shows the selling rate prevailed in November 1998.

Table 12.3.2 Key Macroeconomic Indicators

Year	1991	1992	1993	1994	1995	1996	1997	1998	Annual Average
Real GDP-Industry (%)	4.3	7.1	8	7.8	8.4	5.3	3.6		6.4
Inflation-CPI (%)	8.9	4.2	1.8	4.2	6.9	5.4	2.7		4.9



Source : Country Economic Review (ADB), October 1997

(2) Unit Cost of Labors

Table 12.3.3 shows the unit cost of labors applied to cost estimates, which include such allowances as social benefits, insurance, etc. and are based on and eight-hour work day.

Table 12.3.3 Unit Cost of Labors

Tk./Day

Classification	Unit Cost	
	Rate in 1996	Estimated in 1998
Senior Field Engineer	430	473
Junior Field Engineer	400	440
Foreman	350	385
Driver	250	275
Equipment Operator	250	275
Mason/carpenter etc	160	176
Skilled Labor	130	143
Semi skilled Labor	100	110
Unskilled Labor	60	66

Source : Schedule of Rates for Road & Bridge Works (RHD-Khulna Zone), 1996
Note : Average Inflation of 4.9% p.a. is applied.

(3) Unit Cost of Materials

Table 12.3.4 shows the unit cost of major construction materials. The cost of imported materials is based on the Mongla Port prices including port handling and clearance charges and import duties. The cost of domestic materials is based on the market prices in Khulna area.

Table 12.3.5 shows unit costs of major work items cited in "Schedule of Rates for Road & Bridge Works" published by RHD Khulna Zone in 1996.

(4) Unit Cost of Equipment

Table 12.3.6 shows the unit cost of equipment which will be used for major works of road and bridge construction.

It comprises foreign currency and local currency portions in each unit cost.

F. C. Portion : Ownership cost of equipment per hour used.
L. C. Portion : Fuel, lubricant oil and wage of operator per hour used.

Table 12.3.4 Unit Cost of Major Materials

Description	Unit	Unit Cost (Tk)	
		Rate in 1996	Estimated in 1998
1 Portland Cement	ton	6,050	6,657
2 Asphalt Cement	ton	15,400	16,785
3 Reinforcing Steel			
a) ASTM grade 40	ton	34,314	37,759
b) ASTM grade 60	ton	37,190	40,924
4 Prestressing Strand	kg	92	100
5 Gasoline	lit	22	24
6 Disel	lit	14	15
7 Fine Aggregate			
a) Sand (FM =2.8)	cu.m	825	908
b) Sand (FM =1.8)	cu.m	770	847
c) Sand (FM =1.5)	cu.m	715	787
d) Sand (FM =1.0)	cu.m	660	726
e) Sand (FM =0.8)	cu.m	550	605
f) Sand (FM =0.5)	cu.m	303	333
h) Sand (FM = 0.3)	cu.m	187	206
8 Coarse Aggregate			
a) Boulder	cu.m	1,815	1,997
b) Shingles	cu.m	1,540	1,695
c) Pea-gravels	cu.m	935	1,029
9 Bricks			
1st Class Bricks	1000 no	2,750	3,026
1st Class Bricks	cu.m	825	908
10 Timber			
a) Hard wood	cu.m	16,000	17,606
b) Soft wood	cu.m	5,200	5,722

Source : Statistical Year Book, 1997 (Bangladesh Bureau of Stastics)
Note : Averaged Inflation of 4.9% p.a. is applied to domestic products.
Averaged devaluation of 4.4% p.a. is applied to imported products.

Table 12.3.5 Unit Cost for Major Construction Work Items

Item	Unit	Unit Cost (Tk)	
		Rate in 1996	Estimated in 1998
1 Earth Work			
a) Embankment (Borrow Material)	cu.m	140	154
b) Treatment of Embankment Foundation	sq.m	24	26
2 Pavement			
a) Crusher run sub-base course	cu.m	1,790	1,970
b) Stabilised Aggregate base course (Type I)	cu.m	2,733	3,007
c) Stabilized Aggregate base course (Type II)	cu.m	2,004	2,205
d) Prime and Tack Coat	lit	27	30
e) Dense Premix Wearing Course	cu.m	6,513	7,167
3 Drainage Structures and others			
a) Pipe Culvert (D = 0.8 m)	l.m	6,405	7,048
b) Pipe culvert (D = 1.0 m)	l.m	9,024	9,930
c) Rain Water down pipes	each	1,500	1,651
d) Vechile Guardrail, Standard	l.m	1,740	1,915

Source : Schedule of Rates for Road & Bridge Works (RHD-Khulna Zone), 1996
Note : Averaged Inflation of 4.9% p.a. is applied.

Table 12.3.6 Unit Cost of Equipment

(Per Hour)

Equipment	Capacity	FC Portion (Yen)	LC Portion
Crawler Crane	100 ton	14,900	
Crawler Crane	150 ton	20,200	
Truck Crane, Hydraulic	25 ton	3,510	
Pile Driver with Hammer	4.5 ton Ram Wt	21,800	
Pile Driver with Vibro-hammer	60 kw vibrohammer	24,140	
Three Wing Bit	1200 mm dia	3,000	
Transit Mixer	3.2 cu.m/hr	958	
Concreate Pump, Boom Type	110 cu.m/hr	6,420	
Reverse-Circulation-Drill		4,550	
Generator	500KVA	11,600	
Generator	300KVA	10,600	
Generator	150KVA	5,470	
Vibro-hammer	150KW	5,630	

(5) Direct Construction Cost

The base cost is obtained by multipling the quantity and unit cost.
The direct construction cost is estimated based on the base cost and additional of 10% of the base cost which consists of mobilization and demobilization cost, tax and duty and overhead & profit.

(6) Unit Cost for Major Construction Work Items

The unit cost for major construction work items are shown in Appendix H based on the cost estimate conditions mentioned above.

(7) Physical Contingency

The physical contingency of 10% of Direct Construction Cost is estimated in addition to Direct Construction Cost to obtain Construction Cost.

12.3.3 Land Acquisition and Property Compensation Costs

Land acquisition and property compensation costs are estimated based on the field investigations on affected area where routes planned in the preliminary design would require to acquire land and to compensate affected properties such as homesteads, trees, rights of fishing/farming/common, costs for resettlement and so forth.

The summary of estimated land acquisition and resettlement cost by each alternative plan is shown in Chapter 13.

12.3.4 Estimated Project Cost

The summary of project cost in 1998 prices is shown in Table 12.3.7. The project cost is expressed in term of financial cost by each alternative plan.

Table 12.3.7 Project Cost Estimates (1)

Name of Link: SOUTHERN SECTION OF KHULNA BYPASS
Station: STA 17+600 - STA 27+700
Alternative: ALT 1-1

At 1998 Prices

Description	Financial Cost (Million Taka)
1. Direct Construction Cost	2,527.9
1) Highway	1,173.7
2) Bridge	1,340.8
3) Toll Facilities	13.5
2. Physical Contingency (10% of 1.)	252.8
3. Construction Cost	2,780.7
4. Land Acquisition and Compensation	92.9
5. Engineering Services	83.4
6. Supervisory Services	111.2
Total	3,068.3

Name of Link: SOUTHERN SECTION OF KHULNA BYPASS
Station: STA 17+600 - STA 27+700
Alternative: ALT 1-2

At 1998 Prices

Description	Financial Cost (Million Taka)
1. Direct Construction Cost	2,913.5
1) Highway	1,181.7
2) Bridge	1,718.2
3) Toll Facilities	13.5
2. Physical Contingency (10% of 1.)	291.3
3. Construction Cost	3,204.8
4. Land Acquisition and Compensation	92.9
5. Engineering Services	96.1
6. Supervisory Services	128.2
Total	3,522.1

Name of Link: SOUTHERN SECTION OF KHULNA BYPASS
Station: STA 17+600 - STA 27+700
Alternative: ALT 1-3

