THE STUDY ON CONSTRUCTION OF
THE BRIDGE OVER THE RIVER RUPSA IN KHULNA
(Phase 1)

ALTERNATIVE ROUTE A(6/6)

PACIFIC CONSULTANTS INTERNATIONAL
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Fig. 12.1.19 Alternative Route A and B (6/9)

THE STUDY ON CONSTRUCTION OF
THE BRIDGE OVER THE RIVER RUPSA IN KHULNA
(Phase 1)

ALTERNATIVE ROUTE B(1/4)

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Fig. 12.1.20 Alternative Route A and B (7/9)

THE STUDY ON CONSTRUCTION OF
THE BRIDGE OVER THE RIVER RUPSA IN KHULNA
(Phase 1)

ALTERNATIVE ROUTE B(2/4)

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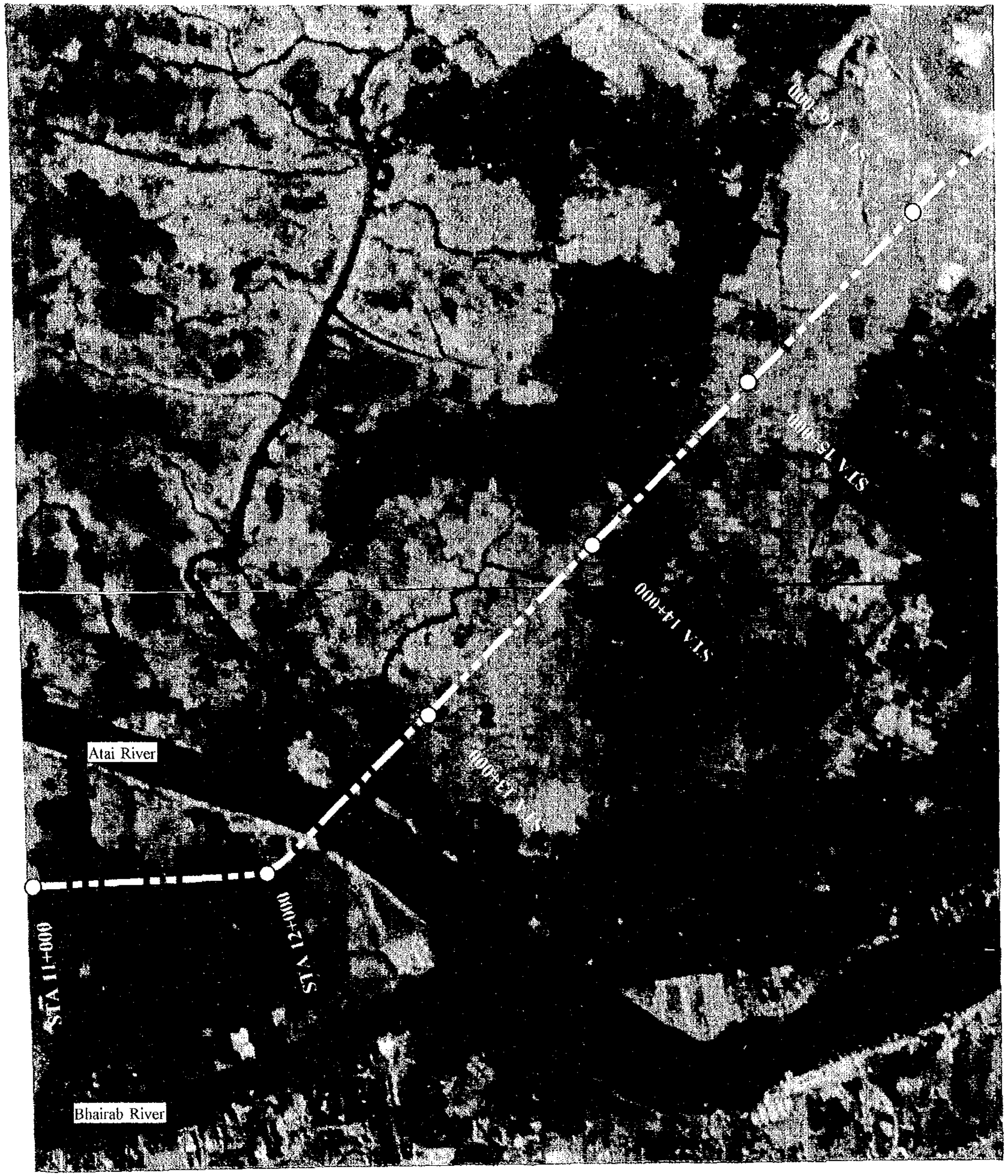
Fig. 12.1.21 Alternative Route A and B (8/9)



THE STUDY ON CONSTRUCTION OF
THE BRIDGE OVER THE RIVER RUPSA IN KHULNA
(Phase 1)

ALTERNATIVE ROUTE B(3/4)

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Fig. 12.1.22 Alternative Route A and B (9/9)