At 1998 Prices

Description	Financial Cost (Million Taka)
1. Direct Construction Cost	3,065.9
1) Highway	1,178.0
2) Bridge	1,874.3
3) Toll Facilities	13.5
2. Physical Contingency (10% of 1.)	306.6
3. Construction Cost	3,372.5
4. Land Acquisition and Compensation	92.9
5. Engineering Services	101.2
6. Supervisory Services	134.9
Total	3,701.4

Table 12.3.7 Project Cost Estimates (2)

Name of Link: SOUTHERN SECTION OF KHULNA BYPASS
Station: STA 17+600 - STA 27+700
Alternative: ALT 1-4

At 1998 Prices

Description	Financial Cost (Million Taka)
1. Direct Construction Cost	3,295.5
1) Highway	1,155.0
2) Bridge	2,126.9
3) Toll Facilities	13.5
2. Physical Contingency (10% of 1.)	329.5
3. Construction Cost	3,625.0
4. Land Acquisition and Compensation	92.9
5. Engineering Services	108.8
6. Supervisory Services	145.0
Total	3,971.7

Name of Link: SOUTHERN SECTION OF KHULNA BYPASS
Station: STA 17+600 - STA 27+700
Alternative: ALT 1-5

At 1998 Prices

Description	Financial Cost (Million Taka)
1. Direct Construction Cost	3,531.2
1) Highway	1,337.5
2) Bridge	2,180.2
3) Toll Facilities	13.5
2. Physical Contingency (10% of 1.)	353.1
3. Construction Cost	3,884.3
4. Land Acquisition and Compensation	92.9
5. Engineering Services	116.5
6. Supervisory Services	155.4
Total	4,249.1

Name of Link: SOUTHERN SECTION OF KHULNA BYPASS
Station: STA 17+600 - STA 27+700
Alternative: ALT 1-6 (I=1%)

At 1998 Prices

Description	Financial Cost (Million Taka)
1. Direct Construction Cost	6,063.7
1) Highway	918.4
2) Bridge	5,131.8
3) Toll Facilities	13.5
2. Physical Contingency (10% of 1.)	606.4
3. Construction Cost	6,670.1
4. Land Acquisition and Compensation	92.9
5. Engineering Services	200.1
6. Supervisory Services	266.8
Total	7,229.9

Table 12.3.7 Project Cost Estimates (3)

Name of Link: EASTERN ROUTE OF KHULNA BYPASS
Station: STA 0+000 - STA 20+100
Alternative: ALT 3-1

At 1998 Prices

Description	Financial Cost (Million Taka)
1. Direct Construction Cost	4,048.7
1) Highway	1,454.3
2) Bridge	2,580.9
3) Toll Facilities	13.5
2. Physical Contingency (10% of 1.)	404.9
3. Construction Cost	4,453.6
4. Land Acquisition and Compensation	275.2
5. Engineering Services	133.6
6. Supervisory Services	178.1
Total	5,040.6

Name of Link: EASTERN ROUTE OF KHULNA BYPASS
Station: STA 0+000 - STA 20+100
Alternative: ALT 3-2

At 1998 Prices

Description	Financial Cost (Million Taka)
1. Direct Construction Cost	4,849.1
1) Highway	1,528.3
2) Bridge	3,307.2
3) Toll Facilities	13.5
2. Physical Contingency (10% of 1.)	484.9
3. Construction Cost	5,334.0
4. Land Acquisition and Compensation	275.2
5. Engineering Services	160.0
6. Supervisory Services	213.4
Total	5,982.6

Name of Link: EASTERN ROUTE OF KHULNA BYPASS
Station: STA 0+000 - STA 20+100
Alternative: ALT 3-3

At 1998 Prices

Description	Financial Cost (Million Taka)
1. Direct Construction Cost	5,118.1
1) Highway	1,497.4
2) Bridge	3,607.2
3) Toll Facilities	13.5
2. Physical Contingency (10% of 1.)	511.8
3. Construction Cost	5,629.9
4. Land Acquisition and Compensation	275.2
5. Engineering Services	168.9
6. Supervisory Services	225.2
Total	6,299.2

Table 12.3.7 Project Cost Estimates (4)

Name of Link: EASTERN ROUTE OF KHULNA BYPASS
Station: STA 0+000 - STA 20+100
Alternative: ALT 3-4

At 1998 Prices

Description	Financial Cost (Million Taka)
1. Direct Construction Cost	5,474.2
1) Highway	1,449.0
2) Bridge	4,011.7
3) Toll Facilities	13.5
2. Physical Contingency (10% of 1.)	547.4
3. Construction Cost	6,021.6
4. Land Acquisition and Compensation	275.2
5. Engineering Services	180.6
6. Supervisory Services	240.9
Total	6,718.3

Name of Link: EASTERN ROUTE OF KHULNA BYPASS
Station: STA 0+000 - STA 20+100
Alternative: ALT 3-5

At 1998 Prices

Description	Financial Cost (Million Taka)
1. Direct Construction Cost	6,014.9
1) Highway	1,805.3
2) Bridge	4,196.1
3) Toll Facilities	13.5
2. Physical Contingency (10% of 1.)	601.5
3. Construction Cost	6,616.4
4. Land Acquisition and Compensation	275.2
5. Engineering Services	198.5
6. Supervisory Services	264.7
Total	7,354.8

Name of Link: EASTERN ROUTE OF KHULNA BYPASS
Station: STA 0+000 - STA 20+100
Alternative: ALT 3-6 (I=1%)

At 1998 Prices

Description	Financial Cost (Million Taka)
1. Direct Construction Cost	10,606.4
1) Highway	947.0
2) Bridge	9,645.9
3) Toll Facilities	13.5
2. Physical Contingency (10% of 1.)	1,060.6
3. Construction Cost	11,667.0
4. Land Acquisition and Compensation	275.2
5. Engineering Services	350.0
6. Supervisory Services	466.7
Total	12,758.9

Table 12.3.7 Project Cost Estimates (5)

NAME OF LINK KHULNA - MONGLA RAILWAY EXTENSION
NAME OF SEGMENT SECTION : KHULNA - MONGLA
ALTERNATIVE : ALT R-1(Eastern route) STA 0+000 - STA 52+500

AT 1998 PRICES

Description	Financial Cost (Million Taka)
1. Direct Construction Cost	5,731.9
1) General	521.1
2) Earthwork	269.1
3) Drainage	429.1
4) Bridge	3,909.1
5) Structural Steel	0.0
6) Incidental Work	603.6
2. Physical Contingency (10% of 1.)	573.2
Sub-total	6,305.1
3. Land Acquisition and Compensation	336.7
4. Engineering Services	189.2
5. Supervisory Services	252.2
Total	7,083.1

NAME OF LINK KHULNA - MONGLA RAILWAY EXTENSION
NAME OF SEGMENT SECTION : KHULNA - MONGLA
ALTERNATIVE : ALT R-3 (Western Rout STA 0+000 - STA 53+000

AT 1998 PRICES

Description	Financial Cost (Million Taka)
1. Direct Construction Cost	3,963.1
1) General	360.3
2) Earthwork	311.5
3) Drainage	204.1
4) Bridge	2,476.5
5) Structural Steel	0.0
6) Incidental Work	610.8
2. Physical Contingency (10% of 1.)	396.3
Sub-total	4,359.4
3. Land Acquisition and Compensation	295.8
4. Engineering Services	130.8
5. Supervisory Services	174.4
Total	4,960.4

CHAPTER 13

INITIAL ENVIRONMENTAL EXAMINATION AND INITIAL SOCIAL EXAMINATION

CHAPTER 13 INITIAL ENVIRONMENTAL EXAMINATION AND INITIAL SOCAL EXAMINATION

13.1 Objectives and Methodology

13.1.1 Objectives of the Study

This Master Plan Study is to formulate a plan for construction of the bridge over the Rupsa River and various impacts on natural and social environment which are expected when implemented.

The study team has therefore conducted initial environmental examination (IEE) and initial social impact examination (ISIE), in order to examine potential positive and negative impacts and assess the necessity for environmental impact assessment (EIA) and social impact assessment (SIA) for the next phase.