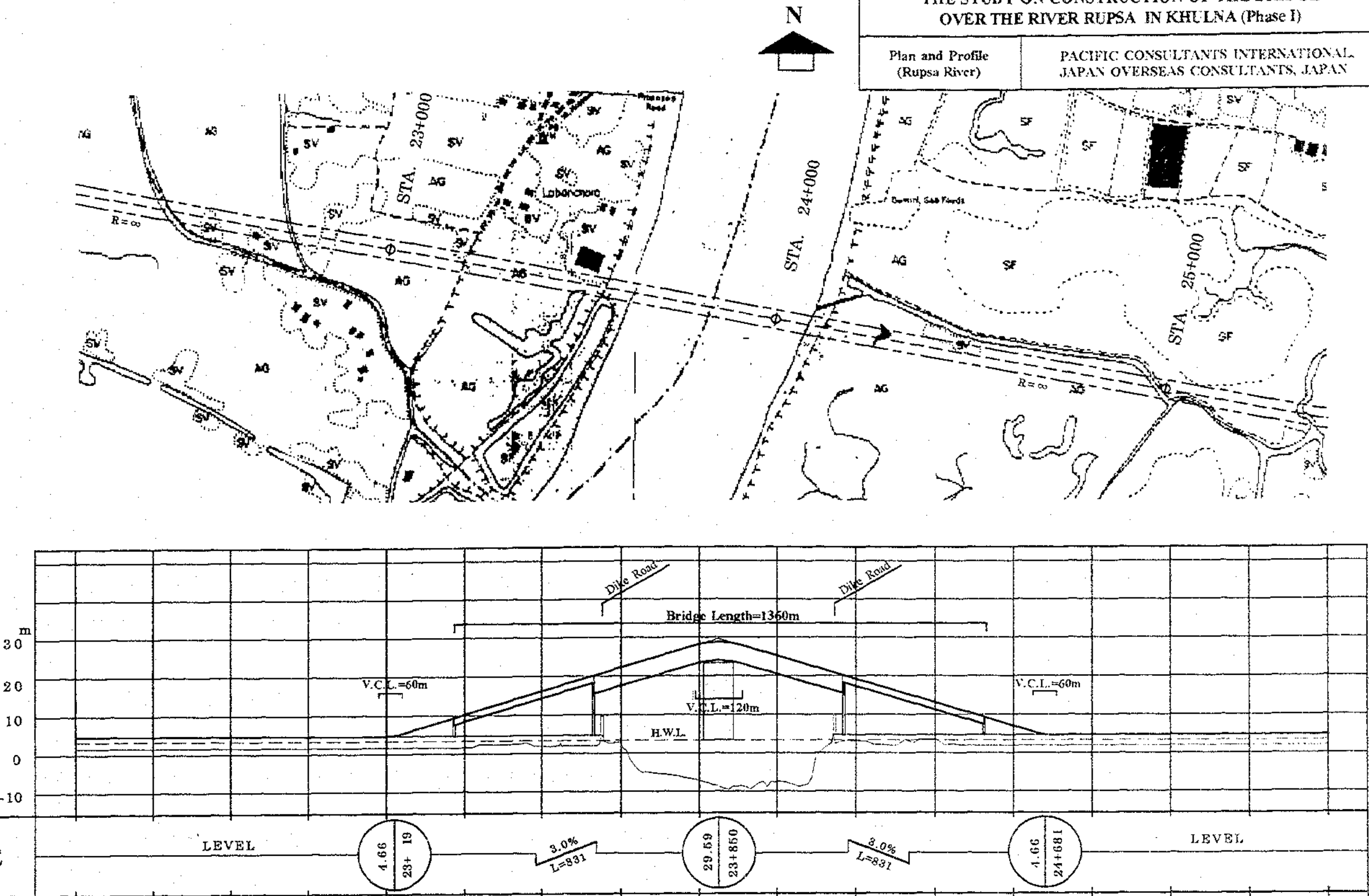
2) Plan and Profiles

Plans and Profiles are prepared on the locations of the four bridges along the Alignments A and B. The basic data used in the design have been topographic maps, aerial photos and the information obtained from the topographic survey, of which details are presented in Chapter 9: Natural Condition Surveys.

Figs.12.1.23 through 26 show the plan and profile of bridges, respectively for Rupsa, Bhairab, Atai and Atherobaki.

THE STUDY ON CONSTRUCTION OF THE BRIDGE
OVER THE RIVER RUPSA IN KHULNA (Phase I)

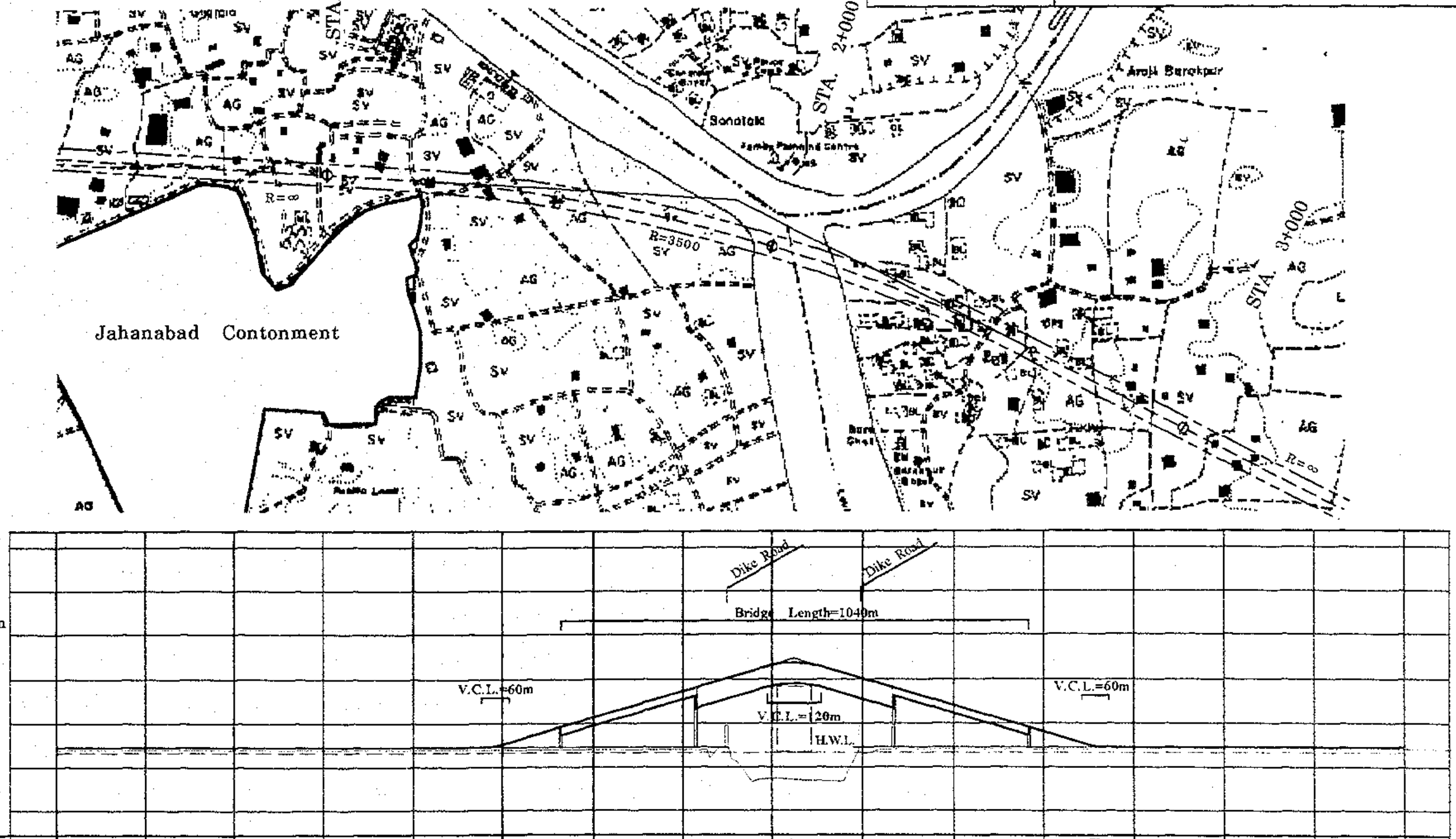
Plan and Profile (Rupsa River)	PACIFIC CONSULTANTS INTERNATIONAL JAPAN OVERSEAS CONSULTANTS, JAPAN