13.1.2 Study Area and Study Method

The survey was carried out along and between the proposed Alignment A and B, as potential impacts not only in the project area also around the project area. Impacts for the short, medium, and long term range including the construction period were considered. Social condition survey included items on relocation of houses, private boat operations, commuters and loss of farming lands.

The JICA Study Team employed a local consulting firm, Sheltech Consultants (PVT.) Ltd. in association with Bangladesh Rural Advancement Committee (BRAC), which are very familiar with the local conditions, as they have been engaged for KDA Master Plan Study since 1997.

The study has been carried out in line with the Environmental Guidelines for Infrastructure Projects-III Road prepared by JICA together with consideration of environmental laws and rules in Bangladesh. The work is based on site visits to the project locations and related areas, meeting and discussion with representatives of related sectors, review of documents, regulation and data concerning the project.

13.2 Description of the Present Environment of the Study Area

13.2.1 Social Environment

Site reconnaissance survey was carried out to obtain the general information on social conditions and land use of the area for possible by-pass alignments from the view points of social and environmental issues related to land acquisition of possible project sites.

(1) General Socio-Economic Conditions

① Demographic Trend

Population density in Khulna city and in Khulna districts is given in Table 13.2.1 and Fig.13.2.1. The growth rate ranges between 2.15 and 2.19 percent / annum. This resembles the national growth rate figure of 2.18 percent / annum.

Table 13.2.1 Demographic trend of three affected districts and Bangladesh (1995, estimate)

	Population (000)			
	Male	Female	Total	Growth rate
Bangladesh	61,804	58,153	119,957	2.18
Khulna city	403	328	731	-----
Khulna district	1,248	1,132	2,380	----
Kotwali thana	53	43	96	----
Khalishpur	115	90	205	-----
Khanzahan Ali	58	47	105	----
Rupsa	92	85	177	----

Source: BBS – Statistical Pocket Book, 1996.

According to 1991 Census Data, Khulna Statistical Metropolitan Area (SMA) covering Khulna City Corporation and its adjoining urban areas has about one million population. SMA was created in 1980 by Census Authority of BBS for the smooth conduct for 1981 population census.

② Household and Housing Characteristics

According to 1991 Census there are 179,028 households in Khulna SMA and the average size of one household is estimated as 5.6 members.

The general conditions of housing in the SMA is still poor as the roof material of about 45.5 % of the total dwelling units are made of straw and bamboo. This is also due to

KHULNA DEVELOPMENT AUTHORITY
AQUA-SHELTECH CONSORTIUM
STRUCTURE PLAN, MASTER PLAN & DETAILED AREA PLAN FOR KHULNA CITY

POPULATION DENSITY, 1991

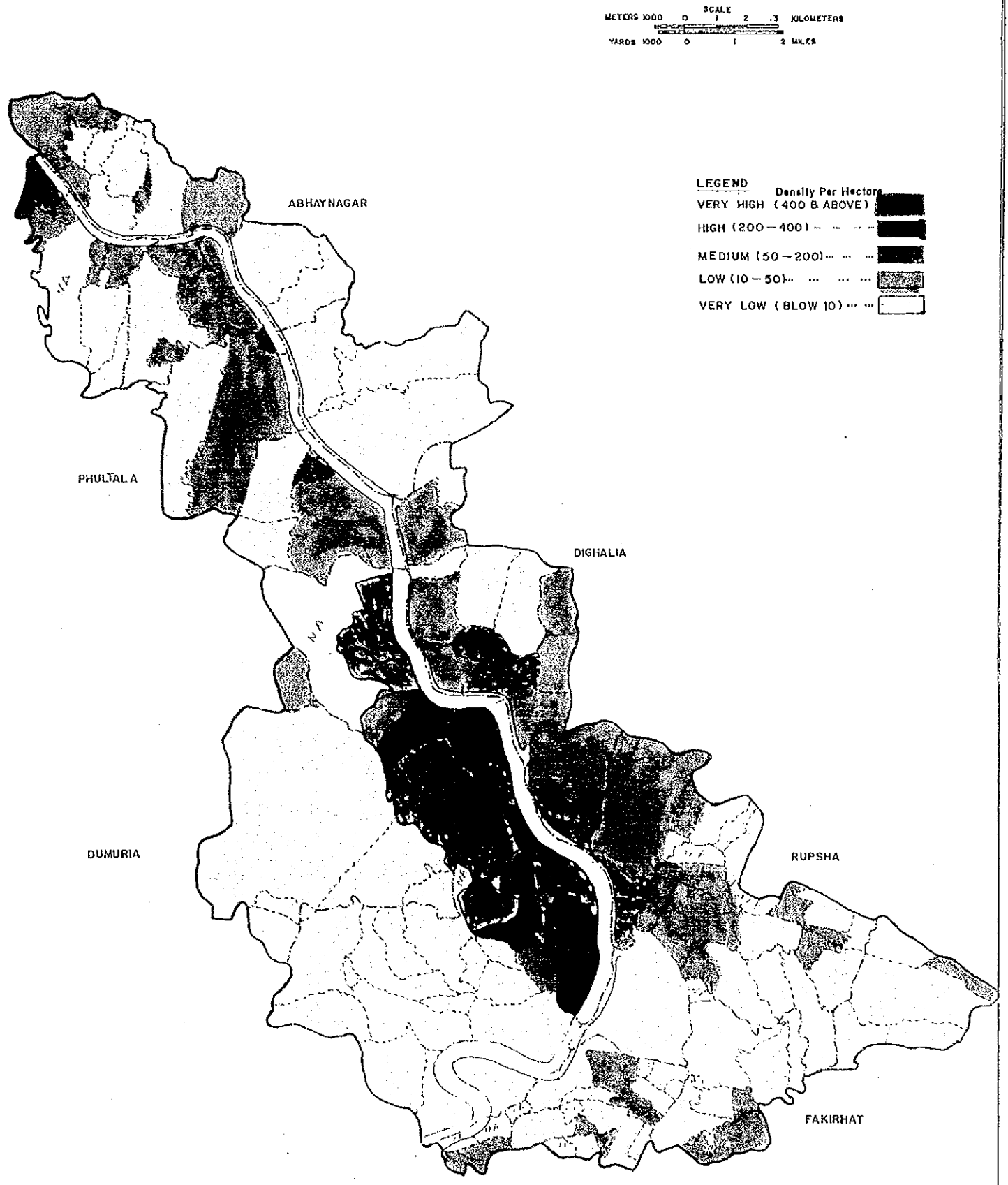


Fig. 13.2.1 Population Density of Khulna

abundant availability in the Sundarban forest on the south of the district. (Based on the KDA Master Plan Study Draft Report)

③ Major Occupation

The total economically active population of SMA aged 10 years and over has been presented in Table13.2.2. Occupation was classified into two broad occupational categories, i.e. (I) persons who are engaged purely in agriculture and (II) persons who are engaged in non-agriculture. It has been observed that 91.9 percent of the total economically active population of the SMA are engaged in non-agriculture occupation and 8.1 percent are engaged in agriculture activities. The percentage of persons engaged in agriculture is found very insignificant in Khulna City Corporation where 97.2 percent are engaged in non-agriculture sector. It could also be seen that a significant percent of economically active population of other urban area is engaged in agriculture sector. The particular situation may be the effect of the inclusion of some areas where agricultural activities still predominantly exist.

Table 13.2.2 Economically Active Persons Aged 10 years and Over by Agricultural and Non Agricultural Occupation – 1991

Locality	Population engaged in Agriculture	Percent	Population engaged in Non-Agriculture	Percent
Khulna SMA	23,305	8.1	264,648	91.9
Khulna City Corporation	5,999	2.8	208,483	97.2
Other Urban Area	17,306	23.6	56,165	76.4

A Comparative view of employed persons by main activity and locality has been presented in Table 13.2.3. It has been observed that 50.2 percent of the employed persons of Khulna SMA are engaged in other activities followed by business. The percentage of persons engaged in industry is 9.9. The participation rate of employed persons in the category of "business and other" are found to be the highest followed by "industry" in the Khulna City Corporation. In case of other urban area, the agriculture has the highest participation rate of the total employed persons.