GROUND LEVEL	1.64	1.64	1.64	1.64	1.64	1.64	1.89	2.79	-7.17	-7.54	3.07	3.48	1.96	1.96	1.96	1.96	1.96
STATION	22+200				23+000					24+000					25+000		25+400

Fig.12.1.23 Plan and Profile of the Rupsa Bridge

THE STUDY ON CONSTRUCTION OF THE BRIDGE OVER THE RIVER RUPSA IN KHULNA (Phase I)	
Plan and Profile (Bhairab River)	PACIFIC CONSULTANTS INTERNATIONAL, JAPAN OVERSEAS CONSULTANTS, JAPAN



GRADE	LEVEL; 4.66 / 1+386; 3.0% L=664; 24.59 / 2+050; 3.0% L=664; 4.66 / 2+714; LEVEL
GROUND LEVEL	4.07, 4.07, 4.07, 4.07, 4.07, 4.07, 4.07, 4.07, -2.58, 3.20, 4.20, 4.20, 4.20, 4.20, 4.20, 4.20
STATION	0+400, 1+000, 2+000, 3+000, 3+400

Fig.12.1.24 Plan and Profile of the Bhairab Bridge

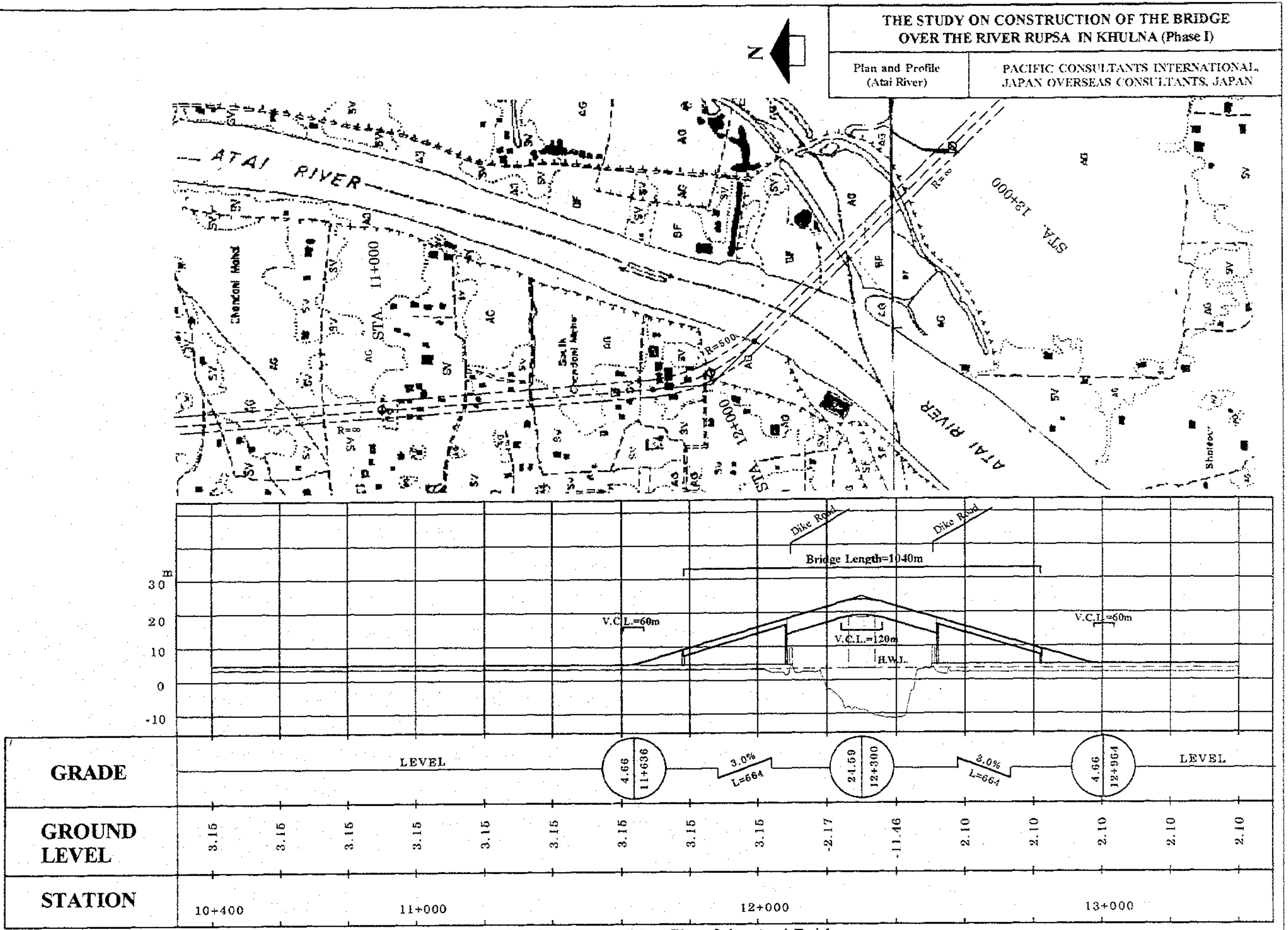


Fig.12.1.25 Plan and Profile of the Atai Bridge

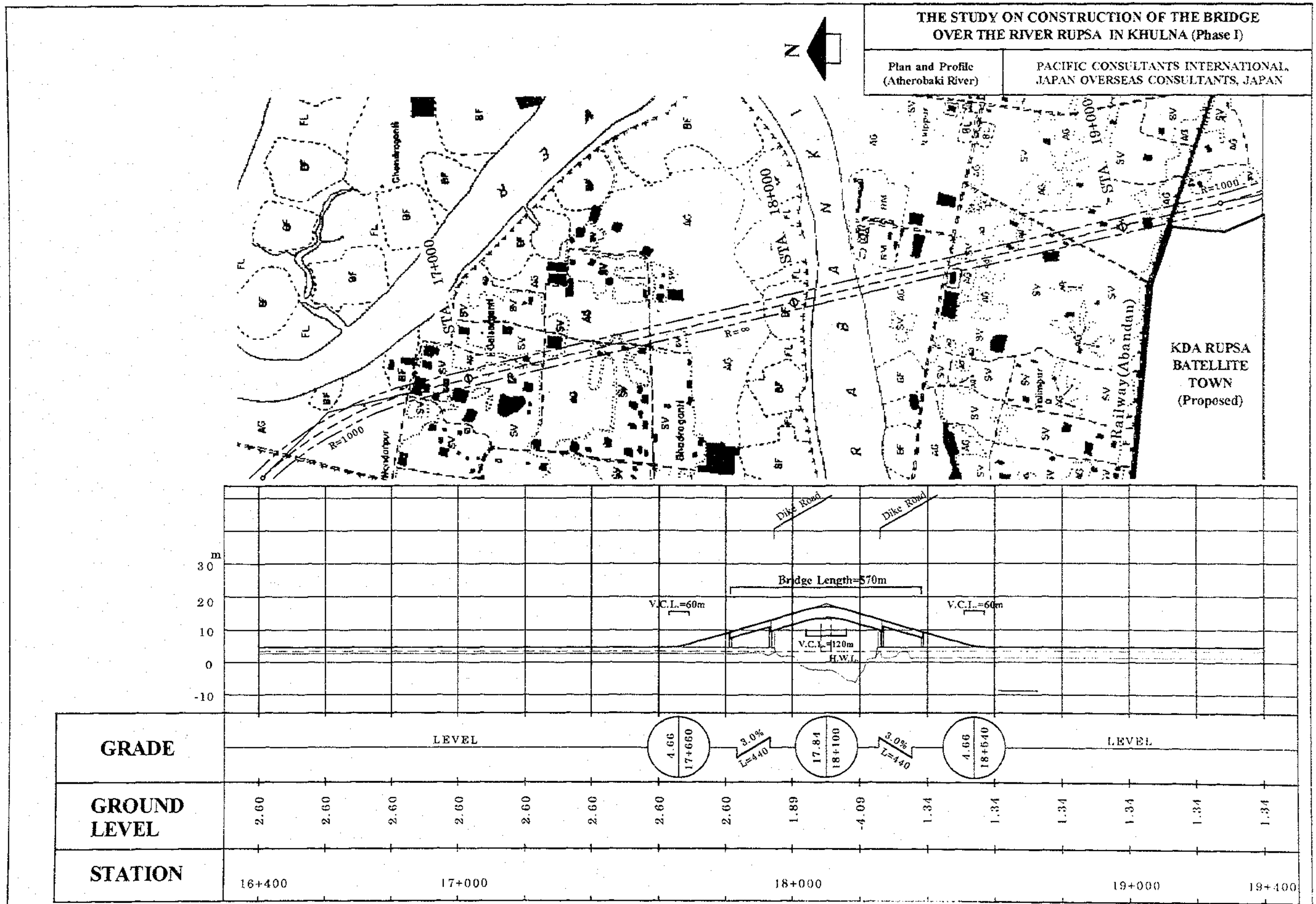


Fig.12.1.26 Plan and Profile of the Atherobaki Bridge

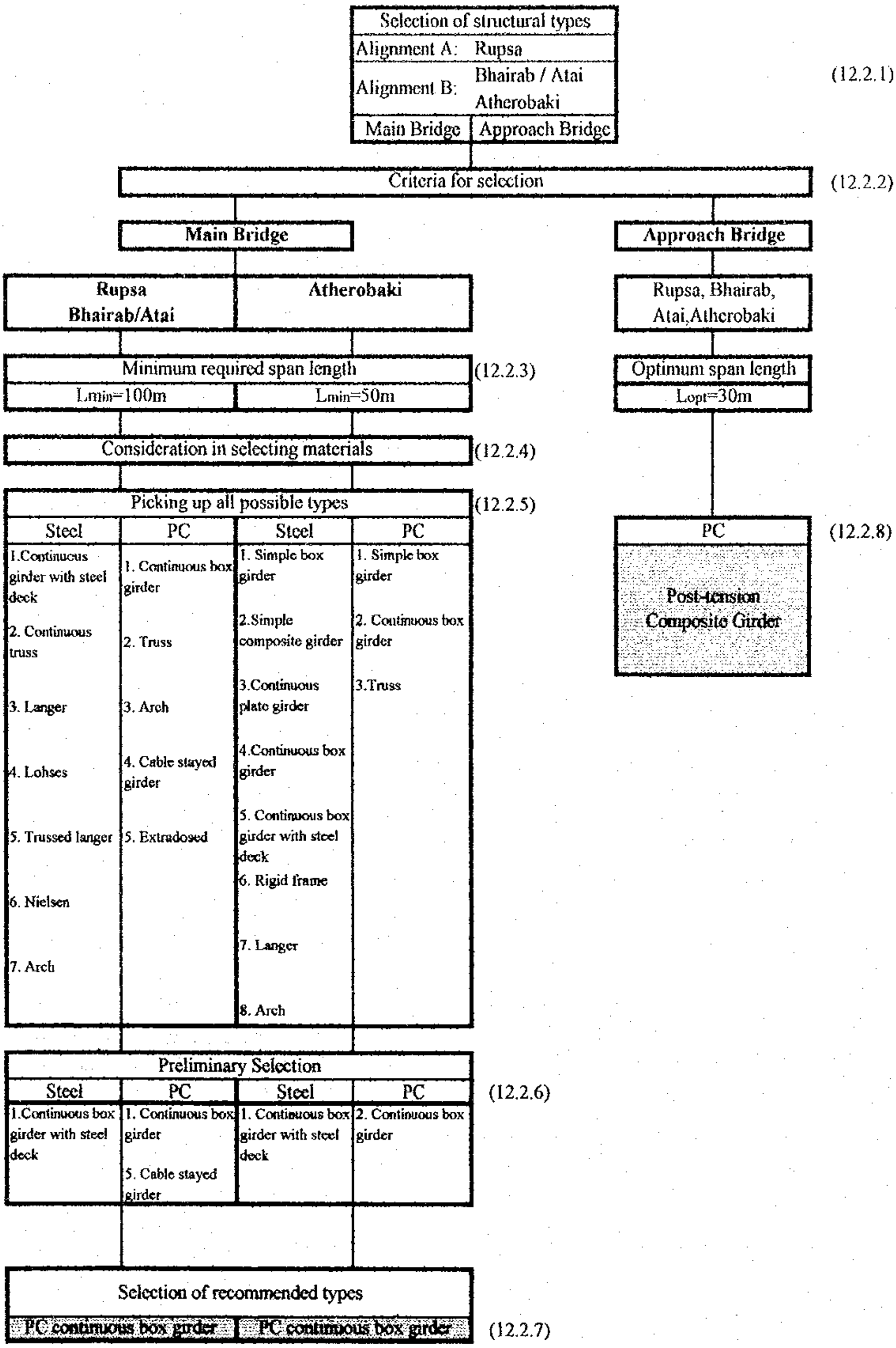
12.2 Bridge Design

It is purposed in this subsection that a structural type of the bridge is selected as the most practical judging from the present information and data, bases of the cost estimation are made clear, and also the technical data required are prepared for the succeeding study, as the Study has been made in a degree of master plan.

12.2.1 Introduction

The best recommended structural types for Rupsa Bridge along the Alignment A, and Bhairab, Atai and Atherobaki Bridge along the Alignment B are selected herein according to the procedure indicated in the Fig. 12.2.1.

Structural types and span lengths for the portion of the bridge crossing the river, (hereinafter referred to as "the Main Bridge"), and the viaduct portion connected to the Main Bridge, (hereinafter referred to as "the Approach Bridge"), are examined separately.



Note:Numbers in parentheses show Clause no. where described.

Fig. 12.2.1 Procedure in Selecting Structural Types

12.2.2 Criteria for Selection of Structural Types of Bridge

Structural types are generally selected judging from the criteria described below. Some criteria like navigation requirements shall be strictly kept, but other criteria such as aesthetics and drivability may be taken into account as the criteria to be balanced well each other on the selection.

The economy of construction and maintenance is usually given the higher priority, especially when the project is of a big scale.

(1) Main Bridge

The bridge type and consequently the length of the spans regarding the Main Bridge depended on the following criteria;

- navigational requirements,
- topography and geology,
- river conditions,
- aviational requirements,
- aesthetics,
- constructability (degree of ease on construction),
- construction cost,
- construction period,
- maintenance
- drivability(degree of smooth driving for driver and passengers), and
- technology transfer/new technology.

(2) Approach Bridge

Meanwhile, criteria for selection of the Approach Bridge are;

- Requirements for clearance below such as for roadway, railway traffic and/or
- river navigation,
- topography and geology,
- aviational requirements,
- aesthetics,
- experience in constructing similar types,
- constructability,
- construction cost,
- construction period,
- maintenance, and
- drivability.

12.2.3 Determination of Required Minimum Span Length for Main Bridge

Span lengths in the river are limited by a horizontal navigation clearance. Bangladesh Inland Water Authority has stipulated it for each river in Bangladesh as below;

River	Rupsa	Bhairab	Atai	Atherobaki
Horizontal Clearance	76.22m	76.22m	76.22m	30.48m

Meanwhile, piers in the river must be installed so as not to obstruct the smooth river flow nor to cause water level excessively boosted, that is to say, to prevent head loss. Usually ratio of area occupied by the piers in the river to the whole river cross-sectional area is limited. Regarding the rivers in the Project, the given navigation clearance dominates determination of minimum span length instead of the head loss effect of the river flow.

1) Rupsa/Bhairab/Atai

As these three bridges have the same horizontal navigation limit, they are treated together hereinafter in selecting structural type.