Table 13.2.3 Employed Persons by Main Activity and Locality-1991

PERSONS									
Locality	Total	Agri.	Industry	Water,Gas / Electoricity	Constr.	Transport/ Communication	Business	Service	Other
Khulna SMA	287,953	23,305	28,641	1,730	7,180	16,078	60,104	64,449	14,466
Khulna City Corporation	214,482	5,999	15,767	1,585	5,737	12,300	47,123	5,368	120,603
OUA	73,471	17,306	12,874	145	1,443	3,778	12,981	1,081	23,863
PERCENT %									
Khulna SMA	100.0	8.1	9.9	0.6	2.5	5.6	20.9	2.2	50.2
Khulna City Corporation	100.0	2.8	7.4	0.7	2.7	5.7	22.0	2.5	56.2
OUA	100.0	23.6	17.5	0.2	1.0	5.1	17.7	1.5	32.4
DIGHLIA	-	8,073	9,987	71	350	814	4,122	313	7,571
RUPSHA	-	9,233	2,887	74	1,093	2,964	8,859	768	16,292

According to the survey on Ferry Ghat (Jetty), ferries and boats performed in KDA Master Plan Study, there operates 3 ferry ghats with 4 ferries and 20 khey ghats with 50 engine boats and non-mortized 200 boats along the rivers in this area.

④ Land Tenure System

The land tenurial arrangement in the project site are (i) cultivate own land; (ii) cultivate own land and rent some land from others; (iii) cultivate own land and rent some out; (iv) rent out all land; (v) rent all land from others and cultivate; (vi) rent from others and rent out their own land. The land less people work as unskilled labor, rickshaw puller, brickfield worker, hawker, petty trader, fisherman, potter and domestic helper for earning their livelihood. The land tenurielal system in Khulna City is controlled by the Khulna Development Authority.

⑤ Agriculture and Fishery

Agriculture is the dominant land use in floodplain area. Irrigated and rainfed rice based cropping pattern is the usual practice in floodplain area. Wheat, oilseeds, pulses, etc. are the major crops and vegetables and horticultural crops are grown locally as alternatives. Fisheries play an important economic role in the area. In the floodplain, some people locally known as fishermen live mainly by fishing in open water bodies, beels and puddles. Many others supplement protein in their day to day meals from capture fisheries while the marginal farmland holders and land less households though are not traditional fishermen also supplement their income from capture fisheries. Numerous ponds, ditches and borrow pits

owned privately are used for captive fisheries or aquaculture for family consumption and marketing.

The people in urban areas are working in the public, private and informal sectors for earning their livelihood.

Several types of divergent landuses characterize the suburban area around the Khulna City. The shallowly flooded (< 30cm) part on the northwest is used for seasamun during the winter season and broadcast aus paddy during the Kharif –1 season. The moderately deeply flooded (30cm to 1.0m) basin sites in the north and west part are used for growing broadcast aman paddy during Kharif –2 season. The deeper basin sites (> 1.0m) are used for boro (winter paddy) cultivation. Large part of the basin area in the northwest of Khulna City has become water logged. Part of this landscape is being used for agriculture while the other part remains under capture fisheries.
The flat basins that occur on the north-west and south-west parts of the Khulna City are shallowly flooded (< 30cm).These basins are used for cultivation of transplanted aman paddy during Kharif – 2 season. The narrow ridges occurring along the tidal channels though remain saturated during the monsoons are not subjected to tidal inundation. These lands are not suitable for paddy cultivation. Part of this landscape is used for cultivation of rabi crops during the winter season and sesbania during the monsoon. The farmers, in order to make this land suitable for paddy cultivation sell the topsoil to the earth filling contractors. This mechanism though makes the land suitable for paddy cultivation may not be considered as environment friendly. Because, this kind of change of inundation level shrinks the crop diversity in the area further.

Orchards in the tidal floodplain area occupy the homestead platforms and the non-flooded parts.

Homestead forests are highly productive and efficiently managed, compared to the low productivity and under-utilization of reserved forests and government controlled lands.
Homestead forests provide about 85% of all the wood consumed, which included nearly 90% of all fuelwood and 80% of all timber. In addition, homesteads provide about 90% of bamboo, extremely important commodity for rural life.

Tree species common in Khulna region are

Fruit trees :-

Mango (Mangifera indica) , Coconut palm (Cocos nucifera)
Plum (Ziziphus spp.), Date palm (Phoenix sylvestris)
Jack fruit (Arlocurpus heterophyliem), Palmira palm (Borassus flabellifer)
Amra (Spondias Pinnata), Betel nut palm (Areca catechu)
Lemon (Citrus spp), Guava (Psidium guayava)
Wood apple (Aegal marmelos), Tamarind (Tamarindus indica)
Shissoo (Dalbergia sissoo)

Timber species :-

Ipil–ipil(Leucaena leococephala), Mahgani (Suritenia spp) Babla (Acacia spp), Silk cotton tree (Bombax ceiba)
Koroi (Albazia spp) --- rain tree, Neem (Azadirecta indica),
Raj koroi (Albazia Richardiana) --- gigantic fern like tree

Fuel wood and other tree species :-

Pitali (Trewia nudiflora) Jeol (Lanea coromandilica)
Bamboo (Bambusa spp.) Banian (Ficus bangalensi

Locally, land under aquaculture occupies large area and common species for aquaculture are:

Common Commercial Fish Species :

Common carps (Rui, Katla, Mrigal), Other local carps (Ghania, Kalbasu, Kalia)
Snake heads (Shoal, Gazar, Taki), Cat fishes (Pangash, Boal, Tengra, Aier, Bacha)
Jew fishes (Poa, Lumbu, Kala Datina, Datina),
Brakish water fishes (Vetki, Faishsa ,Tengra, Datina, Roop Chanda, Tapashsi, Bhol)
Shrimps (Bagda, Golda, Honna, Chaka, Small shrimp), and Hilsa

Common Aquaculture Fish Species :

Rui, Katla, Mrigal, Silver carps, Mirror carps, Glass carps, Thai puti, Bagda, in sweet water Golda.

Common Fishes of Closed Water bodies :

Shoal, Gazar, Taki, Boal, Aier, Kai, Singhi, Magur, Puti, Chela, Rui, Katla, Mrigal, Kalbasu, Pabda, Galda, Chital, Fali, Bheda, Khailsha, Golsha, Tengra, Balashi, Bajari, etc.

Exotic carps, common carps, Thai-puties and Bagda and Golda shrimps. "Ghers" for aquaculture is prepared either on owned or leased lands. In both the cases paddy is sometimes cultivated in "gher" area by hiring local labors as alley, relay and rotation crops. This type of land uses is practiced in the ghers only where the water level does not exceed 60 cm.

⑥ Water Supply and Irrigation Facilities

Water supply system includes supply of water both for irrigation and domestic uses. Surface water sources are utilized through indigenous irrigation methods and low lift pump. Sub-surface water reserve is utilized for irrigation using shallow and deep tube-wells. Small farm holdings use treadle pumps for irrigation. Tube-wells and open wells are the sources of drinking water in rural areas. Demand for irrigation water increased greatly since the eighties because of introduction of HYV paddy during the boro season, and extension of electricity supply network in rural areas by the Rural Electrification Board (REB). Water from surface water sources is used for domestic use. Most part of the Khulna Metropolitan Area has been brought under regular water supply facility.

Since 1993, people living in western Regions of Bangradesh are aware of arsenic pollution, which believed due to excessive lifting of groundwater through deep tube-well. Now, shallow tube-well are also warned. So far, it is not reported in Khulna city area.