A minimum horizontal clearance of 76.22 meters must be kept for the navigation, and additional space is required constructing spread footing, cofferdam plus some allowance. Consequently the minimum span of 100 meters is required for Rupsa, Bhairab and Atai Bridges.

2) Atherobaki

Also Atherobaki Bridge is examined as for the minimum span exactly in the same way, and the resulted minimum span is determined as 50 meters.

12.2.4 Consideration in Selecting Materials for Structural Elements

Materials for modern bridge construction are usually concrete (either reinforced or prestressed) or structural steel. Generally, for a bridge in a similar scale to the bridges of this Project, both materials may be adopted. The main factors which influences the adoption of the structural element are;

(1) Steel Bridge

- Light weight :
  It is easy material to transport, install and handle, and also advantageous for forming a slender girder depth and reducing the burden onto the substructure.

- Possibility of shortening construction period :
  While the substructure is constructed at site, the steel elements for the superstructure can be fabricated simultaneously at a mill in order to reduce the period, and they may be transported and assembled together by bolting or welding at site without delay once the substructure is completed.

- Maintenance
  The remarkable shortcoming of steel is the characteristic of having corrosion and then deteriorating the strength. Steel is vulnerable to flying salt particles from evaporated seawater and liable to rust. The river to be bridged is a tidal river. In addition, the salinity of more than 20,000 micro-mhos has been recorded so far in the river water, which is almost similar to that of seawater, and seems to rise year by year.
  The Study Team observed existing steel structures near the bridge site like ferry ghat and shipyard facilities. Some of them were found in good conditions thanks to easy and periodic maintenance, but others were corroded badly and the strength as designed can never be expected now.
  One of the protection measures against the corrosion of the structural steel materials is paint coating and the other is utilization of weathering steel.
  The nature of steelwork requires high periodic maintenance and inspection costs i.e. repainting of the steelwork every 10 –15 years. Furthermore the bridge under study is a long bridge to be constructed over a high and vast navigation clearance, thus the repaint work requires entire falsework covering the whole steel surface.
  The weathering steel is effective to avoid corrosion under such preferable circumstances as the air does not contain salt particles nor sulfurous acid gas.
  In case a steel bridge is to be adopted for some reasons like for the short construction period, it is advisable to select a bridge with a structural type which enables to

minimize the repaint work later. In other words, a box girder bridge has an minimum exposed surface area to the atmosphere, and thus is easy to maintain. But on the other hand truss bridge, and arch and its family structural types has too much surface area and many numbers of elements, and therefore easy to be corroded and difficult to maintain.

- Importation of materials
  Selection of steel bridge requires importation of various items and skilled labors concerning steelwork.
  Fabricated elements must be imported, because fabrication of large-scale bridge structure needs sophisticated materials, techniques and facilities. Furthermore, for assembling the imported elements at site, skilled workers and high quality materials including paint materials, welding rods, high tension friction grip bolts and other consumables have to be imported.

- Experience in Bangladesh :
  There is not much experience in use of structural steel for long span bridges recently in Bangladesh, although the Hardinge Bridge is a steel railway bridge, which is in good condition as no corrosion damage are observed in the steel structures. Also many Bailey Bridges are found in the country. They are galvanized, easy to be assembled and generally used only for a temporary use.

(2) PC Bridge

- Experience in Bangladesh :
  Bangladesh has experience in constructing prestressed concrete bridges of not only short to medium span but also 100 meter-class long span so far.

- Availability of materials
  Most of major materials for prestressed concrete are available domestically, although prestressing wire/strand have to be purchased from other country. Also for a PC cable stayed girder bridge, cable materials and the anchoring appliances have to be purchased from foreign countries and they are very much expensive.

- Maintenance
  Periodic maintenance is not necessary in general to the structural body, though Cheap construction cost girder bridge must be well maintained to keep their function.

- <u>Cheap construction cost</u>
  Generally speaking PC bridges are cheaper than those of steel, and it is furthermore true in the steel importing countries.

- <u>Long construction period</u>
  Most concrete works are carried out at site step by step, and thus usually it takes longer time than steel bridge. In order to eliminate the disadvantage as much as possible, precast method and segment erection method are adopted.

- <u>Heavy weight of structure</u>
  Concrete is such material as is three times heavier, but has much less strength than steel material. Therefore much more material is required to support the same load. As a result the weight of the structure itself is enormous and necessitates very strong foundation.

12.2.5 Picking up all Possible Candidates for Main Bridge

Table 12.2.1 and Table 12.2.2 show ranges of span length that is suited for each structural type of steel and PC bridges.
They signify that a certain type of superstructure is not only physically possible but also reasonably economical when the span length is within the span range indicated therein, if other conditions mentioned in 12.2.2 are satisfied.

All the types that may be possible to the minimum span of 100 meters and 50 meters are the preliminarly selected.

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

<u>PC Bridge</u>

① Continuous Box Girder Bridge
② Truss Bridge
③ Arch Bridge
④ Cable Stayed Girder Bridge
⑤ Extradosed Bridge

Steel Bridge

① Continuous Girder Bridge with Steel Deck
② Continuous Truss Bridge
③ Langer Arch Bridge
④ Lohse Arch Bridge
⑤ Trussed Langer Bridge
⑥ Nielsen Bridge
⑦ Arch Bridge
⑧ Cable Stayed Girder Bridge
⑨ Suspension Bridge

(2) Possible types for Atherobaki Bridge
(Required minimum span length = 50 meters)

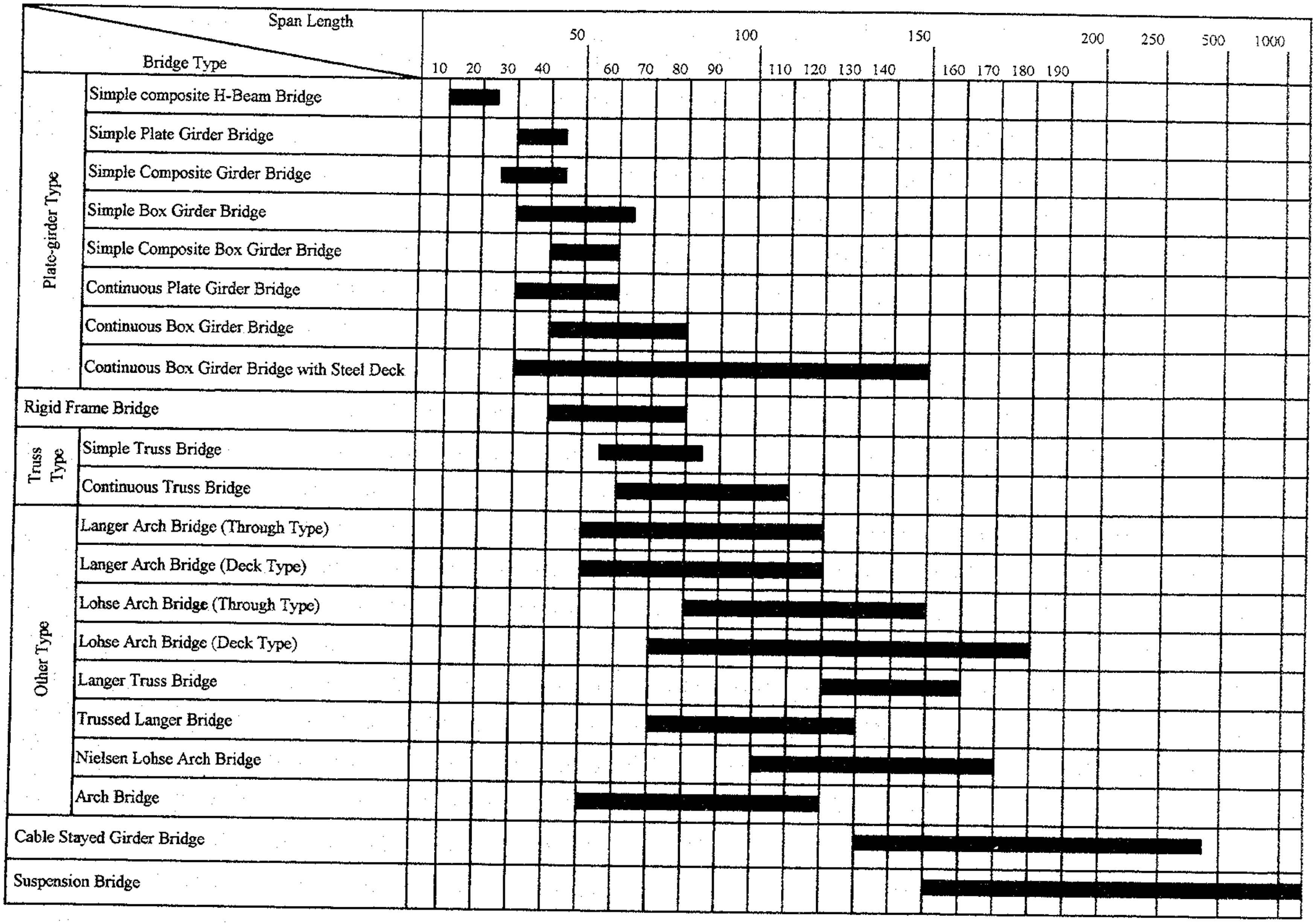
PC Bridge

① Simple Box Girder Bridge
② Continuous Box Girder Bridge
③ Truss Bridge

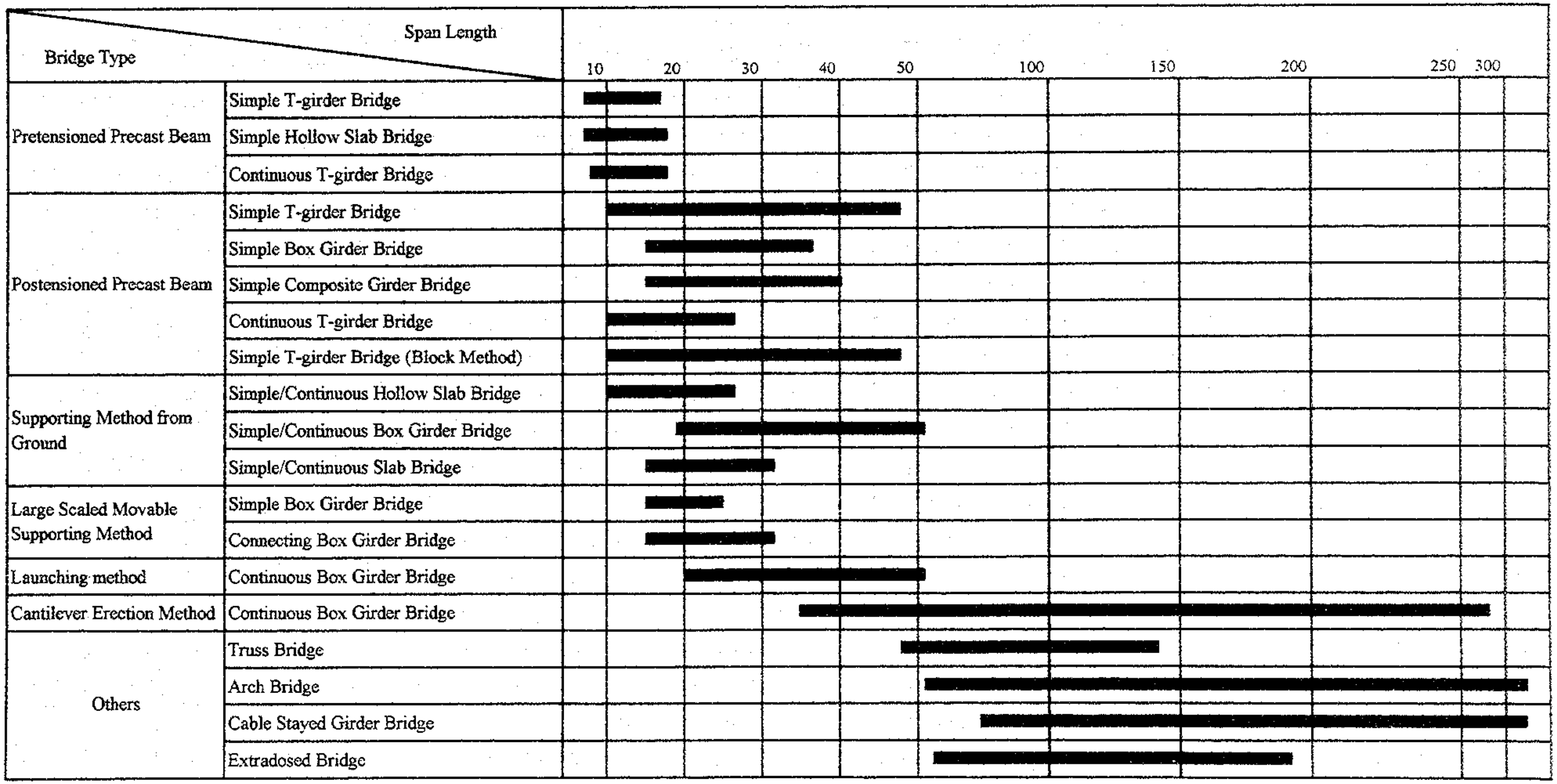
Steel Bridge

① Simple Box Girder Bridge
② Simple Composite Box Girder Bridge
③ Continuous Plate Girder Bridge
④ Continuous Box Girder Bridge
⑤ Continuous Girder Bridge with Steel Deck
⑥ Rigid Frame Bridge
⑦ Simple Truss Bridge
⑧ Continuous Truss Bridge
⑨ Langer Arch Bridge (Through/Deck Type)
⑩ Arch Bridge

Table 12.2.1 Structural Types of Steel Bridge and Range of Span Length Applied



12.2.2 Structural Types of PC Bridges and Ranges of Span Length Applied



12.2.6 Preliminary Selection of Structural Types for Main Bridge

Out of all possible alternattives, the following types were omitted based on the factors previousely described.

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

Those types below are deleted for the reasons stated herein.

PC Bridge

1) ②Truss is a very rare type of concrete and this type is adopted only when constrained to do so for some special reasons.
2) ③ Arch Bridge requires a deep structure below deck, and therefore is disadvantageous to a bridge where navigation clearance is severely limited.
3) ⑤Extradosed Bridge is a too rare and new type to adopt as one of the alternatives. This is a type that is in a position between a girder bridge and a cable stayed girder bridge from viewpoints of appearance and structural engineering.

Steel Bridge

1) The types ③ through ⑦ consists of so many and slender steel elements that they have a complicated details and vast exposed area to the atmosphere. This signifies that they are vulnerable to rust and thus impose much difficulty in maintenance.
2) The types ③ through ⑦ are so-called simply supported structures and thus the erection work necessitates temporary supports installed on the river bed during construction. Otherwise the structure must be lifted up and placed as a whole by employing huge floating cranes onto a right position one span by one span.
3) Criterion on aesthetics to bridge form depends on individuals, but generally speaking forms of truss bridge and trussed langer bridge are not highly appreciated.
1) ⑧ and ⑨ are suitable to a bridge with rather longer span lengths. Therefore it would cost much more in the construction and maintenance, if these types would be adopted.