(2) Present Land Use of the Project Area

① General

The proposed by-pass alignment A and B pass through several distinctly different land areas e.g. rural homesteads, seasonally flooded agricultural land, swampland on recent materials of alluvial plain, and urban area consisting of residential, commercial, industrial and recreation areas. Fig.13.2.1 shows the population density of Khulna area together with the proposed alignments A and B. The rural homesteads occur scattered throughout the area in the floodplain. These homesteads are situated on man-made platforms and are usually densely covered by different tree species in rural suburban areas. The agricultural lands in flood plain are seasonally flooded and possess a narrow range of aquatic biodiversities and weed species. Perennial water bodies surrounded by a narrow swampland occur locally within the project area.

As shown in Fig.13.2.2, the city area of Khulna is situated on narrow and slightly high natural levee, which was naturally made on 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.

In urban areas in Khulna area, which develop along the rivers and main roads, tenurial system for various specialized land uses is controlled by KDA. The residential areas developed by KDA are well planned while the spontaneously grown residential areas are of unplanned slums.

② Alignment A

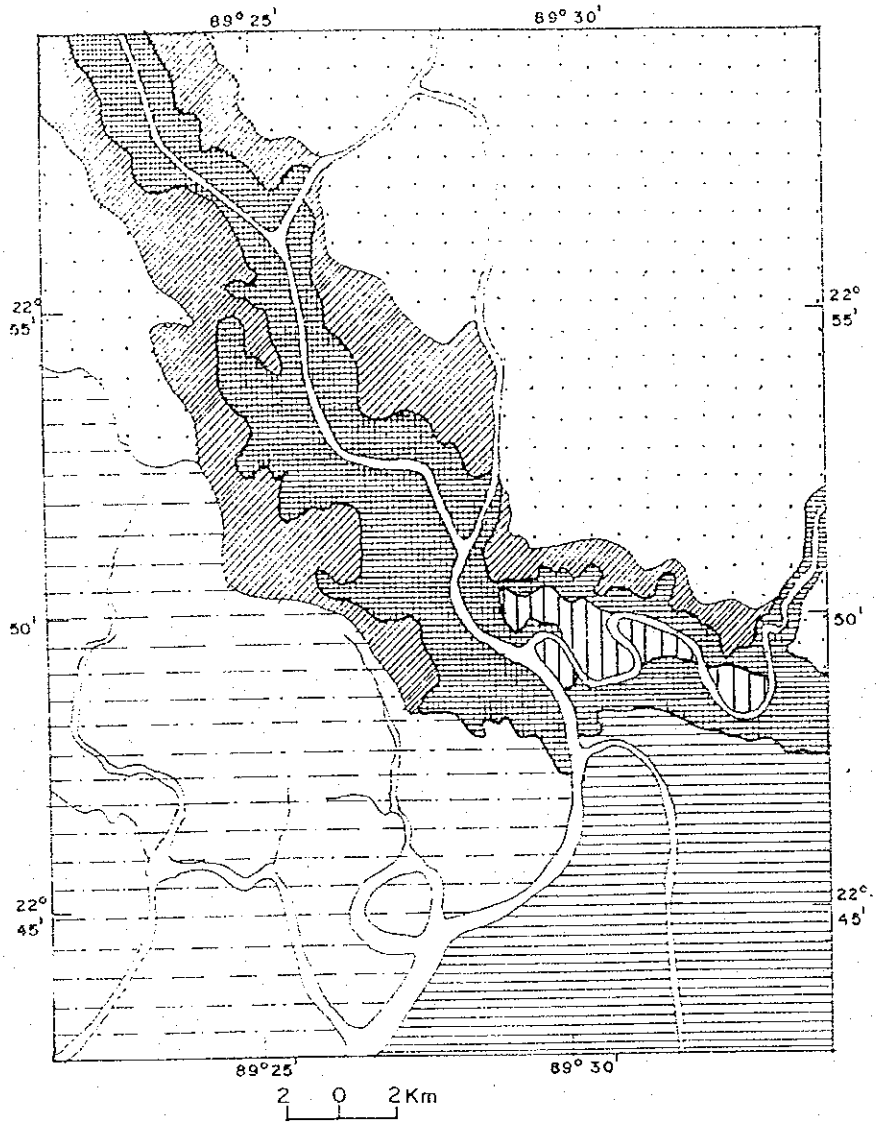
This Alignment is a bypass starting at the National Highway (NH) some 4 km south of the junction of NH#7 and #8 in Phultala and largely detouring to the west of Khulna. It will cross the Rupsa River through a bridge at some 3 km downstream from the ferry terminal and access to the present Khulna-Mongla Road. The total length of this bypass is some 27 km. Site reconnaissance was conducted by utilizing the land use map of 1/10,000 as prepared by KDA. Fig.13.2.3 shows the land use conditions of the Alignment A. As shown, most of the section will pass through agricultural land, which includes swampy low land called "Bil Dakatia".

After the coastal embankment project was completed in1965, the area began to get water logged accumulating much water to the bottom parts of the basin. At present nearly 12,000 hectare of agricultural land in Bil Dakatia is under 2-m deep water since the past 15 years. Due to the nature of development, the sub-soil is expected to contain much of organic matter, which usually causes serious problems in embankment construction for road.

There exists some ponds in the area between the east side of Rupsa River and Khulna-Mongla Road and shrimp farming is undertaken. In rainy season, the water level is raised when attacked by floods, therefore, these ponds are also used for rice farming. Homesteads and surrounding thick vegetation are shown as "SV" and require resettlement. But they are sparsely seen in the Alignment A.

Fig. 13.2.2 KHULNA CITY AND SURROUNDINGS

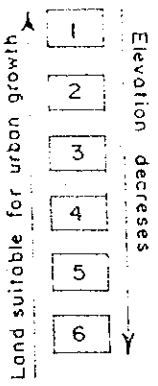
GEOLOGICAL CHARACTERISTICS & TERRAIN ELEVATION



LEGEND

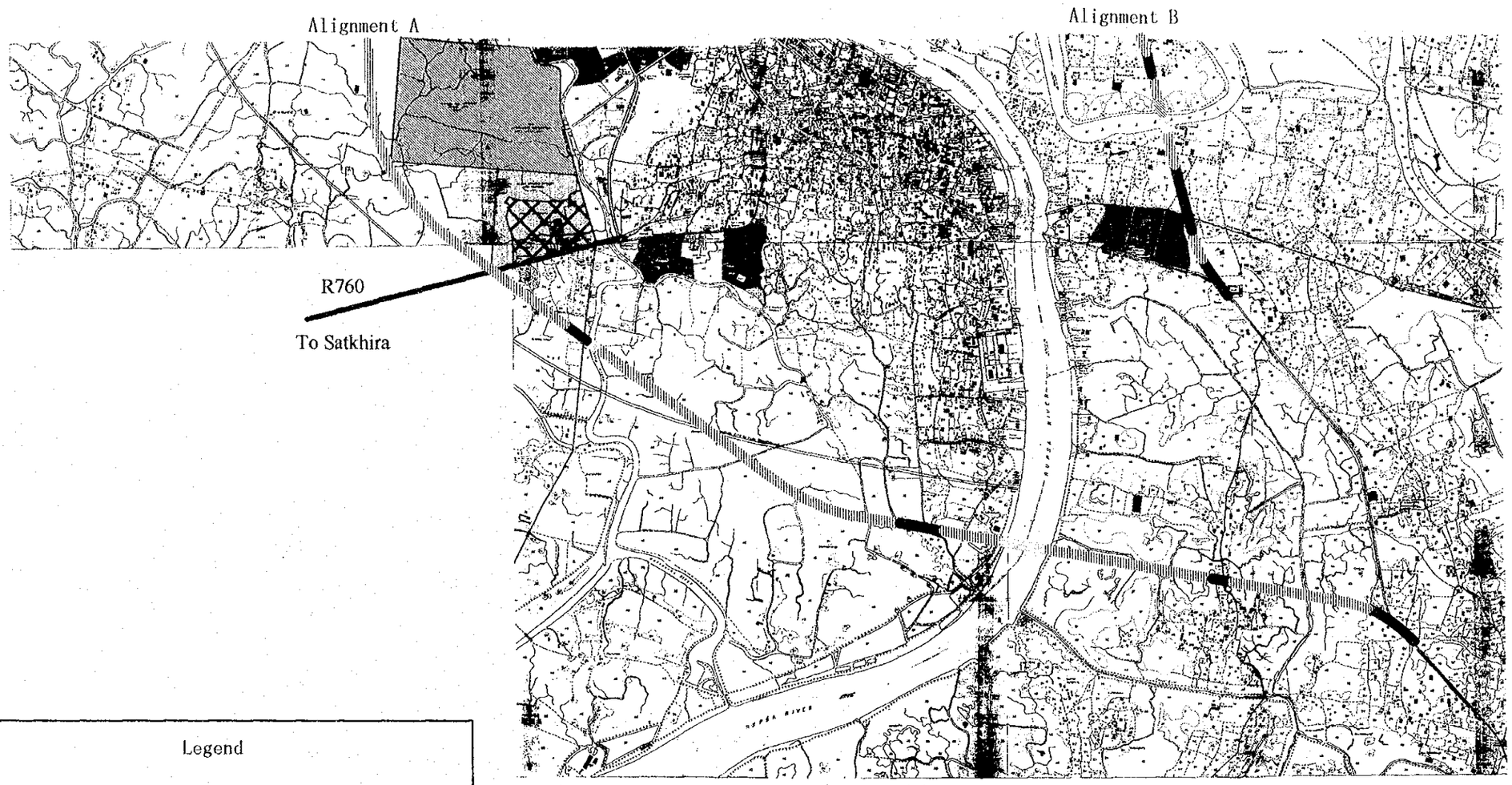
1. Natural levee. (Silty sand, Clayey sand and Sandy silt)
2. Flood plain. (Clayey silt and Silty clay)
3. Old meander complex. (Sand, Silty sand and Sandy silt)
4. Bar. (Silty sand, Sandy silt and Clayey sand)
5. Tidal marsh. (Silty clay, Clayey silt and Peat)
6. Back swamp. (Peaty clay, Clay and Peat)