5) Not only steel materials but also fabricated elements and other relevant parts, tools and consumables must be imported.

(2) Preliminary selection for Atherobaki Bridge
(Required minimum span length = 50meters)

The types below are deleted from the listed alternatives for such reasons as described herein.

PC Bridge

1) All simply supported structures have difficulties of supporting themselves during construction as stated in (1). Thus ① is discarded.
2) For the same reason as stated in (1), ③ Truss Bridge is also discarded.

Steel Bridge

1) Simply supported structures such as ① Simple Box Girder Bridge, ② Simple Composite Box Girder Bridge and ⑦ Simple Truss Bridge deleted.
2) ⑥ Rigid Frame Bridge is adopted only when some special reasons necessitate it.
3) Truss types and arch types of ⑦,⑧,⑨ and ⑩ have problems of maintenance.
4) ③ Continuous Plate Girder Bridge and ④Continuous Box Girder Bridge have no fatal cause other than maintenance and higher cost than PC girder, but in the same way there's no reason to venture to adopt them in spite of the problems mentioned above.

(3) Policy on Locating Piers of the Main Bridge

The minimum span lengths were determined as 100 meters and 50 meters for Rupsa, Bhairab and Atai Bridges, and for Atherobaki Bridge respectively in 12.2.3. Keeping the minimum span length, piers are arranged based on the policies as follows;

1) For a continuous PC box girder bridge and continuous box girder bridge with steel deck, the span length shall be same as the required minimum span length. The reason is that generally speaking, it is most economical to arrange piers at intervals of the minimum span length.
2) Commonly the economical span length for a cable stayed PC girder bridge is much longer than the minimum span length established based on the navigation clearance. It is said that is 200 meters or more. Therefore the span length for the type shall be 200 meters.
3) The number of spans for the Main Bridge shall be odd number so that the clearance for the navigation may be provided in the middle of the river width.
4) The outermost piers of the Main Bridge shall be located outside the river width so that the outermost spans may span above the river banks where roads for bank maintenance are to be situated.
5) Whole length of the Main Bridge shall be equal among the alternative types so that fair comparison can be made.