TERRAIN EVALUATION



SOURCE :-GEOLOGICAL SURVEY OF BANGLADESH, 1998

Fig. 13.2.3 (1/2) **Land Use along Alignment A**



Legend

- Settlement with Mixed Vegetation Including A Few of Other Social and Ecomonic Activities
- Shrimp Farm
- Brick Field
- Agriculture Land
- Low Land

Fig. 13.2.3 (2/2) Land Use along Alignment A

③ Alignment B

This route starts at the cantonment in Siramori 3 km further south of the starting point of the Alignment A. It will cross the Bhairab River at the point some 400 m south from the confluence of the Bhairab River and Majudkhali Nodi, and detour the opposite bank (east-side) of Khulna city. Furthermore, it crosses the Atai River and Atharabanki River and access to Khulna-Mongla Road. The total length of this Alignment is some 20 km. As shown in Fig.13.2.4, agricultural land occupies half of the Alignment and much of the sections pass through rural residential area. Especially, it goes through semi-urban areas at the starting point in the north and the ending point in the south, and the central regions near the Atai River.

(3) Characteristics of Rural Settlement in Bangladesh and in Khulna Area

① Pattern of Rural Settlement

The physical environmental factors, particularly the presence of rivers and ponds and the nature of the topography largely determine the pattern of rural settlement, which may be classified into the following three major patterns:

Nucleated (clustered) Settlements

This generally assumes a regular form roughly close to a square or rectangle or a circle.
This pattern is common in the Barind region in the northwest, in Sylhet in the northeast and also in the hilly areas of Chittagon Hill Tract.

Linear Settlement

Linear settlements have grown along the rivers and roads in many parts in Bangladesh. Natural levees of rivers have been particularly suitable for linear settlement development. Linear villages have been formed on only one side of a river in many areas.

Dispersed (scattered) Settlement

They are typically found in the fertile flood plain where heavy inundation takes place during the rainy season. Land tenure and land holding patterns have encouraged people to build isolated homesteads close to a piece of land they own. People build their houses by raising the homestead land with earth generally by digging a pond. Communication is done by boat during the rainy season mainly.

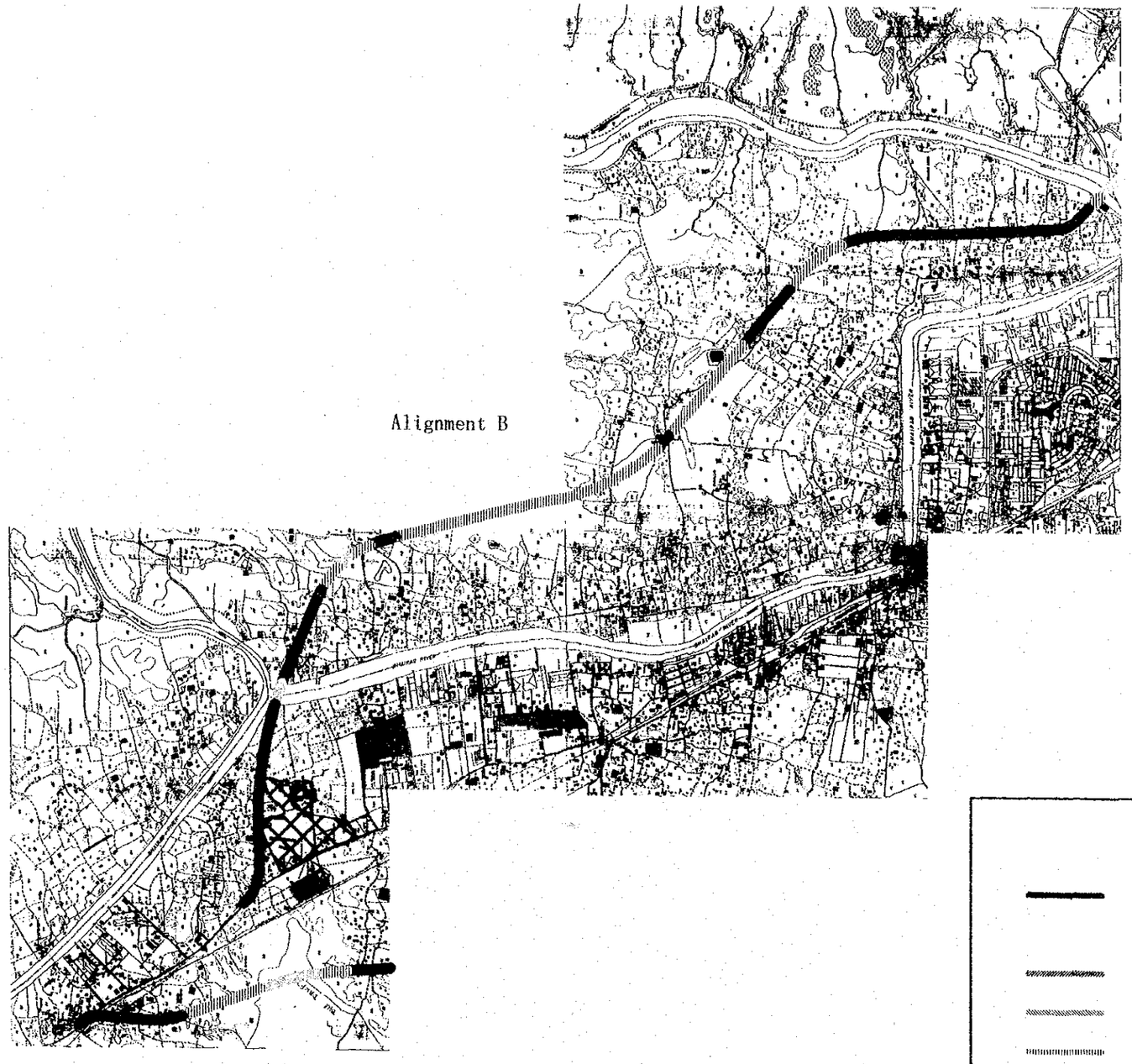


Fig. 13.2.4 (1/2) **Land Use along Alignment B**

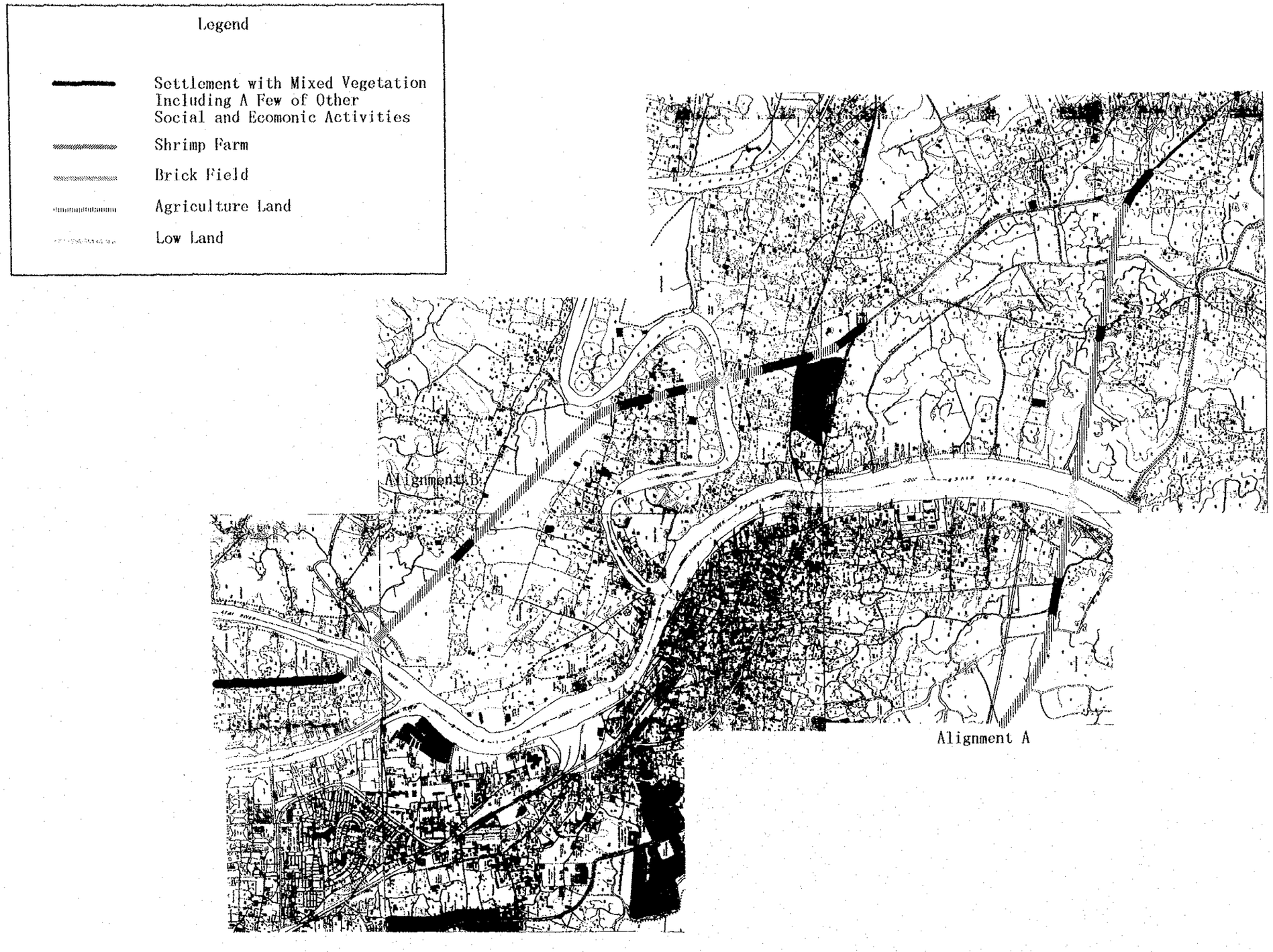


Fig. 13.2.4 **(2/2) Land Use along Alignment B**

② Layout of Homesteads

Islam, Ali and Hussain, (1980) have made an analysis of the layout pattern of rural homesteads taking the role of the open backyard, frontyard and, mainly, the courtyard into consideration. The patterns have evolved as a result of social and cultural conditions. The four types identified, as shown in Fig.13.2.5, are as follows:

i) Homesteads with very small backyard or frontyard. It is generally a small house on a tiny piece of land and belongs to the lowest income group families.
ii) Homesteads having independent enclosed courtyards, generally rectangular in shape, with dwelling units on 3 or even all four sides.
iii) Shared courtyard, with more than one household or family having a common enclosed courtyard. In most cases the several households originally belonged to one joint family.
iv) Interlocking courtyards with open passage joining one another with houses of separate families built on different sides of the yards. These are found in compact nucleated or compact linear villages. This type of courtyard and homestead layout pattern also indicates common ancestry of the now independent households.

The courtyard forms an essential and integral part of the rural homestead and performs several functions. It is used as outdoor living or sitting space for adults, mainly women, as children's play space, and as space for drying field crops, clothes, utensils etc.

Ponds also form an essential element of rural settlements in some areas of Bangladesh and serve multi-purpose activities with bathing, washing and fishing, being major ones.

Tree species growing on homestead platforms include fruits, fuel wood timber and horticultural species.

Table 13.2.4 shows composition of typical homesteads obtained through site survey around the alignments. They have an area of 140 m^2 to 250 m^2 and are consisted of 4 to 6 families with a total member of 8 to 20. Therefore, it might be said that one homestead may have an area of 200m^2 and 5 families living together with 14 members in average.

What is the most important in this living form is that it has very strong bondage among the members of immediate kin who live together on the same homestead or in close proximity.

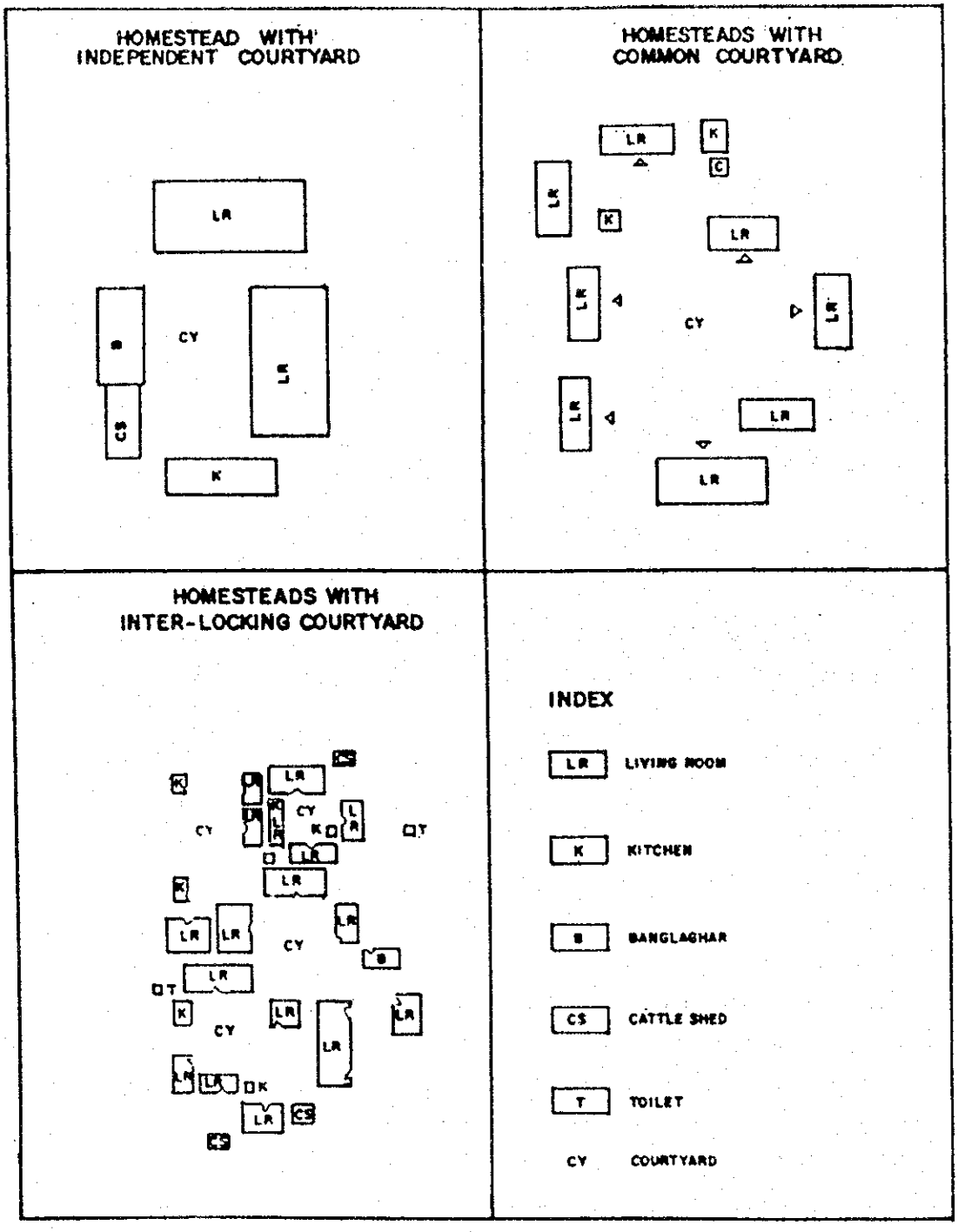


Fig. 13.2.5 Types of Homestead in Bangladesh

Table 13.2.4 Composition of Typical Homesteads around the Proposed Alignment

Location	Route A - Middle Section	Route A - South Section	Route B - North Section	Route B - Middle Section	Route B - South Section
1. Sample site	Village – Salua, U.C., Rangpur, P.S. Domuria. Size of the homestead– 50m × 40m. Number of families 4 – Average size – 4 members / family.	Village : Krishna nagar, U.C. Jalmai, P. S. Baitaghata Size of the homestead – 50m × 30m Number of families live 4, average 3 persons / family	Village – Shamganj, K.C.C. area, P.S. Khan Jahan Ali. 50 % area is under homesteads and 50% under industrial complex. Very congested slum type homesteads. Area 50m × 40m 6 / family on the average.	Village – Khan Muhammad pur, U.C. Isgati, P.S. Rupsha Area. Size of the homesteads – 50m × 50m 2 family of 4 members each live in each household.	Village – Talim pur, U.C. Nayahati, P.S. Rupsha Area – 42m × 33m 1 Family of 9 members 5 Families in the 5 roomed rented house. 20 members in 5 families Family size – average 4 member
2. Description of the sheds	3 mud walled thatched house – 5m × 4m 1 mud walled tile roofed house – 6m × 4m 1 Cowshed – 3m × 2m 1 Kutcha sanitary latrine 1 pond – 15m × 10m (used for captive fisheries)	a. Kutcha house for 3 families : 3 mud walled thatched houses – Average size 5m × 3m 3 Kitchen sheds – 3m × 2m 2 Cowsheds – 3m × 2m 2 Kutcha latrines 1 Borrow pit – 15m × 12 – Used for captive fisheries b. Semi pucca house for one family : 1. Semi pucca house – 10m × 6m / 3 person 1. Kutcha mud walled shed – 5m × 3m / 3 person 1. Fuelwood factory shed – 10m × 7m 1. Non-sanitary latrine 1. Pond with paved stairs – 20m × 10m used for domestic water use and captive fisheries	13 mud walled tin roofed or tile roofed sheds 7m × 5m 13 Kitchens are attached – 2m × 2m 6 Non-sanitary latrines 1 Semi pucca rent house 30m × 12m (18 room) 2 Sanitary latrines	1 60 year old one story building – 10m × 8m 1 Bamboo walled thatched house – 6m × 4m 1 Cowshed (kutcha) – 3m × 2m 1 Store house – 2m × 2m 1 Kutcha non-sanitary latrine 1 Pond – 10m × 8m	1 Mud walled thatched house – 10m × 5m 1 Mud walled kitchen – 5m × 3m 1 Wooden cow shed – 3m × 4m 1 Sami pucca shop – 3m × 4m 1 Kutcha non-sanitary latrine – 2m × 2m 1 Bamboo walled thatched house – 1. 5 × 5m
3. Trees on homesteads	a. Fruit trees : Coconut – 9, Mango – 3,Plum– 2, Date palm– 20, Palmira palm – 3, Jack fruit –1. All the trees are older than 20 years. b. Timber trees : Ipil – ipil – 5, Babla – 2, Mahgani – 3, Koroi – 3; Trees are 25 – 30 years old. c. Fuelwood / other trees : Jeol – 5 (are used for boundary demarcation)	a. Fruit trees : Mango – 5, Jake fruit – 6, Coconut – 12, Betel nut – 30, Date plam – 5, Banana – 50, Papaya – 2, Palmira palm – 1, Ridged apple – 3. All trees are < 10 years old. b. Timber trees : Mahgani – 11, Babla – 4, Silk cotton – 3, Neem – 5, Ipil-ipil – 12. All trees are < 10 years old. c. Fuel wood / other : Pitali – 3, Jeol – 12 (used for boundary demarkation)	a. Fruit trees : Coconut palm– 30, Plum – 30, Amra- 3, Guava – 5, Wood apple – 3, Mango – 3. b. Timber trees : Babla (Khayra) – 5, Koroi – 5 c. Fuelwood / other trees : Nil	a. Fruit trees : Mango – 20, Jack fruit – 4, Coconut palm– 50, Lemon– 5, Betel nut palm– 100, Guava – 5, Trees are mostly over 50 years old. There are some young saplings also over the homesteads. b. Timber trees : Koroi – 3,Tetul – 2, Neem – 4, Mehgani – 15, Shisoo – 5, c. Fuelwood / other trees : Jeol, Bamboo – 50,	a. Fruit trees : Coconut palm– 20, Mango – 5, Jack fruit – 1, Betel nut palm – 100, Palmira palm – 2, Date palm –5, Banana – 30, Lemon – 2, Grape fruit – 2, (small), Many small seedlings. Most of the trees are older than 30 years. b. Timber trees : Koroi – 10, Kadam – 1, Mahgoni – 15 (small), Babla – 3 c. Fuel wood / other trees : Jeol – 30 (small)
4. Agriculture / Aquaculture	Kharif – Paddy < 10 % around the homesteads Rabi – Fallow Aquaculture > 90 % area. Major species are Galda shrimp, local carps and Thai puti.	Kharif – Paddy > 90 %, Arum < 1 %, Sasbania < 1, Rabi – Irrigated paddy 10 %, seasamun 50 % , Vegetable 10 %.	Kharif – Paddy 20 % , sesbania 1 %, Rabi – Vegetables 5 %, fallow 10 %, paddy 5 %, 30 % area is occupied by planned pucca houses with orchards of Coconut palm and Betel nut palm; 50 % area in the locality is occupied for industries, residencial plots and the remaining 20 % is occupied by congested slum houses.	Kharif – Paddy 90 %, Sasbania – 5 % Rabi – Paddy – 20 %, fallow – 30 % Orchard of Betel nut – 5 %, Banana – 5 % Houses in the locality are clustered with various tree species including bamboos, rain tree, babla etc. There are many semi pucca houses covering 20 % in the locality .	Kharif – Paddy > 90 %, vegetables 5 %, fallow 5 %, Rabi – seasamun 30 %, fallow 30 %, paddy 30 %, vegetables 30 %, Annual – Banana 5 %, field and homestead boundaries are clustered by banana plants.
5. Professional occupation	Aquaculture - > 50 % Off- farm activities - < 50 %		Agriculture – 5 % Off-farm activities – 95 %	Agriculture – 80 % Off-farm activities – 20 %	Agriculture - 20 % Off-farm activities – 80 %